



Comparison of Indonesian Herbal Drinks Empon-empon and Wedang Pokak for Vitamin C Content and Antioxidant Activity

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ABSTRACT

Empon-Empon and Wedang Pokak are traditional Indonesian herbal drinks prepared from various spices through a simple production process. Empon-Empon consists of red ginger, turmeric, nutmeg, aromatic ginger, bay leaves, lemongrass, galangal, cinnamon, and cloves. At the same time, Wedang Pokak contains red ginger, cloves, lemongrass, cinnamon, cardamom, pandan leaves, and star anise. Both drinks are widely recognized as sources of antioxidants and vitamin C, and are believed to strengthen the immune system. This study aimed to determine the vitamin C content and antioxidant activity of Empon-Empon and Wedang Pokak. Vitamin C analysis was carried out using UV-Vis spectrophotometry, which showed a maximum wavelength at 245 nm with a linear regression equation $y = 0.0434x - 0.0967$ ($R^2 = 0.9942$). The vitamin C content was 23.33 $\mu\text{g}/\text{mL}$ (0.233%) in Empon-Empon and 20.28 $\mu\text{g}/\text{mL}$ (0.202%) in Wedang Pokak. Antioxidant activity was determined using the DPPH method, yielding inhibition percentages of 21.28% (20 $\mu\text{g}/\text{mL}$), 40.16% (40 $\mu\text{g}/\text{mL}$), 46.48% (60 $\mu\text{g}/\text{mL}$), and 59.67% (80 $\mu\text{g}/\text{mL}$) for Wedang Pokak, with an IC_{50} value of 63.33 $\mu\text{g}/\text{mL}$. This activity was lower than Empon-Empon (IC_{50} 40.53 $\mu\text{g}/\text{mL}$) and pure vitamin C (IC_{50} 3.77 $\mu\text{g}/\text{mL}$). In conclusion, Empon-Empon exhibited higher vitamin C content and stronger antioxidant activity than Wedang Pokak, highlighting its potential as a functional drink to support health.

Keywords: Antioxidant; Empon-Empon; Indonesian herbal drinks; Wedang Pokak; Vitamin C

INTRODUCTION

Indonesia has long been recognized for its abundant diversity of traditional spices, which for centuries have been utilized not only as culinary ingredients but also as remedies for maintaining health and treating various diseases.¹ The use of these natural resources reflects a deep-rooted

cultural heritage, where knowledge of their therapeutic benefits has been passed down through generations and continues to play an important role in community health practices.² Among the traditional herbal formulations developed are Empon-Empon and Wedang Pokak, both of which remain popular as functional beverages.

Empon-Empon is prepared from a mixture of turmeric, red ginger, nutmeg, galangal, bay leaves, cloves, aromatic ginger, cinnamon, and lemongrass³. Its relatively simple preparation, combined with its high content of bioactive compounds such as antioxidants and vitamin C, has made it widely consumed to support immunity and reduce inflammation, including conditions related to viral infections.⁴ In contrast, Wedang Pokak is produced by boiling selected spices and leaves,⁵ such as red ginger, cloves, lemongrass, cinnamon, cardamom, pandan leaves, and star anise.³ This beverage is also appreciated for its antioxidant potential and its ability to strengthen the body's natural defense system.⁶

Vitamin C, one of the key micronutrients present in spices and herbal drinks, plays an essential role in human physiology as an antioxidant, a regulator of blood circulation, and a cofactor that enhances iron absorption.⁷ However, the concentration of vitamin C can vary considerably depending on the raw materials used, making accurate quantification necessary.⁸ Among the available analytical approaches, UV-Vis spectrophotometry is widely applied due to its simplicity, rapid analysis, minimal solvent consumption, and high precision in both qualitative and quantitative measurements.⁹ In addition, the antioxidant capacity of herbal preparations is often evaluated using the DPPH method,¹⁰ which provides reliable information regarding their free-radical scavenging activity.¹¹

