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Zingiber junceum Gagnep., A New Record for the Flora of Vietnam and its Anatomical and Phytochemical Characteristics

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ABSTRACT.– *Zingiber junceum* Gagnep. was first described in 1906 which the type specimens were collected from Angkor, Cambodia and later recorded in Laos and Thailand. In this study, *Z. junceum* is first recorded as an additional species for the flora of Vietnam. This species' micro-morphological traits are described and illustrated. Furthermore, the phytochemical screening of the methanol and ethanol extracts of the different organs of *Z. junceum* is also provided. As a result, the rhizome and leaf shoot of *Z. junceum* contained some bioactive compounds such as tannin, flavonoid, alkaloid, phenolic, saponin, steroid, terpenoid, and coumarin. In contrast, the same constituents were also found in the leaf and flower extracts, except saponin. Additionally, the ethanol and methanol extracts from the different parts of *Z. junceum* contained significant amounts of the total triterpene, polyphenol, and flavonoid.

KEYWORDS: micro-morphology, new record, phytochemistry, *Zingiber junceum*, Zingiberaceae

INTRODUCTION

Zingiber Miller is one of the large genera belonging to the family Zingiberaceae with about 210 species widely found in tropical and subtropical regions (Delin and Larsen, 2000; Kishor and Leong-Škorničková, 2013; https://powo.science.kew.org). In Vietnam, about 39 *Zingiber* species have been recorded for the flora of Vietnam so far (Pham, 2000; Ly, 2016; Ly et al., 2016; Ly et al., 2017; Nguyen, 2017; Le et al., 2019; Leong-Škorničková et al., 2019; Ly et al., 2021; Le et al., 2023). Studies demonstrated that a large number of *Zingiber* plants have been used as medicinal plants in some countries to treat many diseases, including high cholesterol, stomach discomfort, sore throat, migraine headaches, stomach problems, cough, bruises, nausea, muscular pains, liver complaints, atherosclerosis, epilepsy, and rheumatism (Shukla and Singh, 2007). Some members from this genus have been reported to be used as common spices, of these, Z. officinale is the spice plant, the flavoring agent, and has medicinal properties that are widely consumed in the world (Sabulal et al., 2006; Sharma et al., 2016). Additionally, various bioactive components isolated from the rhizomes of some *Zingiber* plants were found to be rich in sesquiterpenoids, diterpenoids, flavonoids, phenylbutenoids, diarylheptanoids, shogaols, and gingerols (Sivasothy et al., 2011; *Chumroenphat et al., 2019*). The essential oils and other extracts obtained from *Zingiber* species were also demonstrated to possess different biological properties like antioxidant, antibacterial, and antifungal activities (Sivasothy et al., 2011; Singh et al., 2008; *Chumroenphat et al., 2019*).

Zingiber junceum Gagnep. was first described in 1906 when the type specimens were collected from Angkor, Cambodia and this species was later recorded in Laos and Thailand (Theilade, 1999; Souvannakhoummane and Leong-Škornicková., 2017; Ragsasilp et al., 2022; Chayamarit et al., 2023). Theanphong et al. (2016) also provided the chemical compounds of the essential oil isolated from the rhizome of *Z. junceum* collected from Laos. Notably, Chumroenphat et al. (2019) showed the chemical components and antioxidant activity of the methanol extract isolated from *Z. junceum* grown in the northeastern region of Thailand. In Vietnam, *Z. junceum* was discovered for the first time by Trần Hữu Đăng and Trương Anh Thơ in 2009. The specimens (*Trần Hữu Đăng and Trương Anh Thơ* 188) of this species were collected from Ea H'leo village, Đăk Lăk province, Vietnam and deposited at the Singapore Botanic Gardens (SING), the Royal Botanic Garden Edinburgh's (E), and the Institute of Tropical Biology (VMN). Unfortunately, no efforts to record this species for the flora of Vietnam have been reported until the present study. In 2024, we conducted some field trips to Định An Commune, Dầu Tiếng District, Bình Dương Province, Vietnam and collected some specimens of one *Zingiber* species. Our careful examination of all specimens indicates that our specimen is indeed *Zingiber junceum* Gagnep. The study presents the first records *Z. junceum* for the flora

TABLE 1. The methods used to determine the qualitative phytochemistry of *Z. junceum*

Phytochemical	Reagent	Positive reaction	References
Coumarins	Taking 2 mL extract to 3 mL NaOH (10%)	If yellow color appears, it indicates the presence of	(Vo et al., 2017)
Terpenoids and steroids	Adding 5 mL of extract to 2 mL of chloroform and 3 mL of concentrated sulfuric acid,	If the reddish brown color appears, it indicates the presence of terpenoids and steroids	(Llauradó et al., 2013)
Saponins	Adding 2 mL of the extract to 10 mL of distilled water then boil for 2 minutes	If the solution forms a foam, it indicates the presence of saponins	(Shaikh and Patil, 2020)
Flavonoids	Adding 2 mL of extract to 2 ml of Pb(COOH)2 (10%)	If the solution turns yellow, it indicates the presence of flavonoids	(Nguyen et al., 2017)
Alkaloids	adding 3-4 drops of Wagner's reagent to 2 mL of the extract	If the reddish brown color appears, it indicates the presence of alkaloids	(Bodi et al., 2014)
Tannins	Adding 2 mL of extract with 2 mL of distilled water then added 2-3 drops of FeCl3 (5%)	If the solution is dark green or brownish green, it indicates the presence of tannin	(Deka et al., 2017)

of Vietnam. In addition, the details of macro and micro-morphological traits, and the phytochemical screening of the methanol and ethanol extracts from this species are also provided for the first time.

MATERIALS AND METHODS

Plant collection

The fresh samples of *Zingiber junceum* were collected from Định An Commune, Dầu Tiếng District, Bình Dương Province, Vietnam. The vouchered specimens, NPN-095-DA and NPN-096-DA were deposited at the Herbarium of the University of Science, Vietnam National University-HCMC (PHH).

Morphological characteristics

The guidelines of the Royal Botanic Gardens, Kew (Bridson and Forman 1999) were used to collect, process samples, and determine the scientific name of the studied taxon. The vegetative and reproductive characteristics of the studied plant were compared with those of previous reports (Pham, 2000; Ly, 2016; Ly et al., 2016; Ly et al., 2017; Nguyen, 2017; Ly et al., 2021; Le et al., 2023)

Anatomical characteristics

The cross section of the different parts of *Z. junceum* was cut into a thin flat piece. These slices were bleached in Javel water and then, the iodine green-carmine double staining method was used to stain them. The samples were washed with water several times before preserving them in 10% glycerol (Truong et al., 2007). The Olympus BX53 Digital Upright Microscope was used to observe.

Extraction procedures

The other parts of *Z. junceum* were dried at 45ºC using a drying cabinet. The various parts were then ground into powder. Then, 5 grams of each powder were soaked in ethanol and methanol 99.98% (Fisher, USA) at a ratio of 1:30 for 8 hours at room temperature. The extracts were then filtered using Whatman paper. This process was repeated twice with filter residue to collect the final extract.

