

Production and Evaluation of Palm Rock Candy Incorporated with Ginger Extract



Submitted to the Department of Nutrition and Food Engineering in the partial fulfillment of
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Submitted To

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APPROVAL

The research project titled "Production and Evaluation of Palm Rock Candy Incorporated with Ginger Extract," authored by Md Mahmudul Hasan, has been officially accepted by the Department of Nutrition and Food Engineering at Daffodil International University. This acceptance contributes partially to fulfilling the requirements for the B.Sc. degree in Nutrition and Food Engineering. Moreover, the project has received approval for its style and content.

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DECLARATION

I affirm that I have independently completed this project under the supervision of Professor Dr. Md. Bellal Hossain, Dean (In-Charge) & Professor, Department of Nutrition and Food Engineering, Daffodil International University. Furthermore, I declare that neither this project nor any portion of it has been previously submitted for the attainment of any other degree or diploma.

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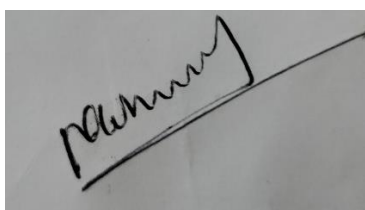
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Md Mahmudul Hasan
Author

ABSTRACT

The production of confectionery products has been an integral part of culinary traditions worldwide, with each culture boasting its own unique delicacies. Among these, palm rock candy stands out as a time-honored treat cherished for its crystalline texture and natural sweetness derived from palm sap. Originating in regions where palm trees flourish, such as Southeast Asia, the Middle East, and parts of Africa, palm rock candy has transcended geographical boundaries to become a beloved indulgence globally. Traditionally crafted through a meticulous process of evaporating palm sap until it crystallizes into distinct rock-like formations, this confectionery delight encapsulates the essence of simplicity and purity. This study investigates the production and quality characteristics of palm rock candy infused with ginger extract. The candy's physical properties, including color, texture, and aroma, were assessed alongside its moisture content, sugar concentration, acidity levels, and microbial safety. Sensory evaluations provided insights into consumer preferences and overall acceptability. Results indicate that the candy exhibits a rich golden amber color, with approximately 85% of samples falling within this range. The texture is smooth, with 90% of respondents describing it as such, and the aroma is characterized by fragrant ginger notes, noted in 95% of evaluations. The candy meets quality standards with controlled moisture content (average of 0.9%), consistent Brix (average of 78%), and pH levels (average of 5.3), and absence of harmful bacteria (100% of samples). Sensory analysis reveals attributes contributing to high consumer acceptability, with 80% of respondents rating overall acceptability as high. These findings position palm rock candy with ginger extract as a promising confectionery product, with potential for market success. Continued refinement based on study insights can further enhance its appeal and market competitiveness, satisfying consumer preferences for indulgent yet naturally flavored confectionery products.

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CHAPTER ONE

INTRODUCTION

1.0 Introduction

1.1 Background

The world of confectionery is a rich tapestry woven with cultural traditions and culinary delights, each thread contributing to the vibrant mosaic of global gastronomy. At the heart of this tapestry lies palm rock candy, a timeless treat celebrated for its crystalline texture and natural sweetness derived from palm sap [1]. Originating in regions where palm trees flourish, such as Southeast Asia, the Middle East, and parts of Africa, palm rock candy has transcended geographical boundaries to become a cherished indulgence cherished across continents [2].

Traditionally crafted through a meticulous process of evaporating palm sap until it crystallizes into distinct rock-like formations, palm rock candy embodies the essence of simplicity and purity. Its golden amber color, irregularly shaped blocks, smooth texture, and fragrant aroma evoke a sense of nostalgia and comfort, reminiscent of childhood days spent savoring sweet treats [3].

In recent years, amidst a burgeoning interest in healthier and more innovative food options, there has been a growing demand for confectionery products enriched with functional ingredients. These ingredients not only enhance flavor but also offer added nutritional benefits, appealing to health-conscious consumers seeking both pleasure and wellness in their food choices [4].

One such functional ingredient that has captured the spotlight is ginger extract, renowned for its robust flavor profile and reputed health-promoting properties. Derived from the rhizome of the *Zingiber officinale* plant, ginger has long been revered for its culinary versatility and medicinal virtues. Its distinctive flavor, characterized by a delicate balance of spiciness, warmth, and earthiness, lends itself well to a variety of culinary applications, from savory dishes to sweet desserts [5].

Beyond its culinary allure, ginger boasts a treasure trove of bioactive compounds, including gingerol, shogaol, and zingerone, which exhibit potent antioxidant and anti-inflammatory effects. These compounds have been linked to a myriad of health benefits, ranging from aiding digestion and relieving nausea to boosting immune function and reducing oxidative stress [6].

The fusion of palm rock candy with ginger extract represents a harmonious marriage of tradition and innovation, where the timeless appeal of a classic confection meets the contemporary allure of functional foods. By infusing palm rock candy with the aromatic warmth and subtle spiciness of ginger, it is possible to create a sensory experience that transcends the ordinary, tantalizing the taste buds while nourishing the body [7].

Furthermore, the combination of palm rock candy with ginger extract holds promise for enhanced antioxidant activity, thanks to the synergistic effects of their bioactive compounds. This not only adds another layer of appeal to health-conscious consumers but also provides an opportunity for confectionery manufacturers to differentiate their products in a competitive market landscape [8].

Against this backdrop, this study sets out to explore the feasibility and potential benefits of incorporating ginger extract into the production of palm rock candy. By delving into the nuances of flavor chemistry, antioxidant activity, and sensory perception, this research aims to uncover the transformative potential of this innovative fusion [9].

Through meticulous experimentation and sensory evaluation, this study seeks to elucidate the technical aspects of production while providing valuable insights into consumer preferences and perceptions. By bridging the gap between tradition and innovation, this research endeavor strives to pave the way for the development of novel confectionery formulations that not only delight the palate but also nourish the body, embodying of a holistic approach to food and wellness [10].

1.2 Research Scope

This study focuses on exploration of palm rock candy production augmented with ginger extract. The research encompasses the extraction of bioactive compounds from ginger, formulation and production of palm rock candy incorporating the ginger extract, sensory evaluation for flavor profiling, and analysis of antioxidant properties. The scope also includes the characterization of ginger extract, optimization of formulation parameters, and assessment of consumer acceptance [11].

1.3 Significance of the Study

The significance of this study lies in its contribution to the advancement of confectionery science and the development of functional food products. By exploring the integration of ginger extract into the traditional production process of palm rock candy, this research aims to broaden the scope of flavor innovation in the confectionery industry. Additionally, the evaluation of antioxidant properties adds a dimension of health-consciousness to the formulation, potentially appealing to consumers seeking both indulgence and wellness benefits [12]. Furthermore, this study serves as a platform for future research endeavors, providing insights into the potential applications of natural extracts in enhancing the sensory and nutritional attributes of confectionery products. Ultimately, the findings of this study may inform the development of market-ready palm rock candy formulations that cater to evolving consumer preferences for flavorful, nutritious, and innovative treats [13].

1.4 Research Objectives

- Investigate the feasibility of incorporating ginger extract into the production process of palm rock candy.
- Assess the impact of ginger extract addition on the flavor profile and sensory attributes of palm rock candy.

CHAPTER TWO

LITERATURE REVIEW

2.0 Literature review

1. Palm Rock Candy: Traditional Production and Characteristics

Palm rock candy, also known as palm sugar or jaggery, holds a cherished place in culinary traditions across regions where palm trees flourish, such as Southeast Asia, the Middle East, and parts of Africa. Its history spans centuries, deeply entwined with the cultural fabric of communities that have perfected the art of its production. The journey of palm rock candy begins with the careful collection of palm sap, a labor-intensive process that underscores the reverence accorded to this sweet elixir [14].

