



Medicinal importance of *Kaempferia galanga* L. (Zingiberaceae): A comprehensive review

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ABSTRACT

Kaempferia galanga included in the Zingiberaceae family is one of the potential medicinal plants with aromatic rhizome. In traditional medicine in Asian countries, this plant is widely used by local practitioners. This plant is widely cultivated in most Southeast Asian countries such as Cambodia, Vietnam, Malaysia, Thailand, and Indonesia. Ethyl-para-methoxycinnamate and ethyl-cinnamate are found as the main compounds in hexane, dichloromethane, and methanol extracts of *K. galanga*. This plant is traditionally used as an expectorant, stimulant, diuretic, carminative, and antipyretic remedy. In addition, *K. galanga* is used for treatment of diabetes, hypertension, cough, asthma, joint fractures, rheumatism, urticaria, vertigo, and intestinal injuries. Therefore, this study aimed to give a sneak peek view on galangal's ethnobotany, toxicology, pharmacology, and phytochemistry.

Implication for health policy/practice/research/medical education:

This review offers a comprehensive insight into the phytochemical, pharmacological, therapeutic activities, and safety of *Kaempferia galanga* and demonstrates that it can be used as a reliable source for the preparation of new drugs.

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Introduction

Medicinal plants have long been used for human health needs (1,2). Active compounds derived from medicinal plants are widely utilized to meet the demands of the pharmaceutical industries. Today, people in developing countries still use medicinal plants to treat various diseases (3,4). Each medicinal plant also has a variety of phytochemicals and pharmacological activities (5,6).

Kaempferia galanga belonging to the Zingiberaceae family, is one of the potential medicinal plants endemic to India and distributed across Indonesia (7,8), Laos (9), Sri Lanka (10,11), China (12), Malaysia (13,14), Nigeria (15), Thailand (16,17), Bangladesh (18), Japan (19), Sudan (20), and Vietnam (21). In traditional medicine in Asian

countries, this plant is widely used by local practitioners (22). Due to overuse of *K. galanga*, this plant is becoming rare and endangered in Bangladesh and India (18,23). As a medicinal plant, *K. galanga* is beneficial to treat asthma, hypertension, stomachaches, headaches, rheumatism, toothaches, indigestion, and bacterial infections (24,25). In addition, the dried rhizome part is a valuable cardiotoxic and sedative remedy (26). The acetone extract from this plant has activity on the retardation of monoamine oxidase (27). *K. galanga* rhizome can be used to restore internal heat and improve blood circulation (28). Its powder has benefited as an expectorant to cure cough with phlegm and chest pain (29), while the rhizomes' essential oil, is able to relieve colds and nasal congestion

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by applying in the nose area (30). Further, the processed rhizome paste is widely used in balm to treat rheumatism and wounds (31). The isolated chemical compounds have beneficial pharmacological properties such as antimicrobial, anthelmintic, anti-dengue, antioxidant, anti-inflammatory, antidiarrheal, antineoplastic, anti-mutagenicity, anti-obesity, anti-allergenic, adaptogenic, analgesic, hypolipidemic, hypopigmentary, sedatives, amoebicidal, vasorelaxant, and wound healing (24,30). According to its valuable properties, *K. galanga* is an important medicinal plant, and this review aims to explain about the taxonomy plant description, geographical distribution, phytochemistry, traditional properties pharmacological activities, and the toxicological effects.

Taxonomy

Kingdom: Plantae
 Division: Magnoliophyta
 Class: Liliopsida
 Order: Zingiberales
 Family: Zingiberaceae
 Genus: *Kaempferia*
 Species: *K. galanga* L. (32)

Origin names

Sand ginger, Resurrection lily (English); Gewürzllilie, Kleiner galgant, Sandingwer, Thai-ingwer, Chinenischer galgant (Germany); Kencur, Kunir putih, Kunci pepet, Temu rapet (Indonesia); Sha jiang, Shan nai, San nai (Chinese); Ingrupiyali, Ingurupiyali (Sinhala); Faux galangal, Galanga camphré (French); Sarn-noi (Hong-Kong); Teu dau (Vietnam); Ban-u-kon (Japan); Doto, Disol, Kisol (Philippines); Krachai, Khiey, Waan teendin, Waan hom, Pro hom (Thailand); Chandra-mula, Kachoram, Achoram, Tjekur, Sugandhavacha, Kachoram, Chandramulika (India); Cekur jawa, Cekur, Kencur (Malaysia) (33).

