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Phytochemical Composition and Antioxidant Activity of Extract of *Salacca zalacca* Peel from Sibetan, Bali

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Abstrak:
Buah salak Bali berpotensi sebagai sumber senyawa bioaktif (fenolik, flavonoid, tanin, saponin) yang dilaporkan memiliki aktivitas antimikroba. Penelitian ini bertujuan untuk mengevaluasi profil fitokimia ekstrak kulit *Salacca zalacca* (buah salak Bali) sebagai alternatif alami yang potensial. Ekstrak tersebut diperoleh menggunakan maserasi berbasis etanol dan dianalisis melalui spektrofotometri UV-Vis. Hasil penelitian menunjukkan bahwa ekstrak mengandung flavonoid (856,92 mg QE/100 g), fenolik total (860,21 mg GAE/100 g), tanin (169,08 mg TAE/100 g), dan vitamin C dalam jumlah sangat tinggi (8391,10 mg/100 g), serta menunjukkan keberadaan saponin secara kualitatif. Uji aktivitas antioksidan dengan metode DPPH menunjukkan kemampuan penangkapan radikal bebas yang lemah dengan nilai IC_{50} sebesar 546,31 ppm, namun kapasitas antioksidan total tergolong tinggi yaitu 2532,20 mg GAE/L. Hasil ini mengindikasikan bahwa meskipun efisiensi penangkapan radikal relatif rendah, ekstrak kulit *S. zalacca* kaya akan senyawa bioaktif yang berkontribusi terhadap potensi antioksidan secara keseluruhan. Dengan demikian, kulit *Salacca zalacca* berpotensi dikembangkan sebagai sumber bahan alami untuk aplikasi pangan fungsional, nutraseutikal, dan kosmeseutikal.

Kata kunci: Salacca zalacca, skrining fitokimia, flavonoid, antioksidan, ekstrak herbal.

Abstract
Balinese snake fruit has the potential to be a source of bioactive compounds (phenolics, flavonoids, tannins, saponins) which are reported to have antimicrobial activity. This study aimed to evaluate the phytochemical profile of Salacca zalacca (Bali snakefruit) peel extract as a potential natural alternative. The extract was obtained using ethanol-based maceration and analyzed through UV-Vis spectrophotometry. The results revealed high levels of flavonoids (856.92 mg QE/100 g), total phenolic compounds (860.21 mg GAE/100 g), tannins (169.08 mg TAE/100 g), and an exceptionally high vitamin C content (8391.10 mg/100 g), along with the qualitative presence of saponins. Antioxidant activity assessment using the DPPH method showed weak free radical scavenging activity with an IC_{50} value of 546.31 ppm, while the total antioxidant capacity was relatively high at 2532.20 mg GAE/L. These findings suggest that although the extract exhibits limited radical scavenging efficiency, it contains abundant bioactive compounds contributing to its overall antioxidant potential. Therefore, S. zalacca peel extract may be further developed as a natural ingredient for functional foods, nutraceuticals, and cosmeceutical applications.

Keywords: *Salacca zalacca, phytochemical screening, flavonoids, antioxidant, herbal extract.*

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INTRODUCTION

Numerous native plants have demonstrated antimicrobial efficacy, and among them, *Salacca zalacca* (snakefruit) stands out due to its accessibility, low cost, and rich phytochemical composition. Several studies have explored the potential of fruit peels—often considered agricultural waste as repositories of bioactive compounds. Peels from mangosteen, pomegranate, and banana have shown varying degrees of antifungal activity against *C. albicans* (Olakunle et al., 2019; Bassiri-Jahromi et al., 2015; Loyaga-Castillo et al., 2020).

Salacca zalacca is a tropical palm species widely cultivated across Indonesia. The Bali cultivar, known locally as "salak Bali," is notable for its high yield and adaptability to dry soil conditions. Agronomic data show that this variety is extensively grown in Karangasem Regency, Bali, an area characterized by fertile volcanic soils with high pH, organic matter, and phosphorus content factors known to influence secondary metabolite production (Ramadhana et al., 2019; Trigunasih et al., 2023). Phytochemical analyses have revealed that *S. zalacca* peel contains flavonoids, tannins, phenolics, saponins, and vitamin C, all of which are associated with antioxidant and antimicrobial properties (Astuti et al., 2023; Shabir et al., 2018). These bioactive constituents are of particular interest due to their reported mechanisms of antifungal action.

