

## Development of the Fruit Peels of Rambutan (*Nephelium lappaceum* L.) into Herbal Tea

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### Abstract

Rambutan (*Nephelium lappaceum*) peel contains various bioactive compounds, including phenolics, flavonoids, and ellagic acid, which function as antioxidants. Antioxidants are compounds needed to inhibit radical reactions and oxidation processes that trigger various diseases. This study aims to determine the potential of rambutan peel to become a herbal tea. The study began with the determination of total phenolic and flavonoid levels in aqueous extracts of rambutan peel, followed by antioxidant activity assessment using the DPPH and FRAP methods. As a comparison, tea from tea leaves (*Camellia sinensis*) and herbal teas from kelor (*Moringa oleifera*) leaves and senduduk (*Melastoma malabathricum* L) leaves were used. The results showed that the aqueous extract of rambutan peel had a total phenolic content of 344.07 mg GAE/g and a flavonoid content of 7.96 mg QE/g, higher than those of tea leaves, kelor leaves, and senduduk leaves. Antioxidant activity test using the DPPH method showed that rambutan peel aqueous extract is an active antioxidant with an  $IC_{50}$  of 0.797  $\mu$ g/mL, with antioxidant activity 5.45 times stronger than tea leaves, 10.33 times stronger than moringa leaves, and 4.32 times stronger than senduduk leaves. Antioxidant test using the FRAP method also showed that the antioxidant capacity of rambutan peel water extract is 29.66 mgTE/g, higher than those of tea leaves, kelor leaves, and senduduk leaves, with values of 19.84 mgTE/g, 6.12 mgTE/g, and 14.52 mgTE/g, respectively. These data indicate that rambutan peel has strong antioxidant activity and has the potential to be developed as a herbal tea.

**Keywords:** *Nephelium lappaceum* peel, antioxidants, herbal tea, DPPH, FRAP

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### Abstrak (Indonesian)

Kulit buah rambutan diketahui mengandung berbagai senyawa bioaktif termasuk golongan fenolik, flavonoid, dan asam ellagik yang berfungsi sebagai antioksidan. Penelitian ini bertujuan untuk mengetahui potensi pengembangan kulit rambutan menjadi teh herbal. Penelitian diawali dengan penentuan kadar total fenolik dan flavonoid dari ekstrak air teh kulit rambutan, kemudian dilakukan pengujian aktivitas antioksidan menggunakan metode DPPH dan FRAP. Sebagai pembanding digunakan teh dari daun teh (*Camellia sinensis*) dan teh herbal daun kelor (*Moringa oleifera*) dan senduduk (*Melastoma malabathricum* L). Hasil penelitian menunjukkan seduhan air kulit rambutan memiliki kadar total fenolik 344,07 mg GAE/g dan kadar flavonoid sebesar 7,96 mg QE/g, lebih tinggi dibandingkan daun teh maupun dari daun kelor dan bunga telang. Pengujian aktivitas antioksidan dengan metode DPPH menunjukkan seduhan air kulit rambutan aktif

antioksidan dengan  $IC_{50}$  0,797 mg/mL dengan kekuatan aktivitas antioksidan 5,45 kali lebih kuat dari daun teh, 10,33 kali lebih kuat dari daun kelor dan 4,32 kali lebih kuat dari daun senduduk. Pengujian antioksidan dengan metode FRAP juga menunjukkan kapasitas antioksidan ekstrak air kulit rambutan 29,656 mgTE/g lebih tinggi dibandingkan dengan pembanding daun teh, daun kelor dan bunga telang dengan nilai masing-masing 19,84 mgTE/g, 6,12 mgTE/g dan 14,52 mgTE/g. Data menunjukkan kulit rambutan memiliki aktivitas antioksidan yang sangat baik dan berpotensi dikembangkan sebagai sediaan teh herbal.

