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Enhancement Of Fruit Leather Incorporating Betel Leaf and Banana Peel

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ABSTRACT

This project involves creating a healthy and sustainable fruit leather made from banana peel and betel leaf, two fruits popular for their health value and ability to be converted into functional foods that can prevent wastage. Banana peel brings about dietary fiber, potassium, and antioxidants, while betel leaf has antibacterial, anti-inflammatory, and antioxidant properties. A mixture of pureed fruit was mixed with crushed banana peel and finely cut betel leaf as a base to dry to obtain the leather. Physicochemical characteristics like pH, moisture, fat, sugar, fiber content, and antioxidant activity were determined to determine quality. Trial 1 with only banana peel and betel leaf yielded a dense, dry, and slightly bitter product, suggesting the requirement of moisture regulation and flavor modification. The finished product contained pH 5.56 marginally found range for microbial stability along with 54% moisture, 5% fat, and 8% reducing sugar. These traits indicate an even texture, long shelf life, and low fat, with enhanced nutrition. Sensory testing showed good flavor, texture, and appearance, which justifies its consumer acceptance. Generally, the addition of banana peel and betel leaf improves the nutritional content and sustainability of the fruit leather, offering an auspicious, environment-friendly functional food with health-promoting properties and room for further enhancement on acidity and drying.

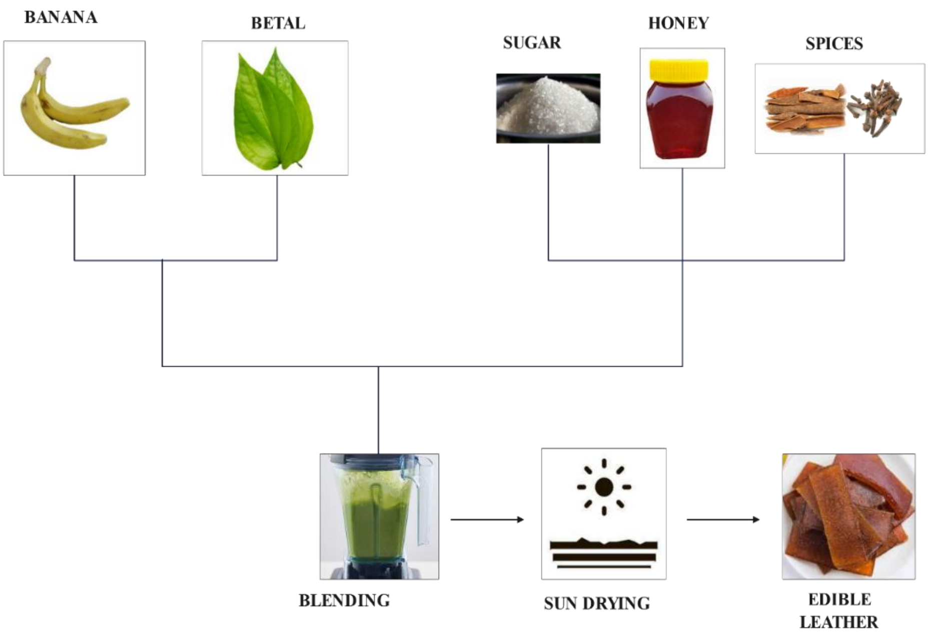
Keywords: *Fruit leather, Betel leaf, Banana peel, Food waste reduction, Nutritional enhancement.*

1. INTRODUCTION

Fruit leather is a dried product manufactured from fruit purees that has become more and more popular due to the growing demand for healthy and handy snacks around. Fruit leather, once valued for its flavor, mobility, and nutritional content, has evolved into a consumer staple for those on a health-conscious diet. But when dietary preferences change to include more functional meals, fruit leather can be improved by adding more natural ingredients with even more health advantages.[1]Banana peels are one such component that is frequently thrown away as garbage. Banana peels are rich in dietary fiber, antioxidants (like polyphenols), and important minerals (including magnesium and potassium). As such, they offer a long-term nutritional improvement opportunity. By using banana peels, fruit leather's overall health profile is improved and food waste is decreased. With its well-known therapeutic qualities, betel leaf (Piper betle) is another novel element. Betel leaf is a great addition to the mix because of its well-known antibacterial, anti-inflammatory, and antioxidant properties. Because betel leaf has preservation properties, adding it can not only improve the nutritional value but also potentially increase the fruit leather's shelf life.

This study is to explore the potential for banana peel and betel leaf to work together to develop a unique fruit leather[4]. The objective is to produce a product that is high in dietary fiber, antioxidants, and functional components while also being aesthetically pleasing and tasty through the optimization of formulation and processing methods. This program, which promotes the benefits of reducing food waste and using traditional components to produce goods with additional value, is in line with the expanding trend of sustainable food production.

GRAPHICAL ABSTRACT



1.1 AIM OF THE STUDY

The primary aim of this study is to develop an enhanced version of fruit leather by incorporating betel leaf and banana peel, two natural ingredients known for their nutritional and functional properties. This enhancement aims to address three key aspects: improving the health benefits of the fruit leather, extending its shelf life, and maintaining or improving its sensory qualities.

Betel leaf is rich in bioactive compounds like antioxidants, antimicrobials, and anti-inflammatory agents, which contribute to overall health improvement [1]. It also has natural preservative qualities that could help extend the shelf life of the product [2]. Banana peel, often discarded as waste, is a valuable source of dietary fiber, antioxidants, and essential nutrients like potassium. By incorporating banana peel, the study seeks to add value to the product while contributing to food waste reduction.

Additionally, the study aims to retain the desirable taste, texture, and appearance of traditional fruit leather, ensuring it remains appealing to consumers [3]. The overall objective is to create a product that not only offers enhanced health benefits but also addresses sustainability and consumer preferences, potentially paving the way for more functional, eco-friendly snack options in the market.

1.2 IMPORTANCE OF THE STUDY

This study is significant as it tackles two important issues: the utilization of food waste and the enhancement of functional health benefits in food products. By incorporating banana peels, often discarded as waste, the research promotes sustainable food production and helps reduce food waste. Banana peels include nutritional fiber,antioxidants,and vital minerals,creating them a valuable resource for fortifying food products[4]. Utilizing this by-product not only adds nutritional value to the fruit leather but also contributes to environmental sustainability.

