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DULCET: Valorization of Rambutan (Nephelium lappaceum) Seed Waste into Herbal Tea as an Environmental Education Project

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Abstrak

Limbah organik yang dihasilkan oleh toko kue lokal berkontribusi terhadap polusi lingkungan, khususnya melalui pembuangan biji buah. Biji rambutan (Nephelium lappaceum) umumnya dibuang meskipun dilaporkan dalam penelitian sebelumnya mengandung senyawa bioaktif seperti flavonoid, tanin, dan polifenol. Penelitian ini bertujuan untuk mengeksplorasi pemanfaatan limbah biji rambutan sebagai produk teh herbal melalui proyek pendidikan lingkungan berbasis siswa. Penelitian ini menggunakan pendekatan observasi berbasis sekolah yang dikombinasikan dengan analisis literatur. Biji rambutan dikumpulkan dari toko kue lokal, diproses melalui pengeringan dan pemanggangan, dan diseduh menjadi infus teh. Bunga Butterfly Pea (Clitoria ternatea) ditambahkan untuk meningkatkan karakteristik sensorik. Pengamatan langsung terhadap warna, aroma, dan rasa dilakukan oleh tim siswa, sedangkan data terkait kandungan fitokimia, aktivitas antioksidan, dan sifat antimikroba dikumpulkan dari penelitian yang telah dipublikasikan sebelumnya. Berdasarkan sumber literatur, teh biji rambutan dilaporkan menunjukkan penghambatan antioksidan sekitar 62% dan aktivitas antibakteri terhadap Escherichia coli dan Staphylococcus aureus. Kombinasi dengan Bunga Telang menunjukkan aktivitas antioksidan yang lebih tinggi (hingga 75%) dan menghasilkan infus berwarna ungu-biru yang menarik secara visual. Hasil observasi menunjukkan karakteristik sensorik yang dapat diterima di antara para peserta. Proyek ini menyoroti potensi pemanfaatan limbah sebagai pendekatan pendidikan untuk meningkatkan kesadaran lingkungan dan inovasi siswa. Temuan menunjukkan bahwa limbah biji rambutan dapat diperkenalkan sebagai konsep teh herbal fungsional berdasarkan literatur yang ada, sekaligus mendukung pengelolaan limbah berkelanjutan dan inisiatif pendidikan lingkungan.
Kata Kunci: Biji rambutan, Teh herbal, Pengelolaan limbah, Ilmu lingkungan

Abstract

Organic waste generated by local sweet shops contributes to environmental pollution, particularly through the disposal of fruit seeds. Rambutan (Nephelium lappaceum) seeds are commonly discarded despite being reported in previous studies to contain bioactive compounds such as flavonoids, tannins, and polyphenols. This study aimed to explore the utilization of rambutan seed waste as an herbal tea product through a student-based environmental education project. The study employed a school-based observational approach combined with literature analysis. Rambutan seeds were collected from a local sweet shop, processed through drying and roasting, and brewed into tea infusions. Butterfly Pea Flower (Clitoria ternatea) was added to improve sensory characteristics. Direct observations of color, aroma, and taste were conducted by the student team, while data related to phytochemical content, antioxidant activity, and antimicrobial properties were compiled from previously published studies. Based on literature sources, rambutan seed tea has been reported to exhibit antioxidant inhibition of approximately 62% and antibacterial activity against Escherichia coli and Staphylococcus aureus. The combination with Butterfly Pea Flower showed higher reported antioxidant activity (up to 75%) and produced a visually appealing purple-blue infusion. Observational results indicated acceptable sensory characteristics among participants. This project highlights the potential of waste valorization as an educational approach to promote environmental awareness and student innovation. The findings suggest that rambutan seed waste can be introduced as a functional herbal tea concept based on existing literature, while simultaneously supporting sustainable waste management and environmental education initiatives.
Keywords: *Rambutan seed, Herbal tea, Waste management, Environmental Science*

