KOFORIDUA TECHNICAL UNIVERSITY

FACULTY OF APPLIED SCIENCE AND TECHNOLOGY

DEPARTMENT OF FOOD AND POSTHARVEST TECHNOLOGY

PRESERVATION OF MANGO AND SOURSOP FRUIT MIX WITH NATURAL PRESERVATIVES

BY

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STUDENT DECLARATION

I hereby declare that this project work is the result of my own original work and that no part of it has been presented for another certificate in this University or elsewhere.

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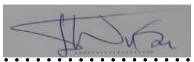
(B206010703) **(SIGNATURE)** **(DATE)**

SUPERVISOR'S CERTIFICATION

I hereby certify that this project work was supervised in accordance with the guidelines on supervision of project work laid down by the Koforidua Technical University.

PROF. JOHN OWUSU	 ………………….	12/12/2023 ………………
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DEDICATION

This project work is dedicated to the Almighty God who gave me the strength, knowledge and wisdom to carry out the work successfully. I also dedicate to Prof John Owusu for being a lecture, father, mentor and a friend. I also dedicate this work to my husband for being supportive throughout my work

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ABSTRACT

Fruit juices are usually preserved with synthetic preservatives. Many consumers have, however, in recent times, expressed concern about the negative effect of synthetic preservatives. This research was therefore focused on the use of natural preservatives honey, ginger and Senegal pepper in the preservation of mango-soursop fruit juice mix. Citric acid was added to the sample used for the treatment A (control), Treatments B, C, D, and E were preserved with honey, ginger, Senegal pepper, and a mixture of ginger and Senegal pepper respectively. Physicochemical qualities such as pH, TA, and TSS were determined before and after storage at 5^{o}C for 25 days, using standard methods. Colour parameters L* (lightness), a* (redness), and b* (yellowness) of the mango-soursop fruit juice mix were determined with a colour meter both before storage and after storage. Microbial analysis of the fruit juice mix done after storage were total viable count and yeast count. Also, after the storage period, vitamin C content of the treatments were determined. A 9-point hedonic scale with 1 as dislike extremely and 9 as like extremely with an untrained panel of twenty (20) was used to assess the preference for the various treatments before storage. The sensory qualities assessed were taste, after taste, colour, aroma, and overall acceptability. The results show that the type of preservative used influenced the pH, TA, TSS, L*, a*, and b*. The results showed that the treatments with natural preservatives honey, ginger, and Senegal pepper had more vitamin C content than the control. The total viable count of the treatments preserved with citric acid (Control) was lower than those of the natural preservatives. All the values obtained were however, below the acceptable limit for fruit juice. However, the yeast count for the control was higher than those of the treatments with natural preservatives. The treatments with natural preservatives had relatively lower preference scores in terms of most their sensory qualities and the overall acceptability. The results indicate that honey, ginger and Senegal pepper can preserve the vitamin C in mango-soursop juice mix better than the citric acid. The mango-soursop juice preserved with natural preservatives were safe for consumption. Also treatments with natural preservatives were least preferred compared to the one with citric acid. It is therefore recommended that the vitamin C content for the juice mix should be determined before and after storage to know the extent of vitamin C loss, the microbial analysis should be done for both before and after storage of the fruit juice mix, and the phytochemical components of the fruit juice mix should be assessed to appreciate its health benefits.

CHAPTER ONE

1.0 INTRODUCTION

1.1 Background of the study

Due to their characteristic aroma and colour, most tropical fruits are used for production of many food products, and have consequently gained attention worldwide (Chang et al., 2019). The belief that fresh fruit extracts and juices contribute to a balanced diet, are good sources of vitamins and minerals, and can lower the risk of many diseases is the reason why their use is rising globally. According to the producer's preference or even consumer desire, juices have been made over the years utilizing a fruit or fruit combination (Khan et al. (2018). Fruit juices are rich in nutrients, have numerous health benefits, and may ultimately help to reduce the risk of developing many diseases (Bhardwaj et al., 2014). Fruit juices are rich in antioxidants, vitamins C, and E (Lebaka et al., 2021). Studies have also shown that fruits possess anticancer and antioxidant capabilities (Moreno Luzia et al., 2012).

The tropical fruit known as the soursop, or *Annona muricata L.*, is a member of the *Annonaceae* family and has a distinctive aroma and flavour (Singh et al., 2016). It is an exotic fruit known for its delicious, somewhat acidic, fragrant, and juicy flesh (Fazilah et al., 2018). The fruit is an important source of vitamins, minerals and dietary fibre (Othman et al., 2014). The soursop fruit is largely underutilized and unexploited because it is frequently eaten raw or occasionally extracted and consumed as fresh soursop juice. The soursop fruit softens incredibly quickly during ripening and is mushy and challenging to swallow fresh, similar to many other tropical fruits with short shelf life. Extreme injury resulting from postharvest handling or uneven shape and size is responsible for rejection by buyers (Minh, 2017). To reduce postharvest loss and optimize its potential in the food processing sector, processing into juice, drinks, beverages, or other similar products capable of maintaining the nutritional and health advantages is of utmost importance. Increasing number of claims about the functional, processing, and consumption advantages of the fruit have been made (Olagunju and Sandewa, 2018).

Mangoes are a widely consumed tropical fruit that have enticing sensory qualities and a healthy nutritional profile (Kabir et al., 2017). As a seasonal fruit, mangoes are frequently turned into purees or juices to be used in jam, yoghurt, ice cream, and other products to prevent waste (Kaushik et al. 2015). Vitamins (A, C, and E), dietary fiber, and the minerals magnesium and potassium are all present in mango in significant amounts (Burton-Freeman et al., 2017). Mangoes also have phytochemicals such phenolic acid, mangiferin, carotenoids, and gallotannins that may be more beneficial to human health than micro- and macronutrients (Fazilah et al., 2018). Phenolic acid and carotenoids have been linked to antioxidant activity, which is crucial for extending the shelf life of dairy products by inhibiting lipid oxidation. It has been reported that the survival of gut bacteria and their ability to adhere to intestinal epithelial cells were enhanced by the phytochemicals (Parkar et al., 2013).

Fruit juice preservation is crucial for extending the shelf life of products while keeping their quality and safety, which is significant for both producers and consumers (Pinela and Ferreira 2017). The ability to minimize pathogenic microbes in fruit juices is a major challenge. The consumer now demands minimally processed food free from chemical preservatives, and some food processing and preservation technologies adhere to these requirements (Svisco et al., 2019). The current trend in fruit juice preservation is focused on the use of certain techniques that can guarantee quality products with few additional preservatives and great nutritional content, while also keeping the product safe (Ranken et al., 2012). Acidification, fermentation, heating (pasteurization and sterilization), and the use of chemical preservatives are some of the preservation techniques used to extend the shelf life of fruit juices. In recent times, non-thermal methods and the inclusion of natural antimicrobials have also become very popular (Pisoschi et al., 2018). In food goods, natural preservatives such bacteriocins, organic acids, essential oils, and phenolic compounds have long been employed (Baptista et al., 2020).

A study carried out on the effect of natural and artificial preservatives and storage temperature on the pH and microbial load of freshly produced apple juice revealed that preservation was enhanced with the combined use of natural preservatives and refrigeration (Ekanem and Ekanem, 2019). According to the authors, microbial count was considerably reduced, and concluded that natural preservatives can replace chemical preservatives. In another study, natural preservatives influenced the physicochemical and microbiological quality of fruit juices as well as its safety (Prisacaru et al., 2023). Natural preservation coupled with refrigeration can be used to increase the shelf life of fruit juices. Usage of natural preservatives is simple, cheap, and convenient, and therefore the consumption of naturally preserved juice should be encouraged. A study by Prisacaru et al. (2023) revealed that the use of natural preservatives influences the physicochemical and microbiological quality of fruit juices and ensures its safety. It was against this background that the research was done to find out the possibility of preserving mango and soursop fruit juice mix with natural preservatives.

1.2. Problem statement

Girma and Garo (2021) estimate that between 30 and 50 percent of the fruits cultivated in underdeveloped nations, including Ghana, are never eaten because they go waste during harvest, transit, handling, restricted storage, and processing. Generally, enzyme and microbial activity negatively influence the shelf life of fresh juice. According to Khan et al. (2018), osmophillic bacteria is the primary cause of fruit juice spoilage. The local consumption of fruit juices does not match up with its production due to the large in-flow into the Ghanaian market. Even though possible measures are being put in place to improve the consumption, utilization and development of values addition of fruit, its postharvest loss, limited shelf life as well as consumer complain about storage and effect of the method of preservation on its health and nutritional profile is a major concern.

According to Anaya-Esparza et al. (2017), pasteurization is now the technology of choice for inactivating microbes and enzymes to increase product shelf life. However, the high processing temperature can alter the nutritional and biochemical characteristics of juice, which can have a negative impact on the overall quality of the product (Chen et al., 2013). Fruit juice is usually preserved with synthetic preservatives, and recently, many have expressed concern about their potential health effects such as food allergy, food intolerance, cancer, multiple sclerosis, attention deficit, hyperactivity disorder, brain damage, nausea and cardiac disease (Yadav and Gupta, 2021). In response to these limitations, it has become necessary to explore other preservation techniques which could extend the shelf life of fruit juice at the same time preserving its quality and presenting little or no health issues Therefore, the study was carried out to find out whether natural preservatives like honey, ginger, and Senegal pepper could be used to preserve mango-soursop juice mix.

1.3 Objectives of the study

1.3.1 Main objective

The main objective of the study was to explore the preservation of mango-soursop blend using honey, ginger and Senegal pepper extract as natural preservatives.

