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Phytochemicals, Bioactivity, and Utilization of *Etlingera elatior* as a Medicinal Plant

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Abstract *— Etlingera elatior,* commonly known as torch ginger, has long been utilized by communities as a medicinal plant and culinary spice. Native to Southeast Asia, this plant is renowned for its rich nutritional content and diverse bioactivities, including antioxidant, antibacterial, antifungal, tyrosinase-inhibiting, cytotoxic, and hepatoprotective properties. These activities are attributed to its abundant phytochemical compounds such as phenols, flavonoids, glycosides, saponins, tannins, steroids, and terpenoids. This study aimed to determine the total phenolic content (TPC), total flavonoid content (TFC), and antioxidant activity of ethanol extract, water, ethyl acetate, and n-hexane fractions derived from E. elatior leaves. TPC and TFC were analyzed using the Folin-Ciocalteu and aluminium chloride methods, while antioxidant activities were evaluated through DPPH and ABTS radical scavenging assays. The ethyl acetate fraction exhibited the highest TPC (5.60 ± 0.02% w/w GAE) and TFC (14.66 ± 0.67% w/w CE). Interestingly, the n-hexane fraction demonstrated the strongest antioxidant activity, with IC50 values of 39.35 µg/mL (DPPH) and 13.04 µg/mL (ABTS), outperforming the ethanol extract, water fraction, and ethyl acetate fraction. All tested extracts and fractions showed IC50 values below 50 µg/mL, indicating potent antioxidant potential. These findings underscore the significant phytochemical and bioactive properties of *E. elatior,* supporting its potential development as a natural medicinal resource in Indonesia.

Keywords *— Etlingera elatior;* Phytochemicals; Bioactivity

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INTRODUCTION

The torch ginger plant, scientifically known as *Etlingera elatior*, originates from Malaysia and Indonesia and is widely cultivated in Southeast Asia [1]. In Malaysia, it is known as “kantan,” and it is a native plant of Sumatra, Indonesia, also extensively cultivated throughout tropical regions. Other local names include Takalo (Dayak Kalimantan), Kincung (Medan), Kincuang and Sambuang (Minangkabau), and Siantan (Malaya) [2]. *E. elatior* is a member of the large ginger plant group that grows in clusters. It has the following characteristics: its rhizome is strong, highly aromatic, and found just beneath the soil surface. The crushed leaves emit a pleasant sour aroma. The leaves are green, with young leaves sometimes tinged with pink. Its inflorescence grows on an upright stem that stands out from the ground, large and striking with prominent bracts [1]. Taxonony from *Etlingera elatior*

Kingdom : Plantae
Phylum : Spermatophyta
Subphylum : Angiospermae
Class : Monocotyledonae
Order : Zingiberales
Family : Zingiberaceae
Genus : Etlingera
Species : *E. elatior* [3]

Etlingera elatior (Jack) R.M. Smith, commonly known as torch ginger, is a plant widely utilized by the people of Indonesia for both culinary and medicinal purposes. The flower buds are commonly used in traditional dishes such as anyang, urap, pecel, and sayur asem, while the powder from young stems is often added to lalapan (raw vegetable salad). Additionally, ripe fruits are mixed into sambal, contributing to the dish's vibrant red color, distinctive taste, and aroma, which enhance overall flavor [4]. Beyond its sensory qualities, *E. elatior* is also recognized for its nutritional value, containing unsaturated fatty acids, proteins, amino acids, and essential minerals, with low heavy metal contamination. The dried flowers have been reported to contain 12.6% protein, 18.2% fat, and 17% fiber [5].

In addition to its culinary applications, *E. elatior* holds significant value in traditional medicine practices across Southeast Asia. In Malaysia and Southern Thailand, young flowers are used not only as food but also as herbal remedies. Extracts from its stem are traditionally applied to reduce swelling, while boiled leaves are used for wound cleansing. Postpartum women often bathe with leaf infusions to eliminate body odor and promote wound healing. In both Malaysia and Indonesia, the fruit is traditionally used to treat earaches, diarrhea, coughs, mouth sores, and to stimulate appetite. Furthermore, the entire stem is processed into a liquid extract used in the treatment of typhoid fever patients in Indonesia. The plant is also commonly found as an ingredient in traditional herbal drinks [3].