Additionally, the study highlights the incorporation of betel leaf, which is known for its antimicrobial, anti-inflammatory, and antioxidant properties. These bioactive compounds can provide functional health benefits such as improved digestion, enhanced immunity, and extended shelf life of the product. The inclusion of betel leaf also taps into traditional medicinal knowledge, offering consumers a natural way to enhance their health through everyday snacks[5]. this study is important for advancing sustainable food innovations by using underutilized resources and improving the nutritional profile of fruit leather. It addresses the growing consumer demand for healthier, eco-friendly snacks while contributing to the broader goal of food waste reduction and functional food development.

2. LITERATURE REVIEW

Betel leaf *(Piper betle)* is a traditional plant, widely recognized for its nutritional and medicinal properties. Commonly known as Paan, the vibrant green leaves of the betel vine are rich in essential nutrients, including fiber, vitamins (notably Vitamin C and various B vitamins), and minerals (such as calcium, iron, and magnesium [6] . These nutritional components contribute to betel leaf's role in promoting digestive health and overall wellness. Known as the "Neglected Green Gold of India," Piper betle L is not only valued for its dietary significance but also for its bioactive compounds, which include flavonoids, alkaloids, phenols, and terpenoids[1].Betel leaf is a commercially cultivated crop, traditionally consumed as a mouth freshener and stimulant in Southeast Asia. It is renowned for its functional and medicinal properties, including antimicrobial, antioxidant, anti-diabetic, and anti-carcinogenic effects.

The leaf contains an essential oil that contributes to its distinct aroma and flavor. This essential oil is a complex mixture of phytochemicals, with key components such as estragole, chavicol, chavibetol, β-cubebene, and caryophyllene, all of which are responsible for its therapeutic properties. Scientific research has demonstrated the bioactive potential of betel leaf extracts and essential oil, highlighting their role in promoting health and preventing disease. However, when consumed in conjunction with areca nut and tobacco, betel leaf can pose health risks, including oral cancers and other health hazards [7]. This review discusses the potential of betel leaf and its essential oil as bioactive ingredients in the food industry, while also addressing safety concerns[2]. Betel leaf-based products, such as syrups, offer nutritional and therapeutic benefits.

Incorporating lemon juice and ginger enhances flavor, with refrigeration improving nutrient stability .Betel leaf has significant therapeutic potential, with antimicrobial, antioxidant, and antihypertensive properties [8]. While tobacco-associated betel quid use poses health risks, betel leaf alone offers health benefits, aiding digestion, regulating heart function, and supporting drug development. Its essential oils have shown promise in enhancing mouth fresheners Betel leaf offers numerous health benefits, including antimicrobial, anti-inflammatory and anti-diabetic properties. It is widely used in medicine, Ayurveda, and cultural practices [9].

Previous studies have highlighted the significance of fruit covers in agriculture. They serve as protective barriers that shield fruits from pests, birds, and adverse weather conditions. This protection is crucial for maintaining fruit quality and yield, as extreme weather can lead to significant losses in agricultural production [10]. The literature would discuss the unique characteristics of banana fiber, which is derived from the banana plant. It is known for its strength, breathability, and biodegradability. Comparisons with other natural fibers, such as bamboo and ramie, would be relevant, emphasizing that banana fiber has superior fineness and spinnability [11]. The chemical composition, including cellulose, hemicellulose, and lignin, contributes to its durability and performance as a fruit cover .The use of neem leaves in agricultural practices has been well-documented. Neem is known for its insect-repelling properties, making it an effective natural pesticide [12]. The extraction methods, such as the double boiling technique mentioned in the paper, would be explored in the literature, highlighting how these methods maximize the efficacy of neem in protecting fruits from insect damage. The literature review would also cover the performance characteristics of fruit covers, including breathability and tear resistance. These metrics are essential for evaluating the effectiveness of the fruit cover in real-world applications. The reported breathability of 70% and tear resistance values would be compared with other materials used in fruit covers to establish the advantages of the banana fabric enhanced with neem extraction [13].The literature review would provide a comprehensive overview of the existing research on fruit covers, the properties of banana fiber, and the benefits of neem leaf extraction, setting the stage for the findings presented in the paper. This context is crucial for understanding the significance of the research and its contributions to agricultural technology.

”Banana Peels is Bioactive Ingredients: A Systematic Review of Nutritional and Pharmacological Attribute. The environmental impact of by-products from plant food production, particularly banana waste, is a significant concern due to the pollution and financial costs linked to improper disposal in landfills. Banana production generates large quantities of biodegradable waste, including peels, leaves, pseudostems, and inflorescences. These materials, rich in polysaccharide polymers such as lignin, cellulose, and gums, present opportunities for sustainable reuse, aligning with the growing need for eco-friendly waste management [14].Rather than allowing banana by-products to decompose in landfills, they can be converted into valuable products through bio-engineering processes. This includes the production of biofuels like bioethanol, food and feed such as single-cell proteins and fodder additives, and biochemicals including citric acid, lactic acid, and enzymes like cellulase [15]. Moreover, banana waste can contribute to the creation of biodegradable materials such as fibers, sanitary pads, and bio-plastics, as well as agricultural products like fertilizers and bio-sorbents.By utilizing banana waste in these ways, the socio-economic benefits extend to developing countries, where reducing plastic usage, managing waste, and creating economic opportunities are critical. This valorization of banana by-products offers ecological and economic solutions, contributing to sustainability and environmental preservation.

Potential Valorization of Banana Production Waste in Developing Countries: A Bio-Engineering Perspective. The study emphasizes how the manufacturing of plant food produces a significant number of by-products, which are frequently thrown away and pollute the environment or take up landfill space. This circumstance results in financial expenses and exacerbates problems with waste management .Reuse and Biodegradability: It highlights that although these byproducts are biodegradable, reusing them can result in greater benefits and financial gains. This implies that creative methods are required for efficient management of agricultural waste Composition of Plant Polysaccharide polymers like cellulose, gums, and lignin make up the majority of plant-based dietary [16]. This composition suggests that these materials can be bioengineered through a variety of techniques to produce valuable products. Use of Banana Waste: The article makes particular reference to banana producing waste, such as peels, leaves, pseudostem [17].