Qualitative phytochemistry of *Z. junceum*

The qualitative phytochemistry of *Z. junceum* was determined by the methods shown in Table 1.

Quantitative phytochemistry of *Z. junceum*

Total polyphenol content (TPC)

Take 0.1 mL of the extract into the test tube. Next, add 1.8 mL of 10% Folin-Ciocalteau reagent to each tube and shake well. Leave for 5 minutes, then add 1.2 mL of 15% Na_2CO_3 solution, shake well and add 6.9 mL of distilled water to make a total volume of 10 mL. Leave for 90 minutes in dark conditions and then measure photoluminescence at wavelength $\lambda = 734$ nm. The distilled water was used as the control agent. The total polyphenol content is expressed in gallic acid equivalent (GAE) milligrams. From the photometric

results and based on the standard curve, the TPC in the study sample is determined according to the following formula (Krisna et al., 2015):

$$\text{TPC (mg GAE/g DW)} = C_x \times \frac{V}{10^3} \times \frac{100}{a \times (100 - W)} \times K$$

Where:

Cx: the TPC in the extract calculated from the standard curve (ppm); V: sample volume (ml); a: initial sample mass (g); W: humidity (%); K: dilution factor; 10^3: conversion factor.

Total triterpene content (TTC)

Take 1 mL of the extract into a test tube, add 1.2 mL of perchloric acid and 0.2ml of 5% acetic acid and mix and incubate for 15 minutes at 70°C, cool down quickly for 2 minutes. Add 2.6 mL of ethyl acetate to the mixture to make up 5 mL and measure the spectrophotometry at wavelength λ = 550nm. Replace the control tube with 5% acetic acid. The TTC is expressed in milligrams of oleanoic acid equivalent (OAE). From the spectrophotometric results and based on the standard curve, the TTC of the study sample is determined using the following formula (Chen et al., 2007):

$$\text{TTC (mg OAE/g DW)} = C_x \times \frac{V}{10^3} \times \frac{100}{a \times (100 - W)} \times K$$

Where:

Cx: the TTC in the extract calculated from the standard curve (ppm); V: sample volume (ml); a: initial sample mass (g); W: humidity (%); K: dilution factor; 10^3: conversion factor.

Total flavonoid content (TFC)

Add 1 mL of the extract and 0.3 ml of 5% $NaNO_2$ solution into a test tube, shake well and let stand for 5 minutes. Afterward, 10% $AlCl_3$ solution was added into the tube, shaken well and let stand for 5 minutes, add 2 mL of 1M NaOH, shaken well and distilled water to make 10ml. Measure the photometric value at wavelength λ=510 nm. The control sample replaces the sample with distilled water. The total flavonoid content is expressed in grams of quercetin equivalent to QE. The TFC in the studied sample was determined using the following formula (Sen et al., 2013):

$$\text{TFC (mg QE/g DW)} = C_x \times \frac{V}{10^3} \times \frac{100}{a \times (100 - W)} \times K$$

Where:

Cx: the TFC in the extract calculated from the standard curve (ppm); V: sample volume (mL); a: initial sample mass (g); W: humidity (%); K: dilution factor; 10^3: conversion factor.

RESULTS

***Zingiber junceum* Gagnep.** Bull. Soc. Bot. France 53: 149 (1906); F1. Indo-Chine 6(1): 80 (1908) (Fig. 1)

Description.— Rhizomatous herbs up to 1.2 m tall; *rhizome* 5–6 cm long, 1–1.2 cm in diameter, pale brown outside, bright yellow inside, aromatic. *Leaf sheaths* 3–4 bladeless, glabrous, pinkish red at base; ligule bilobed, lobes 1–3 mm long, glabrous; blades 20–22, linear, 12–25 by 1.1–1.7 cm, dark green above, bright green below, apex acuminate, sessile. *Inflorescences* arising from rhizomes with long and erect peduncle; peduncle 15–20 cm long, with 6–9 sheathing bracts; spike spindle-shaped, 10–15 by 1.5–3 cm; bracts closely imbricate, elliptic to obovate, bright green, glabrous; bracteoles oblong, 3.2–4 by 1–2 cm, glabrous. *Flower* 5–5.5 cm long, *calyx* tubular 1.5–1.6 cm long; *floral tube* pale yellow, 2.6–3 cm long, dorsal corolla lobe 2–2.4 by 0.8–0.9 cm, lateral corolla lobes 1.8–2 by 0.4–0.5 cm; labellum yellow, midlobe 1.2 by 1.7 cm, apex bilobed, side lobes 2 by 2.7 mm; *stamen* filament 2–3 mm long; anther 0.8–0.9 by 0.3–0.4 cm, anther crest pale yellow, 1.2–1.3 cm long, tip shorter than stigma; *ovary* cylindrical, 3-locular, *ca.* 3–5 by 2.2–2.7 mm, sparsely villous; epigynous glands two, narrowly conical, 4–5 mm long. *Capsules* ellipsoid, *ca.* 1.4 by 0.6 cm, glabrous. *Seeds* reddish brown, aril white, 2.5–2.7 by 5.7–6.5 mm.

Type.— Cambodia, Angkor, *Pierre* s.n. 1873 (P).

Specimens examined.— Vietnam, Bình Dương Province, Dầu Tiếng District, Định An Commune, 25 August 2024, *Nguyen-Phi Nga* NPN-095-DA and NPN-096-DA (PHH); Đăk Lăk Province, Ea H'leo Village, 3 August 2009, *Tran Huu Dang and Truong Anh Tho* 188 (E, SING, VMN).

Distribution.— Thailand, Laos, Cambodia, and Vietnam.

Ecology.— This species grows under the canopy of open dry woodland dominated by *Dipterocarpus obtusifolius* Teijsm ex. Miq. and *Vietnamosasa ciliata* (A.Camus) T.Q. Nguyen, on sandy soil with exposed rocks.

Anatomical charateristics

Roots (Fig. 2)

The cross-section is nearly circular and divided into two distinct regions, a *pith* area accounts for 1/3 of the radius while 2/3 of the radius of the cross-section is the cortical region. Cortical region: the piliferous layer consists of polygonal cells, fairly uniform in size, cellulose walls, and few root hairs. The exodermal layer includes 2-4 cells, polygonal, cork-impregnated walls, arranged radially. The cortical parenchyma is