Considering these aspects, the present study aims to determine the levels of vitamin C and antioxidant activity in Empon-Empon and Wedang Pokak using UV-Vis spectrophotometry and the DPPH assay. Unlike most previous studies that have primarily focused on a single type of herbal beverage or limited their scope to measuring antioxidant capacity alone, the present study provides a comparative analysis between two culturally significant

Indonesian herbal drinks – Empon-Empon and Wedang Pokak – each prepared using distinct spice compositions. Furthermore, this work integrates quantitative determination of vitamin C content with DPPH-based antioxidant profiling to explore potential correlations between micronutrient concentration and radical scavenging ability. The findings are expected to provide new insights into how variations in formulation affect the functional quality of traditional beverages, thereby contributing to the scientific standardization and validation of Indonesia's ethnopharmacological heritage.

METHODS

Determination

To ensure the authenticity of the raw materials used, all plant materials that make up Empon-Empon and Wedang Pokak have been determined and identified at the Research Centre for Plant Conservation and Botanical Gardens, Indonesian Institute of Sciences (LIPI), Bogor, Indonesia. The identification process was carried out in 2021 based on examination of the morphological characteristics of leaves, stems, and fruits, which were compared with comparative specimens from the herbarium collection. The identification results showed that the species used included *Syzygium polyanthum* (bay leaf), *Cymbopogon citratus* (lemongrass), and *Alpinia galanga* (L.) Wild. (galangal), *Cinnamomum burmannii* (cinnamon), *Syzygium aromaticum* (L.) Merr. & L.M. Perry (clove), *Zingiber officinale* var. *rubrum* (red ginger), *Curcuma longa* Linn. (turmeric), *Myristica fragrans* Houtt. (nutmeg), *Kaempferia galanga* L. (galangal), *Pandanus amaryllifolius* Roxb. (pandan), *Amomum cardamomum* L. (cardamom), *Illicium verum* Hook. f. (star anise), and *Piper nigrum* L. (pepper).

Materials

Analytical Balance (AND), Measuring Cup (Iwaki Pyrex), Measuring Flask (Iwaki

Pyrex), Spectrophotometer (Merck), Sonicator (GB-928 Ultrasonic Cleaner), Pipette, Vitamin C (Sigma Aldrich), Aquabides, Turmeric, Nutmeg, Red Ginger, Cloves, Bay Leaves, Cinnamon, Galangal, Lemongrass, Galangal, Cardamom, Pandan Leaves, and Star Anise.

Sample Preparation

The raw ingredients of Empon-Empon and Wedang Pokak were sourced from Prumpung Market, Gunung Sindur District, Bogor Regency. Each material was carefully selected, thoroughly rinsed, cut into small pieces, and dried in a hot-air oven at 40–50 °C. The dried materials were then pulverised into fine powders using a laboratory blender. For beverage preparation, 2 g of each powdered sample was decocted in 100 mL of mineral water until a characteristic brownish colour appeared. The resulting extract was cooled to ambient temperature, filtered, and subjected to subsequent analyses.

Quantitative Analysis of Vitamin C

Preparation of Vitamin C Standard Solution

Vitamin C standard (10 mg) was precisely weighed and dissolved in distilled water in a 100 mL volumetric flask to yield a 100 µg/mL stock solution. The solution was then sonicated to ensure complete dissolution and homogeneity.¹²

Determination of Maximum Wavelength

Aliquots of the vitamin C stock solution were diluted to 25 and 30 µg/mL, and their absorbance was scanned using a UV-Vis spectrophotometer within the wavelength range of 200–400 nm. The maximum absorption wavelength (λ max) was observed at 245 nm.¹³

Calibration Curve

Standard solutions of vitamin C with concentrations of 5, 10, 15, 20, 25, and 30 µg/mL were obtained by serial dilution of the 100 µg/mL stock solution. The absorbance of these standards was recorded at 245 nm using a UV-Vis

spectrophotometer, and the data were used to construct a calibration curve correlating absorbance with concentration.¹²

Measurement of Vitamin C in Samples

Each sample (Empon-Empon or Wedang Pokak, 10 mg) was dissolved in a 100 mL volumetric flask with distilled water and homogenized using a sonicator. A 1 mL aliquot of each solution was diluted to 10 mL, and absorbance was measured at 245 nm. The vitamin C content was calculated using the regression equation from the calibration curve.¹²

