DEVELOPMENT AND QUALITY ASSESSMENT OF MIXED FRUIT JAM PREPARED FROM COCONUT, PINEAPPLE, AND ORANGE

A PROJECT REPORT

BY

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Submitted to the Department of Nutrition and Food Engineering in the partial fulfillment of B.Sc. in Nutrition and Food Engineering

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DECEMBER 2024

APPROVAL

The project titled "**Development and quality assessment of mixed fruit jam prepared from coconut, pineapple, and orange**" by **Shefat Tanjim Summi Akter Shemu** has been accepted by the Department of Nutrition and Food Engineering at Daffodil International University. This acceptance is in partial fulfillment of the requirements for the B.Sc. degree in Nutrition and Food Engineering. Furthermore, the project has been approved for its style and content.

EXAMINING COMMITTEE

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DECLARATION

I hereby declare that this project was completed by me under the supervision of **Ms. Farzana Akter, Lecturer**, Department of Nutrition and Food Engineering, Daffodil International University. I also declare that neither this project nor any part of it has been submitted elsewhere for award of any degree or diploma.

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ACKNOWLEDGEMENT

First, I express my heartiest thanks and gratefulness to almighty for His divine blessing makes it possible to complete the final year project successfully.

I am really grateful and wish my profound indebtedness to **Ms. Farzana Akter, Lecturer**, Department of Nutrition and Food Engineering, Daffodil International University. Her endless patience, scholarly guidance, continual encouragement, constant and energetic supervision, constructive criticism, valuable advice, reading many inferior drafts and correcting them at all stages have made it possible to complete this project.

I would like to express my heartiest gratitude to **Dr. Nizam Uddin, Associate Professor**, and Head**,** Department of Nutrition and Food Engineering, for his kind help to finish our project and also to other faculty members and the staffs of the Department.

I would like to thank my entire course mate in Daffodil International University, who took part in this discussion while completing the course work.

Finally, I must acknowledge with due respect the constant support and patients of my parents.

ABSTRACT

This study aims to develop a mixed fruit jam using coconut, pineapple, and orange, and evaluate its quality characteristics, including proximate composition, physicochemical properties, microbial load, and sensory attributes. Three formulations were prepared: S1 (25% coconut, 50% pineapple, 25% orange), S2 (25% coconut, 25% pineapple, 50% orange), and S3 (50% coconut, 25% pineapple, 25% orange). Proximate composition analysis, including moisture, ash, protein, fat, crude fiber, and carbohydrate, was conducted for each sample. The moisture content ranged from 17.05% to 18.88%, ash from 0.14% to 0.50%, protein from 0.21% to 0.45%, fat from 0.26% to 0.72%, crude fiber from 1.95% to 3.12%, and carbohydrate from 76.33% to 80.24%, respectively. Functional properties such as acidity, pH, and °Brix were measured, with acidity ranging from 1.54% to 2.05%, pH from 2.85 to 3.00, and °Brix from 67.57 to 68.67, respectively. Microbial load analysis showed an increase in colony-forming units per gram from day 0 to day 60 across all samples, were well within the BSTI acceptable limit of 10^4 CFU/g. Sensory evaluations revealed the highest scores for color was 8.04, taste 7.93, flavor 7.74, and overall acceptability 7.89 in sample S3, respectively. Visual observations over 60 days demonstrated a gradual decline in color, flavor, and texture, with noticeable changes by day 60. Sample S3, with its higher fiber, protein, and favorable sensory ratings, was the most acceptable formulation.

Key words: Mixed fruit jam, Quality attributes, shelf-life study.

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CHAPTER 1

INTRODUCTION

1.1 Introduction

Jam is a semi-solid food product, prepared by cooking sugar with fruits or vegetables pulp, pectin, acid and other ingredients to a sensibly consistency. Jam should contain 65% or more TSS and at least 45% pulp. Jams generally have two types, the one which is developed from pulp of single fruit while the second type is prepared by blending two or more fruits pulp (Shinwari et al., 2018). In jam, jellies sugar stops growth of microorganisms and prevent spoilage. Sugar holds water due to which shelf life of the products is increased (Uribe-Wandurraga et al., 2021). Stabilizing, thickening and textural characteristics are improved by pectin in different foods like jam, jelly, bakery products, confectionery and beverages (Yang et al., 2021). Citric acid is essential to accurate balance, which is required in jam and jellies preparation. For the replacement of citric acid lime and lemon juice can be used in the jam preparation because lemon and lime juices have greater amount of citric acid (Liu et al., 2021).

Coconut, scientifically known as *Cocos nucifera*, belongs to the family *Arecaceae* and the genus *Cocos* (DebMandal & Mandal, 2011). It is a versatile tropical plant with significant nutritional and economic value. The coconut palm is often referred to as the “tree of life” due to its wide range of uses, from food and medicine to industrial applications. The fruit of the coconut is composed of several layers, including the exocarp, mesocarp, endocarp, and the kernel, which is surrounded by coconut water (Lestari et al., 2021). The kernel and water are rich in nutrients, making coconut a valuable food source globally, particularly in tropical regions (Aziz et al., 2021). Coconut water is rich in minerals and used as an energy drink, especially for athletes(Parmar et al., 2021). Coconut kernel contains vitamins, phytochemicals, protein, carbohydrates, and fats, including medium-chain triglycerides, MUFA, and PUFA(Parmar et al., 2021). Coconut oil contains alkaloids, tannins, saponins, flavonoids, phenols, steroids, terpenoids, and glycosides, contributing to its health benefits(Ilesanmi & Fakomiti, 2024). It also contains sodium, calcium, potassium, magnesium, phosphorus, copper, zinc, iron, and manganese (Ilesanmi & Fakomiti, 2024). Coconuts are grown in about 93 countries, covering an area of 11.8 million hectares (Aziz et al., 2012). Asia, particularly South India, is a major producer of coconuts (Parmar et al., 2021). Coconut palm is one of the economically important trees. Several traditional foods are processed from coconut due to its admissibility, quality and mercantile viability (Kumar et al., 2007). The major fatty acid of coconut is Lauric acid which has antibacterial, antiviral and antiprotozoal functions. Coconut pulp consists of soft flesh and sweet redolent juice. It contains a high content of minerals as iron, phosphorus and zinc. Coconut pulp can be used to process food preserves such as jam.

Oranges, belonging to the genus *Citrus* and family *Rutaceae*, are a significant fruit crop globally, known for their nutritional benefits and economic value. The scientific name for the orange is *Citrus sinensis (L.) Osbeck* . Oranges are primarily composed of carbohydrates, with sucrose being the main sugar, and they contain minimal protein and fat. They are rich in dietary fiber, vitamin C, and other phytochemicals like carotenoids, flavonoids, and limonoids, which contribute to their health benefits. The production of oranges is widespread, with major contributions from countries like China, Brazil, and the United States. In India, sweet oranges are predominantly grown in states such as Andhra Pradesh and Maharashtra, with a production rate of 3401 thousand metric tons from 190 thousand hectares as of 2018-19 (Gupta et al., 2023; Roussos, 2016; Hazarika et al., 2017; Preeti & Rana, 2021). Orange is a highly nutritious food, a source of phytochemical compounds like vitamin C, flavonoids, and carotenoids, which also give it its antioxidant property. It is commonly consumed fresh and in juices (Teixeira et al., 2020), jams (Igual et al., 2016), extracts for herbal medicines (Menichini et al., 2011), and dietary supplements (Restani et al., 2018).

Table 1: Nutrition facts of Coconut, Orange, Pineapple fruits (Ogunmefun et al., 2018).