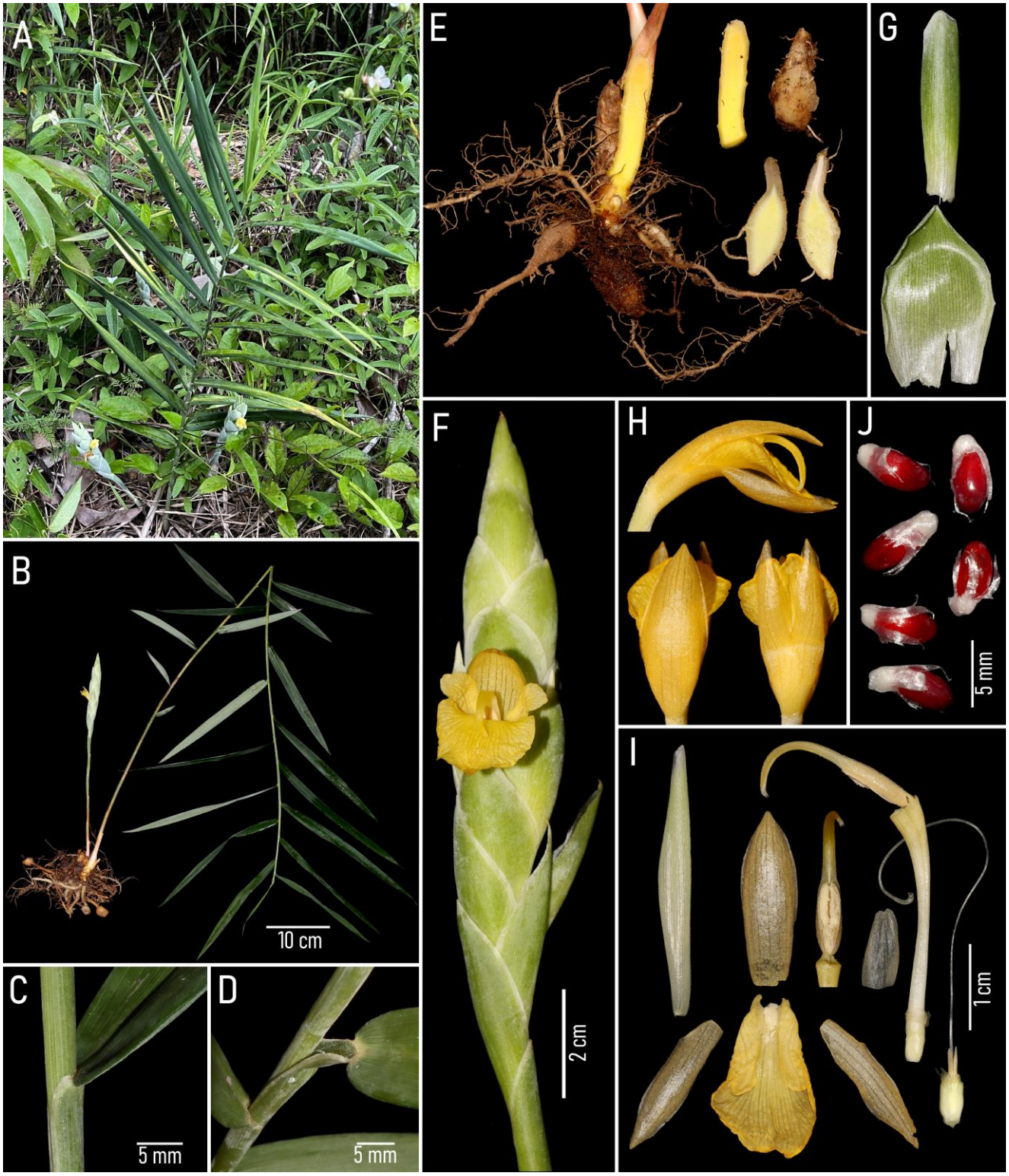

FIGURE 1. *Zingiber junceum* Gagnep. A. Habit. B. Whole plant. C&D. Ligules. E. Rhizomes and root tubers. F. Inflorescence. G. Bracts. H. Flower in different views. I. Dissection (from left, top to bottom): bracteole; corolla lobes and labellum; stamen from front view; calyx; ovary with floral tube and stamen from side view; stigma, style, epigynous glands and ovary. J. Seeds.

arranged with leaving small polygonal or intercellular spaces, consisting of 5-6 layers of cells on the outside, arranged haphazardly, 6-8 layers of cells on the inside, gradually smaller and arranged in radial rows and concentric rings; the endodermis with U-shaped thickening. *Pith* area: the pericycle 1 comprises a layer

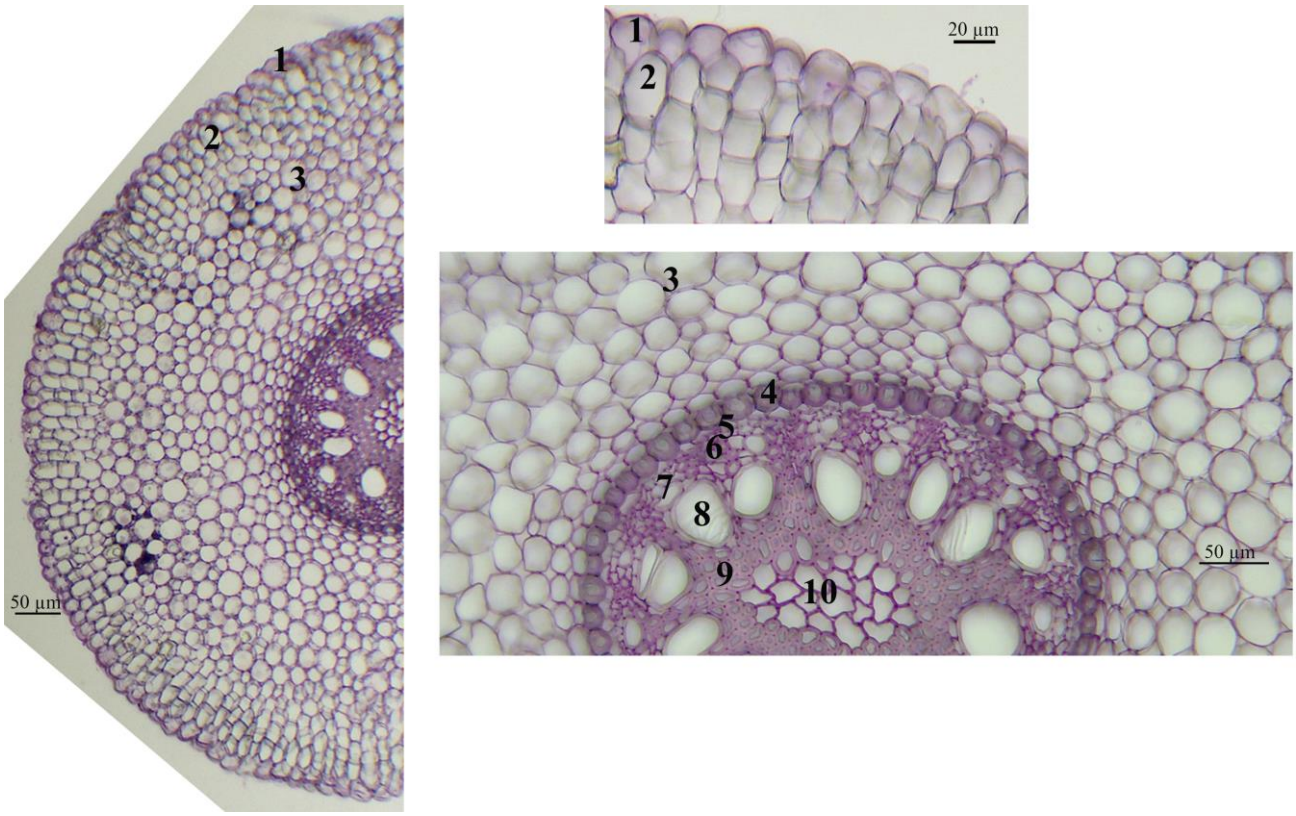

FIGURE 2. The cross section of root. 1: epidermis, 2: exodermis, 3: cortical parenchyma, 4: endodermis with U-shaped thickening, 5: pericycle, 6: primary phloem, 7: protoxylem, 8: metaxylem, 9: sclerenchymatous conjunctive tissues, 10: parenchymatous pith.

