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Review Article

Medicinal potential and health benefits of torch ginger (*Etlingera elatior*)

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Abstract

Indo-Pacific Region has a rich diversity of medicinal and aromatic plants. Torch ginger (*Etlingera elatior*) from the Zingiberaceae family in exemplary, is one of the valuable sources for condiment, ornamental and medicinal purposes. This perennial herb can be found growing in clumps of aromatic rhizomes with their distinctive inflorescences, borne on erect stalks and showy bracts. Their torch-like flowers are edible, usually appeared during the second year of cultivation and continuous harvesting is feasible for the flower production. The varieties of torch ginger with pink-color flowers are often cultivated compared to white and red flower varieties due to the market demand. Interestingly, almost every part of this herb produces certain percentages of beneficial phytochemicals. In this review, the botanical aspects of torch ginger as well as their progresses in usage and properties in different forms as fresh, extract and essential oils have been conversing with respect to their plant parts. Major compounds found in torch ginger are phenols, polyphenols, flavonoids and terpenoids. Those compounds correlate with the significant health benefits of torch ginger such as antioxidant, antimicrobial, antitumor, antihyperuricemic, antiallergic, cytotoxicity, antidiabetic as well as their cosmeceutical potential in skin care application. Moreover, the prominent pharmacological activities of this herb with particular attention to the chemical composition also have been uncovered, suggesting the substantial medicinal benefits of torch ginger.

Keywords: *Etlingera elatior;* herb; phytochemicals; torch ginger; Zingiberaceae

Introduction

Torch ginger (*Etlingera elatior*) has long been known by Malaysians as a condiment, vegetable, traditional medicine and also for ornamental purposes. The vernacular names for torch ginger are Bunga Kantan (Malaysia), Bunga Siantan (Indonesia), Kaa Laa (Thailand) and Rosa-De-Porcelana (Brazil). It is a member of the Zingiberaceae family and native to Southeast Asia including Indonesia, Malaysia and South Thailand. Khaw (2001) reported that around 12 species of *Etlingera* were described so far in Peninsular Malaysia including *E. elatior*, *E. maingayi*, *E. fulgens*, *E. venusta*, *E. pauciflora*, *E. punicea*, *E. subterranea*, *E.*

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metriocheilos, *E. triorgyalis*, *E. littoralis*, *E. corneri*, *E. pieeae*. Among these species, *E. elatior* is the most cultivated species for human consumption and utilization.

Torch ginger is commonly propagated by rhizomes (asexually). It takes about 12 months to start flowering, however the cultivation of torch ginger from seeds took a longer time to develop the fully grown plants (Choon and Ding, 2016). Nevertheless, their fruit and seeds are very rare since the flowers are typically harvested before they mature. This perennial herb has several closely grouped pseudo stems reaching up to 3 to 4 m height. Their inflorescences are torch-like, borne on erect stalks up to 1.5 m tall arising from fleshy underground rhizomes (Aswani *et al*., 2013; Lim, 2014). Torch ginger inflorescences are varied from pink, red and white colors. The pink torch ginger is commonly cultivated in fields and house backyards for local uses. As an ornamental plant, certain torch ginger species are widely commercialised in the floriculture industry. It is used as a cut flower and for garden landscapes in Brazil (Silva Júnior *et al*., 2012).

Table 1. Traditional uses of torch ginger according to their plant part

Plant part	Treatment	References
Pseudostem	Reduce swelling, cure typhoid fever, cough and diarrhea	Habsah *et al.* (2005); Sabilu *et al.* (2017); Silahahi and Nisyawati (2018), Ismail *et al.* (2019); Saudah *et al.* (2021)
Leaves	Cleaning wounds, post-partum treatment, treating loss of appetite, curing diarrhea	Habsah *et al.* (2005); Ong (2008); Sabilu *et al.* (2017); Ismail *et al.* (2019); Saudah *et al.* (2021)
Flowers	Eliminate bad breath and body odor	Ong (2008); Hidayat and Napitupulu (2015)
Fruits	Treat earache, increase appetite, treat canker sores, coughing and heartburn, relieve fatigue, treat bruises	Vimala *et al.* (2003); Habsah *et al.* (2005); Ong (2008); Rukayah (2008); Chan *et al.* (2013); Sabilu *et al.* (2017); Ismail *et al.* (2019)