**Kata Kunci:** Kulit rambutan, antioksidan, teh herbal, DPPH, FRAP

## INTRODUCTION

Tea is a popular beverage worldwide. It comes in various varieties, including green, black, white, and olong tea. Each type of tea has distinct characteristics and flavor. Consuming tea offers a variety of health benefits. Tea contains essential nutrients, including vitamin B1, iron, vitamin B2, potassium, vitamin B3, and vitamin B6.

Furthermore, tea also contains antioxidants such as polyphenols and flavonoids, which are used for the body [1]. The compounds in these secondary metabolites contribute to tea's ability to scavenge free radicals, support heart health, reduce the risk of cancer, maintain blood sugar levels, support bone health, and reduce stress. In addition to these teas, herbal teas are also being widely developed. Herbal tea refers to beverages made from herbal ingredients, not tea leaves. Some well-known herbal teas include kelor leaf tea, chamomile tea, and ginger tea. Herbal teas typically do not contain caffeine and are often consumed by the public due to their health benefits [2]. The development of herbal teas is related to their secondary metabolites, which are beneficial for health. Another herbal tea under development is rambutan peel tea, which has antioxidant properties [3]. People in the Papua region have used rambutan peel as a herbal tea [4].

Rambutan (*Nephelium lappaceum* L.) is a tropical fruit that grows in most Southeast Asian countries, including Indonesia, Malaysia, the Philippines, Vietnam, Sri Lanka, Cambodia, and Thailand. Rambutan peel has been reported to contain compounds from the tannin, saponin, alkaloid, flavonoid, and triterpenoid groups [5]. The antioxidant activity of the ethanol extract of rambutan peel, measured using the DPPH method, was reported to have an  $IC_{50}$  value of 1.155  $\mu$ g/mL [6]. The total flavonoid content in dried rambutan peel reached 20.51 mg/100 g, higher than that of fresh rambutan peel, which was only 9.60 mg/100 g [7]. However, no information on the antioxidant activity of rambutan peel aqueous extracts has been found. The antioxidant properties of rambutan peel are related to its chemical content in the form of ellagic acid, corilagin, geraniin,  $\beta$ -carotene, rutin, quercetin, ethyl gallate, and vitamin

C [7,8]. These antioxidant properties can neutralize free radicals and protect against oxidative damage [9]. To develop the potential of rambutan peel as a commercial herbal tea, it is necessary to test its water extract for antioxidant activity and compare it with that of commercial teas available in the market. Several methods can be used to measure antioxidant activity. The methods are grouped based on their working principles. The 2,2-diphenyl-1-picrylhydrazyl (DPPH) and 2,2'-azino-bis(3-ethylbenzothiazolin-6-sulfonic acid) (ABTS) methods are based on the ability to capture free radicals, the Ferric Reducing Antioxidant Power (FRAP), Cupric Ion Reducing Antioxidant capacity (CUPRAC), and Folin-Ciocalteu (FC) methods are based on the ability to reduce metal ions and the Oxygen Radical Absorbance capacity (ORAC) and Total Reactive Antioxidant Potential (TRAP) methods are competitive methods [10]. This study aims to determine the potential of *N. lappaceum* peel as a herbal tea by assessing the total levels of phenolic and flavonoid compounds in rambutan peel simplicia water extract and the antioxidant activity using the DPPH and FRAP methods. The DPPH and FRAP methods are simple: the DPPH method measures free radical scavenging, while the FRAP method measures antioxidant activity by inhibiting oxidation

## MATERIALS AND METHODS

### Materials

The equipment used in this study included a UV-Vis spectrophotometer. The materials used included 2,2-diphenyl-1-picrylhydrazyl (DPPH), 2,4,6-Tripyridyl-S-Triazine (TPTZ), aluminum (III) chloride, 40 mmol/L hydrochloric acid, sulfuric acid, 10% trichloroacetic acid, iron (III) chloride, acetate buffer pH 3.6, chloroform, Folin-Ciocalteu reagent solution, magnesium, methanol, sodium acetate, sodium chloride, *Nephelium lappaceum* peel, tea leaves, moringa leaf tea, senduduk leaf tea, and Trolox.

