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ECO-FRIENDLY INNOVATION: POTENTIAL OF RED DRAGON FRUIT PEEL EXTRACT IN SILVER NANOPARTICLE BIOSYNTHESIS

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Abstract

East Kalimantan is one of the regions that cultivates red dragon fruit (Hylocereus polyrhizus) in large quantities due to its promising health benefits. The peel of red dragon fruit has antioxidant activity comparable to its flesh, yet it is rarely utilized and often discarded as organic waste. This study aims to explore the potential of water and ethanol extracts from red dragon fruit peel as antioxidant sources that can serve as natural reducing and stabilizing agents in the biosynthesis of silver nanoparticles (AgNPs). Extraction using water and ethanol solvents was conducted to analyze the antioxidant compounds in the peel. The extract with the strongest antioxidant activity was used for AgNP biosynthesis, and the absorption peak was observed using UV-Vis spectrophotometry at a specific wavelength of 400–450 nm, which is characteristic of AgNP surface plasmon resonance. The results showed that the ethanol extract exhibited stronger antioxidant potential based on its lower IC_{50} value and functioned effectively as a reducing and stabilizing agent at synthesis temperatures of 40–50°C, without degrading the extract's secondary metabolites. These findings support the utilization of red dragon fruit peel as a sustainable and eco-friendly raw material for the development of health-related products.

Keywords*: Antioxidant: Biosynthesis; DPPH; Red Dragon Fruit Peel; Silver Nanoparticle.*

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INTRODUCTION

Dragon fruit belonging to the cactus family is a popular fruit widely consumed and cultivated across various regions of Indonesia. There are four common types of dragon fruit: red-fleshed dragon fruit (*Hylocereus polyrhizus*), super red-fleshed dragon fruit (*Hylocereus costaricensis*), white-fleshed dragon fruit (*Hylocereus undatus*), and yellow-fleshed dragon fruit (*Hylocereus megalanthus*) (Safira *et al*., 2021). This plant thrives in tropical climates, easy to cultivate, and rich in nutrients and vitamins, making it a common ingredient in various health products (Muas *et al*., 2016).



Figure 1. Red dragon fruit harvesting in Batuah, Loa Janan, Kutai Kartanegara, East Kalimantan

In East Kalimantan, particularly in the Kutai Kartanegara region, the cultivation of red-fleshed dragon fruit dominates due to its compatibility with local soil types, high rainfall, and strong market demand. Red dragon fruit (*Hylocereus polyrhizus*) is well-known for its high antioxidant content, including flavonoids, betalains, and vitamin C (Winahyu *et al*., 2019). However, most studies focus on the fruit's flesh, while its peel—accounting for about 30% of the fruit's total weight—is often discarded as organic waste and rarely utilized. In fact, the peel of red dragon fruit has antioxidant activity comparable to its flesh, making it a valuable natural source of antioxidants (Wahdaningsih, 2022).

Nanoparticles represent a rapidly advancing technology with broad applications across various fields, including biomedicine, pharmaceuticals, and cosmetics. This technology produces nanoparticles sized between 1–100 nm, enhancing activity and functionality in the development of specific products (Singh *et al*., 2016). Nanoparticle synthesis typically employs top-down (physical) or bottom-up (chemical) methods. However, both methods rely on toxic chemicals and are costly to produce (Iravani *et al*., 2014). In recent years, plant-based synthesis, or biosynthesis, has gained significant

attention due to its simplicity, low cost, safety, and eco-friendliness. Plant extracts can act as reducing and stabilizing agents in nanoparticle synthesis. One commonly biosynthesized metallic nanoparticle is silver nanoparticle (AgNP). AgNPs exhibit consistent characteristics regardless of the plant extract used (Khatami *et al*., 2018). Upon exposure to plant extracts, AgNO3 solution undergoes reduction, converting Ag+ ions into silver particles. This process demonstrates the complete reduction of Ag+ ions by reducing agents in the extract (Bouqellah *et al*., 2019).

