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Phytochemical Profile and Antioxidant Potential of Zingiberaceae and Solanaceae Plants Using the RAMES Method

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Abstract

Plants from the Zingiberaceae and Solanaceae families are recognized for their diverse phytochemical content and pharmacological potential. This study aimed to evaluate the phytochemical profiles and antioxidant activities of ten plant species from these families using the Rapid Metabolome Extraction and Storage (RAMES) method. Fresh rhizomes from Zingiberaceae and fruits from Solanaceae were extracted with ethanol, followed by qualitative phytochemical screening and antioxidant evaluation using the ABTS method. All tested species contained alkaloids, flavonoids, tannins, quinones, and phenols. Triterpenoids were consistently detected in Zingiberaceae species but were largely absent in Solanaceae, which predominantly contained steroids. Antioxidant assays revealed strong activity in all samples, with complete ABTS decolorization (score +3) comparable to ascorbic acid. These findings suggest that antioxidant potential is closely associated with flavonoid and phenolic compound content. The RAMES method proved to be a rapid, efficient, and environmentally friendly approach for small scale extraction of bioactive compounds, enabling sustainable use of medicinal plant resources. This study underscores the therapeutic potential of Zingiberaceae and Solanaceae species as natural antioxidant sources for the development of functional health products and herbal medicines. Further quantitative and biological studies are recommended to identify key active constituents and evaluate their safety and clinical efficacy.

Keyword: Antioxidant Activity, Phytochemical screening, , RAMES, Solanaceae,Zingiberaceae,

INTRODUCTION

Indonesia boasts exceptionally rich biodiversity, particularly concerning the availability of plants with potential for traditional medicinal uses. The utilization of naturally derived bioactive compounds has gained widespread recognition in supporting health promotion and prevention efforts. Traditional medicine has long relied on nature as a primary source for treating various diseases (Ballester *et al.*, 2023). Among the plants frequently used in traditional medicine are those belonging to the Zingiberaceae and Solanaceae families.

Plants from the Zingiberaceae and Solanaceae families are known to contain diverse phytochemicals and exhibit various potential biological activities, such as antioxidant, antitumor, anticancer, antifungal, antibacterial, and other health benefits, including antidiabetic, hepatoprotective, and antiurolithic effects (Ghaffar *et al*., 2024; Sinaga *et al*., 2011). To support the exploration of bioactive compounds from these plants, efficient and sustainable extraction methods are necessary. Rapid Metabolome Extraction and Storage (RAMES) technology offers an innovative solution for fast, simple, low-cost, and eco-friendly extraction of plant secondary metabolites, requiring only 2 grams of fresh tissue, thus minimizing plant damage (Skubel et al., 2018).

Research on the bioactive compound content in Zingiberaceae and Solanaceae family plants using RAMES technology is still scarce. Therefore, this study aims to analyze the phytochemical profiles and antioxidant activities of plants from the Zingiberaceae and Solanaceae families using the RAMES method, and to identify the relationship between their chemical compounds and antioxidant potential. The findings of this research are expected to provide new information in the exploration of plant secondary metabolites and the development of potent natural ingredients.

METHOD

1. Tools and Materials

The tools provided included measuring cylinders, pipettes, a grinding machine (Dremel 8220), knives, sample containers, funnels, sample filters, spatulas, drop plates, and tissue. The chemical used in this study was 95% ethanol, which served as the solvent for plant extraction. Qualitative phytochemical screening was conducted according to analytical standards using Dragendorff's, Mayer's, and Wagner's reagents (for alkaloids), PbCH (for flavonoids), $FeCl_3$ (for iron), 10% NaCl, 10% NaOH, 5% FeCl, H_2SO_4, and HCl. Antioxidant test reagents included ABTS, potassium sulfate, distilled water (aquadest), ascorbic acid solution (Vitamin C), and 95% ethanol.

Figure 1. Research tools and materials

2. Plant Preparation

The plant samples consisted of fruit parts from seven species of the Solanaceae family (namely *Solanum torvum* Sw., *Solanum melongena* var. *esculentum choryoku*, *Solanum macrocarpon*, *Solanum melongena*, *Solanum betaceum*, and *Solanum nigrum*), as well as rhizomes from four species of the Zingiberaceae family (*Zingiber officinale*, *Alpinia galanga*, *Zingiber xanthorrhiza*, and *Curcuma longa*), collected from South Jakarta (Figure 2 and Figure 3). The samples were washed under running water, sliced, and visually documented before being stored for further treatment. Species identification was conducted at the Natural Product Research Laboratory, Universitas Nasional.

