

Review Article**Phytochemical and Pharmacological activities of *Alpinia galanga*: A review**

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Abstract

India is very well known for medicinal aromatic plants used for the treatment of various diseases which are day by day diminishing from the nature. Green plants represent a big source of bioactive compounds. *Alpinia galanga* (Linn.) of the Zingiberaceae family is one of those medicinally important plants. Many countries cultivate this plant, including Indonesia. This plant has numbers of benefits, ranging from being used as a food flavoring, which creates a distinctive aroma in cooking. Active compounds such as 1,8-cineol, α -fenchyl acetate, β -farnesene, β -bisabolene, α -bergamotene, β -pinene, and 1'-acetoxychavicol acetate from the *Alpinia galanga* plant. Among all the bioactive compounds, 1,8-cineol known as a marker compound in the *Alpinia* spp provides strong biological activity. This plant can also be used as a treatment for various diseases. The rhizome of the plant is used as a carminative, digestive tonic, anti-emetic, anti-fungal, anti-tumor, Anti-helminthic, anti-diuretic, anti-ulcerative, anti-dementia. The extract of rhizome shows anti-tubercular activity, hypothermia, bronchial catarrh, tonic, stomachic, and stimulant. It is also used as pungent, bitter, heating, stomachic, improve appetite, disease of heart, aphrodisiac tonic, expectorant, used in heal, ache, lumbago, rheumatic pains, chest pain, diabetes, burning of the liver, kidney disease, disinfectants. The rhizome is also used as an anti-microbial, anti-bacterial, anti-inflammatory, and flavoring agent. The seeds are used as cardiogenic, diuretic, hypotonic, gastric lesions, antiplatelet, anti-tumor, and anti-fungal. The tubers of this plant are used as carminative, irritant action, whooping cough in children, Bronchitis, anti-asthma, dyspepsia, fever, and diabetes mellitus.

Keywords: Rasna, Kulanjan, Sugandha Vacha, Greater galangal, *Alpinia galanga*

Introduction

Treatment with herbal plants is widely used in developing countries, especially in those countries whose communities have a poor economy (Ansari et al., 2020). Herbal medicines are either organic or natural. Pure herbal medicine is obtained from plant extracts that have medicinal benefits, without a mixture of artificial chemicals (synthetic) and without a mixture of animal components. There is currently a rapidly increasing demand for the use of medicines from herbal plants throughout the world (Solikhah et al., 2020).

Plant and plant products are being used as a source of medicine for a long *Alpinia galanga* wild, family Zingiberaceae is used in medication culinary, and cosmetics for centuries (Bensky et al., 1992; Mohd et al., 2003).

Alpinia galanga is also known as Greater galangal in English

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and Kulanjan in Hindi. Most the South Indian physicians of traditional Ayurveda and Siddha medicine system use *Alpinia galanga* to treat various kinds of diseases including diabetes mellitus (Basu and kirtikar, 2001).

The rhizomes are characterized externally by a dark reddish-brown color, and cuttings of the inner rhizome are characterized by the presence of a dark center surrounded by a wider and paler layer on the outer rim, that also darkens considerably when the rhizome is dried during processing. The rhizomes of galanga have a strong aromatic odor and a spicy or pungent taste (Farnsworth et al., 1992).

The seed of *A. galanga* is used in emaciation and cleaning of the mouth, it stimulates the digestive power and appetite. It is also used as a purgative. Usually, the rhizome is used as a spice and a source of essential oil. Young shoots and flowers are used as vegetables or as spices (Arambewela et al., 2006)

Galangal is widely used to treat breathing diseases, stomach diseases, diarrhea, and stomach cramps. Galangal can also function as an antimicrobial replacement for antibiotics (Mayachiew et al., 2010; Yang and Eilerman et al., 1999).

Galangal is also effective for treating fever, abnormal menstruation, and increasing male fertility (Abubakar et al., 2018). Galangal rhizome began to be used in several formulations to prevent cancer and tumors and is also used for the treatment of other diseases such as rheumatism, inflammation, diabetes, and neurological disorders (Arambewela et al., 2006). Galangal is a mixture that has begun to be used by the community to overcome several chronic diseases (Srivastava and Shanker et al., 2012).

From the leaves, stems, rhizomes, and roots of *Alpinia galanga*, the presence of essential oil is reported. Those are mono and sesquiterpene as well as (E) - methyl cinnamate in nature. They are responsible for the characteristic odour as well as for the reported use in (folk) medicine and in food products of A. galangal (Jirovetz et al., 2003). *Alpinia galanga* contained flavonoids and volatile oils (Pal Jain et al., 2012; Yu, 1981). The previous studies, the plant possessed many pharmacological activities, including antibacterial, antifungal, antiviral, Antiprotozoal, immunomodulatory, antioxidant effect, antidiabetic, antiplatelet, hypolipidemic, and many other pharmacological effects (De-Pooter et al., 1985; Kiuchi et al., 2002). This review is a combination of chemical constituents, and pharmacological and therapeutic effects of *Alpinia galanga* based on various current studies.

