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Physicochemical and Sensory Evaluation of Banana Peel Crackers

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Abstrak-This study investigates the influence of banana peel ripeness stage (ripe vs. overripe) on the physicochemical and sensory properties of banana peel crackers. The peels were subjected to blanching, soaking in sugar, and deep-frying, followed by analysis of oil absorption, moisture, ash, calories, protein, fat, and carbohydrate content using AOAC standard methods. A sensory evaluation was conducted using a 5 point hedonic scale with 30 untrained panelists. Expected outcome might show that overripe peels had significantly higher oil absorption due to softened tissue and increased sugar content, while ripe peel crackers demonstrated lower oil uptake and better sensory acceptability. Moisture and fat contents were influenced by ripeness, whereas protein and ash contents were less affected. Sensory evaluations revealed that crackers made from ripe, blanched peels scored highest in overall acceptability, taste, and crispiness. The findings highlight the potential of banana peel as a value added, "low fat" label ingredient in functional snack products and emphasize the importance of peel ripeness and processing conditions in optimizing nutritional composition and consumer acceptance.

Keywords: Banana Peel Crackers; Ripeness Stage; Oil Absorption; Physicochemical Properties; Sensory Evaluation.

1. INTRODUCTION

Previous research has extensively utilized various forms of banana peel, including green, ripe, leaky ripe, and different cultivars such as Musa, Cavendish, Paradisiaca, Saba, and Plantain, as well as dried banana peel powder and extracts derived from them (Mokbel & Hashinaga, 2005; Sundaram et al., 2011; Emaga et al., 2007; Dom et al., 2021; Wachirasiri et al., 2009). While other fruit peels like apple, mango, grape, tomato, citrus, and pomegranate were mentioned for comparison of properties or extraction methods, the primary focus was on banana peel (Sundaram et al., 2011; Wani & Dhanya, 2025). These banana peel materials have been researched for their potential use in a wide range of final food products, including biscuits, cookies, crackers, bread, chapatti, yellow noodles, pasta, pudding, jelly, chicken sausage, fish patties, broiler nuggets, beef burger patties, waffle cones, yogurt, and also as food additives like gelling, thickening, and stabilizing agents, flavoring, natural food coloring, and for edible food wrappers and bioplastic films (Ayoub et al., 2022; Zaini et al., 2022; Dom et al., 2021; Wachirasiri et al., 2009; Wani & Dhanya, 2025).

The incorporation of banana peel significantly affected the final products by enhancing their nutritional value, particularly increasing dietary fibre, total phenolic content, flavonoid content, and mineral levels (like ash, potassium, iron, calcium, magnesium) (Hikal et al., 2022; Emaga et al., 2007; Putra et al., 2022). It also improved various functional properties, such as increasing water holding capacity and oil holding capacity, improving texture (hardness, chewiness, springiness, softness), increasing viscosity, providing gelling and stabilizing effects, and enhancing tensile strength in films (Dom et al., 2021; Wachirasiri et al., 2009; Zaini et al., 2022). Furthermore, it offered health benefits by acting as a source of antioxidants, scavenging free radicals, preventing lipid oxidation, demonstrating antimicrobial activity against various bacteria and fungi, showing potential anti-diabetic effects in term of lowering blood glucose and ACE inhibition, and exhibiting anticancer properties (Mokbel & Hashinaga, 2005; Sundaram et al., 2011; Hikal et al., 2022; Wani & Dhanya, 2025). In some cases, it also improved shelf life by reducing lipid oxidation and decreasing water activity (Wani & Dhanya, 2025; Putra et al., 2022). However, increasing the concentration of banana peel could sometimes lead to adverse effects on sensory attributes like taste (bitterness due to tannins), color, and texture, and the presence of anti-nutrients needs consideration (Ayoub et al., 2022; Wachirasiri et al., 2009).

