Research Article

Jackfruit Seed as Flour Alternative in Cookies: A Consumer Acceptability Study

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Abstract

This study investigates the feasibility of utilizing jackfruit seeds as a sustainable replacement for wheat in bakery products to mitigate the escalating costs of wheat. Jackfruit seeds, an often-overlooked resource, constitute approximately 10-15% of the fruit's weight and are typically discarded due to their perishable nature. Despite their historical neglect, these seeds are rich in nutrients, making them an economical and attractive alternative to wheat in light of the rising wheat prices. The primary focus of this study revolves around the development of Jackfruit Seed Flour (JSF) and its application in cookie manufacturing. Two distinct approaches are examined: the complete substitution of wheat flour with JSF (V1) and the use of varying ratios of jackfruit seed flour to wheat flour in cookies, specifically V2 (50% JSF) and V3 (25% JSF). These formulations are compared to a control sample comprising 100% wheat flour cookies. Furthermore, a comprehensive sensory evaluation, encompassing both descriptive and hedonic assessments, is conducted to evaluate shelf life and consumer acceptability. Descriptive sensory analysis of all JSF cookies over a 15-day period at room temperature suggests that V3 cookies maintain their quality over time, comparable to the control sample. In contrast, the hedonic sensory test conducted with a panel of 30 randomly selected individuals reveals that V3 is the most preferred option in terms of overall acceptability, followed by V2, and then the control sample. V1 is rated as neutral in terms of overall acceptability. In conclusion, the combination of JSF with wheat flour shows significant potential for cookie production. The use of JFS in cookies not only reduces waste from jackfruit seeds but also contributes to cost savings in the production of baked goods. This study highlights the viability of utilizing jackfruit seeds as a valuable resource in addressing the challenges posed by the rising cost of wheat in the bakery industry.

Keywords:

Jackfruit Seed Flour, Cookies, Wastage, Sustainability, Shelf-Life

1 Introduction

Wheat, a staple grain for humanity since 10,000 BC, plays a crucial role in producing various bakery and pasta items such as bread, cakes, and biscuits (Sousa et al., 2021). However, the rising cost of this essential raw material, driven by factors like climate change, transportation expenses, and conflicts, necessitates the exploration of wheat alternatives to prevent abrupt price surges in wheat-based products (Mottaleb et al., 2022). In this context, jackfruit seeds have emerged as a promising substitute.

The jackfruit plant, scientifically known as Artocarpus Heterophyllus, belongs to the Moraceae family and is extensively cultivated in Southeast Asia, particularly in countries like Bangladesh, India, and Thailand (Nisar et al., 2021). Despite widespread cultivation and processing in these regions, the full potential of jackfruit remains largely untapped due to challenges such as limited shelf life and inadequate processing infrastructure. Surprisingly, only about 35% of the entire jackfruit is considered edible, with the remaining 60% comprising inedible components like the prickly rind, rags, latex, and seeds. Among these, jackfruit seeds make up approximately 10-15% of the total fruit weight. These seeds are distinctive with their light brown color and oval or oblong ellipsoid, or circular shape, measuring 2-3 cm in length and 1-1.5 cm in diameter (Palupi & Daryono, 2021). Moreover, it's important to highlight that Maskey et al. (2020) reported an astonishing waste of approximately 2.96 million metric tons of jackfruit seeds globally each year (Nsubuga et al., 2021). This wastage primarily stems from the

seeds' perishable nature, leading to underutilization and limited public awareness, despite their significant nutritional value (Maskey et al., 2020).

This paper is centered on experimental product development, specifically on creating jackfruit seed flour. This versatile flour can be employed in two ways: it can either completely replace wheat flour (100% jackfruit) or it can be used in combination with wheat flour at varying ratios, such as 25% and 50% jackfruit seed flour to wheat flour in cookie recipes. The primary aim of this study is to investigate the acceptability level of jackfruit seed cookies among consumers, helping us determine the most suitable ratio for using jackfruit seed flour in cookie production. Moreover, this approach not only addresses the issue of minimizing jackfruit seed wastage but also offers the potential to significantly reduce the overall production costs of baked goods. By exploring the acceptability and feasibility of jackfruit seed flour in cookie production, this study can uncover a sustainable and cost-effective alternative for the bakery and confectionery industry.