Geographical distribution

Kaempferia galanga originated from tropical countries is extensively cultivated in Southeast Asian countries such as Cambodia, Vietnam, Malaysia, Thailand, and Indonesia. This plant can also be found in South China, Taiwan, and India (33).

Plant description

Kaempferia galanga belongs to the Zingiberaceae family that emerges from a tubed rootstock with fibrous cylindrical roots. Its rhizome has reddish-brown skin and a soft interior that is almost white, while it has 2-5 leaves (8–15 cm) with dark green color spread horizontally, and elliptical to slightly flattened with a circular outline. The blade is often lying flat on the ground, the bottom superficies are hairy with spiders, while the top superficies

are smooth (34).

Each plant has 4-15 white flowers, which appear between the leaves with 1-3 cm long lobes and 2-5 cm long tubes. The lip of the flower is wide oval and white or purple in color with purple spots on the base. Each lateral lobe measures about 2-3 cm × 1-2 cm. Stamens have imperfect anthers that are oval to spear-shaped, white in color, 10-12 mm long, and have two lobes strongly attached to bent lobes (34). The morphology of *K. galanga* can be seen in Figure 1.

Phytochemistry

Several phytochemical studies have been carried out to recognize and dissociate chemical elements from non-polar and polar extracts of *K. galanga*. Ethyl-paramethoxycinnamate and ethyl-cinnamate were found as the main compounds in hexane (36), methanol (37), and dichloromethane extracts (32) of this plant. Approximately 98.98% of the essential oil has been explained, leaving only 1.11% compounds that are still unrecognized (38). The main compounds in essential oil include ethyl-p-methoxycinnamate, pentadecan, and propanoic acid, whereas other compounds are apigenin, germacrenes, camphene, alpha terpineol, caryophyllenes, delta 3-carene, borneol, cadinenes, cymene, luteolin, alpha gurjunene, undecanone, alpha pinene, 1,8-cineol, disicyclohexylpropanedinitrile, isopropyl cinnamate, camphidine, dipentene dioxide, 4-methyl isopulegone, 10-undecyn-1-ol, 3,7-dimethoxycoumarin, 9-hydroxy, 2-nonanone, 2,7-octadiene-1-yl acetate, cis-11-tetradecenyl acetate, ethyl cyclohexyl acetate, trans, trans-octa-2, 4-dienyl acetate, and 2-heptadecanone (24,38).

The important compounds isolated from *K. galanga* extract are pentade cane, 3-carene, heptade cane, tetradecane, alpha gurjunene, cinnamaldehyde, 8-heptade cane, kaempferol, ethyl cinnamate, alpha terpineol, germacrene, cymene, beta-pinene, camphene, cyclooctene, kaempferide, gamma elemente, eucalyptol, 1-methyl-3-(1-methylethyl), 1,6-cyclodecadienen, beta-caryophyllen, cadinenes, delta limonene, borneol, alpha pinene, ethyl paramethoxycinnamate, 3,4-methoxyphenyl, 2-propeonic acid, and 1-methyl,2-(1-methylethyl) (Figure 2).



Figure 1. *K. galanga*. Leaves (left) and Rhizomes (right) (35).