The extensive use of *E. elatior* in both culinary and medicinal contexts is largely attributed to its diverse phytochemical composition, including phenols, flavonoids, glycosides, saponins, tannins, steroids, and terpenoids [3]. These compounds are responsible for a wide range of biological activities, such as antioxidant, antibacterial, antifungal, anti-inflammatory, cytotoxic, hepatoprotective, anti-hyperglycemic, anti-hyperuricemia, larvicidal, skin-whitening, anti-aging, and wound-healing effects. Given these valuable properties, *E. elatior* represents a promising natural resource for the development of functional foods and herbal medicines [3].

However, despite its broad utilization, comprehensive studies focusing on the chemical constituents and bioactivity of E. elatior—especially from its leaves—are still limited. Therefore, this study aims to investigate the total phenolic content (TPC), total flavonoid content (TFC), and antioxidant activity of ethanol extract and its fractions (water, ethyl acetate, and n-hexane) derived from *E. elatior* leaves. This research is expected to contribute to the scientific basis for the development of E. elatior as a potential medicinal plant resource in Indonesia.

MATERIALS AND METHOD

The creation of this review article is based on several studies that discuss *E. elatior*. The sources for this literature were gathered from Google Scholar by searching for the keyword "*Etlingera elatior."* To explore its chemical content, the search was conducted using the keyword "Phytochemicals of *Etlingera elatior*," while for bioactivity, the following keywords were used: "Etlingera elatior as an antioxidant," "Etlingera elatior as an antidiabetic," "*Etlingera elatior* as an antibacterial," "*Etlingera elatior* as an anticancer," "*Etlingera elatior* as an anti-hyperuricemia," "*Etlingera elatior* as hepatoprotective," and others. Through this process, a brief review article was compiled.

RESULTS AND DISCUSSION

E.elatior Chemical Compound

Each part of *E. elatior* contains various phytochemical compounds. This plant is known to contain secondary metabolites such as phenols, flavonoids, glycosides, saponins, tannins, steroids, and terpenoids, which contribute to its bioactivity [5]. A study showed that methanol extracts contain compounds like flavonoids (quercetin and kaempferol), terpenoids, saponins, tannins, anthocyanins, and carbohydrates. The leaves of *E. elatior* contain flavonoids, including isoquercitrin, quercitrin, (+)-

catechin, and caffeoylquinic acid (CQA), specifically 3-CQA (chlorogenic acid), 5-CQA (neochlorogenic acid), and methyl 5-CQA. Additionally, the dominant phenolic compound in the leaves is chlorogenic acid [6]. Another study showed that phytochemical testing of *E. elatior* leaf powder tested positive for alkaloids, flavonoids, saponins, steroids, tannins, and phenols, but negative for glycosides. The stem of *E. elatior* contains compounds like camphene, linalool, phenolics, and sesquiterpenes, which exhibit antimicrobial activity [7], [4].

Phytochemical compounds are not only abundant in the stem, leaves, and flowers but also in the rhizomes. Phytochemical studies on the rhizome of *E. elatior* have led to the isolation of compounds such as 1,7-bis(4-hydroxyphenyl)-2,4,6-heptatrienone, demethoxycurcumin, 1,7-bis(4-hydroxyphenyl)-1,4,6-heptatrien-3-one, 16-hydroxylabda-8(17),11,13-trien-16,15-olide, stigmast-4-en-3-one, stigmast-4-ene-3,6-dione, stigmast-4-en-6β-ol-3-one, and 5α,8α-epidioxyergosta-6,22-dien-3β-ol [8]. In addition to its extract, the essential oil of *E. elatior* is also rich in phytochemical compounds. The essential oil from the leaves contains ß-pinene (19.7%), caryophyllene (15.36%), and (E)-ß-farnesene (27.90%) as the major compounds, while the essential oil from the stem is mainly dominated by 1,1-dodecanediol diacetate (34.26%) and (E)-5-dodecene (26.99%). The essential oils from the flowers and rhizomes contain major compounds such as 1,1-dodecanediol diacetate (24.38% and 40.37%, respectively) and cyclododecane (47.28% and 34.45%, respectively) [9].