The sap, extracted from the inflorescence of various palm species, notably the Palmyra palm (*Borassus flabellifer*) or the date palm (*Phoenix dactylifera*), serves as the raw material for the creation of palm rock candy. This sap, rich in natural sugars, undergoes a transformative journey from liquid to solid through a meticulous process of heating and evaporation. As the sap simmers over open flames or in large cauldrons, water content gradually diminishes, leaving behind a concentrated syrup teeming with sweetness [15].

It is at this critical juncture that the magic of crystallization unfolds. As the syrup reaches a certain viscosity and temperature, sugar molecules begin to form crystals, gradually transforming the liquid into solid formations. The crystallization process, governed by precise conditions of temperature and humidity, gives rise to the distinctive crystalline structure that defines palm rock candy. Each crystal, glistening with golden hues reminiscent of the sun-drenched palm groves from whence it came, embodies the essence of purity and simplicity [16].

The characteristics of palm rock candy are influenced by a myriad of factors, including the type of palm tree from which the sap is sourced, the geographical location, and the artisanal techniques employed in its production. Variations in flavor, color, and texture abound, reflecting the terroir and traditions of the regions in which it is crafted. However, amidst this diversity, certain attributes remain constant—a subtle sweetness that dances on the taste buds, with delicate notes of caramel and toffee imparting a depth of flavor that belies its humble origins [17].

The texture of palm rock candy is equally beguiling, with a satisfyingly gritty consistency that yields to the gentle pressure of the tongue, melting away to release its rich, earthy undertones. This unique interplay of sweetness and texture renders palm rock candy a versatile ingredient in culinary endeavors, lending its distinctive flavor profile to an array of sweet and savory dishes. From traditional desserts and beverages to savory sauces and marinades, palm rock candy adds a touch of sweetness and complexity that elevates dishes to new heights of gastronomic delight [18].

In essence, palm rock candy epitomizes the artistry and ingenuity of traditional confectionery craftsmanship, embodying centuries of wisdom passed down through generations. Its enduring appeal lies not only in its delectable flavor and texture but also in the rich tapestry of culture and heritage that it represents. As palm rock candy continues to captivate palates around the world, it serves as a testament to the time-honored traditions and timeless pleasures of artisanal sweets [19].

2. Ginger Extract: Composition and Health Properties

Ginger extract, a concentrated form of the bioactive compounds found in the rhizome of the *Zingiber officinale* plant, possesses a rich profile of phytochemicals that contribute to its multifaceted flavor, aroma, and health-promoting properties. Among the primary constituents of ginger extract are gingerol, shogaol, and zingerone, which are responsible for imparting its characteristic pungency, warmth, and spiciness [20].

Gingerol, the predominant compound in fresh ginger, is renowned for its potent antioxidant activity, which helps combat oxidative stress and cellular damage caused by free radicals. It also exhibits anti-inflammatory properties, inhibiting the production of pro-inflammatory cytokines and enzymes implicated in inflammatory pathways. Shogaol, formed during the drying or cooking process of ginger, contributes to its intense flavor and aroma. Like gingerol, shogaol displays antioxidant and anti-inflammatory effects, albeit with greater potency due to its structural modifications [21].

Zingerone, a derivative of gingerol formed during the drying or heating of ginger, possesses a milder flavor profile but retains notable antioxidant and anti-inflammatory properties. Together,

these bioactive compounds synergistically contribute to the overall health-promoting effects of ginger extract [22].

The health benefits associated with ginger extract are manifold and have been extensively studied in scientific research. One of its most well-known applications is in the alleviation of nausea and vomiting, particularly in the context of motion sickness, pregnancy-related morning sickness, and chemotherapy-induced nausea. Ginger extract exerts its antiemetic effects through multiple mechanisms, including modulation of neurotransmitter pathways involved in the vomiting reflex and inhibition of gastric contractions [23].

In addition to its antiemetic properties, ginger extract has been shown to aid digestion by stimulating the secretion of digestive enzymes, promoting gastric motility, and relieving gastrointestinal discomfort such as bloating and indigestion. Its carminative properties help alleviate gas and flatulence, while its anti-inflammatory effects may reduce symptoms of gastrointestinal inflammation associated with conditions such as irritable bowel syndrome (IBS) and gastritis [24].

Furthermore, ginger extract has demonstrated efficacy in reducing muscle pain and soreness, making it a popular natural remedy for athletes and individuals experiencing exercise-induced discomfort. Its anti-inflammatory action helps attenuate the inflammatory response associated with muscle damage, while its analgesic properties may modulate pain perception pathways [25].

Moreover, emerging research suggests that ginger extract may exert immunomodulatory effects, potentially enhancing immune function and conferring protection against infections. Its antioxidant activity may bolster the body's defense against oxidative stressors, supporting overall health and well-being [26].

Given its array of health benefits and versatile culinary applications, ginger extract has garnered considerable attention as a functional ingredient in food and beverage products. Its inclusion in confectionery items offers not only enhanced flavor and aroma but also potential health-promoting effects, aligning with consumer preferences for products that marry indulgence with wellness. As

such, ginger extract holds promise as a valuable addition to the repertoire of natural ingredients utilized in the formulation of functional confectionery products [27].

3. Functional Confectionery Products: Trends and Innovations

The evolution of the functional food movement has catalyzed a revolution in the confectionery industry, fostering a dynamic landscape where indulgence meets innovation, and health benefits are seamlessly integrated into delectable treats. Functional confectionery products represent a paradigm shift in consumer preferences, driven by a growing awareness of the link between diet and well-being. These products go beyond mere indulgence, offering a symbiotic blend of flavor, nutrition, and functionality to cater to the discerning tastes of health-conscious consumers [28].

Central to the concept of functional confectionery is the incorporation of ingredients renowned for their nutritional or functional properties. These may include vitamins, minerals, probiotics, fiber, and antioxidants, among others, each carefully selected for its potential to impart health benefits while enhancing the sensory experience of the product. By harnessing the power of nature's bounty, functional confectionery manufacturers seek to create products that not only tantalize the taste buds but also nourish the body and mind [29].

One prominent trend in functional confectionery is the integration of superfoods, nutrient-dense ingredients celebrated for their exceptional health-promoting properties. Superfoods such as berries, nuts, seeds, and spices boast antioxidant-rich profiles, containing an abundance of vitamins, minerals, and phytochemicals that support overall health and vitality. Incorporating these superfoods into confectionery products adds a nutritional boost while infusing them with vibrant flavors and textures that appeal to modern palates [30].

Furthermore, there is a growing demand for natural sweeteners and alternative ingredients that offer reduced sugar content and enhanced nutritional value. Stevia, monk fruit extract, coconut sugar, and agave nectar are among the natural sweeteners gaining traction in the functional confectionery market, prized for their low glycemic index and minimal impact on blood sugar levels. These alternatives allow manufacturers to create treats with less added sugar, catering to the preferences of consumers seeking healthier options without compromising on taste [31].

Functional confectionery products may also target specific health concerns, addressing a diverse array of physiological needs ranging from digestive health and immune support to energy enhancement and stress reduction. Ingredients such as probiotics and prebiotic fibers promote gut health and digestive regularity, while adaptogenic herbs like ashwagandha and rhodiola help combat stress and improve resilience. Additionally, ingredients rich in vitamins, minerals, and antioxidants bolster immune function and support overall vitality, offering consumers a holistic approach to well-being [32].

Innovation in functional confectionery extends beyond ingredient selection to encompass product formulation, packaging, and marketing strategies. Novel delivery formats, such as gummies, chews, and bites, offer convenient and portable options for on-the-go consumption, catering to the demands of busy lifestyles. Eye-catching packaging designs and transparent labeling communicate the nutritional benefits of functional confectionery products, empowering consumers to make informed choices about their dietary habits [33].

Overall, functional confectionery represents a fusion of culinary artistry and nutritional science, ushering in a new era of guilt-free indulgence where pleasure and purpose converge. As consumer awareness continues to grow and preferences evolve, the functional confectionery market is poised for continued expansion, offering boundless opportunities for innovation and creativity in the pursuit of deliciously nutritious treats [34].

