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Original Article

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Analysis of Phenolic Content in *Salacca edulis* from West Seram District

Alwi Smith[1], Kristin Sangur[2*], Rufiati Simal[3] Erika Siahaya[4]

[1,2,4]Program of Biology Education, Faculty of Teacher Training and Education, Universitas Pattimura, Ambon, Indonesia
*Corresponding author's e-mail: sangur_kristin@yahoo.com
[3]Elementary School Teacher Study Program PSDKU Aru Islands, Faculty of Teacher Training and Education, Pattimura University Dobo, Indonesia

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Abstract. *Salacca edulis* is a plant native to the Maluku region, found in villages within the Taniwel District of West Seram Regency, such as Laturake, Riring, Rumasoal, Buria, and Niniari. It is called red salak due to the distinct red color of its fruit flesh. In general, salak contains various secondary metabolites, such as phenols, which can function as natural antibacterial agents and antioxidants, helping to counteract free radicals and environmental stress. Phenolic compounds are also known to potentially prevent cancer, cardiovascular diseases, and osteoporosis, and they play a role in the prevention of neurodegenerative diseases and diabetes mellitus. The phenolic content of red salak from the West Seram region has not previously been studied. This research aimed to determine the total phenolic content in the fruit flesh and peel of red salak from the villages of Riring and Buria, Taniwel District, West Seram Regency. Phenolic levels were analyzed using a spectrophotometric method, and the data obtained were analyzed descriptively. The average total phenolic content in samples from Riring village was 405.06 mg GAE/g for the fruit flesh and 588.94 mg GAE/g for the peel, while in Buria village, the average phenolic content was 243.12 mg GAE/g for the fruit flesh and 546.83 mg GAE/g for the peel.

Keywords: Phenol Content; Salacca edulis; West Seram District

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INTRODUCTION

Phenolic compounds are an important group of secondary metabolites widely distributed in various plant species, particularly fruits, vegetables, seeds, and other plant-derived materials. These compounds have attracted considerable attention in food science, plant physiology, and nutritional research because of their diverse biological activities and potential applications in human health and food industries. Structurally, phenolic compounds are characterized by one or more hydroxyl groups attached to aromatic rings and comprise several major groups, including phenolic acids, flavonoids, tannins, and other polyphenolic compounds. Their biological properties are associated with their chemical structures, concentrations, and interactions with other phytochemical constituents. In particular, phenolic compounds have been recognized for their antioxidant, antimicrobial, anti-inflammatory, and other biological activities (Albuquerque et al., 2021; Araújo et al., 2021; Wang et al., 2020).

Phenolic compounds play an important role in protecting plant cells against oxidative damage caused by reactive oxygen species (ROS). In plants, these metabolites are involved in various physiological and biochemical processes, including growth regulation, defense mechanisms, and responses to environmental stress. Their accumulation may be influenced by genetic characteristics, environmental conditions, light intensity, temperature, and other ecological factors. Kołton et al. (2022) explained that environmental factors, particularly light conditions, contribute to the regulation of phenolic biosynthesis in plants. Furthermore, plant phenolics are involved in protective responses against ultraviolet radiation, pathogen infections, and other environmental stresses (Albuquerque et al., 2021). Consequently, investigating phenolic compounds in locally cultivated fruit species provides valuable information about their biochemical characteristics and potential nutritional properties.

Fruits are among the most important dietary sources of natural phenolic compounds. The composition and concentration of these compounds vary considerably among plant species, cultivars, fruit tissues, and geographical origins. Phenolic compounds may occur in free or bound forms, depending on their chemical associations with cellular structures and other macromolecules. Wang et al. (2020) emphasized that bound phenolics are distributed in different plant tissues and may contribute substantially to the biological activities of plant-derived foods. In addition, the extraction and recovery of these compounds depend on the characteristics of the plant matrix, solvent polarity, and extraction procedures (Ameer et al., 2017; Alara et al., 2021). These characteristics demonstrate the importance of investigating the phenolic content of different tropical fruit species as a basis for understanding their potential as sources of natural bioactive compounds.