The determination of total phenolic content (TPC) was conducted using the Folin-Ciocalteu method, which is based on the reduction reaction of phenolic hydroxyl groups, with gallic acid serving as the standard reference compound. The results were expressed in % w/w Gallic Acid Equivalent (GAE) [52]. The obtained TPC values were calculated from a calibration curve with the regression equation $y = 0.070x - 0.037$ and a high correlation coefficient ($R^2 = 0.998$), indicating excellent linearity (Figure 1). Based on the measurements, the TPC values for the ethanol extract, water, ethyl acetate, and n-hexane fractions were 3.70 ± 0.06, 3.44 ± 3.34, 5.60 ± 0.02, and 3.44 ± 3.34% w/w GAE, respectively (**Table 1**). Among these, the ethyl acetate fraction exhibited the highest phenolic content, while the n-hexane fraction showed the lowest.

Table 1. Comparison between total phenolic and flavonoid contents of extract and fractions of *Etlingera elatior*

Extracts and Fractions	Total Phenol Content (TPC) % w/w GAE	Total Flavonoid Content (TFC) % w/w CE
Extract	3.70 ± 0.06	10.77 ± 0.32
Water Fraction	4.74 ± 0.13	8.65 ± 0.88
Ethyl Acetate Fraction	5.60 ± 0.02	14.66 ± 0.67
Hexane Fraction	3.44 ± 3.34	11.43 ± 0.05

*Data represent mean ± SD; n = 3; level of significance: *P < 0.05.

For total flavonoid content (TFC), the aluminum chloride colorimetric method was employed using catechin as the standard, with results expressed in % w/w Catechin Equivalent (CE). The calibration curve followed a linear regression equation of $y = 0.025x + 0.066$ with $R^2 = 0.989$ (Figure 2) [25]. The ethyl acetate fraction again showed the highest TFC at 14.66 ± 0.67% w/w CE, followed by the n-hexane fraction (11.43 ± 0.05% w/w CE), ethanol extract (10.77 ± 0.32% w/w CE), and the water fraction (8.65 ± 0.88% w/w CE) (Table 1).

The observed variations in TPC and TFC values are closely related to the polarity of the solvents used. Ethyl acetate, being semi-polar, has a high affinity for polyphenolic and flavonoid compounds, which explains its superior extraction efficiency for these phytochemicals. Ethanol is also a commonly used solvent in phenolic extraction due to its safety and effectiveness, while methanol and acetone are known for higher efficiency in extracting polyphenols and flavanols because of their molecular characteristics [24–26].

The significant differences in phenolic and flavonoid contents ($P < 0.05$) among the extracts and fractions suggest that solvent polarity, along with other factors such as plant part, environmental conditions, soil composition, and UV exposure, play crucial roles in determining phytochemical yields [7, 29, 30]. Moreover, phenolic compounds, characterized by their hydroxyl functional groups, act as effective reducing agents by donating hydrogen atoms to neutralize free radicals [31, 32]. Flavonoids, on the other hand, contribute to antioxidant activity through their conjugated double bonds and hydroxyl groups, which enable them to stabilize free radicals and prevent oxidative chain reactions [29].

Previous studies have identified several key flavonoids in *E. elatior* leaves, including kaempferol 3-glucuronide, quercetin 3-glucuronide, quercetin 3-glucoside, and quercetin 3-rhamnoside [29]. These compounds are responsible for the high antioxidant activity observed in *E. elatior* leaves compared to other plant parts. Considering these findings, *E. elatior* holds promising potential for development into herbal products and applications in the food and nutraceutical industries [29, 30].

Bioactivity of E. elatior

E. elatior is a plant that is safe for consumption. A study has demonstrated that its extract is safe for experimental animals at doses of up to 2.0 g of extract per kg of body weight [10]. *E. elatior* is a plant with biological activities such as antimicrobial, antioxidant, antitumor, anti-hyperglycemic, anti-hyperuricemic, anti-inflammatory, larvicidal, skin-whitening, anti-aging, and wound-healing properties.

