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Quality and Potential of Rambutan Peel (Nephelium Lappaceum L.) Kombucha as a Health Drink

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ABSTRACT

Herbal infusion in the form of tea made from the skin of rambutan fruit can be consumed as a healthy homemade drink. Aside from being made into a homemade drink, tea from rambutan fruit skin can also be processed into other beverages such as kombucha drink. To produce a quality kombucha drink with health potential, several chemical characteristics need to be determined. The purpose of this study was to examine the effect of variations in sugar concentration and fermentation time on chemical characteristics. The design used in this study was a randomized group design (RACK) with one factor, namely fermentation duration, which consisted of three levels as follows: L_1 = fermentation for 10 days, L_2 = fermentation for 12 days, L_3 = fermentation for 14 days. Each treatment was repeated three times, resulting in a total of 9 study units. The sugar concentration variations were G_1 = 5%, G_2 = 10%, and G_3 = 15%. The results showed that variations in sugar concentration and fermentation time of rambutan fruit skin kombucha affect total acidity, vitamin C levels, pH, and organoleptic properties, indicating that it is likely beneficial as a health drink. The sugar concentration and fermentation time influenced total acid content, vitamin C, pH, and the organoleptic quality of the rambutan fruit skin kombucha, with the best results achieved at a sugar concentration of 15% and a fermentation period of 14 days.

Keywords: *kombucha, rambutan fruit skin, total acidity, vitamin C content, pH*

INTRODUCTION

Indonesia is a tropical country rich in plant and animal biodiversity (Setiawan, 2022). One of the interesting aspects of biodiversity from plants is rambutan (Nephelium lappaceum L.) (Anggraini, 2017). The skin of the rambutan fruit still has potential to be used in the health sector (Aji et al., 2020). Nurfadillah et al. in 2016 reported that rambutan fruit peel was traditionally used as a medicine for dysentery and fever. Anggara et al. (2019) showed that an herbal brewed drink in the form of rambutan fruit peel tea can be consumed as a practical healthy drink without interfering with daily routines.

The research problem in this study addresses the underutilization of rambutan peel as a substrate for kombucha production, despite its established bioactive compounds and traditional medicinal properties. While rambutan peel has been successfully processed into herbal teas, there remains limited scientific understanding of how different fermentation parameters affect the nutritional quality and health potential of rambutan peel kombucha. This knowledge gap prevents optimal utilization of this agricultural waste for producing functional beverages with standardized quality characteristics.

The urgency of this research stems from the increasing global demand for functional foods and probiotic beverages, combined with the need for sustainable utilization of agricultural waste. Indonesia produces significant quantities of rambutan annually, generating substantial peel waste that is typically discarded. Developing scientific protocols for converting this waste into high-quality health beverages addresses both environmental sustainability and public health nutrition needs. Furthermore, the growing consumer preference for natural, probiotic-rich beverages creates immediate market opportunities for optimized rambutan peel kombucha products.

In addition to being used as a daily drink served in a traditional way or in packaging, rambutan fruit peel tea can be processed into kombucha. Kombucha is a drink produced from the fermentation of a solution of tea and cane sugar with the help of the initial bacteria of kombucha (Khamidah & Antarlina, 2020). The starting bacteria of kombucha are the bacterium Acetobacter xylinum and some variants of yeast, such as Saccharomyces cerevisiae, Zygosaccharomyces bailii, and Candida sp (Mayang Sari & Dan Ketut Budaraga, 2017). Kombucha has long been known in various varieties (Firdaus et al., 2020). This diversity is due to the use of various tea ingredients, the initial bacteria of kombucha, and the length of the manufacturing process (Rahmatullah et al., 2021).

Previous research on kombucha has primarily focused on traditional tea substrates such as black tea and green tea, with limited exploration of fruit peel substrates. Studies by Firdaus et al. (2020) reviewed kombucha as a functional beverage using various tea bases but did not investigate fruit waste substrates. Research by Rosyada et al. (2023) examined sugar concentration effects on kombucha characteristics but used conventional tea substrates rather than agricultural waste materials. While studies have demonstrated the antioxidant properties of rambutan peel extracts (Nurfadillah et al., 2016), there is limited research on how these bioactive compounds behave during kombucha fermentation processes and how fermentation parameters influence the final product quality.