### Methods

#### Sample Preparation

Rambutan fruit peel samples were obtained from the Ogan Ilir region, South Sumatra. The rambutan

peels were cleaned of dirt, rinsed with running water, and then cut into small pieces. The peel was dried at room temperature, and after drying, the rambutan peels were ground into a coarse powder, similar to commercial tea [7].

#### **Preparation of rambutan peel water extract**

The rambutan peel powder (1 g) was brewed with 100 mL of hot water (80 °C) for 3 minutes to obtain an aqueous rambutan peel extract [7]. The same process was carried out for the comparison teas (tea from tea leaves and herbal teas from kelor leaves and senduduk leaves).

#### **Determination of total phenolic content of rambutan peel water extract and standard**

The sample (1 mL) with a series of concentrations 1%, 0.5%, 0.25%, 0.062%, 0.031%, 0.016%, and 0.008% was placed in a 5 mL volumetric flask, and 0.5 mL of 50% (v/v) Folin-Ciocalteu reagent and the mixture was incubated for 5 minutes, then 1 mL of 5% (w/v) sodium carbonate solution was added, followed by distilled water up to the mark. The mixture was homogenized using a vortex until thoroughly mixed. The solution was incubated in a dark bottle for one hour. Absorbance was measured at 795 nm using a UV-Vis spectrophotometer. Total phenolic content was determined using equation 1.

$$\text{Phenolic content} = \frac{C \times V \times F_p}{m} \dots\dots\dots(1)$$

Where C is sample concentration (mg/L), V is sample volume (mL), Fp is dilution factor, and m is Sample weight (g).

#### **Determination of Flavonoid Content**

A 1 mL sample with a series of concentrations of 1%, 0.5%, 0.25%, 0.125%, 0.062%, 0.031%, 0.016%, and 0.008% was dissolved in 2 mL of methanol using a 5 mL volumetric flask. Next, 0.1 mL of 10% aluminum (III) chloride solution, 0.1 mL of 1 M sodium acetate solution, and methanol were added to the mark. The mixture was homogenized using a vortex and incubated at room temperature for 30 minutes. Then, absorbance was measured with a UV-Vis spectrophotometer at the maximum wavelength. Total flavonoid content was calculated using a regression equation from the calibration curve of quercetin [12]. Determination of flavonoid content is described by equation 2.

$$\text{Flavonoid content} = \frac{C \times V \times F_p}{m} \dots\dots\dots(2)$$

Where C is sample concentration (mg/L), V is sample volume (mL), Fp is dilution factor, and m is Sample weight (g).

#### **Antioxidant activity by the DPPH Method**

0.2 mL of a series of concentrations (1, 0.5, 0.25, 0.125, 0.062, 0.031, 0.016, and 0.008%) was added to 3.8 mL of DPPH solution in a dark bottle, and the mixture was homogenized. The mixture was left at room temperature for 30 minutes, then its absorbance was measured using a UV-Vis spectrophotometer at the maximum absorbance of the DPPH solution (516 nm). The percentage of DPPH radical inhibition was calculated using the equation:

$$\% I = \frac{\text{Absorbance control} - \text{Absorbance sample}}{\text{Absorbance control}} \times 100 \% \dots\dots\dots(3)$$

Where % I is the Percent inhibition. Free radical scavenging activity is expressed through the IC<sub>50</sub> value, which is the sample concentration required to inhibit 50% of DPPH free radicals (y = 50). The IC<sub>50</sub> value is calculated using the linear regression equation y = ax + b, with y as the percentage inhibition and x as the concentration [13].