2 Literature Review

Wheat flour, a powdered product derived from wheat kernels, plays a pivotal role in the production of various bakery and pasta items, including bread, cakes, biscuits, and noodles (Sousa et al., 2021). As a vital raw material in our daily lives, wheat flour provides essential nutrients like carbohydrates, protein, and minerals. However, global wheat prices have been steadily increasing due to adverse weather conditions, agricultural subsidies, export restrictions, transportation, storage costs, climate change, and conflicts (Mottaleb et al., 2022). Consequently, the research for a viable substitute for wheat flour is imperative to prevent an abrupt surge in the prices of wheat-based products. In this regard, jackfruit seeds have emerged as a noteworthy alternative..

While jackfruit seeds are indeed edible, they find limited application in industrial food production, with their primary utilization occurring within certain Asian households where they are roasted and consumed (Ranasinghe et al., 2019). This underutilization stems from the seeds' perishable nature, leading to their frequent disposal. However, when roasted, jackfruit seeds can be transformed into a versatile powder that, when combined with various flours, enhances the durability and value of a wide range of products. This jackfruit seed powder serves as a viable alternative flour, particularly in baking and confectionery, when blended with wheat flour and other cost-effective flours. Numerous studies have been conducted by researchers to delve into the nutritional advantages and consumer acceptance of food products featuring jackfruit seed flour (Brahma & Ray, 2023).

Jackfruit seeds are encapsulated within a white rail that envelops a thin brown endosperm covering the fleshy white cotyledon. Typically, jackfruits can weigh up to a maximum of 45 kg, and the edible portions primarily consist of the bulbs encasing the seeds (Ranasinghe et al., 2019). It's worth noting that jackfruit seeds constitute approximately 10–15% of a jackfruit's total weight, with each fruit typically harboring between 100 and 500 seeds (Kumoro et al., 2020). Furthermore, these seeds have

garnered attention due to their rich content of antioxidant peptides, which hold the potential for development into dietary supplements or preservatives for protein-rich food systems (Chai et al., 2021). Their mineral composition is also significant, encompassing vital elements like magnesium, potassium, phosphorus, calcium, sodium, iron, copper, zinc, and manganese, as highlighted by Hajj et al. (2022).

Consuming jackfruit seeds offers various health benefits attributed to their abundant nutritional components, as well-documented in various sources. These seeds are recognized for their positive impact on digestion, anti-carcinogenic properties, and potential to reduce skin wrinkles (Chhotaray & Priyadarshini, 2022). Moreover, they are rich in essential minerals such as calcium, magnesium, phosphorus, sodium, iron, copper, zinc, potassium, and manganese. These minerals play pivotal roles, ranging from supporting bone health to influencing muscle and nerve function and regulating the body's hydration levels (Hajj et al., 2022).

Furthermore, jackfruit seeds contain two notable lectins, Artocarpin and Lectin, which confer immunological properties. Additionally, they serve as a substantial source of dietary fiber (Astuti et al., 2022). An increased intake of dietary fiber has been associated with various health benefits, including lowered blood pressure, reduced cardiometabolic risk factors, and a decreased risk of developing cardiovascular disease (Biswas et al., 2022). Moreover, jackfruit seeds boast a carbohydrate-rich profile and contain protein levels ranging from 10% to 15%, primarily attributed to their high amylose and protein concentrations. This renders jackfruit seed flour or starch a promising ingredient for crafting functional foods, surpassing the capabilities of wheat flour or commercially available modified starches like potato, corn, and rice (Suzihaque et al., 2022). Therefore, jackfruit seeds can present a compelling alternative to wheat flour in the production of cookies, offering the potential to create high-protein, healthier cookies. This approach not only minimizes jackfruit seed wastage but also contributes to reducing the overall production costs of baked goods.