Nutrient	Coconut	Orange	Pineapple
Calories (kcal)	354	47	50
Water (%)	47	86.8	86
Protein (g)	3.33	0.94	0.54
Fat (g)	33.49	0.12	0.12
Carbohydrates (g)	15.23	11.75	13.12
Fiber (g)	9	2.4	1.4
Sugars (g)	6.23	9.35	9.85
Vitamin C (mg)	3.3	53.2	47.8

Pineapple, scientifically known as *Ananas comosus*, is a tropical fruit belonging to the *Bromeliaceae* family, specifically the genus *Ananas* (Cheng et al., 2018; Debnath et al., 2021). It is the only species in this family that is commercially cultivated for its fruit, which is highly valued for its taste and nutritional benefits. Pineapple is a perennial plant that originated in South America and is now grown in tropical and subtropical regions worldwide. It is the third most important fruit in global production, following bananas and citrus fruits. The main producers include Thailand, the Philippines, Indonesia, India, China, Costa Rica, and Brazil (Lobo & Siddiq, 2016; Wali, 2019; Cheng et al., 2018). Pineapple is rich in vitamin C, manganese, copper, and vitamin B complex. It also contains calcium, zinc, and β-carotene(Lobo & Siddiq, 2016). It is a good source of dietary fiber and bromelain, a proteolytic enzyme complex with various health benefits (Lobo & Siddiq, 2016; Gaharwar et al., 2020). The fruit is low in calories, sodium, and free of cholesterol and fat (Lobo & Siddiq, 2016). Pineapple contains significant amounts of phenolic compounds and flavonoids, contributing to its antioxidant properties (Sun et al., 2016). Pineapple production is approximately 25 million tons globally, making it a significant contributor to the economies of producing countries (Wali, 2019). In 2012, Thailand was the largest producer, followed by Costa Rica, Brazil, and the Philippines(Lobo & Siddiq, 2016). The fruit is primarily used for fresh consumption, canned products, and juice(Wakasa, 1989).

The development of mixed fruit jams incorporating tropical fruits like coconut, pineapple, and orange represents an innovative approach in the food processing industry. Traditionally, jams are made from singular fruits like mango or pineapples, but the fusion of these tropical flavors can offer a unique taste profile and enhanced nutritional value. This project aims to explore the feasibility and quality of a mixed fruit jam made from coconut, pineapple, and orange. The selection of these fruits is due to their availability, complementary flavors, and health benefits, providing a novel product for consumers seeking variety and nutrition in their diet.

1.2 Objectives

- To develop a formulation for mixed fruit jam using coconut, pineapple, and orange.
- To assess the proximate composition, microbial characteristics and sensory properties of the developed jam.
- To evaluate the storage stability of the jam by visual observation.

CHAPTER 2

LITERATURE REVIEW

Diversification in food products is essential to enhance their physicochemical properties, nutritional status, and consumer satisfaction. This review focuses on the development and evaluation of mixed fruit jam made from coconut and pineapple pulps, examining the impact of varied ratios, storage conditions, and packaging materials on the jam's quality and stability.

Jam is the product prepared from sound, ripe, fresh, dehydrated, frozen or previously packed fruits including fruit juices, fruit pulp, fruit juice concentrate or dry fruit by boiling its pieces or pulp or puree with nutritive sweeteners namely sugar, dextrose, invert sugar or liquid glucose to a suitable consistency. Jam making is the most suitable method of preservation Jam is defined as fruits or vegetables pulp or juice to which Sugar, pectin and citric acid are added. The mixture is usually boiled until reach reasonable consistency (spreadable) (Bekele et al., 2020).

Rana et al. (2021) investigated the nutritional composition of mixed fruit jam made from coconut and pineapple pulps in different ratios (1:1, 3:1, and 1:3). The study found significant variations ($p \leq 0.05$) in moisture, lipid, protein, fiber, ash, and total carbohydrate contents among the different jam samples. The values ranged from 26.78-29.15% for moisture, 4.12-10.81% for lipids, 0.56-1.13% for proteins, 1.51-3.12% for fiber, 0.30-0.37% for ash, and 62.69-67.91% for total carbohydrates. These variations indicate the potential for optimizing the nutritional profile of mixed fruit jams through careful selection and combination of fruit pulps.

The physicochemical properties of the jam samples were monitored over a six-month storage period at both refrigerated (4°C) and room (30°C) temperatures. Key parameters such as total soluble solids, acidity, pH, and reducing sugar content were evaluated at two-month intervals. The study revealed that total soluble solids, acidity, and reducing sugar content increased over time, while pH levels declined. These changes were influenced by the compositional variances, packaging materials, and storage temperatures.

Sensory evaluation is crucial for consumer acceptance of food products. The study conducted by Rana et al. (2021) assessed the sensory properties of the jam samples, including color, taste, flavor, texture, and overall acceptability. The jam sample with a pineapple-to-coconut ratio of 3:1 received the highest sensory scores, indicating that this combination was preferred by the panelists. This finding underscores the importance of optimizing fruit ratios to enhance the sensory appeal of mixed fruit jams.

The storage stability of mixed fruit jams is influenced by various factors, including packaging materials and storage conditions. The study found that samples packed in plastic containers and stored at room temperature showed positive yeast and mold counts at the end of the storage period. In contrast, samples stored under refrigerated conditions exhibited better shelf life. This highlights the need for proper packaging and storage to maintain the quality and safety of mixed fruit jams over time.

The study by Rana et al. (2021) demonstrates that mixed fruit jams made from coconut and pineapple pulps can achieve improved nutritional and sensory properties through the right combination of fruit ratios. The research also emphasizes the importance of appropriate storage conditions and packaging materials to ensure the product's stability and safety. Future research could explore the incorporation of other fruits and additives to further enhance the nutritional profile and consumer appeal of mixed fruit jams.

Functional foods, which provide additional health benefits beyond basic nutrition, are gaining popularity worldwide. This review discusses the development and evaluation of functional jam made from blends of banana, pineapple, and watermelon pulps, aiming to create a nutritionally rich product using locally available fruits. Various blends were tested to determine the best composition in terms of nutritional and sensory properties.

Awolu et al. (2018) explored different blends of banana, pineapple, and watermelon pulps to produce a functional jam. The blends tested included the following ratios: 50:25:25, 25:50:25, 25:25:50, and 33.33:33.33:33.33. To enhance the jam's viscosity and stability, 2.9% pectin from citrus peel, citric acid, sodium benzoate, and sugar were added to the pulp mixtures, which were then heated at 110°C for 55 minutes. This process aimed to improve the jam's consistency and shelf life.

The study identified the blend with the best nutritional and sensory properties as the 25:25:50 ratio of banana, pineapple, and watermelon pulps. The proximate analysis of this blend revealed the following composition: 8.58% protein, 1.41% fiber, 0.38% ash, 3.92% fat, 2.52% moisture, and 83.20% carbohydrate. The vitamin content included 1.32 mg/100 g of vitamin A, 8.22 mg/100 g of vitamin C, and 0.015 mg/100 g of vitamin E. These results indicate that the selected blend offers a good balance of macronutrients and essential vitamins, making it a valuable addition to a balanced diet.

The physicochemical properties of the best blend were also evaluated. The pH of the jam was 4.16, indicating a slightly acidic nature, which is favorable for jam preservation. The viscosity was measured at 58.77 centipoise (cp), and the specific gravity was found to be 1.016. These properties contribute to the jam's texture and mouthfeel, which are critical factors for consumer acceptance.

Mineral analysis of the best blend showed the presence of several essential minerals: 0.34 ppm iron, 28.90 ppm sodium, 80.90 ppm potassium, 1.50 ppm calcium, and 0.60 ppm magnesium. These minerals are important for various bodily functions, including maintaining electrolyte balance, bone health, and enzymatic activities. The potassium content, in particular, is beneficial for cardiovascular health.

Sensory evaluation is essential to determine consumer acceptability. The blend with the best results from the proximate and nutritional analyses underwent rheological and sensory evaluations. The sensory attributes such as color, taste, flavor, texture, and overall acceptability were assessed by a panel of judges. The blend with the ratio 25:25:50 was found to have the highest sensory scores, indicating a favorable reception among the panelists. This blend's balanced flavor profile and appealing texture likely contributed to its high sensory ratings.

The study by Awolu et al. (2018) demonstrates that a functional jam made from a blend of banana, pineapple, and watermelon pulps can be both nutritionally rich and sensory-pleasing. The selected blend (25:25:50) showed excellent nutritional properties, including a high carbohydrate content and significant amounts of essential vitamins and minerals. Additionally, the physicochemical properties and sensory evaluation results indicate that this blend is suitable for consumer acceptance. Future research could explore the incorporation of other functional ingredients or alternative processing methods to further enhance the jam's health benefits and shelf life.