Antioxidant Activity Assay

Preparation of DPPH Stock Solution

DPPH powder (0.098 g) was dissolved in pro-analysis methanol and diluted to a final volume of 50 mL to obtain a 200 µg/mL stock solution.¹⁴

Preparation of DPPH Blank

A 40 ppm DPPH solution was prepared by diluting 2 mL of the stock solution to 10 mL with methanol. The absorbance spectrum was measured over the 400–800 nm range to determine the maximum absorption wavelength (λ max), which subsequently served as the reference for blank measurements.¹⁴

Preparation of Test Solutions

Wedang Pokak: A 1000 µg/mL stock solution was prepared, and aliquots were diluted to final concentrations of 20, 40, 60, 80 and 100 µg/mL. Each solution was mixed with 2 mL of the 200 µg/mL DPPH solution, adjusted to 10 mL with methanol, and incubated in the dark for 30 minutes. The selected concentration range was based on preliminary trials that confirmed a linear response ($R^2 > 0.99$) within this range, ensuring adequate accuracy for the determination of IC_{50} values.

Empon-Empon: Prepared using the same procedure and concentrations as Wedang Pokak.

Vitamin C standard: Dilutions of 2, 4, 6, 8 and 10 µg/mL were prepared from the vitamin C stock solution. Each dilution was combined with 1 mL of 200 µg/mL DPPH

solution, diluted to a final volume of 10 mL using methanol, and incubated in the dark for 30 minutes to minimize light-induced degradation.¹⁴

Evaluation of Antioxidant Potential Using the DPPH Assay

The antioxidant activity of each solution was expressed as the percentage of DPPH inhibition using the formula:

$$\% \text{Inhibition} = \frac{(A \text{ blank} - A \text{ sample})}{A \text{ blank}} \times 100\%$$

where A blank is the absorbance of the control solution, and A sample is the absorbance of the test solution.

Determination of IC₅₀ Value

The IC₅₀ value was determined by linear regression analysis, where sample concentration was plotted against the percentage of DPPH inhibition.¹⁵ The regression equation (Y = aX + b) was used by substituting Y = 50 to obtain the corresponding concentration (X), defined as the IC₅₀.¹⁶

RESULTS AND DISCUSSION
Empon-empon and Wedang Pokak Formulations

The formulation of Empon-Empon used in this study was based on previous hedonic and organoleptic evaluations, demonstrating the highest level of consumer acceptance. This formulation also showed good stability, with no significant changes in color, taste, aroma, or texture up to seven days of storage at temperatures of -1.5 °C, 27 °C, and 40 °C. The detailed composition of Empon-Empon and Wedang Pokak is presented in Tables 1 and 2.

Empon-Empon predominantly comprises lemongrass (30%) and bay leaves (25%), supported by several rhizomes such as galangal, red ginger, turmeric, and aromatic ginger. This combination contributes to its distinctive flavor, aroma, and phytochemical content. In contrast, Wedang Pokak contains more red ginger (55%) and cardamom (20%), with smaller clove, cinnamon, pandan leaves, and star anise. The different proportions of spices in both formulations are expected to influence their phytochemical profiles,

including vitamin C content and antioxidant activity.

Table 1. Empon-Empon powder formulation

Herb	Ingredients (% w/w)	Herb parts
Red ginger	5	Rhizomes
Turmeric	5	Rhizomes
Nutmeg	5	Seeds
Aromatic ginger	5	Rhizomes
Bay leaf	25	Leaves
Lemongrass	30	Stems
Galangal	15	Rhizomes
Cinnamon	5	Bark
Clove	5	Flowers

Table 2. Wedang Pokak powder formulation

Herb	Ingredients (% w/w)	Herb parts
Red ginger	55	Rhizomes
Clove	5	Flowers
Lemongrass	5	Stems
Cinnamon	5	Bark
Cardamom	20	Fruits
Pandan	5	Daun
Star anise	5	Flowers

Vitamin C Levels

To determine vitamin C content, 2 g of Empon-Empon and Wedang Pokak powder were decocted in 100 mL of water. Quantification was based on a standard calibration curve of ascorbic acid with the maximum absorption wavelength (λ_{max}) was observed at 245 nm.¹³ As the result (Figure 1), with the regression analysis yielding the following equation: y=0.0434x-0.0967(R²=0.9942). The high correlation coefficient (R² = 0.9942) confirms excellent linearity and reliability of the UV-Vis spectrophotometric method used.