#### **Antioxidant Activity by the FRAP method**

##### **FRAP reagent preparation**

The FRAP reagent solution was prepared by mixing 25 mL of acetate buffer, 2.5 mL of TPTZ, and 2.5 mL of FeCl<sub>3</sub>·6H<sub>2</sub>O in a 100 mL volumetric flask, then diluting to a final volume of 100 mL with distilled water [14].

##### **Trolox standard curve preparation**

Trolox standard solutions with series concentrations of 75, 37.5, 18.75, 9.375, and 4.6875 μM were prepared from a 600 μM stock solution. Three mL of FRAP reagent was added to each sample. Absorbance was then measured at a maximum wavelength of 596 nm using a UV-Vis spectrophotometer. The absorbance obtained was plotted against concentration to obtain a linear regression equation.

#### **Determination of antioxidant activity by the FRAP Method**

One mL of each sample (0.008%) was placed in a test tube, then 3 mL of FRAP reagent was added. The mixture was incubated at 37 °C for 30 minutes. The absorbance was measured at 596 nm using a UV-Vis spectrophotometer. The antioxidant activity was determined based on the TEAC (trolox equivalent antioxidant capacity) value, calculated from absorbance and concentration data using a linear regression equation [15]. The antioxidant capacity value can be calculated using equation 4.

$$\text{TEAC} = \frac{C \times V \times F_p}{m} \dots\dots\dots(4)$$

Where C is sample concentration (mg/L), V is sample volume (mL), Fp is dilution factor, and m is Sample weight (g).

## RESULTS AND DISCUSSION

### *Total phenolic and total flavonoid content*

The total phenolic content of a water extract of rambutan peel was determined using a colorimetric method using gallic acid as a standard. Commercial tea, tea leaves (*Camellia sinensis*), herbal teas made from kelor leaves (*Moringa oleifera*), and senduduk leaves (*Melastoma malabathricum* L.) were used as comparisons. The total phenolic content of the water extract of rambutan peel was 344.07 mg GAE/g (Table 1). The tea leaves contained only 172.59 mg GAE/g, kelor leaves 89.90 mg GAE/g, and senduduk leaves 73.08 mg GAE/g. This indicates that rambutan peel has a higher total phenolic content than the comparison teas (tea leaves, kelor leaves, and senduduk leaves). The high phenolic content in rambutan peel is thought to originate from compounds derived from gallic acid, ellagic acid, and geraniin, which also contribute to the skin's distinctive astringent flavor [16]. Furthermore, the drying and

brewing processes at specific temperatures help release soluble phenolic compounds, resulting in rambutan peel tea with a high phenolic content.

In addition to phenolics, the total flavonoid content in the water extract of rambutan peel simplicia was also higher than that of the comparison tea. The total flavonoid content of rambutan peel water was 7.96 mg QE/g, while in commercial tea leaves, 3.27 mg QE/g; in kelor leaves, 2.93 mg QE/g; and in senduduk leaves, 3.28 mg QE/g. The flavonoid content of rambutan peel ethanol extract was reported to be 0.2051 mg QE/g [17]. Flavonoids are polyphenolic compounds that can stabilize free radicals through the formation of stable aromatic resonance structures. Flavonoids, such as quercetin, kaempferol, corilagin, rutin, and ethyl gallate, are found in abundance in rambutan peel and play a role in protecting body tissues against oxidative damage [16]. The high flavonoid content in rambutan peel is directly related to increased antioxidant capacity. The flavonoids act as hydrogen donors and metal chelators, inhibiting the formation of reactive oxygen species (ROS).