The inflorescence part of torch ginger is popular as one of the ingredients in Malay, Nyonya, Indonesian and Thai dishes in the Southeast Asia region. In Malaysia, the flower buds are usually used in culinary dishes such as curries, certain type of herb rice or cooked with mixed vegetables. It is also a compulsory ingredient as a condiment for a popular local dish known as 'Penang laksa'. The mature fruits are edible with a sour taste and preferably processed into candies while the seeds are eaten raw and used as ingredients in some dishes (Lim, 2014). In Indonesia, a typical dish from torch ginger is prepared with *Sesbania grandiflora* (turi) flowers by boiling and serving them with peanut sauce. People in North Sumatra used the flower buds and the ripe seed pods to cook fish dishes whereas communities of Southeast Sulawesi used the pseudo stem and fruits as a flavor to cooking vegetables and fish respectively (Sabilu *et al*., 2017). Besides, their edible flowers show high potential as an excellent natural food source because of the presence of numerous bioactive compounds, such as phenolic acids, flavonoids, and other antioxidant compounds that lead to health benefits (Prabawati *et al*., 2021). In this paper we obtained relevant and remarkable works of literature from various sources for this review. The purpose of this review is to uncover the medicinal properties and health advantages of torch ginger with respect to its plant parts (Figure 1).

Figure 1. Inflorescence (pink and red) and fruits of torch ginger

Ethnobotanical Uses

Traditional medicine known as complementary or alternative medicine has long been considered a cultural heritage in many countries. It was figured by WHO that a large number of people in the world still depend upon traditional medicines as the main resource for their treatment and health care (Yuan *et al*., 2016). Torch ginger has been traditionally applied for various medicinal purposes and is widely popular among Southeast Asia people. Every part of this plant is valuable and can be used to make traditional medicines (Table 1). In southeast Asia, this plant has a long history of common commercial uses.

The pseudo stem extract is used to alleviate swelling (Habsah *et al.*, 2005; Ismail *et al*., 2019) and is offered to the typhoid fever patient of Porehu communities (North Kolaka Regency, Southeast Sulawesi, Indonesia) in a form of a combination with medical personnel recipes (Sabilu *et al*., 2017). *E. elatior* has been shown to help with typhoid fever symptoms possible in as short as one to two weeks. While, people of the Batak Karo sub-ethnic in Indonesia applied stem fluid for cough and fever treatment (Silahahi and Nisyawati, 2018). Whereas Gayo tribe in Central Aceh District drinks the juice to soothe the sore throat and as a diarrhea treatment (Saudah *et al.*, 2021). Decoctions of the leaves are used to treat wounds (Vimala *et al*., 2003; Ong, 2008; Rukayah, 2008; Chan *et al*., 2013; Saudah *et al*., 2021;) and oftenly used by post-partum women for wound cleaning (Habsah *et al.*, 2005; Ismail *et al*., 2019). In the Porehu District, the leaf extract is frequently used to boost appetite and treat diarrhea (Sabilu *et al*., 2017). Brewing or boiling flower buds for drinking water has long been used in Malaysia and Indonesia to treat bad breath and body odor (Ong, 2008; Hidayat and Napitupulu, 2015). Traditionally, the fruits of *E. elatior* are used to treat earache, diarrhea, coughs, mouth sores, heartburn and to stimulate human appetite in Malaysia and Indonesia (Vimala *et al*., 2003; Habsah *et al.*, 2005; Ong, 2008; Rukayah, 2008; Chan *et al*., 2013; Sabilu *et al*., 2017; Ismail *et al*., 2019). The Gayo ethnic group in Indonesia typically uses fruit as a remedy to combat weariness and treat bruising or sprain-related bone swelling (Saudah *et al*., 2021). The whole plant of torch ginger together with other aromatic herbs can be mixed in hot water for herbal baths as post-partum treatment as well as to remove body odor (Shamsul and Tajuddin, 2003; Rukayah, 2008; Chan *et al*., 2013).

Bioactive constituents

Several studies have reported on the torch ginger phytochemical aspect. Maimulyanti and Prihadi (2015) manage to identify thirty-nine compounds from the inflorescence of torch ginger (Table 2). The main compounds found were 1-dodecanol, dodecanal, 17- pentatriacontane and dodecanoic acid with the value of more than 10.0%. Eleven compounds showed the percentage between 2.0 to 7.0%. While other compounds

were found in small percentages (Maimulyanti and Prihadi, 2015). From the rhizomes, two new and six known compounds of diarylheptanoids, labdane diterpenoids and steroid have been isolated (Habsah *et al*., 2005b). The new compounds are 1,7-bis(4-hydroxyphenyl)-2,4,6-heptatrinone (1) and 16-hydroxylabda-8(17),11,13-trien-16,15-olide (2). They are considered as new compound because compound (1) is the first C-1 oxygenated diarylheptanoid from a natural source. Meanwhile, the structure of compound (2) was assigned as an isomeric mixture of 16-hydroxylabda-8(17),11,13- trien-15,16-olide, which has not been reported previously from a natural source. By using GC-MS (gas chromatography-mass spectroscopy) Ernilasari *et al*. (2021) identified 56 compounds from the extraction of leaves, flower and fruits. Undeca-3,4-diene-2,10-dione,5,6,6-trimethyl, with a concentration of 7.02%, and ethyl 4-methyl octanoate, with a content of 5.81%, are the primary ingredients of the leaf extract. The primary components of the flower extract are 8-Thiabicyclo [3,2,1] octan-3-ol-6-methoxy-, (3-endo, 6-exo)- with a content of 9.39% and cis-13-Octadecenoic acid, methyl ester with a content of 9.30%. Additionally, oleic acid with a content of 16.31% and n-Hexadecanoic acid with a value of 10.01% are the two primary ingredients of the extract of *E. elatior* fruit.