One tropical fruit with considerable potential for phytochemical investigation is salak (*Salacca* spp.), which belongs to the family Arecaceae and is widely cultivated in Indonesia and other Southeast Asian countries. Salak is recognized by its distinctive scaly fruit skin, characteristic taste, and edible flesh. Besides its nutritional value, salak contains several phytochemical constituents, including phenolic compounds, flavonoids, and tannins, which are associated with its antioxidant properties. Previous investigations have demonstrated that salak fruit and its different anatomical parts contain bioactive compounds with potential functional applications. Girsang et al. (2021), for example, reported the presence of total phenolics and flavonoids in ethanolic extracts of Salacca zalacca peel and demonstrated their antioxidant activities through several in vitro assays. Similarly, Ilmiah et al. (2021) investigated total phenolic content, flavonoid content, and antioxidant activity in salak fruits subjected to different agricultural treatments. Their findings indicated that agricultural management could influence fruit quality and its phytochemical characteristics.

Further evidence regarding the phenolic composition of salak was provided by (Hlásná Čepková et al. 2021), who identified 19 phenolic compounds in salak pulp using ultra-high-performance liquid chromatography coupled with tandem mass spectrometry (UHPLC-MS/MS). The identified compounds included phenolic acids, flavanols, flavonols, and flavones, with chlorogenic acid identified as the predominant phenolic compound. Other detected compounds included epicatechin, isoquercetin, neochlorogenic acid, ferulic acid, gallic acid, and procyanidin B2. These findings provide important evidence that salak is a potential natural source of phenolic compounds with antioxidant properties.

In addition to the fruit pulp, other parts of salak, including the peel and seeds, have also been investigated as potential sources of phenolic compounds. (Kesuma et al., 2022) examined the total phenolic content of ethanol extracts from different varieties of Bali salak seeds using the Folin–Ciocalteu method and reported variations in phenolic concentrations among the varieties. Yoga and Rabani (2022) also investigated total phenolics, flavonoids, and tannins in probiotic beverages produced from salak juice, demonstrating the presence of phytochemical constituents in processed salak products. These studies indicate that the phenolic characteristics of salak may differ depending on the fruit variety, anatomical part, and processing conditions Lateh et al. (2024) investigated the extraction of phenolic compounds from Salacca zalacca peel using

microwave-assisted extraction. Their results showed that optimized extraction conditions produced a total phenolic content of 86.25 mg gallic acid equivalents (GAE)/g extract. This study highlights the importance of extraction conditions in determining the amount of phenolic compounds recovered from salak materials. Similarly, Widnyani et al. (2024) investigated the antioxidant capacity of fermented Bali salak juice and reported variations in antioxidant capacity associated with fermentation duration. These findings suggest that the phytochemical properties of salak are relevant not only to fresh fruit consumption but also to the development of value-added food products.

The presence and concentration of phenolic compounds in plant materials are also strongly associated with extraction techniques and analytical procedures. Phenolic compounds exhibit different solubility characteristics depending on their molecular structures, polarity, and interactions with the plant matrix. Alara et al. (2021) explained that the selection of an appropriate extraction technique is essential for maximizing the recovery of phenolic compounds from plant materials. Ameer et al. (2017) also emphasized the importance of extraction efficiency and the development of environmentally friendly extraction methods for obtaining polyphenolic compounds. Furthermore, Rashmi and Negi (2020) highlighted that processing and storage conditions can influence the stability and availability of phenolic acids in plant-based foods. Therefore, standardized extraction procedures are necessary to ensure reliable and comparable measurements of phenolic content.

The Folin Ciocalteu spectrophotometric method is widely used to determine total phenolic content in plant extracts. This method is based on the reduction of the Folin–Ciocalteu reagent by reducing substances in the sample, resulting in the formation of a blue-colored complex that can be measured spectrophotometrically. The results are commonly expressed as milligrams of gallic acid equivalents per gram of extract (mg GAE/g extract) or per 100 grams of sample (mg GAE/100 g sample). Raposo et al. (2024) emphasized that analytical conditions, including reaction time, reagent concentration, calibration procedures, and method validation, can substantially influence the reliability of total phenolic measurements. Consequently, standardized analytical procedures are essential when evaluating phenolic content in different plant materials.

