TEXTURE OPTIMIZATION AND CHARACTERIZATION OF VEGAN CREAM CHEESE MADE FROM COCONUT MILK AND JACKFRUIT SEED FLOUR

BACHELOR THESIS

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A thesis submitted in partial fulfillment of the requirements for the degree of bachelor's degree in the Bachelor Program of Food Technology, Faculty of Animal and Agricultural Sciences, Universitas Diponegoro.

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2. All sources either cited or referred to from the work of others in the form of publications or other forms in this thesis have been properly acknowledged in accordance with standard procedures of scientific disciplines.
3. I also recognize that this thesis has been done under the supervision of: **Prof. Ir. Anang Mohamad Legowo, M.Sc., Ph.D.** and **Setya Budi Muhammad Abduh, S.Pt., M.Sc., Ph.D.**

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SUMMARY

AMATULLAH MARYAM. 23020122140165. 2026. Texture Optimization and Characterization of Vegan Cream Cheese Made from Coconut Milk and Jackfruit Seed Flour. **(ANANG MOHAMMAD LEGOWO** and **SETYA BUDI MUHAMMAD ABDUH**).

The increasing demand for plant-based food products has encouraged the development of dairy alternatives with desirable textural and sensory characteristics. However, achieving textures comparable to conventional dairy products remains a challenge. Jackfruit seed flour, a starch-rich local ingredient, offers potential for improving plant-based cheese texture. This research aimed to optimize the texture of vegan cream cheese formulated from coconut milk and jackfruit seed flour and compare its physicochemical and sensory characteristics with commercial dairy cream cheese.

The research was conducted at four laboratories of the Department of Agriculture, Universitas Diponegoro, from February to June 2026. Texture optimization employed a completely randomized design with five jackfruit seed flour concentrations (2%, 3%, 4%, 5%, and 6% w/v) and four replicates. Hardness, hardness work, adhesive force, and adhesiveness were evaluated. The optimum formulation was characterized through proximate and sensory analyses and compared with commercial cream cheese (Puck). Data were analyzed using one-sample t-tests, independent samples t-tests, and Mann–Whitney U tests at a 95% confidence level.

The 3% (w/v) formulation was selected as the optimum, exhibiting the closest overall texture profile to the benchmark, with hardness work, adhesive force, and adhesiveness of 3.47 ± 0.58 mJ, 18.45 ± 0.53 g, and 1.76 ± 0.14 mJ, respectively. The optimum formulation had significantly higher moisture (57.70 ± 0.31%), protein (3.26 ± 0.26%), and fat (24.76 ± 0.02%) but lower ash (1.15 ± 0.03%) and carbohydrate (13.40 ± 0.31%) contents than the benchmark. Sensory evaluation indicated favorable acceptance, particularly for creaminess, spreadability, and overall acceptability. Thus, jackfruit seed flour shows potential as a local ingredient for developing plant-based cream cheese with favorable textural and sensory characteristics.

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Sincerely,

Author

Amatullah Maryam

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CHAPTER 1

INTRODUCTION

1.1 Background

Processed dairy products such as cheese play an important role in daily nutrition because they provide essential nutrients, including protein, calcium, and vitamins. Among these products, cream cheese is widely used due to its soft texture, mild flavor, and versatility in various food applications. However, conventional cream cheese is produced from cow's milk, which contains lactose and animal-derived proteins (Kamath *et al.*, 2022). Not all individuals can tolerate these components, particularly those with lactose intolerance. In addition, increasing consumer awareness of health and plant-based dietary patterns has accelerated the development of dairy alternatives, including vegan cheese products (Mefleh *et al.*, 2021). Consequently, plant-based cream cheese has attracted increasing attention as an alternative that is lactose-free, free from animal-derived ingredients, and suitable for vegan consumers while maintaining characteristics comparable to conventional cream cheese.

Coconut milk is a promising ingredient for vegan cream cheese due to its relatively high fat content, which contributes to emulsion formation and a creamy mouthfeel (Chen *et al.*, 2024). Furthermore, coconut milk is widely available in Indonesia and has long been incorporated into traditional and modern food products, making it a potential raw material for sustainable plant-based cream

cheese production. Nevertheless, previous studies have reported that soft cheese made with coconut milk still exhibits poor spreadability and suboptimal texture due to the absence of the casein network naturally present in dairy cheese (Tekin and Hayaloğlu, 2025). Although improvements have been achieved through starter culture optimization, moisture reduction, and stabilizer addition (Halim *et al.*, 2022), further improvement of the product's structural properties remains necessary.

Texture is a critical quality attribute of cream cheese, influencing its spreadability, mouthfeel, and overall acceptance. In dairy cream cheese, interactions between casein and fat globules contribute to its characteristic structure. In plant-based alternatives, starch can serve as a functional ingredient through gelatinization, water absorption, and gel formation, thereby improving viscosity and structural stability (Johansson *et al.*, 2026). Jackfruit seed flour is a potential starch source for improving the texture of vegan cream cheese. Jackfruit (*Artocarpus heterophyllus* Lam.) is widely cultivated in Indonesia, yet its seeds are frequently discarded despite containing considerable amounts of starch, protein, and dietary fiber (López-Martínez *et al.*, 2025). Previous research by Tharayil Udayarajan et al. (2025) successfully incorporated jackfruit seed flour into a vegan cheese spread formulated with cashew kernels, resulting in improved nutritional quality, enhanced textural properties, and favorable sensory acceptance.