Banana leathers as influenced by polysaccharide matrix and probiotic bacteria The study how consumers' increased concern over the connections between nutrition and health is driving them to look for healthier snack options. Snacks with functional qualities, such probiotics, which are good for gut health, are part of this trend .Utilized Probiotic Bacteria[18]. The study focuses on two types of probiotic bacteria:Bacillus coagulans: a spore-forming bacteria that is well-known for remaining viable and stable during handling and preservation.Lactobacillus acidophilus: A common non-spore-forming bacteria that, as a result of osmotic stress, demonstrated notable viability losses during drying. Biopolymeric Matrices: Two varieties of polymeric matrices are compared in this study that are utilized in the manufacturing of banana leathers: Compitable Banana leathers created with cassava starch were not as robust and rigid as those made using bacterial cellulose.Non-Digestible Bacterial Cellulose [19]. Compared to leathers derived from starch, leathers made from bacterial cellulose showed higher tensile strength, elastic modulus, and shear resistance. Texture and Flavor Impact: Although banana leathers infused with Bacillus coagulans were generally well-received, the study found that there were more complaints about the texture and flavor of bacterial cellulose - based leathers than starch-based leathers. This implies that depending on the kind of matrix employed, consumer preferences can change . Probiotic Viability: It was discovered that the kind of biopolymeric matrix used had no discernible effect on the probiotics' loss of viability throughout processing and storage. An static in vitro simulated digestion model was used to measure the final viable cell count discharged [21] .

Application of Selected Chemical Modification Agents on Banana Fibre for Enhance Composite Production, Banana Fibre as a Resource After fruit is harvested, banana fiber is an underutilized agricultural byproduct that can be obtained for free. In composite materials, this presents banana fiber as a sustainable substitute for synthetic fibers. Difficulties in Composite Production: This section addresses the main disadvantages of employing banana fiber, specifically its weaker interfacial bond with the matrix than with synthetic fibers [22]. Because of this restriction, research into chemical treatments to improve its characteristics is necessary for improved composite performance. Chemical Treatments Examined: Three distinct chemical modification agents are the subject of this study. Alkali : This treatment is known to break hydrogen bonds in the network structure of the fiber, improving its characteristics. Permanganate: This substance is indicated because it helps to modify the fiber surface by generating cellulose radicals . Acetylation This procedure is notable for its ability to lessen the hygroscopic properties of banana fibers, which improves dimensional stability [23]. Chemical Treatment Effects According to the paper, chemical treatments greatly enhance the mechanical, chemical, and morphological characteristics of banana fibers. As an example, the treatments improve tensile strength and flexural modulus, decrease water absorption, and increase surface roughness. Composite Production and Performance: The study also looks into the possibility of reinforcing polyester composites with chemically altered banana fibers [24]. With a claimed 181.5% increase in tensile strength and a 56.63% rise in flexural strength compared to unreinforced polyester.

Quality evaluation and storage stability of mixed fruit leather prepared from mango, banana and papaya A thorough investigation of the production and quality evaluation of fruit leather derived from these three fruits is presented in the publication "Quality evaluation and storage stability of mixed fruit leather prepared from mango,banana,and papaya". The following are the main ideas from the paper: The aim of the research is the main objective was to assess the mixed fruit leather's quality and shelf life, paying particular attention to the ratios of papaya, banana, and mango in the formulation. The study also examined the long-term effects of various storage environments on the stability and quality of the product . The sensory properties, including color, texture, flavor, and overall acceptability were assessed. which had the highest mango content, was found to be the most acceptable among the three formulations, indicating that a higher proportion of mango pulp enhances the sensory quality of the fruit leather The fruit leathers were packaged in sealed low-density and high-density polyethylene and stored at room temperature (25±1°C) and refrigerated (4±1°C) [25]. The findings revealed that the products remained acceptable for up to four months, with high-density polyethylene at room temperature being the most effective storage condition. This literature survey highlights the significant findings of the study, emphasizing the importance of formulation and storage conditions in determining the quality and stability of mixed fruit [26].

2.2 CONCLUSIONS FROM THE LITERATURE REVIEW

Nutritional Enhancement Both betel leaf and banana peel are rich in bioactive compounds, antioxidants, vitamins, and minerals. Their incorporation into fruit leather not only boosts the nutritional profile but also adds potential health benefits, such as antimicrobial and antioxidant properties. **Functional Properties** The addition of banana peel enhances the fiber content and improves the texture of fruit leather. Betel leaf, with its aromatic and medicinal properties, contributes to flavor enhancement and extends shelf life due to its antimicrobial effects.

2.3 OBJECTIVES

- To formulate a fruit leather incorporating betel leaf and banana peel.
- To evaluate its physicochemical properties and sensory attributes.
- To analyze the product’s nutritional enhancement compared to traditional fruit leather.

3. MATERIALS AND METHODS

3.1 ACQUIRING OF RAW MATERIALS

Figure 3.1 Betal leaf

Figure 3.2 Banana

Figure 3.3 Honey

Figure 3.4 Sugar

Figure 3.7 Guar gum

Figure 3.6 Clove

Figure 3.5 Cinnamon

3.1.1 SOURCE OF MATERIALS

Materials of origin for edible fruit leather the objective of this project is to convert banana peel *(Musa paradisiaca*) and betel leaf (*Piper betle*) into nutrient-rich, eco-friendly, and healthy edible fruit leather. The final product will be delicious, eco-friendly, support local agriculture, and reduce food wastage if the appropriate ingredients are selected based on where and how to source them. As bananas and betel leaves are both highly significant crops in tamil nadu, supply chains are readily available and it is more convenient to access near the production roots.

3.1.2 SOURCE OF BETAL LEAF *(Piper Betle*)

The primary place of cultivation for betel leaf (Piper Betle), particularly in Tamil Nadu as specifically in Tiruchirappalli, Salem, and Kanyakumari districts where the climate and soil conditions are best suited for this tropical crop [27]. They yield several crops per year. Betel leaves have been a part of traditional medicine and traditions for ages, especially in preparing "paan." These leaves are a fine method of combining the natural preservation process with nutritional benefits due to their rich amounts of antioxidant, antibacterial, and anti-inflammatory properties as demonstrated in the fig 3.1.