1.3.2 Specific objectives

The specific objectives of the study were to:

(i) determine the effect of different types of preservatives on the physicochemical qualities of mango-soursop juice mix

(ii) assess the effect of different types of preservatives on the sensory qualities of mango-soursop juice mix

(iii) determine the effect of different types of preservatives on the microbial safety of mango-soursop juice mix

(iv) assess the effectiveness of the different types of preservatives on storage stability of mango-soursop juice mix

1.4 Research questions

The study used the following research questions:

(i) What is the effect of different types of preservatives on the physicochemical qualities of mango-soursop juice mix?

(ii) How do different types of preservatives affect the sensory qualities of mango-soursop juice mix?

(iii) To what extent do different types of preservatives affect the microbial safety of mango-soursop juice mix?

(iv) How effective are different types of preservatives on storage stability of mango-soursop juice mix?

1.5 Significance of the study

Fruits like mangos and soursop are perishable in nature. However, by preserving the juice made from these fruits, the shelf life can increase to increase its availability during a time of scarcity. Because the amounts of nutrients in mango and soursop fruit vary, combining the two fruits will result in a product that is much more nutrient-dense than fruit juice made from each fruit alone. The use of natural preservatives is likely to bring about reduction in the use of synthetic preservatives in juice blends. Again the study will help contribute to already existing knowledge in juice blend and preservation using natural substance in other to improve upon the utilization of fruits as well as limit the health implications associated with the use of artificial preservatives.

1.6 Scope of study

This study covered areas such as: production of fruit juice mix using mango and soursop, preserved with preservatives (such as ginger, cloves, and honey). The physicochemical qualities of the fruit juice mix studied were pH, acidity, total soluble solids, and vitamin C. Natural preservatives such as ginger, Senegal pepper, and honey were used for treatments either than the control. The control was preserved with citric acid. The microbial analysis covered only yeast and mould. Sensory evaluation of the fruit juice mix was also carried out using twenty (20) untrained sensory panelists.

1.7 Limitation of the study

The physicochemical properties of the juice blend were limited to pH, acidity, total soluble solids and vitamin C. The shelf life study was done over a period of 25 days at a temperature of 5^o C. The amount of vitamin C left in the fruit juice mix at the end of the 25 days was used as a measure of the effectiveness of the preservative used. This could distort the results because the initial amount of the vitamin C was not determined. Moreover, the various preservatives might contain vitamin C themselves and might have contributed differently to the vitamin C content at the end of the storage period. Therefore, the interpretation of the stability results should be done with care. Only yeast and mould count were used to determine the safety of the fruit juice mix at the end of the storage period. Other microbes could influence the safety of the fruit juice mix, but were not determined, so safety interpretation could be subjected to some errors.

1.8 Organization of the study

The study is organized into chapters. Chapter one is introduction, which is made up of the background of the study, statement of the problem, objectives of the study, research questions of the study, significance of the study, scope of the study, limitation of the study and organization of the study. Chapter two is about the review of existing literature which relates to the topic. Chapter three is the methodology adopted for the study. Chapter four presents the results and discussion and chapter five is concerned with summary, conclusions and recommendations.

CHAPTER TWO

2.0 LITERATURE REVIEW

2.1 Introduction

This chapter presents the literature review of studies related to the present study. It covers areas such as the nutritional composition of mango and soursop fruits, health benefits of mango and soursop fruits, juices, juice blend, spoilage of fruit juice, prevention of fruit juice spoilage, artificial and natural preservatives.

2.2 Fruits

Fruits are the fleshy, seed-related structures that are eaten raw and have a sweet or sour taste. Fruits come in many varieties and serve a variety of purposes. The most commonly grown ones include lemon, orange, grape, strawberry, banana, mango, cashew, pineapple, pawpaw, apple, and grape. Fruits are consumed mainly because they are a healthy source of vitamins, minerals, and fiber (Muhammad et al., 2018). Yogurt, jam, candies, and ice cream may all contain crushed fruits (Bille et al., 2013).

2.2.1 Fruit consumption trends

According to a study by Hall et al. (2009), eating of fruits common in all the developing natio ns examined (including 18 in Africa), with prevalence rates for men and women ranging from 63.4% and 62% in Ghana. According to USDA (2005), despite the relatively high prevalence seen in Ghana, data obtained showed that none of the other developing nations under study including Ghana had reached the recommended (146 kg/day) minimum quota of fruit and vegetable consumption. The researchers also hypothesized that the under consumption of fruits and vegetables contributed to around 3 million deaths and 26 million disability adjusted life years, a trend that could be readily reversed by eating at least five servings of fruits and vegetables each day. In Africa, vegetable is much more consumed than fruits–because vegetables make up the majority of the ingredients in native dishes (Hall et al., 2009; FAO/WHO, 2004), demonstrating a lower prevalence of fruit consumption than vegetable consumption.

2.2.2 Nutritional and health benefits of fruits

Fruits are rich in macronutrients like fiber and micronutrients like minerals and vitamins C, riboflavin, B6, niacin, folate, thiamin, and phytochemicals. Carotenoids, glucosinolates and polyphenols may have much health benefits. Fruits and vegetables are one of the exceptional sources of dietary minerals, micronutrients, vitamins, and fiber that are crucial for human health and wellbeing (Yahia et al., 2019). Because they can prevent vitamin C and A deficiency and lower the risk of many diseases, diets high in fruits and vegetables should be consumed regularly. For this reason, fruits and vegetables are regarded as essential for health and fitness (Khan et al., 2015). Fruits and vegetables are good dietary sources of nutrients and micronutrients for humans.

Fruit-rich foods are particularly significant since they can lower the incidence of several diseases and prevent vitamin A and C deficiency (Chambial et al., 2013). Consumption of fruits and vegetables can prevent cancers and cardiovascular diseases, and this is supported by scientific evidence. The lower risk of chronic disease associated with the consumption of plant-based diets is as a result of the presence of antioxidants, folate, fiber, potassium, flavonoids, and countless other phytochemicals (Chambial et al., 2013). Fruit consumption has significantly increased due to health benefits. People now spend less time cooking at home and, for the most part, dine out rather than at home due to the change in lifestyle (Abadias et al., 2008). A healthy diet is one of the best strategies to maintain and improve health. The state of our health is largely influenced by what we consume. This suggests that there is a link between diet consumed and the possibility of disease development (Nti et al., 2011). Studies have shown that consumption of more fruits and vegetables lowers the risk of cancer and cardiovascular diseases development (Wang et al., 2014). According to the World Health Report (2002), throughout the world, consumption of too few fruits and vegetables accounts for about 11% of strokes and 31% of heart diseases. According to the research by World Health report, (2002), eating enough fruits and vegetables could save around 2.7 million lives every year. This may be explained by the fact that fruits and vegetables are endow with vital nutrients like vitamins, minerals, fiber, and water, all of which contribute to proper nutrition and overall health (Pamplona-Roger, 2006).

2.3 Juice blend

Blending fruit juices is one of the best ways to boost the nutritional value of the drinks; depending on the type and quality of the fruits used, it may also improve the amount of vitamins and minerals present (De Carvalho and coworkers, 2007). In addition to its nutritional value, blended juice can be improved in its interactions with other factors, therefore it cannot fully represent the entire effect of other factors. A natural health drink that can serve as both an appetizer and a beverage can be produced through mixing (De Carvalho et al., 2007). Fruit juice mixes have been actively marketed in recent years due to their distinctive and delicious flavour (Jan and Masih, 2012). Juices of fruits of different physical and chemical compositions, when combined together enhances the nutritional worth of the juice. Juices of improved nutritional and gustatory properties are produced as the key components are combined (Akusu et al., 2016). The medicinal, nutritional, and sensory advantages of two or more fruits are combined in unique, high-quality beverages made by modern fruit beverage processing companies using blending technology (Dhumal et al., 2014).

2.4 Overview of mango

The mango, scientifically known as *Mangifera indica L.*, is a luscious stone fruit that is grown around the world, primarily in tropical regions. It is a member of the *Anacardiaceae* family in the order of Sapindales. Only a few of the available varieties are grown and traded on a commercial scale (Sols-Fuentes, 2011). Mangoes are being grown on over 3.7 million acres of land worldwide. In terms of productivity and land utilized, mango fruit takes second place among tropical crops, trailing only bananas (Muchiri et al., 2012). Mango fruits are a significant source of minerals, vitamins, and other compounds, as has been extensively established. Mango fruits also contribute to proper human growth, development, and health (Tharanathan et al., 2006) and offer energy, dietary fiber, carbs, proteins, lipids, and phenolic substances (Jahurul, 2015).

Mangos are also the most important tropical fruit crop after bananas and plantains (FAO, 2011). The mango fruit, which may weigh up to 1 kg in some cultivars, is a sizable, fleshy drupe that is widely diverse in terms of size, shape, color, and flavor. There are more than a thousand varieties of mango (Kent mango, Keith mango, Atualfo, Haden mango etc). (Ediriweera et al., 2017). Unripe fruit starts as green, then after 3 to 6 months when it ripens, it turns orange-reddish. A thick exocarp (skin), a sticky edible mesocarp (flesh), and a woody endocarp (pit) make up the fruit. The bulk of mango production is used for fresh consumption, and just 1% to 2% of it is processed to create goods like juices, nectars, concentrates, jams, jelly powders, fruit bars, flakes, and dried fruits (Berardini et al., 2005). Juice can be made from mango cultivars that are too fibrous or soft to eat fresh (Beyene and Araya, 2015).