Despite the increasing number of studies investigating the phytochemical composition and antioxidant properties of salak, research focusing on the phenolic content of Salacca edulis from West Seram District, Maluku Province, Indonesia, remains limited. Previous investigations have primarily examined Salacca zalacca from other geographical locations, different fruit varieties, and various anatomical parts. Therefore, the existing findings cannot be directly generalized to Salacca edulis cultivated in West Seram District. Differences in geographical conditions, soil characteristics, climatic factors, plant genetic characteristics, and agricultural practices may contribute to variations in the accumulation of secondary metabolites, including phenolic compounds. The investigation of locally cultivated salak is thus necessary to provide region-specific scientific information regarding its phytochemical characteristics.

West Seram District has agricultural and biological resources that offer opportunities for further scientific investigation, particularly regarding the phytochemical potential of locally cultivated tropical fruits. However, the biochemical characteristics of Salacca edulis from this region have not been adequately documented. This limitation represents an important research gap because information about total phenolic content can contribute to the scientific characterization of local fruit resources and provide a foundation for subsequent studies on antioxidant properties and potential functional food applications. Furthermore, documenting the phytochemical characteristics of local plant resources may support the development of regional agricultural products through science-based approaches.

Based on these considerations, the present study aims to analyze the phenolic content of Salacca edulis obtained from West Seram District, Maluku Province, Indonesia. The research is expected to provide preliminary information regarding the total phenolic content of locally cultivated salak and contribute to the scientific documentation of its phytochemical characteristics. The findings may also serve as a reference for further investigations into antioxidant activity, the identification of individual phenolic compounds, and the potential utilization of Salacca edulis as a natural source of bioactive compounds.

MATERIALS AND METHODS

The researcher will analyze the phenol content in the peel and flesh of red salak (*Salacca edulis*) using the UV-VIS spectrophotometry method, which is employed for quantitative testing.

Sample Extraction

Weigh 20 grams of the pulverized peel and pulp of *Salacca edulis* from Riring and Buria villages, and place it into an Erlenmeyer flask. Add 250 ml of methanol and stir the mixture for 1 hour using a shaker. Allow it to undergo maceration for 6 hours shaking it occasionally followed by further soaking for another 18 hours.

Filter the resulting macerate using filter paper, then evaporate the filtrate at 45°C until a concentrated or nearly dry residue is obtained.

Determination of Phenol Content

The total phenolic content of the flesh and peel of *Salacca edulis* was determined spectrophotometrically using the Folin Ciocalteu reagent, with gallic acid as a reference standard. The principle of this method is the formation of a blue colored complex compound resulting from the reaction between phenolic compounds in the sample and the Folin-Ciocalteu reagent under alkaline conditions; this complex can be measured using a visible light spectrophotometer and subsequently expressed in terms of gallic acid equivalents.

Determination of operating time

A gallic acid solution with a concentration of 100 ppm was prepared. A 0.1 mL aliquot of this solution was then transferred into a test tube. To this, 7.9 mL of distilled water and 0.5 mL of Folin-Ciocalteu reagent were added, followed by vortexing for one minute. The mixture was then transferred to a 10 mL volumetric flask and brought to volume with a 20% sodium carbonate solution. The absorbance of the solution was measured at a wavelength of 700 nm at one-minute intervals to determine the point at which the absorbance became stable; this duration was then established as the operating time.

Determination of the maximum wavelength of Gallic Acid

A gallic acid solution with a concentration of 100 ppm was prepared. A 0.1 mL aliquot of this solution was then transferred into a test tube. To this, 7.9 mL of distilled water and 0.5 mL of Folin Ciocalteu reagent were added, followed by vortexing for one minute. The mixture was then transferred to a 10 mL volumetric flask and diluted to the mark with a 20% sodium carbonate solution. The solution was subsequently incubated for the required operating time. The maximum wavelength was measured using a spectrophotometer at approximately 700 nm.

Preparation of a gallic acid calibration curve

Gallic acid solutions with concentrations of 2, 4, 6, 8, 10, and 12 ppm were prepared. A 0.1 mL aliquot of each gallic acid solution was transferred into a test tube. To this, 7.9 mL of distilled water and 0.5 mL of Folin-Ciocalteu reagent were added, followed by vortexing for one minute. The mixture was then transferred to a 10 mL volumetric flask and diluted to the mark with a 20% sodium carbonate solution. The solution was incubated for the established operating time. Its absorbance was measured at the wavelength of maximum absorption, yielding a gallic acid calibration curve and a linear regression equation, $y = ax + b$.