3.1.3 SOURCE OF BANANA PEEL AND PULP (*Musa Paradisiaca)*

Banana peels (*Robusta banana)* are a rich source of nutrients and functional fiber, such as pectin and lignin, that add structure and texture to the fruit leather [28]. Pectin specifically serves as a natural gelling agent in aiding to produce the chewy, leathery consistency associated with fruit leather Banana Fruit quality and shelf life were tested following two years of storage in active and passive modified environment packaging at 12 ± 1°C and 85-90%. [29]. assist in neutralizing free radicals in the body and offer health benefits upon consumption. The peels are also a very good source of potassium, which maintains heart health and stabilizes blood pressure, making the fruit leather not only a convenient snack but also a nutritionally advantageous one as depicted in the fig 3.2.

3.1.4 SOURCE OF SWEETNERS

3.1.4.1 HONEY

The natural sweet substance called honey is drawn from nectar, which flowers yield and bees take in. Bees obtain nectar from open flowers by sucking it onto their bodies, especially their honey stomach, where enzymes break down the sugars. The nectar is then taken from the bees after they return to the hive and is put into honeycomb cells for further processing. To collect nectar and store it as honey, the bees first evaporate the excess water by spreading their wings as indicated in the fig 3.3. The liquid is stored in the honeycomb for safe keeping as food within the colony after slowly solidifying within the barrier of wax [30]. Depending on flowers from where the bees gather nectar, honey may have varied flavours, colours, and texture. Manuka, wildflower, and clover

3.1.4.2 SUGAR

Sugarcane and beetroot sugar are the two most widespread plant sources of sugar. Most prevalent in warm climates such as Brazil, India, and Southeast Asia, sugarcane is a tropical grass with tall stalks. Raw sugar is produced by treating the stalks of sugarcane to get the juice, which is then evaporated to the point where it crystallises. The sugar beetroot, cultivated in cold climates such as Europe and some parts of North America, offers a substitute source. Table sugar consists of sucrose, a chemical compound that is synthesized by both plants. Sugar from beets is obtained through harvesting, cutting, and soaking them; this sugar is refined into crystals as depicted in the fig 3.4. To provide foods and drinks a sweet taste, sugar is used everywhere. It is used by bakers to preserve

3.1.5 SOURCE OF CLOVE

Dried flowers buds of clove tree *(Syzygium aromaticum*) an evergreen plant native to the Maluku Islands of Indonesia, also known as the Spice Islands, to produce this spice. The flower buds are harvested while still unopened and the dark brown changes their color in the sun light. Due to the intense flavor and intense, sweet taste, the cloves become a highly desirable ingredient in food and medicine, as indicated by fig 3.5. Cloves are an essential ingredient in spice mixtures such as garam masala and pumpkin spice since they are primarily utilized to season meats, sauces, and baked foods. Eugenol, a compound present in cloves, possesses antibacterial and analgesic property.

3.1.6 SOURCE OF CINNAMON

The inner bark of Cinnamomum genus trees produces cinnamon; the two types are cassia, or Chinese cinnamon, Cinnamomum cassia, and true cinnamon, or Ceylon cinnamon, Cinnamomum verum. Cinnamon as indicated in the fig 3.6, which is native to Bangladesh, India, Sri Lanka, and Myanmar, has been utilized as a spice and medicine for thousands of years. While cassia is cultivated in China, Indonesia, and Vietnam, ceylon is mainly cultivated in Sri Lanka. Cassia has a more pungent flavour. Once peeled, the wrapped quills project out of the bark and are ready to be dried

3.1.6 SOURCE OF GUAR GUM

Guar gum, which is a guar bean polysaccharide, is a primary hydrocolloid used in fruit leather production to provide texture, moisture level, and strength to the final product. Guar gum, when used as a gelling and thickening agent, increases the puree's viscosity, enabling even spreading upon drying and preventing phase separation. Its good water-holding capacity retains the moisture, preventing over dehydration and yielding a softer, more pliable final product rather than a brittle one. This is particularly beneficial in the maintenance of the chewiness and flexibility of fruit leather for some time. Guar gum is also a stabilizer that inhibits syneresis (water separation) and maintains the fruit components evenly distributed. It also contributes to film formation, resulting in a glossy and smooth appearance, providing an added visual attractiveness to the product. Controlled release of water by guar gum's hygroscopic character enhances shelf life by minimizing hardening and microbial growth, hence improving storage stability. It also acts as a fat replacement in low-calorie foods, imparting a rich mouthfeel without any added fats or sugars. Guar gum's ability to blend with other hydrocolloids. Although generally applied in low amounts, too much guar gum will produce an overly sticky or rubbery texture, so accurate formulation is essential. Its natural origin and nutritional profile, including dietary fiber content and digestion regulation, provide it with an outstanding additive with the ability to improve the quality, texture, and shelf stability of fruit leather with a clean-label, consumer-friendly profile. Overall, guar gum significantly improves the sensory and structural properties of fruit leather, improving its shelf stability and attractiveness

3.2 METHODS

3.2.1 TRADITIONAL METHOD (SUN DRYING)

Fruit leather is sun naturally dehydrated, which is a significant phase in the production of fruit leather. This assists sunshine in evaporation of water, which prevents microorganisms' growth and prolongs the life of the product. This is not only harmless to the environment but also conserves energy, particularly in sunny regions. Sun drying is an additional preservation. Depending on the weather, this can take several days, but it also serves to keep the fruit's flavors and nutrients intact. Fruit leather achieves its chewy consistency and intense flavor from sun drying, which evaporates the fruit's water content to concentrate its sugars [31]. Nevertheless, strict observation is required to avoid contamination by dust, insects, or temperature fluctuations.

3.2.2 INSTRUMENTAL METHOD (HOT AIR OVEN)

Fruit leather makes the hot air oven significantly helpful in controlled fruit puree dehydration. Although evaporation of some of it reduces moisture and maintains natural sugars and flavouring in fruits, the circulation of hot air facilitates equal drying. Drying temperature for the product is between 50°C and 70°C [32]. The hot air oven slowly evaporates the water content of the fruit puree to produce a leathery texture without overcooking or charring. Gradual drying helps retain the fruit's colour and nutrients, giving a product that is both healthy and pleasing to the eye. Moreover, the temperature distribution is very accurate and stable, eliminating the possibility of microbial growth and preserving the integrity of the fruit This fruit leather is shelf-stable because the temperature distribution is also very accurate and stable, eliminating the possibility of microbial growth and preserving the integrity of the fruit in its end form [33]. Also, this unit has evenly flowing air, which prevents the development of such problems as sticky spots or an uneven texture.