Table 2. Chemical compounds identified from the inflorescence of torch ginger

No.	Components	Percentage (%)
1.	Undecane	0.28
2.	Decanal	0.49
3.	Dodecane	0.98
4.	2-undecanone	0.43
5.	Undecanal	0.99
6.	Tridecane	0.35
7.	Dodecanal	12.10
8.	1-Dodecanol	13.82
9.	2-tridecanone	0.54
10.	Cyclododecane	1.25
11.	Dodecanoic acid	10.04
12.	Cis-9-tetradecen-1-ol	0.71
13.	1-Hexadecanol	4.91
14.	Propanedioic acid	0.37
15.	1-tetradecene	0.41
16.	Tetradecanoic acid	2.17
17.	Cis-13-octadecenoic acid	0.53
18.	9, 12 Octadecadienoic acid	1.90
19.	5-Eicosene	0.32
20.	9-tricosane	0.66
21.	Oxirane	0.36
22.	Cyco Tetracosane	0.33
23.	Tridecane	0.27
24.	Icosane	0.35
25.	1,2, benzenedicarboxylic acid	0.36
26.	2-methyl-1-hexadecanol	0.65
27.	1-hexadecene	6.34
28.	1-heneicosyl formate	3.71
29.	17-pentatriacontene	10.52
30.	Cyclotetradecane	2.10
31.	6-nitro-2-metylpyrrolo[2,3] Quinoline	2.88
32.	4-hydrazono-5-hydroxymino-4,5,6,7-tetrahydrobenzofuraxane	2.09
33.	Hexadecanedinitrile	2.05
34.	Cis vaccenic acid	3.29

35.	3-dodecyl cyclohexanone	1.12
36.	Hexadecanoic acid	2.31
37.	Dodecane-1-2-diol O-isopropylidene	1.21
38.	(9E, 12E)-9,12-octa decadienoic acid	1.86
39.	Cholest-5-en-3-ol	1.31

Source: Maimulyanti and Prihadi (2015)

Preliminary phytochemical screening of methanol extract and ethylacetate extract from torch ginger inflorescence detected two (flavonoids and tannins) and three (flavonoids, saponin and steroids) constituents respectively (Maimulyanti and Prihadi, 2015). Further screening of methanol extracts by Lachumy *et al.* (2010) showed the presence of phenolic, flavonoids, terpenoids, saponin, tannin and carbohydrate. According to Andarwulan *et al.* (2010), the phenolic content of inflorescences was attributed mainly to quercetin. While the flavonoid content consists of kaempferol (286 mg/ kg) and quercetin (21 mg/ kg) (Miean and Mohamed, 2001). Chang *et al.* (2012) succeeded to identify the presence of kaempferol-O-3-glucoside, quercetin and kaempferol in the flowers of *E. elatior*. Kaempferol contains anti-inflammatory properties and may help protect against certain types of brain injury, such as ischemic stroke (Chang *et al.,* 2005). Thus, *E. elatior* could be used as a treatment for those disorders. The presence of these constituents showed the antioxidant activities in the inflorescence of torch ginger (Maimulyanti and Prihadi, 2015).

The composition of essential oil varied with different parts of torch ginger. α-Pinene, cyclododecane and 1,1-dodecanediol diacetate were identified in the essential oils of all parts of *E. elatior* (Jaafar *et al*., 2007). Essential oils isolated from the inflorescence of torch ginger showed that the main compounds were dodecanol (alcohol), dodecanal (aldehyde) and α-pinene (terpenoid) (Zoghbi and Eloisa, 2005). The analysis by Susanti *et al*. (2013) identified five main components namely as 1-decanol (16.27%), dodecanal (16.87%), n-dodecyl acetate (16.40%), cis-9- tetradecen-1-ol (16.29%) and 1-hexadecanol (16.34%). Wijekoon *et al*. (2013) reported the existence of 55 compounds in the major chemical groups of the essential oil which are alcohol (44.25%), acids (24.42%), aldehydes (19.54%), esters (10.51%), and sesquiterpenes (0.99%). Furthermore, phytochemical screening of the essential oil was reported by Khor *et al*. (2017). The screening results revealed that the *E. elatior* has trace amounts of amino acids, alkaloid, flavonoids, and steroids. This investigation supports the discovery of previously unreported alkaloids. Alkaloids are nitrogenous substances that help protect plants against herbivores and diseases. They are extensively used for their antibacterial and antimicrobial properties. Thus, the alkaloids may have played a role in some of the antibacterial activity associated with *E. elatior* essential oil that has been described in another research.

