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Review Article

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REVIEW OF LITERATURE ON *KAEMPFERIA GALANGA* LINN

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ABSTRACT

Kaempferia galanga Linn, commonly known as sand ginger, is a rhizomatous, aromatic, and perennial herb widely distributed across tropical regions including India, China, Thailand, and Malaysia. It has been traditionally used in various medicinal applications such as treating headaches, respiratory ailments, inflammatory conditions, and gastric disorders. This review comprehensively examines the pharmacognostic, phytochemical, and pharmacological properties of *K. galanga*, highlighting its diverse bioactive constituents, including terpenoids, flavonoids, and essential oils. The plant exhibits significant anti-inflammatory, analgesic, antibacterial, antioxidant, and wound-healing properties. Additionally, *K. galanga* demonstrates potential applications in cancer therapy, diabetes management, and neuroprotection. The review also discusses its propagation methods, taxonomy, and ethnomedicinal uses, providing a foundation for further research and development of this promising medicinal plant.

KEYWORDS: *Kaempferia galanga*, Pharmacognosy, Phytochemistry, Anti-inflammatory, Antioxidant, Ethnobotany, Medicinal Plants.

INTRODUCTION

Kaempferia galangal Linn is a stem less, rhizomatous, aromatic,perennial and indigenous herb. It is native to India and distributed in China, Bangladesh, Myanmar, Sri Lanka, Japan, Thailand, Indonesia, Malaysia, Sudan, Laos, Nigeria, Vietnam and South Africa.[1] It is an important Indian medicinal herb that has a long history of use in the treatment of several kinds of human ailments like headache ,cough and cold, fever, pains disorders, skin diseases, rheumatic diseases, arthritis, joint fractures, vertigo, wounds, gastritis, antidote for snake venoms, inflammations, blood vomiting, mouth sores and tongue blisters in infants.[2] Its powder has benefited as an expectorant to cure cough with phlegm and chest pain[3] while the rhizomes by applying in the nose area.[4] Moreover, the processed rhizome paste is widely used in balm to treat rheumatism and wound.[5]

TAXONOMY[6]

BOTANICAL NAME	***Kaempferia galanga*L**
KINGDOM	*Plantae*
DIVISION	*Magnoliophyta*
CLASS	*Liliopsida*
ORDER	*Zingiberales*
FAMILY	*Zingiberaceae*
GENUS	*Kaempferia*
SPECIES	*galanga*

SYNONYMS[7]

Malayalam	Kacholam
English	Sand Ginger
Germany	Sandingwer
Indonesia	Kencur
Chineese	Shan nai

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.[7]

DESCRIPTION

It is a monocotyledonous plant in the Z*ingiberaceae* family that emerges from a tube rootstock with fibrous cylindrical roots. Its rhizome has reddish-brown skin and a soft interior that is almost white, while it has a thick, flat, rounded leaves. It is a small low-growing herb. The plant typically consists of 2-3 (occasionally up to 5) broadly elliptical to sub orbicular leaves which occur in a rosette. The leaves are held horizontally, close to the ground and are on top, but hairy below. Each plant has 4-15 white flowers.[8]

Figure 1: Whole plant of *kaempferia galanga L.*

PROPAGATION

Kaempferia galanga, is a medicinal plant that can be propagated through various methods

- **Rhizome division**: Divide the rhizome into sections, making sure each section has at least one growing point. Replant the sections in a well-draining potting mix.
- **Seeds**: Sow seeds in a seed tray or small pots filled with a well-draining mix. Keep the soil moist and warm until germination.
- **Tissue culture**: This method involves using plant tissue to generate new plants in a laboratory setting.
- **Layering**: Bend a long stem down to the ground and secure it with a rock or U-shaped wire. Cover the buried part with soil and wait for roots to develop.[9]

CHEMICAL CONSTITUENTS:

The Chemical characteristics of *Kaempferia galanga*Linn showed the existence of various types of secondary metabolites such as terpenoids, phenolics[10], cyclic dipeptides, diarylhaptanoids, flavonoids,polysaccharides, and essential oils. A total of 97 compounds have been obtained from the rhizome of *Kaempferia galangal* Linn.[11]