1. Antioxidant

E. elatior has antioxidant activity. Torch ginger and the compounds contained within it have the ability to neutralize free radicals. The antioxidants in *E. elatior* exhibit significant antioxidant properties. One example is that *E. elatior* flower extract can counteract oxidative stress reactions caused by lead. The flower extract can also serve as a therapeutic agent against lead toxicity [11]. In addition to having antioxidant activity against lead, *E. elatior* also exhibits antioxidant activity against DPPH and FRAP radical activities, with an inhibition percentage of 76.4%, and a FRAP activity of 6.88 mM Fe (II)/g, with a half-maximal inhibitory concentration (IC50) of 34.5 µg/mL. This is supported by its high content of flavonoids, phenolics, and terpenoids. The water extract of *E. elatior* flowers has a Total Phenolic Content (TPC) of 618.9 mg/100 g DM, a total flavonoid content of 354.2 mg/100 g DM, and a total terpenoid content of 129.5 mg/100 g DM. The high phenolic and flavonoid contents make *E. elatior* highly antioxidant [12], [5]. The antioxidant activity of the *E. elatior* flower extract is almost comparable to the standard ascorbic acid. In a study, the antioxidant activity of the flower extract was tested for its inhibition against DPPH radical activity (1,1-diphenyl-2-picrylhydrazyl). The result showed that the IC50 of *E. elatior* flower extract was 4.34 µg/mL, while the IC50 of the standard ascorbic acid was 4.25 µg/mL [13]. The antioxidant activity of *E. elatior* is also found in the ethanol extract of the resin precipitate (EERS) from young *E. elatior* flowers. A study demonstrated that the ethanol extract of the resin precipitate from young *E. elatior* flowers has antioxidant activity in neutralizing DPPH and ABTS radicals, with EC50 values of 44.19 and 56.61 µg/mL, respectively, and shows high antioxidant activity in inhibiting FRAP radicals [14]. The most abundant compounds in *E. elatior* include α-pinene, decanal, and 1-dodecanol [15]. Extracts from *E. elatior* exhibit high antioxidant activity, whether obtained using acetone or other solvents. Its activity was tested against DPPH, FRAP, and ABTS radicals [16], [10].

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decanal, and 1-dodecanol [15]. Extracts from *E. elatior* exhibit high antioxidant activity, whether obtained using acetone or other solvents. Its activity was tested against DPPH, FRAP, and ABTS radicals [16], [10].

2. Anticancer

The activity of *E. elatior* not only functions as an antioxidant but also as an anticancer agent. Previous research has shown that the ethyl acetate extract exhibits significant cytotoxic activity against the CEM-SS and MCF-7 cell lines (4 µg/ml and 6.25 µg/ml, respectively) [8]. The flower extract of *E. elatior* demonstrates strong anticancer activity with IC50 values of 173.1 and 196.2 µg/mL against the MCF-7 and MDA-MB-231 tumor cell lines [12]. Another study showed that in the MTT assay, the ethanol extract of the resin precipitate (EERS) from young *E. elatior* flowers exhibited strong anticancer activity, with IC50 values of 19.82, 37.001, 50.49, and 53.29 µg/mL against the HT-29, HCT 116, HeLa, and MCF-7 tumor cell lines. This activity is comparable to or almost equivalent to the reference standard drug, 5-fluorouracil. This anticancer activity is attributed to the polyphenols and flavonoids present, which have a selective antiproliferative effect against colon cancer in vitro [14].

Subsequent research showed that extracts of *E. elatior* (95% ethanol and acetone) exhibited antiproliferative activity in HT-29 cells. At concentrations close to IC50, the acetone extract from the leaves induced a 2.353±0.003-fold increase in apoptosis and a negligible increase in necrosis compared to the negative control in HT-29 cells. Therefore, the cell death mechanism is suspected to occur through apoptosis [20]. Furthermore, *E. elatior* contains compounds that have the potential to be anticancer agents, particularly for breast cancer, with ergosterol peroxide identified as the most potent anticancer compound [21].