of polygonal cells with cellulose walls, irregular in size, interspersed with the endodermis. The vascular bundles consist of 16-18 primary phloem bundles alternating with 7-8 protoxylem bundles arranged in a ring, separated by medullary rays. The phloem bundles form clusters of irregular, polygonal cells. The protoxylem bundles consist of 1-3 polygonal vessels and centripetally differentiated; 14-18 metaxylem vessels are usually located right below the protoxylem. The medullary ray consists of 1-2 rows of horizontally flattened polygonal parenchyma cells with cellulose walls. The medullary parenchyma is polygonal cells, irregular in size, leaving polygonal spaces, 5-7 outer layers of cells with lignin walls and 3-5 inner layers with cellulose walls.

Leaf blade (Fig. 3)

The midrib is slightly concave on the upper surface and convex on the lower surface. The upper and lower epidermis consist of a single layer of rectangular, fairly even cells. The mesophyll consists of 4-6 cell layers of large, closely packed, polygonal angular collenchyma located above and 6-8 layers of spongy parenchyma cells containing many chloroplasts below. The vascular bundles with xylem bundles above, the phloem bundles below, arranged in rows above the lower epidermis; in the spongy parenchyma area, below the phloem supported by the sclerenchyma clusters; in addition, there are 2-3 small vascular bundles located in the angular collenchyma area above, these vascular bundles are smaller and have no sclerenchyma below the phloem. *Major lamina*: the upper and lower epidermis consists of a layer of polygonal cells with cellulose walls. The upper epidermal cells are larger than the lower epidermis. Under the epidermis on both sides is a layer of hypodermis cells with cellulose walls. The spongy parenchyma contains many chloroplasts. Small xylem bundles are scattered in rows above the lower epidermis in the spongy parenchyma area.

Leaf sheath (Fig. 4)

This part curls around the stem. The upper and lower epidermis consist of a layer of polygonal cells with cellulose walls. The parenchyma consists of polygonal, irregular cells, closely packed or with small spaces. The vascular bundles with xylem above and phloem below, arranged in rows in the parenchyma region, below the phloem and above the xylem supported by clusters of sclerenchyma; large intercellular spaces exist between the vascular bundles.

Leafy shoot (Fig. 5)

The cross section is circular, 1/4 of the radius of the cross-section is the cortical region while a *pith* area

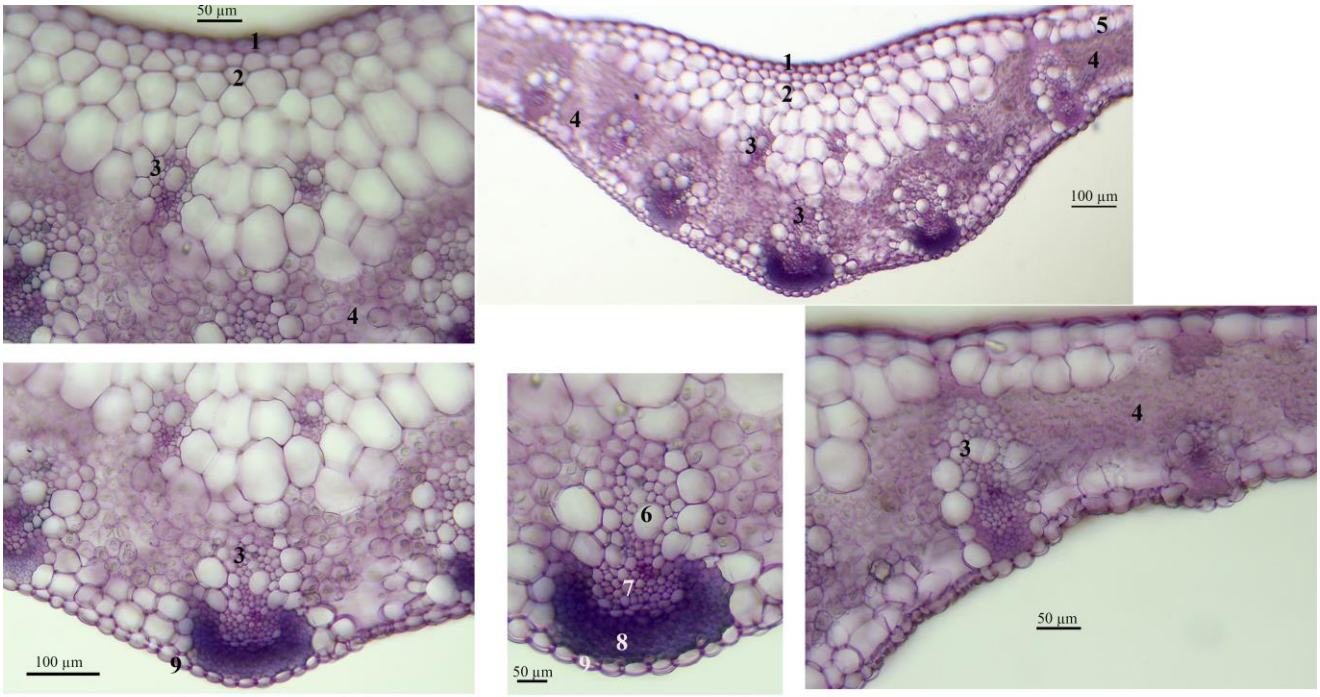

FIGURE 3. The cross section of leaf blade. 1: upper epidermis, 2: angular collenchyma, 3: vascular bundle, 4: spongy parenchyma, 5: hypodermis, 6: xylem, 7: phloem, 8: sclerenchyma, 9: lower epidermis.