Figure 2. Plant of the Zingiberaceae family

Figure 3. Plant of the Solanaceae family

3. Plant Extraction Using the RAMES Method

The grinding procedure for rhizomes and soft fruit materials followed the steps outlined by Skubel et al. (2018) :

a. The Dremel device was first ensured to be in the OFF position, and the battery was removed. The white cap was then securely fastened to the end of the Dremel tool after confirming proper attachment. The blade was loosely placed at the tip of the tool, aligned correctly with the cap.
b. The metal grinding chamber was carefully attached to the cap to adjust the blade position, then removed again. The blade was gently pushed downward to create a gap between the chamber base and the blade. The Dremel's locking button was pressed, and the blade was tightened using a wrench. A final check ensured the tool remained OFF and all settings were on low before reinserting the charged battery.
c. Four grams of plant material were weighed and cut into small pieces. The chopped material was then placed in the metal grinding chamber, and 10 mL of 95% ethanol was added using a measuring tube.
d. The chamber was mounted onto the Dremel vertically, supported from underneath with one hand to prevent it from falling. The power was gradually turned on from the lowest to the highest setting and operated at optimal speed for approximately 5 seconds, then lowered before turning off. The chamber was carefully removed to ensure complete grinding; if not, the process was repeated.
e. After grinding, the sample was left to stand for 5 minutes. If not used immediately, the sample could be stored and kept stable for up to 24 hours.
f. For the filtration process, a plastic funnel was placed over a collection bottle, and a mesh filter was attached. The plant extract mixture was poured into the filter. The chamber was tapped to ensure all material was released, and the bottom of the chamber was used to press out the remaining extract.
g. All equipment (Dremel, metal grinding chamber, mesh filter, funnel, etc.) was rinsed with water or 95% ethanol before reuse in the extract loading process onto disks.

Procedure for Loading Plant Extracts onto Disks:

a. A clean piece of wire mesh was placed on a box, and 10 mm-diameter disks were arranged carefully on the mesh to prevent adhesion or damage.
b. The bottle containing the extract was shaken to ensure homogeneity. The disk was held with tweezers and dipped into the extract for a few seconds to absorb approximately 90 µL. The soaked disk was placed back on the wire mesh, and the vial was gently swirled before the next application.
c. Loaded disks were arranged by piercing through the center using pins, spaced 3–5 mm apart. Pins were secured to the side of a Styrofoam box to hold their position.
d. A portable fan was positioned approximately 6 cm from the pins and turned on to dry the disks for 3–8 minutes, depending on humidity and temperature. Pins containing different extracts were not placed in a horizontal line to avoid cross-contamination via airflow.
e. After drying, the disks were collected into sealed plastic bags, labeled with unique identification numbers, and stored together in one bag for each sample group.

4. Qualitative analysis of phytochemicals

The preliminary phytochemical screening of the ethanol extracts from the rhizomes of Zingiberaceae species and fruits of Solanaceae species was conducted using standard laboratory procedures to detect the presence of major phytochemicals, including alkaloids, flavonoids, tannins, triterpenoids and steroids, quinones, and phenols.

a. Alkaloid assay

Identification of alkaloid compounds in ethanol extracts was performed using Mayer's, Wagner's, and Dragendorff's reagents. To support the solubility of basic alkaloid compounds, sulfuric acid was added to enable extraction in an acidic medium. A positive result with Mayer's reagent was indicated by the formation of a yellow precipitate, presumed to be a potassium-alkaloid complex. Mayer's reagent is formed by mixing mercuric chloride solution with potassium iodide, producing red mercuric iodide precipitate, which further reacts with excess potassium iodide to form tetraiodomercurate(II) complexes (Fitriani & Nashihah, 2021; Tiwari et al., 2011).

b. Flavonoid assay

Flavonoid screening was based on the formation of flavilium salts, which produce a deep red color due to protonation of the carbonyl group by hydrochloric acid. The Shinoda test was conducted by adding 0.05 g of magnesium powder and 1 mL of concentrated HCl to 4 drops of extract, followed by stirring. A red, yellow, or orange coloration indicated a positive result. Additionally, the lead acetate test was conducted by adding 1 mL of 10% $Pb(C_2H_3O_2)_2$ solution to 4 drops of extract in a test tube and shaking it. A yellowish-brown color change confirmed the presence of flavonoids (Minarno, 2015; Pauner & Hamzah, 2022).