Free radicals are reactive molecules capable of damaging body cells through oxidative processes. Prolonged and continuous exposure to free radicals can lead to various degenerative diseases, such as cancer, diabetes, and immune-related disorders. To counter these harmful effects, antioxidant compounds are needed to inhibit, neutralize, or prevent free radical reactions in the body (Winahyu *et al*., 2019). Currently, natural antioxidants are gaining increasing attention due to their safety compared to synthetic antioxidants, which may cause harmful side effects with prolonged use. Given Indonesia's rich biodiversity and the antioxidant activity of red dragon fruit peel extract as a natural antioxidant source.

Research by Adhayanti & Ahmad (2021) demonstrated that ethanol extract of red dragon fruit peel exhibits high antioxidant activity, with an IC50 value comparable to the antioxidant activity of ascorbic acid as a positive control. Similarly, a study by Noviyanty & Anggriani (2019) found that red dragon fruit peel contains significant amounts of phenolic and flavonoid compounds, highlighting its potential as a natural antioxidant. The antioxidant activity is also influenced by the type of solvent used to extract compounds from the peel, underscoring the need for further studies to optimize the extraction process and maximize its antioxidant potential. Water extraction can be employed to target polar compounds like vitamin C and certain polyphenols, while ethanol extraction is considered effective for dissolving semi-polar. compounds such as phenolics and flavonoids (Noviyanty & Anggriani, 2019).

This study aims to explore the potential of aqueous and ethanol extracts of red dragon fruit peel using two solvents, water and ethanol, to provide a comprehensive understanding of the peel's antioxidant properties and its capability as a reducing and stabilizing agent in nanoparticle synthesis. The findings are expected to contribute to the development of raw materials for health

formulations while supporting efforts to reduce organic waste.

RESEARCH METHOD

Sample Collection and Simplicias Preparation

The sample used in this study was the peel of red dragon fruit (*Hylocereus polyrhizus*) harvested from Batuah Village, Loa Janan District, Kutai Kartanegara, East Kalimantan. Harvesting was conducted in the morning, one month after the flowers bloomed on the stem. Before processing the dragon fruit peel into simplicias, plant identification was carried out at the Laboratory of Ecology and Tropical Forest Biodiversity Conservation, Faculty of Forestry, Mulawarman University, Samarinda, East Kalimantan.



Figure 2. Red dragon fruit peel before and after drying

Fully ripened red dragon fruit was peeled, and the peel was cut into strips with a thickness of 1 cm. The peel strips were weighed and then dried in an oven at 70°C for 28 hours. The dried peel was weighed again to calculate the yield of the dried red dragon fruit peel. The dried simplicias was then ground and sieved using a 60-mesh sieve. The powder passing through the sieve was used for further extraction processes.

Preparation of Aqueous and Ethanol Extracts of Red Dragon Fruit Peel

The infusion method began by weighing 250 g of simplicias and dissolving it in 1 L of distilled water. The mixture was then heated in an infusion pot until it reached 90°C. Once the temperature was reached, the heating was continued for 15 minutes, ensuring that all the simplicia was fully submerged to maximize the extraction process. The fresh extract was immediately prepared for subsequent analysis.

For the ethanol extract, 500 g of simplicia*s* powder were soaked in 1 L of 70% ethanol, stirred for 2 hours, and left to stand for 24 hours. The macerate was then filtered using filter paper and collected for concentration. The residue was soaked again with another 1 L of 70% ethanol following the same procedure for remaceration. All collected macerates were concentrated using a vacuum rotary

evaporator at 40°C and further evaporated in a water bath until a thick extract was obtained. The extract was weighed, and the ethanol extract yield of the red dragon fruit peel was calculated. The extract was subsequently analyzed for phytochemical content and antioxidant activity.

Phytochemical Screening

Alkaloid. The sampels were added with 1 mL of 2 N HCl and 9 mL of distilled water, heated over a spirit lamp for 2 minutes, cooled, and filtered. The filtrate was divided equally into three test tubes. Tube 1 was treated with two drops of Mayer's reagent, tube 2 with two drops of Bouchardat's reagent, and tube 3 with two drops of Dragendorff's reagent. The presence of alkaloids was indicated by turbidity or colored precipitate in at least two of the three tests (Oktavia *et al*., 2020; Sulistyarini *et al*., 2020).