**Table 1.** Total phenolic and flavonoid content of aqueous extract of rambutan peel

Sample	Total phenolic (mg GAE/g)	Flavonoid (mg QE/g)
Rambutan peel	344.07	7.96
<b>Standard</b>		
Tea leaves	172.59	3.27
Kelor leaves	89.90	2.93
Senduduk leaves	79.16	1.26

### *Antioxidant Activity by DPPH Method*

The DPPH method was used to measure the antioxidant activity of compounds by scavenging free radicals. The DPPH (2,2-diphenyl-1-picrylhydrazyl) reagent has a deep purple color and acts as a stable free radical, absorbing at approximately 517 nm. When DPPH reacts with antioxidant compounds, such as phenolics or flavonoids, the free radicals are neutralized through the donation of hydrogen atoms or electrons from the antioxidant compound. This reduction process causes the solution to change color from dark purple to yellow. The intensity of the color change depends on the concentration and strength of the reacting antioxidant. The greater the decrease in purple color intensity, the lower the absorbance value and the higher the antioxidant activity. Antioxidant activity is expressed as a percentage inhibition value. The lower the absorbance value, the greater the percentage inhibition value and the stronger the

antioxidant activity (Table 2). Based on the % inhibition value, the IC<sub>50</sub> was determined using a linear regression of % inhibition (y) versus concentration (x) (Table 3) [18, 19].

The aqueous extract of rambutan peel has an IC<sub>50</sub> of 0.797 mg/mL, while tea leaves have an IC<sub>50</sub> of 4.347 mg/mL, kelor leaves 8.227 mg/mL, and senduduk leaves 4.42 mg/mL. A smaller IC<sub>50</sub> value indicates stronger antioxidant activity. The data show that rambutan peel shows stronger activity than tea leaves and the comparison herbal teas, both kelor leaves and senduduk leaves. The capacity or antioxidant strength of rambutan peel water extract was compared to the comparison tea leaves and with other herbal teas (kelor leaves, senduduk leaves) by comparing the IC<sub>50</sub> value of rambutan peel to the IC<sub>50</sub> of the comparison. The antioxidant strength of rambutan peel herbal tea was 5.454 times stronger than tea from tea leaves, while kelor leaves tea and

senduduk leaves were 10.32 and 4.32 times stronger, respectively. This shows that rambutan peel has much greater potential to be developed as a herbal tea compared to tea from tea leaves or other commercial herbal teas (kelor leaves and senduduk leaves). The antioxidant activity of rambutan peel ethanol extract, measured using the DPPH method, yielded an  $IC_{50}$  value of 1.155  $\mu\text{g/mL}$  [20], and the ethyl acetate

fraction showed antioxidant activity with an  $IC_{50}$  value of 26.22  $\mu\text{g/mL}$  [21]. The data show that the antioxidant activity of rambutan peel ethanol extract is higher than that of the water extract. The antioxidant properties of rambutan peel are related to its chemical content in the form of ellagic acid, corilagin, geraniin,  $\beta$ -carotene, and vitamin C.

**Table 2.** % Inhibition value of samples and standard

Concentration (% w/v)	% Inhibisi			
	Sample	Standard tea		
	Rambutan peel	Tea leaves	Kelor leaves	Senduduk leaves
1	83.18	69.33	59.90	90.88
0.5	82.87	55.69	31.79	64.76
0.25	82.56	32.62	21.33	59.27
0.125	78.36	25.64	12.21	32.22
0.062	34.56	14.05	11.59	19.27
0.031	18.87	13.13	11.08	20.93
0.016	16.92	12.31	10.77	9.32
0.008	14.87	11.90	8.92	7.77