2.4.1 Production and commercialization of mango

More than 87 nations have recorded commercial mango production. According to Tharanathan et al. (2006), the top mango-producing nations are India, China, Thailand, Indonesia, the Philippines, Pakistan, and Mexico. In places like Central and South America, Australia, South-east Asia, Hawaii, Egypt, Israel, and South Africa outside the typical mango-growing regions mango production is rising, especially for export markets (Tharanathan et al., 2006). The most important exporting countries are Mexico (41% of the world market) followed by the Philippines (7.6%) and Pakistan (7.8%) (Sauco, 2004).

2.4.2 Utilization of mango

Both green matured (unripe) and ripe mango can be processed into many different food products. Green mangoes are made into pickles, chutneys, dry powder, and brine stock. The most recent advancements include drum-dried green mango powder, instant mango pickles, and raw mango beverage bases (Chau et al., 2000). According to Chau et al. (2000), unripe mango slices are also kept with salt for subsequent use as pickles, chutney, or salt stock for export. In the culinary preparations for traditional Indian cookery, mechanically dried and powdered ingredients are used.

Siddiq et al., (2017) reported that ripe mangoes (mature and post climacteric ripe fruit with full flavour development) are processed into: i) frozen mango products (e.g. slices in syrup, pulp and beverage base); ii) canned products e.g. slices in syrup, pulp, juice and nectar; iii) ready to serve beverages; and iv) dehydrated products e.g. mango fruit bar, mango cereal flakes, mango powder, strained baby foods, mango toffees. Crushed fruits are used in yoghurt, jam, sweets, and ice cream (Oyeyinka et al., 2009).

Ampomah-Nkansah (2015), found that mangoes are typically canned as slices, cheeks, or dices when they are just beginning to ripen. The Alphonso mango type from India is best because other varieties produce canned goods with a mild flavor and color. Additionally, adding ascorbic acid to the canned mango slices in syrup at various amounts (50-100mg/l) improves flavour retention.

2.4.3 Chemical composition of mango

Mango fruits are reportedly acidic, astringent, and high in ascorbic acid (vitamin C) at the beginning of the ripening phase. Although ripe mangoes have a moderate amount of vitamin C, they also have a fair amount of pro vitamin A and vitamins B1 and B2 (Litz, 2003). According to Modawi (2016), malic and citric acids, along with oxalic, malonic, succinic, pyruvic, adipic, galacturonic, glucuronic, tartaric, glycolic, and mucic acids, are the main causes of fruit acidity. The acidity of mango is influenced by its cultivar, and acidity level decreases during ripening. Following fruit set, starch accumulates in the mesocarp. Free sugars like glucose, fructose, and sucrose usually increase as fruit ripens and so climacteric fruits have a three- to four-fold increase in sucrose content due to the hydrolysis of starch (Bello et al., 2007). The mango seed kernel is an abundant source of fat, protein, carbs, and tannins. The kernel fat (on average 12%) has potential application for making sweetmeats due to its blandness, plasticity, and lack of hazardous chemicals (Eipeson and Ramteke, 2003). The peel/skin of fully ripe mangoes is known to be rich in many nutrients such as terpenoids, but it is not consumed because of its unpleasant taste (Dzamic et al. 2010).

2.4.4 Nutritional value of mango

Mango, a flavourful and nutrient-rich fruit, is an excellent source of vitamins C and A, both of which are important in human health. According to the NMB (2015), a one-cup serving of edible portion of mango has only 100 calories, and provides daily recommended allowance of 100% for vitamin C, 35% vitamin A, and 12% of daily fiber. Mango fruit has very low sodium (2 mg/100 g) and high potassium (156 mg/100 g) contents. Potassium, an important component of cell and body fluids, is helpful in controlling heart rate and blood pressure (Evans et al., 2017). Mango fruit is an excellent source of flavonoids, beta-carotene, and beta-cryptoxanthin. According to USDA (2004), Nutritive value of 100g edible portion of raw mango fruit has been reported to be as follows: inedible waste (34%), energy (59kcal or 253kJ), protein (0.5g), fat (0. 0g), carbohydrate (as monosaccharide) (15.3g), water (83g), Ca (10mg), iron (0.5mg), Na (7mg), Vitamin A (retinol equivalent) (200g), Thiamine (0.3mg), Riboflavin (0.04mg), 38Niacin equivalent (0.4mg), and Vitamin C (30mg).

2.4.5 Postharvest Losses of Mango

Mango is a highly perishable fruit. The perishability of the fruit is attributed to rapid deterioration after harvest. It is also susceptible to insect-pest infestation and decay causing postharvest losses due to lack of proper pre-harvest practices. Mango has a short shelf life and vulnerable to environmental stress especially high temperature. Considerable quantities of mangoes are lost every year during harvesting, transport and marketing (Hassan, 2010). Postharvest losses occur all along the value chain, beginning for the time of harvesting right up to packaging, storage, transportation, retailing and consumption. In most developing countries this is mainly due to the combination of poor infrastructures and logistics, poor farm practices, lack of postharvest handling knowledge and a convoluted marketing system. As a result of postharvest losses of fruits, the nutritional status of the population and the economy of the developing countries are deeply affected. It is reported that 25-45% postharvest loss occurs at different postharvest stages of mango (Hassan, 2010).

The major causes of postharvest losses are improper harvesting, traditional handling practices at different stages of supply chain, postharvest diseases and poor storage conditions (Gorney et al., 2002). Non-technological factors also contribute to postharvest loss, such as lack of capable human resources, lack of knowledge about technical and scientific technologies, inefficient commercialization and marketing systems, lack of logistical support, and lack of enabling policy for the use and administration of human, economic, technical, and scientific resources (Kader and Rolle, 2004). These losses are particularly high in underdeveloped countries (almost 50%) and most of them are due to pathogen attacks (Shoji et al., (2011).

2.4.6 Processing and storage of mango

Mango pulp is perfectly suited for conversion to juices, nectars, drinks, jams, fruit cheese and so on. It can also be used in puddings, bakery fillings, and fruit meals for children, flavours for food industry, and also to make the most delicious ice cream and yoghurt. While the raw fruits are utilized for products like chutney, pickle, amchoor (mango powder), green mango beverage, etc. ripe ones are used in making pulp, juice, nectar, squash, leather, slices, etc (Siddiq et al., 2012). Major export products include dried and preserved vegetables, mango and other fruit pulp, jams, fruit jellies, canned fruits and vegetables, dehydrated vegetables, frozen fruits, vegetables and pulp, freeze dried products and traditional Indian products like pickles and chutneys (Liu et al 2003). Processed mangoes enable exporters to serve their markets even during off-season period for fresh mangoes. Ripe mangoes may be frozen whole or peeled, sliced and packed in sugar (1-part sugar to 10 parts mangoes by weight) and quick-frozen in moisture-proof containers (Brecht et al., 2010). The diced flesh of ripe mangoes, bathed in sweetened or unsweetened lime juice, to prevent discoloration, can be quick-frozen, as can sweetened ripe or green mango puree (Paull and Chen 2004). Since processing is known to affect the physico-chemical, nutritional, and sensory quality of processed mango products, it is important to design and optimize processes to preserve these qualities (USDA 2016).

Kadam et al. (2010) investigated the effect of drying air temperature (65, 75, and 85 °C) on the chemical properties of foam-mat dried mango juice powder. Chemical properties such as total sugars, ascorbic acid, total carotenes, minerals, total acid, pH, TSS, and microbial load (fungal and bacterial) of foam-mat dried mango powder were determined. Generally, all chemical properties showed a decreasing trend with an increase in drying air temperature. The decrease in ascorbic acid content was most pronounced (5.60, 4.05, and 3.20 mg/100 g in 65, 75, and 85 °C dried mango powder). Total acids and total carotenoids also decreased significantly with the corresponding increase in drying air temperature.

Zafar and Sidhu, (2017), evaluated the chemical composition of mango pulp and canned mango juice. Whole mangoes were blanched in boiling water for 3 min and mechanically crushed to obtain pulp. Juice was obtained by filtering the pulp and diluting it with water. Then the juice was preheated through a plate heat exchanger at 80 °C and hot-filled into cans, and thermally processed at 100 °C for 30 min. Mango juice had a significantly lower content of ascorbic acid and carotenoids as compared to pulp since both ascorbic acid and carotenoids are heat sensitive.

2.5 Soursop fruit description

The soursop tree produces spiky aggregation fruits that are dark green and made of fused-together berries and associated flower parts (Blancke, 2016). The soursop fruit can weigh more than 4 kg and occasionally has an oval or heart-shaped shape (Badrie and Schauss, 2010). A fruit might have 5 seeds or it might contain 200 seeds. The skin is reticulated and has small spines (Patel and Patel, 2016). Its creamy-colored, granular interior is covered with a white, fibrous, juicy covering that can be readily peeled away from its soft, pithy core (Badrie and Schauss, 2010). The soursops can be broadly categorized into three categories: acid, subacid, and sweet. They are next split into oblong, round, heart-shaped, or angular shapes. Finally, they are grouped according to how hard the flesh is, which can range from wet and soft to stiff and extremely dry (Matsuda, 2017).