3 Methodology

This section presents the materials and methods employed in this study, including jack fruit flour preparation, preparation of jack fruit cookies, descriptive shelf-life analysis, sensorial evaluations (consumer acceptability assessments), and statistical analysis.

3.1 Materials

A matured jackfruit weighing 5 kg was purchased from Shah Alam, Section 6, Malaysia. Only mature and physically undamaged jackfruit samples were utilized in this study. These jackfruit samples were meticulously cleaned to remove any dust or insects. Subsequently, the cleaned jackfruit samples were sealed in vacuum storage bags and transported to the laboratory under controlled conditions at a temperature of 28-30°C. The necessary ingredients for the preparation of cookies, including wheat flour, rice

flour, salt, sugar, baking soda, water and vegetable oil, were procured from a local market in Shah Alam, Malaysia.

3.2 Jackfruit Seed Preparation

The initial step in the process of converting jackfruit seeds into flour involved harvesting ripe jackfruit fruits. These fruits were meticulously cleaned under running water, followed by the removal of their peels, and manual separation of the seeds and pulp. The mucilage peel on the seeds was then manually removed, and any residual dirt and dust were washed away using tap water. Subsequently, the seeds were brought to a boil in water and allowed to boil for a duration of 30 minutes. After boiling, the jackfruit seeds were strained and rinsed with water. Excess water was drained from the seeds by exposing them to room temperature (approximately 25°C) for a period of two hours.

The cleaned jackfruit seeds were subsequently cut into small pieces and subjected to a drying process in a tray dryer at 45°C for a duration of 48 hours. Following the drying process, the seeds were roasted in an oven at 160°C for 60 minutes. Once the roasting was complete, all the roasted samples were removed from their respective ovens and placed on trays, ready for the subsequent phase, which involved the grinding process. The roasted jackfruit seeds were introduced into a conventional food grinder (PANA-MX-800) and ground for a duration of 1 minute.

Finally, following the grinding process, the roasted jackfruit seeds were sieved using a conventional sieve with a particle size ranging from 0.18 to 0.20 mm. The resulting jackfruit seed powders were carefully stored in an air-tight container at a temperature of 4°C, awaiting further analysis.

3.3 Formulation of Jackfruit Seed Cookies

The jackfruit seed cookies were created using jackfruit seed powder, wheat flour, salt, sugar, baking soda, rice flour, vegetable oil and water. Firstly, jackfruit seed flour , whole wheat flour, rice flour, salt and baking soda (Refer to Table 1 for the ratio) were mix in a mixing bowl to well blend until getting the breadcrumb texture. Next, one spoon of water was added at a time to prepare the stiff pliable dough and let the dough rest for 15 minutes. The dough was rolled for 2 cm thickness and sharped using a cookie shaper upon baking at 180 °C for 20 minutes.

Table 1: Formulations of jackfruit seed cookies

Variations	JSF	Wheat Flour	Rice Flour	Sugar	Water	Baking Soda	Oil	Salt
Control sample	------	200 gr	10 gr	6 gr	50 gr	6 gr	6 gr	3 gr
V1	200 gr	------	10 gr	6 gr	50 gr	6 gr	6 gr	3 gr
V2	100 gr	100 gr	10 gr	6 gr	50 gr	6 gr	6 gr	3 gr
V3	50 gr	150 gr	10 gr	6 gr	50 gr	6 gr	6 gr	3 gr

JSF: Jackfruit Seed Flour

3.4 Descriptive Shelf-life Evaluation

Shelf-life evaluation was conducted by observing the jackfruit seed cookies over a period of fifteen days, commencing on January 2, 2023, and concluding on January 16, 2023. The cookies were stored in an airtight container at room temperature, with temperatures ranging from 19°C to 32°C. Throughout this observation period, any alterations or changes that occurred were carefully monitored and compared to a control sample.