Determination of Total Phenol Content

a 0.2-gram sample of *Salacca edulis* extract was dissolved in 10 ml of methanol. A 0.1 ml aliquot of this solution was transferred into a test tube. Then, 7.9 ml of distilled water and 0.5 ml of Folin-Ciocalteu reagent were added, and the mixture was vortexed for one minute. The solution was transferred into a 10 ml volumetric flask and brought to volume with a 20% sodium carbonate solution. The mixture was then incubated for the required operating time. Its absorbance was measured using a spectrophotometer at a wavelength of 700 nm. The total phenolic content of the red salak extract was determined by substituting the mean absorbance values of the sample into the linear regression equation derived from the calibration curve to obtain the concentration. The resulting sample concentration was then substituted into the following formula for calculating the total phenolic content:

$$\text{Total Phenol Content} = c \times v/g$$

Note:
c = Gallic acid equivalent concentration (mg GAE/ml)
v = Volume of the extract solution used (ml)
m = Mass of the extract used (grams)

RESULTS AND DISCUSSION

The determination of phenol content begins with the construction of a gallic acid standard curve, which is used to calculate the phenol concentration within the samples. To create this standard curve, a series of gallic

acid standard solutions with concentrations of 2, 4, 6, 8, 10, 12, and 14 ppm are prepared, and their absorbance is measured at a wavelength of 700 nm. The results of the absorbance measurements for the gallic acid standards are presented in Table 1.

Table 1. Absorbance readings of standard solutions

Concentration	Absorbance
2	0,157
4	0,268
6	0,405
8	0,536
10	0,662
12	0,799
14	0,925

Based on the absorbance values obtained in Table 1, a standard curve was constructed using MS Excel 2010, with concentration on the x-axis and absorbance on the y-axis. The standard curve is shown in Figure 1.

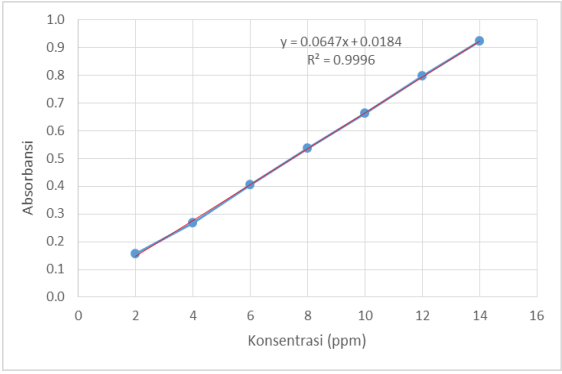


Figure 1. Gallic Acid Standard Curve

Figure 1 shows that the relationship between concentration and absorbance is linear. This linear standard curve indicates that a higher concentration results in a higher absorbance. This linear relationship yields a regression equation of Y = 0.0647X + 0.0184, with a coefficient of determination (R^2) of 0.9996 (or 99.96%).

The results demonstrated a positive relationship between the concentration of the standard solution and its corresponding absorbance values. As the concentration increased from 2 to 14, the absorbance increased from 0.157 to 0.925. This pattern indicates that higher concentrations of the standard solution produced greater absorbance values under the experimental conditions. The relationship between concentration and absorbance is an important characteristic of spectrophotometric analysis, particularly when determining total phenolic content using the Folin–Ciocalteu method. In this method, phenolic compounds react with the Folin–Ciocalteu reagent under alkaline conditions, producing a blue-colored complex. The intensity of the resulting color is measured spectrophotometrically, and the absorbance is used to estimate the concentration of phenolic compounds based on a calibration curve prepared using gallic acid as a reference standard (Raposo et al., 2024). The high linearity is important because the reliability of quantitative spectrophotometric analysis depends on the consistency of the relationship between analyte concentration and absorbance. Raposo et al. (2024) emphasized that analytical conditions, calibration procedures, and method validation are important considerations in obtaining reliable total phenolic measurements.