The development of innovative food products, particularly functional foods, has gained increasing attention in recent years, particularly due to their potential health benefits and appeal to health-conscious consumers. Jam production, utilizing diverse fruits and vegetables, is one avenue where research continues to expand. Orange-fleshed sweet potato (OFSP) and pineapple, known for their high nutritional values, have become focal ingredients in research aimed at developing nutritionally fortified products, particularly β–carotene-enriched foods, as seen in the work of Afoakwah et al. (2023).

OFSP is recognized for its rich β–carotene content, making it a valuable ingredient in addressing vitamin A deficiencies. The incorporation of OFSP in jam formulations has shown potential not only in enhancing the nutritional profile of jams but also in improving sensory and textural qualities. Afoakwah et al. (2023) demonstrated that increasing the proportion of OFSP in jam formulations significantly impacted nutritional factors, such as fat, protein, and carbohydrate content, while also lowering moisture content. These findings align with existing literature that underscores the role of OFSP in improving the functional attributes of food products, particularly in boosting antioxidant capacity through its β–carotene content (Afoakwah et al., 2023).

Moreover, the use of OFSP as a jam ingredient extends beyond its nutritional value. Its gelling properties are also noteworthy, as OFSP contributes to desirable textural characteristics in food formulations. The decline in β–carotene content with a reduction in OFSP levels, as observed by Afoakwah et al. (2023), suggests that maximizing OFSP content is crucial for maintaining the nutritional quality of the final product. This result aligns with the general understanding of the degradation of carotenoids during food processing (Chaudhary et al., 2019).

Pineapple, globally recognized as the third most important tropical fruit, contributes significantly to processed fruit products, including jams. Pineapple pulp is widely used due to its natural sweetness, flavor, and rich supply of vitamin C and bromelain, an enzyme known for its digestive health benefits. Pineapple's high moisture content aids in creating a balanced jam formulation when combined with other fruits or vegetables that have higher dry matter content, such as OFSP (Chaudhary et al., 2019). In the study by Afoakwah et al. (2023), the combination of OFSP and pineapple in varying ratios produced jams with acceptable sensory properties, with the 50% OFSP and 50% pineapple formulation showing higher consumer acceptance.

The review by Chaudhary et al. (2019) highlights that pineapple's processing potential has long been recognized for producing jams, fruit juices, and other preserved products. In developed countries, the processing rates of tropical fruits, including pineapple, are significantly higher than in regions such as India, where only 2.2% of the total produce is processed. This reflects the growing demand for efficient processing techniques to extend shelf life and maintain the nutritional quality of pineapple-based products, as explored by Kudahetty (2003) in tender coconut jam research.

Jams, like other fruit preserves, must meet consumer expectations for sensory attributes, such as flavor, texture, and appearance, while also maintaining microbiological safety. The absence of coliforms and molds in the jam samples developed by Afoakwah et al. (2023) highlights the importance of effective food processing and preservation techniques in maintaining product safety. Microbial spoilage can often be mitigated through careful control of pH, sugar content, and processing temperatures, as evidenced by Kudahetty (2003), whose study on tender coconut jam also emphasized the stability of pH values and suppression of microbial growth over time.

The sensory evaluation of food products plays a vital role in their market acceptance. In Afoakwah et al. (2023), the jam formulation containing equal parts OFSP and pineapple was preferred over others, suggesting that balancing sweetness, texture, and visual appeal is essential in creating products that resonate with consumers. This finding is consistent with the broader literature on sensory evaluation, which often points to the necessity of optimizing ingredient ratios to achieve the best possible consumer experience (Kudahetty, 2003). As functional foods continue to rise in popularity, food products enriched with bioactive compounds, such as β–carotene from OFSP, present an attractive option for health-conscious consumers. The combination of OFSP and pineapple in jam offers a product that not only meets the sensory and nutritional demands of consumers but also offers potential health benefits, such as enhanced antioxidant activity and contributions to daily vitamin A requirements. The work by Afoakwah et al. (2023) supports the idea that fortifying traditional food products with nutrient-dense ingredients can help address public health concerns, particularly in regions prone to nutrient deficiencies.

Research in fruit and vegetable-based jam production, particularly using OFSP and pineapple, indicates a promising pathway for developing nutritious and functional food products. Continued exploration of ingredient ratios, sensory evaluation, and shelf-life stability will be necessary to optimize these formulations for commercial success.

Roselle (*Hibiscus sabdariffa*) calyces are widely used in the production of jams due to their vibrant color, unique flavor, and rich nutritional profile, particularly in antioxidants such as vitamin C. The investigation into jams made from both fresh and dried roselle calyces has provided valuable insights into how the form of the calyces influences the physico-chemical and sensory properties of the final product (Ochelle et al., 2024).

One of the key differences between jams produced from fresh and dried roselle calyces lies in their vitamin C content. Vitamin C is a well-known antioxidant that contributes significantly to the health benefits of roselle, including immune support and the prevention of oxidative stress. The study by Ochelle et al. (2024) showed that jams made from fresh roselle calyces retained significantly higher levels of vitamin C compared to those made from dried calyces. The reduced vitamin C content in dried calyces is consistent with the broader literature on nutrient degradation during drying processes, where heat and exposure to oxygen can lead to a significant loss of thermolabile nutrients like vitamin C (Ochelle et al., 2024).

Despite the reduction in vitamin C in dried calyces, other physico-chemical properties such as ash content, moisture content, and titratable acidity (TTA) remained relatively unchanged between the two types of jam. This suggests that drying does not significantly impact the overall mineral content or the acid balance of the roselle calyces, which are important for maintaining the structural and flavor integrity of the jam. Previous studies have also emphasized the stability of these components in jams made from dried fruits or vegetables, reinforcing the idea that drying primarily affects the nutrient profile rather than the basic physical properties (Afoakwah et al., 2023).

The sensory evaluation of jams is crucial for determining their market potential and consumer acceptance. The study by Ochelle et al. (2024) found that there were no significant differences in the sensory attributes, such as appearance, aroma, taste, mouthfeel, and overall acceptability, between jams made from fresh and dried roselle calyces. Both forms of jam scored highly in consumer evaluations, indicating that the drying process does not compromise the sensory qualities that are most important to consumers.

This finding aligns with existing research that suggests sensory attributes such as color and flavor, which are important for jams, are preserved during the drying process due to the high pigment concentration in roselle calyces. The intense red color of roselle is attributed to anthocyanins, which are relatively stable during processing and contribute to the visual appeal of roselle-based products. These attributes are critical for consumer acceptance, as visually appealing products often have higher market success (Chaudhary et al., 2019).

The research conducted by Ochelle et al. (2024) highlights the potential for producing high-quality jams using either fresh or dried roselle calyces. However, the significant difference in vitamin C content suggests that fresh calyces are preferable for producing jams with higher nutritional value, especially for consumers seeking products with added health benefits. The study’s recommendation to prioritize fresh calyces in jam production is consistent with the broader understanding that fresh produce retains more nutrients, particularly those that are sensitive to heat and oxidation.

On the other hand, dried calyces offer advantages in terms of storage and availability, especially in regions where fresh roselle is seasonal or where long-term preservation is necessary. Drying roselle allows for year-round jam production, which can help stabilize market supply and reduce waste during peak harvest seasons. The use of dried calyces in jam production can also reduce transportation and storage costs, making it a practical option for food manufacturers (Chaudhary et al., 2019).

The production of jams from roselle calyces, whether fresh or dried, offers significant nutritional and sensory benefits, with both forms being highly acceptable to consumers. The retention of essential minerals and consistent sensory properties across fresh and dried calyces demonstrates that dried roselle can serve as a viable alternative to fresh in jam production, especially when considerations such as shelf life and processing costs are factored in. However, to maximize the nutritional benefits, particularly vitamin C content, the use of fresh calyces should be prioritized when possible. Further research could explore advanced preservation techniques, such as freeze-drying or vacuum-drying, which might mitigate the loss of vitamin C in dried calyces while maintaining the other desirable attributes of roselle-based jams.

CHAPTER 3

MATERIALS AND METHODS

3.1 Location of the study

The study was conducted at Food Processing Lab, Department of Nutrition and Food Engineering, Daffodil International University, Daffodil Smart City, Ashulia, Dhaka, Bangladesh.