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INTRODUCTION

Organic waste from food industries and local sweet shops significantly contributes to environmental pollution, particularly through the disposal of fruit processing by-products such as seeds. Rambutan (Nephelium lappaceum) is widely consumed in Southeast Asia, and its seeds are frequently discarded as waste after processing (Jusuf et al., 2025). Improper disposal of organic waste can lead to environmental issues and inefficient resource use. Recent research has shown that rambutan seeds contain phenolic compounds and exhibit

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antioxidant activity, indicating potential for value-added use rather than mere disposal (Jusuf et al., 2025). This suggests that rambutan seed waste could be repurposed into functional products through appropriate processing.

In addition, Butterfly Pea Flower (Clitoria ternatea), known locally as bunga telang, has gained attention for its rich content of anthocyanins and other bioactive compounds with antioxidant properties. Studies have demonstrated that Clitoria ternatea flower extracts contain phenolic compounds and anthocyanins that contribute to their antioxidant potential and distinctive natural coloration, which have applications in food and beverage products such as herbal tea (Putri & Mandasari, 2024).

Despite the identified bioactive potential of both rambutan seeds and butterfly pea flower, there has been limited exploration of their combined utilization as a waste-based herbal tea concept, particularly within student research projects. Therefore, this study aims to explore the utilization of rambutan seed waste combined with butterfly pea flower through a school-based observational and literature-based approach.

As an initial step to support this study, direct observations were conducted on the utilization process of rambutan seeds as a herbal tea ingredient, starting from the collection of rambutan seed waste from a local sweet shop to simple processing stages including washing, drying, and roasting. The observations aimed to identify physical changes in the raw materials, such as color, aroma, and texture, after each processing stage. In addition, observations were carried out on the characteristics of the brewed tea, including infusion color, aroma, and taste, both for rambutan seed tea and its combination with butterfly pea flower. The observational data were then used as a basis for comparison with scientific findings from previous literature related to bioactive compounds, antioxidant activity, and the potential use of natural materials as herbal beverage products.

Several previous studies have reported that rambutan (Nephelium lappaceum) seeds contain bioactive compounds such as flavonoids, tannins, and polyphenols, which are associated with antioxidant and antibacterial activities (Siregar et al., 2021; Rahman et al., 2023). These findings indicate that rambutan seeds have potential to be utilized as value-added materials, although in practice they are still frequently discarded as organic waste.

In addition, butterfly pea flower (Clitoria ternatea) has been widely reported to contain anthocyanins that function as natural antioxidants while providing a distinctive blue–purple coloration in herbal beverage products (Chusak et al., 2020; Lakshan et al., 2022). Several studies have also noted that butterfly pea flower extracts are commonly used in the development of functional beverages and herbal teas due to their attractive sensory properties and phenolic compound content (Nguyen et al., 2021).

The observational results of this study showed consistency with these previous findings, particularly in terms of changes in physical and sensory characteristics after processing. The drying and roasting of rambutan seeds produced a characteristic aroma and a golden-brown tea infusion, while the addition of butterfly pea flower resulted in a visually appealing blue–purple coloration. The alignment between observational data and previous research suggests that the utilization of rambutan seeds and butterfly pea flower as a waste-based herbal tea concept is supported by existing scientific evidence.

This research emphasizes environmental education, demonstrating how organic waste can be transformed into a useful product concept. By integrating waste valorization with student research, the study seeks to promote environmental awareness, sustainable practices, and scientific curiosity at the school level. Despite the documented potential of rambutan seeds and butterfly pea flower, their combined use as a waste-based herbal tea product has received limited attention, particularly within the context of student-based environmental projects. Therefore, this study aims to explore the utilization of rambutan seed waste combined with butterfly pea flower as an herbal tea concept through a school-based observational and literature-based approach.

RESEARCH METHOD

Study Design

This study employed a school-based observational and literature-based approach designed for educational purposes. The method did not involve laboratory-scale experimental testing or biological assays conducted by the research team. Instead, the study focused on simple material processing, direct sensory observation, and comparison with findings from previous scientific literature.