c. Tannin assay

Tannin detection was performed using the $FeCl_3$ test by adding 1 mL of 3% $FeCl_3$ solution to 4 drops of extract. The formation of a greenish-black or bluish-black color indicated the presence of tannins. Further confirmation was done by adding 2 M H_2SO_4 solution; the disappearance of the blue-black color and the formation of a yellowish-brown precipitate confirmed the presence of tannins (Minarno, 2015; Putria et al., 2022).

d. Triterpenoid and Steroid assay

Four drops of extract were mixed with 10 drops of glacial acetic acid and 2 drops of concentrated H_2SO_4. The mixture was gently shaken and left to stand for a few minutes. A blue or green color indicated the presence of steroids, while a red or purple color indicated triterpenoids. Alternatively, 2 mL of extract was mixed with 3 drops of concentrated HCl and 1 drop of concentrated H_2SO_4; a red or purple color indicated triterpenoids, while green indicated steroids (Minarno, 2015; Nuryanti & Pursitasari, 2014).

e. Quinone assay

Four drops of extract were mixed with 10 drops of glacial acetic acid and 2 drops of concentrated H_2SO_4. The mixture was gently shaken and left to stand for a few minutes. A blue or green color indicated the presence of steroids, while a red or purple color indicated triterpenoids. Alternatively, 2 mL of extract was mixed with 3 drops of concentrated HCl and 1 drop of concentrated H_2SO_4; a red or purple color indicated triterpenoids, while green indicated steroids (Rajkumar et al., 2022).

f. Phenol assay

Four drops of ethanol-dissolved plant extract were placed on a spot plate, followed by the addition of 2 drops of 5% $FeCl_3$ solution. A reddish-brown color change indicated a positive result for phenolic compounds (Minarno, 2015; Tiwari et al., 2011).

5. Antioxidant Activity Assay

The antioxidant activity assay was carried out qualitatively based on the method developed by Skubel et al. (2018). Each number used in the well labeling represented the identity of the corresponding test plant.

Initially, 600 µL of ABTS solution was added to each well using a pipette. Subsequently, plant extract-infused disks were placed into the wells according to their respective labels. Disks containing ascorbic acid served as positive controls and were placed in wells labeled (+), while three blank disks served as negative controls and were placed in wells labeled (−).

Following the addition of disks, color changes in each well were observed to assess the antioxidant activity of each sample. The intensity of antioxidant activity was evaluated based on the following color change scale:

Score	Observation	Antioxidant Activity
0 (−)	Solution remains dark green	No antioxidant activity
+1	Bright solution – green	Low antioxidant activity
+2	Bright solution – light green	Moderate antioxidant activity
+3	Clear or nearly colorless solution	High antioxidant activity

RESULT

Skrining Fitokimia *Zingiberaceae* dan *Solanaceae*

Phytochemical screening of ten plant species from the Zingiberaceae and Solanaceae families revealed that all samples contain alkaloids, flavonoids, tannins, quinones, and phenols. For the Zingiberaceae family (*Zingiber officinale, Alpinia galanga, Curcuma xanthorrhiza,* and *Curcuma longa*), all species consistently showed the presence of triterpenoids but no steroids. Conversely, among the Solanaceae species (*Solanum torvum, S. melongena, S. macrocarpon, S. nigrum*, and others), triterpenoids were only detected in *S. betaceum*, while most species showed the presence of steroids. Generally, the pattern of bioactive compound content between the two families exhibits distinct differences: Zingiberaceae species consistently contain triterpenoids, whereas Solanaceae species are predominantly rich in steroids. These findings indicate that both families have potential as natural sources rich in secondary metabolites with important biological activities.