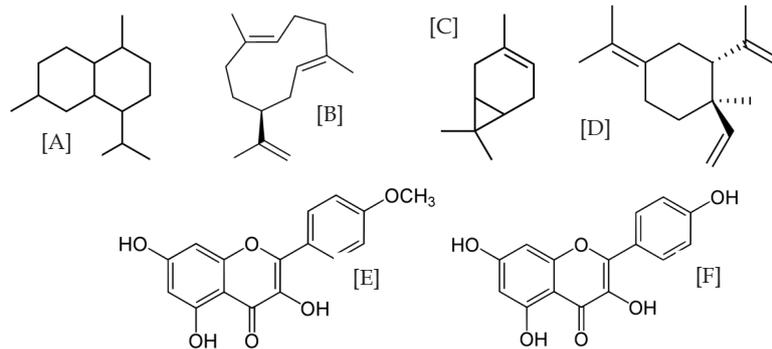


Figure 2. Phytochemicals of *K. galanga* that have medicinal effects. A) Cadinenes; B) Germacrene; C) 3-carene; D) Gamma elemente; E) Kaempferide; and F) Kaempferol (35).

Traditional uses

The use of *K. galanga* as a natural treatment has been a pioneer in the development of new drugs (39). Researchers have attempted to gather information on the use of *K. galanga* as traditional medicine (6,40,41).

Kaempferia galanga has traditionally been used as an expectorant, stimulant, diuretic, carminative, antipyretic (42). In addition, *K. galanga* is used to treat diabetes, hypertension, cough, asthma, joint fractures, rheumatism, urticaria, vertigo, and intestinal injuries (43–45). *K. galanga* is a notable medicinal material of some Ayurvedic medicines like Rasnairandadi kashayam, Valiya narayana tailam, Kaccoradi churnam, Sutura, Hinguvacadi churna, Nisakathakathi kashayam, Asanaeladi tailam, Palaashi rasa, Valiya rasnadi kashayam, Dasamularistam, which are used to cure various types of diseases (13). In addition, its aromatic rhizome has traditionally been utilized as a flavoring, fragrance, kitchen spice, and cosmetic (46–48).

Local tribes in Northeast and South India such as the Kuruma, Manipur, Malayali, Kurichiya, Mullu kuruma, and Meghalaya tribes use the plant to treat several diseases such as ear inflammation in children, indigestion, stomach pain, vomiting of blood, gastroenteritis, whooping cough, tongue blisters in babies, menstrual pain, baldness, intestinal wounds, abortifacient, toothache, rheumatism, flatulence, headaches, mouth sores, dandruff, sore throat, body aches, diarrhea, runny nose, and snake poison antidote (49).

Pharmacological and therapeutic activities

Kaempferia galanga has many pharmacological and therapeutic activities as listed below:

Antimicrobial activity

The plant's extract contains ethyl-p-methoxycinnamate compounds, which have considerable antimicrobial activities to combat *Mycobacterium tuberculosis* (16,25). A study conducted by Lakshmanan et al (2011) (50) tested ethyl-p-methoxycinnamate with the resazurin microtiter test and indicated the ability to impede sensitive and

resistant of *M. tuberculosis* cultures. Moreover, the extract exhibited antimicrobial activity against several bacteria such as *Klebsiella pneumonia*, *Vibrio cholera*, *Enterococcus faecalis*, *Staphylococcus aureus*, *Salmonella typhi*, *Escherichia coli*, *Serratia marcescens*, *Streptococcus pyogenes*, *Vibrio parahaemolyticus*, and *Pseudomonas aeruginosa* (51).

Anthelmintic activity

A research evaluated the anthelmintic activity of *K. galanga* extract at doses of 25, 50 and 100 mg/mL in brine against the *Pheretima posthuma* earthworm compared to albendazole 10 mg/mL as the standard drug. Mortality occurred in extract concentration of 25, 50, and 100 mg/mL. The extract at a dose of 25 mg/mL showed a paralytic effect on the worms in approximately 48 minutes and over 80 minutes to die. Meanwhile, at the concentrations of 50 and 100 mg/mL the extract was able to impose paralytic effect followed by death. Thus, *K. galanga* extract showed dose-dependent anthelmintic activity (52).