However, research on jackfruit seed flour in coconut milk-based vegan cream cheese remains limited, particularly regarding texture optimization and the characterization of the optimum formulation. Therefore, varying the concentration

of jackfruit seed flour is proposed as a means of improving texture, with the optimum formulation expected to exhibit favorable physicochemical and sensory characteristics. This study aimed to optimize the texture of coconut milk-based vegan cream cheese using different jackfruit seed flour concentrations and characterize the optimum formulation through proximate and sensory analyses in comparison with commercial dairy cream cheese.

1.2 Study Objectives

This study aimed to optimize the texture of coconut milk-based vegan cream cheese using different concentrations of jackfruit seed flour (*Artocarpus heterophyllus* Lam.). The optimum formulation was subsequently characterized through proximate and sensory analyses and compared with commercial dairy cream cheese.

1.3 Significance of Study

This study provides scientific information on the potential of jackfruit seed flour as a functional ingredient for improving the texture of coconut milk-based vegan cream cheese. The findings also contribute to the utilization of underused agricultural resources and the development of value-added plant-based food products. Furthermore, the characterization of the optimum formulation provides insights into its nutritional composition and sensory acceptance, supporting further research and development of plant-based dairy alternatives.

CHAPTER II

LITERATURE REVIEW

2.1 Cream Cheese

Cream cheese is a soft, fresh cheese characterized by its high moisture content, mild acidic flavor, smooth texture, and spreadable consistency. It has a semi-solid structure in which finely dispersed fat droplets are immobilized within a protein-stabilized matrix. This structure can be described as an interpenetrating gel that determines the firmness, yield stress, and flow behavior of the product. The distribution of fat, water retention capacity, and integrity of the protein network contribute to the structural uniformity and creamy mouthfeel of cream cheese (Wang *et al.*, 2024). These characteristics are primarily influenced by the distribution of fat, water retention capacity, and the integrity of the protein network (Junaid *et al.*, 2024).



Figure 1. Cream cheese

((Marx, 2015)

The structure of cream cheese consists of a continuous protein matrix that entraps water and fat droplets, forming a stable semi-solid emulsion. During manufacture, acidification and heat treatment promote the aggregation of casein micelles, creating a three-dimensional gel network responsible for the characteristic body and spreadability of cream cheese. Fat globules are uniformly dispersed within this network, where they contribute to lubrication, creaminess, and a smooth mouthfeel, while the aqueous phase remains immobilized within the protein matrix (Sözeri Atik and Huppertz, 2025). The stability of this microstructure is essential for maintaining desirable textural attributes and preventing phase separation during storage.

The quality and functionality of cream cheese are largely determined by the interactions among milk proteins, fat, and water within the gel network. Proteins provide the primary structural framework that supports the formation and stability of the gel network. Meanwhile, fat contributes to creaminess and lubricity, while water influences softness and spreadability. The interactions among these components determine important quality attributes, including firmness, cohesiveness, viscosity, and spreadability, which collectively influence the product's sensory characteristics (Lu *et al.*, 2025). Understanding these structural characteristics is therefore important for developing alternative products that aim to reproduce the texture and functionality of conventional cream cheese.

2.2 Vegan Cream Cheese

Vegan cream cheese is a plant-based alternative to conventional cream cheese that is formulated entirely from non-dairy ingredients. It is developed to provide

sensory and functional characteristics comparable to those of dairy cream cheese while accommodating vegan dietary preferences and certain dietary restrictions. Depending on the formulation, vegetable oils, plant proteins, starches, hydrocolloids, legumes, and nuts can be used as the primary ingredients. These ingredients serve different functions in developing the texture, stability, and sensory characteristics of the final product. The selection of ingredients is therefore an important consideration in formulating vegan cream cheese (Grossmann and McClements, 2021).



Figure 2. Vegan Cream Cheese Made from Coconut Milk and Jackfruit Seed Flour

(Personal Documentation, 2026)

Unlike conventional cream cheese, which relies on a continuous casein network to entrap fat and water, vegan cream cheese must establish its structural matrix using interactions among plant-derived proteins, polysaccharides, starches, and lipids (Surber *et al.*, 2021). The absence of casein presents a major technological challenge because plant proteins and carbohydrates exhibit different gelation, emulsification, and water-binding behaviors compared with dairy proteins (Ali *et al.*, 2025). These differences may affect the formation of a stable matrix and

the ability of the product to retain water and fat. the functional properties of individual ingredients need to be considered when developing plant-based alternatives. Appropriate ingredient selection and formulation optimization are essential for achieving desirable structural and functional characteristics.

Texture is one of the most critical quality attributes of vegan cream cheese because it influences firmness, spreadability, mouthfeel, and structural stability. Excessive firmness may reduce spreadability and make the product difficult to apply, whereas insufficient firmness may result in a product with poor structural stability (Silva *et al.*, 2024). These characteristics are influenced by interactions among fat, proteins, polysaccharides, and water. Plant-derived fats contribute to lubrication and creamy mouthfeel, while proteins and polysaccharides contribute to structural integrity and water-binding capacity (Dobson and Marangoni, 2025). Therefore, achieving an appropriate balance among these components is important for developing vegan cream cheese with desirable textural and sensory characteristics.

In addition to texture, the physicochemical characteristics of vegan cream cheese, including moisture, protein, fat, ash, and carbohydrate contents, influence product quality, stability, and consumer acceptance. These compositional characteristics affect water retention, gel formation, and the overall sensory perception of the product (Gurbuz *et al.*, 2024). Despite considerable progress in plant-based dairy alternatives, reproducing the structural complexity and sensory characteristics of conventional cream cheese remains challenging (Rune *et al.*, 2026). Therefore, the incorporation of functional plant-based ingredients capable of

improving gel formation, water retention, and structural integrity is essential for developing high-quality vegan cream cheese with characteristics comparable to those of conventional dairy cream cheese (Choe *et al.*, 2025). One potential ingredient is jackfruit seed flour, which contains starch and exhibits functional properties relevant to the development of semi-solid food products.