Materials and Preparation

Rambutan (Nephelium lappaceum) seeds were collected as organic waste from a local sweet shop. The seeds were washed thoroughly to remove residual pulp, sun-dried for approximately 48 hours, and then roasted at 120°C for 20 minutes. After roasting, the seeds were ground into a fine powder using simple household equipment.Butterfly pea flowers (Clitoria ternatea) were obtained fresh, dried at 50°C, and stored in airtight containers prior to use.

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Product Preparation

Two herbal tea formulations were prepared:

1. Rambutan Seed Tea, consisting of 1 g rambutan seed powder infused in 100 ml of hot water (approximately 95°C) for 10 minutes.
2. Rambutan Seed and Butterfly Pea Tea, consisting of 1 g rambutan seed powder combined with 0.5 g dried butterfly pea flowers, infused under the same conditions.

These preparations were intended to observe differences in visual appearance and sensory characteristics rather than to measure chemical or biological activity directly.

Data Collection and Sensory Observation

Data collection consisted of direct observational assessment and simple sensory evaluation. Sensory observations were conducted by 20 participants using a non-instrumental, descriptive approach suitable for school-level research. Participants evaluated the tea samples based on:

1. color of the infusion,
2. aroma,
3. taste preference.

The evaluation aimed to assess general acceptability and observable characteristics, not to perform standardized sensory testing or statistical sensory analysis. In addition, information related to phytochemical content, antioxidant activity, and antibacterial properties was obtained through a review of previously published scientific studies. These literature-based data were used for comparison and discussion purposes only and were not generated experimentally in this study.

RESULT AND DISCUSSION

Result

Based on literature findings, rambutan (*Nephelium lappaceum*) seeds have been reported to contain several bioactive compounds, including flavonoids, tannins, polyphenols, and saponins, while alkaloids were not detected. The presence of these compounds is commonly associated with antioxidant and antimicrobial potential in plant-based materials. These reported phytochemical components support the potential utilization of rambutan seed waste as a value-added material rather than being discarded as organic waste.

Table.1 Qualitative Phytochemical Screening of Rambutan Seed-Based Materia

Compound	Presence
Flavonoids	+
Tannins	+
Polyphenols	+
Saponins	+
Alkaloids	-

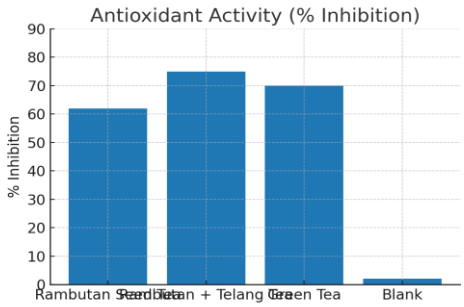
Sources : Compiled based on Siregar et al. (2021) and Rahman et al. (2023).

Literature-based data indicate that rambutan seed tea exhibits antioxidant activity with an inhibition percentage of approximately 62% using the DPPH assay. When combined with butterfly pea flower, the reported antioxidant activity increased to around 75%, which is higher than rambutan seed tea alone and comparable to green tea (70%). In contrast, distilled water showed negligible antioxidant activity (2%). These findings suggest that the addition of butterfly pea flower may enhance the antioxidant potential of the tea formulation, as reported in previous studies.

Table 2. Antioxidant Activity (DPPH assay)

Sample	% Inhibition of Free Radicals
Rambutan Seed Tea	62%
Rambutan + Telang Tea	75%
Green Tea	70%
Distilled Water (blank)	2%

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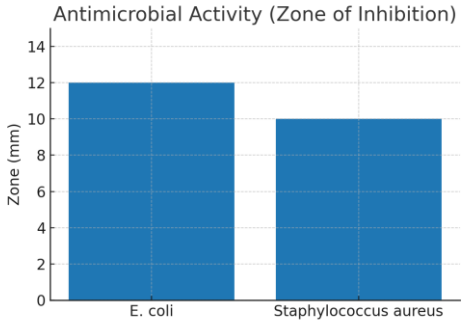


Sources : Compiled based on Siregar et al. (2021) and Rahman et al. (2023).