**Table 3.**  $IC_{50}$  value of the sample and the standard herbal tea

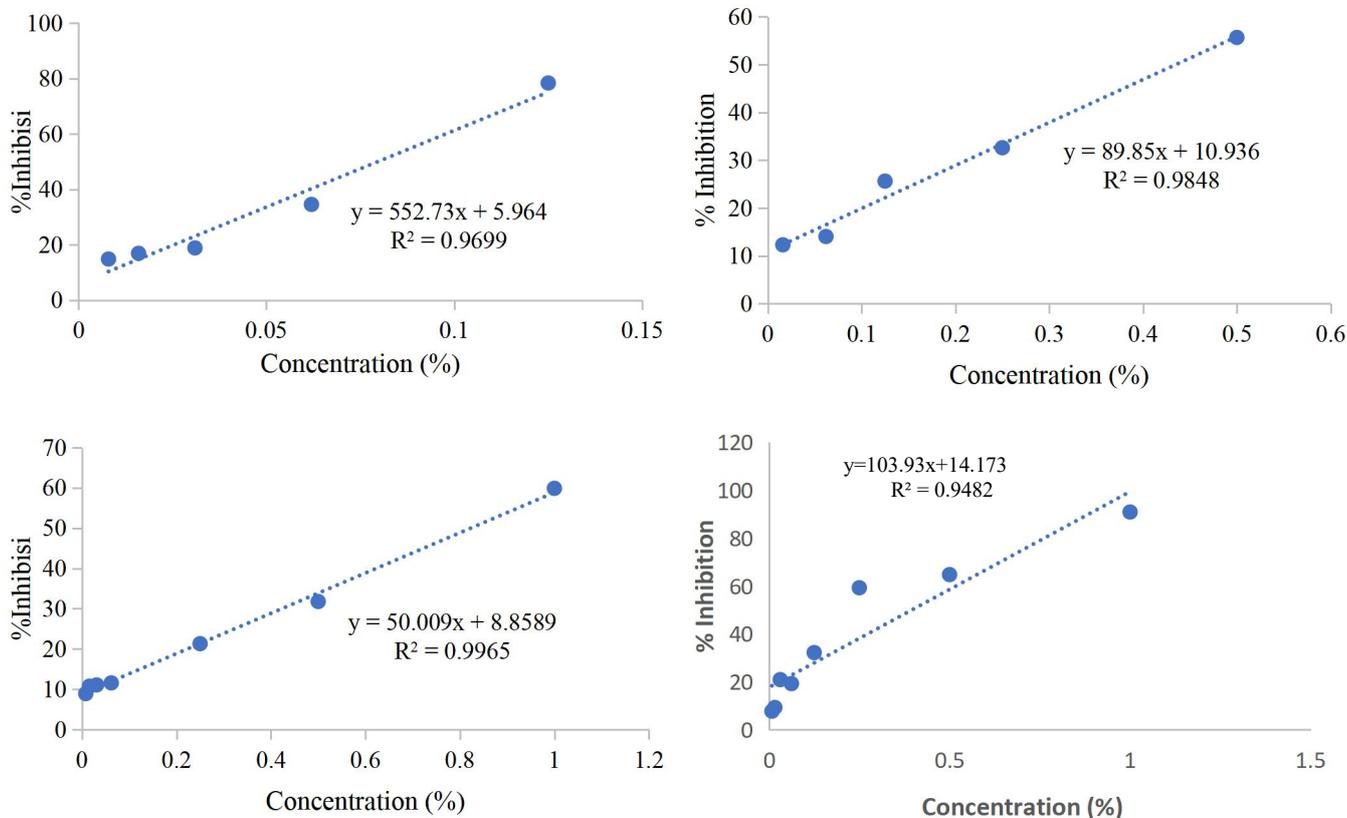
Sampel	$IC_{50}$ (%)	$IC_{50}$ (mg/mL)	Antioxidant strength relative to the standard
Rambutan peel	0.0797	0.797	
Standard tea			
<i>Tea leaves</i>	0.4348	4348	5.45
<i>Kelor leaves</i>	0.8227	8227	10.32
<i>Senduduk leaves</i>	0.3447	3447	4.32