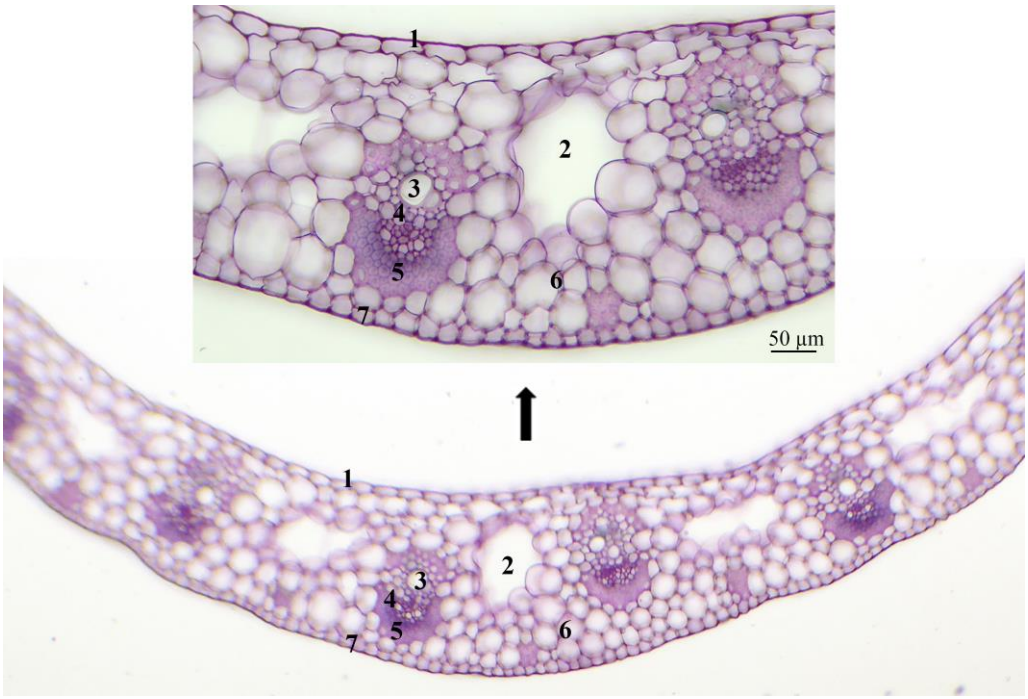

FIGURE 4. The cross section of leaf sheath. 1: upper epidermis, 2: intercellular spaces, 3: xylem, 4: phloem, 5: sclerenchyma, 6: parenchyma, 7: lower epidermis.

accounts for 3/4 of the radius. The epidermis includes a layer of cells, and a rectangular, cellulose wall. The cortical parenchyma is arranged to form small polygonal or intercellular spaces. The vascular bundles with phloem above, xylem below and surrounded by clusters of sclerenchyma, lying disorderly in the

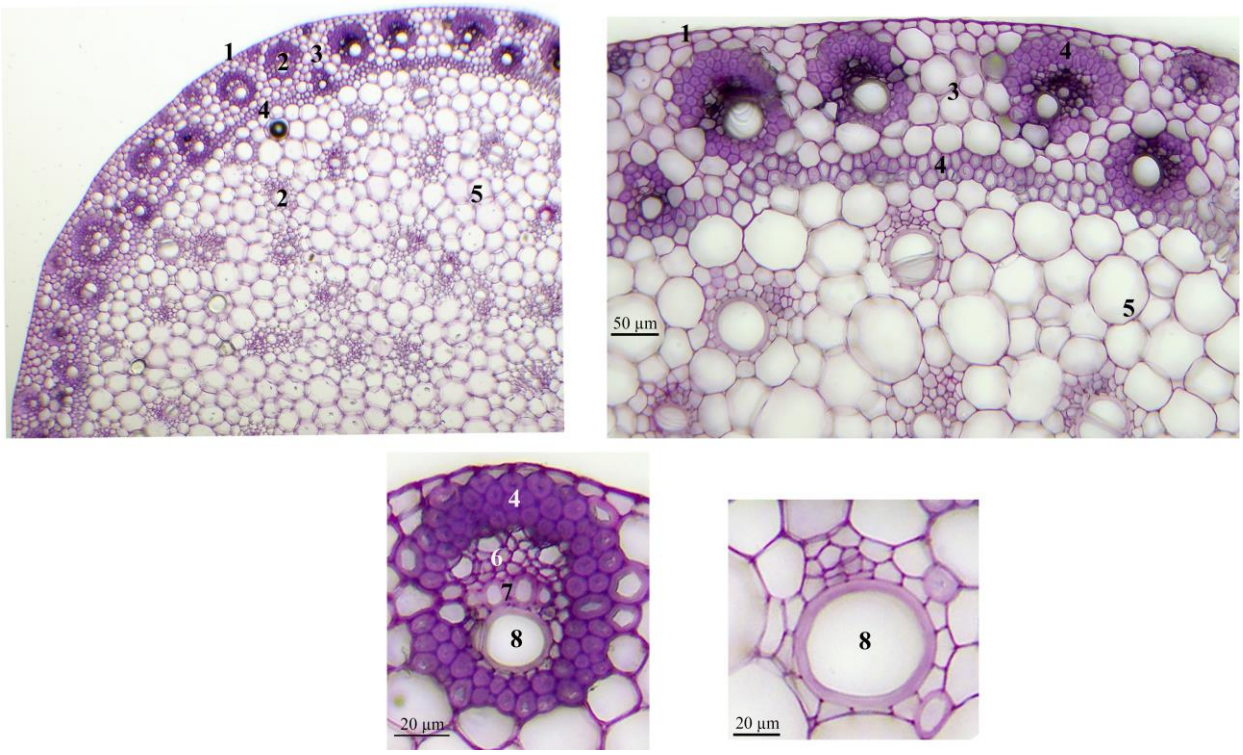

FIGURE 5. The cross section of leafy shoot. 1: upper epidermis, 2: vascular bundle, 3: cortical parenchyma, 4: sclerenchyma, 5: medullary parenchyma, 6: phloem, 7: protoxylem, 8: metaxylem.

cortical parenchyma. Each xylem bundle comprises 1-4 small protoxylem vessels and 1-2 larger metaxylem vessels below the protoxylem. No endodermis is visible. Surrounding the *pith* area are 1-3 layers of sclerenchyma cells and lignin impregnated walls. The medullary parenchyma is polygonal and forms air cavities. The vascular bundles are arranged in a disorderly manner throughout the medullary parenchyma. The vascular bundles in the *pith* area are usually smaller, with little or no surrounding sclerenchyma, the xylem usually has only 1-2 large metaxylem vessels. No protoxylem is visible.

Rhizome (Fig. 6)

The cross section is circular. cortical region: The epidermis consists of a single layer of rectangular cells with cellulose walls. The cortical parenchyma is usually solid or has small polygonal spaces; scattered vascular bundles are in the parenchyma; the endodermis with casparian *strip*. *Pith* area: The pericycle consists of 1-2 layers of rectangular cells, alternating with the endodermis. The vascular bundles are scattered throughout the parenchyma. The vascular bundles in the rhizome are usually not surrounded by the sclerenchyma and in the parenchyma (cortex and stele) are scattered cells containing secretory components.

Preliminary phytochemicals of the ethanol extracts of *Z. junceum*

The data from Table 2 showed that the ethanol and methanol extracts obtained from the rhizome and leaf shoot of *Z. junceum* were contained some bioactive compounds such as tannin, flavonoid, alkaloid, phenolic, saponin, steroid, terpenoid, and coumarin. In contrast, the same constituents were also found in the leaf and flower extracts, except saponin.

Quantitative phytochemical content of *Z. junceum*

The Total triterpene, polyphenol, and flavonoid contents of the ethanol and methanol extracts from the different parts of *Z. junceum* are shown in Table 3.