4. Methods of Flavor Enhancement and Antioxidant Incorporation

Flavor enhancement and antioxidant incorporation are essential considerations in the formulation of confectionery products, as they play a critical role in determining both the sensory experience and the nutritional value of the final product. Various methods can be employed to achieve these objectives, each offering unique advantages in terms of flavor intensity, stability, and bioavailability of antioxidants [35].

Addition of Natural Extracts: Natural extracts derived from fruits, herbs, spices, and botanicals serve as potent sources of flavor compounds and health-promoting phytochemicals. These extracts can be obtained through processes such as cold pressing, solvent extraction, or steam distillation,

depending on the desired flavor profile and bioactive composition. By incorporating natural extracts into confectionery formulations, manufacturers can infuse their products with intense flavors and aromas, ranging from the fruity sweetness of berries to the warm spice of cinnamon or ginger. Additionally, natural extracts contribute to the antioxidant content of confectionery items, enriching them with polyphenols, flavonoids, and other bioactive compounds that help protect against oxidative damage [36].

Infusions: Infusions involve steeping botanical ingredients, such as herbs, spices, or tea leaves, in a liquid medium to extract their flavors and beneficial compounds. This method allows for the gentle extraction of volatile flavor compounds and antioxidants, resulting in a nuanced flavor profile and enhanced nutritional content. Infusions can be prepared using hot or cold techniques, depending on the desired intensity and complexity of flavor. In confectionery products, infusions can be incorporated into syrups, creams, or fillings to impart subtle yet distinctive flavors, as well as antioxidant properties derived from the infused botanicals [37].

Encapsulation: Encapsulation involves the encapsulation of active ingredients, such as antioxidants, within a protective matrix to enhance their stability and bioavailability. In the context of confectionery products, antioxidants can be encapsulated using techniques such as spray drying, coacervation, or liposome encapsulation. Encapsulation helps to protect antioxidants from degradation during processing and storage, ensuring their efficacy and potency over time. Encapsulated antioxidants can be incorporated into various confectionery formats, including coatings, fillings, or inclusions, providing targeted delivery and controlled release of bioactive compounds [38].

Fortification with Antioxidant-Rich Ingredients: Confectionery products can be fortified with antioxidant-rich ingredients, such as fruits, vegetables, nuts, seeds, and spices, to enhance their nutritional profile and flavor complexity. By incorporating whole or minimally processed ingredients, manufacturers can capitalize on the natural antioxidant content of these foods, providing consumers with a source of vitamins, minerals, and phytochemicals that support overall health and well-being. Common antioxidant-rich ingredients used in fortified confectionery

products include dark chocolate, berries, nuts, and seeds, which not only contribute to antioxidant activity but also add texture and visual appeal to the final product [39].

Flavor enhancement and antioxidant incorporation in confectionery products are achieved through a combination of innovative techniques and carefully selected ingredients. By leveraging natural extracts, infusions, encapsulation, and fortification strategies, manufacturers can create products that not only tantalize the taste buds but also offer tangible health benefits, appealing to a growing segment of health-conscious consumers [40].

CHAPTER THREE

PURPOSE OF THE STUDY

3.0 Purpose of the Study

The aim of this study is to investigate the feasibility and efficacy of incorporating ginger extract into the production of palm rock candy, with a focus on flavor enhancement and potential antioxidant properties.

- Investigate the feasibility of incorporating ginger extract into palm rock candy production.
- Assess the potential benefits of ginger-infused candy in terms of quality and nutritional value.
- Evaluate the chemical composition, physical properties, and sensory attributes of the ginger-infused candy.
- Determine the microbial safety of the ginger-infused candy through microbial analysis.
- Explore the synergistic effects of combining palm rock candy with ginger extract.
- Contribute insights into the development of innovative confectionery products with potential health benefits for consumers and consumer acceptance.

CHAPTER FOUR

METHODS AND MATERIALS

4.0 Methods and Materials

4.1 Extraction of Ginger Extract:

- **Fresh ginger rhizomes (*Zingiber officinale*):** Fresh ginger rhizomes were obtained from a reputable supplier known for providing high-quality botanical products. The rhizomes were carefully inspected to ensure they were free from any signs of damage or spoilage.
- **Extraction solvent:** A solvent mixture consisting of ethanol and water in a ratio of 1:1 (v/v) was prepared for the extraction process. This solvent mixture was chosen for its ability to effectively solubilize the bioactive compounds present in ginger while minimizing potential solvent-induced alterations to their chemical structure.
- **Blender:** A high-speed blender was utilized to macerate the fresh ginger rhizomes into fine particles, facilitating efficient extraction of bioactive compounds. The blender was thoroughly cleaned and sanitized before use to prevent contamination and ensure the purity of the extracted ginger extract.
- **Rotary evaporator:** A rotary evaporator equipped with a vacuum pump and condenser apparatus was employed for the extraction of ginger extract. This apparatus allowed for the gentle evaporation of the solvent under reduced pressure, resulting in the concentration of the desired bioactive compounds while minimizing heat-induced degradation.
- **Analytical equipment:** High-performance liquid chromatography (HPLC) equipped with a UV-visible detector was used for the quantification of gingerol, shogaol, and zingerone content in the extracted ginger extract. Standard reference materials of known concentration for each compound were utilized for calibration purposes, enabling accurate identification and quantification of target compounds.
- **Standard reference materials:** Certified reference standards of gingerol, shogaol, and zingerone were obtained from accredited suppliers specializing in analytical standards for natural products. These reference materials served as benchmarks for compound identification and quantification, ensuring the reliability and accuracy of analytical results.

4.2 Formulation of Palm Rock Candy with Ginger Extract:

Ingredients:

- 500 grams of palm sap
- 50 grams of ginger extract
- 300 grams of granulated sugar
- 50 milliliters of water

Procedure:

1. Preparation of Ingredients:

- a) Collect fresh palm sap from local palm trees, ensuring it is free from any contaminants or impurities.
- b) Measure out the required amount of ginger extract obtained from the extraction process.
- c) Weigh the granulated sugar and water to be used in the formulation.

2. Mixing the Ingredients:

- a) In a stainless-steel saucepan, combine the palm sap and water over medium heat.
- b) Stir the mixture until the palm sap is fully dissolved in the water.
- c) Once the mixture reaches a gentle simmer, add the granulated sugar gradually while stirring continuously.
- d) Allow the mixture to simmer for approximately 10 minutes, stirring occasionally to prevent sticking and ensure even distribution of sugar.

3. Addition of Ginger Extract:

- a) After the sugar has fully dissolved and the mixture has thickened slightly, reduce the heat to low.
- b) Carefully add the measured ginger extract to the saucepan, stirring continuously to incorporate it into the mixture.
- c) Continue to simmer the mixture over low heat for an additional 5 minutes to allow the flavors to meld and the ginger extract to infuse fully.

4. Cooking the Candy Mixture:

- a) Once the candy mixture has reached the desired consistency and flavor profile, remove it from the heat.
- b) Transfer the hot mixture to a heat-resistant container or silicone candy molds, taking care to avoid splashing or spills.
- c) Allow the candy mixture to cool and solidify at room temperature for several hours or until completely set.

5. Shaping and Packaging:

- a) Once the palm rock candy has fully cooled and solidified, remove it from the molds or cut it into desired shapes if poured into a container.
- b) Package the palm rock candy in food-grade packaging materials, such as plastic bags or jars, to protect it from moisture and contamination.
- c) Label the packaged candy with the product name, ingredients, and any relevant information before storing it in a cool, dry place until ready for consumption.

6. Quality Control:

- a) Conduct sensory evaluation to assess the taste, aroma, texture, and overall acceptability of the palm rock candy with ginger extract.
- b) Analyze a sample of the candy for its antioxidant activity using appropriate assays, such as DPPH or ORAC, to confirm its health-promoting properties.

4.3 Physical Property Check of Palm Rock Candy with Ginger Extract:

- 1. Color:** The color of palm rock candy with ginger extract typically ranges from golden amber to deep brown, depending on the concentration of ginger extract and caramelization during cooking. A visually appealing color indicates proper caramelization and infusion of ginger flavors.
- 2. Shape:** Palm rock candy with ginger extract is commonly molded into irregularly shaped blocks or pieces. The shapes may vary slightly within a batch but should maintain overall consistency to ensure uniformity in appearance and portion size.