The research gap specifically lies in the absence of systematic studies examining the interaction effects of sugar concentration and fermentation time on rambutan peel kombucha quality parameters. While individual studies have explored either fermentation time or sugar concentration effects on kombucha quality using conventional substrates, there is no comprehensive analysis of how these factors simultaneously influence the nutritional and sensory characteristics of fruit peel-based kombucha. This gap is particularly significant for rambutan peel, which contains unique bioactive compounds that may behave differently during fermentation compared to traditional tea substrates.

The novelty of this research lies in its systematic investigation of rambutan peel as a novel kombucha substrate, combining sustainable waste utilization with functional food development. Unlike previous studies that focused on conventional tea substrates, this research explores the unique fermentation characteristics of fruit peel substrates and their potential for producing health beverages with distinct nutritional profiles. The factorial experimental design examining both sugar concentration and fermentation time effects provides comprehensive insights into optimal processing conditions for this novel application.

The specific objectives of this study are: (1) to evaluate the effect of different sugar concentrations (5%, 10%, 15%) on the chemical characteristics of rambutan peel kombucha; (2) to assess the influence of fermentation time (10, 12, 14 days) on product quality parameters; (3) to determine the optimal combination of sugar concentration and fermentation time for producing high-quality rambutan peel kombucha; (4) to analyze the vitamin C content, pH levels, total acidity, and organoleptic properties of the resulting products; and (5) to establish the potential of rambutan peel kombucha as a functional health beverage.

The benefits of this research include providing scientific protocols for converting agricultural waste into value-added products, contributing to sustainable food processing practices, offering new product development opportunities for the beverage industry, providing evidence-based information for functional food applications, and supporting economic

development through agricultural waste valorization. The practical implications extend to food manufacturers, agricultural waste management systems, and health-conscious consumers seeking natural probiotic beverages with documented nutritional benefits.

The researcher aims to improve the quality of kombucha through a variety of sugar concentrations and fermentation process times, resulting in the title of the study "The Effect of Variations in Sugar Concentration and Fermentation Time of Rambutan Fruit Peels (Nephelium lappaceum L.) Against the Quality of Kombucha Drinks".

METHOD

This study employed a quantitative experimental research design using a randomized complete block design (RCBD) to investigate the effects of sugar concentration and fermentation time on rambutan peel kombucha quality. The population consisted of all possible kombucha samples produced from rambutan peel under different processing conditions. The sample included 27 experimental units (9 treatment combinations × 3 replications) representing different combinations of sugar concentration and fermentation time treatments.

The randomized group (RAK) design involves one factor, namely the length of fermentation days with three different levels: L1 = 10 days, L2 = 12 days, and L3 = 14 days. Each level is repeated three times, resulting in a total of nine research units. and sugar concentration variation G1 = 5%, G2 = 10%, G3 = 15%. The tools in this study are burettes, analytical scales, petri dishes, hot plates, test tubes, drip pipettes, measuring cups, beakerglass, Erlenmeyer, measuring flasks, funnels, incubators, pH meters and handrefractometers. The ingredients used are rambutan fruit peels obtained in private gardens, kombucha starters, sugar and aquadest, chemicals for the analysis of vitamin C levels, total acidity and organoleptic tests of taste, aroma and color.

RESULTS AND DISCUSSION

Up to vitamin C

The purpose of knowing the vitamin C level from the fermented kombucha is to provide information to the public that kombucha contains vitamin C which is beneficial for the body (Fermentasi & Masa, 2024).