Various plant-based ingredients have been investigated for the development of vegan cream cheese, including plant proteins, legumes, seeds, and alternative milk sources. Michel et al. (2022) reported that formulations containing pea protein, pea fiber, potato fiber, and plant oil exhibited different physical and lubrication properties depending on the type of oil used. Similarly, Palatzidi et al. (2025) found that cream cheese analogues made with chickpea or red lentil flour and avocado demonstrated suitable adhesiveness and spreadability. Choe et al. (2025) showed that combining pea protein isolate and soybean oil could produce an emulsion gel with cream cheese-like characteristics. Furthermore, Janpeng et al. (2026) developed a cream cheese analogue using watermelon seed milk, maltodextrin, and hydrocolloids, with the optimized formulation exhibiting desirable textural properties and acceptable sensory characteristics. These studies demonstrate the potential of various plant-based ingredients and combinations to develop vegan cream cheese analogues with desirable textural and sensory properties.

2.3 Jackfruit Seed Flour

Jackfruit seed flour is a plant-based ingredient obtained by processing jackfruit seeds into a fine powder. Jackfruit seed flour is composed of carbohydrates, particularly starch, and also contains protein, dietary fiber, minerals,

and low amounts of fat. Its starch content contributes to its potential application in food formulations, particularly through gelatinization and water-binding properties (Akter and Haque, 2018). From a functional perspective, jackfruit seed flour exhibits desirable properties such as water absorption capacity, oil absorption capacity, swelling power, and gel-forming ability. These characteristics influence the behavior of flour when incorporated into different food systems. Its water absorption and swelling properties may contribute to thickening, while its gel-forming ability may support the development of a structured matrix. Its incorporation may also influence rheological behavior, texture, and product stability, depending on the formulation and processing conditions (Ushkalova *et al.*, 2025).

Jackfruit seeds are by-products of jackfruit consumption that are frequently underutilized despite their nutritional potential. They contain substantial amounts of macronutrients, particularly carbohydrates in the form of starch, as well as protein, dietary fiber, and essential minerals (Dhani *et al.*, 2025). *Artocarpus heterophyllus Lam.*, commonly known as jackfruit, is a tropical fruit from the *Moraceae* family widely distributed in South and Southeast Asia, including Indonesia. It is known for its high yield, year-round availability, and adaptability to humid climates, making it a valuable commodity for food security (Srivastava and Singh, 2020). Jackfruit also contains bioactive compounds, such as phenolics, flavonoids, and carotenoids, which contribute to its antioxidant properties (Ranasinghe *et al.*, 2019). Due to their starch content, jackfruit seeds have potential

as a functional ingredient in vegan cream cheese, particularly when combined with coconut milk to develop the desired texture.

2.4 Coconut Milk

Coconut milk is a plant-based emulsion obtained from the grated endosperm of mature coconut (*Cocos nucifera* L.). It is widely used in tropical food systems because of its characteristic flavor, rich composition, and creamy texture. Coconut milk has a high fat content, with its lipid fraction consisting predominantly of saturated fatty acids, including lauric, myristic, and palmitic acids. Its natural oil-in-water emulsion structure makes it a potential ingredient for plant-based products that require richness and creaminess. These characteristics support its application as a base ingredient in plant-based dairy alternatives (Patil and Benjakul, 2018).

The stability of coconut milk emulsions is influenced by the interactions between their oil and aqueous phases. Coconut proteins can adsorb at the oil–water interface and contribute to the stabilization of dispersed fat droplets (Chen *et al.*, 2023). This interfacial behavior influences the physical stability and functionality of coconut milk in food formulations. The interactions between coconut milk and jackfruit seed flour may influence the structural and mechanical properties of vegan cream cheese. Therefore, texture analysis is necessary to evaluate the effects of different jackfruit seed flour concentrations on the final product.

2.5 Texture Properties

Texture is a fundamental quality attribute that describes the mechanical and sensory characteristics of food products. In cream cheese and its plant-based alternatives, textural properties influence firmness, spreadability, mouthfeel, and

structural stability. Instrumental texture analysis is commonly used to evaluate these properties by applying controlled mechanical forces to food samples, providing objective measurements of their structural and mechanical behavior (Foegeding *et al.*, 2003). Firmness or hardness represents the resistance of a sample to deformation, whereas cohesiveness indicates the extent to which its internal structure withstands deformation without breaking apart. Adhesiveness describes the work required to overcome the attractive forces between the sample and a contacting surface, while elasticity represents the ability of the sample to recover its original shape after deformation. These parameters provide information about the structural integrity and mechanical characteristics of semi-solid food systems (Póltorak *et al.*, 2015).

Texture measurements are affected by several factors, including sample composition, preparation conditions, probe geometry, and testing speed. Therefore, standardized testing conditions are necessary to obtain reliable and comparable measurements. In plant-based cream cheese, textural characteristics are also influenced by the formation and stability of the gel network. Starch-based ingredients, such as jackfruit seed flour, may contribute to structural development through gelatinization, while lipid components from coconut milk may affect lubrication and the distribution of fat within the matrix. The interaction between these components can alter the firmness and other textural characteristics of the final product (Lanur *et al.*, 2025).