USE

The plant is used as analgesic, diuretic,expectorant, stimulant, carminative, antipyretic remedy. Apart from this, it is traditionally used for the treatment of headache, respiratory ailments, gastric irritations.[12,13].The leaves are used in lotions and as a poultice for sore eyes, sore throat, swellings, fevers. Rhizome juice is applied for toothache. In paralysis rhizome paste is applied on legs and arms and is also applied on forehead in headache.[14]

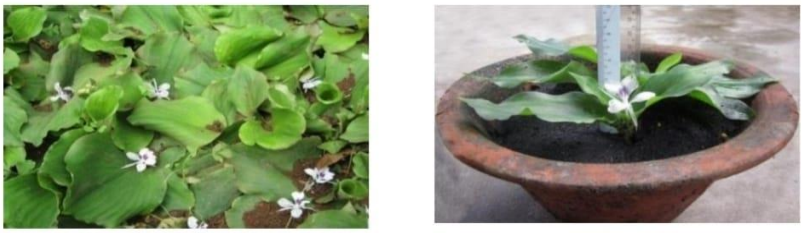


Figure 2: Plants in natural habitat and close up view of plant.

Figure 3: Habit and Rhizome.

Figure 4: T.S of rhizome and ventral view of leaves.

Figure 5: Dorsal view of leaves and Bract with flower.

PHARMACOGNOSTICAL REVIEW

Macroscopic evaluation of *kaempferia galanga*Linn

Morphological characters of *Kaempferia galanga*L.

Phyo moh moh zin*et al* (2019)[15] Explore the plant specimens of *Kaempferia galanga* L. and were collected from Ka-wa Township, Bago Region during the flowering and fruiting periods from June to October, in the year 2013. For morphological study, the specimens were measured and found that herbs with aromatic rhizome, rhizomes yellowish white inside, fragrant. Leaves opposite and distichous, simple, the lamina broadly elliptic to slightly orbicular, 12.0-15.5cm long and 10.0-13.1cm wide, the bases cuneate, the margins entire, the tips acuminate, both surfaces glabrous; shortly petioles; leaf-sheath open,10.0 -23.0 cm long and 0.35 - 0.5 cm wide. Inflorescence terminal, compact spike; bracts lanceolate, 5.8-6.0 cm long and about 1.0 cm wide. Flower white with violet center, 5.6- 5.8 cm long and 2.6-2.8 cm wide, complete, bisexual, irregular, zygomorphic, trimerous, epigynous; sepals (3), synsepalous, tubular, 2.0-2.3 cm long and about 0.3 cm wide, spathaceous splitting, white; petals (3), synpetalous, tubular, the tubes 3.6-3.8 cm long and about 0.3 cm wide, the lobes 1.6-1.8 cm long and 0.25-0.35 cm wide, white; stamens 1+ (2)st+2st, epipetalous, 1 fertile stamen4.5mm long and 5.0mm wide , 2 - outer staminodes fused to form a labellum, 17.0mm long and 18.0mm wide, white with violet center and 2- inner lateral petaloid free staminodes, 12.0 mm long and 8.0 mm wide, filaments grooved, exserted, anthers dithecous, introrse, dorsifixed, longitudinal dehiscence; ovary inferior, ovoid, 2.5 mm long and 2.0 mm wide, tricarpellary, syncarpous, trilocular, axile placentation, the style long and slender, 37.0mm long and 0.5 mm wide the stigma capitate .It is reported that fruits and seeds are not seen.

Ibrahim H *etal*(1999)[8] found that*Kaempferia galanga* is a small herb that grows up to 1000m in altitude, thriving in slightly shaded areas such as open forests, forest edges, and bamboo forests, on various soils. Its leaves are typically 2-3(-5) in number, with sheaths that are 1.5-5 cm long, and blades that are broadly elliptical to sub orbicular, measuring 6-15 cm x (2-)5-10 cm. The leaves are glabrous above and arachnoid-hairy below, with an acuminate tip and a horizontal orientation that is often apprised to the soil. The inflorescence emerges from between the leaves, is sessile, and bears 4-12(-15) flowers. The calyx is 2-3 cm long, the corolla is white with a tube that is 2.5-5 cm long, and the lobes are 1.5-3 cm long. The labellum is broadly obovate, divided to about halfway or more, and is white or pale purple with violet to purple spots at the base. Each lateral lobe measures about 2-2.5 cm x 1.5-2 cm, while the other staminodes are oblong-obovate to oblanceolate, measuring 1.5-3 cm long, and are white. The fertile stamen is 10-13 mm long, with a deeply bilobed connective that has reflexed lobes, which are reported.