The vitamin C levels of the fermented kombucha of rambutan skin are as follows

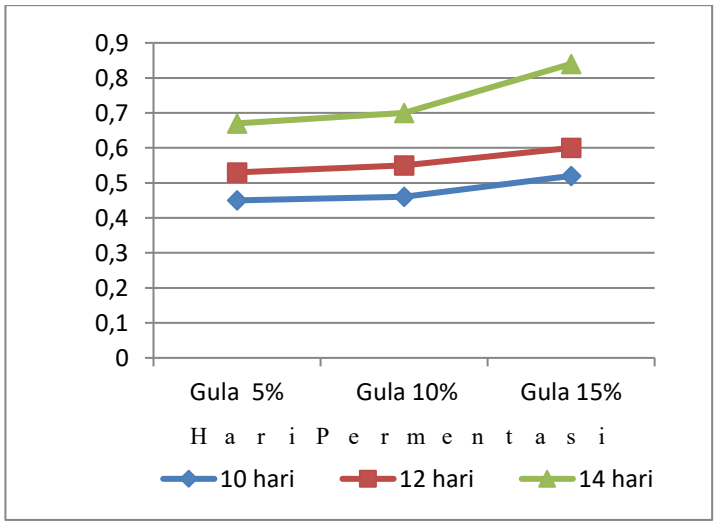

Figure 1 Graph of the effect of sugar concentration and fermentation time on the average level of vitamin C in kombucha of rambutan fruit peel

The vitamin C levels in kombucha vary depending on the fermentation time and heating temperature, as seen in the graph of the increase in vitamin C levels on day 14 due to the conversion of glucose into vitamin C (Apriani, 2017).

In the fermentation process, Acetobacter xylinum bacteria will produce vitamin C. D-Glucose will be reduced to D-sorbitol. In the early stages of fermentation, the D-sorbitol compound will undergo a change to L-sorbose in the presence of an enzyme produced by the bacterium Acetobacter xylinum. The alcohol groups of sugar compounds can be oxidized by bacteria in the presence of oxygen. L-sorbose is further fermented into ascorbic acid. The longer the fermentation is carried out, the more the content of ascorbic acid (vitamin C) in the kombucha produced will increase (Apriani, 2017).

Ph

pH is one of the crucial environmental factors in its influence on the kombucha fermentation process. The acids produced in the process include acetic acid and gluconic acid (Rahmi Hafsari et al., 2021).

The pH of the fermented kombucha of rambutan peel tea is as follows:

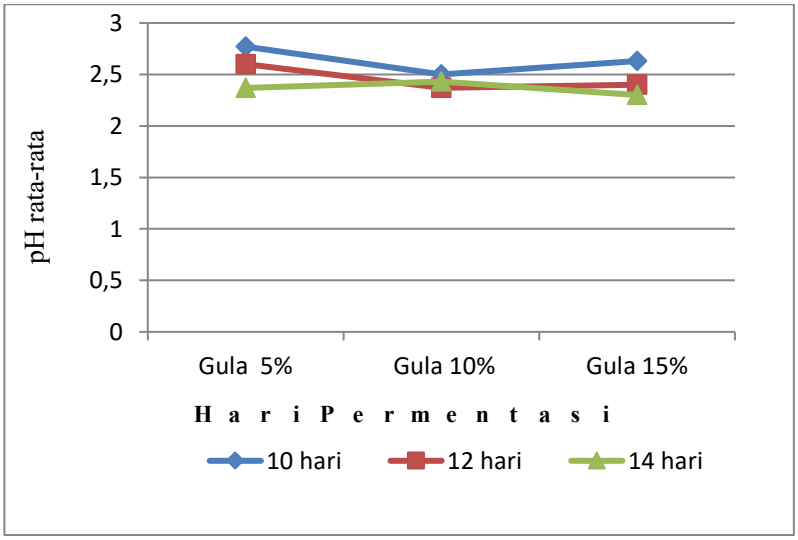

Figure 2 Graph Average pH of kombucha the influence of sugar concentration and the fermentation time of rambutan fruit peel tea

The pH value of kombucha that is safe to consume is between 3-5.5 (Rosyada et al., 2023). When the pH of kombucha is below the safe threshold for consumption, it is recommended to dilute it first. It is known that there is a decrease in pH during the fermentation time. This decrease in pH indicates that the acid content in kombucha is getting higher.