DISCUSSION

The chemical compositions and biological activities of *Z. junceum* collected from Thailand and Laos have been reported by previous study. For instance, the methanol extract of *Z. junceum* collected from Thailand contained total phenolics (16.48 mg GAE/100 g), total flavonoids (17 mg RE/100 g), curcumin (26.82 µg/ g DW), 6-gingerol (137.03 µg/ g DW), eugenol (8.23 mg/ 100 g DW), vitamin C (12.34 mg/ 100 g DW) (Chumroenphat et al., 2019). In addition, the antioxidant effects of this extract were also

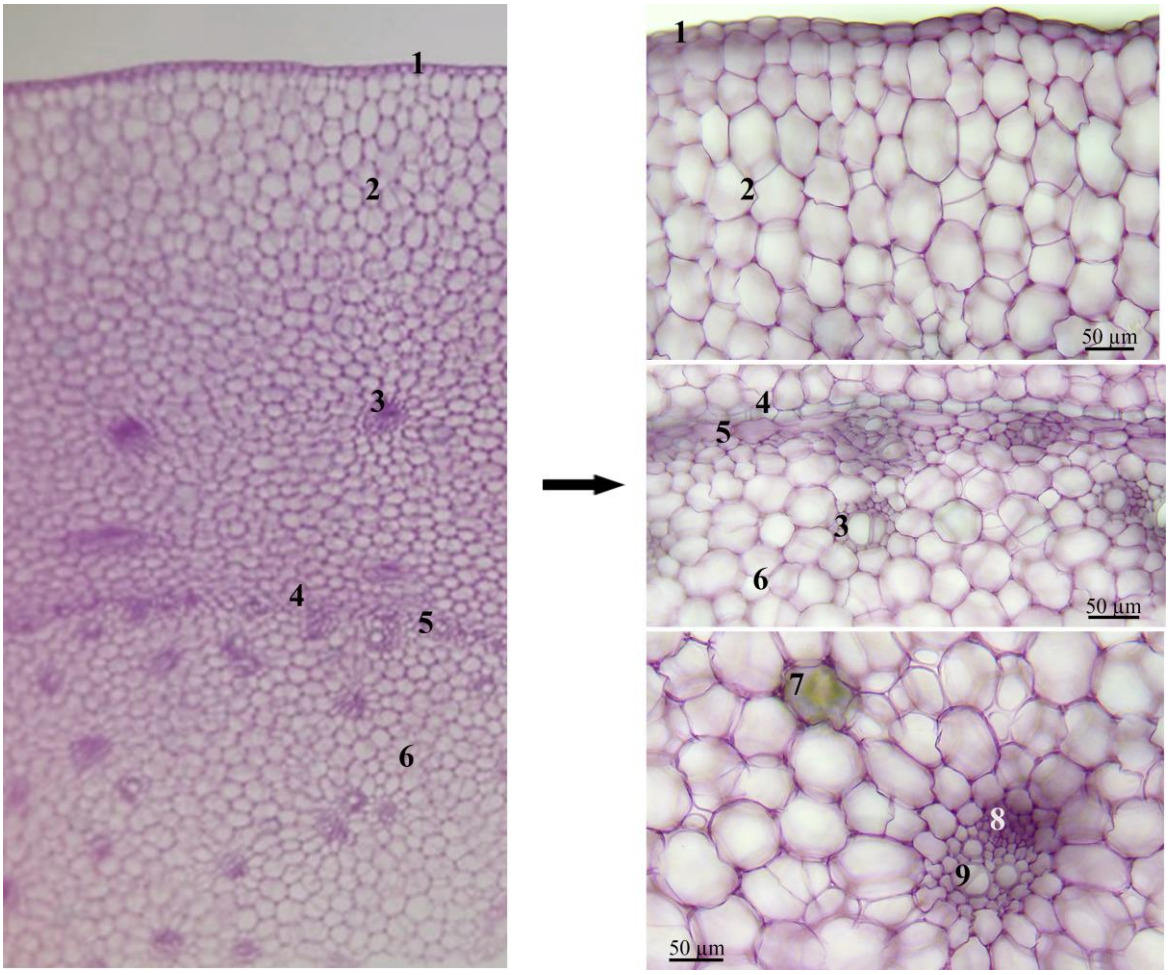

FIGURE 6. The cross section of rhizome. 1: epidermis, 2: cortical parenchyma, 3: vascular bundle, 4: endodermis, 5: pericycle, 6: medullary parenchyma, 7: secretory cell, 8: phloem, 9: xylem.

TABLE 2. Preliminary phytochemistry of ethanol extract of *Z. junceum*

	Leaf		Flower		Rhizome		Leafy shoot	
	Ethanol	Methanol	Ethanol	Methanol	Ethanol	Methanol	Ethanol	Methanol
Phenolic	++	++	++	++	++	++	++	++
Tannin	++	++	++	++	++	++	++	++
Flavonoid	++	++	++	++	++	+++	++	++
Coumarin	++	+	++	+	+	++	+	+
Alkaloid	+	++	++	++	++	++	+	++
Terpenoid	++	+++	+++	+++	+++	+++	++	+++
Steroid	++	+++	+++	+++	+++	+++	++	+++
Saponin	-	-	-	-	+	+	+	+

investigated using the DPPH and FRAP methods with the measured values of 2.40 mg Trolox/g and 0.91 mmol FeSO4 /g, respectively (Chumroenphat et al., 2019). Theanphong et al. (2016) showed the chemical constituents of the essential oil isolated from the *Z. junceum* rhizome collected from Laos and this essential oil was found to be rich in methylisoeugenol (55.90%); methyleugenol (16.54%); 3,4-dimethoxy-mandelic acid methyl ester (12.74%).

TABLE 3. Total triterpene, polyphenol, and flavonoid contents of ethanol and methanol extracts of *Z. junceum*

	Parts	Ethanol	Methanol
TPC (mg GAE/g DW)	Leaf	27.60 ± 1.39	47.62 ± 1.39
	Flower	11.84 ± 0.18	25.09 ± 1.00
	Rhizome	5.80 ± 0.26	8.85 ± 0.38
	Leafy shoot	16.83 ± 0.81	38.09 ± 1.06
TFC (mg QE/g DW)	Leaf	19.06 ± 0.21	30.05 ± 0.16
	Flower	5.00 ± 0.11	11.36 ± 0.12
	Rhizome	4.85 ± 0.26	19.05 ± 0.13
	Leafy shoot	8.13 ± 0.53	25.67 ± 0.18
TTC (mg OAE/g DW)	Leaf	2.98 ± 0.20	5.15 ± 0.20
	Flower	0.73 ± 0.10	3.17 ± 0.10
	Rhizome	1.67 ± 0.20	5.71 ± 0.20
	Leafy shoot	1.33 ± 0.40	2.27 ± 0.10

Studies provided the phytochemical screening of the solvent extracts isolated from various *Zingiber* species. For example, Shalaby et al. (2023) provided the phytochemistry of the aqueous extracts of *Z. officinale* peels grown in Egypt. Accordingly, the hot water extracts were composed of various bioactive compounds, including alkaloids, phenolics and flavonoids, carbohydrates, reducing sugar, glycosides, and tannins, the same compounds were found in the cool water extracts, except alkaloids. Moreover, hot water extract also consisted of the total polyphenol and flavonoid with the contents of 0.333 and 0.0968 g/100 g fresh weight whereas 0.323 and 0.0637 g/100 g fresh weight were the total polyphenol and flavonoid contents towards the cool water extract (Shalaby et al., 2023). Moreover, the hydroalcoholic, alcoholic, and aqueous extracts of the rhizomes of *Z. officinale* collected from India contained alkaloids, flavonoids, and tannins (Trivedi et al., 2019) while the aqueous extract of this species grown in Plateau State, Nigeria was found to be rich in saponin, alkaloid, steroid, and cardiac glycoside (Olamilekan et al., 2021).