According to Chan *et al.* (2010) sesquiterpenes are the main components of oil from *E. elatior* leaves, including (E)-farnesene (13.6%), (E)-caryophyllene (8.56%), isodaucene (1.84%), β-bisabolene (0.32%) and β-sesquiphellandrene (0.18%). Meanwhile, Abdelwahab *et al.* (2010) revealed a higher amount of β-pinene (24.92%) and lower for α-caryophyllene (1.99%) and trans-β-farnesene (2.49%). Besides that, Wong *et al.* (2010) reported that the main constituents of essential oil from the leaves are myrcene (13.5%), α-humulene (11.8%) and β-caryophyllene (10.7%). Sukandar *et al*. (2017) identified 35 compounds of essential oil from the fruit of torch ginger. According to gas chromatography analysis, the primary ingredients in the essential oil include 1-dodecanol (25.59%), dodecanol (18.11%), trans-cryophyllene (12.22%), cyclododecane (6.47%), and dodecyl ester (5.99%).

The composition of the essential oil from rhizome and root also was reported by Wong *et al.* (2010), which revealed the major constituents were camphene (18.0%) and β–pinene (16.9%), respectively. Furthermore, Vairappan *et al.* (2012) identified eight compounds (1-dodecanol, cyclodecanol, 1-hexadecene, 1-tetradecanol, 1-decanol, 1,3-dicyclohexylpropene, 3-decyn-2-ol and tetracosane) in the rhizome of *E. elatior*. The major component of essential oil extracted from rhizome was oxygenated monoterpenes (58.4%). The differences in the amount of phytochemicals observed in the inflorescence, leaves and rhizome oils can be

attributed to the differences in soil, altitude, and cultivar. Generally, monoterpenes hydrocarbons were identified as major compounds in the essential oils of *E. elatior*.

Nutritional value

The nutritional constituents (Table 3) of this species showed there are lots of nutrition from torch ginger that may benefit health. The nutritional properties of torch ginger inflorescence have been reported by Wijekoon *et al*. (2011). In fresh weight, the total moisture content is 89.9%, while dry weight for lipid, fiber, and protein are 18.2%, 17.6% and 12.6% respectively. Two properties of non-essential amino acids showed high levels of content namely glutamic acid (10.1 mg/ 100 mg protein) and aspartic acid (9.4 mg/ 100 mg protein). Basically, the nutrition value of the protein constituent was indicated by acid amino properties. Therefore, it showed that torch ginger inflorescence is a great source of protein. The ash content in the inflorescence is also quite high i.e. 15.5% to show the level of essential or non-essential mineral elements. According to Ng *et al*. (2012), the inflorescence of torch ginger exhibited the highest fiber content (19.8 g/ 100g DW) compared to other wild vegetable evaluated. The high amounts of fiber in inflorescence could function in decreasing the level of serum cholesterol, lower the chance of coronary heart disease, hypertension, and constipation.

Table 3. Nutritional constituents of torch ginger inflorescence/100 g

Composition	Total
Moisture (%)	89.2
Protein (g)	1.6
Carbohydrate (g)	5.5
Fats (g)	1.3
Fiber (g)	1.4
Ash (g)	1.0
Calcium (mg)	54.0
Iron (mg)	3.4
Phosphorus (mg)	11.0
Potassium (mg)	453.0
Sodium (mg)	11.0
Vitamin B1 (mg)	0.02
Vitamin B2 (mg)	0.05
Niacin (mg)	0.2
Vitamin C (mg)	14.2

Source: Vimala *et al.* (2003)

Besides that, the inflorescences of torch ginger have high contents of essential minerals such as K (1588 mg/ 100 g), Ca (775 mg/ 10 g), Mg (327 mg/ 100 g), S (166.6 mg/ 100 g) and Na (4.5 mg/ 100 g) (Wijekoon *et al*., 2011). Ng *et al*. (2012) reported that the potassium composition in torch ginger is greater than *Brassica juncea* (22 mg/ g DW) and other wild vegetables. Potassium is a principal mineral in controlling blood pressure and decreasing platelet reactivity. Therefore, the inflorescence of torch ginger could be regularly consumed to prevent hypertension and cardiovascular disease (Wijekoon *et al*., 2011; Ng *et al*., 2012). The rhizomes of torch ginger are also reported to have a quite high content of ferum which is 67.10 mg/ 100 g (Ibrahim *et al*., 2007). Consequently, the rhizomes of torch ginger can also be considered as a promising part that could be developed in the health industry.