Some researchers also incorporated various fruit and vegetable peels, such as orange peels (OP), banana peels (BP), and potato peels (PP), as well as by-products like oat bran, wheat bran, rice bran, red onion skin powder (ROSP), mango peel powder (MPP), and corn leaf powder (CLP) (Abozed & Ahmed, 2015) into final products primarily such as crackers, standard crackers; shallot peel flour crackers; and tapioca crispy crackers. The incorporation of these peels significantly enhances nutritional and functional quality through increases in total dietary fiber, total carotenoids, total phenolics/flavonoids, and antioxidant activity, contributing to health benefits and reducing rancidity (Elhassaneen et al., 2016; Agustin et al., 2021; Sirinjullapong et al., 2024; Abozed & Ahmed, 2015). Peels also supply minerals and can raise crude protein on a non-fat dry-matter basis (Elhassaneen et al., 2016; Abozed & Ahmed, 2015). Sensory outcomes vary by peel type and processing: some additions improve aroma or taste, while others impart darker color or aftertastes, although boiling banana peel can mitigate bitterness (Sirinjullapong et al., 2024). Overall, these studies demonstrate that incorporating peels is a viable approach to create functional, nutrient-enriched foods.

The primary problem statements revolve around the generation of large amounts of food processing by products, specifically fruit and vegetable peels, and the environmental and economic issues associated with their disposal. These by products, such as prickly pear peel and potato peel (Elhassaneen et al., 2016), shallot peel (Agustin et al., 2021), orange, potato peels, and banana generally (Zoair et al., 2016) and ripe banana peel (Sirinjullapong et al., 2024) which are often considered waste with limited uses. Their disposal poses a major problem that causes environmental pollution, including potential pollution of air and water. Simultaneously, these peels especially banana peels are rich in valuable

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components like dietary fiber, bioactive compounds, and antioxidants, which are often lost when the by products are discarded. Therefore, this research aims to address the problem of waste disposal and pollution by exploring the utilization or valorization of banana peels as functional ingredients in food products like crackers, leveraging its nutritional and health promoting properties. A specific challenge identified in utilizing overripe and ripe banana peels that its phenolic compounds can lead to bitterness in enriched crackers, limiting the amount that can be directly incorporated (Sirinjullapong et al., 2024). Processing methods are crucial to enhance final products nutritional aspects and sensory evaluation.

Research Objectives: a) To determine the effect of two ripeness stages (ripe vs. overripe) on oil absorption, b) To investigate physicochemical (e.g., moisture, ash, calorie, protein, carbohydrate, and fat) results for each banana-peel cracker processing variant?, c) To evaluate sensory evaluation (color, texture (crispiness), taste, odor, and overall acceptability) of crackers from each ripeness stage. Research Questions: a) How do ripeness stage influence oil absorption of banana peel crackers?, b) What physicochemical determination (e.g., moisture, ash, calorie, protein, carbohydrate, and fat) results for each banana-peel cracker processing variant?, c) What are the differences in consumer liking (color, texture (crispiness), taste, odor, and overall acceptability) among crackers produced under the different ripeness?

2. METHODOLOGY

2.1 Research Design

This study adopts an experimental laboratory-based design to evaluate the suitability of banana peel as crackers. The research will be conducted in three phases: preparation of banana peel crackers, physicochemical analyses, and sensory evaluation.

2.2 Sample Preparation

The study utilized banana peels, banana (Musa spp.) sourced from local markets. There are two types of ripeness stages (ripe vs. overripe) for the research. Banana peels were washed under running water, blanched in boiling water for 3 minutes, and soaked in sugary for 10 minutes. The banana peels were oven-dried at room temperature for approximately 24 hours. The sugary banana peels were deep fried for 3 minutes until browning and let cool down for 30 minutes. The resulting crackers were stored in container at 4°C until consumption.