Table 1. Qualitative Phytochemical Screening of Zingiberaceae and Solanaceae

Family	Extract name Local	Species	Phytochemical Screening Alkaloid	Flavonoid	Tannin	Triterpenoid	Steroid	Quinone	Phenol
Zingiberaceae	Ginger	*Zingiber officinale*	(+)	(+)	(+)	(+)	(-)	(+)	(+)
	Galangal	*Alpinia galanga*	(+)	(+)	(+)	(+)	(-)	(+)	(+)
	Java Turmeric	*Curcuma xanthorrhiza*	(+)	(+)	(+)	(+)	(-)	(+)	(+)
	Turmeric	*Curcuma longa*	(+)	(+)	(+)	(+)	(-)	(+)	(+)
Solanaceae	Turkey Berry	*Solanum torvum*	(+)	(+)	(+)	(-)	(+)	(+)	(+)
	Coryoku Eggplant	*Solanum melongena* var. *esculentum* 'Choryoku'	(+)	(+)	(+)	(-)	(-)	(+)	(+)
	Engkol Eggplant	*Solanum macrocarpon*	(+)	(+)	(+)	(-)	(+)	(+)	(+)
	Purple Eggplant	*Solanum melongena*	(+)	(+)	(+)	(-)	(+)	(+)	(+)
	Tamarillo	*Solanum betaceum*	(+)	(+)	(+)	(+)	(-)	(+)	(+)
	Black Nightshade	*Solanum nigrum*	(+)	(+)	(+)	(-)	(+)	(+)	(+)

Antioxidant Activity of Zingiberaceae and Solanaceae

A study on ten plant extracts from the Zingiberaceae family (including ginger and turmeric) and the Solanaceae family (such as various types of eggplants and leunca) demonstrated strong antioxidant activity in all samples when tested using the ABTS method. A positive measurement of +3 was observed, visually confirmed by the ABTS solution turning clear or nearly colorless. This color change, similar to that seen in the ascorbic acid control, indicates that the antioxidant compounds in these plants effectively neutralize $ABTS^{+}$ free radicals. As shown in Figures 9 and 10, the clear reaction wells further support these findings. Therefore, both Zingiberaceae and Solanaceae plants hold promise as natural sources of antioxidants for pharmaceutical, cosmetic, and functional food applications.

Table 2. Antioxidant Activity Test Results

Extract	Result	Adverb	
Zingiber officinale	+3	A clear or nearly colorless solution	indicates high antioxidant activity
Alpinia galanga	+3	A clear or nearly colorless solution	indicates high antioxidant activity
Curcuma xanthorrhiza	+3	A clear or nearly colorless solution	indicates high antioxidant activity
Curcuma longa	+3	A clear solution or the absence of a dark blue color in the ABTS solution	indicates high antioxidant activity
Solanum torvum	+3	A clear or nearly colorless solution	indicates high antioxidant activity
Solanum melongena var. esculentum	+3	A clear or nearly colorless solution	indicates high antioxidant activity

Solanum macrocarpon	+3	A clear or nearly colorless solution	indicates high antioxidant activity
Solanum melongena	+3	A clear or nearly colorless solution	indicates high antioxidant activity
Solanum betaceum	+3	A clear or nearly colorless solution	indicates high antioxidant activity
Solanum nigrum	+3	A clear or nearly colorless solution	indicates high antioxidant activity

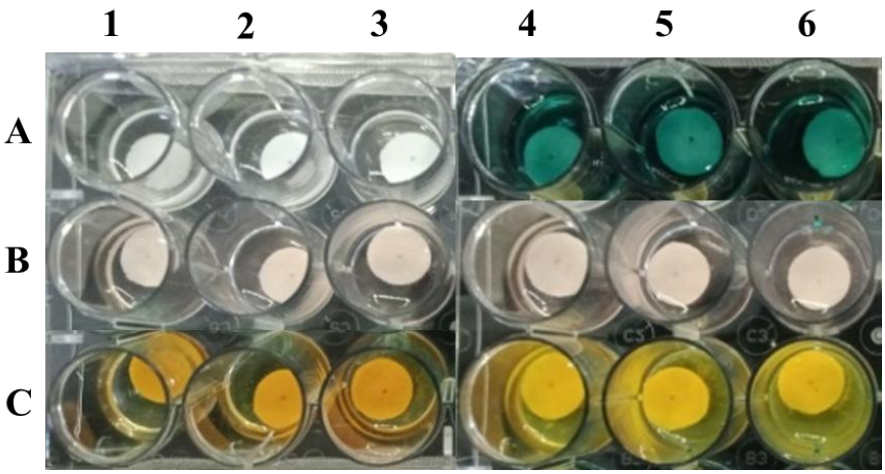

Figure 4. Antioxidant Activity Assay of Zingiberaceae Extracts

Description:
A1, A2, A3 : Positive control (Ascorbic acid)
A4, A5, A6 : Negative control (Ethanol)
B1, B2, B3 : *Zingiber officinale*
B4, B5, B6 : *Alpinia galanga*
C1, C2, C3 : *Curcuma longa*
C4, C5, C6 : *Zingiberaceae xanthorrhiza*