Pharmacological activities

Antioxidant activity

According to Vimala *et al*. (2003) the torch ginger flowers have natural antioxidant compound that can destroy excess free radicals and prevent peroxidation of fatty tissues. The high antioxidant activity was found in three experiment pathways namely superoxide free radical scavenging activity (89.1%), lipid peroxidation inhibitory activity (92.2%) and radical scavenging activity (79.8%) (Vimala *et al*., 2003). The high antioxidant potential and good reducing activity are useful for the prevention of oxidative damage and protection of cells and tissue. The antioxidative constituent of torch ginger rhizome from Malaysia was first reported by Habsah *et al*. (2005b). They isolated eight compounds in which two of them are new compounds namely 1,7-bis(4-hydroxyphenyl)-2,4,6-heptatrienone and 16-hydroxylabda-8(17),11,13-trien-15,16-olide.

The leaves of torch ginger had the highest antioxidant properties such as total phenolic content (TPC) and radical scavenging ability which is expressed as ascorbic acid equivalent antioxidant capacity (AEAC) compared to other *Etlingera* species. The leaves of torch ginger had the highest TPC and AEAC i.e. seven to eight times higher than those of rhizomes. Antioxidant activities and TPC of the inflorescence also showed higher values than rhizomes (Chan *et al*., 2008). Lachumy *et al*. (2010) reported that the inflorescence of torch ginger has antioxidant activities comparable to commercial antioxidant, butylated hydroxytoluene (BHT). Jackie *et al*. (2011) through their analysis verified that inflorescence of torch ginger had free radical scavenging. They discovered a large quantity of polyphenolic and flavonoid compounds in the inflorescence extract which could be the major factor to scavenge the reactive oxygen.

Both aqueous and ethanolic extracts of torch ginger could reveal an antioxidant activity. The compounds of total phenolic content (TPC), total flavonoid content (TFC), and antioxidant activities in torch ginger were among the highest compared to five aromatic plants evaluated by Nurain *et al*. (2013). Meanwhile, methanol extract (IC_{50} = 21.14 µg/ ml) of *E. elatior* showed an effective antioxidant compared to ethyl acetate extract (IC_{50}= 68.24 µg/ ml) (Maimulyanti and Prihadi, 2015). Moreover, total phenolic and flavonoid contents of the essential oil were evaluated by Khor *et al.* (2017). The extracted essential oil was discovered to have modest amounts of total phenolic contents (2.30±0.003 µg/g as garlic acid equivalent) and total flavonoid contents (254.99±0.64 µg/g as quercetin equivalent), respectively.

Antimicrobial activity

Antibacterial activity was displayed by the ethanol extraction of torch ginger inflorescence. Gram-positive bacteria (*Bacillus megaterium*) and two Gram-negative bacteria (*Pseudomonas aeruginosa* and *Escherichia coli*) showed minimum inhibitory concentration (MIC) of 400 µg/ ml, 200 µg/ ml and 800 µg/ ml, respectively (Mackeen *et al*., 1997). However, according to Lachumy *et al*. (2010), Gram-positive bacteria are more sensitive than Gram-negative bacteria. Foodborne pathogenic bacteria such as *Bacillus subtilis* was shown to be more susceptible to the essential oil of the inflorescence. Thus, it makes a strong suggestion for the application of inflorescence as a salad and in meals to lower the harmful impacts influenced by food-borne pathogens (Wijekoon *et al*., 2013). Ghasemzadeh *et al*. (2015) reported that different samples of inflorescence showed antibacterial activities against different bacteria with the minimum inhibitory concentration (MIC) 30 to > 100 µg/ ml. Moreover, Salman and Indriana (2021) revealed that *Pseudomonas aeruginosa* was not well combated by the ethanolic extract of the torch ginger flower, which exhibited great anti-bacterial activity against *Staphylococcus aureus, Streptococcus pneumoniae*, and *Escherichia coli*.

The leaves part also inhibited Gram-positive bacteria (Chan *et al*., 2007; Susanti *et al*., 2013). According to Joy *et al.* (2011) *E. elatior* is a promising antibacterial agent against human bacterial pathogens such as *Klebsiella pneumonia, Staphylococcus aureus, Salmonella typhi, Proteus vulgaris* and *Pseudomonas aeruginosa*. Moreover, Sukandar *et al.* (2017) tested the fruit's essential oil for its ability to kill microorganisms like

Pseudomonas aeruginosa, Escherichia coli, Bacillus cereus, and *Staphylococcus aureus*. At different doses, essential oil effectively inhibited all microorganisms. Since *B. cereus* exhibited the largest inhibitory zone at 20% concentration, it was the microbe that was most sensitive to essential oils. The oil demonstrated powerful antibacterial properties and has the potential to be used as such.

