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Total Flavonoid, Total Phenolic Content, and Antioxidant Activity of Cardamom (Wurfbainia Compacta) Fruit Extract

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Total Flavonoid, Total Phenolic Content, and Antioxidant Activity of Cardamom (*Wurfbainia Compacta*) Fruit Extract

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ABSTRACT

Excessive free radicals contribute to oxidative stress, highlighting the need for natural antioxidants. This study aimed to determine total flavonoid and total phenolic contents and evaluate the antioxidant activity of *Wurfbainia compacta* Sol. ex. Maton fruit extracts. An experimental laboratory study was conducted using sonication with 70% ethanol and 70% ethyl acetate. Total flavonoid and total phenolic contents were determined spectrophotometrically using quercetin and gallic acid as standards, respectively, while antioxidant activity was measured using the FRAP assay with Trolox as a standard. The flavonoid contents of the 70% ethanol and 70% ethyl acetate extracts were 0.651 and 0.856 mg QE/g, respectively, while phenolic contents were 46.85 and 44.56 mg GAE/g for ethanol and ethyl acetate extracts, respectively. The antioxidant capacities of the 70% ethanol and ethyl acetate extracts of cardamom fruit were 345.58 and 454.24 mg TE/g, respectively.

INTRODUCTION

Free radicals are unstable molecules that can trigger oxidative stress when accumulated excessively in the body. This condition may contribute to the development and progression of various non-communicable diseases, including degenerative, metabolic, neurological, cardiovascular diseases, and cancer (Reddy, 2023; Chandimali et al., 2025). The global burden of these diseases remains substantial, with the World Health Organization reporting approximately 43 million deaths from non-communicable diseases in 2021 (World Health Organization, 2025). In Indonesia, non-communicable diseases account for nearly 75% of national deaths, with approximately 800,000 deaths reported annually (Biro Komunikasi dan Informasi Publik Kementerian Kesehatan RI, 2025). Therefore, maintaining the balance between free radicals and antioxidant defense is important for preventing oxidative damage. Although the human body produces endogenous antioxidants, exogenous antioxidants obtained from food and other natural sources are also needed to support antioxidant defense, particularly when endogenous capacity is insufficient (Nurkhasanah, Bachri, & Yuliani, 2023; Manful et al., 2025).

Cardamom (*Wurfbainia compacta* Sol. ex-Maton) is a spice belonging to the Zingiberaceae family and has long been used as a culinary ingredient and in traditional medicine. The plant is also recognized for its potential pharmacological properties, including antioxidant, antibacterial, anti-inflammatory, antidiabetic, cardioprotective, and hepatoprotective activities (Abdurahim et al., 2022; Heydarian et al., 2023). Previous research has reported that cardamom fruit contains several bioactive compounds, including tannins, alkaloids, saponins, flavonoids, steroids, triterpenoids, and polyphenols, which may contribute to its antioxidant potential (Nofriyaldi, Endah, & Mutiara, 2023). Flavonoids and phenolic compounds are particularly relevant because their chemical structures enable them to contribute to antioxidant activity through mechanisms associated with electron donation and reduction of reactive species.

The extraction process is an important factor affecting the amount and composition of bioactive compounds obtained from plant materials. In particular, solvent polarity can influence the ability of a solvent to extract specific phytochemical constituents and consequently affect antioxidant activity. Differences in solvent polarity have been reported to produce differences in phytochemical content and antioxidant capacity (Halim, Ranggaini, & Tedjokusumo, 2025). However, information regarding the relationship between solvent polarity, total flavonoid, phenolic, and tannin contents, and antioxidant activity specifically in *W. compacta* fruit remains limited. This study therefore contributes to knowledge by evaluating cardamom fruit extracts obtained using two solvents with different polarities, 70% ethanol and 70% ethyl acetate, and examining their total bioactive compound contents and antioxidant capacity. The comparison provides information on how solvent selection may influence the extraction of antioxidant-related compounds from cardamom fruit.