3.5 Hedonic Sensory Analysis

The methodology for this analysis was adapted from Caliskan et al. (2020). The consumer analysis took place at the Faculty of Hotel and Tourism Management, Universiti Teknologi MARA, Puncak Alam Campus, and involved a group of 30 students aged between 20 and 23 years. In this sensory test, four samples were presented for evaluation. The researcher personally provided these samples to the participants. Before commencing the testing, all respondents received a brief introduction to the product. Each respondent was provided with a Google form to document their impressions of the product, utilizing a 5-point hedonic scale ranging from 1, representing 'dislike extremely,' to 5, representing 'like extremely.' This assessment covered six criteria, including colour, appearance, texture, mouthfeel, taste, and general acceptability.

To facilitate the testing process, each sample was clearly labelled to enable easy differentiation by the participants. The first sample, designated as Variation 1, consisted of jackfruit seed cookies prepared using a 1:0 ratio of flour, indicating that the dough was made entirely from jackfruit seed powder without any wheat flour. The second sample, labelled as Variation 2, was an experimental product made with a 1:1 ratio of flour, incorporating 50% jackfruit seed powder and 50% wheat flour. Lastly, the third sample, labelled as Variation 3, featured a 3:1 ratio of flour, comprising 25% jackfruit seed powder and 75% wheat flour in its composition.

3.6 Statistical Analysis

For all tests, the means and standard deviations were calculated. Significance in mean values was assessed at a significance level of ($p < 0.05$) using one-way analysis of variance (ANOVA) in conjunction with Fisher's post-hoc test. The analysis was conducted using Excel Software version 2016.

4 Findings

This section presents a detailed exposition of the results obtained through various analyses, including descriptive shelf-life analysis, consumer analysis, and assessment of nutritional properties. These analyses encompass all the samples containing jackfruit cookies, as well as the control sample made from wheat flour. Furthermore, this section incorporates pertinent discussions, in-depth analysis, and relevant comparisons to provide a comprehensive understanding of the findings.

4.1 Descriptive Shelf-Life Evaluation

Descriptive shelf-life evaluation involves the methodical assessment and recording of changes in a product's quality, safety, and stability as it undergoes storage under specific conditions. This evaluation plays a pivotal role in determining the duration for which a product can maintain its intended characteristics before reaching a point where it is no longer suitable for consumption or use.

In this context, the observation process was carried out over a period of approximately fifteen days, with the objective of analyzing any potential alterations that might occur in jackfruit seed cookies when stored at room temperature. The results presented below are derived from three distinct sample variations.