The ethanol extract of the *Z. officinale* rhizome collected from Wonokromo, Indonesia was composed of terpenoids, flavonoids, steroids, phenolics, tannins, and alkaloids. Also this extract contained the total phenolic content with a concentration of 0.0438 mg/L (Amalia et al., 2021). In addition, Arawande et al. provided the phytochemical screening of the different solvent extracts of *Z. officinale* rhizome collected from Ondo State, Nigeria. Accordingly, of the 16 analyzed indicators (flavonoids, phenol, tannin, saponin, anthraquinone, volatile oil, steroid, ascorbic acid, glycoside, reducing sugar, phlobatannin, amino acid, resin, balsams, acid test, and chalcone), the ethanol extract had the highest proportion with 10 out of 16 constituents, the acetone and water extracts included 8 compounds, chloroform and ethylacetate extracts were found 7 and 5 components, respectively (Arawande et al., 2018). In addition, the flavonoid, saponin, and phenolic, have been reported as the phytochemical screening in the aqueous extract of *Z. officinale* var. *amarum* collected from Indonesia (Hasanela et al., 2023).

The aqueous extract of *Z. zerumbet* collected from Saudi Arabia contained gelatin, steroid, flavonoids, and triterpenoids. Also, this extract consisted of some flavonoid and phenolic compounds, including gallic acid, chlorogenic acid, caffeic acid, sinapic acid, and benzoic acid with the contents of 0.173, 0.021, 0.126, 0.016, and 0.045 (Assiry et al., 2023). Similarly, the various extracts of the *Z. zerumbet* rhizome grown in Malaysia were tested with 11 bioactive compounds, including flavonoids, glycosides, phenols, coumarins, alkaloids, quinones, steroids, anthraquinones, terpenes, tannins, saponin. Of these, the ethyl acetate and methanol extracts were found in 8 out of 11 components (except saponins, glycosides, and anthraquinones in ethyl acetate extract and saponins, quinones, and anthraquinones in methanol extract) and the n-hexane extract contained terpenes, steroids, and quinones (Preshahdin et al., 2023). Furthermore, the methanol, ethanol, chloroform, and aqueous extracts of the *Z. neesanam* leaf, stem, and rhizome collected from Kerala, India was found to be rich in saponin, cardiac glycoside, tannin, alkaloid, flavonoid, terpenoid, phenol, and sterol (Judin, 2016).

CONCLUSION

The present study first recorded *Z. junceum* as an additional species for the flora of Vietnam which its micro-morphological characteristics were described and illustrated. The phytochemical screening of the methanol and ethanol extracts of the different organs of *Z. junceum* is also provided. The results from this study enhance the understanding of this species' distribution, micro-morphological and pharmacological characteristics.

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LITERATURE CITED

Amalia, R.T., Tukiran, T., Sabila, F.I. and Suyatno S. 2021. Phytochemical screening and total phenolic compounds of red ginger (*Zingiber officinale*) and secang wood (*Caesalpinia sappan*) as preliminary test of antiarthritis. Chimica et Natura Acta, 9: 34230.

Arawande, J.O., Akinnusotu, A. and Alademeyin, J.O. 2018. Extractive value and phytochemical screening of ginger (*Zingiber officinale*) and turmeric (*Curcuma longa*) using different solvents. International Journal of Traditional and Natural Medicines, 8: 13-22.

Assiry, A.A., Ahmed, N., Almuaddi, A., Saif, A., Alshahrani, M.A., Mohamed, R.N. and Karobari, MI. 2023. The antioxidant activity, preliminary phytochemical screening of *Zingiber zerumbet* and antimicrobial efficacy against selective endodontic bacteria. Food Science and Nutrition, 11: 4853-4860.

Bodi, D., Gottschalk, C., Behr, N., Skibba, A., Wagner, M., Lahrssen-Wiederholt, M., Preiss-Weigert, A. and These, A. 2014. Determination of pyrrolizidine alkaloids in tea, herbal drugs and honey. Food Additives & Contaminants: Part A, 31(11): 1886-1895.

Chayamarit, K., Balslev, H., Newman, M.F. and Sangvirotjanapat, S. 2023. Flora of Thailand, Volume 16, Part 2, Zingiberaceae. Forest Herbarium, Royal Forest Department.

Chen, Y., Xie, M.Y. and Gong, X.F. 2007. Microwave-assisted extraction used for the isolation of total triterpenoid saponins from *Ganoderma atrum*. Journal of Food Engineering, 81: 162-170.

Chumroenphat, T., Somboonwatthanakul, I., Saensouk, S. and Siriamornpun, S. 2019. The diversity of biologically active compounds in the rhizomes of recently discovered Zingiberaceae plants native to North Eastern Thailand. Pharmacognosy Journal, 11(5): 1014-1022.

Deka, C.A., Sarma, I., Dey, S. and Sarma T.C. 2017. Antimicrobial properties and phytochemical screening of some wild macrofungi of Rani-Garbhanga Reserve Forest Area of Assam, India. Advances in Applied Science Research, 8(3):17-22.

Delin, W. and Larsen, K. Zingiberaceae. 2000. Flora of China, 24: 322-377.

Hasanela, N., Bandjar, A., Yanyaan, V.K. and Hitijahubessy, H. 2023. Phytochemical tests and antioxidant activities of the rhips ginger (*Zingiber officinale* var. amarum.). Indonesian Journal of Chemical Research, 11: 128-134.

Judin, C.J. 2016. Preliminary analysis of secondary metabolites and antibacterial activity of *Zingiber neesanam* Graham. International Journal of Herbal Medicine, 4: 20-22.

Kishor, R. and Leong-Škorničková, J. 2013. *Zingiber kangleipakense* (Zingiberaceae): A new species from Manipur, India. Gardens' Bulletin Singapore, 65: 39-46.

Krisna K.D., Sasongko, H.S.D. and Sukasih, E. 2015. Total phenol and antioxidant from seed and peel of ripe and unripe of Indonesian sugar apple (*Annona squamosa* L.) extracted with various solvents. IOSR Journal of Pharmacy, 5(10): 20-25.