3.3 EXPERIMENTAL SETUP

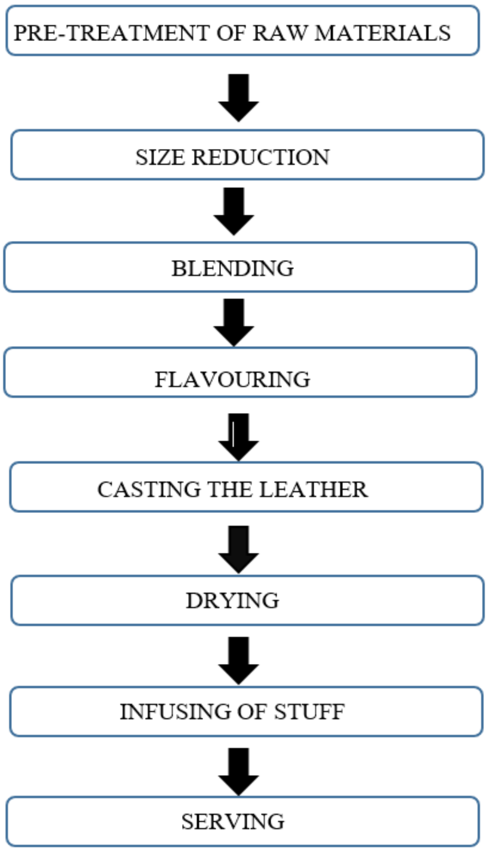


Figure :3.5 Process Flow

3.4 PROCESS FLOW DESCRIPTION

3.4.1 CLEANING AND WASHING (PRE TREATMENT)

Banana Peel Wash the banana peels clean to eliminate dirt, chemicals, and other contaminants. You can also blanch them quickly in hot water to soften the peel. Betel Leaf Wash the betel leaves with water to eliminate dust and any extraneous contaminants. As betel leaves are soft, use a soft wash so that they will not tear.

3.4.2 DRYING

Banana Peel Dry the peels in a controlled environment (sun-drying, oven-drying) to dehydrate them. Proper dehydration minimizes microbial growth and prepares the peel for additional treatment. Betel Leaf Air-drying is ideal for betel leaves to avoid mold development while keeping them intact. Avoid over-drying since it will lead to brittleness

.3.4.3 SIZE REDUCTION

Banana Peel Cut the banana peels into minute pieces to provide more surface area for the extraction of desirable compounds such as cellulose and tannins during the tanning process. Betel Leaf Shred the betel leaves into a workable size to ease handling and enhance the blending with the banana peel in the development of leather. Banana Peel Extract the cellulose fibers from the banana peel for use in the leather. This is achievable by mechanical means such as mixing or through solvents that dissolve the undesired compounds.Betel Leaf Extract fibers or bioactive substances that will add to the strength, flexibility, or antimicrobial activity of the leather**.**

3.4.4 BLENDING

Blend both banana peel and betel leaf pulp/fibers together in specific ratios depending on the desired properties of the leather (Texture, strength, and flexibility).

3.4.5 BINDING OF INGREDIENTS USING NATURAL BINDER

Banana *(Musa paradisiaca)* adds natural fibers and sugars that play the role of a binder, whereas Betel leaf (Piper betle) adds astringency with a binding influence that makes ingredients more cohesive. The leaves of betel add antioxidants and understated flavor as well. Such bars, created nutrient content from betel leaf, become better nutritionally as well as flavorably. Nuts, seeds, dried fruits, and sweeteners can also be added according to individual choice .The process starts with ripe bananas, This serves as the natural binding solution. Nuts are powdered, seeds are powdered, dried fruits are choppings, and other ingredients such as spirulina or sweeteners are measured out for addition.

3.4.6 CASTING THE LEATHER

In order to cast the fruit leather, use silicone sheets to line a flat pan to avoid sticking. Pour the banana peel and betel leaf mixture that has been prepared onto the tray, then use a knife to spread it out evenly, with the aim of reaching a thickness of 1-3 millimeters. This creates a constant drying and texture. If the mixture is too in thickness, it can dry unevenly, while being too thin can make it brittle. To make fruit leather, dry the mixture low-temperature In a Help oven of or By Sun drying it until hard but flexible.

3.5 BETAL AND BANANA LEATHER COMPOSTION

Table: 3.1 Composition of leather

Ingredients	Quantity (%)						
	Trail 1	Trail 2	Trail 3	Trail 4	Trail 5	Trail 6	Trail 7
Betal	30	60	20	35	45	50	30
Banana Peel & Pulp	50	30	50	55	45	40	50
Cinnamon	10	10	20	-	10	5	-
Clove	10	-	-	10	-	5	-
Flavour	-	-	-	-	-	-	10
Guar gum	-	-	-	-	-	-	10
Sun Drying	12 hours	6 - 7 Hours	-	-	7 - 8 Hours	9 - 10 Hours	8-9 hours
Hot air oven (°C)	-	-	45°C	75°C	-	-	-