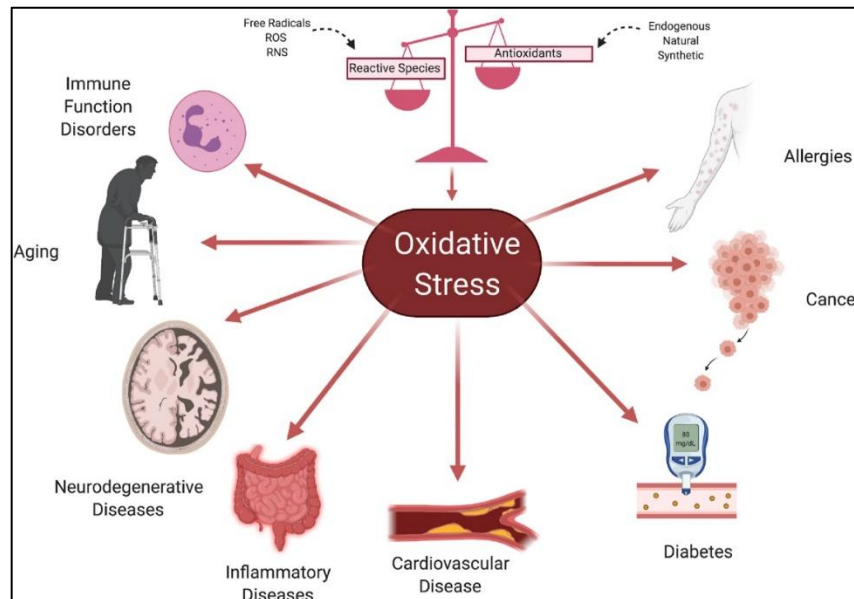


Figure 1. The Role of Oxidative Stress in the Pathogenesis of Various Diseases

Source: Adapted from Fleming and Luo (2021)

Antioxidants play an important role in protecting the body against free radicals and oxidative stress. They neutralize free radicals by donating electrons, thereby reducing cellular damage and protecting essential biological molecules. Antioxidants may be endogenous, such as superoxide dismutase (SOD), glutathione peroxidase (GPx), and catalase (CAT), or exogenous, obtained from food and supplements (Nurkhasanah, Bachri, & Yuliani, 2023). Exogenous antioxidants are particularly important when endogenous defenses are insufficient, such as during aging, metabolic stress, environmental toxin exposure, and chronic inflammation (Manful et al., 2025). Therefore, natural dietary sources of antioxidants are important for strengthening antioxidant defense against oxidative stress.

Cardamom (*Wurfbainia compacta* Sol. ex Maton) is a Zingiberaceae spice containing bioactive compounds with potential antioxidant properties. Previous studies have identified tannins, alkaloids, saponins, flavonoids, steroids, triterpenoids, and polyphenols in cardamom fruit (Nofriyaldi et al., 2023). However, the amount of extracted bioactive compounds and antioxidant activity can be influenced by solvent type and polarity. Differences in solvent polarity may affect phytochemical extraction and antioxidant capacity (Halim et al., 2025). Therefore, this study aimed to determine the total flavonoid and phenolic contents and evaluate the antioxidant activity of cardamom fruit extracts using 70% ethanol and 70% ethyl acetate, with the FRAP method used to assess antioxidant capacity.

METHODOLOGY

This laboratory experimental study used whole cardamom fruits (*Wurfbainia compacta* Sol. ex Maton) from a West Sumatra accession, Indonesia,

which were extracted by sonication using 70% ethanol and ethyl acetate as solvents. Total flavonoid and phenolic contents were determined spectrophotometrically at wavelengths of 425 nm and 730 nm, using quercetin and gallic acid as standards, respectively. Antioxidant activity of the extract was evaluated using the FRAP assay with Trolox as the standard, and absorbance was measured at 593 nm. All measurements were performed in triplicate. Data were analyzed using calibration curves and linear regression, with results expressed as mg standard equivalent /g extract and descriptively compared between the two extracts.

RESULTS AND DISCUSSION

Cardamom Fruit Extract Yield

The extraction of cardamom fruit simplicia using the sonication method with 70% ethanol and 70% ethyl acetate produced concentrated extracts with a dark color and characteristic odor, with the respective extraction yields presented in Table 1.