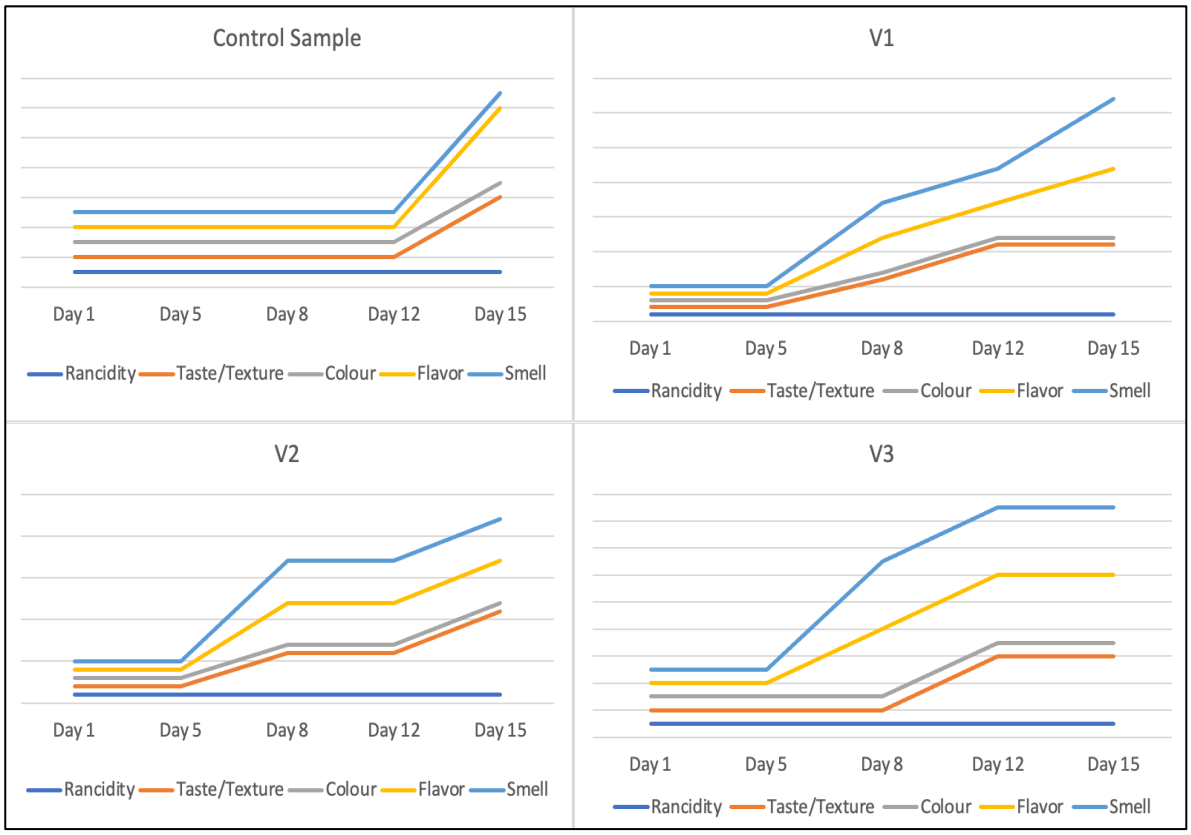

Figure 1: Changes in taste, texture, and smell during 15 days of sensory testing

Figure 1 shows the data gathered from three distinct variations subjected to a fifteen-day visual inspection. Notably, no indications of rancidity or mold growth were observed during this monitoring period. This lack of visible signs can be attributed to the product's low moisture and fat content, which effectively impedes bacterial growth and rancidity.

However, it is imperative to acknowledge that there were subtle taste variations in the jackfruit seed cookies (JSC) as the shelf life extended. These fluctuations can be attributed to the presence of odor-active compounds in jackfruit seeds, as proposed by

Spada et al. in 2021. In terms of texture, Variation 3 (25% JSF and 75% wheat flour) exhibited no change and remained crunchy throughout the entire fifteen-day storage duration, whereas Variation 1 (100% JSF) and Variation 2 (50% JSF and 50% wheat flour) transitioned from a crunchy to a slightly stiff texture over the same period. This transformation can be attributed to the proportions of jackfruit seed flour used in Variations 1 and 2. A study conducted by Habibah et al. (2021) corroborates this, revealing that an increase in the proportion of jackfruit seed flour in the macaron recipe leads to increased hardness in the macaron sample.

Regarding aroma, on the fifteenth day, Variation 1, which consisted of 100% JSC, emitted a strong smell of jackfruit seeds in its cookie sample. In contrast, Variations 2 and 3 exhibited a milder scent of jackfruit seed. This variation can be attributed to Variation 1 being exclusively composed of 100% jackfruit seed flour, while Variations 2 and 3 consisted of a combination of jackfruit seed flour and wheat flour at 50% and 25%, respectively. Visually, no noticeable changes were observed in the mixture, which is expected when a product has low moisture and low-fat content. There were no clumps or alterations in color within the powdered mixture of the jackfruit seed cookies.

In conclusion, based on the findings from the fifteen-day inspection, it can be inferred that a mixture of 25% jackfruit seed flour with wheat flour may be more suitable for use in the production of jackfruit seed cookies. This is because, after a 15-day storage period, the 100% jackfruit seed cookie (Variation 1) exhibited a strong jackfruit aroma, and both Variation 1 and Variation 2 (50% JSF) showed a transition in texture from crunchy to slightly stiff.