Figure 6: *K galanga*.Leaves (left) andrhizomes (right).

Raden bayu indradi *et al* (2022)[16] Studied pharmacognostic characteristic of *kaempferia galanga* rhizome dried by oven and combination methods.It showed The time of *kaempferia galanga* drying process for oven-based (OB) and combination-based (CB) drying were 19.03±5.08 and 12.63±1.44 h. The rendement of dried product for OB and CB drying were 22.36±4.30% and 24.91±1.14% .Macroscopic evaluation showed that the dried product shape was irregular, averaging 4.5, 3.3, and 0.4 cm in length, width, and thickness. It had wavy and wrinkled edges and brown edges color with white middle parts as shown in fig. 7. The odor was a specific K. galanga aroma and the taste was spicy.

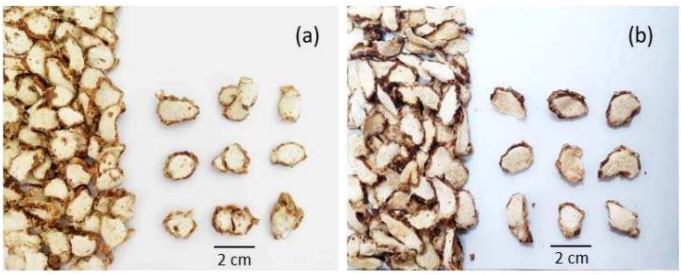


Figure 7: Dried *K .galanga* product(a) Oven- based drying,(b)Combination- based drying.

Tanasorn tunsaringkarn *et al* (2007)[17] Studies have done ondried rhizomes of *Kaempferia galanga*Linnwhich are collected from 15 Thai traditional drug stores of 13 provinces in four regions of Thailand for pharmacognostic specification study. Crude drug evaluations were performed by macroscopic evaluation by World Health Organization (WHO) guideline standard methods.And the results arethe dried rhizomes of crude drugs were ovate, oblong or pear-shaped. The colour was light yellow with brown bark. The smell was pleasant odor.

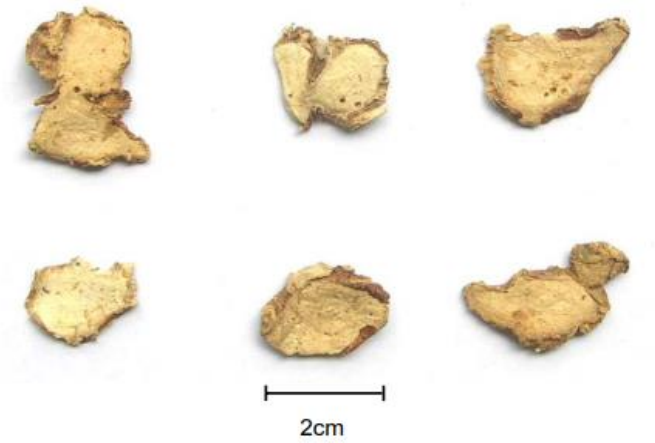


Figure 8: The dried rhizome of *K.galanga* (transverse sliced*)*

Akoijam Ranjita Devi* et al *(2019)[18] Kaempferia galanga *is an important medicinal plant belonging to family Zingiberaceae. It forms a component of various Ayurveda medicines. Two morphotypes of* Kaempferia galanga *collected from Arunachal Pradesh and Kerala were evaluated for growth and yield. Result showed the morphotype ArPCG-1 with higher number of tillers, leaves and plant spread. The morphotype KCG-1 exhibited higher growth and yield parameters i.e. It was evident from the growth parameters and rhizome characters that the morphotype collected from Kerala (KCG1) possessed larger leaves and larger rhizomes when compared with the Arunachal Pradesh collection*.