Flavonoids, for example, have been shown to disrupt microbial membranes, inhibit hyphal formation, and interfere with fungal DNA replication. Tannins act by forming complexes with fungal proteins and cell wall polysaccharides, effectively impairing cell wall synthesis and permeability. Saponins, on the other hand, increase membrane permeability by forming sterol complexes, leading to cell lysis (Dahanayake et al., 2019; Muhammad & Daniyan, 2024). Despite these promising attributes, the antifungal efficacy of *S. zalacca* peel especially from the Bali cultivar has not been systematically studied.

Previous investigations on other cultivars, such as the pondoh variety, have reported significant inhibition of *C. albicans* growth when treated with *S. zalacca* peel extracts. For instance, Shabir et al. (2018) demonstrated that the ethanol extract of pondoh snakefruit peel interfered with fungal cell wall integrity and inhibited biofilm development. However, generalizing such findings across different cultivars is problematic, given that phytochemical profiles are influenced by environmental factors, plant age, and cultivation practices. The specific conditions in Karangasem—richer soil nutrients and unique agroecological parameters—are likely to produce a distinct phytochemical signature in the Bali cultivar.

Given the phytochemical richness of Bali-grown *S. zalacca* and the rising need for alternative antimicrobial agents, a targeted study is warranted. It is critical to identify and quantify the bioactive compounds present in the peel extract. Yet, despite the presence of potentially antimicrobial phytochemicals, prior studies rarely couple phytochemical analysis with functional antimicrobial assays using standardized methods. Moreover, most research focuses on either the fruit pulp or on cultivars from different geographic regions. There is thus a considerable gap in the literature regarding both the chemical composition and the bioactivity of *S. zalacca* peel from Sibetan, Bali.

This study seeks to address this gap by focusing on a comprehensive phytochemical profiling of *S. zalacca* peel extract from Sibetan, Bali, using qualitative and quantitative

spectrophotometric methods. This approach combining chemical characterization with functional bioassay offers a more integrated understanding of the extract's therapeutic potential.

The novelty of this study lies in its focus on a specific regional cultivar (*Salacca zalacca* from Sibetan, Bali), its use of standardized laboratory protocols for phytochemical quantification, and its empirical evaluation of antifungal effects under controlled in vitro conditions. The study's scope is limited to limited standard agent of saponin assessments, which serves as a foundational assay for screening antimicrobial activity. However, the findings will provide valuable insights into whether *S. zalacca* peel extract holds promise as an alternative or complementary treatment.

RESEARCH METHOD

This research employed a laboratory-based experimental design to evaluate the phytochemical profile of *Salacca zalacca* (Bali snakefruit) peel extract. The investigation was conducted through standardized in vitro procedures and followed ethical laboratory protocols. This section elaborates on the experimental framework, sampling methods, and phytochemical screening.

Research Design

The study evaluates phytochemical profiling of *S. zalacca* peel extract from Karangasem, Bali, using qualitative and quantitative spectrophotometric methods without requiring baseline measurements. This design facilitated the assessment of treatment effects solely based on post-treatment observations. The independent variable in this experiment was the maceration of the ethanol extract, while the dependent variable was the result of phytochemical profiling of *S. zalacca* peel extract. The experimental setup was designed to evaluate whether the extract exhibits phytochemical activity by qualitative and quantitative spectrophotometric methods comparable to standard pharmacological treatment under similar test conditions.

Sample Collection and Preparation

Salacca zalacca fruits were collected from Desa Sibetan, located in Karangasem Regency, Bali a region known for its favorable agroecological environment and fertile volcanic soil enriched in organic matter and phosphorus (Ramadhana et al., 2019; Trigunasih et al., 2023). These environmental attributes are known to influence secondary metabolite synthesis in plants.