Table 1. Percentage Yield of Cardamom Fruit Extract

No	Type of solvent	Weight of crude drug (grams)	Extract weight (grams)	Yield (%)
1	Etanol 70%	200	13,950	6,980
2	Etil aetat 70%	200	5,600	2,800

Based on Table 1, the yield of the 70% ethanol extract of cardamom fruit was 6.980%, whereas that of the 70% ethyl acetate extract was 2.80%.

Total Flavonoid Content of Cardamom Fruit Extract

The total flavonoid content of the cardamom fruit extract was determined from the quercetin absorbance standard curve (Figure 2). The absorbance values of the cardamom fruit extracts (70% ethanol and 70% ethyl acetate) were converted into quercetin equivalent (QE) concentrations using the regression equation obtained from the quercetin standard curve. The absorbance values and QE concentrations of the cardamom fruit extracts are presented in Table 2.

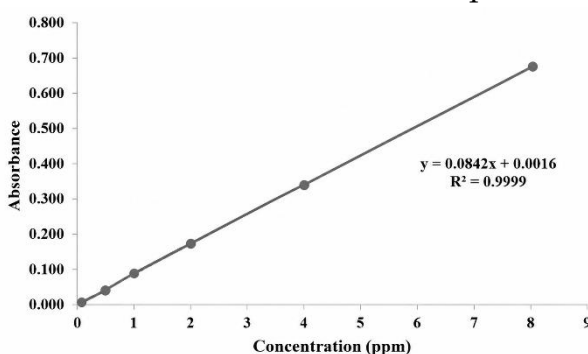


Figure 2. Quercetin Standard Regression Curve

The quercetin standard curve demonstrated a linear relationship between quercetin concentration and absorbance, with the regression equation $y = 0.0842x + 0.0016$, as shown in Figure 2. The coefficient of determination ($R^2 = 0.999$), which is close to 1, indicates that the regression equation is suitable for calculating the total flavonoid content of the extract samples. Based on the obtained regression equation, the total flavonoid content of the cardamom fruit extracts is presented in Table 2.

Table 2. Total flavonoid content of cardamom fruit extract

Type of solvent	Test	Absorbance	Total flavonoid content (mg QE/g extract)	Mean total flavonoid content (mg QE/g extract)
Etanol 70%	1	0,019	0,616	0,651
	2	0,021	0,686	
Etil asetat 70%	1	0,025	0,789	0,856
	2	0,029	0,924	

Based on Table 2, the total flavonoid content of the 70% ethanol and 70% ethyl acetate extracts of cardamom fruit was found to be 0.651 mg QE/g extract and 0.856 mg QE/g extract, respectively.

Total Phenolic Content of Cardamom Fruit Extract

The total phenolic content of the cardamom fruit extracts was determined using the regression equation obtained from the gallic acid standard curve and subsequently converted into gallic acid equivalent (GAE) content. The gallic acid standard curve and its regression equation are presented in Figure 3, while the total phenolic content of the cardamom fruit extracts is presented in Table 3.

Based on the measured concentration and absorbance values of gallic acid, the standard curve demonstrated a linear relationship with the regression equation $y = 0.0025x + 0.039$, as shown in Figure 4. The coefficient of determination ($R^2 = 0.9991$), which is close to 1, indicates that the standard curve is suitable for calculating the total phenolic content of the extract samples. Based on the obtained regression equation, the total phenolic content of the cardamom fruit extracts was calculated, and the results are presented in Table 3.