2.5.1 Chemical composition of soursop fruit

According to Uchegbu et al. (2018), the soursop fruit has 20% skin, 67.5% edible pulp, 4% core, and 8.5% seeds by weight. The white edible pulp is 80–81% water, 1% protein, 18% carbohydrate, 3.43% titratable acidity, 24.5% non-reducing sugar, and vitamins B1, B2, and C, among other components. Some of the physicochemical characteristics included refractive indices of 1.335 for the seeds and 1.356 for the pulp, pH values of 8.34 for the seeds and 4.56 for the pulp, and soluble solids concentrations of 1.51^0 Brix for the seeds and 151^0 Brix for the pulp (Gavamukulya et al., 2017). According to Gavamukulya et al. (2017), Soursop contain 53.1-61.3 calories, 82.8 g of moisture, 1 g of protein, and 0.97 g of fat. 0.79 grams of fiber and 60 grams of ash, Vitamin A(β-carotene) 10.3 mg of calcium, 27.7 mg of phosphorus, 0.64 mg of iron, and 0.11 mg of thiamine. Niacin 1.28 mg, riboflavin 0.05 mg, and vitamin C 29.6 mg in the soursop pulp, which contains tryptophan (11 mg), methionine (7 mg), and 60 g of lysine, sugars account for between 67.2 and 69.9% of the total solids, making them the second-most prevalent element after water

According to Patel and Patel (2016), the fructose, D-glucose, and sucrose percentages in the soursop pulp were 1.80, 2.27, and 6.57%, respectively, for a total sugar content of 10.48%. In addition to pectin, potassium, salt, calcium chloride, and citrate, the soursop fruit also contains 12% sugar (Siqueira et al., 2015). Gavamukulya et al. (2017) found that 0.78 to 0.95% of a soursop's pulp is made up of fiber. Pectin makes up the majority of the alcohol-insoluble solids in ripe fruit, which are present in amounts of 4.0% by dry weight from pre-climacteric to climacteric stages, respectively, and 0.91 percent by fresh weight from pre-climacteric stages.

2.5.2 Processing and food uses of soursop

In the tropics, the soursop fruit is mostly used to make juice, and the seeds are a common byp roduct of this business (Villacís-Chiriboga et al., 2020). There are two varieties of soursops: guanaba acida (very sour), which was only used for beverages, and guanaba azucaron (sweet), which was consumed raw and used for beverages (Anilakumar et al., 2015). Yet, industrial sour fruit processing is still in its infancy. You can buy fresh or frozen pulp, strained soursop juice, and frozen concentrates of the fruit. According to de Lima and Alves (2011), these products have been preserved and used to make delicious foods like yoghurt, shakes, syrups, jellies, preserves, ice cream, jams, sherberts and nectars. With the addition of some gelatin, it can be turned into a fruit jelly, or it can be used to make drinks, sherbets, ice cream, and syrups. (de Lima and Alves, 2011). In Brazil and Cuba, the fruit is combined with milk and sugar to make champola, but in Puerto Rico, water is typically added (Badrie and Schauss, 2010). Sánchez et al. (2018) also developed juice blend from a soursop-papaya drinks from 20% soursop pulp, 30% papaya pulp. The tender seeds of the immature fruits have been used in soups, as vegetables, and with coconut milk. In Brazil, seeds are consumed or used medicinally after being roasted or fried (Anilakumar et al., 2015).

2.5.3 Medicinal uses of soursop

Soursop is a plant that is used in herbal medicine as an antispasmodic, emetic, and sudorific. While a decoction of the leaves is used to get rid of bedbugs and head lice, a tea made from the leaves is well known in the West Indies for its calming effects (Wijeratne et al., 2016). The juice of fruit is taken orally for urethritis, liver problems, and hematuria (Bandara et al., 2023). Extract from the stem bark of A. muricata has been shown to have anti-stress qualities. Studies have shown that an ethanol extract of the soursop stem bark dramatically reduces stress levels in anxious rats, suggesting that the extract may have adaptogenic effects (Rethinam and Sundararaj, 2016). The plant extract was found to reduce the rise in brain 5-hydroxytryptamine (5-HT) and 5-hydroxyindole acetic acid (5-HIAA) levels brought on by stress by increasing the levels of the MAO enzyme, which was reported to have decreased 5-HT and 5-HIAA. Furthermore, it has been demonstrated that administering the ethanol extract to rats significantly lowers the increase in lipid peroxidation induced by the cold immobilization stress in the rats' liver and brain (Lewis and Lewis, 2012).

2.5.4 Post-harvest issues in soursop

The post-harvest loss was estimated at 75.8% in a preliminary analysis of the post-harvest issues involving tropical fruits (Badrie and Schauss, 2010). The primary issues were brought on by poor field procedures and fruit growers' ignorance of the factors affecting fruit quality. The loss is further made worse by improper management during the marketing process. Annona fruits have a limited shelf life and are climacteric (Badrie and Schauss, 2010). The fruits of the soursop are picked when fully developed, firm, yet somewhat yellow-green. They will fall and be crushed if they are allowed to deteriorate on the tree. Fruits that are ripe are highly delicate and prone to bruising which shortens the post-harvest life (Devall, 2004). Ripening at room temperature is advised since the young fruits do not fully develop flavor and aroma when ripened off the tree (Jha et al., 2007). Fruits of the soursop are highly sensitive to cold temperatures. According to de Lima and Alves (2011), the signs of chilling injury in soursop include skin darkening, inability to ripen, pulp discoloration, poor flavor and aroma, and a rise in rot. Storage of soursop fruits at 101°C for 1 day results in a pronounced loss of flavor and aroma (Jiménez-Zurita et al., 2017). Fully mature soursop fruits can be kept in the refrigerator for a further 2-3 days. As fruit ripens, its composition changes, which are reflected in trends in respiration and ethylene production. The preclimacteric post-harvest stage of the growth cycle experiences a low degree of ethylene production (Badrie and Schauss, 2010). In order to prevent the production of ethylene gas and to slow down ripening, all soursop fruits that are damaged must be removed (Jiménez-Zurita et al., 2017). Additionally, since immature soursop fruits ripen quickly, it is best to remove them all because they will slow down the ripening of mature soursop fruits. The creation of cultivars with various maturity durations has been prompted by the short harvest season and the quick ripening of the fruit in an effort to balance the market supply (Badrie and Schauss, 2010).

2.6 Fruit juice spoilage

Fruit juice consumption provides a number of health benefits, but consumers are worried about the rising incidence of food-borne illness outbreaks and spoiling issues (Chorianopoulos et al., 2008). Reported increased cases of food borne disease outbreaks, has made contamination of fresh fruits to become a major public health concern (Oussalah et al., 2007). Although contaminations have not been conclusively linked to the pathogen in any outbreak of fruit juice, there are a number of serious food safety issues associated with consumption of fruit juice that are documented. The use of dropped fruit and non-potable water are the main causes in outbreak cases. Most of the reported outbreaks involve unpasteurized juices such as pineapple, apple, banana, acai, carrot, orange, lemon and mixed fruit juices (Bevilacqua et al., 2011). Fruit juice deterioration has three main causes: microbiological spoiling, rancidity-causing oxidation, and browning. Fruit juice components offer the perfect habitat for microbes to degrade food; yet, because most juices have a pH of 4.5 or below, the majority of the possible spoiling agents are bacteria that prefer acidic conditions. Yeasts are commonly found in juices due to their high acid tolerance and the ability of many of them to develop anaerobically. They are also responsible for over half of the documented commercial fruit juice contamination, which is mostly linked to inadequate plant hygiene (Stratford et al., 2000). The majority of spoilage yeasts are extremely fermentative and produce ethanol and CO2 from sugar. Pichia anomala, a yeast that forms films, has been linked to reports of wine and fruit juice deterioration (Le-Dinh and Kyung, 2006; Pitt and Hocking, 2009). Among the most important fruit juice spoilage yeasts are *Saccharomyces cerevisiae* and *Schizosaccharomyces pombe* (Stratford, 2006). The principal genera responsible for damaged fruit juices are Pichia, Candida, *Saccharomyces,* and *Rhodotorula* (Bevilacqua et al., 2011). Salmonella contamination of fruits or fruit juices has been linked to several outbreaks of sickness, Escherichia coli O157:H7, and Cryptosporidium have been reported in the United States by the Center for Disease Control and Prevention (CDC, 1997). The most common pathogens associated with fruit juice contamination are E. coli O157:H7 and O111, Salmonella sp., Cryptosporidium, and norovirus. Other outbreaks caused by yeasts, Clostridium botulinum, and Vibrio cholerae have also been documented, unpasteurized juices were the source of all reported incidences of harmful microorganism contamination (CDC, 2011). Even though outbreaks linked to fresh juice have been documented as far back as 1922, salmonella infections are typically linked to foods derived from animals. According to reports by (CDC, 2011; EFSA, 2015), consumption of a range of unpasteurized juices has been linked to several outbreaks of salmonellosis and *enterohemorrhagic E. coli.*

Lactic acid and acetic acid bacteria, as well as Propionibacterium cyclohexanicum, Bacillus coagulans, and Bacillus megaterium, are examples of acid-tolerant bacteria that can flourish in juices. Frozen concentrated orange juice is known to have bad flavors due to the presence of the bacteria Lactobacillus plantarum var. mobilis, Lactobacillus brevis, Leuconostoc mesenteroides, and L. dextranicum (Keller and Miller, 2005).

Another important pathogen is Listeria monocytogenes as it can grow at refrigerated temperatures and in acidic conditions, the major preservative factors of fruit juices. According to reports by Keller and Miller, (2005) malic acid, the main acidulant naturally present in many juices, has a minimum pH of 4.4–4.6, which is necessary for L. monocytogenes to proliferate. In addition to meningitis, septicemia, and spontaneous miscarriage in immune-compromised people and pregnant women, this bacterium also causes the deadly disease listeriosis.

2.7 Prevention of spoilage in fruit juices

The current trend in fruit juice preservation is based on the use of specific techniques that can ensure high-quality products with minimal preservative additions and high nutritional value, while maintaining the product's microbiological safety (Gould, 2000; Ranken et al., 2005). Fruit juices are preserved using a variety of techniques, including heating (pasteurization and sterilization), acidification, fermentation, and the use of chemical preservatives. Natural antimicrobials and non-thermal methods have also recently entered the picture (Nikiforov et al., 2016).