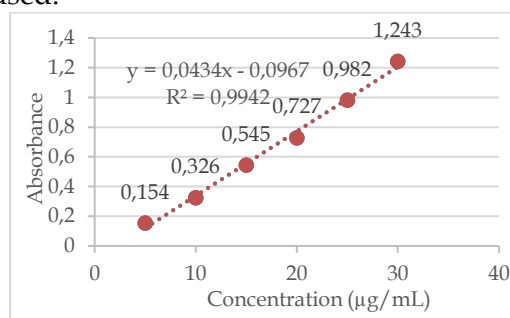


Figure 1. Ascorbic Acid (Vitamin C) standard calibration curve

Table 3 shows that the vitamin C content of boiled Empon-Empon reached an average of 23.33 µg/mL (0.233%), while Table 4 indicates that Wedang Pokak contained 20.28 µg/mL (0.202%). These findings demonstrate that both herbal decoctions are rich sources of vitamin C, with Empon-Empon exhibiting slightly higher levels than Wedang Pokak.

Table 3. Vitamin C level in boiled Empon-Empon

R	Abs	[C] (µg/mL)	Level (%)	Average level (µg/mL)	Average level %
1	0,924	23,52	0,2352	23,33	0,233
2	0,908	23,15	0,2315		

R: Repetition, [C]: Concentration, Abs: Absorbance

Table 4. Vitamin C level in boiled Wedang Pokak

R	Abs	[C] (µg/mL)	Level (%)	Average level (µg/mL)	Average level %
1	0,795	20,55	0,2055	20,28	0,202
2	0,772	20,02	0,2002		

The results indicate that Empon-Empon provides a higher vitamin C concentration than Wedang Pokak. This may be due to turmeric, lemongrass, bay leaves, and multiple rhizomes in Empon-Empon, which contribute additional ascorbic acid and phytochemical precursors that stabilize vitamin C during the boiling process. In contrast, Wedang Pokak, which relies heavily on red ginger (55%) and cardamom (20%), offers a different phytochemical profile that may not retain vitamin C as effectively.

Interestingly, the vitamin C content in these formulations is higher than that measured in individual plant components, such as turmeric (0.660 µg/mL),¹⁷ lemongrass (15 µg/mL),¹⁶ and a red ginger combination with lime and honey (103.88 µg/mL).⁸ This suggests a synergistic effect when multiple herbs are combined in traditional formulations, enhancing flavor and aroma and increasing nutritional and therapeutic value.¹⁸ Vitamin C is a well-known antioxidant critical in scavenging free radicals, regulating inflammatory responses, and supporting immune cell function.¹⁹

Previous studies have reported that concentrations exceeding 0.8 µg/mL can inhibit

free radicals and stimulate the activity of neutrophils and macrophages. Therefore, the concentrations observed in Empon-Empon (23.33 µg/mL) and Wedang Pokak (20.28 µg/mL) are considered biologically significant.

Antioxidant Activity

The antioxidant activity of Empon-Empon and Wedang Pokak was evaluated using the DPPH method, which is widely applied due to its simplicity, rapid execution, and minimal sample requirement.²⁰ The calibration curves obtained from vitamin C and the linear regression plots for both formulations are shown in Figures 2, 3, and 4.