Hot air oven (Hours)	-	-	8 Hours	4 Hours	-	-	-

FINAL PRODUCT

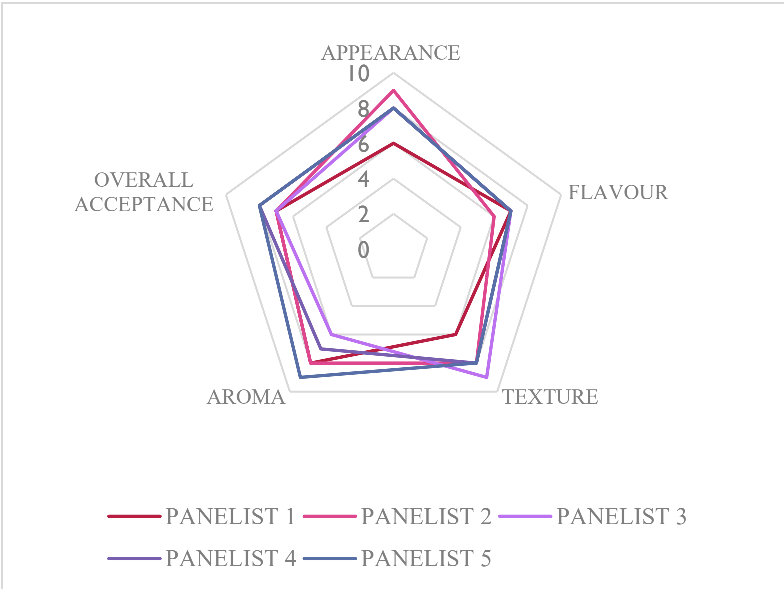


Figure :3.6 Betal leather

GULKAND COMPOSITION

Sugar = 20g

Rose petal = 15g

Elachi =1g

Water =20 ml

REMARKS

Raw taste of the source material to be change

Need to enhance the Aroma of the Leather

Need to increase elasticity of leather

4.1 ANALYSIS OF PROXIMATE COMPOSITION

4.1.1 SPECTROPHOTOMETER

Spectrophotometric determinations are often made with solutions, wateror organic solvent contained within a measuring cell in the path of a direction of a beam of monochromatic radiation of a given wavelength [34], as illustrated by Figure 4.6. A proportion of the overall radiation of the initial intensity which is incident on a layer of solution is absorbed while passing through the solution, another is passed on, and one is reflected and scattered by the cell wall

Fig :4.7 Spectrophotometer

4.1.2 PRINCIPLE

- **Light Source:** The spectrophotometer employs a stable source of light that produces a series of wavelengths, typically from ultraviolet to visible light. Certain models also include the near-infrared region
- **Selection of Wavelength**: A monochromator or filtering system discriminates between chosen wavelengths of light based on the needs of the measurement. The chosen wavelength can be the absorption maximum of the analyte of concern or the color.and the nanometer reading is 570nm
- **Sample Interaction:** In liquids, it directs light through the sample. When light moves to a solid, in this instance, onto its surface, then some wavelengths are absorbed depending on its composition and other wavelengths transmitor are reflected.
- **Detector**: A photodetector quantitates the intensity of reflected or transmitted light following interaction with the sample. The contrast in light intensity before and after transmission through the sample is equivalent to the absorbance or transmittance of a given Wavelength
- **Data Processing and Display:** The calculated light intensities are translated via the spectrophotometer into values of absorbance, which because of Beer-Lambert's law for absorbance can be correlated to concentrations of the material [35]. In measurements of color, it gives a value which is quantified on its specified color scale as depicted in the fig 4.7.

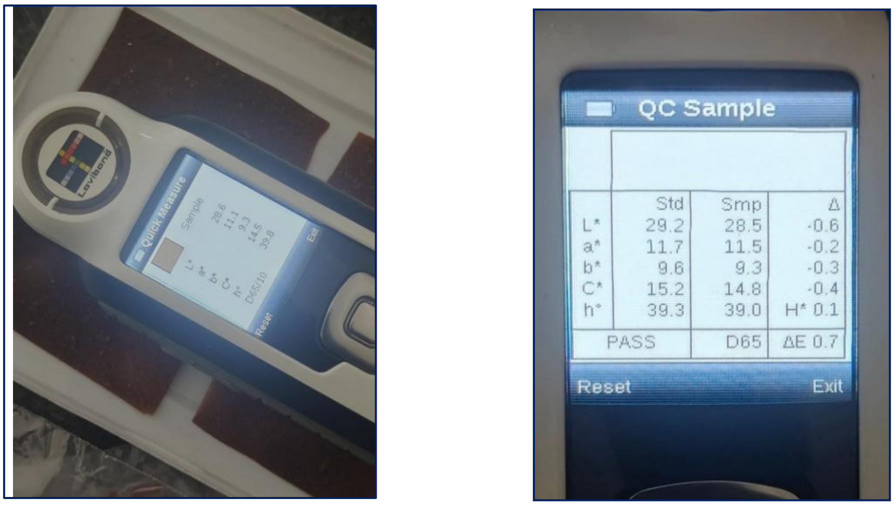


Fig:4.8 Spectrophotometer Readings

4.1.3 TABULATION OF READINGS

Table :4.2 Spectrophotometer readings

	STD (nm)	**SMP(nm)**	**ΔA**
L*	29.2	28.5	-0.6
a*	11.7	11.5	-0.2
b*	9.6	9.3	-0.3
c*	15.2	14.8	-0.4
h*	39.3	39.0	H* 0.1
	PASS	D65	E 0.7

4.2 DETERMINATION OF MOISTURE CONTENT

PRINCIPLE:

The moisture content of a sample is determined by calculating the weight loss after drying it at 130°C for 2 hours. This weight loss, represented as a percentage, represents moisture content.

REQUIRED APPARATUS:

Mettler balance, Aluminum dishes, Hot air oven, Desiccator

PROCEDURE:

- Weigh 10 grams of powdered sample onto a pre-weighed aluminum dish.
- Place the dish in a hot air oven set at 130°C for 2 hours.
- After drying, cool the dish to room temperature in a desiccator before reweighing it.
- The decrease in weight is due to the moisture content..

FORMULATION

$$\text{Moisture } \% = \frac{(A-B)}{(A-C)} X\ 100$$

$$\text{Moisture } \% = \frac{(27.3-24.6)}{(27.3-22.3)} X\ 100$$

$$\text{Moisture \%} = 54\%$$

Where,

A = Wt. of the flour + Aluminium dish before drying

B = Wt. of the flour + Aluminium dish after drying

C = Wt. of the Aluminium dish

4.3 DETERMINATION OF ASH CONTENT

PRINCIPLE:

Total ash is the inorganic residue left after a sample is burned in an oven at atmospheric pressure. Acid-insoluble ash contains additional mineral debris, such as dirt and sand.

REQUIRED APPARATUS:

Mettler balance, Silica crucible, Muffle furnace, Desiccator

PROCEDURE:

- Weigh 5g of samples in a silica crucible.
- Pllace the crucible at muffle furnance and set the Temperature at 600°C for 6 hours.
- After incineration, Cool the Crucible i a room temperature

FORMULATION

$$\text{Total ash \%} = \frac{W3 - W1}{W2 \ - W1} X\ 100\ X(100 - \text{Moisture})$$

$$\text{Total ash \%} = \frac{51.43 - 50}{55 \ - 50} X\ 100\ X(100 - \text{Moisture})$$

$\text{Total ash \%} = 28.6$

Where,

W1 = Wt. of Silica crucible

W2 = Wt. of Silica crucible + Sample

W3 = Wt. of Silica crucible + As

4.4 DETERMINATION OF PH ANALYSIS

Ph analysis is essential to determine the acidity or alkalinity of your edible leather, which directly affects shelf life, texture, microbial stability, and sensory quality.