2.7.1 Pasteurization

Thermal processing has historically been used to extend the shelf life of fruit juices; however, this also causes a loss of the juice's natural flavor ingredients. The two most widely used pasteurization methods for juice are low-temperature long-time and high-temperature short-time treatments. Pasteurization, however, frequently degrades the product's quality and freshness. As a result, several non-thermal pasteurization techniques have been put forth in recent years (Rupasinghe and Yu, 2012). These new methods appear to have the ability to produce fruit juices that are safe and have a long shelf life. High hydrostatic pressure, pulsed electric fields, and ultrasound are a few of the techniques that have already seen commercial success. These non-thermal techniques can produce fresh, safe juices with a long shelf life and have the potential to achieve 5-log microbial reductions (Aneja et al., 2014), but they are extremely expensive.

2.7.2 Chemical preservatives

To increase the shelf life of fruit juices and beverages, chemical preservatives such sodium benzoate, potassium metabisulfite, and potassium sorbate are frequently added. The risks and advantages of chemical preservatives, however, have generated a great deal of debate because some of them have been associated to obesity, cancer, neurological disorders, attention deficit hyperactivity disorder, heart disease, and digestive issues (Sharafati-Chaleshtori et al., 2017). Many of the chemical food preservatives still need to be tested for safety. Chemical preservatives have been linked to attention deficit hyperactivity disorder (ADHD), respiratory issues, and anaphylactic shock in sensitive people (Winnett et al., 2014). Benzoic acid and its derivatives, such as salicylic acid, sorbic acid, and SO2, are some of the chemical preservatives that are frequently used in fruit juices (Silva and Lidon, 2016). However, consumers associate synthetic preservatives with artificial products, leading them to reject this category of food products (Pandey and Negi, 2018). According to recent reports (United Kingdom Food Standards Agency, 2006), benzene can be produced from benzoic acid in food. According to Stratford et al. (2007), S. cerevisiae and P. anomala can decarboxylate sorbic acid to 1,3-pentadiene, which gives off a kerosene-like odor. S. pombe can also create off tastes if sulfite is present in fruits juice.

2.7.3 Natural preservatives

Food technologists are becoming more interested in using natural antimicrobials as alternatives to physical and chemical-based antimicrobial treatments. Numerous plant extracts or plant-based products have broad-spectrum antimicrobial properties, and numerous phytochemicals that have inhibitory effects on various types of microorganisms in vitro have been discovered by researchers worldwide. Chemical preservatives have been documented to have adverse health consequences (Tribst et al., 2009), while thermal pasteurization tends to generate certain unfavorable effects on foods, such as loss of nutrients and degradation of fresh-like flavor (Corbo et al., 2010). Therefore, in recent times, consumer demand for fresh and safe foods without the addition of chemically synthesized preservatives has increased the interest in the use of food preservatives from natural sources (Pandey and Negi, 2018). There has been a long history of the use of natural preservatives in food items, including bacteriocins, organic acids, essential oils, and phenolic compounds (Massilia et al., 2009; Rico et al., 2007).

2.7.3.1 Sources of natural preservatives

2.7.3.1.1 Plants

The notion that some plants had the ability to heal and that they included elements now known as antimicrobial activity was widely recognized before the discovery of the presence of bacteria. Plants have been utilized by humans to treat common infectious ailments since ancient times, but the usage of antimicrobials derived from plants in food products has only recently gained momentum (Aumeeruddy-Elalfi et al., 2016).

According to Sakkas and Papadopoulou (2017), extracts from plant parts with antimicrobial properties include herbs and spices, which have historically been utilized to flavor and scent foods. *Staphylococcus aureus* and *L. monocytogenes* were rendered inactive by the addition of green tea extracts to the watermelon juice after 2 and 3 days, respectively. According to Lee et al. (2003), green tea extracts have numerous uses as antibacterial agents against a variety of diseases. According to Kim and Fung (2004), arrowroot tea extract has antibacterial action against E. coli O157:H7. The antimicrobial activity of green tea is probably due to the combination effect of the tea phenolic compounds and the low pH of the plant infusions. According to Ibrahim et al. (2006), caffeine has the potential to be an efficient antibacterial agent for the inactivation of E. coli O157: H7 at a concentration of 0.5% or higher. According to these findings, tea infusions and extracts may be utilized as a natural preservative to improve the microbiological safety of fruit juices by extending their shelf life. Fruits and vegetables product have also been successfully treated with citrus fruit extracts (Fisher and Phillips, 2008). The minimum inhibitory doses detected were in the range of 100-150 ppm for a few spoilage bacteria, including B. licheniformis, Lactobacillus spp., Pichia subpelliculosa, S. cerevisiae, and Candida lusitaniae (Conte et al., 2007).

2.7.3.1.2 Essential oils

According to Massilia et al. (2009), essential oils are aromatic oily liquids that can be produced by fermenting, extracting, or distilling plant materials such as flowers, buds, seeds, leaves, twig bark, herbs, wood, fruits, and roots. Essential oils are created from a variety of plant components, including fruits, rhizomes, and other plant parts as well as leaves of plants like basil and tea, as well as garlic and onion bulbs, clove buds, and parsley seeds. Stronger antimicrobial activity can be found in plant parts high in essential oil content. Terpenes, alcohols, ketones, phenols, acids, aldehydes, and esters are just a few of the many different substances that can be found in essential oils (Massilia et al., 2009). According to the USFDA (2011), essential oils are GRAS (generally recognized as safe) substances that can be used as flavoring agents as well as antimicrobial barriers against a variety of microorganisms, such as bacteria, yeasts, and molds (Speranza and Corbo, 2010). Some plant essential oils have been shown to be effective against a variety of fungi as antifungal agents (Prakash et al., 2012) and as antiaflatoxigenic agents (Jaya and Dubey, 2011).

2.7.3.2 Application of natural preservatives in juices

Fruit juices can have various natural preservatives applied directly or indirectly to them to enhance their shelf life. The majority of these organic preservatives are regarded as GRAS. To achieve more effective preservation in food products, these preservatives have been used as antibacterial agents, antioxidant agents, antibrowning agents, as well as in combination with cutting-edge preservation techniques (Gokoglu, 2019). The reduction or inhibition of pathogenic and spoilage microorganisms has been documented for natural antimicrobials, which are derived from three different natural sources, including plants, animals, and microorganisms (Massilia et al., 2009). Many researchers have examined the antimicrobial activity of natural preservatives derived from plants in fruit juices, and these substances use various mechanisms to inactivate microorganisms (Table 2.1).

Table 2.1: Various juices and preservatives used for preserving them

Juice	**Preservative Used**	**Used Concentration**	**Reference**
Watermelon	Assam green tea	and 25%	
juice	B infusion	0.45% and 0.9%	Siddiqua et al. (2015)
	Clove essential	0.4%-2%	Massilia et al. (2006)
	oil	0.5% and 1%	Nwachukwu and Ezejiekwu
Mango juice	Citric acid and	25%	(2014)
Apple juice	malic acid	0.4%-2%	
	Lemon essential	0.0%, 0.05%, 0.20%	Aneja et al. (2014)
	oil	and 0.30%	Massilia et al. (2006),
	Lemongrass oil	0.0%, 0.05%, 0.20%	Friedman et al. (2004)
	Basil	and 0.30%	Eissa et al. (2008)
	Rosemary	0.0%, 0.05%, 0.20%	Eissa et al. (2008)
	essential oil	and 0.30%	Eissa et al. (2008)
	Sage essential oil	0.0%, 0.05%, 0.20%	Eissa et al. (2008)
Mixed fruit	Clove essential	and 0.30%	Emam et al. (2012)
juices	oil	0.5%	Emam et al. (2012)
Orange juice	Sheikh	0.5%	Emam et al. (2012)
	Kafoor	0.5%	Tyugi et al. (2013)
	Neem	0.5%	Kapoor et al. (2014)

CHAPTER 3

3.0 MATERIALS AND METHODS

3.1 Introduction

This chapter contains the materials used and methods adopted for the research.

3.2 Study location

The study was conducted at the Food Product Development Laboratory and the Chemistry Laboratory of the Department of Food and Postharvest Technology, Koforidua Technical University (KTU), Koforidua Ghana.

3.3. Materials and source

The materials that were used to conduct the research were mango, soursop, ginger, citric acid, honey, and Senegal pepper. The materials were bought from Koforidua Central Market, Eastern Region of Ghana.

3.4 Juice extraction process

3.4.1 Mango juice extraction process

The mango fruit was washed several times under running tap water. The fruit was then peeled and chopped into pieces using a sterilized knife. The chopped mango was put into a juice extractor to extract the juice. The various stages of the processes are shown in the Figure 3.1.

Fully ripped mango fruit

↓

Washing of fruit under running water

↓

Peeling of mango fruit

↓

Chopping of peeled mango fruit into smaller pieces

↓

Extraction of juice using a juice extractor

↓

Pasteurize at 70 °C for 10 to 15 seconds

↓

Cool for 15 to 20 minutes

↓

Fresh mango juice

Figure 3.1: Mango juice extraction process

3.4.3 Soursop juice extraction process

Soursop was prepared according to the method by Wang et al. (2002). Soursop was sorted and washed with cold running water after which it was gently peeled using a sterilized knife. The fruits were then cut into chunks to help them blend easily. The blended fruits were then sieved to obtain the juice (Figure 3.2).