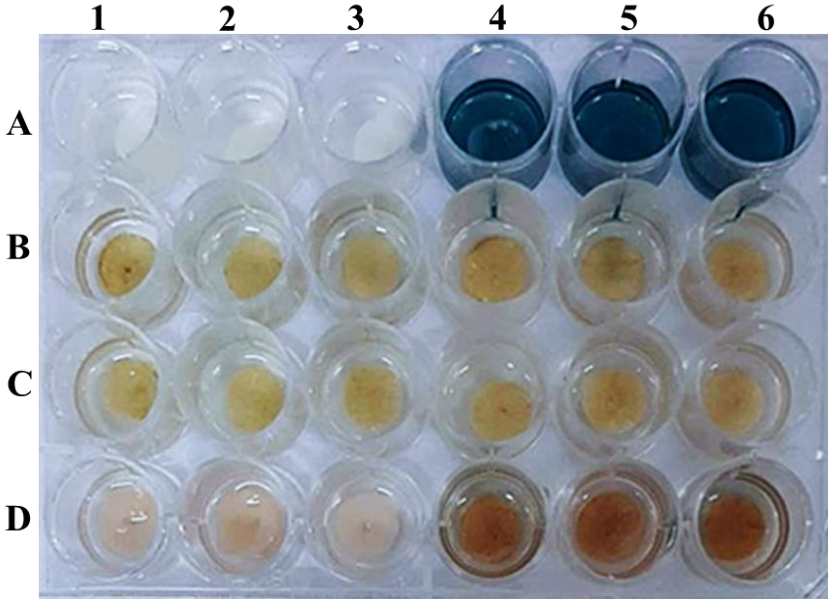

Figure 5. Antioxidant Activity Assay of Solanaceae Extracts

Description:
A1, A2, A3 : Positive control (Ascorbic acid)
A4, A5, A6 : Negative control (Ethanol)

B1, B2, B3 : *Solanum torvum*
B4, B5, B6 : *Solanum melongena var. esculentum*
C1, C2, C3 : *Solanum macrocarpon*
C4, C5, C6 : *Solanum melongena*
D1, D2, D3 : *Solanum betaceum*
D4, D5, D6 : *Solanum nigrum*

DISCUSSION

This study comprehensively explores the phytochemical profiles and antioxidant potential of ten plant species from the Zingiberaceae and Solanaceae families using the Rapid Metabolome Extraction and Storage (RAMES) method. The results of the phytochemical screening clearly demonstrated the richness of secondary metabolites in both plant families, which serves as a strong foundation for the observed biological activities. Consistently, all tested species from both families were found to contain alkaloids, flavonoids, tannins, quinones, and phenols, compounds widely recognized for their crucial roles in health and medicine (Table 1). For instance, flavonoids and phenols are powerful antioxidants that act by donating hydrogen atoms, chelating metals, and neutralizing free radicals, making them highly relevant for preventing oxidative cellular damage and degenerative diseases such as cancer, inflammation, microbial infections, tumors, and cardiovascular disorders (Adilah et al., 2022; Altemimi et al., 2017; Ballester et al., 2023; Grgić et al., 2020; Ha et al., 2020; Nisha et al., 2009; Shahidi & Ambigaipalan, 2015). Takokak and leunca contain flavonoids and phenols, which is consistent with previous research (Nisha et al., 2009) showing that several eggplant varieties such as terong engkol, choryoku, and purple eggplant have been proven to contain polyphenols and flavonoids. Furthermore, a study by Elizalde-Romero et al. (2021) found that Dutch eggplant and purple eggplant contain phenols, while takokak and leunca have been proven to contain alkaloids.

The phytochemical presence of alkaloids, tannins, and quinones detected in all samples also serves as an important indicator of the biological activities of the plant extracts. Alkaloids with antioxidant properties can prevent various degenerative diseases by scavenging free radicals or by binding to catalysts involved in oxidative processes within the human body. Furthermore, these compounds possess antibacterial, antifungal, antiprotozoal, antidiabetic, anti-obesity, and anti-hyperlipidemic activities (Nassiri, 2012; Thawabteh et al., 2019). Tannins, detected in all species including ginger, temulawak, turmeric, takokak, and leunca, are polyphenolic compounds known for their radical-scavenging ability, astringent properties, anti-inflammatory, and antibacterial effects. They function through active hydroxyl groups that stabilize reactive oxygen species and inhibit oxidative stress(Fraga-corral et al., 2021; Kumar, 2020). Similarly, quinones are known for their cytotoxic activity against abnormal cells and have been widely reported as natural anticancer agents. The presence of quinones in species such as ginger, lengkuas, turmeric, purple eggplant, and leunca reinforces their potential for further development in plant-based cancer research (Campos-Xolalpa et al., 2021; Singh et al., 2025).