3.2 Ingredients

All raw materials including fresh coconut, fresh pineapple, fresh orange, sugar, pectin, citric acid was collected from local market of Ashulia bazar, Ashulia, Dhaka, Bangladesh.

Figure 1: Raw materials

3.3 Equipment

Refractometer, pH meter, moisture analyzer, muffle furnace, Kjeldahl apparatus, Soxhlet apparatus, microbiological incubator, and sensory evaluation tools (hedonic scale questionnaire) were used during the study period.

Figure 2: Fresh cut fruits before pulping

3.4 Mixed Jam Formulation

The table 2 presents the formulation of mixed fruit jams using three fruits: coconut, pineapple, and orange, each in specific ratios. The first sample, coded as S1, consists of

25% coconut, 50% pineapple, and 25% orange, indicating a predominant pineapple content. The second sample, coded as S2, comprises 25% coconut, 25% pineapple, and 50% orange, highlighting a higher proportion of orange compared to the other fruits. The third sample, coded as S3 , includes 50% coconut, 25% pineapple, and 25% orange, with coconut being the dominant ingredient.

Table 2: Mixed fruit jam formulation

Ingredients	**Sample formulation**		
	S1	S2	S3
Coconut(g)	112.5	112.5	225
Pineapple(g)	225	112.5	112.5
Orange(g)	112.5	225	112.5
Sugar(g)	550	550	550
Citric Acid (%)	1	1	1
Pectin (%)	1	1	1

3.5 Jam making procedures

At first Fruits pulp were mixed in standardized proportions (Table 1). 45% fruits pulp, 55% sugar along with 1% pectin were mixed in a stainless-steel pan. The mixture was heated and stirred under a low flame gas stove. 1% citric acid was added when the mixture attains TSS to 60°Brix. Heating was stopped when TSS of the mixture reached to 67- 68°Brix. Finally, the hot finished product will be filled in sterilized glass/plastic containers.

Figure 3: Mixed fruit jam from coconut, orange and pineapple.

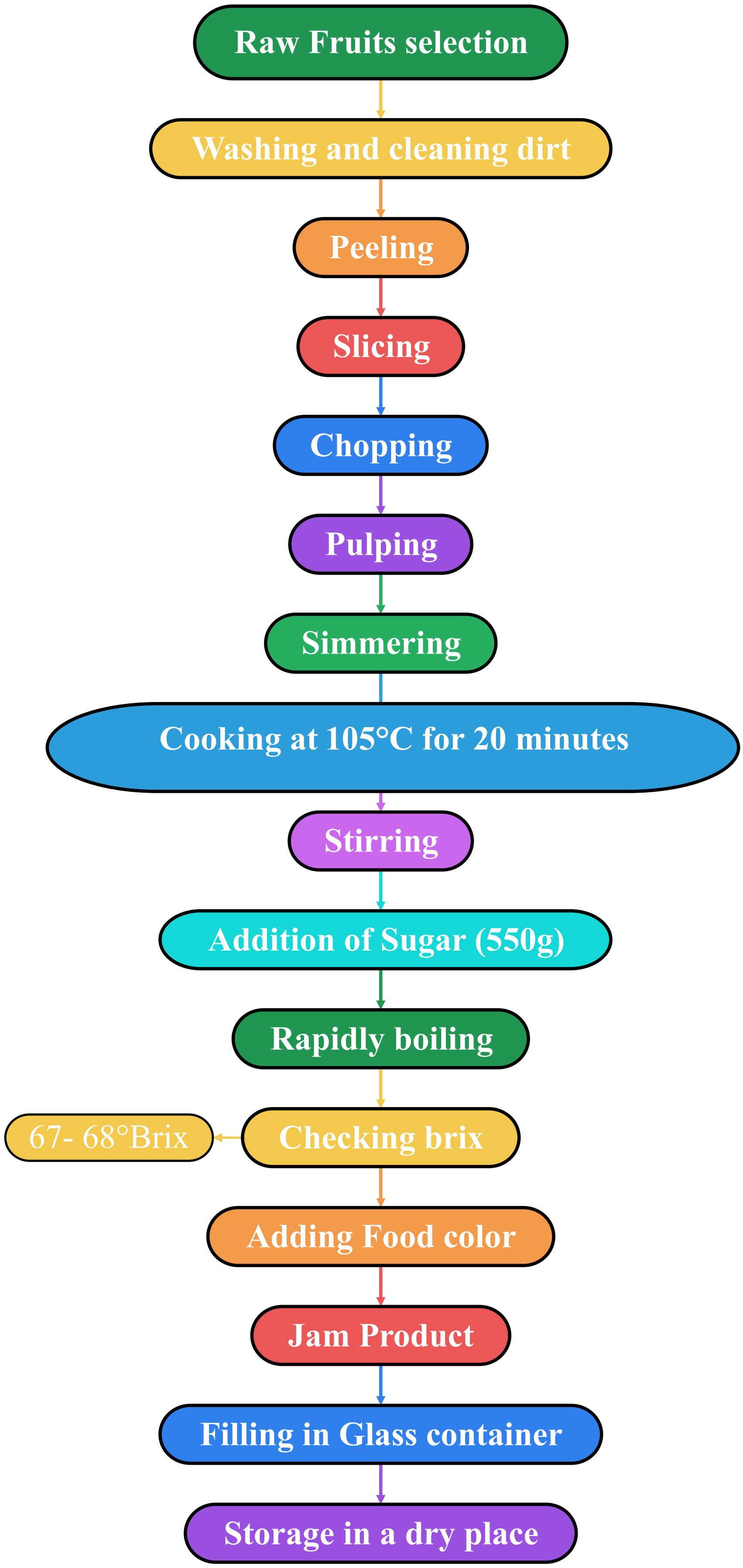

Figure 4: Flowchart for preparation of mixed fruit jam.

3.6 Proximate analysis

Proximate analysis was conducted according to AOAC (2019), to determine the nutritional composition of samples, including moisture, ash, fat, protein, crude fiber, and carbohydrate contents.

3.6.1 Determination of moisture content

The moisture content was determined using the Digital Moisture Analyzer (MA-105MW) at 120°C (AOAC, 2019). Approximately 1.2 g of the sample was weighed accurately.

3.6.2 Determination of ash content

The ash content was determined by incinerating approximately 2 g of the sample in a muffle furnace at 700°C until for 6 hours (AOAC, 2019). The ash content was calculated using the formula:

$$\text{Ash content (\%)} = \frac{\text{Weight of ash}}{\text{Weight of sample}} \times 100$$

3.6.3 Determination of fat content

The fat content was determined using the Soxhlet extraction method (AOAC, 2019). About 5 g of the sample was used in extraction process with n-hexane for 6 hours. The fat content was calculated using the formula:

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

3.6.4 Determination of protein content

The protein content was determined using the Kjeldahl method (AOAC, 2019). Approximately 2 g of the sample was digested with concentrated sulfuric acid, followed by neutralization and distillation. The nitrogen content was converted to protein content using the factor 6.25. The protein content was calculated using the formulas:

$$\text{Nitrogen content (\%)} = \frac{\mathrm{V_0} - \mathrm{V_1} \times C \times \mathrm{M}}{\mathrm{m}} \times 100$$

$$\text{Protein content (\%)} = \text{Nitrogen content} \times 6.25$$

Where V_0 is the volume(ml) of sodium hydroxide solution required for the blank test, V_1 is the volume(ml) of the sodium hydroxide solution required for the nitrogen content determination, C is the concentration(moles per litre) of sodium hydroxide solution used for the titrations, M is the molar mass (in grams per mole) of nitrogen (M = 14 g/mol), m is the mass(grams) of the test sample.