Research on the anticancer activity of *E. elatior* comes not only from its extract but also from the compounds isolated from it. Two isolated compounds identified as quercetin and quercetin-3-O-rhamnoside from the ethyl acetate fraction exhibited cytotoxic activity against HeLa cervical cancer cells, as shown by the inhibition of cell proliferation, with IC50 values of 29.49 and 46.67 µg/mL, respectively. This indicates that quercetin and quercetin-3-O-rhamnoside could be potential candidates for anticancer drugs [22]. The anticancer activity of *E. elatior* is also demonstrated by its essential oil. The essential oil of *E. elatior* showed significant inhibition against the four cell lines tested: human breast adenocarcinoma (MCF-7), human cervical carcinoma (HeLa), lymphocytic leukemia (P388), and human promyelocytic leukemia (HL 60) [23]. Based on the findings from several studies above, it can be concluded that *E. elatior* has anticancer activity.

3. Antibacterial

The antibacterial activity of *E. elatior* is demonstrated by the flower extract, essential oil, and rhizome. The flower extract of *E. elatior* exhibits antibacterial activity. For example, methanol and water extracts from *E. elatior* flowers show antibacterial activity against *S. aureus* and *E. coli* [24]. Another study revealed that the water extract of *E. elatior* flowers also exhibited antibacterial activity against *Staphylococcus aureus*, *Bacillus subtilis*, *Listeria monocytogenes*, *Escherichia coli*, *Salmonella typhimurium*, and *Pseudomonas aeruginosa* [12], [13]. In addition to alcohol and water extracts, the dichloromethane flower extract demonstrated inhibitory activity against *P. acnes*, with the largest inhibition zone (11.39 ± 0.45 mm) at 25 mg/mL and the lowest MIC (6.25 mg/mL) and MBC (12.5 mg/mL) [25]. Furthermore, the acetone extract from *E. elatior* showed antibiofilm activity against *S. aureus*, making it beneficial for various applications such as antimicrobial topical creams and wound dressings [26].

In addition to the extracts from various parts of the plant, compounds isolated from the stem of E. elatior, namely stigmast-4-en-6β-ol-3-one and p-hydroxybenzoic acid, demonstrate antibacterial activity against Bacillus subtilis FNCC 0060, Escherichia coli ATCC 35218, Pseudomonas aeruginosa ATCC 27853, Salmonella enterica ATCC 14028, Staphylococcus aureus ATCC 25923, and Streptococcus mutans ATCC 25175 [19]. The essential oil obtained by steam distillation from the rhizome of

E. elatior can inhibit the activity of Staphylococcus aureus, Staphylococcus sp., Streptococcus pyogenes, and Salmonella enteritidis. E. megalocheilos, E. coccinea, and E. elatior inhibited all four bacteria tested with MIC values less than 10 µg/mL. Additionally, other studies have shown that the essential oil from E. elatior exhibits antibacterial activity against the gram-negative bacterium Klebsiella pneumoniae [23, 27]. The oil, dodecanal, and 1-dodecanol are active against Staphylococcus aureus, with their respective minimum bactericidal concentrations of 124, 31, and 62 µg/mL. For Pseudomonas aeruginosa, the essential oil exhibits inhibitory effects against multi-drug-resistant isolates (minimum inhibitory concentration (MIC): 4,000 µg/mL) [28].

In addition to its antibacterial properties, *E. elatior* also demonstrates antifungal activity. Dodecanal has an MIC of 60,000 µg/mL for all *Candida* species, but fungicidal activity is only detected for *Candida albicans* (minimum fungicidal concentration: 60,000 µg/mL). 1-Dodecanol (60,000 µg/mL) shows fungistatic activity against *C. albicans* [28]. *E. elatior* flower extract also inhibits the activity of *C. albicans* [29]. All insect nutritional parameters were altered by consuming artificial food mixed with EeIEO, NAL, and NOL, which increased insect mortality and had a strong preventive effect (food prevention index from 70.5% to 92.0%). EeIEO, NAL, and NOL were also able to inhibit at least 67% of the amylase activity from the insect's gut. The results demonstrate the insecticidal activity of EeIEO, NAL, and NOL as a natural option for controlling *S. zeamais*. NOL achieved the best results in terms of toxicity through contact and consumption, while NAL was most effective through fumigation [30].