The resulting regression equation serves as a mathematical model used to predict the value of one variable based on a known value of another—in this case, predicting phenol concentration based on absorbance. The standard curve equation, Y = 0.0647X + 0.0184, is used to calculate the phenol concentration. The calibration curve developed in this study provides an analytical basis for investigating the phenolic content of Salacca edulis from West Seram District. The investigation is relevant because previous research has demonstrated that salak contains various phenolic compounds that contribute to its phytochemical characteristics.

Identified several phenolic compounds in Salacca zalacca pulp using UHPLC-MS/MS, including chlorogenic acid, epicatechin, catechin, ferulic acid, gallic acid, caffeic acid, and procyanidins. (Hlásná Čepková et al., 2021) Among the compounds identified, chlorogenic acid was the most abundant. Their findings demonstrate that salak fruit contains a diverse range of phenolic substances that may contribute to its antioxidant properties. However, the presence of these compounds in Salacca zalacca does not establish that the same compounds occur at identical concentrations in Salacca edulis from West Seram. Differences in

botanical identity, genetic characteristics, maturity, and growing environments may influence phytochemical composition. Therefore, the present study provides an important initial analytical framework for examining the phenolic characteristics of salak originating from Maluku.

The phenol concentration derived from this regression equation is then used to determine the phenol content, with the results presented in Table 2.

Table 2. Total Phenol Content

Sample Code		Weight of Extract (g)	Phenol Concentration (mg GAE/g)	Phenol Content (mg GAE/g)	Average Phenol Content (mgGAE/g)
Fruit Riring	U1	0.2	9,1746	458,84	405,06
	U2	0.2	7,0262	451,31	
Fruit Buria	U1	0.2	4,7542	237,72	243,12
	U2	0.2	4,9706	248,53	
Skin Riring	U1	0.2	12,3122	615,61	588,98
	U2	0.2	11,2457	562,28	
Skin Buria	U1	0.2	11,2148	560,74	546,83
	U2	0.2	10,6584	532,92	

Table 2 shows that the phenol content in the peel and flesh of *Salacca edulis* from Riring Village and Buria Village, Taniwel District, West Seram Regency, varies. The highest phenol content in the flesh of *Salacca edulis* was approximately 405.06 mgGAE/g (from Riring Village), while the lowest was approximately 243.12 mgGAE/g (from Buria Village). The highest phenol content in the peel of *Salacca edulis* was approximately 588.94 mgGAE/g (from Riring Village), and the lowest was approximately 546.83 mgGAE/g (from Buria Village). Based on these research findings regarding the phenol content in the peel and flesh of *Salacca edulis*, it is concluded that the highest phenol content of *Salacca edulis* is found in its peel.

The determination of total phenolic content may provide preliminary information about the bioactive characteristics of Salacca edulis from West Seram District. Phenolic compounds are frequently associated with antioxidant properties because several phenolic structures can donate electrons or hydrogen atoms to reactive species. However, total phenolic content should not be interpreted directly as antioxidant activity because antioxidant capacity also depends on the individual phenolic structures, their concentrations, and interactions with other chemical constituents.

The research conducted by Hlásná Čepková et al. (2021) supports the importance of further phytochemical investigations into salak, particularly through the identification of individual phenolic compounds. Their findings indicate that salak pulp contains several phenolic acids and flavonoids that may contribute to its potential as a functional food resource.

From a regional perspective, investigating the phenolic characteristics of salak from West Seram District may contribute to the scientific documentation of local agricultural products. The resulting information could provide a foundation for future studies concerning antioxidant activity, phytochemical characterization, and the development of food products based on local tropical fruits.

CONCLUSION

Based on the results of this study, it can be concluded that the phenol content in the peel and flesh of *Salacca edulis* from Riring village is higher than that of *Salacca edulis* from Buria village. The average total phenol content for samples from Riring village is 588.94 mgGAE/g for the peel and 405.06 mgGAE/g for the flesh, whereas for samples from Buria village, the average total phenol content is 546.83 mgGAE/g for the peel and 243.12 mgGAE/g for the flesh.

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CONFLICT OF INTEREST

The manuscript contains no conflicts of interest, and the authors assume full responsibility for the content of the article, including any implications arising from content generated by artificial intelligence (AI).

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