3.6.5 Determination of crude fiber

The crude fiber content was determined using an acid-base digestion method (AOAC, 2019). Approximately 2 g of the sample was digested with 0.128M sulfuric acid and 0.313M sodium hydroxide. The residue was dried, weighed, and incinerated to obtain the crude fiber content, calculated using the formula:

$$Crude\ fiber\ (\%) = \frac{\text{Weight of residue} - \text{Weight of ash}}{\text{Weight of sample}} \times 100$$

3.6.6 Determination of carbohydrate content

The carbohydrate content was calculated by difference, subtracting the sum of moisture, ash, protein, fat, and fiber contents from 100% (AOAC, 2019).

$$\text{Carbohydrate content } (\%) = 100\% - (\text{Moisture} + \text{Ash} + \text{Protein} + \text{Fat} + \text{Fiber})$$

3.7 Functional properties analysis

3.7.1 Determination of titratable acidity

Titratable acidity is a measure of the total acidity in a sample, representing the amount of acid present in the form of hydrogen ions that can be neutralized by a base. It is commonly determined by titrating the sample with a standard base (e.g., sodium hydroxide, NaOH) and is expressed as a percentage of a specific acid, such as citric acid (AOAC, 2019).

$$\text{Titratable Acidity } (\%) = \frac{V_{NaOH} \times N_{NaOH} \times \text{Eq. wt. of acid} \times 100}{\text{Weight of sample (g)}}$$

where:

- V_{NaOH} is the volume of NaOH used (in mL)
- N_{NaOH} is the normality of the NaOH solution
- Eq. wt. of acid is the equivalent weight of the acid of interest (for citric acid, it is approximately 64.04 g/mol)

3.7.2 Determination of pH

The determination of pH in jam according to AOAC guidelines involves using a calibrated pH meter with a glass electrode. The pH was measured using a Hanna HI 8424 pH meter, by calibrating the pH meter with standard buffer solutions pH 4.0, 7.0, and 10.0 (AOAC, 2019).

3.7.3 Determination of °Brix

Total soluble solids content of a jam sample was determined by the index of refraction. This was measured using a refractometer, and is referred to as the degrees Brix (AOAC, 2019).

3.8 Microbial analysis

Plate count agar media were prepared accordance with the instructions provided by the manufacturer. Pour plate method was used. The plate was flipped upside down and placed in an incubator set at a temperature of 37°C for a duration of 24 hours (Harrigan, 1998). Bacterial counts in colony-forming units per gm of sample was calculated using the following formula:

$$\text{Colony forming unit} = \frac{(\text{no. of colonies x dilution factor})}{\text{volume of culture plated in gm}}$$

a b c

Figure 5: Determining moisture content using moisture analyzer (a), Weighing crucible with sample (b), Ashing in muffle furnace (c).

a b

Figure 6: Extracting fat using Soxhlet apparatus (a), Sample digestion in kjeldahl aparratus (b).

a b

Figure 7: Titration with NaOH (a), Titration endpoint color changed (b).

3.9 Sensory Evaluation

Sensory evaluation was conducted to assess the acceptability of the cookies in terms of color, texture, flavor, and overall acceptance (Sidel & Stone, 2006). A panel of 38 evaluators was used for sensory evaluation. One tablespoon from each lot of jam was presented to 38 panelists as randomly coded samples. The panelists were asked to rate the sample for color, odor, flavor, and overall acceptance on a 1-9 point scale, where 1= dislike extremely; 2= dislike very much; 3= dislike moderately; 4= dislike slightly; 5= neither like nor dislike; 6= like slightly; 7= like moderately; 8= like very much; 9= like extremely.

3.10 Shelf-life studies of jam

All the jam samples were packed in low-density polyethylene (LDPE) and stored at an ambient temperature (32±2°C) for a period of 60 days. During the storage period, the evaluation of shelf-life was done by visual observation method as described by Tobal and Rodrigues (2019). The changes in color, flavor, and texture, along with microbial analysis of jam samples were observed at an interval of 15 days up to 60 days.

3.11 Statistical Analysis

Statistical analysis was performed using Microsoft Office Excel version 2021. All the analyses were carried out in triplicates. Results were expressed using mean±SD.

CHAPTER 4

RESULTS AND DISCUSSION

4.1 Proximate composition

The proximate composition analysis of the mixed fruit jam samples reveals significant differences in their nutritional profiles. S3 has the highest moisture content (18.88 ± 0.06%), compared to S1 (17.98 ± 0.14%) and S2 (17.05 ± 0.10%). This higher moisture content in S3 lead to a softer texture but may reduce its shelf life due to increased microbial growth potential, aligning with findings by Shinwari & Rao (2018), that higher moisture levels in fruit preserves can affect shelf stability. In terms of ash content, which indicates the mineral content, S3 (0.50 ± 0.01%) is significantly higher than both S1 and S2 (0.14 ± 0.01%). Similar results were reported by Shahnawaz et al. (2009), who found variations in ash content among different jam samples, highlighting the influence of the fruit mix used. Protein content is also highest in S3 (0.45 ± 0.01%), followed by S2 (0.28 ± 0.02%) and S1 (0.21 ± 0.01%).

Table 3: Proximate composition of mixed fruit jam

Characteristics	S1	S2	S3
Moisture(%)	17.98±0.14	17.05±0.10	18.88±0.06
Ash(%)	0.14±0.01	0.14±0.01	0.50±0.01
Protein(%)	0.21±0.01	0.28±0.02	0.45±0.01
Fat(%)	0.26±0.02	0.34±0.02	0.72±0.02
Crude Fiber(%)	2.24±0.12	1.95±0.09	3.12±0.04
Carbohydrate(%)	79.16±0.13	80.24±0.19	76.33±0.06

Mean ± SD, for each assessment, the mean of three trials is used. S1= 25% coconut + 50% pineapple + 25% orange; S2= 25% coconut + 25% pineapple + 50% orange; S3= 50% coconut + 25% pineapple + 25% orange.

This suggests that S3 may offer more nutritional benefits, consistent with findings by Jaiswal et al. (2015) who noted that mixed fruit jams can have varying protein levels based on their composition. S3 has the highest fat content (0.72 ± 0.02%), which could contribute to a richer taste and smoother texture compared to S2 (0.34 ± 0.02%) and S1 (0.26 ± 0.02%). This is in line with studies by Barrett & Lloyd (2012), which found that higher fat content in fruit jams can enhance flavor and texture. Regarding crude fiber, S3 again leads (3.12 ± 0.04%), which is beneficial for digestive health. Similar conclusions were drawn by McRae (2017), who emphasized the health benefits of higher fiber content in fruit-based products . Carbohydrate content is highest in S2 (80.24 ± 0.19%), making it the sweetest, followed by S1 (79.16 ± 0.13%) and S3 (76.33 ± 0.06%).

4.2 Functional properties

The Functional analysis shows that S1 has the highest acidity (2.05 ± 0.23%), making it the tangiest, while S3 has the lowest acidity (1.54 ± 0.06%), giving it a milder taste. These results are consistent with those of Saeed et al. (2010), who found that variations in acidity affect the tartness of fruit jams . The pH levels correspond with acidity, with S3 having the highest pH (3.00 ± 0.02) and S1 the lowest (2.85 ± 0.01). According to Chawla and Patil (2010), higher pH values in fruit preserves indicate lower acidity, contributing to a milder flavor. The °Brix values, indicating sugar content, are highest in S2 (68.67 ± 0.06%), followed by S3 (68.30 ± 0.10%) and S1 (67.57 ± 0.06%). Higher °Brix values suggest that S2 is the sweetest, which could appeal to consumers with a preference for sweeter products. These findings are supported by research from McGrath and Fugate (2012), who noted that higher °Brix levels enhance the sweetness and consumer appeal of fruit preserves.

Table 4: Functional properties of mixed fruit jam

Samples	Acidity (%)	pH	°Brix
S1	2.05±0.23	2.85±0.01	67.57±0.06
S2	1.66±0.10	2.91±0.02	68.67±0.06
S3	1.54±0.06	3.00±0.02	68.30±0.10

Mean ± SD, for each assessment, the mean of three trials is used. S1= 25% coconut + 50% pineapple + 25% orange; S2= 25% coconut + 25% pineapple + 50% orange; S3= 50% coconut + 25% pineapple + 25% orange.

4.3 Sensory characteristics

The sensory evaluation results reveal varying levels of color preference across samples S1, S2, and S3. Overall, there is a strong positive response to color across all samples, with the highest ratings concentrated in the “Liked very much” and “Liked extremely” categories. Sample S3 stands out, with 40.7% of respondents rating it as “Liked extremely,” making it the most preferred color among the samples. Sample S1 follows closely with 37% in the same category, while S2 shows a slightly lower preference at 33.3%. In the “Liked very much” category, both S1 and S2 show identical results, with 22.2% of respondents expressing high satisfaction, while S3 leads with 33.3%.