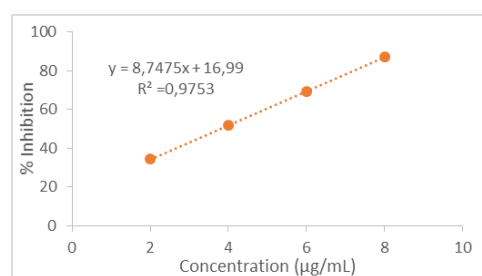


Figure 2. Standard calibration curve of antioxidants on vitamin C

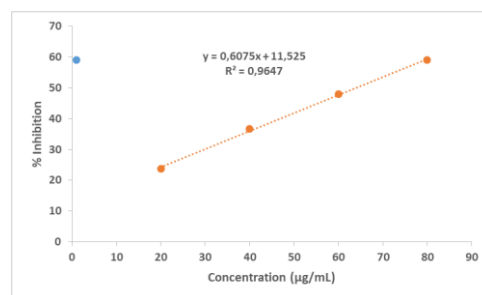


Figure 3. Linear regression of Wedang Pokak antioxidants

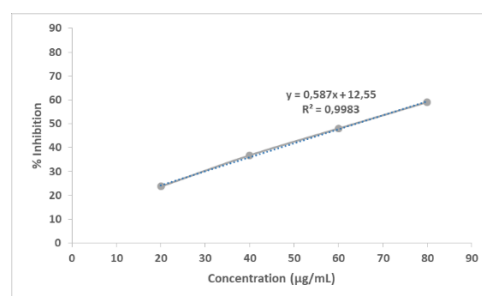


Figure 4. Linear regression of Empon-empon antioxidants

Based on the regression analysis, the Wedang Pokak formulation exhibited a linear regression equation of $y = 0.6075x +$

11.525 ($R^2 = 0.9647$), while the Empon-Empon formulation yielded $y = 1.0178x + 8.745$ ($R^2 = 0.978$). For comparison, the vitamin C standard showed a regression equation of $y = 8.5525x + 17.645$ ($R^2 = 0.9756$), confirming the method's reliability. The IC_{50} values, indicating the concentration at which 50% of DPPH radicals are scavenged, were obtained by extrapolating the regression equations.

The results demonstrated that Wedang Pokak had an IC_{50} value of 63.33 ppm, categorised as a potent antioxidant. Empon-Empon showed a more vigorous activity with an IC_{50} value of 40.53 ppm, falling into the powerful antioxidant category. As expected, vitamin C exhibited the highest antioxidant capacity with an IC_{50} of 3.77 $\mu\text{g/mL}$, consistent with its role as a natural antioxidant standard.^{21,22}

These findings align with previous reports on the antioxidant properties of the individual herbs. For instance, cinnamon exhibited an IC_{50} value of 44.87 $\mu\text{g/mL}$,²³ pandan leaf extract showed 39.7 $\mu\text{g/mL}$,²⁴ and star anise extract achieved a 97.6% inhibition.²⁵ Interestingly, the IC_{50} values of the Wedang Pokak formulation (63.33 $\mu\text{g/mL}$) and Empon-Empon (40.53 $\mu\text{g/mL}$) suggest that combining herbs can enhance antioxidant effects beyond the contribution of single extracts alone. This phenomenon may be attributed to synergistic interactions among bioactive compounds, including phenolics, flavonoids, and essential oils, which can work cooperatively to neutralize free radicals more efficiently.

Comparable synergistic interactions have been reported in earlier studies; for instance, the combination of sappanwood and cinnamon bark extracts demonstrated higher antioxidant activity than the individual extracts.²⁶

Similarly, a multi-herbal drink prepared from black grass jelly, ginger, and cinnamon exhibited significantly enhanced radical scavenging capacity.²⁷ These parallels reinforce the notion that traditional formulations like Empon-Empon and Wedang Pokak benefit from multi-component synergy, which improves sensory attributes such as taste and aroma and augments their therapeutic potential as functional beverages.

This study employed the DPPH assay as a reference method to determine antioxidant capacity. This approach's principle lies in reducing the stable violet-colored DPPH radical to its non-radical yellow form when exposed to hydrogen-donating antioxidants. This transformation is quantitatively expressed as a decrease in absorbance at 517 nm. The magnitude of this reduction reflects the tested sample's electron- or hydrogen-donating ability, which in turn represents its potential to neutralize free radicals. Compared with other antioxidant assays, DPPH remains highly favored due to its operational simplicity, rapid response, and suitability for a wide range of natural product extracts. More importantly, the assay provides a reliable estimation of radical scavenging activity relevant to understanding the therapeutic potential of traditional formulations such as Empon-Empon and Wedang Pokak.