Soursop fruit

↓

Sorting

↓

Washing of fruits

↓

Peeling and slicing of fruit

↓

Blending and sieving

↓

Soursop fruits juice

Figure 3.2: Flow chart for blended Soursop

3. 5 Experimental design

A completely randomized design (CRD) with each mango and soursop juice mix as experimental unit and each of the different preservatives allocated randomly to the juice mix to give treatments, with each treatment triplicated. The independent variable in this study was the type of preservative, and the dependent variables were the various physicochemical parameters such as pH, titratable acidity (TA), total soluble solids (TSS), vitamin C, lightness, L*, redness, a*, and yellowness, b*, as well as the yeast and mould count. The other dependent variables were the preference for the various sensory parameters (colour, aroma, taste, mouthfeel, aftertaste, and overall acceptability).

Table 3.1: Different treatments of mango and soursop juice mix

Treatment	Mango (ml)	Soursop (ml)	Citric Acid(g)	Honey (ml)	Ginger (g)	Senegal pepper(g)
A (control)	300	200	0.025	-	-	-
B	285	190	-	25	-	-
C	285	190	-	25	2.5	-
D	285	190	-	25	-	2.5
E	285	190	-	25	1.25	1.25

4.6 Determination of physicochemical properties of Mango and Soursop juice blends.

3.6.1 pH determination

The pH of fruit juice was measured by using a digital pH meter. The pH meter was calibrated using buffers 4, 7 and 10. The pH values of the juice blends were measured according to Association of Official Analytical Chemist (AOAC, 2010) method. The determinations were done in triplicate and the mean value calculated.

3.6.2 Titratable acidity (TA)

The titratable acidity was determined by the method described by Association of Official Analytical Chemist (AOAC, 2010). Ten milliliters of the sample was transferred into a 125 ml conical flask and 100 ml of distilled water was added. Three drops of phenolphthalein indicator were added to the solution and titrated against, 0.1N of sodium hydroxide (NaOH) until the final colour turned pink. The titre values were recorded and the percentage citric acid was calculated using the formula:

$$\% \text{ TA} = \frac{Ml \times Normality(NaOH) \times 0.064}{Volume\ of\ sample\ (ml)}$$

Where 0.064* = acid milliequivalent factor for citric acid

TA = Titrable acidity   Ml = molarity or average titre value

3.6.3 Determination of total soluble solids (TSS)

A digital refractometer was used for the determination of total soluble solids of the fruit juice mix. The refractometer was standardized by placing a drop of distilled water on the prism. The refractometer was placed such in a way that it allowed entry of sunlight into the prism. The eye-piece was used to observe the standardization after adjusting the coarse and fine adjustment properly. The process was repeated for each sample and the appropriate correction factors made depending on the temperature of the sample (AOAC, 2010). All measurements were done in triplicates.

3.6.4 Colour determination

Colour was determined by standard method using a colour meter (Precise Colour Reader, Model WR-10QC). Five grams of each treatment was placed in a dish and the colour reader held directly towards it. The values of the samples were measured according to Association of Official Analytical Chemist (AOAC, 2010) method. The colour parameters obtained were lightness, L*, redness, a*, and yellowness, b*. The determinations were done in triplicate and the mean values calculated.

3.6.5 Determination of vitamin C content

Indophenol dye was prepared by dissolving 42 mg sodium bicarbonate, 50 mg of 2,6-dichloroindophenol sodium salt and diluted to 200 ml with distilled water. It was then filtered into an amber bottle. Metaphosphoric acetic acid was prepared by diluting 20ml acetic acid in 100ml distilled water and dissolving 7.5g metaphosphoric acid and diluting to the 250ml mark with distilled water. The solution was then filtered into a stopper bottle. Ascorbic acid standard solution was prepared by weighing 50 mg of ascorbic acid and diluted to 50 ml in a volumetric flask. The dye was standardized with the blank and the ascorbic acid. The mango and soursop juice blend was titrated against indophenol solution to a rose-pink colour and titre values recorded (McGorrin, 2009). The vitamin C content of the sample was calculated using the formula:

Ascorbic acid (mg/ml) $(X - B)\,\frac{F}{E} \times \frac{V}{Y}$

X = Vol. of sample for titration

B = Vol. of blank

F = Titre of dye

E = Vol. assayed (2 ml)

V = Vol. of initial assay solution (7 ml)

Y= Vol. of sample aliquot titrated (7 ml)

F = Ascorbic acid (mg) in vol. of standard solution titrated=

(Average vol. of dye used to titrate standard solution) – (average vol. of dye used to titrate blank).

3.7 Shelf life analysis

Different types of preservatives (ginger, citric acid, Senegal pepper and honey) were added to the various juice samples to determine their effects on storage stability. Sample A was preserved with 0.025g citric acid, sample B was preserved with honey, sample C with honey and ginger, sample D with honey and Senegal pepper, and sample E with honey, ginger and Senegal pepper. The physiochemical qualities pH, TA, TSS were measured before storage and after storage at $5^{o}C$ for 25 days. Also the colour parameters L*, a*, and b* were also measured both before and after storage. However, in the case of vitamin C, its determination for each of the treatments was done only after storage. Furthermore, microbial analysis (total viable count and yeast and mould count) was done after storage.

3.8 Sensory evaluation

The sensory parameters taste, colour, aroma, mouthfeel, after taste and overall acceptability were assessed by twenty (20) untrained panelists from the Department of Food and Postharvest Technology, Koforidua Technical University. The sensory parameters were assessed using a seven (9) point hedonic scale, where 9=like extremely, 8=like very much, 7=like much, 6=like moderately, 5 =neither like nor dislike, 4=dislike slightly, 3=dislike much, 2=dislike very much and 1=dislike extremely. The various treatments were coded with three digits to differentiate between samples. The samples were served in plastic cups and water was given to the panelists to rinse their mouths in-between tastings.

3.9 Data analysis

The statistical package for social scientists (SPSS), Version 20 was used to analyze the data. One-way Analysis of Variance (ANOVA) was performed, and means were separated from each other using the Fisher's Least Significant Difference (LSD). Means were considered significant at $P<0.05$.

CHAPTER FOUR

4.0 RESULTS AND DISCUSSION

4.1 Introduction

This chapter presents the results and discussion for the study. It comprises of the presentation of the results and discussion on physicochemical qualities of mango and soursop juice mix before and after storage, its sensory evaluation and its microbial safety.

4.2 Physicochemical qualities of mango and soursop fruit juice mix before storage

The physicochemical qualities of the mango and soursop juice mix studied were pH, TA, TSS, and colour (Table 4.1). The pH of the mango soursop juice mix before storage was in the range 3.750-3.997. Treatment A, preserved with citric acid had the lowest pH, but its pH was not significantly different from the treatments D, and E. The pH values in this study were lower compared with 5.10 to 5.34 reported for watermelon fruit juice (Yau, et al., 2010). Low pH can help to protect the juice against microbial spoilage. After storage at 5^{o}C for 25 days, the pH values ranged from 4.140-4.320 (Table 4.2). Clearly, the values went up after storage. In similar studies pH values of 3.95-4.28 for whey-mango mixed beverage after storage for 25 days (Ahmed et al., 2023), 4.07-4.33 for mango juice-apple-guava-peach juice stored for 30 days (Rehman et al., 2014), and 3.10 - 3.02 for cashew, pineapple and water melon juice stored for 5week (Olaniran et al., 2020).

Table 4.1: Physicochemical qualities of mango and soursop fruit juice mix before storage

Treatment	pH	TSS (^{o}Brix)	TA(% citric acid)	L*	a*	b*
A	3.750±0.030^{b}	10.750±0.010^{a}	0.199±0.006^{a}	17.977	4.420	31.637
B	3.997±0.064^{a}	18.960±01.723^{b}	0.171±0.001^{b}	17.337	1.027	18.070
C	3.923±0.058^{a}	17.050±0.100^{c}	0.183±0.002^{b}	16.993	1.457	17.603

D	3.827±0.006^{b}	16.517±0.153^{d}	0.239±0.008^{c}	17.937	2.803	17.230
E	3.820±0.010^{b}	16.487±0.055^{d}	0.247±0.002^{c}	13.927	2.563	15.707

Means with different superscripts in the same column are significant at P<0.05. Treatment A (Control)-fruit juice mix+0.025g citric acid, Treatment B-fruit juice mix+25ml honey, Treatment C-fruit juice mix+25ml honey + 2.5g ginger, Treatment D- fruit juice mix+25ml honey + Senegal pepper, Treatment E-fruit juice mix+25ml honey +1.25g Senegal pepper + 1.25g ginger.

Titratable acidity (TA) measures the total amount of acid in solution as determined by titration with standard solution of sodium hydroxide. The TA values of the mango soursop juice mix before storage were 0.171-0.247 (% citric acid). The mango fruit juice mix preserved with only honey gave the lowest TA. The values obtained in this present study were higher than 0.09 to 0.14 (% citric acid) reported by Olaniran et al. (2020) for cashew, pineapple and water melon juice blends with ginger, garlic and benzoate acid.

Table 4.2: Physicochemical qualities of mango and soursop fruit juice mix after storage

Treatment	pH	TSS	TA	Colour		
				L*	a*	b*
A	4.320±0.026^{a}	12.857±0.055^{a}	1.770±0.064^{a}	19.683	2.823	18.300
B	4.177±0.015^{b}	17.583±0.058^{b}	2.379±0.021^{b}	14.743	2.207	12.910
C	4.140±0.010^{c}	18.666±0.055^{c}	2.152±0.007^{c}	11.927	1.717	12.520
D	4.140±0.010^{c}	18.255±0.005^{d}	1.141±0.151^{d}	14.637	2.320	15.463
E	4.217±0.015^{b}	17.750±0.010^{e}	2.151±0.028^{e}	18.340	3.613	13.867

Means with different superscripts in the same column are significant at P<0.05. Treatment A (Control)-fruit juice mix+0.025g citric acid, Treatment B-fruit juice mix+25ml honey, Treatment C-fruit juice mix+25ml honey + 2.5g ginger, Treatment D- fruit juice mix+25ml honey + Senegal pepper, Treatment E-fruit juice mix+25ml honey +1.25g Senegal pepper + 1.25g ginger.