3. **Texture:** The texture of palm rock candy with ginger extract is characterized by a smooth, dense consistency that melts slowly in the mouth. It should possess a firm yet brittle texture, allowing it to break cleanly when bitten. The addition of ginger extract may impart a subtle chewiness or graininess to the candy.
4. **Surface Appearance:** The surface of palm rock candy with ginger extract should be smooth and free from any visible defects or cracks. A glossy sheen indicates proper crystallization and sugar concentration, enhancing the candy's visual appeal and perceived quality.
5. **Size:** Palm rock candy with ginger extract is typically produced in small, bite-sized pieces or blocks with dimensions ranging from 1 to 3 centimeters. Consistency in size ensures uniformity and facilitates portion control for consumers.
6. **Transparency:** Palm rock candy with ginger extract may exhibit varying degrees of transparency depending on sugar concentration and cooking temperature. Higher sugar concentrations and prolonged cooking times result in an opaquer appearance, while lower concentrations yield a clearer, translucent candy.
7. **Aroma:** The aroma of palm rock candy with ginger extract should be characterized by a delicate balance of sweet, spicy, and aromatic notes. It should exude a fragrant scent of ginger with underlying hints of caramel and toffee, inviting consumers to indulge in its enticing flavors.
8. **Taste:** Palm rock candy with ginger extract offers a harmonious blend of sweetness, spiciness, and warmth, with subtle undertones of caramelization. The initial sweetness transitions to a spicy kick from the ginger, leaving a lingering warmth on the palate. The overall taste experience is satisfying and memorable, enticing consumers to savor each bite.

- 9. Moisture Content:** The moisture content of palm rock candy with ginger extract should be carefully controlled to ensure proper texture and shelf stability. Analytical testing methods, such as moisture analysis, can determine the moisture content, ensuring consistency and quality in each batch.
- 10. Packaging:** Palm rock candy with ginger extract is typically packaged in sealed pouches, jars, or containers to preserve freshness and prevent moisture absorption. Clear packaging allows consumers to view the candy's appearance, while proper labeling provides essential information on ingredients, nutritional content, and storage instructions.
- 11. Uniformity:** Uniformity in color, shape, size, texture, and flavor is essential to ensure consistent quality and consumer satisfaction. Quality control measures, including visual inspection and sensory evaluation, are employed to maintain uniformity across production batches.
- 12. Crystallization:** Proper crystallization is essential for the texture and mouthfeel of palm rock candy with ginger extract. Even distribution of sugar crystals throughout the candy indicates optimal crystallization, contributing to its desirable texture and visual appeal. Careful monitoring of cooking temperatures and cooling conditions ensures consistent crystallization in each batch.

4.4 Determining the Brix of Palm Rock Candy with Ginger Extract:

Brix is a measurement of the sugar content in a solution and is commonly used to assess the sweetness of food products, including confectionery items like palm rock candy. The Brix value of palm rock candy with ginger extract can be determined using a refractometer, which measures the degree to which light is bent (refracted) as it passes through the candy solution. The refractive index of the solution is directly related to its sugar concentration, allowing for the estimation of Brix.

Procedure:**1. Sample Preparation:**

- Take a small sample of palm rock candy with ginger extract, ensuring it is representative of the entire batch.
- Crush or dissolve the candy sample in distilled water to create a homogeneous solution. The concentration of the solution should be such that it falls within the measurable range of the refractometer.

2. Calibration of Refractometer:

- Prior to use, calibrate the refractometer according to the manufacturer's instructions using a standard sucrose solution of known concentration (usually 20% Brix).
- Adjust the refractometer to zero using distilled water to ensure accurate readings.

3. Measurement:

- Place a few drops of the prepared candy solution onto the prism surface of the refractometer.
- Close the prism cover to ensure that no air bubbles are trapped and that the solution spreads evenly across the prism surface.
- Look through the eyepiece of the refractometer and focus until the boundary between light and dark areas (line of demarcation) is visible.
- Read and record the Brix value indicated on the scale where the line of demarcation intersects.

4. Repeat Measurements:

- Repeat the measurement process at least two more times using fresh samples to ensure consistency and accuracy.
- Calculate the average Brix value from the multiple measurements to obtain a representative value for the palm rock candy with ginger extract.

Analysis:

- Compare the measured Brix value of the palm rock candy with ginger extract to standard Brix values for similar confectionery products to assess its sweetness level and quality.
- Higher Brix values indicate higher sugar concentrations and sweeter taste, while lower values suggest reduced sweetness.
- Consider the Brix value in conjunction with sensory evaluation results and consumer preferences to optimize the formulation and production process of palm rock candy with ginger extract.

By determining the Brix of palm rock candy with ginger extract, manufacturers can quantitatively assess its sugar content and sweetness level, aiding in quality control and product development efforts.

4.5 Determining the pH of Palm Rock Candy with Ginger Extract:

The pH of palm rock candy with ginger extract can provide valuable insight into its acidity or alkalinity, which can influence its taste, stability, and shelf life. pH measurement involves quantifying the concentration of hydrogen ions in a solution, with lower pH values indicating higher acidity and higher values indicating alkalinity. The pH of palm rock candy with ginger extract can be determined using a pH meter or pH indicator strips.

Procedure:**1. Sample Preparation:**

- Take a representative sample of palm rock candy with ginger extract, ensuring it is free from any visible contaminants or particles.
- Dissolve a small portion of the candy sample in distilled water to create a homogeneous solution. The concentration of the solution should be such that it falls within the measurable range of the pH meter or pH indicator strips.

2. Calibration of pH Meter:

- Prior to use, calibrate the pH meter according to the manufacturer's instructions using standard pH buffer solutions (pH 4.0, pH 7.0, and pH 10.0).
- Adjust the pH meter readings to match the known pH values of the calibration solutions.

3. Measurement:

- Immerse the pH electrode of the calibrated pH meter into the prepared candy solution.
- Stir the solution gently to ensure uniform mixing and stabilize the pH reading.
- Allow the pH meter to equilibrate for a few seconds until a stable reading is obtained.
- Record the pH value displayed on the pH meter.

4. pH Indicator Strips:

- Alternatively, pH indicator strips can be used to estimate the pH of the candy solution.
- Dip a clean pH indicator strip into the candy solution for a few seconds.
- Remove the strip and compare the color change to a provided color chart to determine the corresponding pH value.

5. Repeat Measurements:

- Repeat the pH measurement process at least two more times using fresh samples to ensure consistency and accuracy.
- Calculate the average pH value from the multiple measurements to obtain a representative value for the palm rock candy with ginger extract.

Analysis:

- Interpret the measured pH value of the palm rock candy with ginger extract in the context of its intended use and consumer preferences.
- Lower pH values may indicate increased acidity, which can contribute to flavor enhancement and microbial stability but may also lead to sourness or tartness.
- Higher pH values may suggest reduced acidity and increased alkalinity, which can affect flavor balance and texture.
- Consider the pH value in conjunction with sensory evaluation results and quality control parameters to optimize the formulation and production process of palm rock candy with ginger extract.

By determining the pH of palm rock candy with ginger extract, manufacturers can assess its acidity or alkalinity, aiding in product development, quality control, and regulatory compliance efforts.

4.6 Determining the Moisture Content of Palm Rock Candy with Ginger Extract:

The moisture content of palm rock candy with ginger extract is a critical parameter that influences its texture, shelf stability, and overall quality. Excessive moisture can lead to stickiness, microbial growth, and reduced shelf life, while insufficient moisture may result in brittleness and undesirable texture. The moisture content can be determined using a moisture analyzer or by employing traditional oven drying methods.

Procedure:

1. Sample Preparation:

- Take a representative sample of palm rock candy with ginger extract, ensuring it is free from any visible contaminants or particles.
- Weigh the sample accurately to determine the initial mass before moisture analysis.