Total Acid

The total kombucha acid produced from the fermentation process will increase with the fermentation time (Hanggaeni et al., 2021).

The total acidity from the fermentation of kombucha is as follows

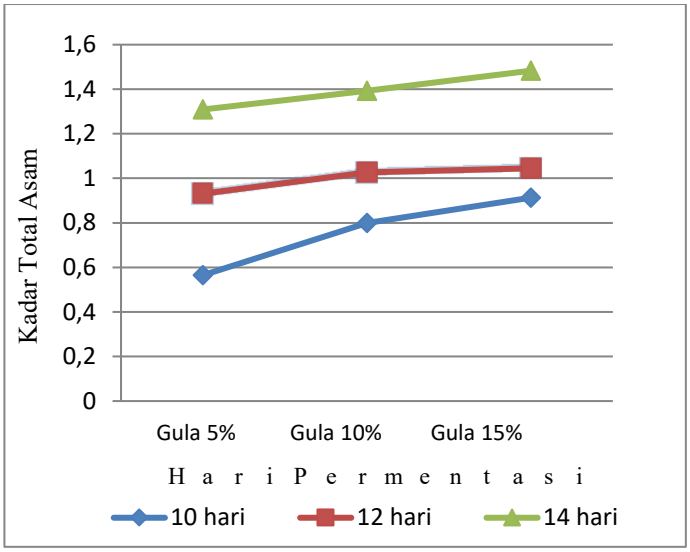

Figure 3 Graph Total Kombucha acid effects of sugar concentration and length of fermentation time of rambutan fruit peel tea

Total acid is closely related to total lactic acid bacteria. The longer the fermentation process, the more lactic acid bacteria develop. The increasing number of bacteria causes lactic acid production to increase from the ongoing bacterial metabolism (Rosyada et al., 2023).

Organoleptic tests

Organoleptic tests on kombucha fermentation results were carried out to assess the quality and acceptability of kombucha to color, taste, and aroma (Kushargina et al., 2023). The color organoleptic test of the fermentation of kombucha kilit rambutan is as follows

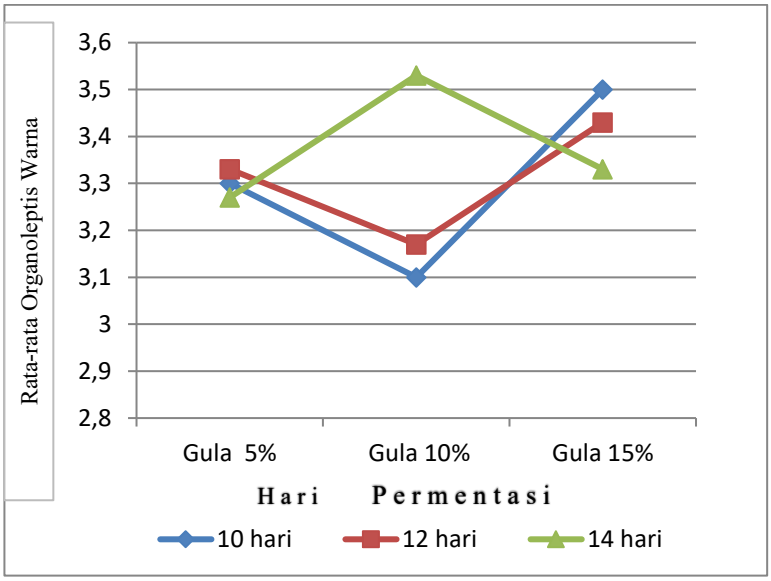

Figure 4 Graph of the color organoleptic average of the panelists' assessment of the kombucha of rambutan fruit peel

There was a significant difference in the color testing of kombucha. Kombucha's 15% sugar content on day 14 reached its highest peak during the fermentation process (Jamilah,

2019). The aroma organoleptic test from the fermentation of kombucha kilit rambutan is as follows