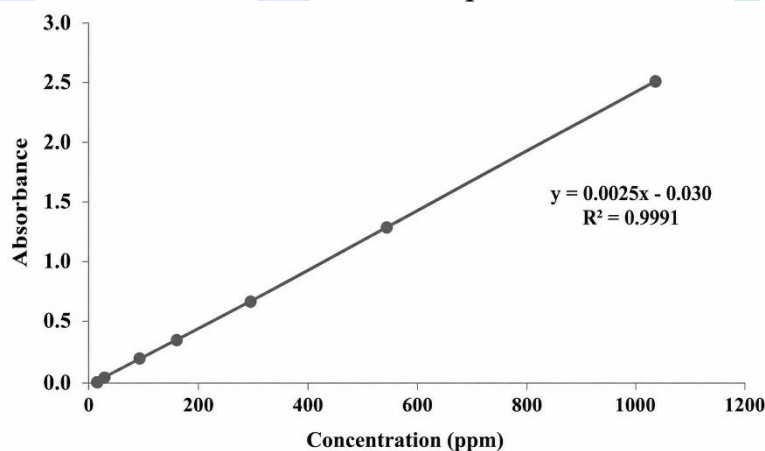


Figure 3. Gallic Acid Standard Regression Curve

Table 3. Total phenolic content of cardamom fruit extract

Type of solvent	Test	Absorbance	Total flavonoid content (mg QE/g extract)	Mean total flavonoid content (mg QE/g extract)
Etanol 70%	1	1,211	46,880	46,853
	2	1,207	46,720	
	3	1,213	46,960	
Etil asetat 70%	1	1,150	44,440	44,560
	2	1,156	44,680	
	3	1,153	44,560	

Based on Table 3, the total phenolic contents of the 70% ethanol and 70% ethyl acetate cardamom fruit extracts were 46.853 mg GAE/g extract and 44.560 mg GAE/g extract, respectively.

Antioxidant Activity of Cardamom Extract

The antioxidant activity of cardamom fruit extracts was evaluated using the FRAP method with a Trolox standard curve (Figure 4) and subsequently expressed as Trolox Equivalent Antioxidant Capacity (TEAC). The antioxidant activity of the cardamom fruit extracts is presented in Table 4.

Based on the Trolox standard curve shown in Figure 4, the linear regression equation was $y = 0.0015x - 0.0293$, with a coefficient of determination ($R^2 = 0.9999$). The R^2 value, which is close to 1, indicates an excellent linear relationship between Trolox concentration and the corresponding absorbance. This high coefficient of determination demonstrates that the measurement response had high precision, confirming the validity of the standard curve for calculating the antioxidant activity of the extract samples. Based on the Trolox standard curve equation, the antioxidant activity of the cardamom fruit extracts was calculated, with the results presented in Table 4.

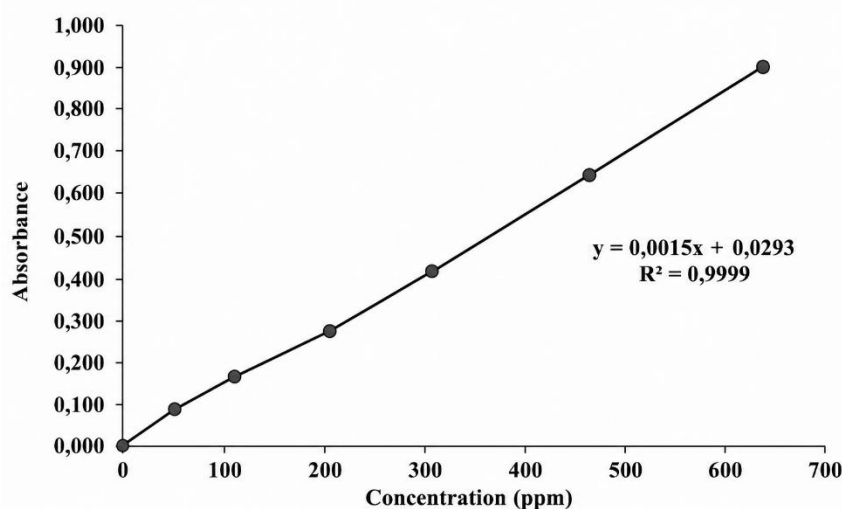


Figure 4. Trolox Standard Regression Curve

Table 4. Antioxidant Activity of Cardamom Fruit Extract

Type of solvent	Test	Absorbance	Antioxidant potential (mg TEAC/g extract)	Mean antioxidant potential (mg TEAC/g extract)
Etanol 70%	1	0,531	334,470	345,580
	2	0,560	353,800	
	3	0,552	348,470	
Etil asetat 70%	1	0,708	452,470	454,243
	2	0,706	451,130	
	3	0,718	459,130	

Based on Table 4, the antioxidant activities of the 70% ethanol and 70% ethyl acetate cardamom fruit extracts were 345.580 mg TEAC/g extract and 454.243 mg TEAC/g extract, respectively.