Taxonomy (Udjiana, 2008)

Kingdom	:	Plantae
Division	:	Magnoliophyta
Class	:	Liliopsida
Subclass	:	Zingiberidae
Order	:	Zingiberales
Family	:	Zingiberaceae
Subfamily	:	Alpinioideae
Tribe	:	Alpinieae
Genus	:	Alpinia
Species	:	<i>Alpinia galanga</i>

Botanical description

Alpinia galanga (Zingiberaceae) commonly known as Greater galangal; root-stock tuberous, slightly aromatic. Leaves oblong-lanceolate, acute, glabrous, green above, paler beneath, with slightly callus white margins, sheaths long, glabrous; ligule short and rounded. Flowers greenish-white, in dense flowered, 30 cm Panicles; bracts ovate-lanceolate. Calyx tubular, irregularly 3-toothed. Corolla lobes oblong, claw green, blade white, striated with red, rather more than 1 cm long, broadly elliptic, shortly 2-lobed at the apex, with a pair of subulate glands at the base of the apex, with a pair of subulate glands at the base of the claw. Fruit have size of a small cherry, orange red (Gupta, 2010).

Geographical distribution

It is found in India, China, Indonesia, and Arabic gulf areas,

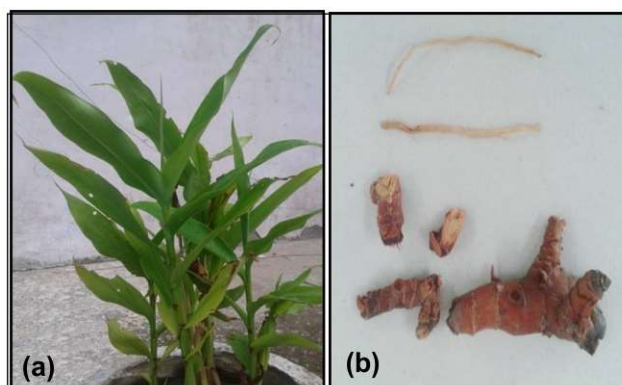


Figure. 1 (a) Whole plant (b) *Alpinia galanga* Rhizomes and roots of *Alpinia galanga*

Malaysia, Egypt, and Sri Lanka. It grows in open sunny places, forests, and brushwood. It is commonly cultivated in the mid and low-country in Sri Lanka. The plant is distributed in Himalayas and Southern region of the Western Ghats in India. It is often cultivated in Konkan and North Kanara (Shetty et al., 2015).

Traditional uses

Alpinia galanga is an important medicinal plant in different traditional systems of medicine to treat several diseases, including microbial infections, inflammations, rheumatic pains, chest pain, and dyspepsia, fever, burning of the liver, kidney disease, tumours, diabetes, and even HIV (Ramesh et al., 2011). The plant has an active role in the treatment of eczema, bronchitis, coryza, mobile, pityriasis Versicolor, otitis internal, gastritis, ulcers, and cholera. The seed is used for emaciation and to clean the mouth. It stimulates the digestive power and appetite and acts as a purgative. The rhizome is generally used as a spice. It is also a good source of essential oil. The flowers and young shoots are also used as a vegetable or as a spice (Arambewela et al., 2006).

Active compounds

Active compounds from the various parts A. galanga were widely studied by many researchers. Many active compounds were successfully isolated and identified by previous researchers. The major active compounds found in A. galanga are 1,8-cineol, α -fenchyl acetate, β -farnesene, β -bisabolene, α -bergamotene, β -pinene, and 1'-acetoxychavicol acetate. 1, 8-cineole is known as a marker compound for *Alpinia* spp and was reported as the most abundant compound in most of the studies on A. galanga (Abdullah et al., 2015).

Phytochemistry Chemical investigations of *Alpinia galanga* include galango flavonoid, 1'S-1'-acetoxychavicol acetate (ACE), phenylpropanoids and phydroxybenzaldehyde (1'S-1'- acetoxychavicol acetate