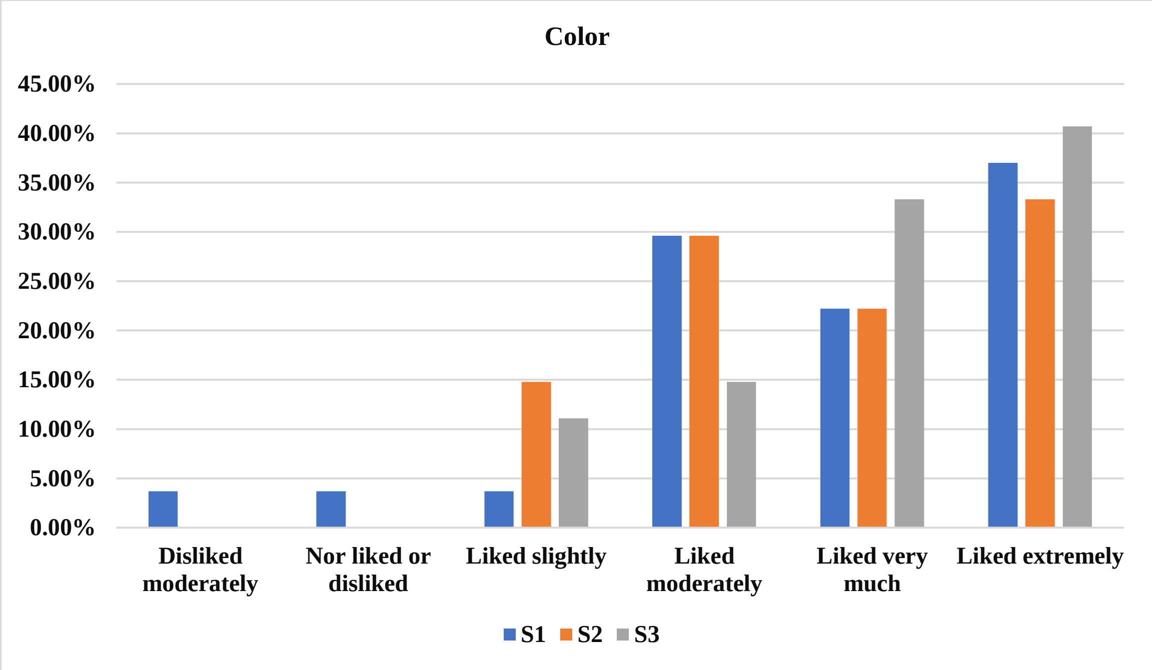

Figure 8: Color as Sensory attribute of mixed fruit jam

This trend indicates that S3's color may have broader appeal. When it comes to moderate liking, S1 and S2 perform equally, each garnering 29.6% in the "Liked moderately" category, whereas S3 shows a lower preference here, with only 14.8%. Very few participants rated any sample in the "Disliked moderately" or "Nor liked or disliked" categories, which further emphasizes the overall positive reception of color across the samples. In summary, S3's color appears to have the strongest appeal, though S1 and S2 are also well-liked, particularly in moderate to high liking levels.

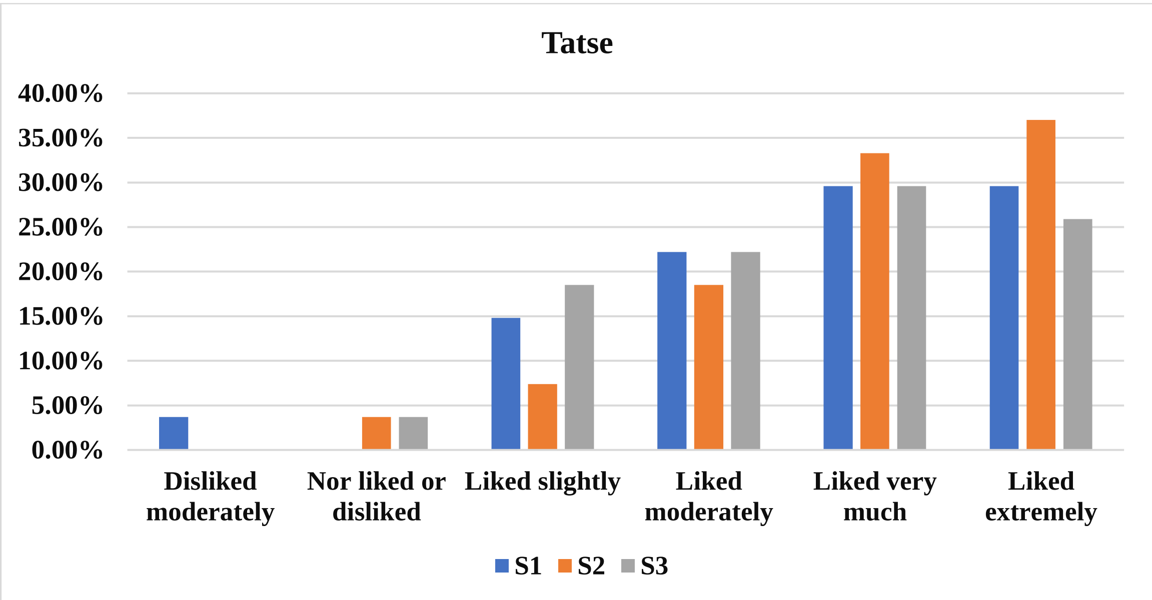

Figure 9: Taste as Sensory attribute of mixed fruit jam

Based on the sensory evaluation results for taste, preferences show some variation among samples S1, S2, and S3. In general, the highest ratings for taste are concentrated in the

"Liked very much" and "Liked extremely" categories across all samples, indicating positive taste perceptions. Sample S2 receives the highest preference, with 37% of respondents rating it as "Liked extremely," indicating that S2's taste is particularly well-regarded. In comparison, both S1 and S3 are rated as "Liked extremely" by smaller percentages—29.6% for S1 and 25.9% for S3. This trend suggests that S2 has a taste profile that is especially appealing to respondents. In the "Liked very much" category, S2 also leads with 33.3%, while S1 and S3 are both rated at 29.6%. For moderate liking, S1 and S3 have identical ratings at 22.2%, while S2 is slightly lower at 18.5%. The "Liked slightly" category shows varied responses, with S3 having the highest rating at 18.5%, followed by S1 at 14.8%, and S2 at 7.4%. There is minimal dissatisfaction across samples, as shown by the low percentages in the "Disliked moderately" and "Nor liked or disliked" categories. Overall, S2 stands out for its strong taste appeal, though S1 and S3 also show positive feedback in moderate to high liking levels.

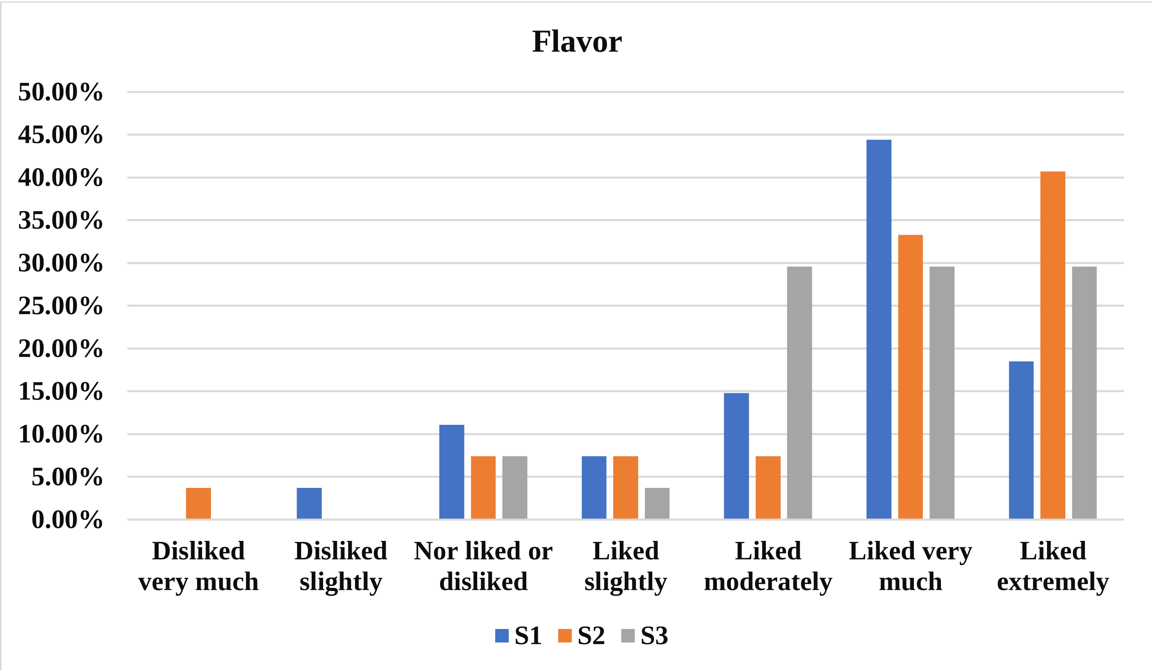

Figure 10: Flavor as Sensory attribute of mixed fruit jam.