The extraction yield of cardamom fruit was 6.98% for the 70% ethanol extract and 2.80% for the 70% ethyl acetate extract. The higher yield obtained with ethanol is associated with its higher polarity and ability to extract a broader range of polar secondary metabolites, including phenolic and flavonoid compounds. This finding is comparable to Nofriyaldi et al., who reported a yield of 6.84% using 80% ethanol. In contrast, 70% ethyl acetate, which is relatively less polar, has more limited extraction capacity and consequently produced a lower yield. The total flavonoid content was 0.651 mg QE/g in the ethanol extract and 0.856 mg QE/g in the ethyl acetate extract. The higher flavonoid content in the ethyl acetate extract is consistent with the findings of Waras et al. (2025) and may be related to the formation of less-polar flavonoid aglycones during hydrolysis, which have greater affinity for semipolar solvents such as ethyl acetate.

The total phenolic content was higher in the 70% ethanol extract than in the ethyl acetate extract, with values of 46.853 and 44.560 mg GAE/g extract, respectively. This result is consistent with previous findings indicating that polar solvents are generally more effective in extracting phenolic compounds because many phenolics possess polar characteristics and occur as glycosides.

Flavonoids and phenols are considered to be natural antioxidants present in plant life. Therefore, there is a strong correlation between the content of phenols and flavonoids in a particular plant part and its antioxidant activity (Stojkovic et al., 2014). Antioxidant activity was evaluated using the FRAP (Ferric Reducing Antioxidant Power) method, which measures the ability of antioxidants to reduce Fe^{3+} -TPTZ to Fe^{2+} -TPTZ. The antioxidant activity of the ethanol and ethyl acetate extracts was 384.643 and 493.31 mg TEAC/g extract, respectively, indicating higher antioxidant capacity in the ethyl acetate extract. This finding is consistent with Waras et al. (2025), who reported greater antioxidant activity for ethyl acetate extract than ethanol extract using the DPPH method. The higher antioxidant capacity of the ethyl acetate extract may be associated with its higher flavonoid content, which can contribute to electron donation and reducing

capacity. These findings suggest that solvent polarity plays an important role in determining the composition of extracted bioactive compounds (Tsaturyan *et al.* 2025) and, consequently, the antioxidant capacity of cardamom fruit extracts. Differences in secondary metabolite content play an important role in the antioxidant activity of the samples used. According to Chen *et al.* (2022), the biological activity of plant secondary metabolites is strongly influenced by the polarity of the extraction solvent. Therefore, extraction using solvents of varying polarities is necessary to optimally evaluate the profile of secondary metabolites.

CONCLUSIONS AND RECOMMENDATION

The cardamom fruit (*Wurfbainia compacta* Sol. ex-Maton) extracts demonstrated antioxidant potential. The 70% ethanol and 70% ethyl acetate extracts contained total flavonoids of 0.651 and 0.856 mg QE/g extract, respectively, while their total phenolic contents were 46.853 and 44.560 mg GAE/g extract, respectively. The antioxidant capacities were 345.580 mg TEAC/g extract for the 70% ethanol extract and 454.243 mg TEAC/g extract for the 70% ethyl acetate extract. Overall, the ethyl acetate extract showed higher flavonoid content and antioxidant capacity, whereas the ethanol extract showed higher total phenolic content. These findings indicate that solvent polarity influences the extraction of bioactive compounds and the antioxidant capacity of cardamom fruit.

Further research should identify the specific antioxidant compounds present in cardamom fruit extracts using advanced analytical techniques such as LC-MS or HPLC. Optimization of solvent selection and analytical procedures is also recommended, particularly for tannin determination, to improve the detection and quantification of tannin compounds.

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