Table 1: Qualitative parameters in *K. galanga L.*

Parameters	Details
Rhizome colour: Scale Inner core	Dark reddish brown Pearl white
Rhizome shape	Globous
Presence of root tubers	Present
Colour of root tubers	Creamy white
Mature leaf colour	Dark green
Leaf tip shape	Acute
Growth habit	Sprawling

MICROSCOPIC EVALUATION

Raden bayu indradi *et al* (2022)[16] Studied pharmacognostic characteristic of *Kaempferia galanga*Linn. rhizome dried by oven and combination methods.It showed that the time of *Kaempferia galanga*Linn. drying process for oven-based (OB) and combination-based (CB) drying were 19.03±5.08 and 12.63±1.44 h. The rendement of dried product for OB and CB drying were 22.36±4.30% and 24.91±1.14% .Microscopic evaluation showed that in both samples of

Kaempferia galanga Linn were found to contain fragments consisting of starch, parenchyma, periderm, spiral secondarily thickened vessel, parenchyma with secretion cells, and reticulate secondarily thickened vessel.

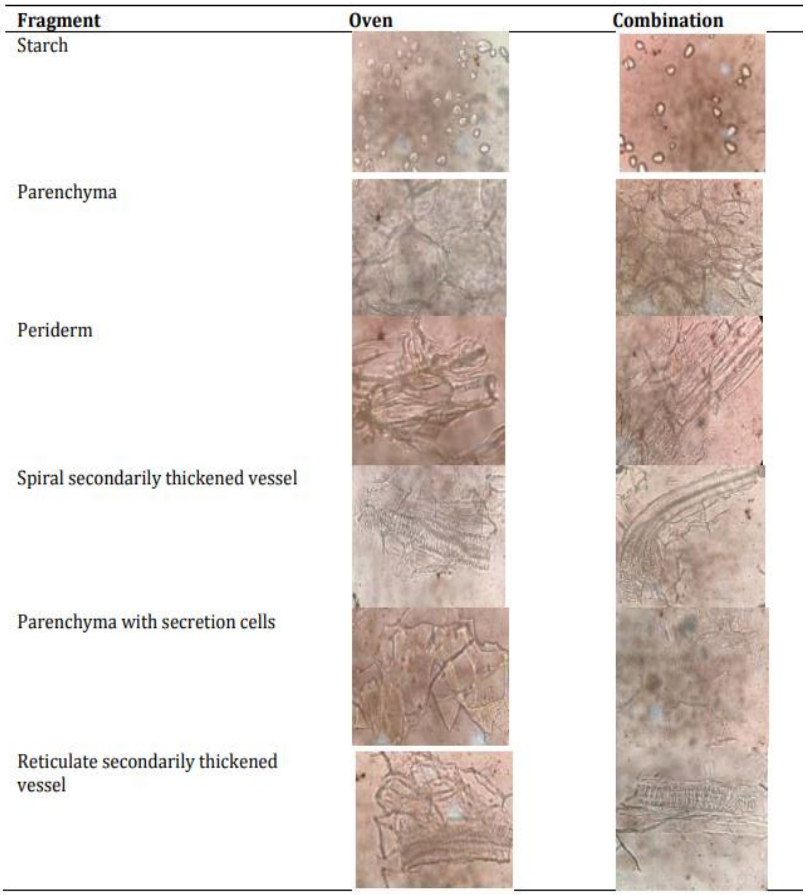


Figure 9: Microscopic fragments of*Kaempferia galanga*Linn.

Tanasorn tunsaringkarn *et al* (2007)[17] Studies have done on dried rhizomes of *Kaempferia galanga*Linn which are collected from 15 Thai traditional drug stores of 13 provinces in four regions of Thailand for pharmacognostic specification study. Crude drug evaluations were performed by microscopic evaluation by World Health Organization (WHO) guideline standard methods. Anatomical and histological characters were determined. Transverse sections and powdered samples (ground and sifted through a 250 micron sieve) were inspected respectively under microscope (Olympus BX41) with a magnification of 4x, 10x and 40x and compared the scale with the 0.01 mm micrometer. Anatomical characterization of *Kaempferia galanga*Linn dried rhizome was showed in (figure10). Secretory sac containing volatile oil, oleoresin, and starch grain were found. Histological characteristics composed of parenchyma, periderm, starch grain, parenchyma containing starch grain, reticulate vessel, annular vessel, reticulate vessel, and spiral vessel (Figure 11).