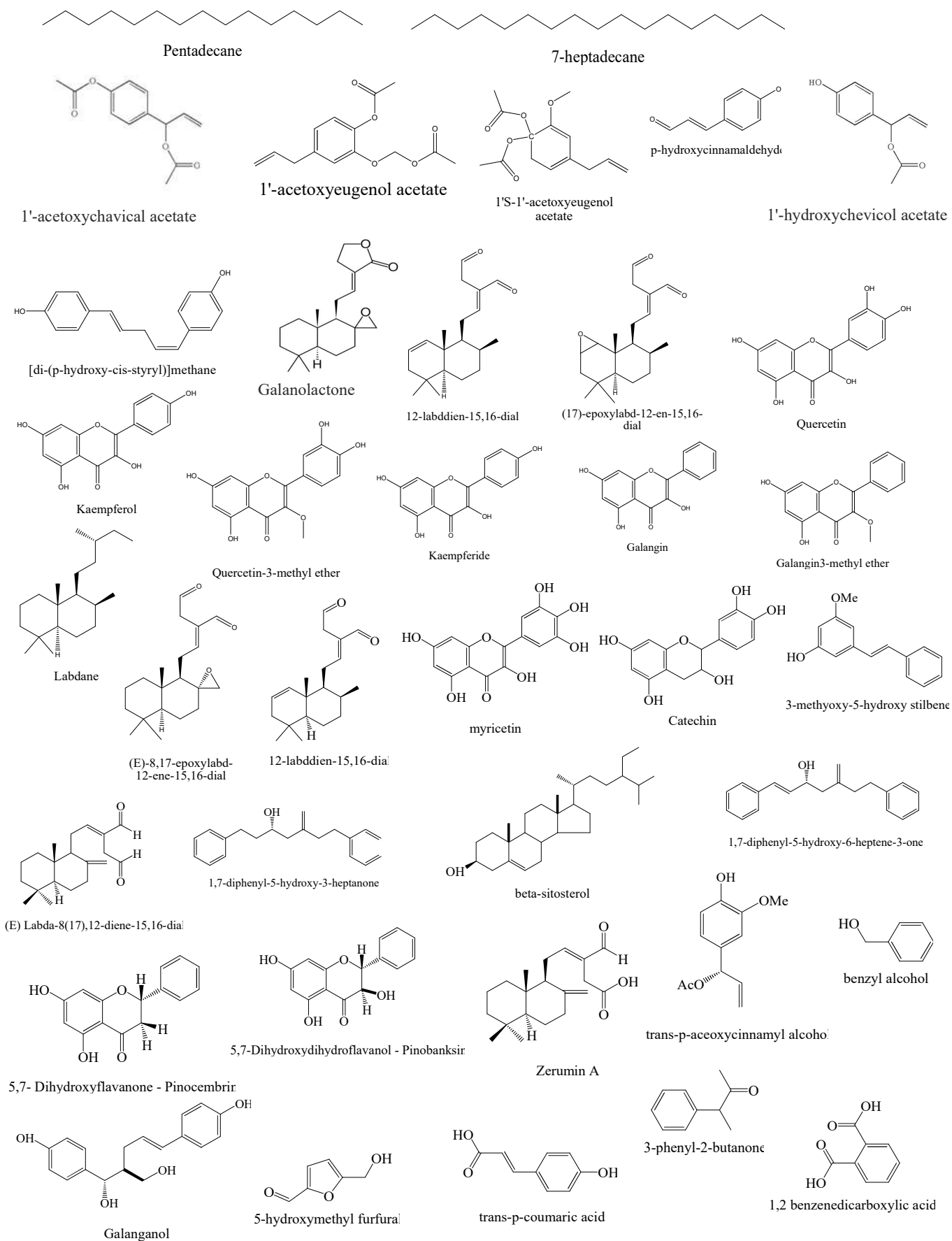


Figure 2. Chemical structures of phytoconstituents of *Alpinia galanga*

and 1'S-1'-acetoxyeuginol acetate), acetoxycineoles (trans and cis)-2-and 3-acetoxy- 1, 1, 8-cineoles, 1'-acetoxychavicol acetate (galangal acetate), β -Sitosterol diglucoside (AG-7) and β -sitsteryl Arabinoside (AG-8), hydroxy-1,8-cineole glucopyranosides, (1R, 2R, 4S)-and (1S, 2S, 4R)-trans-2-hydroxy-1,8-cineole β -D-glucopyranoside, and (1R, 3S, 4S)-trans-3-hydroxy-1, 8- cineole β -D-glucopyranoside (Abdullah, et al., 2015; Morikawa et al., 2005; Misawa et al., 2008).

Pharmacological activities

Anti-allergic Activity

The Antiallergic activity of 80% aqueous acetone extract of the rhizomes of *Alpinia galanga* which was found to inhibit release of β -hexosaminidase, as a marker of antigen-IgE-mediated degranulation in RBL-2H3 cells (Matsuda et al., 2003). Compounds 1 'S-1'-acetoxychavicol acetate and 1 'S-1'-acetoxyeugenol acetate isolated from *Alpinia galanga* rhizome, were also examined for their anti allergy activities in RBL-2H3 cells (Yoshikawa et al., 2004).