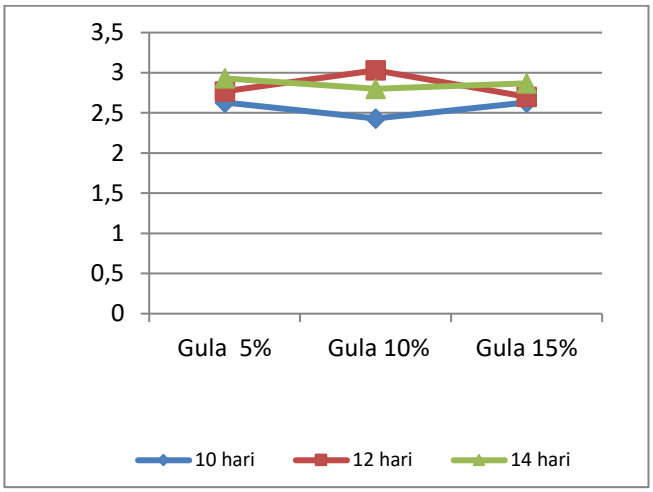

Figure 5 Average graph of aromatic organoleptic results of panelists' assessment on kombucha fruit peels

The aroma of kombucha is thought to have acidic elements according to organoleptic panelists During the fermentation process of rambutan peel tea, scoby cultures produce a variety of compounds, including volatile and non-volatile acids, as well as non-carbonyl kombucha. These compounds include acetic acid, acetaldehyde, acetone, acetone, acetone, and diacetyl, all of which play a role in determining the distinctive aroma of kombucha (Kushargina et al., 2023).

The organoleptic taste test from the fermentation of kombucha kilit rambutan is as follows:

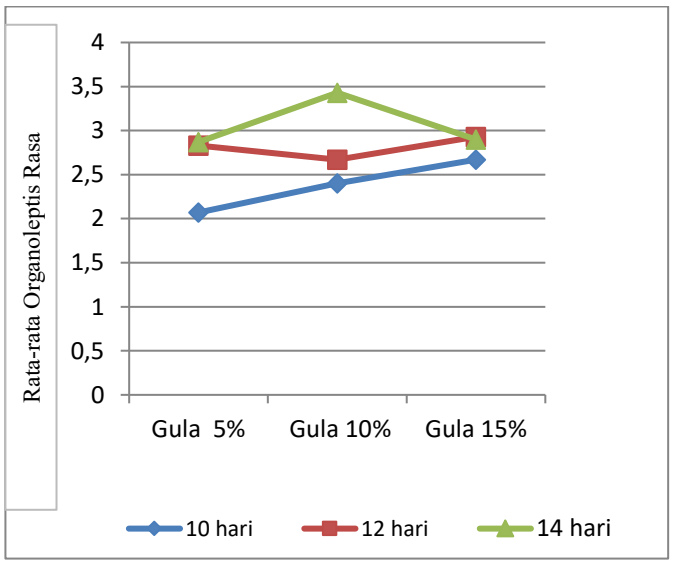

Figure 6 Graph of the average taste organoleptic results of the panelists' assessment of the kombucha of rambutan fruit peels

Discussions

Based on the experimental results, the data clearly demonstrate that both sugar concentration and fermentation time significantly influence the key quality parameters of rambutan peel kombucha. The highest vitamin C content was achieved at the 15% sugar

concentration (G3) and the longest fermentation period of 14 days (L3). This can be interpreted as a direct result of the metabolic activity of the microbial consortium in the kombucha culture (SCOBY). The conversion of glucose into ascorbic acid by *Acetobacter xylinum* is a well-documented pathway, and the ample sugar substrate (15%) provided the necessary energy and carbon source for this biosynthesis to proceed efficiently over the extended 14-day period. This finding aligns with the work of Apriani (2017), who reported a positive correlation between fermentation duration and vitamin C content in soursop leaf kombucha, confirming that prolonged fermentation allows for greater accumulation of this vital antioxidant.