PROCEDURE

SAMPLE PREPARATION:

- Take **5g of edible leather** and cut it into small pieces.
- Mix with **50 ml of distilled water** (1:10 dilution).
- Stir well for **10 minutes** to extract ph-sensitive components.

PH MEASUREMENT:

- Calibrate the **ph meter** with **standard buffer solutions (ph 4.0, 7.0, 10.0)**.
- Immerse the **ph electrode** into the sample solution.
- Wait for **stable reading** (~1-2 minutes).

- Record the **ph value**.

CLEANING:

Rinse the electrode with **distilled water** before and after use.

- **pH < 4.5** → Prevents microbial growth, improves shelf lifeA more acidic environment inhibits spoilage microbes. Ensures better preservation without artificial preservatives.
- **pH > 5.0** → Increases microbial risk, shortens shelf life.Higher pH favors the growth of yeasts, molds, and bacteria.May lead to spoilage, off-flavors, and texture changes.
- **Optimal pH (4.0 - 4.5)** → Balances taste, texture, and safetyMaintains a mild tangy flavor (not too sour or bland).Ensures good chewiness & flexibility in the leathe. Keeps microbial activity under control for better shelf stability.

4.5 DETERMINATION OF REDUCING SUGAR ANALYSIS

Edible leather is made from **banana peel and betel leaf**, determining the **reducing sugar content** is essential for understanding its sweetness, texture, and potential browning reactions (Maillard reaction).The **DNS (3,5-Dinitrosalicylic Acid) Method** is a commonly used technique for **quantitative estimation of reducing sugars** in food products.

PROCEDURE:

- **Sample Preparation:**
    - Take **1g of edible leather** and mix it with **10mL distilled water**.
    - Heat at **60°C for 30 minutes** to extract sugars.
    - Filter the solution to remove solids.
- **Reaction with DNS Reagent:**
    - Take **1mL of sample extract** in a test tube.
    - Add **1mL of DNS reagent**.
    - Heat in a **boiling water bath (100°C) for 5-10 minutes** until an **orange-red color** develops.
    - Cool to room temperature.
- **Measurement:**
    - Dilute the reaction mixture with **10mL of distilled water**.
    - Measure **absorbance at 540 nm** using a **spectrophotometer**.

FORMULA

Reducing Sugar (% w/w)=C×V×D/W ×100

- **C** = Concentration of reducing sugar from the standard curve (mg/mL)
- **V** = Total volume of extracted sample solution (mL)
- **D** = Dilution factor (if any dilution is applied)
- **W** = Weight of the sample taken (**g**)

Reducing Sugar (% w/w)=0.8×10×1/1 ×100 = 8%

(Reducing Sugar Content)= **8%**

4.6 DETERMINATION OF FAT ANALYSIS

Edible leather is made from **Musa paradisiaca (banana peel) and Piper betle (betel leaf)**, the fat content is expected to be **low**, but measuring it is essential for nutritional labeling and shelf-life analysis.

PROCEDURE:

- **Weigh the Sample (W1):** Take **2-5g** of finely ground edible leather and place it in a **thimble**.

- **Extraction:**
  - Place the thimble in the Soxhlet extractor.
  - Add **petroleum ether** to the round-bottom flask.
  - Run the extraction for **4-6 hours** (solvent continuously cycles through the sample).
- **Solvent Evaporation:**
  - After extraction, remove the solvent using a rotary evaporator or gentle heating.
- **Weigh the Extracted Fat (W2):**
  - Dry the flask with extracted fat in an oven at 105°C for **30 min**, cool in a desiccator, and weigh.

FORMULA

Fat Content (%)=W1/W2×100

Initial sample weight (W1) = 5g

Extracted fat weight (W2) = 0.25g Fat Content = 0.25/5×100

=5%

4.7 DETERMINATION OF MICROBIAL ANALYSIS

Microbial fruit leather analysis indicates that although its low pH and lower moisture content (often less than 15%) restrict most bacteria, some microorganisms such as yeasts, molds, and aerobic mesophilic bacteria may still grow under poor production conditions. Analysis has revealed yeasts and mold up to 4×10^2 CFU/g and aerobic mesophilic bacteria up to 3×10^2 CFU/g in conventional fruit leathers. Interestingly, Escherichia coli was also found in some of the samples, reflecting possible fecal contamination as a result of poor hygiene practices. Conversely, fruit leathers made under controlled conditions, e.g., iron and vitamin C-enriched fruit leathers, have shown much lower microbial loads, with bacterial levels of approximately 20 CFU/g and no coliforms. These results highlight the significance of strict hygiene procedures and correct drying methods in fruit leather manufacture to guarantee microbial safety and quality of the product.

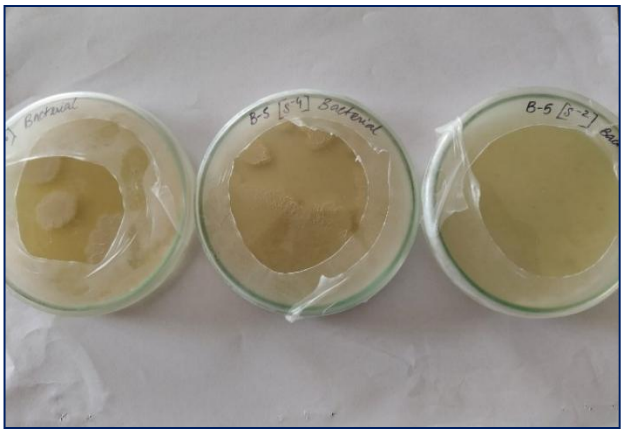


Figure : 4.9 Test tube sample

Figure: 4.10 Bacterial sample

4.7.1 PLATE-WISE OBSERVATIONS

Low [S^{-2}]