2.6 Proximate Composition

Proximate composition is a fundamental analysis used to determine the major chemical constituents of food products, including moisture, ash, protein, fat, and carbohydrate contents. This analysis provides essential information regarding the nutritional composition and quality of food products. It is widely applied in food research and product development to evaluate the effects of ingredients and processing methods on the final product (Mario et al., 2024). In plant-based dairy alternatives, proximate composition is particularly important because different raw materials may influence the nutritional profile and physicochemical characteristics of the product. Therefore, proximate composition analysis was conducted in this study to characterize the selected coconut milk–based vegan cream cheese formulated with jackfruit seed flour by determining its moisture, ash, protein, fat, and carbohydrate contents.

2.6.1 Moisture Content

Moisture content refers to the amount of water present in a food product and is one of the most important parameters used to evaluate food quality. Water content influences physicochemical properties, microbial stability, shelf life, texture, appearance, and chemical reactions occurring during food processing and storage (Zambrano et al., 2019). In products such as vegan cream cheese, moisture content also affects texture, spreadability, and overall product stability, making it an essential parameter for quality evaluation. Moisture content is commonly determined using gravimetric methods, with the oven-drying method being one of the most widely adopted reference methods in food analysis (Ahn *et al.*, 2014).

2.6.2 Protein Content

Protein content refers to the amount of protein present in a food product and is an important parameter for evaluating its nutritional quality. Protein is one of the three major macronutrients, alongside fat and carbohydrates. It plays essential roles in supporting growth, tissue repair, and various physiological functions (Savarino et al., 2020). In addition to its nutritional significance, protein also contributes to the functional properties of foods, including water-binding capacity, emulsification, gel formation, and texture. These are the important attributes in dairy and plant-based products. In vegan cream cheese, protein content is influenced by the composition of the raw materials used and may affect the product's overall nutritional value and quality. Protein content is commonly determined using nitrogen-based analytical methods, with the Kjeldahl method being one of the most widely recognized reference methods in food analysis (Mæhre *et al.*, 2018) .

2.6.3 Fat Content

Fat content refers to the amount of lipids present in a food product and is an important parameter for evaluating its nutritional composition and quality. Fat is one of the three major macronutrients that serve as a concentrated source of energy and functions as a carrier of fat-soluble vitamins (Vostrikova *et al.*, 2018). In addition to its nutritional role, fat contributes significantly to the physicochemical and sensory properties of food by influencing texture, mouthfeel, creaminess, flavor perception, and overall product acceptability. In plant-based dairy alternatives such as vegan cream cheese, fat content is largely determined by the lipid composition of the raw materials and plays an important role in achieving desirable product

characteristics. Therefore, fat content is an essential parameter for assessing the nutritional value, functional properties, and overall quality of vegan cream cheese. Fat content is commonly determined using solvent extraction methods, with the Soxhlet method being one of the most widely recognized reference methods in food analysis (Vostrikova *et al.*, 2018)

2.6.4 Ash Content

Ash content refers to the total inorganic mineral residue remaining after the complete combustion of organic matter in a food product and is commonly used as an indicator of its total mineral content. Determination of ash content is an important component of proximate composition analysis because it provides information regarding the nutritional quality and overall chemical composition of food materials (Mario et al., 2024). In addition to reflecting the mineral composition of raw ingredients, ash content is also influenced by formulation and processing conditions. In plant-based dairy alternatives such as vegan cream cheese, ash content is useful for evaluating the contribution of mineral-rich ingredients to the final product. It serves as an indicator of its overall nutritional quality. Ash content is commonly determined using gravimetric methods, with dry ashing being one of the most widely recognized reference methods in food analysis (Quirino *et al.*, 2022).

2.6.5 Carbohydrate Content

Carbohydrate content refers to the amount of carbohydrates present in a food product and is an important parameter for evaluating its nutritional composition. Carbohydrates are one of the three major macronutrients and serve as the primary

source of energy in the human diet. They mainly consist of sugars, starch, and dietary fiber. This contributes not only to nutritional value but also to the structural and functional properties of food products (Campos *et al.*, 2022). In plant-based dairy alternatives such as vegan cream cheese, carbohydrate content is influenced by the composition of ingredients that are derived from plants, particularly starch-rich materials such as jackfruit seed flour. It may affect the product's texture, stability, and overall quality. Therefore, carbohydrate content is an essential parameter for assessing the nutritional profile and physicochemical characteristics of the final product. Carbohydrate content is commonly estimated by the calculation-by-difference method in proximate analysis, as recommended by AOAC (2006) and widely applied in food analysis (Deepika *et al.*, 2024).

2.7 Sensory Evaluation

Sensory evaluation is a method used to assess food products through human sensory perception. This evaluation involves the use of the senses to examine product characteristics such as color, aroma, taste, texture, appearance, and overall acceptability. Sensory evaluation is widely applied in food product development to evaluate product quality, characterize sensory properties, determine panelist acceptance, and compare newly developed products with existing or commercial products. Compared with instrumental analyses, sensory evaluation provides a comprehensive assessment of multiple sensory attributes simultaneously, making it an essential tool in food quality evaluation and product development (de Albuquerque *et al.*, 2022). Based on its objective, sensory evaluation can generally be classified into descriptive tests and affective tests.

2.7.1 Organoleptic Scoring Test

The organoleptic scoring test is a descriptive sensory evaluation method used to assess the intensity of specific sensory attributes of food products. Unlike affective tests that measure consumer preference, the scoring test evaluates the perceived intensity of individual characteristics, such as color, aroma, taste, and texture, using a predetermined numerical scale (Lawless and Heymann, 2010). This method provides a detailed description of product sensory characteristics and is useful for identifying quality differences among formulations or comparing innovative products with reference or commercial products (Heymann and Ebeler, 2016). Therefore, the organoleptic scoring test is widely applied to characterize the sensory profile of food products based on the intensity of each evaluated attribute.