Previous studies have also reported antimicrobial activity of rambutan seed extracts against common bacteria. Zones of inhibition of approximately 12 mm against Escherichia coli and 10 mm against Staphylococcus aureus have been documented, indicating moderate antibacterial activity. Although antimicrobial testing was not conducted directly in this study, these reported findings provide supporting evidence for the potential functional properties of rambutan seed-based products.

Table. 3 Antimicrobial Activity

Bacteria	Zone of Inhibition (mm)
E. coli	12 mm
Staphylococcus aureus	10 mm



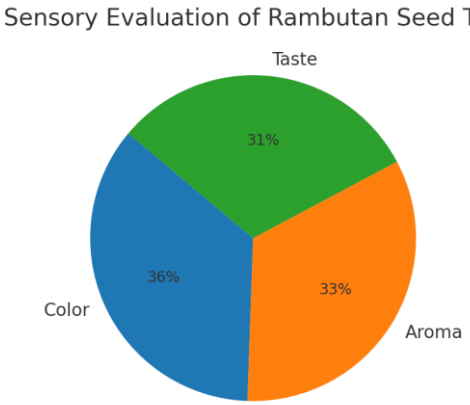
Sources : Compiled based on Siregar et al. (2021) and Rahman et al. (2023).

Based on direct observational sensory evaluation conducted in this study, the herbal tea formulations demonstrated acceptable sensory characteristics. Color acceptance reached 80%, aroma 75%, and taste 70%. The addition of butterfly pea flower notably improved the visual appearance of the tea infusion, producing a blue–purple color that was perceived as more attractive by participants. These observations indicate that the product concept is acceptable from a basic sensory perspective at the school level.

Table 4. Sensory Evaluation

Attribute	Acceptance (%)
Color	80
Aroma	75
Taste	70

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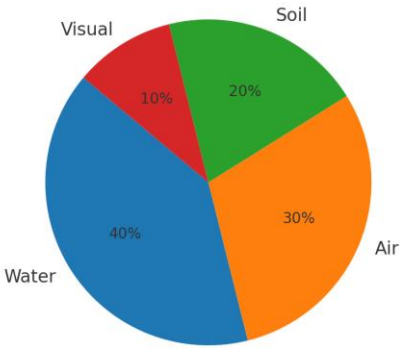
Sources : Compiled based on Siregar et al. (2021) and Rahman et al. (2023).

The disposal of rambutan seeds as organic waste can contribute to several forms of environmental pollution. Decomposed seeds may generate leachate that increases biological and chemical oxygen demand (BOD/COD) in water bodies, leading to reduced dissolved oxygen levels. Anaerobic decomposition can release methane gas (CH_4), contributing to air pollution and unpleasant odors. In addition, the accumulation of organic waste can reduce soil quality and create visual pollution around food processing areas. The utilization of rambutan seed waste as a herbal tea ingredient therefore represents a practical approach to reducing these environmental impacts.

Tabel 5. Environmental Pollution Aspect

Type of Pollution	**Cause**	**Environmental Impact**
Water Pollution	Leachate from decomposed seeds	High BOD/COD, reduced oxygen in water
Air Pollution	Anaerobic decomposition → methane (CH_4)	Greenhouse gas, foul odor
Soil Pollution	Accumulation of organic waste	Reduced soil quality, pest growth
Visual Pollution	Piles of seed waste near sweet shops	Unsanitary appearance, insects

The Contribution of Pollution from Rambutan Seeds Waste



Sources : Compiled based on Siregar et al. (2021) and Rahman et al. (2023).