A total of 10 kilograms of whole snakefruit was obtained. The fruit peels were manually separated, producing 150.33 grams of wet peel. These were then dehydrated using a food-grade dehydrator at 40°C for 24 hours, yielding 116.72 grams of dry peel. The dried peels were subsequently ground into a semi-fine powder using a household blender.

Extraction was performed using the maceration technique with 500 mL of 96% ethanol as the solvent. The powdered peels were soaked for 48 hours at room temperature, with manual agitation conducted every 6 hours to enhance solute dissolution. Following maceration, the extract was filtered and concentrated using a rotary evaporator. The concentrated extract was then further dried in a conventional oven at 40°C, yielding a thick ethanol-based crude extract

totaling 2.82 grams or 2.4% of the total yield of snake fruit skin extract, which was stored in sterile, opaque containers to prevent degradation.

Phytochemical Screening Procedures

To characterize the extract's phytochemical constituents, both qualitative and quantitative analyses were performed.

Qualitative phytochemical screening employed colorimetric tests using specific reagents:

1. Phenolics were identified via the formation of a green-blue color upon the addition of 1% $FeCl_3$.
2. Flavonoids were detected by a red-yellow color reaction with 2% $AlCl_3$.
3. Tannins were confirmed by the formation of a blue volor using 5% NA_2CO_3.
4. Saponins were evaluated through persistent foaming in 2% NaOH solution after vigorous shaking.

Quantitative analysis was performed using **UV-Vis spectrophotometry**, involving standardized calibration curves for the following parameters:

a. Total Phenolic Content, expressed as mg/100 g dry weight.
b. Total Flavonoid Content, measured in mg/100 g.
c. Tannin Content, measured similarly in mg/100 g.
d. Vitamin C Content, quantified as mg/100 g using appropriate colorimetric assays.
e. Antioxidant Activity, evaluated via DPPH radical scavenging assay to determine IC_{50} values (ppm).
f. Total Antioxidant Capacity, measured in Gallic Acid Equivalents (GAE)/L.

RESULT AND DISCUSSION

This section presents the experimental findings derived from the phytochemical profiling of *Salacca zalacca* (Bali snakefruit) peel extract. The results are organized into five main subsections: extraction yield, quantitative and qualitative phytochemical analysis, and antioxidant evaluation.

Yield and Extraction Results

The initial processing of the raw *S. zalacca* fruits involved the separation of peel material from 10 kilograms of whole fruit. From this, 150.33 grams of wet peel were obtained. Upon dehydration at 40°C for 24 hours, the weight was reduced to 116.72 grams, representing the dry peel mass used for extraction.

The extraction process, conducted via ethanol-based maceration for 48 hours, yielded 2.82 grams of concentrated thick extract after evaporation and drying. This extract was the core material used for all subsequent phytochemical and antifungal assessments. The yield represented a modest but sufficient concentration of secondary metabolites, reflecting efficient recovery via conventional maceration using 96% ethanol.

These values are consistent with previous extraction studies from fruit peels, confirming that *S. zalacca* peels, though a byproduct, serve as a viable source of bioactive compounds.

Phytochemical Content Analysis

The phytochemical content of the *S. zalacca* peel extract was evaluated using both qualitative screening and quantitative spectrophotometric methods, focusing on major classes of secondary metabolites with known antimicrobial and antioxidant activity.

Table 1. Phytochemical Content Analysis

Phytochemical Test	Results
IC_{50}	546.31 ppm
Antioxidant Content	2532.20 mg GAE/L
Phenolic Content	860.21 mg GAE/100 g
Flavonoid Content	856.92 mg QE/100 g
Tannin Content	169.08 mg TAE/100 g
Vitamin C Content	8391.10 mg/100 g
Qualitative Saponin Detection	Positive for saponins

Antioxidant Activity (IC_{50} Value)

The antioxidant capacity was determined using the DPPH radical scavenging method. The IC_{50} value defined as the concentration of extract required to inhibit 50% of DPPH radicals. According to Molyneux (2004), this value indicates very weak antioxidant activity, suggesting that the extract must be present in high concentrations to exert a moderate radical scavenging effect. While the presence of antioxidants is evident, their potency in free radical neutralization is limited under the test conditions.