Anti-cancer Activity

The DL-1'-Acetoxychavicol acetate (I) and DL-1'-acetoxyeugenol acetate (II) isolated from *Alpinia galanga* evaluated anti-tumor activity against Sarcoma 180 ascites in mice (Itokawa et al., 1987) and also evaluated the anti-tumor activity of diterpene compounds I (15 α - and 15 β -isomer) and II, isolated from the seeds of *Alpinia galanga* (Itokawa and Morita, 1988). The two new skeletal diterpenes, named galanal A (I), B (II), and two new labdane-type diterpenes, named galanolactone (III), (E)-8 β (17),12-labdadiene-15,16-dial, isolated from *Alpinia galanga* act as cytotoxic activity (Morita and Itokawa, 1988). The Ethyl trans-cinnamate (III) and Et 4-methoxy-trans-cinnamate (IV) from galanga root oil, which was found to exhibit significant activity in the mouse liver and intestines (Zheng et al., 1993). The ethanolic extract by brine shrimp lethality bioassay of *Alpinia galanga* (Khattak et al., 2005), [MCF7 (breast adenocarcinoma) and LS174T (colon adenocarcinoma)] cell lines of the methanol extracts, water extracts and volatile oils of the fresh rhizomes of *Alpinia galanga* (Zaeoung et al., 2005). The mechanism of cell death of human leukemic HL-60 and U937 cells induced by 4'-hydroxycinnamaldehyde (4'-HCA) isolated from *Alpinia galanga*. 4'-HCA was found to be cytotoxic to both cell lines in a dose-dependent manner ($p < 0.05$) as demonstrated by MTT assay (Banjerdpongchai et al., 2011).

Anti-diabetic Activity

The methanolic extract of *Alpinia galanga* rhizome shows the hypoglycemic activity in rabbits. Which significantly lowered the blood glucose (Akhtar et al., 2002). The ethanolic extract of rhizome of *Alpinia galanga* (EEAG) in normoglycaemic and hyperglycemic rats. Single-dose of EEAG (50, 100, and 200

mg/kg) was administered orally in normoglycaemic, glucose (1.5 g/kg) fed hyperglycemic and alloxan-induced diabetic rats (n=5). Single-dose administration of EEAG (200 mg/kg) induced a significant ($P < 0.05$) decrease in blood glucose level in glucose-fed hyperglycemic rats at 1/2 h compared to control glucose-fed rats and in alloxan-induced diabetic rats at 6h after EEAG treatment (Chudiwal et al., 2008), and of phenolic and methanolic also act as Antidiabetic and anti-inflammatory activities of extract of rhizome of *Alpinia galanga* (Jaju et al., 2009).

Anti-inflammatory activity

The total alcoholic extract (TAE) and total aqueous extracts (TAQ) of *Alpinia galanga* rhizomes evaluated in acute (carrageenan-induced paw edema; M1) and sub-acute (cotton-pellet-induced granuloma; M2) rat models (Satish et al., 2003; Nagashekhar et al., 2006). Antinociceptive activity were found the ethanolic (95%) extract of rhizome of *Alpinia galanga* (EEAG). EEAG was examined for analgesic activity using hot plate, formalin-induced paw licking, and acetic acid-induced writhing method (doses 200 mg/kg and 400 mg/kg administered orally) Shivgunde et al., 2008). Yu also reported p-coumaryl diacetate (CDA) was found to have an anti-inflammatory activity which was isolated from *Alpinia galanga* (Yu et al., 2009). The Anti-arthritic activity of petroleum ether, chloroform, alcoholic extracts of the *Alpinia galanga* rhizomes in the presence of chemically active compounds by standard methods and evaluated for their antiarthritic activity by using Complete Freund's Adjuvant (CFA) induced rat model. Application of all the three extracts exhibited statistically significant edema inhibition when compared with the arthritic control group (Chandur et al., 2010). The anti-psoriasis activity of ethanolic extract of *Alpinia galanga* by using a HaCaT keratinocyte cell line as an *in-vitro* model (Chanachai et al., 2011). Petroleum ether, Chloroform, Methanolic, and Aqueous methanolic (1:1) extracts of *Alpinia galanga* in carrageenan-induced paw edema in Wistar rats and compared to a positive control drug-using Ibuprofen. These extracts were given orally at a concentration of 500 mg/kg between 1 hour before carrageenan injection. Methanolic extract of *Alpinia galanga* showed maximum inhibition of 79.51 % on carrageenan-induced rat paw edema (Unnisa and Thahera, 2011). The ethanolic extract of A. galanga rhizome by scientifically validated anti-inflammatory screening technique on rats by carrageenan-induced pleurisy rats. the ethanolic extract had significant activity in rats in all the tested groups A. galanga 100, 200, and 400 mg with $P < 0.005$ compared to that of control (Subash et al., 2016).