Table 1. Formulation of banana peel crackers

Ingredients	Ripe	Overripe
Banana peel	1000 g	1000 g
Sugar	120 g	120 g
Warm water	500 ml	500 ml

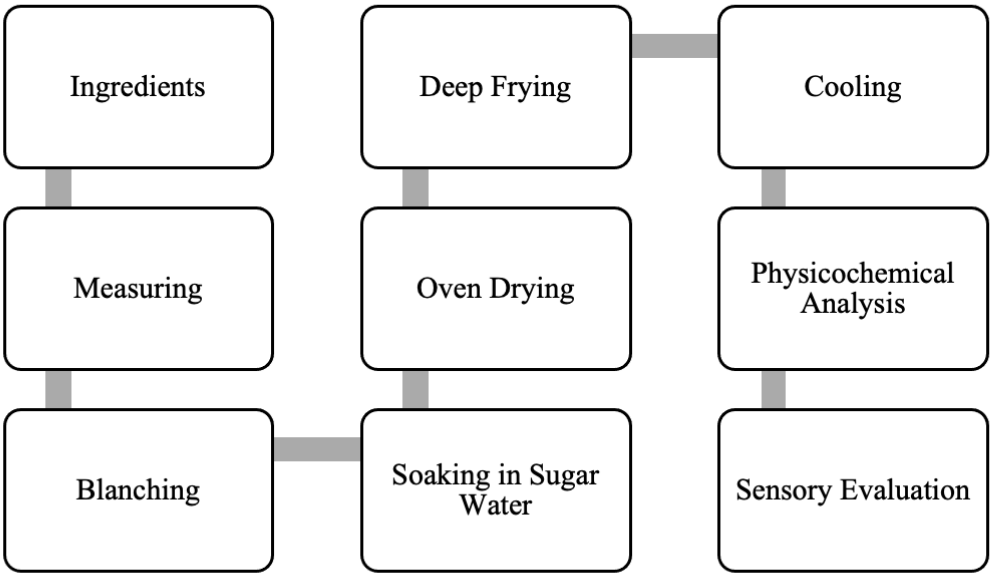

Figure 1: Banana Peel Crackers's Process Diagram

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Figure 2: Banana Peel Crackers

2.3 Physicochemical Analyses

The oil absorption of banana peel crackers were determined before (w1) and after (w2) deep frying according to AOAC method (1975). The following equation was used to measure the oil absorption of crackers.

$$Oil\ absorption\ = \left(\frac{w2-w1}{w1}\right) \text{x } 100 \quad (1)$$

The physicochemical properties of the developed crackers were evaluated using standardized procedures. Physicochemical composition such as moisture, calorie, protein, carbohydrate, and fat were determined according to the AOAC (2000) standard method. Moisture content of the banana peel crackers was determined using a hot-air oven at 100-105°C for 4 hours (Method 925.40; AOAC 2000), ash contents were measured by muffle furnace incineration (Method 940.26: 2000). Protein content (% N6.25) was determined by the Kjedahl Method (Method 955.04; AOAC 2000). Crude fat test was carried out based on the Soxhlet extraction method utilizing petroleum ether at 40-60°C (Method 920.39; AOAC 2000). All results were expressed in grams per 100 g flour. Carbohydrate content was determined by difference through the following equation:

$$\text{carbohydrate} = 100\% - (\text{moisture content} + \text{crude protein} + \text{crude fat} + \text{ash})\,\%. \quad (2)$$

2.4 Sensory Evaluation

Sensory evaluations were conducted to assess product acceptability. A 5 point hedonic scale was used in the banana peel crackers's sensory study, where 1 represented "most disliked" and 5 represented "most liked". Consumer preference of banana peel crackers was evaluated in terms of colour, texture , taste, aroma, and overall acceptability. A descriptive analysis with line scale scoring test was conducted to compare the different perceptions. Evaluations involving 30 untrained panelists from the Unit Pemprosesan dan Teknologi Makanan, Kolej Komuniti Arau. All the banana peel crackers samples cut into the same size and arranged on a plate while the drinking water served for mouthrinsing. The test sample was coded with a three digits random number. The panel is required to deliver an intensity score for each attribute in scale. There are five attributes evaluated which were color, texture (crispiness), taste, aroma, and overall acceptability of banana peel crackers. For hedonic tests, panels were asked to give a score for the samples.

2.5 Statistical Analysis

A one-way experimental design was used to analyse physichochemical analysis and sensory evaluation. An ANOVA procedure was carried out to determine the statistical differences among formulations, and afterwards a Tukey test ($p<0.05$) was conducted. All analyses were performed with SPSS software version 23.