After storage at 5^{o}C for 25 days, the values of TA were in the range 1.141-2.379, indicating that the juices became more acidic. The present results are higher than 0.44 - 0.64 (% citric acid) reported for whey mango mixed beverage stored for 25 days (Ahmed et al., 2023); 0.52

- 0.69 (% citric acid) reported for mango juice preserved for 90 days (Akhtar et al., 2010); and 0.21- 0.18 (% citric acid) reported for cashew, pineapple and water melon juice blends preserved with different preservatives and stored for 5weeks (Olaniran et al., 2020). The rise in weakly ionized acid and its salt concentration during storage may be the cause of the acidity increase. This increase in acidity may also result from the breakdown of pectic compounds and uronic acid, or from the oxidation of reducing sugars and the breakdown of polysaccharides (Hussain et al., 2008). According to Nampoothiri et al. (2007), a rise in TA levels could be due to microbial activity, such as the fermentation of sugars by bacteria or yeast to give acidic byproducts. According to Holst and Williamson (2004), the hydrolysis of certain compounds or the breakdown of acidic components can contribute to a rise in TA.

The TSS of the fruit juice mix was 10.750-18.960^{o}Brix before storage. All treatments with honey gave significantly higher ($P<0.05$) TSS than the treatment A (Control) which did not have any honey. The high sugar content of honey might account for the high TSS of treatments preserved with honey. A study reported TSS values of 8.85 -12.80 ^{o}Brix for soursop and watermelon fruit juice (Arum and Ani, 2021) before storage. However, after storage at 5^{o}C for 25 days, the values of TSS were in the range 12.857-18.666 ^{o}Brix. Generally, the values became higher after storage. Lower TSS values 10.00 -16.80 ^{0}Brix were reported by Rehman et al. (2014) for mango-apple-guava-peach juice after 30 days of storage period, and very low TSS (5.09 to 5.65 ^{o}Brix) also reported for cashew, pineapple and water melon juice blends preserved with different preservatives and stored for 5weeks (Olaniran et al., 2020). It has been documented that the TSS value increases when fruit juice is stored under all circumstances, which may be related to a persistent rise in acid hydrolysis of polysaccharides (Bhardwaj, 2013). According to Singh and Mathur (1983), non-reducing sugars and acids may gradually transform into reducing sugars, which could explain the increase in sugar levels during storage.

Before storage of the mango soursop juice mix, the lightness (L*) varied from 13.927 to 17.993. The addition of honey to treatments either than the one preserved with citric acid generally led to a reduction in lightness, meaning, the treatments were darker compared to the control. The colour of honey might be a contributory factor to this. The reduction in lightness agrees with 31.70 to 17.35 reported by Hashemi et al. (2018) for freshly sweet orange juice preserved with moringa leaves, beetroot and ginger extract. Lightness after storage varies from 11.927 to 19.683. Generally, there was a reduction in lightness after storage. The addition of honey and ginger to treatments generally led to decrease in lightness. The decrees in lightness can be as a result of storage temperature and dark colour imparted to the juice by the honey.

Redness (a*) before storage of the treatments ranged from 1.027 to 4.420. The addition of honey to treatments either than the one preserved with citric acid generally led to a reduction in redness. After storage redness (a*) of the treatments ranged from 1.717 to 3.613. The redness values were generally higher after storage than before storage. The addition of the preservatives generally led to increment in the redness after storage. The findings are in line with an increase trend −1.22 to 11.92 before storage and 0.20 to 10.23 after storage reported by Hashemi et al. (2018) for freshly sweet orange juice preserved with moringa leaves, beetroot and ginger extract. In that study, the addition of beetroot and ginger decreased the lightness after storage.

The yellowness (b*) values before storage of the mango soursop juice mix varied from 15.707 to 31.637. The addition of honey, Senegal pepper and ginger to treatments either than the one preserved with citric acid generally led to a reduction in yellowness. Mango is an important source of beta-carotene. Beta-carotene is responsible for the yellow colour of the mango, and so reduction in yellowness may be attributed to the variation in the ability of the preservatives to prevent the degradation of beta-carotene. The findings agree with the results 0.05 to 11.61

before and 0.05 to 10.07 after storage reported by Hashemi et al. (2018) for freshly sweet orange juice preserved with moringa leaves, beetroot and ginger extract, where the addition of beetroot and ginger decreased the yellowness after storage. The result obtained disagree with an increasing trend 10.46 to 13.56 before storage and 10.46 to 13.71 reported by El-Saadony et al. (2020) for chemical and natural preservatives on cucumber juice. After storage yellowness (b*) values of the mango soursop juice mix varied from 18.300 to 12.520. The yellowness (b*) values for the juices were significantly affected by the different preservatives. The addition of Senegal pepper, honey and ginger to treatments generally led to decrease in yellowness (b*). Storage temperature, oxygen and carbon dioxide levels of the storage atmosphere affect color changes, which could lower the amount of beta-carotene in the sample (Limbo et al., 2007). According to Klimczak and Gliszczyńska-Świgłoet (2017), enzymatic reactions may lead to browning and hence changes in the yellowness value of the food product.

4.3 Vitamin C content of mango and soursop after storage

The vitamin C content of the mango soursop juice mix was assessed after storage at 5^{o}C for 25 days and the values were in the range 72.85-78.44 mg/100g. The extent of prevention of vitamin C loss was different for each of the preservatives used. The fruit juice mix preserved with Senegal pepper was able to prevent the loss of vitamin C better than all other preservatives. The fruit juice mix preserved with citric acid, i.e. the control was the least effective in the preservation of vitamin C. Generally, the natural preservatives protected the vitamin C better than the citric acid. Therefore, the natural preservatives prevented oxidation of the vitamin C better than the citric acid. This might be due to their antioxidant effect. The Senegal pepper might have showed a better antioxidant effect than all the other preservatives. The value obtained was higher than 53.24 60.50 mg/100g reported by Francis et al. (2017) for soursop and watermelon fruits blend preserved with lime and sodium benzoate and higher than 37.14

mg/100g, 41.07 mg/100g, 35.19 mg/100g for pineapple, mango, pawpaw juice respectively reported by Agbaje et al. (2020).

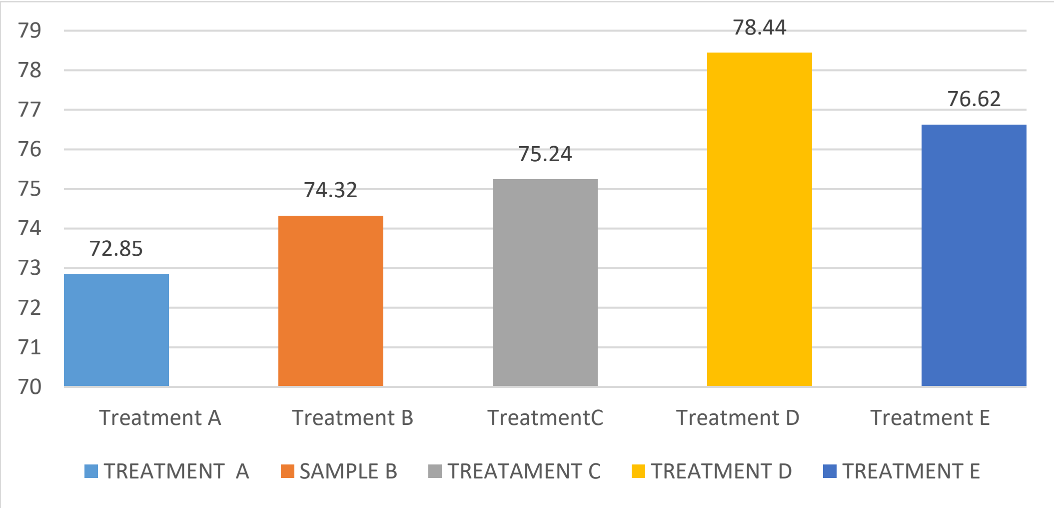

Fig 4.1 Vitamin C Content after storage at 5 ^{0}C for 25 days

Means with different superscripts in the same column are significant at P<0.05. Treatment A (Control)-fruit juice mix+0.025g citric acid, Treatment B-fruit juice mix+25ml honey, Treatment C-fruit juice mix+25ml honey + 2.5g ginger, Treatment D- fruit juice mix+25ml honey + Senegal pepper, Treatment E- fruit juice mix+25ml honey +1.25g Senegal pepper + 1.25g ginger.

4.4 Sensory evaluation of mango soursop juice mix

Sensory evaluation is used to invoke, measure, analyze and interpret those responses to food as perceived by the sense of sight, smell, touch and hearing. The sensory parameters assessed in this study were taste, colour, aroma, mouthfeel, aftertaste, and overall acceptability (Table 4.3). The results show that taste preference for the fruit juice mix ranged from 5.31 to 7.00 on a 9-point hedonic scale. Taste preference for treatment A (Control) was not significantly different from that of treatment B, but all other treatments showed significantly lower preference in taste than the Control. Preservatives generally influenced the taste preference for the juice mix. Higher taste preference values of 8.82-8.89 on a 9-point hedonic scale were reported for cashew, pineapple and water melon juice blends preserved with different preservatives (Olaniran et al., 2020).