A notable difference was observed in the distribution of triterpenoids and steroids between the two families. Triterpenoids were consistently found only in the Zingiberaceae species (ginger, lengkuas, temulawak, turmeric), but were largely undetected in most Solanaceae species. These triterpenoids, which are squalene derivatives, are known to exhibit significant anti-inflammatory, antimicrobial, antiviral, and anticancer activities (Bishayee et al., 2011;

Mantiniotou et al., 2025; Xu et al., 2004). In contrast, steroids dominated in most Solanaceae species (takokak, terung engkol, purple eggplant, leunca), except in Terung Coryoku and Terung Belanda, which showed the presence of triterpenoids instead. This difference in biosynthetic patterns highlights the unique chemical characteristics of each family and may be influenced by genetic factors, environmental conditions, and cultivation techniques (Skubel et al., 2018). Intraspecific variation, such as that observed in Terung Coryoku, which lacks both steroids and triterpenoids but is rich in other compounds, further underscores the complexity of secondary metabolite biosynthesis in plants.

The ABTS antioxidant assay demonstrated that all plant extracts from both families exhibited very high antioxidant potential, as evidenced by the color change of the ABTS solution to clear or nearly colorless (Table 2). According to Utami et al. (2024), the ABTS technique measures the ability of an antioxidant to react directly with the ABTS cation radical by monitoring the decrease in absorbance of the colored ABTS cation as it is neutralized. Upon reduction by an antioxidant, the nitrogen-centered ABTS radical transforms from a blue-green colored radical into a colorless, non-radical compound. Due to its high sensitivity to light, the assay procedure requires incubation in the dark. The level of antioxidant activity observed in the plant extracts was comparable to that of the positive control (ascorbic acid), indicating the effective ability of the antioxidant compounds in these plants to neutralize free radicals (Ghaffar et al., 2024).

This study suggests that the antioxidant activity originates from polyphenol compounds in the plants, which serve as natural phenolic antioxidants and possess significant potential as functional foods and nutraceuticals for the prevention and management of neurodegenerative diseases (Campisi et al., 2019; Suprihatin et al., 2020). The findings of this research reinforce a significant correlation between high antioxidant activity and the content of flavonoids and phenols detected in all samples. Furthermore, the analysis by Nisha et al. (2009) shows that extracts from small-sized purple eggplant exhibit high antioxidant activity, likely due to their phenolic content, which is known as a major contributor to antioxidant activity. However, not only the purple eggplant but all tested samples also demonstrated high antioxidant activity, as shown in Table 2. The strong antioxidant activity of all these extracts is highly important in the context of preventing chronic and degenerative diseases such as cancer, atherosclerosis, liver protection, and neurodegenerative disorders (Adilah et al., 2022; Paumgartten et al., 2022). These compounds have potential as nutraceuticals and active ingredients in functional health products, and they can serve as the basis for the development of modern herbal medicines. In addition, the RAMES method has proven to be effective, rapid, and environmentally friendly for extracting bioactive compounds from fresh plant tissues, thereby highlighting its potential for sustainable exploration of medicinal plant resources (Armas et al., 2024; Skubel et al., 2018).

Overall, the combination of the simple yet effective RAMES extraction technology and phytochemical screening analysis provides strong evidence that plants from the Zingiberaceae and Solanaceae families are important sources of bioactive compounds. The pharmacological potential demonstrated by these compounds underscores the urgency for further quantitative research, including the identification of key constituents, in vitro and in vivo testing, and evaluation of safety and toxicity for broader clinical applications.

CONCLUSION

Plants from the Zingiberaceae and Solanaceae families were found to contain diverse secondary metabolites, including alkaloids, flavonoids, tannins, quinones, and phenols, which

contribute to their strong antioxidant activity. The RAMES method proved to be effective in rapidly and environmentally friendly extracting bioactive compounds from fresh plant tissues. The high antioxidant potential, primarily attributed to flavonoids and phenols, highlights the promise of these plant families as natural sources for the development of health products and herbal medicines. Further studies are needed to identify the major active compounds and evaluate their biological efficacy and safety.

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