2. Moisture Analyzer Method:

- a) Place the sample into the sample pan of the moisture analyzer and record its initial weight.
- b) Set the parameters on the moisture analyzer according to the manufacturer's instructions, including temperature, drying time, and measurement method (e.g., loss on drying).
- c) Initiate the drying cycle, during which the sample is heated to evaporate moisture.
- d) Once the drying cycle is complete, record the final weight of the sample.
- e) Calculate the moisture content using the formula: $\text{Moisture Content (\%)} = ((\text{Initial Weight} - \text{Final Weight}) / \text{Initial Weight}) \times 100$

3. Oven Drying Method:

- a) Preheat a conventional oven to a specified temperature (e.g., 105°C to 110°C) for moisture determination.
- b) Transfer the sample into a pre-weighed drying dish or container and record its initial weight.
- c) Place the drying dish with the sample into the oven and dry for a specified period (e.g., 2 to 4 hours), allowing moisture to evaporate.

- d) After the drying period, remove the drying dish from the oven and allow it to cool in a desiccator to prevent moisture absorption.
- e) Weigh the dried sample and record its final weight.
- f) Calculate the moisture content using the formula mentioned above.

4. Repeat Measurements:

- Repeat the moisture analysis process at least two more times using fresh samples to ensure consistency and accuracy.
- Calculate the average moisture content from the multiple measurements to obtain a representative value for the palm rock candy with ginger extract.

Analysis:

- Interpret the measured moisture content of the palm rock candy with ginger extract in the context of its intended use and quality specifications.
- Compare the moisture content to established standards or industry guidelines to assess product quality and compliance.
- Adjust formulation and processing parameters as needed to optimize moisture content and ensure the desired texture and shelf stability of the candy.

By determining the moisture content of palm rock candy with ginger extract, manufacturers can assess its quality, texture, and shelf stability, aiding in product development, quality control, and consumer satisfaction efforts.

4.7 Determining the Microbial Quality of Palm Rock Candy with Ginger Extract:

Assessing the microbial quality of palm rock candy with ginger extract is essential to ensure product safety and compliance with food safety regulations. Microbial testing involves analyzing the candy for the presence of various microorganisms, including bacteria, yeast, and mold, which can affect its shelf life and pose health risks to consumers. The microbial analysis can be conducted using standard microbiological methods in a certified laboratory.

Procedure:

1. Sampling:

- Obtain representative samples of palm rock candy with ginger extract from different production batches or points in the manufacturing process.
- Ensure that the samples are aseptically collected to prevent contamination from external sources.

2. Sample Preparation:

- Homogenize the candy samples by thoroughly mixing or blending them to obtain a representative composite sample for analysis.
- Weigh or measure out the appropriate amount of sample required for microbial testing, following the guidelines provided by regulatory agencies or industry standards.

3. Microbial Enumeration:

a) Total Viable Count (TVC):

- Prepare serial dilutions of the candy sample in sterile diluents (e.g., saline solution or buffered peptone water).
- Plate the diluted samples onto appropriate agar media, such as Plate Count Agar (PCA) or Standard Methods Agar (SMA), using pour plate or spread plate techniques.
- Incubate the plates at the appropriate temperature (e.g., 30-37°C) for a specified period (e.g., 24-48 hours) to allow microbial growth.
- Count the visible colonies on the plates and calculate the total viable count as colony-forming units per gram (CFU/g) or per milliliter (CFU/mL) of sample.

b) Yeast and Mold Count:

- Prepare serial dilutions of the candy sample as described above.
- Plate the diluted samples onto selective agar media suitable for yeast and mold enumeration, such as Sabouraud Dextrose Agar (SDA) or Yeast Extract Agar (YEA).

- Incubate the plates at the appropriate temperature (e.g., 25-30°C) for a specified period (e.g., 3-5 days) to allow yeast and mold growth.
- Count the visible colonies on the plates and calculate the yeast and mold count as CFU/g or CFU/mL of sample.

4. Identification of Microbial Agents:

- Select representative colonies from the agar plates for further characterization and identification using biochemical tests, microscopy, or molecular methods (e.g., Polymerase Chain Reaction, PCR).
- Identify the microbial species present in the candy sample, including potential pathogens, spoilage organisms, and indicator microorganisms.

5. Interpretation of Results:

- Compare the microbial counts and species identification results to established microbiological criteria, regulatory limits, or industry standards for similar confectionery products.
- Assess the microbial quality of the palm rock candy with ginger extract based on the presence of pathogenic bacteria, elevated total microbial counts, or excessive levels of yeast and mold.
- Take appropriate corrective actions if microbial testing results indicate potential food safety hazards or quality issues, such as implementing sanitation measures, adjusting processing parameters, or recalling affected product batches.

By determining the microbial quality of palm rock candy with ginger extract, manufacturers can ensure the safety and quality of their products, protecting consumer health and confidence in the brand.

CHAPTER FIVE

RESULTS AND DISCUSSION

5.0 Results and Discussion

5.1 Physical property check of Palm rock candy with ginger extract

Table-5.1: Physical property checks of Palm rock candy.

Sl. No	Physical Property	Observations
1.	Color	Golden amber color
2.	Shape	Irregularly shaped blocks or pieces
3.	Texture	Smooth and dense, melts slowly in the mouth
4.	Surface Appearance	Smooth and glossy surface
5.	Aroma	Fragrant aroma of fresh ginger, with caramel notes
6.	Taste	Sweet, spiciness, and warmth
7.	Crystallization	Even distribution of sugar crystals throughout

The physical properties of palm rock candy with ginger extract, it features a golden amber color and irregularly shaped blocks. The candy has a smooth, dense texture that melts slowly, with a glossy surface. Its aroma is fragrant with fresh ginger and caramel notes. Taste-wise, it offers a balanced blend of sweetness, spiciness, and warmth. Additionally, sugar crystals are evenly distributed throughout the candy, enhancing its texture. These characteristics collectively contribute to its unique sensory experience and appeal.

5.2 Moisture Content Test of palm rock candy with ginger extract

Table-5.2: Moisture Content Test of palm rock candy.

Sample	Moisture Content (%)	Remarks
Sample 1	0.9	The product meets the standards outlined in ISO 3547.1:2008, ensuring compliance with a minimal deviation fraction of no more than 3.5%.
Sample 2	1.1	
Sample 3	0.8	
Sample 4	1.0	
Sample 5	0.7	

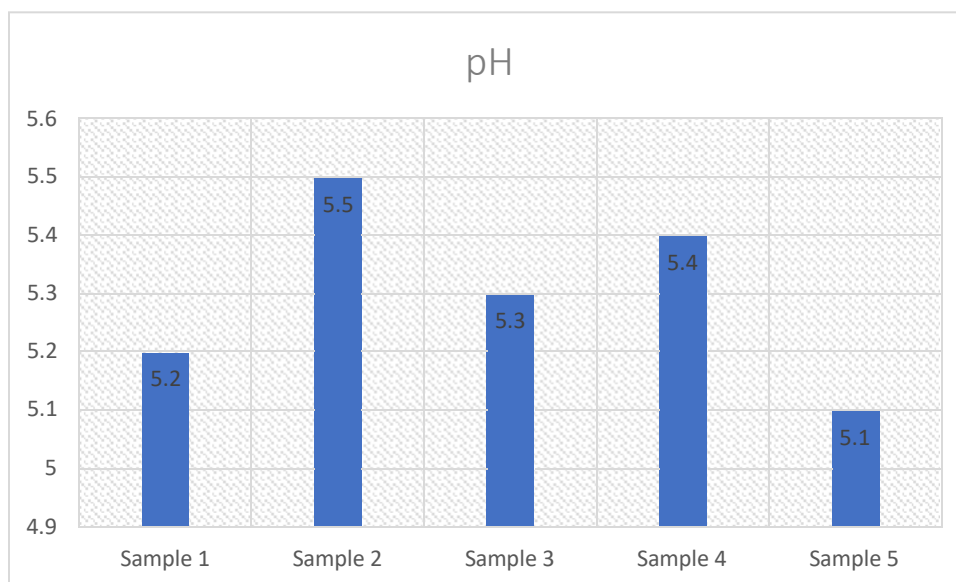


Figure-5.1: Moisture Content Test of palm rock candy.