Tannin. The sampels were each mixed with 10 mL of distilled water, boiled for 3 minutes, and filtered. Two milliliters of the filtrate were diluted until pale in color, and 1–3 drops of 1% $FeCl_3$ were added. A greenish-black or bluish-black color indicated the presence of tannins (Asniati & Muthmainnah, 2021; Islami & Kurniawan, 2023).

Flavonoid. The sampels were each mixed with 10 mL of hot water, boiled for 5 minutes, and filtered. Five milliliters of the filtrate were transferred to a test tube and treated with 0.1 g magnesium powder, 2 mL amyl alcohol, and 1 mL concentrated HCl, shaken, and allowed to separate. A red, orange, or yellow color in the amyl alcohol layer indicated the presence of flavonoids (Sulistyarini *et al*., 2020; Asniati & Muthmainnah, 2021).

Saponin. The sampels were each mixed with 10 mL of hot water, cooled, and vigorously shaken for 10 seconds. Stable foam of 1–10 cm height lasting more than 10 minutes and unaffected by 1 drop of 2 N HCl indicated the presence of saponins (Islami & Kurniawan, 2023; Nur Oktavia *et al*., 2020).

Steroid/Triterpenoid. The sampels were macerated with 20 mL of n-hexane for 2 hours, covered with plastic wrap, and filtered. The filtrate was evaporated in a porcelain dish. After drying, Liebermann-Burchard reagent was added. A blue or greenish-blue color indicated steroids, while a red, pink, or purple color indicated triterpenoids (Hanifa *et al*., 2021).

Antioxidant Activity Test

Four milligrams of DPPH were dissolved in 100 mL of 70% ethanol (40 ppm). Sampel solutions and the standard (vitamin C) were prepared at various concentrations. For aqueous extract: 4000, 8000, 16000, 32000, and 64000 ppm; and ethanol extract: 4, 8, 16, 32, and

64 ppm. The solutions were mixed with DPPH in a 1:2 ratio, incubated in the dark for 30 minutes, and analyzed using UV-Vis spectrophotometry at 522 nm. The % inhibition was calculated to determine the IC_{50} for each sample.

Biosynthesis of AgNPs

A total of 0.17 g of $AgNO_3$ powder was dissolved with distilled water in a 500 mL volumetric flask to make a 2 mM solution. One percent NaOH was added dropwise to the extract until pH 11 was reached. Fifty milliliters of 0.05% w/v red dragon fruit peel extract were added to 50 mL of $AgNO_3$ solution. The mixture was stirred with a magnetic stirrer at varying temperatures (40°C, 50°C, and 60°C) for 60 minutes. Absorbance was measured every 15 minutes using UV-Vis spectrophotometry to confirm AgNP formation and stability check

RESULTS AND DISCUSSION

The preparation of simplicias involved several stages, starting with the collection of raw materials in the form of dragon fruit, a wet sorting process by peeling the skin to separate it from the flesh, and total weight of the fresh peel was recorded before being dried in an oven to produce simplicias, then re-weighed to calculate the dry simplicias yield, as shown in Table 1.

The simplicias yield met the required standard, with a good yield being defined as greater than 10% (Kementerian Kesehatan Republik Indonesia, 2017). The dried simplicias was ground into powder using a blender and sieved through a mesh no. 60. This process aimed to reduce the particle size and increase the surface area exposed to the solvent.

Table 1. The dragon fruit peel simplicia yield

Wet weight (g)	Dry weight (g)	Simplicia yield (%)
8.930	2.210	24,64

The extraction process using the cold method, specifically maceration, yielded a thick extract. The thick extract was then weighed to calculate the extraction yield, as shown in Table 2. A yield greater than 10% is considered good, indicating that the thick extract of red dragon fruit peel obtained in this study met the criteria (Kementerian Kesehatan Republik Indonesia, 2017). While for the hot extraction method, fresh water extract is used.

Table 2. The ethanol extract yield

Wet weight (g)	Dry weight (g)	Simplicia yield (%)
1000	301,524	30,152

Both extracts (ethanol and water) were subjected to phytochemical analysis to evaluate the presence of alkaloids, flavonoids, saponins, tannins, steroids, and/or triterpenoids through qualitative testing using color reaction methods with specific reagents.