Total Antioxidant Content

Despite the weak IC_{50} value, the total antioxidant capacity, expressed in Gallic Acid Equivalents (GAE), showed a high numerical value: This result implies a substantial presence of phenolic-based antioxidant compounds. The apparent disparity between IC_{50} and GAE values suggests that although phenolic antioxidants are abundant, their efficiency in DPPH scavenging may be influenced by compound structure, molecular weight, or extract solubility.

Total Phenolic Content

Phenolic compounds, known for their antimicrobial and antioxidant properties, were quantitatively abundant in the extract: This high concentration is consistent with the elevated GAE value and affirms the role of *S. zalacca* peel as a rich phenolic source. Phenolic molecules contribute to antimicrobial activity through protein precipitation and disruption of microbial membranes.

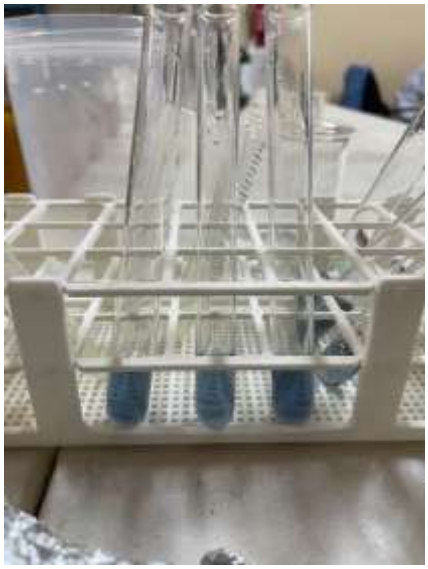

Figure 1. Qualitative Phenolic Detection

Total Flavonoid Content

Flavonoids, another major class of bioactive phytochemicals, were also present in large quantities: High Flavonoids content suggest a strong antioxidant foundation. Flavonoids have been extensively linked to antifungal mechanisms, including inhibition of hyphal transition and biofilm formation in *C. albicans* (Shabir et al., 2018; Muhammad & Daniyan, 2024).

Figure 2. Qualitative Flavonoids Detection

Total Tannin Content

Tannins are known to inhibit fungal growth by binding to fungal enzymes and proteins, interfering with their metabolism and reproduction. While present in lower quantities than flavonoids or phenolics, this value remains significant for a plant-based extract.

Figure 3. Qualitative Tannin Detection

Vitamin C Content

Ascorbic acid (vitamin C) content was remarkably high. This finding confirms the extract's strong antioxidant profile, despite limited radical scavenging activity in the DPPH test. High vitamin C levels also support its potential as a wound healing or cytoprotective agent.

Qualitative Saponin Detection

The extract was also screened for the presence of saponins using a foam test with NaOH. Samples exhibited stable foam formation:

Although no quantitative data were recorded due to reagent limitations, the qualitative presence of saponins confirms the extract's structural potential to disrupt fungal membranes and improve antimicrobial penetration.

Collectively, these results illustrate that *S. zalacca* peel extract possesses a robust phytochemical profile, with high concentrations of phenolics, flavonoids, and vitamin C, in addition to saponins and tannins—all of which are known to contribute to antifungal and antioxidant actions.

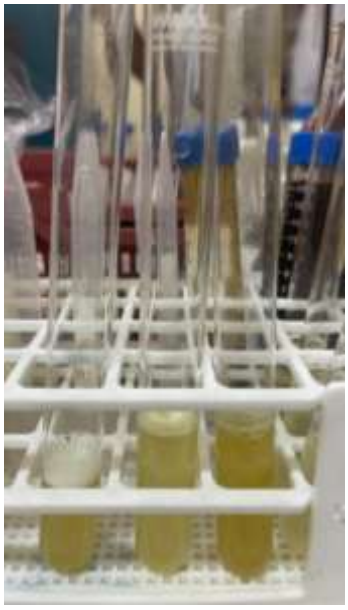

Figure 4. Qualitative Saponin Detection

Discussion

The results of this study indicate that the peel extract of *Salacca zalacca* (Bali snakefruit) contains a high concentration of phytochemical compounds, including phenolics, flavonoids, tannins, vitamin C, and the qualitative presence of saponins. These findings support previous studies suggesting that fruit peels, which are often regarded as agricultural waste, represent an important source of secondary metabolites with significant functional value (Astuti et al., 2023).