The observed decrease in pH, which was most pronounced in the G3L3 treatment, is a direct indicator of organic acid production, primarily acetic and gluconic acids, as metabolic byproducts of the fermentation process. The inverse relationship between pH and total acidity is a fundamental biochemical principle, and our data robustly confirms this, showing the highest total acidity at the highest sugar level and longest time. This trend is consistent with previous research by Hanggaeni et al. (2021) on coffee cascara kombucha, who also noted a steady decline in pH coupled with a rise in total acid content over time. The pH values recorded for all treatments remained within the safe consumption range of 3.0-5.5, as stipulated by Rosyada et al. (2023), indicating that the fermentation process was both effective and safe, producing a characteristically tangy kombucha beverage.

Organoleptic assessment revealed that the G3L3 treatment was also superior in terms of sensory attributes, receiving the highest scores for color, aroma, and taste. The development of a more complex and acceptable flavor profile after 14 days suggests that the longer fermentation allowed for the full development and balance of volatile compounds, such as acetic acid, acetaldehyde, and diacetyl, which contribute to kombucha's distinctive aroma. This finding partially contrasts with the results of Kushargina et al. (2023), who found that a shorter fermentation time was preferred for butterfly pea flower kombucha to avoid excessive sourness. This discrepancy highlights a critical point: the optimal fermentation parameters are highly substrate-dependent. The unique composition of rambutan peel, rich in distinct bioactive compounds and sugars, necessitates a longer fermentation to mellow potential astringency and develop a desirable flavor complexity compared to other substrates.

When compared to the broader body of kombucha research, this study's novelty lies in its successful application of a waste-oriented agricultural byproduct. While Firdaus et al. (2020) extensively reviewed functional kombucha from various tea bases, they did not explore fruit peel substrates. Our research bridges this gap by demonstrating that rambutan peel is not merely a viable alternative but a substrate capable of producing a high-quality beverage with optimized nutritional and sensory properties. The factorial approach (sugar x time) provides a more comprehensive and industrially relevant optimization model than studies that manipulate a single variable, such as Jamilah (2019) who only varied starter concentration.

A practical solution derived from this analysis is the establishment of a standardized protocol for rambutan peel kombucha production: utilizing a 15% sugar concentration and a 14-day fermentation period at ambient temperature to consistently achieve a product high in vitamin C, with a safe pH, and desirable organoleptic qualities. This protocol provides a clear roadmap for small-scale producers and the beverage industry to valorize rambutan waste, transforming an environmental liability into an economic asset. Furthermore, monitoring pH

serves as a simple, effective quality control measure to ensure product safety and consistency across batches.

The practical implications of these findings are substantial for the functional food and beverage sector. This research provides a scientifically-backed method for creating a novel health drink that aligns with consumer trends towards natural, probiotic-rich, and sustainable products. By utilizing rambutan peel, producers can reduce agricultural waste, lower raw material costs, and market a product with a unique story of sustainability and innovation. The documented high vitamin C content offers a strong nutritional marketing angle, positioning the beverage as an immune-supporting functional drink.

For future commercial application, it is recommended that producers conduct consumer acceptance trials to fine-tune the flavor profile for specific target markets and invest in stability studies to determine shelf-life and optimal packaging conditions. Scaling up the process from the laboratory to an industrial scale will be the next critical step, requiring further research into the kinetics of fermentation in larger vessels and the potential need for slight parameter adjustments to maintain the high quality demonstrated at the bench scale. This research ultimately paves the way for a new value chain centered on the sustainable exploitation of fruit processing waste.

CONCLUSION

The quality of rambutan peel kombucha tea was enhanced by varying sugar concentrations and fermentation times, with the best results observed at 15% sugar concentration and 14 days of fermentation, positively affecting total acidity, vitamin C content, pH, and organoleptic properties. Based on these findings, it is recommended that commercial producers adopt these parameters for optimal product quality, while quality control should include monitoring pH levels within the safe range of 3–5.5. Future research should focus on analyzing changes in bioactive compound profiles during fermentation, assessing the feasibility of scaling up production for the industry, conducting shelf-life and storage stability studies to optimize packaging and distribution, and performing consumer acceptance studies to evaluate market potential and inform product positioning strategies for this promising functional beverage.

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