4. Antidiabetic

E. elatior also has antidiabetic activity. Several studies have demonstrated the antidiabetic activity of *E. elatior* both in vitro and in vivo. The antidiabetic activity is shown by the extract, isolated compounds, and essential oils of *E. elatior*. The extract of *E. elatior* exhibits in vitro antidiabetic activity by inhibiting the activity of the enzymes α-amylase and α-glucosidase. One study showed that *E. elatior* flowers have a high percentage of inhibition activity against α-amylase (99.70 ± 2.88%) and moderate activity against α-glucosidase (52.39 ± 1.50%). Additionally, it demonstrated a dose-dependent antihyperglycemic effect and significantly reduced elevated levels of total cholesterol, triglycerides, and low-density lipoprotein in an in vivo study [31]. Another study revealed that all extracts from different parts of *E. elatior*, including the rhizome, stem, leaves, flowers, and fruit, showed significant inhibition activity against α-glucosidase at a concentration of 500 µg/mL, with the stem extract showing the most effective α-glucosidase inhibition with an IC50 value of 5.15 µg/mL, indicating its promising potential as an antidiabetic agent [32].

Another study showed that the flower extract of *E. elatior*, in addition to inhibiting the activity of α-glucosidase and α-amylase, also demonstrated the ability to reduce fasting blood glucose (FBG), microalbuminuria, serum creatinine, and serum blood urea nitrogen. The aqueous extract of *E. elatior* flowers also reduced malondialdehyde (MDA) levels and increased antioxidant markers—superoxide dismutase (SOD), catalase (CAT), glutathione (GSH), and total antioxidant capacity (T-AOC). Additionally, inflammatory markers (interleukin (IL)-6) and fibrosis markers (transforming growth factor-beta (TGF-β), and connective tissue growth factor (CTGF)) significantly decreased in the group treated with *E. elatior* flower extract. The antidiabetic activity was attributed to the presence of the active compound cyanidin-3-O-glucoside, an anthocyanin antioxidant, found in the aqueous extract of *E. elatior* flowers [33].

Antidiabetic activity is also demonstrated by stigmasterol as one of the active compounds. The IC50 values of the total extract, n-hexane, EtOAc, BuOH, and isolated compounds against α-glucosidase were 16.0, 7.5, 13.5, 9.7, and 2.0 ppm, respectively. The IC50 values for α-amylase inhibition were 88.6, 48.6, 23.2, 29.1, and 27.5 ppm, respectively. The positive control (acarbose) for both α-glucosidase and amylase showed IC50 values of 153.2 and 12.3 ppm, respectively [34].

Furthermore, the ethanol extract of nano chitosan-encapsulated *E. elatior* was effective in lowering blood glucose and malondialdehyde levels, as well as increasing superoxide dismutase levels in streptozotocin-induced hyperglycemic rats. The nano-extract, made by encapsulating bioactive compounds, has significant potential for development as a bioactive compound delivery system in medical fields [35]. The antidiabetic effects of this plant are attributed to bioactive compounds such as flavonoids and phenolics. *E. elatior* has the ability to prevent complications of diabetes, such as nephropathy and cataracts, in addition to lowering blood glucose levels [36].