Growth of bacteria on the culture medium, showing a large amount of microbial activity. The colonies are large and spreading, with irregular and uneven borders and wrinkled surfaces. These types of morphological features are generally seen for motile or biofilm-producing bacteria, and it would suggest that the organisms could have a mechanism for surface movement or aggregation. Colonies show a translucent, slightly waxy appearance and the areas of growth are obvious, which would be indicative of vigorous metabolic processes and potential excretion of extracellular products. Such characteristics in combination with quick and extensive occupation of the medium imply that bacteria must be opportunistic and fast-growing in character. Their capacity to be biofilm formers or show motility might be responsible for increased survival under fluctuating environmental conditions, making them extremely flexible. The gross colony morphology and growth pattern are indicative of vigorous proliferation and can indicate the existence of species with the ability to survive in various or even extreme habitats. Such traits are typically seen in environmental isolates, soil microorganisms, or surface-contaminating bacteria or organisms found in rich organic environments. More specific studies, including Gram staining, tests for motility, or biochemical characterization, would be required in order to reliably determine the species and to support the initial assumption based on morphology of the colony and growth habit.

Figure 4.11 Bacterial Growth (Low)

Medium [S^{-4}]

Minimal bacterial growth is seen on the culture plate, which is sterile with no contamination or colony formation. The lack of any bacterial colonies indicates that either the sample contained no viable bacteria or that conditions were not suitable for bacterial growth. Some possible explanations are an inoculation error, like poor sample transfer or incorrect technique, which could have caused failure in bacterial deposition on the medium. Another reason is that the sample may have had inhibitory substances—like antimicrobial agents or chemical residues—that inhibited bacterial growth. Also, reasons like improper incubation conditions (e.g., temperature, time, or atmosphere) or the use of outdated or improperly prepared media could have been responsible for the failure to grow. In any case, the sterile look of the plate means that no microbial growth has taken place. In order to elucidate the cause of the negative outcome, it would be appropriate to check the procedures for handling the sample, check the viability of the culture media, and repeat the experiment with appropriate controls. A positive control must also be run in order to verify that the bacterial growth is being facilitated by the culture conditions. Additional study needs to be done to ascertain whether the outcome represents the actual state of the sample or an error in the experiment.

Figure 4.12 Bacterial Growth (Medium)

High [S^{-6}]

There is no visible growth of bacteria on the culture plate, which is sterile with no contamination or colony formation. There being no colonies of bacteria implies that either there were no viable bacteria in the sample or the conditions were not suitable for bacterial growth. Probable explanations are a mistake during inoculation, i.e., insufficient sample transfer or inappropriate technique, that could have caused the inability of bacterial deposition onto the medium. Another possibility is that the sample had inhibitory substances—like antimicrobial substances or chemical residues—that suppressed bacterial growth. In addition, improper incubation conditions (e.g., time, temperature, or atmosphere), expired or inadequately prepared media, or other conditions could have prevented the growth. In any case, the sterile look of the plate means that there has been no microbial activity. To explain why the result is negative, reviewing the sample handling protocol, ensuring the viability of the culture medium, and rerunning the experiment with appropriate controls would be sensible. A positive control should be added to verify that the conditions in the culture are favorable for bacterial growth. Additional research must be conducted to identify if the result indicates the actual nature of the sample or an experimental anomaly.

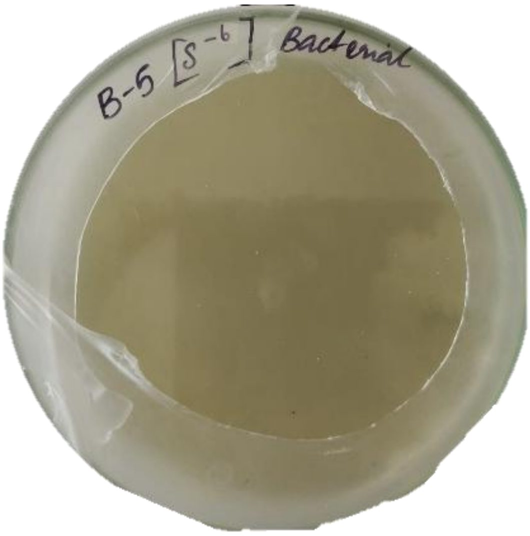


Figure 4.13 Bacterial Growth (High)

4. RESULT AND DISCUSSION

The creation of banana peel and betel leaf fruit leather was with the vision to produce a sustainable, eco-friendly product that would have enhanced texture, taste, and functionality. In Trial 1, only banana peel and betel leaf were used, and this created a dense, dry leather that had an unpalatable, slightly bitter taste, thus pointing towards moisture control and flavor correction.The pH analysis of edible leather from banana peel and betel leaf indicated the value of 5.56, which comes within the optimum value of 4.0 to 4.5 range that guarantees microbial stability and increased shelf life. Below 4.5, microbial growth gets prevented, while above 5.0 it raises the chances of spoilage. 54% moisture content made the product balanced between chewiness and microbial safety, as high moisture causes stickiness and microbial growth, and extremely low moisture causes a hard texture. Fat content was 5%, validating the low-fat character of the product, which acts against rancidity. Reducing sugar content was 8%, affecting texture, sweetness, and color stability. Increased sugar enhances softness and Maillard browning, and decreased sugar tightens the leather. General composition makes the edible leather rich in nutrients, shelf-stable, and sensorially palatable. The pH balance, moisture, protein, and sugar content contribute to its quality, safety, and market value, making it a potential functional food product with room for further optimization in acidity and drying methods.The Testing methods conducted in the fruit leather to ascertain it Quality

5. CONCLUSION

The addition of betel leaf and banana peel to fruit leather effectively boosted its nutrient profile, notably in terms of fiber and antioxidant levels. Not only did this enhance the product's health effects but also solved the essential problem of food waste minimization by incorporating banana peels, a readily discarded by-product. The research illustrated an effective way of producing healthier, more sustainable fruit fruit-based snacks through the utilization of the functional attributes of both products. The inclusion of betel leaf helped to impart the antimicrobial activity of the product, possibly increasing its shelf life and incorporating preservative functionality. Producing environmentally friendly and high-nutrient-value snack foods that meet the needs of health-conscious consumers. improving the drying techniques to further enhance the texture of the product, which is a critical factor in consumer acceptability, and optimize its shelf life.

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