2.7.2 Hedonic Test

The hedonic test is an affective sensory evaluation method used to determine the degree of liking or acceptance of a food product by panelists. In this method, panelists express their preference toward specific sensory attributes or the product as a whole using a structured rating scale (Heymann and Ebeler, 2016). Although the five-point hedonic scale is the most widely used, seven-point and nine-point scales are also commonly employed depending on the objectives of the study. Hedonic testing is commonly conducted to evaluate panelist acceptance of attributes such as color, aroma, taste, texture, and overall acceptability. This provides valuable information for formulation optimization and product development.

CHAPTER III

MATERIALS DAN METHODS

3.1 Materials

The research was conducted at the Food Processing Laboratory, Food Chemistry and Nutrition Laboratory, Sensory Laboratory, and lastly in Food and Agricultural Products Engineering Laboratory. These laboratories are located in the Faculty of Animal and Agricultural Sciences, Universitas Diponegoro, Semarang.

The materials used in this study included fresh jackfruit seeds for the preparation of laboratory-made jackfruit seed flour and coconut milk (Kara) as the primary fat source in the vegan cream cheese formulation. Commercial cream cheese (Puck) was used as a reference sample for texture and sensory comparison. The jackfruit seed flour was prepared through a series of processes including boiling, cleaning, roasting, grinding, and sieving to obtain a fine powder. Additional materials included bread for sensory evaluation, distilled water, and mineral water for palate cleansing during sensory testing. Chemical reagents used for proximate analysis included a mixed selenium catalyst, sulfuric acid (H_2SO_4), sodium hydroxide (NaOH) 45%, hydrochloric acid (HCl) 0.1 N, boric acid (H_3BO_3) 4%, methyl red (MR), methylene blue (MB), and n-hexane solvent for Soxhlet fat extraction. All chemicals used in this study were of analytical grade.

The equipment used in this study included both processing and analytical instruments. Processing equipment consisted of boiling utensils, roasting equipment, a household blender (Mito BL100) for milling the samples, and 200-

mesh sieves to obtain a uniform particle size. Analytical equipment included an analytical balance, moisture dishes, porcelain crucibles, a drying oven, a muffle furnace, a desiccator containing silica gel, a Kjeldahl digestion and distillation apparatus, Erlenmeyer flasks, a Soxhlet extraction apparatus, a water bath, filter paper, mortar and pestle, beakers, measuring cylinders, pipettes, a texture analyzer for texture profile analysis, stainless steel trays, a thermometer, serving containers for sensory evaluation, airtight plastic containers, and a refrigerator for sample storage.

3.2 Methods

The research method included experimental design, research procedures, parameter testing, and data analysis based on the experimental results. The detailed description of each component of the research method is presented as follows.

3.2.1 Experimental Design

The study was conducted in two sequential stages: texture optimization and characterization of the optimum formulation. In the first stage, different concentrations of jackfruit seed flour (2%, 3%, 4%, 5%, and 6% w/v) were evaluated to determine their effects on the texture properties of coconut milk-based vegan cream cheese. Each formulation was prepared independently with four replicates. A commercial dairy cream cheese (Puck) was included as a benchmark for texture comparison but was not considered an experimental treatment. The optimum formulation was selected based on its texture properties relative to the benchmark. The experimental design for the optimization stage is presented in Table 1.

Table 1. Experimental design for texture optimization of coconut milk–based vegan cream cheese with different levels of jackfruit seed flour

Replication	Treatment				
	T_1	T_2	T_3	T_4	T_5
1	T_1R_1	T_2R_1	T_3R_1	T_4R_1	T_5R_1
2	T_1R_2	T_2R_2	T_3R_2	T_4R_2	T_5R_2
3	T_1R_3	T_2R_3	T_3R_3	T_4R_3	T_5R_3
4	T_1R_4	T_2R_4	T_3R_4	T_4R_4	T_5R_4

Description:
T_1 : Jackfruit seed flour at 2% (w/v)
T_2 : Jackfruit seed flour at 3% (w/v)
T_3 : Jackfruit seed flour at 4% (w/v)
T_4 : Jackfruit seed flour at 5% (w/v)
T_5 : Jackfruit seed flour at 6% (w/v)

Based on the texture optimization results, the optimum formulation was selected for further characterization. The optimum formulation was analyzed for proximate composition and sensory properties and compared with a commercial dairy cream cheese (Puck) as a benchmark. The benchmark sample was used solely for comparison and was not included as experimental treatment.