Antidengue activity

Another extract's compound, cystargamide B, had the inhibitory activity on dengue virus replication in the cell-based virus replication against NS2B/NS3 complex. Protease activity in the presence of cystargamide B (0.194 and 0.149 relative fluorescence units (RFU) per second) at doses of 100 and 200 µg/mL indicated a decrease of 44% and 67%, respectively, in comparison with absent (0.343 and 0.453 RFU per second). Therefore, it is successively proved that the cystargamide B compound derived from *K. galanga* had inhibitory activity protease of the NS2B/NS3 complex, thus making it a good candidate for anti-dengue drugs (53).

Antioxidant activity

The antioxidant activity (51,54) was found in the leaf and rhizome extracts with total phenolic content of 146 mg gallic acid equivalent/100 g and 57 mg gallic acid equivalent/100 g, respectively. Moreover, the antioxidant

activities of leaf and rhizome of *K. galanga* extracts were 77 mg ascorbic acid/100 g and 17 mg ascorbic acid/100 g (54). However, the antioxidant activity decreased by drying with distinct non-thermal and thermal drying methods. However, this reduction was averted if the plant underwent freeze drying (55). Additionally, the antioxidant activity of *K. galanga* extract might be influenced by the total content of flavonoids, phenolics, apigenin, and luteolin (46).

Anti-inflammatory activity

Cyclohexane, ethyl acetate, chloroform, and diarylheptanoids derived from *K. galanga* extract indicated retardation of lipopolysaccharide-induced nitric oxide in 264.7 RAW macrophages compared to indomethacin (48). The compounds from *K. galanga* have significant anti-inflammatory activity based on the expression of the mRNA nitric oxide synthase gene, accentuation of nitric oxide production, and cyclooxygenase-2 (56,57).

Antidiarrheal activity

In a study in mice, diarrhea was orally induced with 0.3 mL castor oil. The amount of wet and dry manure released by mice was counted every hour for 4 hours. In this experiment, the group of without *K. galanga* extract showed typical diarrhoea symptoms such as watery water and frequent bowel movements. *K. galanga* extract significantly inhibited the severity of diarrhoea in mice caused by castor oil (19).

Antineoplastic activity

The methanol extract of *K. galanga* has been notified to exhibit antineoplastic activity (58,59), which demonstrated inhibitory activity at the neoplasia stage as a factor in tumour emergence. When examined by Western blot and indirect immunofluorescent assay, it was proven that the methanol extract of *K. galanga* inhibited 12-O tetradecanoyl-phorbol-13-acetate that induced activation of the initial antigen of the Epstein-Barr virus in Raji cells (59).

Anti-mutagenicity activity

The extracted soluble fraction of dichloromethane and ethyl acetate indicated anti-mutagenicity activities. The methoxylated compounds isolated from this extract showed potential activity with IC_{50} values of 0.4, 0.4, 0.47, and 0.42 nmol/plate. The compound also indicated significant activity with IC_{50} values of 64.3 μ M, 54.3 μ M, and 20.4 μ M (60).

Anti-obesity activity

The ethanol extract of *K. galanga* found to be beneficial to combat an obesity-induced dermatopathy system in Tsumura Suzuki obese diabetic (TSOD) mice as a model of obesity. It was shown a decrease in the body weight of rats and the thickness of the subcutaneous fat layer more than

the polymethoxyflavonoid fraction, which was utilized as a dietary supplement in controlling skin disorders due to obesity (61).

Anti-allergenic activity

Polymethoxyflavone compounds relieved symptoms of type I allergy by suppressing cell degranulation of Basophilic Leukaemia (RBL2H3) (62).

Adaptogenic activity

Chloroform, hexane, ethanol, and methanol extracts showed adaptogenic activity compared to the raw ginseng root powder (63). The dose of *K. galanga* extract (60% EtOH extract) increased the potential outlay of the whole body in humans (64). *K. galanga* is also known to improve health and physical health by reducing oxidative stress (65).

Analgesic activity

In a study, the *in vivo* analgesic activity of the alcoholic *K. galanga* extract was examined with the hot plate method and the tail-flick model in Wistar rats. The results indicated that the alcohol extract significantly augmented the stress tolerance capacity of animals at concentrations of 1200 and 600 mg/kg BW at 60 min via the hot plate method and 30 min via the tail-flick model (28).