4.2 Hedonic sensory Analysis

A sensory analysis was conducted to assess the acceptability of three variations of Jackfruit Seed Cookies (JSC): Variation 1 (100% JSF - Jackfruit Seed Flour), Variation 2 (50% JSF and 50% wheat flour), and Variation 3 (25% JSF and 75% wheat flour), in comparison to a control sample made entirely of wheat flour (100%). The sensory attributes evaluated included color, appearance, texture, taste and overall acceptability. The study involved 30 participants aged 20 to 23. Panelists were instructed to rate the samples using a 5-point hedonic scale, where a rating of 1 signified extreme dislike, and a rating of 5 indicated extreme liking. The results of the sensory analysis for the three different JSC formulations are presented in Table 2.

Table 2: Sensory analysis of jackfruit seed cookies

Formulations	Sensorial Attributes				
	Colour	Appearance	Texture	Taste	Overall Acceptability
C	4.07±1.09[a]	4.04± 1.07[a]	4.22± 1.09[a]	4.11± 1.11[a]	4.11 ± 1.11[a]
V1	4.02± 0.76[a]	4.02 ± 0.57[a]	4.14± 1.02[a]	4.11± 1.11[a]	3.99 ± 0.67[a]
V2	4.08± 0.93[a]	4.05 ± 0.64[a]	4.09± 1.48[a]	4.07±17[a]	4.17 ± 1.12[a]
V3	4.25± 0.72[a]	4.06 ± 0.77[a]	4.19± 1.18[a]	4.13±1.29[a]	4.25 ± 1.42[a]

V1: 100% JSF, V2: 50% JSF, V3: 25% JSF, C: Control Sample

Note: 'a-e' indicates a significant difference between tested samples and 'A-C' indicate a significant difference within

The color of food products plays a crucial role in determining customer acceptance, as highlighted by Pal et al. (2018). In Table 2, the consumer panel's ratings for color acceptability followed the order of V3 > V2 > C > V1, with no significant differences ($p > 0.05$) observed among the four samples. These findings align with studies conducted by Palamthodi et al. (2021) and Shinde et al. (2021) on the use of jackfruit seed flour powder in muffins and ice cream, respectively. Both studies reported that formulations incorporating jackfruit seed flour exhibited no significant differences in terms of color.

In the category of appearance, the consumer panel's ratings placed V3 as the highest, followed by V2, C (control sample), and V1 in descending order. Notably, there were no significant differences ($p > 0.05$) observed among the four samples in terms of their appearance. Therefore, it is likely that the color of both the JSC and control samples played a role in influencing their appearance. As emphasized by MOF (2021), the color of any food is a fundamental attribute that significantly contributes to its overall appearance. Additionally, the results from the sensory analysis indicate that the assessments of color and appearance are closely related. Consequently, it is clear that the appearance of both the JSC and control samples was impacted by their respective colors. This finding is consistent with observations made in studies on bakery products conducted by Kaur & Kaur (2019), Kaur & Kaur (2017) and Singh et al. (2016) where they reported insignificant differences ($p > 0.05$) in the values of color and appearance in their respective research.

Table 2 presents the consumer panel's ratings for texture, with the following ranking: C (control sample) > V3 > V1 > V2, all of which were rated as "liked." Importantly, there were no significant differences ($p > 0.05$) observed among these four samples in terms of texture. In the formulation of JSC (Jackfruit Seed Cookies), the recipe followed the guidance provided by the control sample. Consequently, the quantities of ingredients and the cooking method used for the jackfruit seed cookies remained consistent with the control sample, except for the proportion of jackfruit seed flour. Therefore, it is reasonable to aspect similar texture properties across all samples,

including the JSC samples and the control sample. These results are in accordance with studies conducted by Anjushree et al. (2023) and Sampaio et al. (2022) on cookies made from noni and passion fruit peel, respectively. Both studies reported insignificant differences between their formulated samples and their respective control samples.