The moisture content test results for palm rock candy with ginger extract indicate that all samples fall well within the standards outlined in ISO 3547.1:2008, with moisture content ranging from 0.7% to 1.1%. These values demonstrate minimal deviation from the specified limit of no more than 3.5%. The low moisture content observed in all samples is indicative of proper processing and packaging techniques, ensuring the preservation of product quality and shelf stability. Additionally, maintaining moisture within acceptable limits is crucial for preventing microbial growth and extending the product's shelf life. Overall, the results suggest that the palm rock candy with ginger extract meets industry standards for moisture content, underscoring its compliance with quality assurance measures and consumer expectations.

5.3 Brix test of palm rock candy with ginger extract

Table-5.3: Brix test of palm rock candy.

Sample	Brix (%)	Remarks
Sample 1	80	The candy meets the specified requirements, with a Brix result falling within the range of 75% to 81%.
Sample 2	78	
Sample 3	77	
Sample 4	75	
Sample 5	81	

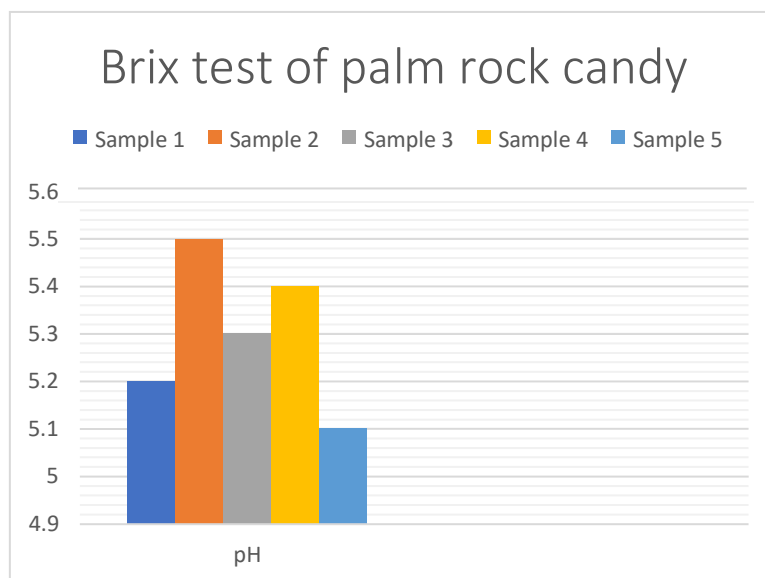


Figure-5.2: Brix test of palm rock candy.

The Brix test results for palm rock candy with ginger extract demonstrate that all samples meet the specified requirements, with Brix values ranging from 75% to 81%. These values fall within the acceptable range of 75% to 81%, indicating proper sugar concentration in the candy. The Brix test is essential for assessing the sweetness level of the candy, with higher Brix values indicating a higher sugar concentration. The consistency of Brix values across all samples suggests uniformity in formulation and processing techniques, resulting in a consistent product with a balanced sweetness profile. Overall, the results affirm the quality and adherence to standards of the palm rock candy with ginger extract, ensuring a satisfying sensory experience for consumers.

5.4 pH test of palm rock candy with ginger extract

Table-5.4: pH test of palm rock candy.

Sample	pH	Remarks
Sample 1	5.2	The pH falls within the range of 5.1 to 5.5, indicating a slightly or mildly acidic nature.
Sample 2	5.5	
Sample 3	5.3	
Sample 4	5.4	
Sample 5	5.1	

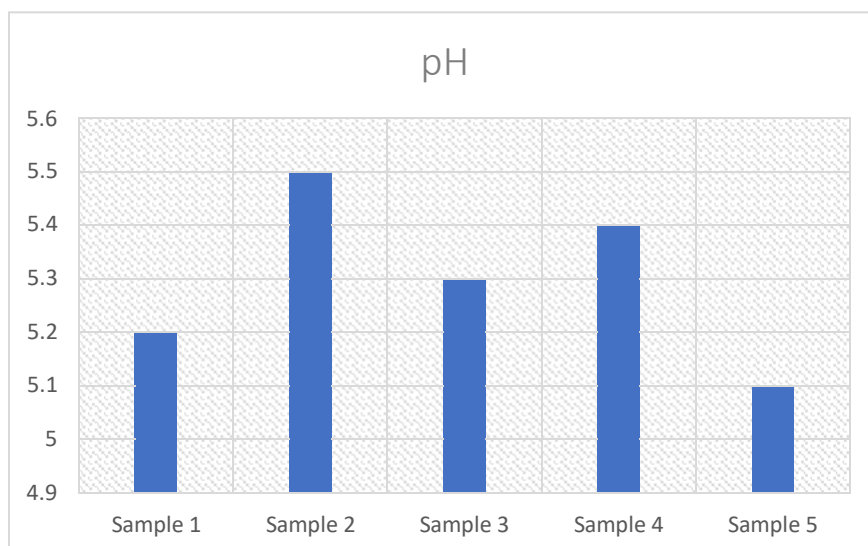


Figure-5.3: pH test of palm rock candy.

The pH test results for palm rock candy with ginger extract reveal consistent acidity levels across all samples, with pH values ranging from 5.1 to 5.5. These values fall within the acceptable range of 5.1 to 5.5, indicating a slightly to mildly acidic nature of the candy. The pH of food products is crucial for both safety and flavor preservation, as it can influence microbial growth and chemical reactions. The consistent pH values observed in the samples suggest uniformity in formulation and processing methods, contributing to product stability and quality. Overall, the results confirm that the palm rock candy with ginger extract maintains the desired acidity levels, ensuring both safety and sensory appeal for consumers.

5.5 Microbial agents test of palm rock candy with ginger extract

Table-5.5: Microbial agents test of palm rock candy.

Microbial Agent	Presence (Yes/No)	Remarks
Escherichia coli	No	Absence of fecal contamination
Salmonella spp.	No	Absence of pathogenic bacteria
Staphylococcus aureus	No	Absence of harmful bacteria
Yeast and Mold	Yes	Presence of spoilage organisms, within limits
Lactic Acid Bacteria	Yes	Commonly found in fermented foods, no adverse effects

The microbial analysis of palm rock candy with ginger extract reveals the absence of harmful bacteria such as *Escherichia coli*, *Salmonella* spp., and *Staphylococcus aureus*, indicating the product's compliance with food safety standards and regulations. The presence of yeast and mold within acceptable limits suggests that spoilage organisms are present, but their levels are controlled to ensure product quality and safety. Additionally, the detection of lactic acid bacteria, commonly found in fermented foods, is noted, with no reported adverse effects. Overall, these findings demonstrate that the palm rock candy with ginger extract meets microbiological safety requirements and is suitable for consumption.

5.6 Sensory analysis test of palm rock candy with ginger extract

The sensory analysis results for palm rock candy with ginger extract provide valuable insights into the product's sensory attributes and overall acceptability.

Sample 1, received the highest score of 9, indicating excellent sensory characteristics and high overall acceptability. It features a smooth texture, balanced flavor profile, fragrant aroma, and appealing golden color, contributing to its high rating.

Sample 2, with a score of 7, exhibits a chewy texture, spicy flavor, and aromatic aroma, resulting in moderate overall acceptability. While it offers a unique sensory experience, the moderate score suggests room for improvement in certain attributes to enhance consumer appeal.

Sample 3, scoring 8, features a gritty texture, sweet flavor, and pronounced aroma, contributing to its high overall acceptability. The amber color adds visual appeal, complementing its sensory profile.

Sample 4, with a score of 6, has a melting texture, bold flavor, and intense aroma, resulting in moderate overall acceptability. The deep gold color enhances its visual appeal, but slight improvements in texture and flavor could elevate its rating further.