3. POTENTIAL RESEARCH OUTCOME

Physicochemical analysis and sensory evaluation's result will be analyzed using one-way ANOVA followed by Tukey's post hoc test to determine statistically significant differences ($p < 0.05$) between the overripe and ripe banana peel. All experiments will be performed in triplicate, and data were reported as mean ± standard deviation.

3.1 Effect of Two Ripeness Stages (Ripe vs. Overripe) on Oil Absorption

The ripeness stage of banana peels significantly influences the oil absorption in banana peel cracker formulations. Overripe banana peels, due to their enzymatic softening and higher sugar content, tend to retain more moisture and absorb more oil during frying and increase in fat absorption. This is attributed to the breakdown of cell walls and greater porosity, which facilitates oil penetration. This observation is in line with Sirinjullapong et al. (2024), where stated that crackers enriched with ripe banana peels exhibited high fat content (up to 29.41%) as a result of oil absorption from deep frying, while moisture content in fresh banana peel reached 91.68%, indicating high initial water activity. Moisture reduction was emphasized to improve crispiness and shelf stability. This explains the reason to understand ripeness's related differences is critical in optimizing the frying performance and nutritional profile of banana peel crackers, particularly when targeting "low fat" label products.

3.2 Physicochemical Results (Moisture, Calorie, Protein, Carbohydrate, and Fat)

The physicochemical composition of banana peel crackers varies according to ripeness and processing method. In this research, the results may exhibit high content of fat, mositure, protein, carbohydrate and fibre. It makes an agreement with previous research in enriched crackers from the Sirinjullapong et al. (2024) study, crude fat content reached 29.41% due to frying, while total dietary fiber increased significantly in enriched samples. Although protein levels increased on a dry matter basis, they were not statistically significant in final products. Besides that, other studies, such as Elhassaneen et al. (2016), provided total dietary fiber data (up to 45.91 g/100g in potato peel) but lacked full macronutrient profiles. Furthermore, the inclusion of ripe banana peels thus enhances dietary fiber content in banana peel crackers while requiring careful control of oil absorption to maintain desirable fat content.

3.3 Sensory Evaluation (Color, Texture, Taste, Aroma, and Overall Acceptability) of Banana Peel Crackers

Sensory evaluation is crucial in determining consumer acceptance of banana peel crackers prepared from different ripeness stages. Based on previous studies, ripe banana peel crackers are expected to perform better in terms of color and crispiness due to balanced sugar and fiber content, whereas overripe peels may produce darker, softer products with stronger aroma but compromised texture. Sirinjullapong et al. (2024) suggested, crackers made with ripe banana peels were rated highly for texture and taste. Similar results were also showed by Agustin et al. (2021) that incorporating shallot peel flour significantly influenced aroma and flavor, with high panelist acceptance. Blanching, while effective in reducing microbial load and oil absorption, may slightly reduce flavor intensity, as suggested in fiber-enriched formulations by Zoair et al. (2016). Thus, balancing sensory quality with blanching pretreatment and ripeness stage is essential to produce consumer preferred, sustainable crackers.

4. CONCLUSION

Utilizing banana peels as crackers was explored to valorize agricultural food waste such as banana peels and enhance nutritional value. The effect of ripeness of banana on cracker's oil absorption was not consistently reported from previous researches. The most consistent physicochemical result was a significant increase in total dietary fiber content in crackers with peel's utilization. The impact on other components varied; the banana peel study reported increased oil absorption during frying, leading to higher crude fat and total calories in enriched crackers, while protein content was not significantly increased, and ash was not significantly affected. Sensory evaluation results regarding panel acceptance differed depending on the type and amount of peel used; optimized banana peel crackers were very well received, sometimes improving specific attributes like crispiness or taste but not always overall liking. Overall, the utilization of banana peel clearly affected the physicochemical composition, notably increasing fiber, and had varied but significant effects on sensory acceptance and related properties like oil absorption, demonstrating that the specific peel ripeness stage and its pretreatment method such as blaching are crucial factors.

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