The results demonstrate that rambutan seeds, typically discarded as waste, can be transformed into functional tea with notable antioxidant and antimicrobial properties. The addition of Butterfly Pea Flower significantly improved antioxidant activity and visual appeal. From an environmental perspective, utilizing

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waste seeds reduces pollution risks and contributes to sustainable waste management aligned with SDG 12 (Responsible Consumption and Production).

Discussion

The findings of this study align with previous research that has reported the presence of bioactive compounds in rambutan (*Nephelium lappaceum*) seeds, including flavonoids, tannins, polyphenols, and saponins (Siregar et al., 2021; Rahman et al., 2023). These compounds are widely associated with antioxidant and antimicrobial activities in plant-based materials. The absence of alkaloids, as reported in previous studies, further supports the consistency of the phytochemical profile summarized in this study. The agreement between the compiled literature data and the observational context of this research suggests that rambutan seed waste has scientifically recognized potential for value-added utilization.

The antioxidant activity values reported in previous studies indicate that rambutan seed tea exhibits moderate antioxidant capacity, as reflected by a DPPH inhibition of approximately 62%. The increase in antioxidant activity to around 75% when combined with butterfly pea flower is consistent with earlier findings highlighting the strong antioxidant properties of *Clitoria ternatea*, particularly due to its anthocyanin content (Chusak et al., 2020; Lakshan et al., 2022). The comparable antioxidant activity between the combined formulation and green tea further emphasizes the potential role of butterfly pea flower in enhancing the functional properties of herbal beverages.

Similarly, previous studies have documented the antimicrobial activity of rambutan seed extracts against both Gram-negative and Gram-positive bacteria, including *Escherichia coli* and *Staphylococcus aureus* (Siregar et al., 2021; Rahman et al., 2023). Although antimicrobial testing was not conducted directly in the present study, the reported inhibition zones provide supporting evidence that rambutan seed-based products may possess antibacterial potential. This reinforces the relevance of utilizing rambutan seed waste beyond its conventional disposal as organic waste.

The sensory evaluation conducted in this study revealed acceptable levels of color, aroma, and taste, indicating that the herbal tea concept is feasible from a basic consumer perspective at the school level. The improved visual appeal observed with the addition of butterfly pea flower corresponds with previous reports describing its natural blue–purple pigmentation and favorable sensory characteristics in beverage applications (Nguyen et al., 2021). These findings suggest that sensory acceptance may play an important role in promoting the utilization of waste-based herbal products.

From an environmental standpoint, the discussion of pollution aspects related to rambutan seed waste is supported by existing literature on organic waste management. The decomposition of fruit seeds has been associated with water pollution through leachate formation, air pollution via methane emissions, and soil degradation due to waste accumulation. By converting rambutan seed waste into a herbal tea product, this study demonstrates a practical example of waste valorization that addresses environmental concerns while introducing an educational innovation.

Overall, the discussion highlights that the results of this study are consistent with findings from previous research and demonstrate how literature-based evidence can be integrated with observational data in a student research context. The utilization of rambutan seeds combined with butterfly pea flower as a waste-based herbal tea concept supports sustainable practices and aligns with Sustainable Development Goal (SDG) 12 on Responsible Consumption and Production. While the study does not replace laboratory-scale experimentation, it provides an educational model for applying scientific knowledge to real-world environmental issues.

CONCLUSION

Rambutan seeds obtained as waste from local sweet shops can be introduced as a herbal tea concept through a school-based, observational, and literature-supported approach. Based on previous studies, rambutan seeds contain bioactive compounds associated with antioxidant and antimicrobial potential. The combination of rambutan seed and butterfly pea flower enhances the visual appeal of the tea and is supported by literature indicating increased antioxidant activity. From an environmental perspective, the utilization of rambutan seed waste represents a practical example of waste valorization that contributes to the reduction of organic waste and supports environmental awareness at the school level.

This study demonstrates that student-based research can play a role in promoting sustainable practices and environmental education. The findings highlight how scientific literature and simple observations can be integrated to develop environmentally oriented product concepts without relying on laboratory-scale experimentation.

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