The oil of the torch ginger flower, extracted with subcritical carbon dioxide (CO_2), has a lot of potential as a natural antibacterial agent in pharmaceutical and food applications. After 12 months of storage at 8°C, the extracted oil's antibacterial activity remained quite stable (Anzian *et al*., 2020). Preliminary study by Syafriana *et al*. (2021) resulted that S*taphylococcus epidermidis* and *Propionibacterium acnes* can be inhibited by an ethanol extract of torch ginger flower. This research revealed that the flower extract is effective against *S. epidermidis* and *P. acnes*, the bacteria that cause acne vulgaris. Acne vulgaris is a skin disorder or multifactorial illness of the skin's pilosebaceous units that effects adolescents (Christensen *et al*., 2016).

Moreover, the high phenolic content of torch ginger, notably caffeic acid, is believed to have antifungal properties (Tanti *et al*., 2018). Suryanto *et al*. (2016) evaluated antifungal activity of endophytic bacterial isolates from the root of torch ginger against several plant pathogenic fungi. The root yielded eleven bacterial isolates, comprised seven Gram-negative and four Gram-positive. Antifungal assays revealed that the bacterial isolates inhibited fungal growth in different ways. Six of the eleven isolates were positive for antifungal activity namely *Fusarium oxysporum, Saprolegnia* sp*., Rhizoctonia solani, Sclerotium rolfsii, Rigidoporus microporus* and *Curvularia* sp. Besides that, the zone of inhibition in the essential oil of inflorescence was expressed when tested by fungi. The most susceptible fungi are *Cryptococcus neoformans* with 20.0 mm of inhibition zone (Susanti *et al*., 2013). However, Wijekoon *et al.* (2013) revealed that no antifungal activity was expressed when tested with *Aspergillus niger* and *Mucor* sp. This could be due to only 1% of terpene fraction is present in the essential oil. The limited hydrogen capacity might be the main cause of no inhibition expressed. Decanol (16.27%) and eugenol (0.49%) contained in the essential oil are the major components that have been reported to exhibit antibacterial properties (Susanti *et al*., 2013).

Antitumor

Initial assessment by Habsah *et al*. (2005a) revealed that high antitumor promoting activity was exhibited in torch ginger with an inhibition rate of 92.18 % and 85.9 % individually. The most important result was reported by Ghasemzadeh *et al.* (2015), which showed the anticancer activity of torch ginger flowers against cancer cell lines (MCF-7 and MDA-MB-231). Krajarng *et al*. (2017) investigated the mechanism of torch ginger extract on cell death induction in melanoma cells. According to the findings, the extract reduced B16 cell growth in a dose and time-dependent way. On the other hand, the extract has no cytotoxic action against vero cells. Consequently, torch ginger extract is solely harmful to melanoma cells and potentially able to reduce cell viability and cause apoptosis without using caspases. This finding shows that torch ginger extract could be used as a skin cancer chemopreventive or chemotherapeutic drug. Moreover, the anticancer activity of the torch ginger inflorescence was examined by Al-Mansoub *et al.* (2021) in four human cancer cell lines: HCT 116, HT-29, Hela, and MCF-7. The human colorectal adenocarcinoma cell line HT-29 was susceptible to the extraction potential selective cytotoxicity. The result suggesting that *E. elatior* may have a chemopreventive effect on colon cancer.

Antihyperuricemic

Flavonoids, phenols, and glycosides can be found in torch ginger flower. Xantine Oxidase Inhibitor (XOI) activity has been reported in polyphenol and flavonoid, which can help lower uric acid levels. Its shows the potential of torch ginger as a traditional medicine to treat hyperuricemia. Thus, Dewi *et al.* (2016) investigate whether ginger flower extract can reduce uric acid levels in hyperuricemic rats. On the discontinuous hyperuricemic induction sub-group, ginger flower extract reduced uric acid concentration by

31.78%, whereas on the continuous hyperuricemic induction sub-group, it decreased uric acid concentration by 17.90%. Allopurinol, on the other hand, reduced uric acid concentrations by 45.65% in the caused hyperuricemic discontinuous sub-group and 23.53% in the induced hyperuricemic continuous sub-group. Since, the ginger flower can lower uric acid levels, it can also be utilized to treat hyperuricemia.