3.2.2 Research Procedures

This study was carried out through a series of sequential steps, beginning with material preparation, followed by the preparation of jackfruit seed flour and the formulation of vegan cream cheese made with coconut milk with different concentrations of jackfruit seed flour. A commercial dairy cream cheese (Puck) was included as a benchmark throughout the study for comparison but was not considered an experimental treatment. The formulated products were evaluated through texture analysis to determine the optimum formulation. Subsequently, the selected optimum formulation and the benchmark sample were characterized by proximate and sensory analyses to assess their physicochemical and sensory properties.

a. Material Preparation

The primary materials used in this study consisted of fresh jackfruit seeds, coconut milk (Kara), and salt as a flavoring agent. All materials were obtained from a local traditional market and were carefully selected to ensure freshness, quality, and suitability for consumption. Prior to processing, the materials were visually inspected to remove any damaged or spoiled components, thereby minimizing variability in raw material quality that could affect the final product characteristics.

b. Preparation for Jackfruit Seed Flour

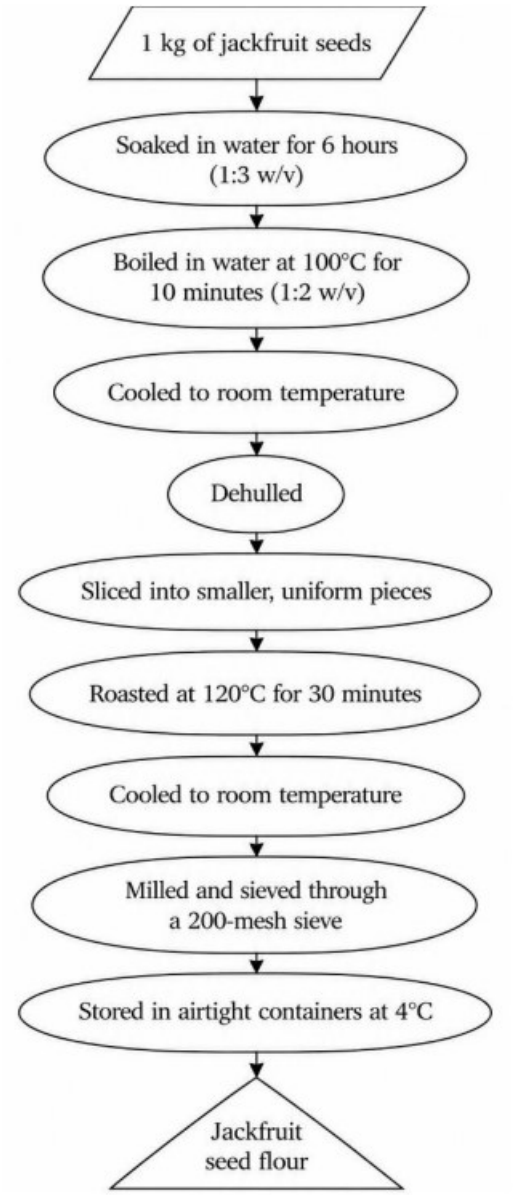


Figure 3. Process Flow Diagram of Jackfruit Seed Flour Preparation

Jackfruit seeds were initially cleaned to remove adhering impurities such as dirt and residual fruit pulp. The cleaned seeds were then soaked in distilled water for 6 hours at room temperature (approximately 25°C) using a seed-to-water ratio of 1:3 (w/v). Following soaking, the water was discarded. This hydration step plays

a critical role in softening the seed matrix and facilitating subsequent processing, particularly dehulling, by weakening the adhesion between the seed coat and cotyledon (Reddy and Narayanan, 2023).

The soaked seeds were subsequently boiled at 100°C for 10 minutes using a seed-to-water ratio of 1:2 (w/v), with the seed coats still intact. This thermal treatment further softened the seed tissues and facilitated dehulling. In addition, boiling contributes to the reduction of antinutritional compounds such as tannins and phytic acid, which may interfere with nutrient bioavailability (Nguyen, 2020).

After boiling, the seeds were cooled to room temperature and manually dehulled to remove the seed coats. The dehulled cotyledons were then cut into smaller, uniform pieces to ensure consistent heat transfer during roasting. The sliced seeds were roasted in a hot-air oven at 120°C for 30 minutes. This roasting condition was adapted from the method reported by Anaya-Esparza et al. (2018), which involved roasting at 120°C for 2 hours. Roasting reduces moisture content, enhances flavor, and induces partial modification of starch structure, which may influence functional properties such as water absorption and gel formation.

The roasted samples were cooled and milled into flour using a household blender (Mito BL100), followed by sieving through a 200 mesh sieve to obtain uniform particle size distribution. The resulting flour was stored in airtight containers at approximately 4°C to prevent moisture absorption and quality deterioration.

c. Preparation of Vegan Cream Cheese Using Coconut Milk and Jackfruit Seed Flour

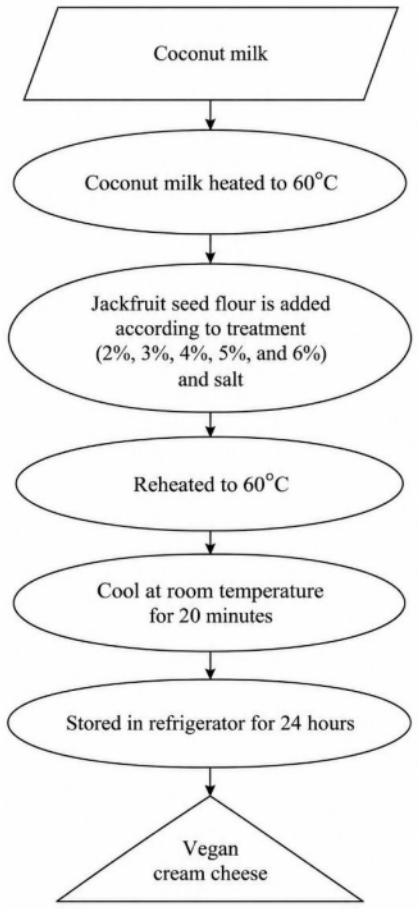


Figure 4. Process Flow Diagram of Vegan Cream Cheese Preparation

Coconut milk was first heated to approximately 60°C to facilitate homogenization and improve component interaction. After reaching the target temperature, jackfruit seed flour was gradually added while continuously stirring to ensure uniform dispersion and prevent lump formation. Controlled heating is essential to maintain stability for emulsion and prevent phase separation.