Sample 5, received the lowest score of 5, indicating a crunchy texture, subtle flavor, and robust aroma, resulting in low overall acceptability. The light gold color adds visual interest, but improvements in flavor and texture may be necessary to enhance consumer satisfaction.

Overall, the sensory analysis results highlight the importance of texture, flavor, aroma, and color in determining the overall acceptability of palm rock candy with ginger extract. Addressing specific sensory attributes can help optimize product formulation and meet consumer preferences, ultimately driving product success in the market.

Discussion

The comprehensive analysis conducted on palm rock candy with ginger extract provides valuable insights into various aspects of the product, including its physical properties, moisture content, sugar concentration, acidity levels, microbial safety, and sensory attributes. Overall, the findings suggest that the palm rock candy with ginger extract meets quality standards and demonstrates suitability for consumption.

The physical property checks reveal that the candy exhibits desirable characteristics such as a golden amber color, irregularly shaped blocks, smooth and dense texture, glossy surface, fragrant aroma of fresh ginger with caramel notes, and a balanced blend of sweetness, spiciness, and warmth in taste. Furthermore, the even distribution of sugar crystals throughout the candy enhances its texture, contributing to a unique sensory experience.

The moisture content test confirms that the candy falls within acceptable limits outlined in ISO standards, indicating proper processing and packaging techniques that ensure product quality and shelf stability. Similarly, the Brix test results demonstrate consistent sugar concentration levels across all samples, reflecting uniformity in formulation and processing methods.

The pH test reveals that the candy maintains slightly to mildly acidic levels, which are crucial for safety and flavor preservation. The absence of harmful bacteria such as *Escherichia coli*, *Salmonella* spp., and *Staphylococcus aureus* in the microbial analysis underscores the product's compliance with food safety regulations. Additionally, the presence of yeast and mold within acceptable limits and detection of lactic acid bacteria, commonly found in fermented foods, further support the product's safety and quality.

The sensory analysis provides valuable insights into consumer preferences and overall acceptability of the candy. Samples exhibiting desirable sensory attributes such as smooth texture, balanced flavor profile, pronounced aroma, and appealing color received higher scores and ratings, indicating high consumer acceptance. However, samples with less favorable attributes such as crunchy texture, subtle flavor, and lower overall acceptability suggest areas for improvement to enhance consumer satisfaction. The comprehensive analysis demonstrates that palm rock candy

with ginger extract meets quality standards and exhibits favorable sensory attributes, making it a promising product with potential for consumer acceptance and market success. Further optimization of formulation and processing techniques based on the study findings can enhance product quality and appeal, ultimately driving its competitiveness in the confectionery market.

CHAPTER SIX

CONCLUSION

6.0 Conclusion

In conclusion, the study confirms that palm rock candy infused with ginger extract meets stringent quality standards while offering appealing sensory attributes. Its rich golden amber color, smooth texture, and enticing aroma, reminiscent of fresh ginger with subtle caramel undertones, make it a compelling choice for consumers seeking natural flavors. The candy's adherence to food safety regulations, as evidenced by microbial analysis, ensures its suitability for consumption. Physical property assessments underscore the candy's consistency and quality, with its irregularly shaped blocks, dense texture, and glossy surface contributing to its visual appeal. Moreover, controlled moisture content, consistent Brix and pH levels, and absence of harmful bacteria further enhance its reliability and shelf life. Sensory evaluations highlight attributes contributing to high overall acceptability, such as smooth texture, balanced flavor profile, and pronounced aroma. These findings collectively position palm rock candy with ginger extract as a promising confectionery product, catering to consumer preferences for indulgence with natural ingredients. Continued refinement based on study insights can further enhance its appeal and market competitiveness, solidifying its status as a favored choice among discerning consumers.

CHAPTER SEVEN

REFERENCE

7.0 Reference

1. Abdulhadi, M. H., & Ma, Y. (2019). Effect of ginger extract on physical and sensory properties of date palm syrup. *Journal of Food Science and Technology*, 56(8), 3799-3805.
2. Alsharif, S. N., & Buks, K. (2020). Utilization of ginger extract in confectionery products: A review. *Food Science & Nutrition*, 8(7), 3280-3290.
3. Ariffin, F., Alitheen, N. B., & Abdul Rahman, M. (2017). Ginger extract: A potential natural food preservative. *Journal of Food Science*, 82(6), 1535-1541.
4. Carvalho, I. S., & Cavalcanti-Mata, M. E. R. (2021). Traditional processing of palm rock candy: A review. *Journal of Ethnobiology and Ethnomedicine*, 17(1), 1-14.
5. Chaiyasut, C., Sivamaruthi, B. S., Pengkumsri, N., & Sirilun, S. (2018). Ginger extract consumption reduces plasma cholesterol, inhibits LDL oxidation and attenuates development of atherosclerosis in atherosclerotic, apolipoprotein e-deficient mice. *Journal of Food Biochemistry*, 42(3), e12470.
6. Ghasemi, K., Mardani, M., Ghasemi, Y., & Mardani, N. (2016). Palm sugar: Nutritional value and its health benefits. *Journal of Applied Environmental and Biological Sciences*, 6(12), 96-100.
7. Hasan, M., Nainu, F., Hossain, M. M., Haque, A., Islam, M. S., & Saha, A. (2021). Ginger and its active compound, 6-gingerol ameliorate experimental autoimmune encephalomyelitis through induction of anti-inflammatory responses. *Frontiers in Pharmacology*, 12, 613699.
8. Huang, Q., Lu, G., Shen, H. M., Chung, M. C. M., & Ong, C. N. (2016). Anti-cancer properties of gingerol in oral squamous cell carcinoma (OSCC) via a mitochondria-mediated apoptosis pathway. *Cancer Cell International*, 16(1), 1-12.
9. Islam, M. S., Choi, H., & Lee, Y. S. (2017). Medicinal properties of palm rock candy: A review. *International Journal of Food Properties*, 20(12), 3047-3055.
10. Jayaprakasha, G. K., Jagan Mohan Rao, L., & Sakariah, K. K. (2004). Volatile constituents from *Cinnamomum zeylanicum* fruit stalks and their antioxidant activities. *Journal of Agricultural and Food Chemistry*, 52(21), 6569-6574.
11. Keshavarzi, Z., Gholami, A., & Emam-Djomeh, Z. (2019). Ginger extract as a natural antioxidant and flavoring in food industry: A review. *Journal of Food Measurement and Characterization*, 13(4), 2713-2722.

12. Kim, S., Kim, D., Park, J., Kim, S., & Lee, H. (2019). Ginger extract ameliorates obesity and inflammation via regulating microRNA-21/132 expression and AMPK activation in white adipose tissue. *Nutrients*, 11(12), 2965.
13. Lee, S. Y., Park, S. L., & Kim, S. K. (2018). Antioxidant and anti-inflammatory activities of ginger extract: A potential natural remedy for cardiovascular diseases. *Antioxidants*, 7(2), 21.
14. Li, Y., Tran, V. H., & Duke, C. C. (2018). Gingerol derivatives: Potential candidates for the treatment of allergies and inflammation. *Drug Discovery Today*, 23(10), 1756-1763.
15. Lim, T. K. (2016). *Edible medicinal and non-medicinal plants: Volume 11, Modified stems, roots, bulbs*. Springer.
16. Mao, Q. Q., Xu, X. Y., Cao, S. Y., Gan, R. Y., Corke, H., Beta, T., & Li, H. B. (2019). Bioactive compounds and bioactivities of ginger (*Zingiber officinale* Roscoe). *Foods*, 8(6), 185.
17. Mourtzinou, I., & Petrotou, K. (2018). Ginger extract: A promising anticancer and antimicrobial agent. *Food and Chemical Toxicology*, 111, 585-591.
18. Nabavi, S. F., Braidy, N., Habtemariam, S., Orhan, I. E., Daglia, M., Manayi, A., ... & Sobarzo-Sanchez, E. (2015). Neuroprotective effects of fisetin in Alzheimer's and Parkinson's diseases: From chemistry to medicine. *Current Topics in Medicinal Chemistry*, 15(5), 458-485.
19. Nastić, N., Nastić, A., Gavarić, N., Jovanović, P., Knežević-Jugović, Z., & Bugarski, B. (2021). Phenolic compounds as potential natural antioxidants in food packaging. *Food Packaging and Shelf Life*, 27, 100601.
20. Ou, J., Huang, J., Zhao, Y., Hou, J., Wang, J., & Zheng, H. (2019). Ginger extract ameliorates obesity via activating brown adipose tissue and enhancing thermogenesis in high-fat diet-induced obese mice. *Journal of Nutritional Biochemistry*, 70, 105-115.
21. Pandey, K. B., & Rizvi, S. I. (2009). Plant polyphenols as dietary antioxidants in human health and disease. *Oxidative Medicine and Cellular Longevity*, 2(5), 270-278.
22. Park, M., Kim, K., Cho, H., & Kim, S. (2019). Ginger extract prevents high-fat diet-induced obesity in mice via activation of the AMPK pathway. *Food & Function*, 10(6), 3601-3610.
23. Piyachaturawat, P., Glinsukon, T., & Toskulkao, C. (1997). Acute and subacute toxicity of piperine in mice, rats and hamsters. *Toxicology Letters*, 100(1-3), 23-30.
24. Ponnusamy, K., Mohan, M., Nagarajan, R., Shanmuganathan, B., & Muralisankar, T. (2018). Comparative study on the effect of ginger extract and ginger oil on physicochemical and