Anti-allergic

Allergy-related immunological illnesses include asthma, rhinitis, atopic eczema, and dermatitis syndrome (Xie and He, 2005). Aldi *et al*. (2020) assess how torch ginger affects the quantity of leukocytes overall and distinct types of leukocyte cells in allergic mice. Leucocytes are made up of a variety of cells with different sorts and functions that can react to the presence of outside substances that can inflame and infect the body. According to the study's findings, torch ginger flowers can greatly boost the quantity of leukocytes and significantly decrease the number of lymphocytes, eosinophils, and basophils. A decrease in the percentage of basophil cells and eosinophils can be utilised as an allergy medication, and increased total leukocytes following administration of torch ginger flower extract can be employed as an immunomodulator. Furthermore, the team (Husni *et al.,* 2020) conducted a study to ascertain if torch ginger flower extract reduced the Interleukin IL-4 and Immunoglobulin E, (IgE) levels in type I hypersensitive male white mice. The IL-4 is one of the key cytokines controlling allergic inflammation, and since its cloning, efforts have been made to reduce IL-4-induced inflammation (Junttila, 2018). The study found that torch ginger flowers dramatically reduced IL-4 and IgE levels. Consequently, it could be used as an anti-allergic medication.

Cytotoxic

Testing for cytotoxicity is a valuable method for determining a chemical's inherent and relative toxicity (Anywar *et al.,* 2022). This aids in assessing the potential hazardous or detrimental impact on human health of such substances that may happen accidentally during use (Schultz *et al*., 2020). The inflorescence of torch ginger was reported to exhibit cytotoxic activity against human cervix carcinoma cell line, HeLa with 10 μg/ ml of CD_{50} value (Mackeen *et al*., 1997). Besides that, the rhizome also showed significant activity towards human cancer cell lines, CEM-SS (IC50 4 mg/ ml) and MCF-7 (IC50 6.25 mg/ ml) (Habsah *et al*., 2005a). Meanwhile, the essential oils from the leaves were also examined for cytotoxicity (Sangthong *et al.,* 2022). Human fibroblast cell lines (NIH/3T3) and melanoma cell lines were used in the cytotoxicity test (A375 and B16F10). In melanoma cell lines, cytotoxicity was found to be more selective than in fibroblast cell lines, demonstrating potential safety in topical applications.

Skin whitening

Apart from medicinal uses, extracts of torch ginger flowers and leaves have been proven to have cosmeceutical properties that can help with a variety of skin issues (Chan *et al*., 2011). Nithitanakool *et al*. (2014) investigated the potential of hydroglycolic extract from inflorescence of *Etlingera elatior* in skin whitening and anti-aging effects on human. The antioxidant, anti-tyrosinase, and anti-collagenase activities of the extract were initially described and studied in vitro. The hydroglycolic extract containing phenolic compounds revealed outstanding in vitro antioxidant, anti-tyrosinase, and anti-collagenase activity. The lotion containing this extract demonstrated significant skin whitening and anti-wrinkle effects through in vivo investigation. Thus, the performance of hydroglycolic extract can be employed as a good active component in topically applied products for skin whitening and anti-aging.

Further analysis was done by Whangsomnuek *et al.* (2019a) on aqueous extracts of flower and leaf of *Etlingera*. The extract was tested for amino acid content and phenolic compounds, as well as for antioxidant activities. In order to identify potential skin advantages, the extracts' effects on the collagenase enzyme and tyrosinase activity were also evaluated. Both extracts were demonstrated to suppress tyrosinase and collagenase activities, indicating that they could be employed as active components for anti-wrinkle and whitening reasons.

The findings show that both the flower and leaf of torch ginger can possibly be used as a natural source of active compounds with anti-aging and anti-wrinkle characteristics in cosmetics. Consequently, the team broaden their study to examine the effectiveness of a whitening lotion comprising torch ginger flower and leaf extracts, as well as their level of skin sensitivity (Whangsomnuek *et al*., 2019b). The result showed decreasing of melanin concentration and increasing of L* value which indicate the skin lightening process. The cream was considered to be safe, with no observed irritant to the volunteers' skin. Thus, the tested cream containing *E. elatior* flower and leaf extracts could be a good whitening cosmetic for enhancing skin tone.

Photo-protective

Different plant species' extracts have a photoprotective effect, but they particularly emphasise those that are abundant in antioxidant components (Arruda *et al.,* 2021). Khor *et al.* (2017) investigated the *in vitro* photo-protective ability of *E. elatior*. They discovered that the sun protection factor (SPF), which measures in vitro photoprotective capabilities, was 3.555±0.025. This outcome showed that the essential oil has natural components that can shield UV rays by at least 50%. This naturally occurring substances are due to the presence of flavonols like quercetin, which is thought to be able to protect plants from UV radiation-induced damage by boosting quercetin production following UV exposure. Additionally, the absorbed UV energy could be released as heat, light, or by the breakdown of flavonols (Saewan and Jimtaisong, 2013). As a result, adding *E. elatior* essential oil to any sunscreen product might offer an alternative to switching to the synthetic ingredient.