As shown in Table 5, both Empon-Empon and Wedang Pokak demonstrated concentration-dependent scavenging activity: higher concentrations of the extracts resulted in greater DPPH inhibition and lower absorbance values. This trend reflects the increasing availability of antioxidant molecules in the solution, leading to more effective radical neutralisation.

Table 5. Results of absorbance and inhibition percentage measurements

Sample	[C] ($\mu\text{g/mL}$)	A_{control}	A_{Sample}	% Inhibition
Wedang Pokak Formulation	20		0,3849	21,28
	40		0,2926	40,16
	60		0,2617	46,48
	80		0,1972	59,67
Empon-Empon Extract	20		0,3638	25,60
	40	0,4890	0,2291	53,14
	60		0,1323	72,94
	80		0,0643	86,85
Vitamin C	2		0,3289	32,74
	4		0,2127	56,50
	6		0,1677	65,70
	8		0,0587	87,99

The DPPH assay is widely recognized as a standard technique for assessing antioxidant activity because it is fast,

straightforward, and requires only minimal sample preparation. Its working principle involves the reduction of the stable purple-colored DPPH radical by antioxidant compounds through electron or hydrogen atom donation, which converts it into a non-radical form. This reaction is marked by a visible color shift from violet to yellow and can be quantitatively monitored as a decline in absorbance at 517 nm.²⁸

As shown in Table 5, both Empon-Empon and Wedang Pokak demonstrated concentration-dependent scavenging activity: higher concentrations of the extracts resulted in greater DPPH inhibition and lower absorbance values. This trend reflects the increasing availability of antioxidant molecules in the solution, leading to more effective radical neutralization.

Among the tested samples, Vitamin C exhibited the most vigorous activity, with 87.99% inhibition at eight ppm, consistent with its role as a standard antioxidant. Empon-Empon showed higher radical scavenging activity than Wedang Pokak across all tested concentrations, reaching 86.85% inhibition at 80 ppm, compared to 59.67% inhibition for Wedang Pokak at the same concentration. This suggests that Empon-Empon contains a more diverse set of antioxidant phytochemicals, likely contributed by its multiple rhizome components (red ginger, turmeric, galangal, and aromatic ginger) and phenolic-rich spices (cloves and cinnamon).

The differences in antioxidant activity between the two formulations may also be explained by their phytochemical composition. Previous studies have shown that the antioxidant potential of herbal extracts correlates with their total phenolic content and the number and position of hydroxyl groups in their molecular structures, which directly influence electron or hydrogen-donating ability.²⁹ Furthermore, synergistic effects between different bioactive compounds in multi-herb formulations may enhance radical scavenging capacity, as demonstrated in

combinations such as sappanwood with cinnamon or ginger with cinnamon in traditional beverages.^{26,27}

These findings reinforce the importance of Empon-Empon and Wedang Pokak not only as culturally significant Indonesian beverages but also as potential sources of natural antioxidants that can support immune function and reduce oxidative stress.

CONCLUSION

Empon-Empon and Wedang Pokak are traditional Indonesian beverages rich in antioxidants and vitamin C, with potential health benefits, particularly for enhancing the immune system. This study successfully quantified the vitamin C content and antioxidant activity in both drinks, demonstrating that Empon-Empon has higher vitamin C levels (23.33 µg/mL) and more potent antioxidant activity (IC₅₀ of 40.53 µg/mL) compared to Wedang Pokak (vitamin C at 20.28 µg/mL and IC₅₀ of 63.33 µg/mL). These findings reveal the potential of these traditional beverages as functional drinks with antioxidant properties, although Empon-Empon shows superior efficacy compared to Wedang Pokak.

Conflict of Interest

The authors declare no conflicts of interest regarding this research and publication.

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Authors' Declaration

All authors were involved in the conceptualization, design, data analysis of the experiment, and manuscript editing. They have all reviewed and approved the final version of the manuscript

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