Antimicrobial activity

The antifungal activities of two new skeletal diterpenes,

named galanal A (I) B (II), and two new labdane-type diterpenes, named galanolactone (III), (E)-8 β (17),12-labddiene-15,16-dial, isolated from *Alpinia galanga* (Morita and Itokawa, 1988). The antibacterial activity against different multi-resistant Gram-positive and Gram-negative bacteria of ether and ethyl acetate extracts of *Alpinia galanga*. Both extracts of *Alpinia galanga* had significant effects on *Staphylococcus aureus* and *Klebsiella pneumoniae* (Elsamma et al., 1996). The anti-fungal activity of essential oils, of *Alpinia galanga* against five dermatophytes (*Trichophyton mentagrophytes*, *T. rubrum*, *Microsporum canis*, *Microsporum nanum* and *Epidermophyton floccosum*), three filamentous fungi (*Aspergillus niger*, *Aspergillus fumigatus* and *Mucor* sp.) and five strains of yeast (*Saccharomyces cerevisiae*, *Cryptococcus neoformans*, *Candida albicans*, *Candida tropicalis* and *Torulopsis glabrata*). The anti-fungal property evaluation was carried out by broth microdilution and disc gel diffusion methods (Ibrahim Jantan et al., 2003). Endophytic actinomycetes activity of roots of *Alpinia galanga* against phytopathogenic fungi (*Colletotrichum musae* and *Fusarium oxysporum*), and tested against *Candida albicans*. The strain identified as *Streptomyces aureofaciens* CMUAc130 was the most effective in antifungal activity among those investigated (Taechowisan and Lumyong, 2003).

The antifungal activities against *Trichophyton longifusum* [*Keratinomyces longifusus*] (65% and 60%, respectively) from the ethanolic extract of *Alpinia galanga*. This extract was found quite inert in antibacterial bioassay involving *Escherichia coli*, *Bacillus subtilis*, *Shigella flexneri*, *Staphylococcus aureus*, *Pseudomonas aeruginosa*, and *Salmonella typhi* (Khattak et al., 2005). The antimicrobial action of ethanolic extract of *Alpinia galanga* (galangal) on *Staphylococcus aureus* 209P and *Escherichia coli* NIHJ JC-2 by using an agar disc diffusion assay. The galangal extract had the strongest inhibitory effect against *Staphylococcus aureus* (Oonmetta-aree, 2006). The anti-amoebic activity of chloroform, methanol, and water extracts from *Alpinia galanga*. The extracts were incubated with 2×10^5 *E. histolytica* trophozoites/ml of the medium at 37°C under anaerobic conditions for 24 h. The cultures were examined with an inverted microscope and scored (1-4) according to the appearance and numbers of the trophozoites. The IC (50) of a standard drug, metronidazole, was 1.1 μ g/ml (Sawangjaroen et al., 2006).

The Anti-bacterial effect of essential oil of *Alpinia galanga* was obtained by hydro-distillation and two different solvent extractions (petroleum ether and ethanol) against *Escherichia coli*, *Staphylococcus aureus*, *Bacillus cereus* and *Listeria monocytogenes* which were tested by a disc diffusion assay (Krittika et al., 2007). The antimicrobial activity of galangal (*Alpinia galanga*) extract using disc diffusion and agar dilution methods against *Staphylococcus aureus*. The minimum inhibitory concentration (MIC) value of galangal extracts were

found to be 13.97 and 0.78 mg/ml and the minimum biocidal concentration (MBC) value was 2.34 mg/ml, respectively (Mayachiew and Devahastin, 2008). The antimicrobial activity of different solvent extracts of *Alpinia galanga* against gram-positive and gram-negative bacteria and some fungal strains was studied (Rao et al., 2008). The anti-fungal activity of crude ethanolic extract of *Alpinia galanga* rhizomes which was tested against selected zoonotic dermatophytes (*Microsporum canis*, *Microsporum gypseum*, and *Trichophyton mentagrophyte*) and the yeast-like *Candida albicans*. A broth dilution method was employed to determine the inhibitory effect of the extract and compared it to those of ketoconazole and griseofulvin (Trakranrungsie et al., 2008).

The crude acetone extract of the rhizomes of *Alpinia galanga* exhibited anti-plasmid activity against *Salmonella typhi*, *Escherichia coli* and vancomycin-resistant *Enterococcus faecalis* with an efficiency of 92%, 82% and 8% at 400 micro g/ml SIC respectively (Latha et al., 2009). The anti-bacterial activity of essential oil of *Alpinia galanga* against *Escherichia coli*, *Staphylococcus aureus*, *Bacillus cereus*, and *Listeria monocytogenes* which were tested by a disk diffusion assay (Natta et al., 2009). Antimicrobial activity of various extracts of *Alpinia galanga* which were screened against the common foodborne bacteria such as *Escherichia coli*, *Salmonella enteritidis*, *Clostridium perfringens*, *Staphylococcus aureus*, *Campylobacter jejuni*, *Bacillus cereus* and fungi such as *Saccharomyces cerevisiae*, *Hansenula anomala*, *Mucor mucedo*, *Candida albicans* using disc diffusion method (Sunilson et al., 2009). The anti-fungal activity of methanol extract of flowers of *Alpinia galanga* against *Micrococcus luteus* and *Aspergillus niger* which showed the largest zone of inhibition. The antimicrobial activity was also screened by using the disc diffusion method (Wong et al., 2009). The antifungal activity of the leaf extracts of *Alpinia galanga*, which was evaluated on the plant pathogenic fungus; *C. gloeosporioides* isolated from mango. Different antifungal assays were employed, i.e. Agar-Disc Dilution assay as the primary screening assay, followed by determination of Minimum Inhibition Concentration (MIC), and the rate of sporulation assay. Methanol crude extract reduced the radial growth of *C. gloeosporioides* by 66.39%, followed by chloroform crude extract 63.26%, and 61.56% for acetone crude extracts (Johnny et al., 2010). The antibacterial activity of methanol, acetone, and Di-ethyl ether extract of *Alpinia galanga* against pathogens viz. *Bacillus subtilis* MTCC 2391, *Enterobacter aerogene*, *Enterobacter cloacae*, *Enterococcus faecalis*, *Escherichia coli* MTCC 1563, *Klebsiella pneumoniae*, *Pseudomonas aeruginosa*