Table 3. Qualitative phytochemical screening of water and ethanol extracts of dragon fruit peel

Compound	Reagent	Water extracts	Ethanol extracts
Alkaloid	Mayer	-	+
	Bourchardat	-	+
	Dragendorff	+	-
Flavonoid	Mg+HCl	+	+
Saponin	Uji Forth	+	+
Steroid/ triterpenoid	Lieberman- Burchard	-	-
Tanin	FeCl3 1%	+	+

Table 3 presents the results of the qualitative phytochemical screening of water and ethanol extracts of dragon fruit peel using various specific reagents for each compound group. The ethanol extract of dragon fruit peel contained active compounds such as alkaloids, flavonoids, saponins, and tannins, whereas the water extract revealed the presence of flavonoids, saponins, and tannins. These results slightly differ from those reported by La *et al*. (2020), which indicated that the ethanol extract of red dragon fruit peel contains flavonoids, alkaloids, steroids, and tannins. This variation may be influenced by both internal and external factors.

External factors affecting phytochemical content in plants include climate, geography, altitude, and morphological differences. Meanwhile, internal factors such as genetic variation, developmental stage, age of the plant, and specific organ used (e.g., peel, pulp, seed) also play a crucial role in determining the types and concentrations of phytochemicals present. Differences in biosynthetic pathways among plant cultivars or even within individual plants at different growth phases can result in varying phytochemical profiles. These internal dynamics influence the metabolic responses of the plant, thereby contributing to the differences observed in extract composition (Idris & Rahmadina, 2022). These factors influence the presence of secondary metabolites in dragon fruit peel, which may vary depending on the plant's growing region.

The antioxidant activity tests for the ethanol and water extracts showed IC_{50} values of 29.154 ppm and 3108.85 ppm. Meanwhile, vitamin C, used as a reference, had an IC_{50} value of 3.158 ppm. The antioxidant activity is indicated by the IC_{50}

value, which represents the concentration of the sample solution required to inhibit 50% of DPPH free radicals. Antioxidant strength is categorized by IC_{50} values as follows: very strong (<50 ppm), strong (50–100 ppm), moderate (101–150 ppm), and weak (>150 ppm). The choice of solvent used in the extraction process significantly influences the antioxidant activity (Molyneux & Associates, 2003). These results indicate that the ethanol extract has potential as a very strong natural antioxidant compared to the water extract.

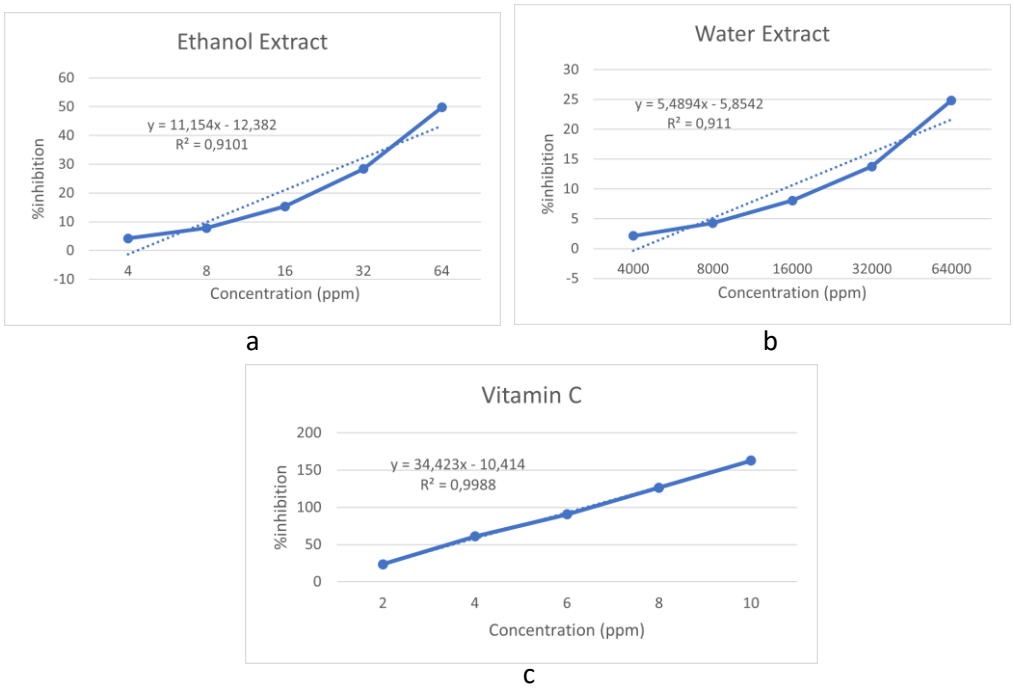


Figure 3. Absorbance curve of antioxidant test (a) Ethanol extract (b) Water extract (c) Vitamin C