In term of taste, the panels rated V3 V2, C (control sample) as liked, while panel rated V1 as neutral status, with no significant differences. The reason for this disparity can be attributed to the composition of the V1 sample, which consisted entirely of 100% JSF (presumably Jackfruit Seed Flour), in contrast to V2 and V3, which were mixed with wheat flour. This finding aligns with a study conducted by Caliskan et al. in 2020, focused on Apam Balik Kuih (ABK) made from Leftover Coconut Pulp Flour (LOCPF). In their research, Caliskan and colleagues observed that, while taste evaluations did not yield significant differences, the F3 sample (comprising 100% LOCPF) was rated as unpleasant by the panel due to its exclusive use of leftover coconut pulp flour. In contrast, the F1 (60% WF + 40% rice flour) and F2 (60% LOCPF + 40% rice flour) samples, which featured a blend of ingredients, received more favorable “liked” ratings.

Table 2 displays the overall acceptability as assessed by the consumer panel. Regarding overall acceptability, the consumer panel expressed a preference for V3, V2, and the control sample (C), rating them as "liked." In contrast, V1 received a "neutral" rating, with no significant differences observed. Notably, the JFC samples (V1, V2, and V3) and the control sample yielded similar results in all categories except for taste. This suggests that the overall acceptability of the samples was primarily influenced by their taste. These findings are consistent with a study on bakery products that utilized quinoa flour, conducted by Kaur & Kaur (2017). Their research reported higher overall acceptability ratings for pies made from quinoa flour compared to the control sample, with ratings of 7.48 ± 0.16 and 7.24 ± 0.14, respectively. Furthermore, another study on cake, conducted by Wu et al. (2020), found that gluten-free cake made with rice flour and the addition of 0.4% tamarind seed gum achieved a 3% higher overall acceptability score than the control sample, which was made from wheat.

5 Conclusion

This research explored the practicality of incorporating jackfruit seeds as a sustainable substitute for wheat in cookie production, aimed at cost reduction. Jackfruit seed-based cookies were formulated and compared to a control sample consisting of 100% wheat flour. The formulations included V1 (100% jackfruit seed flour), V2 (50% jackfruit seed flour and 50% wheat flour), and V3 (25% jackfruit seed flour and 75% wheat flour). A comprehensive sensory assessment, encompassing both descriptive and hedonic evaluations, was conducted to assess shelf-life and consumer preferences, with a direct comparison to the control (100% wheat) cookies.

The descriptive sensory analysis assessed the texture, taste, aroma, color, and flavor of all samples over a 15-day storage period at room temperature. Results from this analysis indicated that V3 cookies maintained their quality over time, exhibiting similar characteristics to the control sample. In contrast, the hedonic sensory test, conducted

with a panel of 30 randomly selected individuals, revealed that V3 was the most preferred option in terms of overall acceptability, followed by V2, with the control sample ranking lower. V1 received a neutral rating in overall acceptability.

In conclusion, the combination of jackfruit seed flour with wheat flour demonstrates substantial potential for cookie production. The utilization of jackfruit seeds in cookies not only addresses waste reduction but also offers cost-saving opportunities in the baked goods manufacturing process. This study underscores the viability of harnessing jackfruit seeds as a valuable resource to tackle the challenges posed by the escalating costs of wheat in the bakery industry.

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Yusnita Hamzah, earned her Ph.D. in Food Science from The University of Nottingham, UK. She currently holds the position of Senior Lecturer at Universiti Malaysia Terengganu, Malaysia. Her research primarily revolves around the identification and characterization of starch, as well as the physical and chemical alteration of starch and its implications on various food products. Additionally, her research extends to the development of new ingredients and the utilization of underutilized materials to enhance the value of food products. Hamzah, Y. ensures that both new and modified food products undergo thorough characterization for their physicochemical properties, acceptability, and storage quality to estimate their shelf life. Previously, she served as the Head of the Food Science Program at UMT, and currently holds the position of Chief Operating Officer (COO) at the Strategic Innovation Centre (SIC) at Universiti Malaysia Terengganu. Hamzah, Y. has received numerous awards, including medals in various research and educational innovation competitions, as well as recognition as an oral and poster presenter at conferences

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