MTCC 6642, *Salmonella typhimurium*, *Staphylococcus aureus* and *Streptococcus epidermis* using agar well diffusion method (Rao et al., 2010).

Antimicrobial activity of hexane, ethanolic and aqueous extracts from galangal (*Alpinia galanga*) which had strong antimicrobial activity against *Staphylococcus aureus* and/or *Listeria monocytogenes* (Weerakkody et al., 2010). The antimicrobial activity of acetone, ethanolic and aqueous extract *A. galanga* exhibits anti-*Mycobacterium tuberculosis* activity with multiple modes of action. Since the activity of the extracts was observed under reducing oxygen concentrations, it may be effective in treating the dormant and non-replicating bacteria of latent TB (Gupta et al., 2014).

The ethanolic extract prevents the infectious diseases *Vibrio harveyi* and white spot syndrome virus in Pacific white shrimp (*Litopenaeus vannamei*). A commercial diet mixed with galangal ethanol extract was fed to shrimp for 1 or 2 months. The number of *V. harveyi* in the hemolymph of the galangal diet group was significantly lower than that in the control diet group ($P < 0.05$), indicating the higher clearance ability of the galangal diet group (Chaweepack et al., 2015). The Minimum Inhibitory Concentration (MIC) of essential oils and crude extracts was evaluated by broth dilution method against foodborne bacteria *Bacillus subtilis*, *Escherichia coli*, *Staphylococcus aureus*, *Salmonella Typhimurium*, and *Vibrio cholera*. MIC of crude extract and essential oils of galangal and ginger against all tested microorganisms were relatively high (Hamad et al., 2016). The methanolic extract of *Alpinia galanga* exhibited antibacterial activity against all the three tested gram-positive bacterial strains. The minimum inhibitory concentration of *A. galangal* against *S. aureus*, *S. epidermidis*, and *L. monocytogenes* was less than 1mg/ml. Based on the result obtained, *A. galangal* has higher total phenolic content (122 ± 2.6 mg GE/g), followed by total flavonoid content (110 ± 4.4 mg QE/g). However, the DPPH content in this plant extract was the least with a value of 20 ± 1.0 mg TE/g (Muniandy et al., 2019).

Antioxidant activity

1'-Acetoxychavicol acetate (ACA) is a unique phenylpropanoid compound in *Alpinia galanga* that has been evaluated as an effective aroma, pungent and anti-oxidative component. In addition, the anti-oxidative activity of linoleic acid was examined. Although ACA indicated the highest activity, related compounds also showed significant anti-oxidative activity (Kubota et al., 2001). The antioxidant activity of ethanolic extract of Galangal (*Alpinia galanga*). Antioxidant activity of extract at neutral pH was higher than at acidic pH ranges (Juntachote and Berghofer, 2005). Antioxidant activity of the methanol, aqueous extracts, and volatile oil of the fresh rhizomes of *Alpinia galanga*, which was assessed for free

radical scavenging activity against 1,1-diphenyl-2-picrylhydrazyl (DPPH) radical (Zaeoung et al., 2005). Antioxidant activity of rhizomes of *Alpinia galanga*, measured by DPPH and β -carotene-linoleic acid method after extraction with two different solvents- methanol and dichloromethane (Vankar et al., 2006).

The antioxidant activity of the essential oils of *Alpinia galanga* was determined by using two complementary methods: 2,2-diphenyl-1-picrylhydrazyl (DPPH) radical scavenging assay and 2,2'-azinobis-(3-ethylbenzothiazoline-6-sulfonic acid) (ABTS) free radical decolorization assay. The results obtained indicated that the essential oil of *Alpinia galanga* possessed stronger antioxidant activity with the IC₅₀ values of 550 and 3721 μ g/ml, respectively (Chowwanapoonpohn and Tachakittirungrod, 2007). Antioxidant and tyrosinase inhibition properties of leaves and rhizomes of *Alpinia galanga* by using total phenolic content (TPC) and Ascorbic acid equivalent antioxidant capacity (AEAC) methods. The most outstanding was the FIC value of *Alpinia galanga* leaves which was more than 20 times higher than that of rhizomes. It displayed the strongest tyrosinase inhibition activity (Chan et al., 2008). The antioxidant activity of galangal (*Alpinia galanga*) extract, which was evaluated by the β -carotene bleaching method, was 70.3%, respectively (Mayachiew and Devahastin, 2008).