Antioxidant Activity Test by the FRAP Method the Ferric Reducing Antioxidant Power (FRAP) method is one method that is widely used because it is simple, fast, inexpensive, and does not require special equipment. The basic principle of the FRAP method is the ability of antioxidant compounds to reduce iron (III) ions ( $Fe^{3+}$ ) to iron (II) ( $Fe^{2+}$ ) [18]. The increase in absorbance indicates the antioxidant capacity of a sample. This mechanism illustrates the ability of antioxidant compounds to neutralize oxidants that can damage body cells. For comparison, a standard of Trolox, a synthetic antioxidant with a chemical structure similar to that of  $\alpha$ -tocopherol (vitamin E), was used. Trolox has high antioxidant activity and is often used as a standard in determining antioxidant capacity. Sample activity values are expressed in units of TEAC (Total Equivalent Antioxidant Capacity), which is the concentration of trolox equivalent to the sample's antioxidant capacity. The higher the TEAC value, the greater the antioxidant capacity of the sample being analyzed. The FRAP

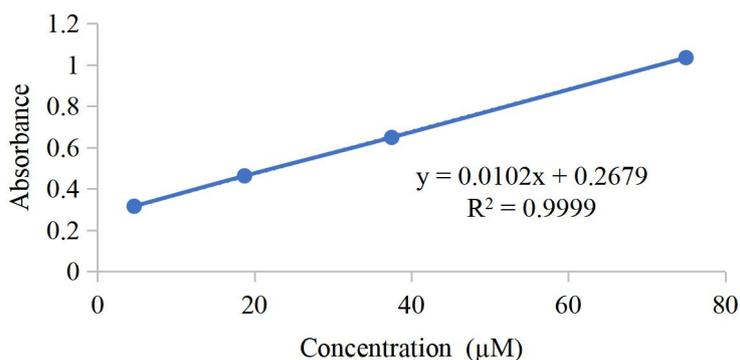
method shows that the rambutan peel samples have an antioxidant activity of 29.66 mg TE/g. For commercial tea comparisons, tea leaves were 19.84 mgTE/g, Kelor leaves tea were 6.12 mgTE/g, and Senduduk leaves tea were 14.52 mgTE/g. These results are correlated with total phenolic and flavonoid content, as well as antioxidant activity measured using the DPPH method [22]. Soleshe et al. (2022) [23] also reported a correlation between total phenolic and flavonoid content and antioxidant activity in tests of 18 functional plants in Korea. The use of rambutan peel as an ingredient in herbal tea not only has health benefits but also environmental and economic value. Rambutan peel is considered a household organic waste that is rarely utilized and often discarded. In fact, the bioactive compound content is actually higher than in the fruit flesh. By processing rambutan peel into herbal tea, the potential for organic waste can be reduced, and a high-value product can be produced for development as a functional beverage. Some of the pharmacological

activities of rambutan fruit peel reported include antioxidant, cytotoxic, antimicrobial, antidiabetic, anti-hypercholesterolemic, anti-hyperuricemia,

analgesic, anti-inflammatory, immunomodulatory, anticancer, and antiviral activities against the dengue virus [24].



**Figure 1.** Correlation between % inhibition value and concentration of rambutan peel (A), tea leaves (B), kelor leaves (C), and senduduk leaves (D)



**Figure 2.** Trolox standard curve

**Table 4.** TEAC value of the aqueous extract of rambutan peel

Sample (g)	TEAC (mgTE/g)	Sample (g)	TEAC (mgTE/g)
Rambutan peel	29.66	Kelor leaves	6.12
Tea leaves	19.84	Senduduk leaves	14.52

Noted: TEAC (trolox equivalent antioxidant capacity)

## CONCLUSION

Rambutan (*Nephelium lappaceum* L.) peel has great potential as a raw material for herbal tea, with total phenolic and flavonoid contents higher than those of commercial tea leaves, kelor leaf tea, and senduduk leaves tea. The rambutan peel by the DPPH method showed an antioxidant strength 5.45 times stronger than tea leaves, 10.33 times stronger than kelor leaf tea, and 4.32 times stronger than senduduk leaves tea. Antioxidant activity testing using the FRAP method also showed results consistent with the DPPH method, with an antioxidant capacity of 29.66 mgTE/g. These data indicate the potential of rambutan peel for development into herbal tea products.

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