The mixture was then reheated to approximately 60°C under continuous stirring to induce starch gelatinization, which is the primary mechanism for gel

formation in this plant-based system (Braitmaier *et al.*, 2024). During gelatinization, starch granules absorb water, swell, and lose their crystalline structure. This results in the formation of a viscous matrix with viscoelastic properties.

The gelatinized starch matrix interacts with lipid components from coconut milk, contributing to the formation of a stable, cream cheese-like structure. After heating, the mixture was cooled at room temperature for approximately 20 minutes to allow initial gel setting. The product was then stored under refrigeration for 24 hours to complete gel formation. During this stage, starch retrogradation occurs, involving the reassociation of starch molecules into a more ordered structure, which enhances gel firmness and stability.

3.2.3 Texture Optimization

Texture optimization was conducted to determine the optimum concentration of jackfruit seed flour based on the texture properties of coconut milk-based vegan cream cheese. Texture properties were analyzed using a CT3 Texture Analyzer (Brookfield Engineering Laboratories, USA) following the general principles of instrumental texture evaluation described in ISO 11036:2020 and the Brookfield Texture Application Note for cream cheese. Prior to analysis, all vegan cream cheese samples and the commercial cream cheese were stored under refrigerated conditions and equilibrated to the same temperature before testing to ensure consistent measurement conditions. The samples were transferred into uniform cylindrical containers and placed centrally on the instrument platform.

A TA43 spherical probe was used to perform a compression test under the following operating conditions: pre-test speed of 2.0 mm/s, test speed of 1.0 mm/s, post-test speed of 1.0 mm/s, target distance of 10 mm, and trigger load of 4.5 g. During the analysis, the probe penetrated the sample to generate a force–distance curve, from which the texture parameters were obtained.

The texture parameters evaluated included hardness, hardness work done, adhesive force, and adhesiveness. Hardness was defined as the maximum force required to compress the sample, whereas hardness work done represented the total energy required during compression. Adhesive force was defined as the maximum force required to detach the probe from the sample surface, while adhesiveness represented the total energy required to overcome the attractive forces between the sample and the probe during probe withdrawal. The optimum formulation was selected based on the smallest absolute difference (Δ) in texture parameters relative to the commercial dairy cream cheese (Puck), which served as the benchmark.

3.2.4 Characterization of the Optimum Formula

Based on the texture optimization results, the optimum formulation was characterized through proximate and sensory analyses. A commercial dairy cream cheese (Puck) was included as the benchmark for comparison.

a. Moisture Content

Moisture content was determined using the gravimetric method according to AOAC (2006), which measures the amount of water in the sample by drying it at a controlled temperature until a constant weight is reached.

Prior to analysis, an empty moisture dish was dried in a hot-air oven at 105°C for 30 minutes, cooled in a desiccator for 15 minutes, and weighed. Approximately 2 g of the sample was then placed into the pre-weighed dish and dried in the oven at 105°C for 4 hours. After drying, the dish containing the sample was transferred to a desiccator and allowed to cool for 15 minutes before weighing to prevent moisture absorption from the surrounding air. The drying, cooling, and weighing steps were repeated at 1-hour intervals until a constant weight was obtained, which was defined as a weight difference of less than 0.5 g between two consecutive measurements.

The moisture content of the sample was calculated using the following equation:

$$Moisture\ Content\ (\%) = \frac{[A\ -(\ C\ -B)]}{A} \times 100\ \%$$

Description:

A = Weight of the sample before oven drying (g)
B = Weight of the dish after oven drying (g)
C = Weight of the dish and sample after oven drying (g)

b. Protein Content

Protein content was determined using the Kjeldahl method according to AOAC (2007), which is a standard procedure for measuring total nitrogen and estimating protein content. Approximately 0.5 g of the sample was weighed into a Kjeldahl digestion flask, followed by the addition of 0.5 g of mixed selenium catalyst and 10 mL of concentrated sulfuric acid (H_2SO_4). The mixture was digested under a fume hood until a clear green solution was obtained, indicating complete digestion, and was then allowed to cool.

After digestion, 100 mL of distilled water and 40 mL of 45% sodium hydroxide (NaOH) solution were added to create an alkaline condition, converting ammonium ions into ammonia (NH_3). The liberated ammonia was distilled and collected in 5 mL of 4% boric acid (H_3BO_3) solution containing two drops each of methyl red (MR) and methylene blue (MB) indicators. Distillation continued until approximately 40 mL of distillate had been collected and the receiving solution changed from purple to green.

A blank sample was prepared following the same procedure without the addition of the test sample. The collected distillate was titrated with 0.1 N hydrochloric acid (HCl) until the endpoint was reached, indicated by a color change from green to purple. The protein content was subsequently calculated using the following equation:

$$Protein\ Content\ (\%) = \frac{(V_a - V_b) \times\ N_{HCl}\ \times 14{,}008}{Weight\ of\ sample\ (g) \times 1000} \times 100$$

$$\text{Protein total (\%)} = \text{protein content (\%)} \times \text{conversion factor of } 6.25$$

Description:

V_a = volume of HCl for sample (mL)

V_b= volume of HCl for blank (mL)

N = normality of HCl

c. Fat Content

Fat content was determined using the Soxhlet extraction method according to AOAC (2007). The analysis was performed on jackfruit seed flour, coconut milk, commercial cream cheese, and the optimized vegan cream cheese. For coconut milk, commercial cream cheese, and the optimized vegan cream cheese, the

procedure was modified based on Safari et al., (2024) because of their high moisture content. These samples were pre-dried in a hot-air oven at 105°C until a constant weight was achieved before extraction.