The naturally occurring phenolic compounds, such as chavicol analogs, have been shown to have potent antioxidant activity in the rhizomes of *Alpinia galanga* (Jung et al., 2009). The p-coumaroyl diacetate (CDA) isolated from *Alpinia galanga* was found to have antioxidant activity (Yu et al., 2009). The antioxidant activity of methanol extract of *Alpinia galanga* leaves was evaluated for total phenolic content. The AOA was investigated using 1,1-diphenyl-2-picrylhydrazyl (DPPH), reducing power (RP), ferrous ion chelating as well as β -carotene bleaching assays. It was found that *Alpinia galanga* leaves and flowers showed the highest chelating and β -carotene bleaching abilities (Wong et al., 2009). Antioxidant Activity of ethanolic extract of *Alpinia galanga* which showed the potent scavenging activity by DPPH method with the IC₅₀ value of 69.5 ± 1.375 μ g/ml, by lipid peroxidation method with the IC₅₀ value of 77 ± 1.876 μ g/ml, hydrogen peroxide radical scavenging activity with the IC₅₀ value 55 ± 1.59 μ g/ml, ABTS radical scavenging method with the IC₅₀ value 0.086 ± 1.10 μ g/ml (Srividya et al., 2010).

The methanolic extracts of galangal samples irradiated showed the highest antioxidant activity and phenolic compounds compared with those from non-irradiated samples (Araby et al., 2013), it was measured by 1, 1-diphenyl-2-picrylhydrazyl (DPPH) scavenging potential and Ferric reducing antioxidant power (FRAP) potential (Avasthi

et al., 2015). The aqueous extract was filtered and used for DPPH, FRAP, TPC, and MDA tests to determine its antioxidant value (Hasan et al., 2020).

Anthelmintic Activity

The anthelmintic activity on alcoholic extracts of rhizomes of *Alpinia galanga* showed good *in-vitro* anthelmintic activity against human *Ascaris lumbricoides* (Raj, 1975). The ethanolic extracts from the leaves of *Eupatorium triplinerve* and the rhizome of *Alpinia galanga* were compared for their anthelmintic activities, based on traditional claims (Subhash et al., 2012).

Anti-viral Activity

The anti-HIV agents and inhibitors for nuclear export of HIV-derived proteins such as Rev essential to HIV replication contain 1'-acetoxychavicol acetate (I). Thus, 1'-acetoxychavicol acetate, isolated from a Methanolic extract of *Alpinia galanga* fruits, inhibited the replication of HIV-1 NL43 in MT-4 cells without affecting the viability of MT-4 cells (Murakami and Tamura, 2005). The antiviral activity of methanol and aqueous extracts of *Alpinia galanga*, inhibited proteases from human immunodeficiency virus type 1 (HIV-1), hepatitis C virus (HCV), and human cytomegalovirus (HCMV) and it was found that methanol extract inhibits the enzymes more effectively than the aqueous extract (Sookkongwaree et al., 2006).

Anti-HIV activity of 1'-S-1'-acetoxychavicol acetate isolated from *Alpinia galanga* rhizomes extract by blocking Reverse Transport (Ye and Li, 2006). Rev-export inhibitor (ACA) from the medicinal plant *Alpinia galanga* clarified the formation of the quinone methide intermediate ii to be essential for exerting the inhibitory activity (Murkami et al., 2010).

Hepatoprotective Activity

The hepatoprotective effect of the crude extract of *Alpinia galanga* at 200 and 400 mg kg⁻¹ against paracetamol-induced hepatotoxicity in rats. The findings from the study showed that the crude extract of *Alpinia galanga* has protective effects against paracetamol-induced hepatotoxicity (Hemabarathy et al., 2009).

Analgesic Activity

Analgesic activity of ethanolic extract of *Alpinia galanga* percentage inhibition rate of Aspirin (100mg/kg) was 82.15% compared to *Alpinia galanga* (100mg/kg) 19.63%, (200mg/kg) 33.02% and (400mg/kg) 57.13% by acetic acid-induced abdominal constrictions antinociceptive mice model. *Alpinia galanga* 400mg/kg (71.70%) had comparable percentage inhibition of nociception to standard group indomethacin (88.71%) in the formalin-induced nociceptive mice model. Among 20 compounds screened for pharmacokinetic and drug-like features, Galanal B had the binding free energy -56.664

when compared to control compound 2AZ5-56.000 (Subash et al., 2018). Ethanolic extract of *Alpinia galanga* rhizomes was given orally to experimental animals. EEAGR was evaluated for central analgesic activity by using the tail-flick method and peripheral analgesic activity by using the acetic acid-induced writhing test using aspirin (300 mg/kg b.w and 100 mg/kg b.w orally) as the standard drug respectively (Dasari et al., 2018).