The ethanol extract, which exhibited better antioxidant activity than the water extract, was further utilized for the biosynthesis of AgNPs by varying the synthesis temperature and time. The resulting nanoparticles were analyzed using UV-Vis spectrophotometry based on the Surface Plasmon Resonance (SPR) absorption band. SPR is associated with the color of the AgNP solution, caused by electron excitation in the conduction band near the nanoparticle surface and light-induced vibrations on the nanoscale structure (Bhakya *et al.*, 2016). The plasmon resonance generates absorption during measurement, influencing the peak absorbance spectrum. Absorption between 400–500 nm indicates the presence of AgNPs (Kumari *et al.*, 2010; Leela & Vivekanandan, 2008; Tippayawat *et al.*, 2016).

Table 4. Results of UV-Vis spectrophotometer analysis on AgNP

Temperature (°C)	Time (minute)	Wavelengths (nm)	Absorbtion
40	15	405.30	2.2190
	30	405.00	2.2119
	45	406.00	2.3198
	60	405.90	2.4200
50	15	401.70	1.9949
	30	402.10	1.9993
	45	401.30	2.1481
	60	401.60	2.2048
60	15	398.20	2.2367
	30	399.50	2.3740
	45	400.60	2.6785
	60	400.90	2.9599

The sample solution synthesized at 40°C and 50°C showed absorption at wavelengths of 400–406 nm. In contrast, the sample synthesized at 60°C exhibited wavelengths around 390–400 nm. Absorption at 400–450 nm corresponds to silver nanoparticles (Ag^0), while absorption at 370–400 nm indicates silver ions (Ag^+) (Wahyudi *et al*., 2011). High temperatures are necessary to facilitate reduction and regulate the size of AgNPs. However, this is likely due to rapid agglomeration caused by the degradation of secondary metabolites in the extract, which should function as reducing and stabilizing agents during AgNP synthesis, resulting in less optimal stabilization of the formed AgNPs. It is necessary to adjust the temperature according to the extract used (Tippayawat *et al*., 2016). Based on the resulting SPR, a single band suggests spherical nanoparticles, while two or more SPR bands indicate anisotropic molecules (Udayasoorian *et al*., 2011; Bhakya *et al*., 2016).

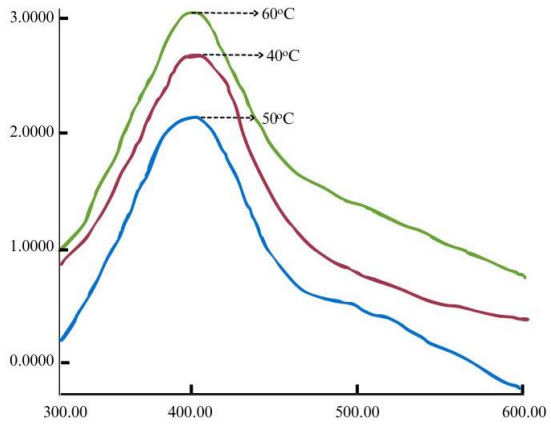


Figure 4. AgNPs biosynthesis absorbance in 60 minutes with temperature variation

CONCLUSION

The ethanol extract demonstrated significant antioxidant activity based on DPPH measurements, with an IC50 value superior than the water extract. In the biosynthesis of AgNPs, the ethanol extract

functioned effectively as a reducing and stabilizing agent at 40–50°C, accelerating synthesis without degrading all secondary compounds. These findings reinforce the potential use of red dragon fruit peel. The ethanol extract offers new opportunities for developing eco-friendly and economically valuable health products. This study highlights the importance of optimizing red dragon fruit peel in the health industry and underscores the need for further research to explore its potential applications in pharmaceutical, cosmetic, and health supplement products.

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