Table 4.3 Sensory Evaluation of the product

Parameters	A	B	C	D	E
Taste	7.00±1.566[a]	6.63±1.60[a]	6.06±1.46[b]	5.13±1.601[c]	5.313±1.891[d]
Colour	7.135±1.72[a]	6.94±1.85[a]	6.00±1.44[b]	5.13±1.83[c]	5.63±2.152[d]
Mouthfeel	7.38±1.24[a]	6.81±1.73[b]	5.94±1.50[c]	5.40±1.69[d]	5.00±2.032[e]
After taste	7.25±0.98[a]	6.63±1.79[b]	5.69±1.60[c]	5.38±1.68[d]	5.125±2.121[e]
Overall Acceptability	7.69±0.100[a]	6.81±1.94[b]	5.94±1.50[c]	5.25±1.74[d]	4.94±2.31[e]

Means with different superscripts in the same column are significant at P<0.05. Treatment A (Control)-fruit juice mix+0.025g citric acid, Treatment B-fruit juice mix+25ml honey, Treatment C-fruit juice mix+25ml honey + 2.5g ginger, Treatment D- fruit juice mix+25ml honey + Senegal pepper, Treatment E-fruit juice mix+25ml honey +1.25g Senegal pepper + 1.25g ginger.

From the results shown on Table (4.3) colour preference for the fruit juice mix ranged from to 5.13 to 7.135 on a 9-point hedonic scale. Colour preference for treatment A (Control) was not significantly different from that of treatment B, but all other treatments showed significantly lower preference in taste than the Control. The reduction in colour preference was in line with study where preservative generally influenced the colour preference for strawberry juice preserved with chemical preservatives reported by Ayub et al. (2010) as well as findings of Tiencheu, (2021) for natural fruit juice formulated from orange, lemon, honey and ginger.

The result also shows that, mouthfeel, after taste, and overall acceptability preference for the fruit juice mix ranged from 5.00 to 7.38, 5.13 to 7.25 and 4.94 to 7.69 respectively on a 9-point hedonic scale. The result shows a general decrease in preference for mouthfeel, after taste, and overall acceptability with variation in preservatives. There was generally significant difference among various treatments with the highest preference being recorded in treatment A, and the lowest preference in treatment E. Preservative generally influenced the mouthfeel, after taste, and overall acceptability preference for the juice mix. Similar findings were observed by Olaniran et al. (2020) for cashew, pineapple and water melon juice blends with different preservatives.

4.5 Microbial quality assessment of mango and soursop juice mix

The microbial parameters assessed in this study were the yeast and mould count, and total viable count. This assessment was done after storage of the fruit juice at 50 ^{0}C for 25 days Yeast and mould count values were in the range 1.215 x 10^5 to 1.852 x 10^5 cfu/ml (Table 4.4). Treatments B and C gave significantly higher ($P<0.05$) yeast and mould count values than treatments A (Control), D, and E. The preservatives used in treatments A, D, and E were more effective in the prevention of microbial growth than those used for the treatments B and C. Yeast and mould count values for orange juice preserve with essential oil and oleoresins of black pepper ranged from 0.24×10^2 to 6.4×10^2 cfu/ml (Kapoor et al., 2014), which were quite lower than the results for the present study. According to FSSAI, (2011) yeast and mould count values in juice should not exceed 5(cfu/ml), hence the present findings are within this range making the various juice safe for consumption.

Total viable count of the fruit juice mix was in the range of 2.518×10^5 to 5.729×10^5. The treatments with natural preservatives were of significantly lower ($P<0.05$) total viable count than the one preserved with citric acid. The natural preservatives were more effective in reducing the total viable count. The total viable count values of the treatments were higher than 1.0×10^2 to 3.4×10^2 cfu/ml reported for orange juice preserve with essential oil and oleoresins of black pepper (Kapoor et al., 2014). According to ICMSF (1974) and Owolade et al. (2017), total viable count of the fruit juice should not exceed 10^6 cfu/ml thus all treatments were within acceptable limit for human consumption.

Table 4.4 Microbial Analysis of the juice before storage

Treatment	**Yeast and Mould** (cfu/ml)	**Total viable count (cfu/ml)**
A(control)	$1.215\times 10^5 \pm 0.017^b$	$5.729\times 10^5 \pm 0.028^a$
B	$1.748\times 10^5 \pm 0.050^a$	$2.518\times 10^5 \pm 0.017^e$
C	$1.852\times 10^5 \pm 0.050^a$	$4.911\times 10^5 \pm 0.011^b$
D	$1.328\times 10^5 \pm 0.025^b$	$4.615\times 10^4 \pm 0.017^c$
E	$1.230\times 10^5 \pm 0.028^b$	$3.200\times 10^5 \pm 0.100^d$

Means with different superscripts in the same column are significant at P<0.05. Treatment A (Control)-fruit juice mix+0.025g citric acid, Treatment B-fruit juice mix+25ml honey, Treatment C-fruit juice mix+25ml honey + 2.5g ginger, Treatment D- fruit juice mix+25ml honey + Senegal pepper, Treatment E-fruit juice mix+25ml honey +1.25g Senegal pepper + 1.25g ginger.

CHAPTER FIVE

5.0 SUMMARY, CONCLUSIONS, AND RECOMMENDATIONS

5.1 Summary

The main objective of the study was to explore the preservation of mango-soursop blend using a honey, ginger powder and Senegal pepper powder as natural preservatives and their effectiveness compared with citric acid. The specific objectives for the study were to: i) determine the effect of different types of preservatives on the physicochemical qualities of mango-soursop juice mix, (ii) assess the effect of different types of preservatives on the sensory qualities of mango-soursop juice mix, (iii) determine the effect of different types of preservatives on the microbial safety of mango-soursop juice mix, and (iv) assess the effectiveness of the different types of preservatives on storage stability of mango-soursop juice mix.

The physicochemical qualities of the juice mix studied were pH, TA, TSS, and vitamin C content. The microbial analysis done were yeast and mould count, and total viable count. The colour parameters determined were lightness, redness, and yellowness. Before and after storage of the fruit juice mix, the pH, TA, and TSS generally increased as different natural preservatives were added to the fruit juice mix. The sensory qualities (colour, aroma, taste, mouthfeel, aftertaste, and overall acceptability) of the fruit juice mix generally reduced significantly as different natural preservatives were added to the fruit juice mix. Significantly higher yeast and mould count values were generally obtained for treatments preserved with natural preservatives (honey, ginger, and Senegal pepper) than the artificial preservative (citric acid). However, in the case of the total viable count, the treatments preserved with natural preservatives gave fruit juice mix of lower total viable count compared with the control. The yeast and mould count, and the total viable count values for all fruit juice mix were within acceptable limits. The treatments which were preserved with natural preservatives generally had more vitamin C content after storage at 5oC for 25 days than the control.

5.2 Conclusions

The natural preservatives made the fruit juice mix more acidic than the control, therefore the fruit juice mix preserved with natural preservatives may prevent microbial growth better than the control. The fruit juice mix had acceptable yeast and mould count and total viable count, and are safe for consumption. The addition of different natural preservatives made the fruit juice mix less preferred. Finally, the natural preservatives were more effective in protecting the vitamin C from losses than the control.

5.3 Recommendations

Based on the findings of the study, the following recommendations are made:

(i) the vitamin C content for the juice mix should be determined before and after storage to know the extent of vitamin C loss,

(ii) the microbial analysis should be done for both before and after storage of the fruit juice mix, and

(iii) the phytochemical components of the fruit juice mix should be assessed to appreciate its health benefits.

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APPENDIX A SENSORY QUESTIONAIRES

KOFORIDUA TECHNICAL UNIVERSITY

FACULTY OF APPLIED SCIENCE AND TECHNOLOGY

DEPARTMENT OF HOSPITALITY MANAGEMENT

PRODUCT SENSORY AND EVALUATION QUESTIONNAIRES

This research aims to determine if consumers will accept juice made from blend mango-soursop with ginger juice extract as a natural preservative You are required to assess for taste, colour, mouthfeel and overall Acceptability of each food sample. Please provide accurate information as possible in order to determine which product is well accepted and preferred by. Information provided will be used for the research purposes only, and it will be kept confidential.

Thank you.

SECTION A- RESPONDENTS DEMOGRAPHIC INFORMATION

Please tick the appropriate box.

1. Status: Student [ ] Lecturer [ ] Other [ ]
2. Age (18-25) [ ] (26-32) [ ] (33-39) [ ] (40 and above) [ ]
3. Gender: Male [ ] Female [ ]

SECTION C: SENSORY EVALUATION

Quantify the degree of liking or disliking of each giving product. Please indicate each sample code and the level of likeness of the product using a 9-point hedonic scale, where 9=like extremely, 8=like very much, 7=like much, 6=like moderately, 5 =neither like nor dislike, 4=dislike slightly, 3=dislike much, 2=dislike very much and 1=dislike extremely.

SENSORY ATTRIBUTE	**SAMPLES**				
	Sample code	**Sample code**	**Sample code**	**Sample code**	**Sample code**
Taste					
Colour					
Mouth feel					
After taste					
Overall acceptability					

Please arrange accordingly your purchasing order of the various samples?...

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FACULTY OF APPLIED SCIENCE AND TECHNOLOGY

DEPARTMENT OF FOOD AND POSTHARVEST TECHNOLOGY

PRESERVATION OF MANGO AND SOURSOP FRUIT MIX WITH NATURAL PRESERVATIVES

PROJECT WORK SUBMITTED TO THE DEPARTMENT OF FOOD AND POSTHARVEST TECHNOLOGY, KOFORIDUA TECHNICAL UNIVERSITY, KOFORIDUA, GHANA IN PARTIAL FULFILMENT OF THE REQUIREMENT FOR THE AWARD OF BACHELOR OF TECHNOLOGY IN FOOD TECHNOLOGY.

BY

PRINCESS HANNAH DJIEAGU - [illegible]

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