5. Anti-inflammatory

The phytochemical compounds contained in the plant *E. elatior* (Jack) RM Sm. are predominantly flavonoids, saponins, tannins, phenolic terpenoids, and essential oils, which are widely distributed in the leaves, flowers, stems, and rhizomes. Based on the results of pharmacological studies, the plant *Etlingera elatior* (Jack) RM Sm. exhibits anti-inflammatory activity by inhibiting the regulation of NF-κB-p65 expression. This plant can reduce paw edema in rats induced by carrageenan and stabilize erythrocyte membranes [37]. Previous research on *E. elatior* as an anti-inflammatory agent has been conducted, and the results demonstrated that the flower extract of *E. elatior* at a dose of 1000 mg/kg body weight reduced the ulceration index and inflammatory cell infiltration. The anti-inflammatory activity of *E. elatior* flowers is achieved by downregulating the expression of NF-kappaB-p65 in the fundus of Wistar rats with induced gastric ulcers [38]. Furthermore, other research has also proven that a 3% concentration gel of *kecombrang* (torch ginger) flower extract statistically has almost the same effectiveness as a positive control as an anti-inflammatory agent in mice induced with carrageenan [39].

Besides the flowers that possess anti-inflammatory activity, extracts from the leaves and fruit also exhibit anti-inflammatory effects. One study demonstrated that the ethanol extract of *kecombrang* leaves at a dose of 200 mg/kg body weight has good anti-inflammatory activity, reaching values of 0.972, 0.994, and 1.000 [40]. Furthermore, in addition to the leaf and flower extracts, the fruit also shows anti-inflammatory activity. A study conducted by Fristiohady and colleagues investigated the anti-inflammatory activity of *E. elatior* fruit extract using a determination method based on the percentage of stability and hemolysis. This research has shown that *E. elatior* fruit also has an anti-inflammatory effect. The ethanol extract of *E. elatior* fruit has the potential to be an anti-inflammatory agent, exhibiting percentages of stability and hemolysis identical to the positive control (sodium diclofenac) [41].

6. Bioactivity from E.elatior

The biological activities of *E. elatior* are numerous. Among these are its potential as an anti-aging and wound-healing agent, its ability to protect against sun exposure and rejuvenate the skin. The essential oil from *E. elatior* leaves can reduce melanin levels by inhibiting the growth of melanoma cell lines [18, 42, 43] and improve lung damage caused by cigarette smoke [44]. Furthermore, *E. elatior* can also act as an immunomodulator, reducing the percentage of basophil and eosinophil cells, thus having potential as an anti-allergy medication [45]. The anti-allergic activity of *E. elatior* has also been reported by other researchers, with *kincung* flowers significantly lowering IL-4 and IgE levels, suggesting its use as an anti-allergy drug [46]. The benefits of *E. elatior* also extend to liver protection. Research has shown that *E. elatior* fruit extract reduces the levels of total bilirubin, direct bilirubin, indirect bilirubin, SGOT, SGPT, and ALP at doses of 200, 300, and 400 mg/kg body weight ($p<0.05$). Based on these findings, it can be concluded that *E. elatior* fruit extract has a protective effect against CCl4-induced hepatotoxicity at doses of 200 and 300 mg/kg body weight and is able to lower bilirubin, SGOT, SGPT, and ALP levels. The liver-protecting activity is attributed to the flavonoid content in the extract, which is believed to play a role in its cell-protective effects [47]. Besides being effective as a liver protectant, *E. elatior* (Jack) is also effective as a kidney protectant. A study

demonstrated that the ethanol extract of *E. elatior* exhibits nephroprotective effects by normalizing urea and creatinine levels in rats and protecting renal tubular cells [48]. In addition to protecting the kidneys, *E. elatior* flowers also have the ability to lower uric acid levels in hyperuricemic rats to normal levels [49, 50]. The benefits of *E. elatior* extend beyond human use, also proving beneficial in livestock production, one example being in the cultivation of African catfish [51].

CONCLUSION

Etlingera elatior is a plant that possesses abundant phytochemical compounds with diverse bioactivities. Various parts of this plant—such as the flowers, stems, leaves, and rhizomes—contain significant amounts of bioactive constituents that contribute to its antimicrobial, antioxidant, antitumor, antihyperglycemic, antihyperuricemic, anti-inflammatory, larvicidal, skin-whitening, anti-aging, and wound-healing properties. Given its broad spectrum of biological activities, *E. elatior* is not only valuable as a culinary ingredient but also holds promising potential for further development in the pharmaceutical and cosmetic industries as a natural-based product candidate.

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