Prior to analysis, the filter papers were dried in an oven at 105°C for 1 hour. Approximately 2 g of each sample was accurately weighed, wrapped in the pre-dried filter paper, and covered with an additional layer of filter paper on both sides. The wrapped samples were then dried at 105°C for 4 hours, cooled in a desiccator for approximately 15 minutes, and weighed. The drying, cooling, and weighing steps were repeated at 1-hour intervals until a constant weight was obtained, defined as a weight difference of less than 0.02 g between consecutive measurements.

The dried samples were transferred into a Soxhlet extraction apparatus, and n-hexane was added at a volume approximately 2.5–3 times that of the extraction flask. Lipid extraction was carried out using a water bath maintained at approximately 50°C for a minimum of six extraction cycles. Following extraction, the samples were air-dried at room temperature for approximately 30 minutes, then further dried in an oven at 105°C for 1 hour, cooled in a desiccator, and weighed. The fat content was subsequently calculated using the following equation:

$$Fat\ Content\ (\%) = \frac{Weight\ B - Weight\ C}{Weight\ A} \times 100$$

Description:

A = Weight of the initial sample before oven drying (g)

B = Constant weight of the sample after oven drying before Soxhlet extraction (g)

C = Final weight of the sample after Soxhlet extraction and oven drying (g)

d. Ash Content

Ash content was determined using the dry ashing method according to AOAC (2006), a standard gravimetric procedure for measuring the total mineral content of a sample. Approximately 2 g of the sample was weighed into a pre-weighed porcelain crucible. The crucible containing the sample was then placed in a muffle furnace and heated at 600°C for 4–6 hours to ensure complete combustion of the organic matter. During this process, the organic components were oxidized, leaving inorganic ash as the mineral residue.

After ashing, the crucibles were removed from the furnace and allowed to cool in a desiccator to prevent moisture absorption from the surrounding environment. Once cooled, the crucibles were weighed to determine the weight of the remaining ash. The ash content was subsequently calculated by comparing the weight of the ash residue with the initial sample weight using the following equation:

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

e. Carbohydrate Content

Carbohydrate content was determined using the calculation by difference method according to AOAC (2006). This method estimates the total carbohydrate content indirectly by subtracting the measured values of the other proximate components from the total sample composition.

The carbohydrate content was calculated after determining the moisture, protein, fat, and ash contents using their respective analytical methods. Based on the difference principle, carbohydrates represent the remaining fraction of the

sample after accounting for all other major components. The carbohydrate content was calculated using the following equation:

$$Carbohydrate\ Content\ (\%) = 100 - (Moisture + Protein + Fat + Ash)$$

f. Organoleptic Scoring Test

The organoleptic scoring test was conducted following a modified procedure adapted from Lawless and Heymann (2010). A total of 30 untrained panelists participated in the evaluation. The vegan cream cheese samples and commercial cream cheese were served in small containers and identified using random three-digit codes. Each panelist received all samples, drinking water for palate cleansing, and a sensory evaluation form. Panelists were instructed to evaluate the samples and record their assessments on the evaluation form.

The evaluated attributes included color, creaminess, saltiness, savoriness, and spreadability. Spreadability was assessed by spreading each sample onto white bread using a knife provided to each panelist. All attributes were evaluated using a five-point descriptive scoring scale, with the scale descriptors defined according to each attribute. The organoleptic scoring form is presented in Appendix 1.

g. Hedonic Test

The hedonic test was conducted following a modified procedure adapted from Setiaji et al., (2019) using a five-point hedonic scale. A total of 30 untrained panelists participated in the evaluation. The vegan cream cheese samples and commercial cream cheese were served in small containers and identified using random three-digit codes. Each panelist received all samples, drinking water for

palate cleansing, and a sensory evaluation form. Panelists were instructed to evaluate the samples and record their preferences on the evaluation form.

The evaluated attributes included color, creaminess, saltiness, savoriness, spreadability, and overall acceptability. Spreadability was assessed by spreading each sample onto white bread using a knife provided to each panelist. All attributes were evaluated using a five-point hedonic scale consisting of 1 (dislike), 2 (slightly dislike), 3 (neither like nor dislike), 4 (slightly like), and 5 (like). The hedonic evaluation form is presented in Appendix 2.

3.2.5 Data Analysis

The data obtained from texture analysis, proximate analysis, and sensory evaluation were statistically analyzed to evaluate the effect of different concentrations of jackfruit seed flour on the characteristics of vegan cream cheese made with coconut milk. The data were tabulated and checked for completeness prior to statistical analysis. All statistical analyses were performed using the Statistical Package for the Social Sciences (SPSS) version 24.0.

Prior to statistical analysis, the data were evaluated to ensure that the assumptions for parametric analysis were satisfied. For the texture optimization stage, each treatment was compared with the corresponding texture value of the commercial dairy cream cheese (Puck), which served as the benchmark, using a one-sample *t*-test at a 95% confidence level ($\alpha = 0.05$). In addition, the absolute difference (Δ) between each treatment and the benchmark was calculated to evaluate the degree of similarity. The optimum formulation was selected based on

the overall texture similarity to the commercial benchmark by considering both the results of the one-sample *t*-test and the calculated Δ values.

For the characterization stage, the optimized formulation was compared with the commercial dairy cream cheese (Puck) using an independent samples *t*-test at a 95% confidence level ($\alpha = 0.05$). The results are presented in tables to facilitate data interpretation and discussion.