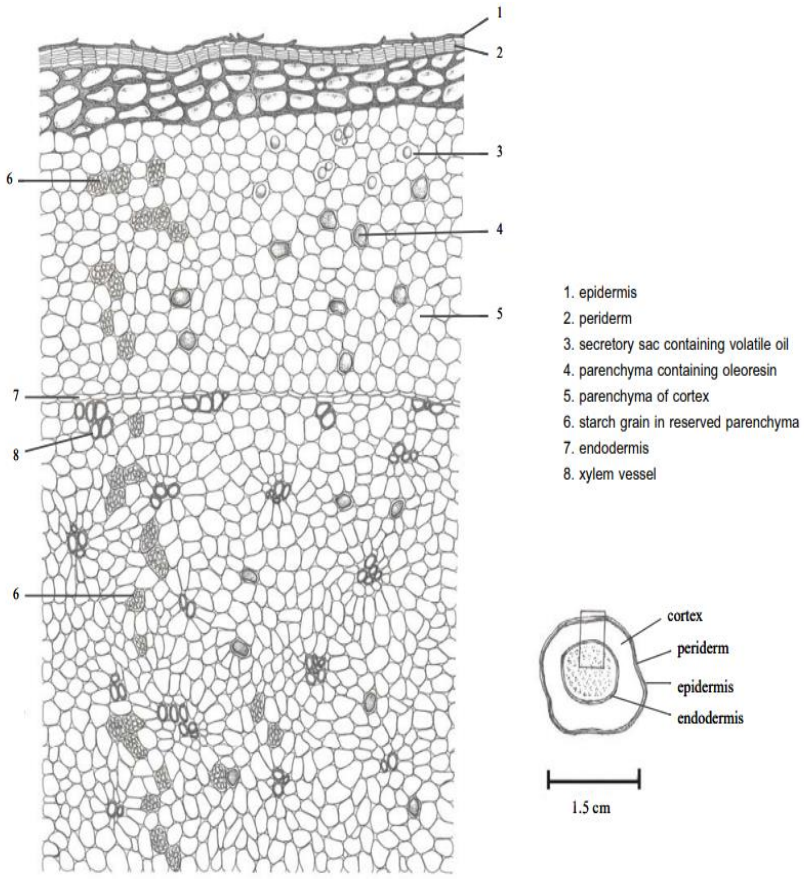


Figure 10: Anatomical character (transverse section) of *K .galanga rhizome.*

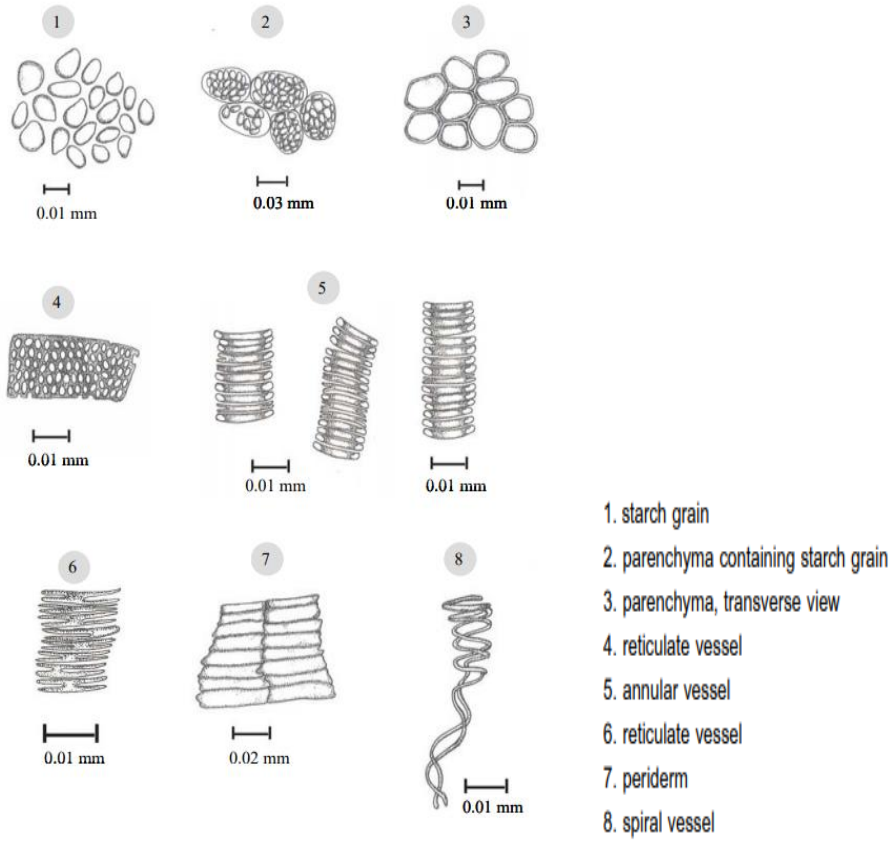


Figure 11: **Histological character (powdered) of *k galangal.***

PHYSICAL EVALUATION

Tanasorn tunsaringkarn *et al* (2007)[17] Dried rhizomes of *Kaempferiagalanga* were collected from 15 Thai traditional drug stores of 13 provinces in four regions of Thailand for pharmacognostic specification study. Crude drug evaluations were performed by macroscopic and microscopic methods whilst constant numbers due to quality of crude drug were performed by World Health Organization (WHO) guideline standard methods. Anatomical and histological characters showed secretory sac containing volatile oil, parenchyma containing oleoresin and a numerous of starch grains. The mean contents of foreign matter, total ash, acid insoluble ash, ethanol–soluble extractive, water–soluble extractive, loss on drying, moisture and volatile oil were 0.06, 7.03, 3.75, 2.39, 16.05, 10.39, 9.62 and 0.72 % of dry weight respectively.

Specification	Mean ± SD*	Min – Max*	n
Foreign matter	0.06 ± 0.03	0.02 – 0.15	29
Total ash	7.03 ± 1.33	5.32 –10.59	28
Acid-insoluble ash	3.75 ± 8.98	1.99 – 5.82	28
Ethanol-soluble extractive	2.39 ± 0.95	0.70 – 4.30	45
Water-soluble extractive	16.05 ± 2.64	11.00 – 19.20	45