Miscellaneous Activity

The Gastric antisecretory, antiulcer and cytoprotective properties of ethanolic extract of *Alpinia galanga* Wild. in rats. Which showed significantly reduced gastric secretion and marked cytoprotective activity; it was suggested that these properties may be responsible for the antiulcer activity of *Alpinia galanga* (Al-Yahya et al., 1990). The gastroprotective activity and the effects of 1'-S-1'-acetoxychavicol acetate and related phenylpropanoids isolated from the rhizomes of *Alpinia galanga* on ethanol-induced gastric lesions in rats (Matsuda et al., 2003). Aphrodisiac activity of an isolated compound named (3)-shogaol from the extract of *Alpinia galanga* in guinea pigs (Jean and Cariel, 2002). The treatment on cytological and biochemical changes induced by cyclophosphamide in mice by the effect of *Alpinia galanga* from the ethanolic extract. The rhizomes of *Alpinia galanga* were also used to treat dyspepsia, gastralgia, seasickness, abdominal colic, and digestive and tonic (Qureshi et al., 1994). The insecticidal activity of 1'-acetoxychavicol acetate from the rhizome of *Alpinia galanga* had a molecular formula of C₁₃H₁₄O₄ (Dadang and Ohsawa, 1998). The platelet activity from *Alpinia galanga* and their inhibitory effects on platelet-activating factor (PAF) binding to rabbit platelets, using 3H-PAF as a ligand (Jantan et al., 2005).

The anti-giardial activity of chloroform, methanol, and water extracts of the *Alpinia galanga* plant. The plant extracts and a standard drug, metronidazole, were incubated with 2x10⁽⁵⁾ trophozoites of *Giardia intestinalis* per milliliter of growth medium in 96-well tissue culture plates under anaerobic conditions for 24 h. The cultures were examined with an inverted microscope and the minimum inhibitory concentration and the IC₅₀ value for each extract were determined. The chloroform extracts from *Alpinia galanga* as "active", i.e. with an IC₅₀ of <100 µg/ml (Sawangaroen et al., 2005).

The effects of *Alpinia galanga* extract on metabolism and gene expression involved in the interleukin-1β (IL-1β) response of human chondrocyte and synovial fibroblast. *Alpinia galanga* extract was also found to inhibit IL-1β enhanced matrix breakdown of the cartilage explants in a

dose-dependent manner (Pothacharoen et al., 2006). Antileishmanial activity of the (hexane, chloroform, and ethyl acetate) extracts and isolated constituents of rhizome of *Alpinia galanga*. Twelve compounds namely, methyleugenol (1), p-coumaryl diacetate (2), 1'-acetoxychavicol acetate (3), 1'-acetoxyeugenol acetate (4), trans-p-acetoxycinnamyl alc. (5), trans-3,4-dimethoxycinnamyl alc. (6), p-hydroxybenzaldehyde (7), p-hydroxycinnamaldehyde (8), trans-p-coumaryl alc. (9), galangin (10), trans-p-coumaric acid (11), and galanganol B (12) were isolated from these extracts. These compounds 2, 3, 4, and 5 were found most active *in-vitro* against promastigotes of *L. donovani* with IC₅₀ values of 39.3, 32.9, 18.9, and 79.9 μ M respectively (Kaur et al., 2010). The Neuroprotective Effect of *Alpinia galanga* (L.) fractions on A β (25–35) induced amnesia in mice. The increased habituation memory and decreased escape latency in behavioral parameters are indicative of the cognitive enhancement after treatment with *Alpinia galanga* fractions. Increment in Na⁺/K⁺-ATPase and antioxidant activity depicts brain membrane integrity improvement and free radical scavenging property. AChE level was decreased to improve cognition by enhancing cholinergic transmission (Singha et al., 2011). Two compounds, 1,7-bis(4-hydroxyphenyl)-1,4,6-heptatrien-3-one (BHPHTO) and bisdemethoxycurcumin (BDMC) from the rhizome of *Alpinia galanga* both the compounds on the human melanoma A2058 and showed that significantly inhibited the proliferation of melanoma cells in the cell viability assay. This research was also taken on the tests of B16-F10 cell line and showed minor inhibitory consequences of cellular tyrosinase activities and melanin contents (Lo et al., 2013).

Conclusion

From the various scientific research based on *Alpinia galanga*, the plant has a huge biological potential. *Alpinia galanga* is a common herbal plant, is widely used as a treatment for various diseases, and has a diverse pharmacological spectrum. Several chemicals present in the plant show wide pharmacological and medicinal properties. More research and evaluation needs to be done to isolate and identify different chemicals present in the plant which will be used for innumerable application for human welfare in the near future.

Conflict of interest: None

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