The sensory evaluation for flavor across samples S1, S2, and S3 shows noticeable differences in preference levels. Sample S2 appears to have the strongest flavor appeal, with 40.7% of respondents rating it as "Liked extremely." This high rating suggests that S2 has a flavor profile that is particularly well-regarded among participants. Sample S3 follows, with 29.6% of respondents in the "Liked extremely" category, while S1 has the lowest preference at 18.5% in this category. In the "Liked very much" category, S1 leads with 44.4%, indicating a high level of satisfaction with its flavor, whereas S2 and S3 have lower but still favorable ratings at 33.3% and 29.6%, respectively. For moderate liking, S3 has the highest rating, with 29.6% of respondents selecting "Liked moderately," compared to lower percentages for S1 (14.8%) and S2 (7.4%). The lower preference categories, including "Disliked very much," "Disliked slightly," and "Nor liked or disliked," show minimal dissatisfaction across all samples, with most responses concentrated in the higher liking categories. This suggests an overall positive reception of flavor, though preferences vary by sample. Overall, S2 is the most favored in terms of extreme liking, while S1 stands out in the "Liked very much" category, indicating varying appeal across the flavor profiles of the samples.

The sensory results for overall acceptance show distinct preferences among samples S1, S2, and S3. Sample S3 has the highest acceptance, with 40.7% of respondents rating it as "Liked extremely." This indicates a particularly strong positive response to S3, making it the most accepted sample. Sample S2 follows closely, with 37% in the "Liked extremely" category, suggesting that it is also well-regarded by participants. Sample S1 has the lowest rating in this category, at 29.6%. In the "Liked very much" category, S2 leads with 37%, followed by S1 with 29.6%. S3 shows a lower preference here, with only 14.8% of respondents rating it as "Liked very much." These findings imply that S2 has a strong appeal across both "Liked very much" and "Liked extremely" categories, indicating consistent overall acceptance. The "Liked moderately" category shows a high preference for S3, with 33.3%, whereas S1 and S2 receive lower percentages at 22.2% and 7.4%, respectively. This further underscores S3's broad appeal. Lower preference ratings, such as "Disliked moderately," "Disliked slightly," and "Nor liked or disliked," are minimal across all samples, reinforcing the generally favorable reception of each sample. In summary, S3 demonstrates the highest overall acceptance, with S2 also showing strong acceptance, especially in the highest liking categories. S1 is moderately accepted, with some respondents expressing high satisfaction but not to the extent seen with S2 and S3.

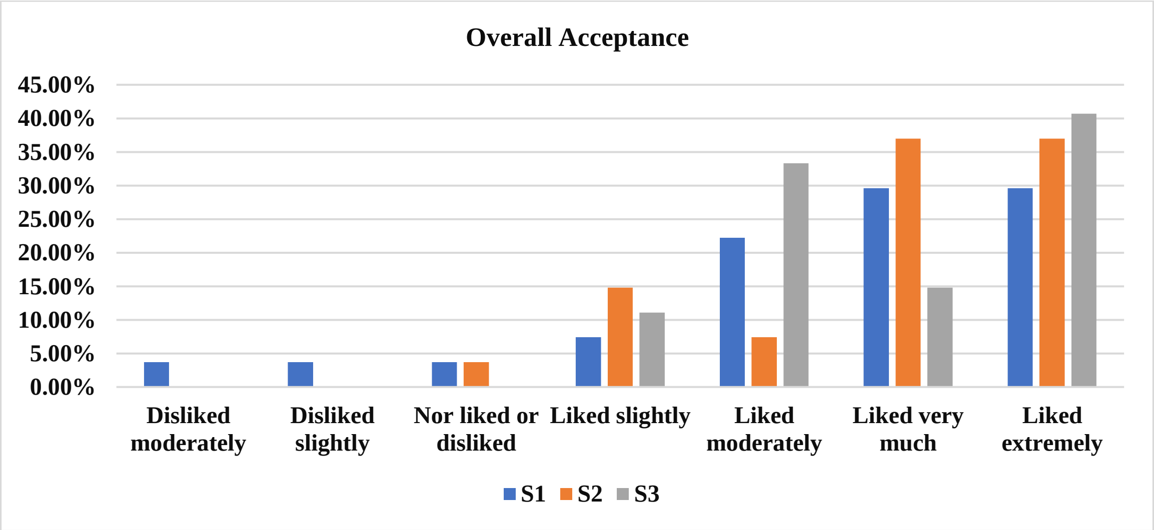

Figure 11: Color as Sensory attribute of mixed fruit jam

Table 6 represents the mean sensory scores for the mixed fruit jam samples. The color scores indicate that all samples are well-received, with S3 scoring the highest at 8.04 ± 1.02, suggesting it has the most visually appealing color among the three. S2 follows closely with a score of 7.74 ± 1.10, and S1 has the lowest color score at 7.70 ± 1.44. The higher score for S3 may indicate a more vibrant or desirable color, which can enhance consumer appeal. In terms of taste, S3 again scores the highest at 7.93 ± 1.11, indicating it is the most preferred in terms of flavor profile.

Table 5: Sensory evaluation of mixed fruit jam samples.

Sample Code	Color	Taste	Flavor	Overall Acceptance
S1	7.70±1.44	7.59±1.39	7.41±1.39	7.48±1.58
S2	7.74±1.10	7.56±1.19	7.70±1.17	7.85±1.10
S3	8.04±1.02	7.93±1.11	7.74±1.68	7.89±1.19

Mean ± SD, for each assessment, the mean of three trials is used. S1= 25% coconut + 50% pineapple + 25% orange; S2= 25% coconut + 25% pineapple + 50% orange; S3= 50% coconut + 25% pineapple + 25% orange.

S1 and S2 have similar taste scores at 7.59 ± 1.39 and 7.56 ± 1.19, respectively, showing that while they are also well-received, they may not be as flavorful as S3. Flavor scores show a slight variation, with S3 scoring 7.74 ± 1.68, S2 scoring 7.70 ± 1.17, and S1 scoring 7.41 ± 1.39. These scores indicate that S3 and S2 are preferred over S1 in terms of flavor. The flavor score for S3, though slightly higher, shows more variability, as indicated by the larger standard deviation. Overall acceptance scores provide a summary of the overall sensory experience. S3 has the highest overall acceptance score at 7.89 ± 1.19, suggesting it is the most preferred sample overall. S2 follows closely with a score of 7.85 ± 1.10, while S1 has the lowest score at 7.48 ± 1.58. These scores suggest that while all samples are generally well-accepted, S3 and S2 are slightly more favored by consumers. These findings are in agreement with those of Souza et al. (2011), who observed that sensory attributes such as color, taste, and overall acceptance are critical determinants of consumer preferences for fruit jams.

4.4 Storage stability

The evaluation of sensory attributes such as color, flavor, and texture is essential for assessing the quality and acceptability of mixed fruit jam during storage. The initial characteristics of the jams (S1, S2, and S3) displayed vibrant colors, fresh and fruity flavors, and smooth, spreadable textures, which are indicative of high-quality products. However, significant changes were observed after 60 days of storage. The color of all samples faded, with S1 exhibiting noticeable color loss, while S2 and S3 showed a faded golden and pale yellow appearance, respectively. This degradation can be attributed to the breakdown of natural pigments like carotenoids and anthocyanins due to oxidation and exposure to light and oxygen during storage, as reported in previous studies (Thakur et al., 2020).