Le, T.H., Trinh, T.H., Do, N.D., Nguyen, V.H. and Ly, N.S. 2019. *Zingiber vuquangense* (Sect. cryptanthium: Zingiberaceae): A new species from north central coast region, Vietnam. Phytotaxa, 388: 295-300.

Le, C.T., Nguyen T.L.T., Nguyen HT., Nguyen V.C., Truong Q.C., Nguyen V.K., Pham T.T.D. and Nguyen D.D. 2023. A newly recorded species *Zingiber densissimum* (sect. *Cryptanthium*) for the flora of Vietnam. Academia Journal of Biology, 45: 63-71.

Leong-Škorničková, J., Nguyen, Q.B., Tran, H.D., Sida, O., Rybková, O. and Truong, B.V. 2015. Nine new *Zingiber* species (Zingiberaceae) from Vietnam. Phytotaxa, 219: 201-220.

Llauradó, G., Morris, H.J., Lebeque, Y., Gutiérrez, A., Fontaine, R., Bermúdez, R.C. and Perraud-gaime, I. 2013. Phytochemical screening and effects on cell-mediated immune response of *Pleurotus* fruiting bodies powder. *F* Food and Agricultural Immunology, 24: 295-304.

Ly, N.S. 2016. *Zingiber skornickovae*, a new species of Zingiberaceae from Central Vietnam. Phytotaxa, 265: 139-144.

Ly NS., Tran, B.V. and Le, T.H. 2016. *Zingiber ottensii* Valeton (Zingiberaceae) a newly recorded species for Vietnam. Bioscience Discovery, 7: 93-96.

Ly, N.S., Dang, V.S, Do, D.G., Tran, T.T., Do, N.D. and Nguyen D.H. 2017. *Zingiber nudicarpum* D. Fang (zingiberaceae), a newly recorded species for Vietnam. Bioscience Discovery, 8: 1-5.

Ly, N.S., Do D.G., Cao N.G., Truong B.V., Nguyen V.T. and Leong-Škorničková, J. 2021. *Zingiber magang* and *Z. Tamii* (Zingiberaceae), two new species from central vietnam. Taiwania, 66: 232-240.

Nguyen, D., Vo, NT., Nguyen, V.B., Phan, TK., Nguyen, T.T. and Huynh, N.T.T. 2017. Investigation of biochemical properties and antibacterial properties of extracts from *Colocasia esculenta*. Journal of Agricultural Science and Technology, Hue University of Agriculture and Forestry, 1: 265-274.

Nguyen, Q.B. 2017. Zingiberaceae-Flora of Vietnam. Publishing House for Science and Technology.

Olamilekan, A.R., Ogbole, E., Itodo, A.E., Salami, O. and Dasola Abdulazeez, M. 2021. Aqueous extracts of Ginger (*Zingiber officinale* Roscoe) and Garlic (*Allium satium* L.) bulbs: Phytochemical screening and in vivo antitrypanosomal effect. World News of Natural Sciences, 37: 135-150.

Pham, H.H. 2000. Araceae, in: Pham-hoang, H. (Ed.) Cây cỏ Việt Nam: An Illustrated Flora of Vietnam, vol. 3. Youth Publishing House, Ho Chi Minh City.

Preshahdin, N.A., Jani, N.A. and Iberahim, R. 2023. Phytochemicals and Antibacterial Activity of Zingiber zerumbet Growing in Negeri Sembilan, Malaysia. Journal of Science and Mathematics Letters, 11: 20-29.

Ragsasilp, A., Saensouk, P. and Saensouk, S. 2022. Ginger family from Bueng Kan Province, Thailand: Diversity, conservation status, and traditional uses. Biodiversitas, 23(5): 2739-2752.

Sabulal, B., Dan, M., Anil John .J, Kurup, R., Pradeep, N.S., Valsamma, R.K. and George, V. 2006. Caryophyllene-rich rhizome oil of *Zingiber nimmonii* from South India: Chemical characterization and antimicrobial activity. Phytochemistry, 67: 2469-2473.

Sen, S., De, B., Devanna, N. and Chakraborty, R. 2013. Total phenolic, total flavonoid content, and antioxidant capacity of the leaves of Meyna spinosa Roxb., an Indian medicinal plant. Chinese Journal of Natural Medicines, 11: 149-157.

Shalaby, E.A., Shanab, S.M.M., Hafez, R.M. and El-Ansary, A.E. 2023. Chemical constituents and biological activities of different extracts from ginger plant (*Zingiber officinale*). Chemical and Biological Technologies in Agriculture, 10: 185.

Sharma, P.K., Singh, V. and Ali, M. 2016. Chemical composition and antimicrobial activity of fresh rhizome essential oil of *Zingiber officinale* Roscoe. Pharmacognosy Journal, 8: 185-190.

Singh, G., Kapoor, I.P.S., Singh, P., Heluani, CS., Lampasona, MP. and Catalan, CAN. 2008. Chemistry, antioxidant and antimicrobial investigations on essential oil and oleoresins of *Zingiber officinale*. Food and Chemical Toxicology, 46: 3295-3302.

Sivasothy, Y., Chong, W.K., Hamid, A., Eldeen, I.M., Sulaiman, SF. and Awang, K. 2011. Essential oils of *Zingiber officinale* var. *rubrum* Theilade and their antibacterial activities. Food Chemistry, 124: 514-517.

Shaikh, J.R. and Patil, M. 2020. Qualitative tests for preliminary . phytochemical screening: An overview. International Journal of Chemical Studies, 8: 603-608.

Shukla, Y. and Singh, M. 2007. Cancer preventive properties of ginger: A brief review. Food and Chemical Toxicolog, 45: 683-690.

Souvannakhoummane, K. and Leong-Škornicková, J. 2017. Eight new records of *Zingiber* Mill. (Zingiberaceae) for the flora of Lao P.D.R. Edinburgh Journal of Botany, 75(1):1-16.

Theanphong, O. and Jenjittikul, T., Mingvanish, W. 2016. Chemotaxonomic study of volatile oils from rhizomes of 9 *Zingiber* species (Zingiberaceae). Thai Journal of Botany, 8(1): 127-139.

Theilade, I. 1999. *A synopsis of the genus Zingiber (Zingiberaceae) in Thailand*. Nordic Journal of Botany, 19(4): 389-410.

Trivedi, R.V., Bansod, P.G., Taksande, J.B., Mahore, J.G., Tripurneni, S.R., Rai, K.R. and Umekar M.J. 2019. Investigation of hair growth promoting ability of herbal gel containing Zingiber officinale. International Journal of Research in Pharmaceutical Sciences, 10: 3498-3507.

Truong, T.D., Nguyen, T., Nhuyen, T.T.N. and Lieu, H.M.T. 2017. *Medicinal Plants.* Viet Nam Education Publishing House.

Vo, T., Nguyen, T., Nguyen, T., Tran, H. and Nguyen, D. 2017. Investigation of total phenolic content, total flavonoids, antioxidant activity and antibacterial activity of ethanol and methanol extracts of leaves and rhizomes of *Imperata cylindrica*. Can Tho University Journal of Science, 52: 16-22.