The total phenolic content obtained in this study (860.21 mg GAE/100 g) can be considered relatively high when compared to several tropical fruit peels that are widely recognized for their antioxidant properties, such as banana and pomegranate peels (Lopes et al., 2020). Phenolic compounds play a crucial role in antioxidant defense mechanisms through hydrogen atom donation, electron transfer, and metal ion chelation, thereby contributing to the protection of biological systems against oxidative stress (Molyneux, 2004). The high phenolic concentration observed in this extract is consistent with the elevated total antioxidant capacity measured in gallic acid equivalents.

Similarly, the flavonoid content of the *S. zalacca* peel extract (856.92 mg QE/100 g) confirms that this plant material is a substantial source of flavonoid compounds. Flavonoids are known not only for their antioxidant activity but also for their contribution to oxidative stability in natural matrices, which makes them attractive for application in functional foods and plant-based cosmetic products (Astuti et al., 2023). The abundance of flavonoids observed in this study suggests that the extract may support product stability and quality in oxidative environments.

Despite the high total antioxidant capacity (2532.20 mg GAE/L), the DPPH radical scavenging assay resulted in a relatively weak IC_{50} value (546.31 ppm). This discrepancy between antioxidant quantity and antioxidant efficiency has been frequently reported in

phytochemical research and can be explained by differences in molecular structure, polarity, and reaction mechanisms of individual antioxidant compounds (Dahanayake et al., 2019). The DPPH assay primarily reflects hydrogen-donating capacity and may therefore underestimate the antioxidant potential of complex phenolic compounds and polymeric tannins that act through alternative redox pathways (Molyneux, 2004).

The exceptionally high vitamin C content observed in this study (8391.10 mg/100 g) represents one of the most notable findings. Ascorbic acid is a well-established antioxidant that plays an essential role in collagen synthesis, tissue repair, immune modulation, and protection against oxidative damage (Putri et al., 2022). The concentration reported here exceeds that of many commonly consumed fruits, indicating that *S. zalacca* peel extract may be particularly suitable for nutraceutical or cosmeceutical applications.

In addition, the tannin content (169.08 mg TAE/100 g) contributes to the functional profile of the extract. Tannins are known for their protein-binding properties, which are beneficial in natural preservation, enzyme inhibition, and stabilization of bioactive formulations (Lopes et al., 2020). Although present at lower levels than phenolics and flavonoids, tannins may act synergistically with other phytochemicals to enhance the overall functional properties of the extract.

The qualitative detection of saponins further complements the phytochemical profile of *S. zalacca* peel extract. Saponins possess natural surfactant properties that can improve the solubility and dispersion of bioactive compounds in formulations, thereby supporting the development of plant-based delivery systems (Azwanida, 2015).

Environmental and agronomic factors are likely to have influenced the phytochemical composition observed in this study. The cultivation area in Sibetan, Bali, is characterized by volcanic soils with high organic matter and phosphorus content, conditions that are known to promote secondary metabolite biosynthesis in plants (Trigunasih et al., 2023). Such environmental variation may account for differences in phytochemical profiles reported for *S. zalacca* cultivars grown in different regions.

Overall, the findings of this study demonstrate that *S. zalacca* peel extract is rich in antioxidant-related phytochemicals and holds strong potential as a natural functional ingredient. Rather than emphasizing antimicrobial properties, the extract may be more appropriately positioned for applications in functional foods, nutraceuticals, and cosmeceuticals. Further studies focusing on compound fractionation, stability evaluation, and formulation performance are recommended to optimize the utilization of *S. zalacca* peel as a value-added natural resource.

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