Table 6: Visual Observation of Color, Flavor, and Texture of mixed fruit jam.

Storage Days	Sample	Color	Flavor	Texture	Remarks
0 Days	S1	Bright, vibrant yellow	Fresh, fruity, citrusy	Smooth, spreadable	Good
	S2	Bright, golden yellow	Strong pineapple notes	Smooth, slightly thick	Good
	S3	Light yellow	Mild coconut aroma	Soft, medium consistency	Good
15 Days	S1	No change	No change	No change	Good
	S2	No change	No change	No change	Good
	S3	No change	No change	No change	Good
30 Days	S1	No change	No change	No change	Good
	S2	No change	No change	No change	Good
	S3	No change	No change	No change	Good
45 Days	S1	No change	No change	No change	Good
	S2	No change	No change	No change	Good
	S3	No change	No change	No change	Good
60 Days	S1	Noticeable color loss	Reduced fruity aroma	Further thickening	Very slightly spoiled
	S2	Color faded	Less pineapple taste	Noticeably firmer texture	Slightly spoiled
	S3	Pale yellow	Slight coconut essence	Thick and less spreadable	Slightly spoiled

Mean ± SD, for each assessment, the mean of three trials is used. S1= 25% coconut + 50% pineapple + 25% orange; S2= 25% coconut + 25% pineapple + 50% orange; S3= 50% coconut + 25% pineapple + 25% orange.

Flavor degradation was also evident, as the fruity aroma in S1 diminished, S2 experienced a reduction in pineapple notes, and S3 retained only a faint coconut essence. Such changes are likely due to the volatilization of aromatic compounds and reactions like lipid oxidation and Maillard reactions, which are common during prolonged storage (Damodaran et al., 2008). Texture alterations were marked by thickening and reduced spread-ability across all samples, likely caused by moisture loss, gel syneresis, and pectin depolymerization, which affect the consistency of jams (Rao et al., 2016). In comparison, the other samples (S2 and S3) also showed stability until 45 days but exhibited changes in texture and flavor that were slightly more pronounced by 60 days. S2 became firmer and lost its pineapple notes, while S3's texture became thicker and less spreadable, with only a faint coconut essence remaining. Thus, S1 demonstrates the best storage stability, retaining its sensory attributes for a longer duration.

4.4.1 Microbial analysis

The microbial load of mixed fruit jam stored over 60 days demonstrates a gradual increase in total plate count (TPC) across samples S1, S2, and S3. The results align with the expected microbial growth pattern in jam during prolonged storage, as environmental conditions and nutrient availability can foster the growth of microorganisms over time.

Table 7: Microbial load(TPC) of Mixed Fruit Jam

Storage Days	Colony Forming Unit per gram		
	S1	S2	S3
Day 0	1.15 x 10^2	1.02 x 10^2	1.24x 10^2
Day 15	5.07x 10^2	4.82x 10^2	5.01x 10^2
Day 30	1.03x 10^3	9.53x 10^2	1.24x 10^3
Day 45	1.9x 10^3	1.65x 10^3	1.87x 10^3
Day 60	2.4 x 10^3	2.2 x 10^3	2.4 x 10^3

Mean ± SD, for each assessment, the mean of three trials is used. S1= 25% coconut + 50% pineapple + 25% orange; S2= 25% coconut + 25% pineapple + 50% orange; S3= 50% coconut + 25% pineapple + 25% orange.

This increase in microbial load, although gradual, can be attributed to factors such as the jam's pH, sugar concentration, and water activity (aw), which influence microbial stability during storage (Jay, 2000; Sperber & Doyle, 2009).

On Day 1, the initial TPC is relatively low, with values of 1.15 × 10^2 CFU/g for S1, 1.02 × 10^2 CFU/g for S2, and 1.24 × 10^2 CFU/g for S3. This low microbial load at the beginning of storage may result from effective processing and preservation methods, which initially inhibit microbial growth. Preservatives and high sugar content in jams often create an environment with low aw, which limits microbial activity (Cakir, 2019). By Day 15, the TPC increases to approximately 5.07 × 10^2 CFU/g for S1, 4.82 × 10^2 CFU/g for S2, and 5.01 × 10^2 CFU/g for S3. This increase could be due to minor contamination that may occur post-processing or due to gradual microbial adaptation to the storage environment. Previous studies have shown that while jams generally resist rapid microbial proliferation, certain resilient microorganisms, such as osmophilic yeasts and molds, can grow slowly over time (Mossel et al., 1995). As storage continues to Day 30, microbial loads rise further, reaching 1.03 × 10^3 CFU/g for S1, 9.53 × 10^2 CFU/g for S2, and 1.24 × 10^3 CFU/g for S3. This continued increase suggests that the remaining sugar and other ingredients are still providing substrates for microbial growth, albeit at a limited rate. It's typical for preserved foods like jam to experience slower microbial growth due to high sugar content, which exerts osmotic pressure that restricts water availability for microbial metabolism (Davidson et al., 2013).

By Day 45, microbial counts have nearly doubled from Day 30, with values reaching 1.9×10^3 CFU/g for S1, 1.65×10^3 CFU/g for S2, and 1.87×10^3 CFU/g for S3. This trend illustrates the effect of storage time on microbial growth in jam, as long-term storage at ambient conditions can gradually lead to increased microbial load despite initial preservation efforts (Jay, 2000). On Day 60, the TPC reaches its peak, with S1 and S3 both at 2.4×10^3 CFU/g and S2 at 2.2×10^3 CFU/g. While the microbial load remains within BSTI acceptable limits $<10^4$ CFU/g, suggests that jams should ideally be consumed before extended storage to avoid any potential quality decline due to microbial growth. Studies indicate that over time, spoilage microbes can affect sensory quality, even in preserved foods like jam (Sperber & Doyle, 2009).

CHAPTER 5

CONCLUSION AND RECOMMENDATION

5.1 Conclusion

The study evaluated mixed fruit jam samples (S1, S2, S3) with varying fruit concentrations, focusing on nutritional quality, functional properties, microbial safety, and sensory acceptability. Sample S3 stood out with higher fat (0.72±0.02%), protein (0.45±0.01%), and fiber (3.12±0.04%) content, softer texture due to higher moisture (18.88±0.06%), and balanced acidity (1.54±0.06%) and sweetness (68.30±0.10°Brix). Microbial analysis revealed that while TPC increased for all samples over 60 days, S2 had the lowest microbial load, indicating better preservation. Sensory evaluations ranked S3 highest in color (8.04±1.02), taste (7.93±1.11), flavor (7.74±1.68), and overall acceptance (7.89±1.19), attributed to its nutritional profile and balanced attributes. S3 emerged as the most promising formulation for further development, offering superior nutritional benefits, sensory appeal, and functional stability. Future research could focus on extending storage stability, exploring health benefits, and refining consumer preferences through larger sensory panels.

5.2 Recommendation

- Improved packaging, such as vacuum-sealed or airtight glass containers, should be used to reduce oxygen exposure and prevent quality degradation.
- The proportions of fruit ingredients and processing conditions should be optimized to maintain consistent color, texture, and taste.
- Further research is recommended to investigate the long-term storage stability, antioxidant potential, the application of various preservatives, and the health benefits associated with the jams.
- Consumer preferences should be assessed through larger and more diverse sensory panels to refine the product further.

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Appendix 2: Plagiarism Report

Project Report

ORIGINALITY REPORT

19%	15%	9%	9%
SIMILARITY INDEX	INTERNET SOURCES	PUBLICATIONS	STUDENT PAPERS

PRIMARY SOURCES

1	Submitted to Higher Education Commission Pakistan Student Paper	2%
2	www.myfoodresearch.com Internet Source	2%
3	scidoc.org Internet Source	2%
4	baures.bau.edu.bd Internet Source	1%
5	www.researchgate.net Internet Source	1%
6	www.baripmis.org Internet Source	1%
7	article.sciencepublishinggroup.com Internet Source	1%
8	archive.org Internet Source	1%
9	Submitted to University of Teesside Student Paper	<1%