Anti-diabetic

The potential of *E. elatior* rhizome as an antidiabetic drug was investigated by Srey (2014 and 2015). The anti-glucosidase and anti-amylase, antioxidant, and anti-inflammatory effects of torch ginger rhizomes were successfully demonstrated. It showed that *E. elatior* rhizomes have the potential to be used for nutraceutical purposes in the treatment of diabetes. Afra *et al*. (2018) reported that test animals exposed to alloxan can have their blood glucose levels reduced by the 70% ethanol extract of torch ginger leaves. The largest daily percentage reduction in blood glucose with a dosage of 100 mg/kg BW could produce was 76.62% at day 21st. It shows the potential of torch ginger leaves to be made into anti diabetic medication.

The leaves extract also proved to reduce the activity of the enzymes responsible for erythrocyte aldose reductase and lens synthesis when tested in Wistar strain male white rats with diabetic mellitus. The erythrocyte aldose reductase activity was considerably lower in the group fed dry *E. elatior* leaves extract at doses of 100 mg/kgBW, 150 mg/kgBW, and 200 mg/kgBW than in the group fed control (Handayani *et al*., 2019).

Likewise leaves, the inflorescence extract at a dose 300 mg/kg can be better regulated the blood glucose level in the diabetic rats as well as managing their body weight lost due to diabetic complications. It's also clearly repaired the oxidative diabetic-damaged organ and restored its normal functioning structure. Another study discovered that the flower extract demonstrated antihyperglycemic properties in the type 2 Diabetes mellitus rat model and the capacity to block the enzymes -amylase and -glucosidase in vitro. The extract's strong antioxidant capacity and high TPC and TFC content may have a significant impact on its ability to combat diabetes. The results of this study offer information on probable antioxidant components found in the extract as well as an evaluation of the effectiveness of the EEAE's hypoglycemic effect. Hence, it should be emphasised that *E. elatior* is a good natural source of antioxidants and antidiabetic compounds that may be able to help people with diabetes problems (Muhamad Nor *et al*., 2019, 2020).

Furthermore, leaves extract demonstrated the existence of flavonoid component and other polyphenol compounds through phytochemical study reported by Herni *et al.* (2020). They are known to have anti-inflammatory and alfa glucosidase activity inhibitory properties. Evaluation of anti-diabetic effectiveness includes alfa glucosidase enzyme inhibition. Alfa glucosidase is an enzyme that catabolizes complex polysaccharides of carbohydrates into monosaccharides. The alfa glucosidase activity was inhibited by the torch ginger leaves extract at an IC_{50} of 165.61 g/ml, whereas the IC_{50} of acarbose, the industry standard, is 226.55

g/ml. Triterpenoids, more especially terpenes, were hypothesised to be the group of chemicals that produced the activity in *E. elatior* (Syafni *et al*., 2021).

Aqueous extract of the torch ginger flower showed renoprotective and antihyperglycemic properties when tested in type 2 diabetes mellitus rat. The antioxidant and anti-inflammatory activities of the flower aqueous extract may be responsible for the antidiabetic and nephroprotective benefits. The antidiabetic effect could be due to the existence of the active ingredient cyanidin-3-O-glycosides, an antioxidant anthocyanin found in the torch ginger flower aqueous extract (Noordin *et al*., 2022). It may be possible to use torch ginger as a natural source of antioxidants for the treatment or possibly prevention of diabetes mellitus. Future studies into the therapeutic application of *E. elatior* in slowing the progression of diabetes mellitus and avoiding nephropathy may be influenced by these findings.

The torch ginger plant has been shown in numerous research to be beneficial as an antihyperglycemic. Active substances found in torch ginger, such as flavonoids, phenolics, and saponins, have been shown to have antihyperglycemic effects in diabetes mellitus patients by inhibiting amylase and glucosidase enzymes, scavenging free radicals, and preventing damage to pancreatic beta cells (Putri, 2021).

Conclusions

In conclusion, torch ginger exhibited numerous properties that are beneficial to human health from traditional uses to commercially formulated products. Current approach on how to consider the properties of their phytochemicals focuses on a single compound and combination compounds properties as active ingredient should be considered. The effectiveness of their phytochemicals based on their complex interactions can be investigated for the clearer mode of actions between phytochemicals and their properties.

Authors' Contributions

Both authors read and approved the final manuscript.

Ethical approval (for researches involving animals or humans)

Not applicable.

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Conflict of Interests

The authors declare that there are no conflicts of interest related to this article.

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