Hypolipidemic activity

A study showed that the oral administration of ethanol extract at a concentration of 20 mg/kg BW every day was effective in decreasing serum total cholesterol, phospholipids, triglycerides, and increasing serum high density lipoprotein levels in white Wistar rats fed high cholesterol diet for 4 weeks. Thus, the ethanol extract of *K. galanga* showed hypolipidemic activity but no active compound has been found to be responsible for this activity (66).

Hypopigmentary activity

In one study, the ethyl p-methoxycinnamate compound was isolated using nuclear magnetic resonance technique from chloroform fraction of *K. galanga* ethanol extract to evaluate activity in skin whitening on B16F10 murine melanoma cells. The results of this study indicated that ethyl p-methoxycinnamate significantly reduced melanin synthesis in B16F10-induced murine melanoma cells with α -melanocyte excite hormone. Thus, the ethyl p-methoxycinnamate compound from *K. galanga* might be expanded as a cosmetic in whitening skin (67).

Sedative activity

Acetone extract from rhizome (200 mg/kg) and leaf (200 mg/kg) indicated a significant reduction in the onset and sleep duration of sodium thiopental induced rats, which certify its potential as sedative substance for central

nervous system (19). Inhalation of hexane extract at doses ranging from 1.5 to 10 g/kg BW indicated an appreciable subtraction in locomotor activity in mice. This sedative activity is caused by ethyl-cinnamate and ethyl trans-p-methoxycinnamate compounds, which inhibit the locomotor activity of the central nervous system (37).

Amoebicidal activity

In a study evaluating the in vitro amoebicidal activity of non-polar and polar extracts using a microscope reported that non-polar extracts possessed amoebicidal property against *Acanthamoeba castellanii*, *Acanthamoeba culbertsoni*, and *Acanthamoeba polyphaga*. This study proves that *K. galanga* extract is effective in fighting intestinal parasites (68).

Vasorelaxant activity

Kaempferia galanga extract showed a dose-related decrease in basal mean arterial pressure with maximum effect seen 5 to 10 minutes after injection (32). Ethyl cinnamate compound in a dose depending manner inhibited tonic contraction caused by increased entry of phenylephrine and potassium. However, this vasorelaxant activity was inversely proportional to aortic pre-treatment with indomethacin and methylene blue. This vasorelaxant mechanism might implicate retardation of calcium entry into vascular cells as well as the detachment of prostaglandins and nitric oxide from endothelial cells (69).

Wound healing activity

The ethanol extract of *K. galanga* indicated wound healing activity in mice that was almost comparable to dexamethasone (70).

Toxicological study

Kaempferia galanga ethanol extract at concentrations of 50, 25, 100, and 800 mg/kg BW caused a reduction in motor activity, depression of the central nervous system, and decreased respiratory rate in mice. Administration of *K. galanga* ethanol extract to mice at the dose of up to 5 mg/kg BW did not result in death, nor was there any significant discrepancy in organ and body weight between the control group and the tested group. However, the ethanol extract of *K. galanga* 50, 25 and 100 mg/kg BW for 28 days resulted in a slight reduction in the number of lymphocytes in mice with all other parameters normal. The hexane fraction from *K. galanga* applied to rabbit skin did not show any signs of skin irritation (25).

Conclusion

To sum up, *K. galanga* is an important medicinal plant with many medicinal uses and has been widely used in various countries in the world because this plant has various pharmacological activities. In addition, further research

on the use of *K. galanga* will increase the application of this plant in a wider and more suitable range.

Authors' contributions

ARK, TIS, ANMA conceived of the presented idea; ARK, ANMA, GAP, and AF developed the article, wrote, and prepared the manuscript; NM encouraged; while TIS supervised the research and critical revision of the article. RHH, GAP, AF, and SCR made the final version. All authors read the manuscript and confirmed the publication of the final version.

Conflict of interests

There is no conflict of interest.

Ethical considerations

Ethical issues including text plagiarism, misconduct, manipulation or appropriation, data fabrication, falsification, redundant publication as well as duplicate submissions have been carefully observed by authors.

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