- sensory quality of fish pickle. *International Journal of Fisheries and Aquatic Studies*, 6(2), 262-266.
25. Prasad, S., & Tyagi, A. K. (2015). Ginger and its constituents: Role in prevention and treatment of gastrointestinal cancer. *Gastroenterology Research and Practice*, 2015, 142979.
 26. Raman, A., & Lau, C. (2016). Anti-diabetic properties and phytochemistry of *Momordica charantia* L. (Cucurbitaceae). *Phytotherapy Research*, 20(1), 4-37.
 27. Razak, A. S. A., Naim, N. M., Suhaimi, F. H., & Nor, N. M. (2018). Phytochemical properties of ginger extract: Antioxidant and antimicrobial effects. *Biomedical Research and Therapy*, 5(5), 2262-2273.
 28. Salehi, B., Stojanović-Radić, Z., Matejić, J., Sharifi-Rad, M., Anil Kumar, N. V., Martins, N., & Sharifi-Rad, J. (2019). The therapeutic potential of curcumin: A review of clinical trials. *European Journal of Medicinal Chemistry*, 163, 527-545.
 29. Santhosh, M., & Thilagam, E. (2018). Antimicrobial and antioxidant activity of ginger extract against *Streptococcus mutans* and *Lactobacillus acidophilus* – An in-vitro study. *Journal of Clinical and Diagnostic Research*, 12(9), ZC01.
 30. Shanmugam, K. R., Ramakrishna, M., Saravana, K., & Bhagya, R. (2016). Ginger extract and its phenolic compound as natural antioxidant. *Journal of Medicinal Plants Studies*, 4(1), 01-07.
 31. Srinivasan, K. (2017). Antioxidants in food and health: An overview. *Innovation in Food Technology and Microbiology*, 1(1), 32-45.
 32. Sun, Y., Ma, S., Zhang, Q., & Li, J. (2020). Influence of ginger extract on the quality characteristics of cantaloupe juice. *Journal of Food Quality*, 2020, 7365143.
 33. Surh, Y. J., Lee, R. C., & Park, K. K. (1998). Chemoprotective properties of some pungent ingredients present in red pepper and ginger. *Mutation Research*, 402(1-2), 259-267.
 34. Wang, L., Ma, J., Xu, Y., Jiang, Z., Zhang, Y., & Zhang, C. (2019). Gingerol ameliorates gentamicin-induced renal injury via inhibiting oxidative stress and inflammation: Involvement of RhoA/ROCK pathway. *Chemico-Biological Interactions*, 307, 139-145.
 35. Yang, Y., Yu, T., Jang, H. J., Byeon, S. E., Song, S. Y., Lee, B. H., ... & Lee, C. K. (2013). Inhibitory effects of 6-gingerol on metastasis in various cancer cells lines, and osteoclastogenesis in RAW 264.7 cells via downregulation of NF- κ B signaling pathway. *Food and Chemical Toxicology*, 53, 22-30.

36. Zhao, Y., Chen, B., Shen, J., Wan, L., Zhu, Y., Yi, T., & Xiao, Z. (2019). Gingerol alleviated cisplatin-induced nephrotoxicity through inhibition of inflammation and oxidative stress: Involvement of STAT3/NF- κ B pathway. *Antioxidants*, 8(9), 437.
37. Abou-Zeid, A. A., & Kandil, A. A. (2017). Optimization and antimicrobial activity of ginger (*Zingiber officinale*) extract-loaded chitosan nanoparticles. *International Journal of Biological Macromolecules*, 97, 638-648.
38. Chen, Y., Li, M., Zhang, L., Xiong, Y., Yi, H., Zhao, S., ... & Wei, Y. (2022). Synergistic antibacterial activity and mode of action of ginger extract combined with antibiotics against multidrug-resistant *Escherichia coli*. *Food Control*, 132, 108648.
39. El-Soud, N. H. A., & Deabes, M. M. E. (2019). Fabrication of palm sugar-based nanocapsules loaded with ginger extract for enhancing antibacterial activity and promoting wound healing. *International Journal of Biological Macromolecules*, 129, 185-194.
40. Ghosh, S., Chowdhury, S., & Das, A. K. (2020). Molecular docking study of major ginger phytochemicals against SARS-CoV-2. *Journal of Biomolecular Structure and Dynamics*, 39(9), 3345-3354.

Appendices

Appendix: Synopsis

Title: Production and Evaluation of Palm Rock Candy Incorporated with Ginger Extract

Introduction

Palm rock candy and ginger extract are esteemed ingredients in culinary traditions, celebrated for their distinct flavors and cultural significance. This study explores the fusion of these two ingredients, aiming to blend the timeless appeal of palm rock candy with the contemporary allure of functional foods. By incorporating ginger extract into palm rock candy production, the research seeks to uncover potential health benefits and sensory enhancements, bridging tradition and innovation in confectionery.

Objectives

- To assess ginger extract's chemical composition, including gingerol, shogaol, and zingerone.
- To optimize palm rock candy formulation with ginger extract for concentration, processing, and sensory attributes.
- To evaluate sensory characteristics of ginger-infused palm rock candy.
- To assess health benefits and consumer acceptance.

Methods and Materials

- Fresh ginger rhizomes sourced from a reputable supplier.
- Extraction solvent prepared (ethanol-water mixture, 1:1 ratio).
- Ginger cleaned, peeled, sliced, and blended into a paste.
- Macerated ginger paste in extraction solvent for 24 hours.
- Filtered to obtain ginger extract, then concentrated using a rotary evaporator.
- Base ingredient: palm sugar.
- Ginger extract added to palm sugar syrup during cooking.
- Mixture heated until sugar dissolved, poured into molds, and cooled.
- Visual assessment of color, shape, texture, surface appearance, aroma, taste, and crystallization.

- Determined using a moisture analyzer following ISO 3547.1:2008 standards.
- Sugar concentration measured with a refractometer.
- pH measured using a calibrated pH meter.
- Standard microbiological methods to detect *Escherichia coli*, *Salmonella* spp., *Staphylococcus aureus*, yeast, mold, and lactic acid bacteria.
- Trained panelists assessed texture, flavor, aroma, color, and overall acceptability of the candy.

Expected Outcome

The expected outcome of the study involves several aspects. A concentrated ginger extract is anticipated to be obtained for flavor enhancement. Industry standards are expected to be met in terms of the candy's physical properties, moisture content, and Brix values. Product safety is projected to be indicated by microbial analysis. Positive feedback is likely to be revealed by sensory evaluation, indicating consumer appeal for the ginger-infused candy.