Loss on drying	10.39 ± 0.76	8.35 – 12.23	45
Moisture	9.62 ± 0.92	7.60 – 10.88	30
Volatile oil content	0.72 ± 0.45	0.17 – 2.01	30

*% dry weight

Figure 12: The constant numbers due to quality of *K. galanga* rhizomes.

PHARMACOLOGICAL REVIEW

Evaluation of anti-inflammatory and analgesic activities of alcoholic extract of *Kaempferia galanga* in rats

Amberkar Mohanbabu Vittalrao *et al*(2011)[19] Studies have investigated the analgesic and anti-inflammatory properties of *Kaempferiagalanga*Linn extracts.studies found that the alcoholic extract of *Kaempferiagalanga*Linn exhibited significant anti-inflammatory activity in the carrageenan model and cotton pellet granuloma model at doses of 600 mg/kg and 1200 mg/kg. Additionally, the extract showed significant analgesic activity in the tail flick model and hot plate model.

Drugs	*Dose/ route*	*Increase in paw volume (Mean±SEM) (ml) (% Inhibition of paw edema)*						
		Before	*+1h*	*+2h*	*+3h*	*+4h*	*+5h*	*+6h*
gum acacia	2 ml po	0.633±0.023	0.408±0.025	0.868± 0.033	1.196±0.031	1.316±0.028	1.433±0.027	1.266±0.031
K. galanga	300 mg/ kg po	0.672±0.006	0.348±0.010 (13.42)	0.776± 0.009 (10 .02)	1.12±0.017 (5.670)	1.22±0.025 (7.26)	1.310±0.014 (8.41)	1.241±0.024 (1.456)
	600 mg/ kg po	0.735±0.015	0.246±0.019[a] (36.95)	0.631± 0.018[ab] (26.41)	0.79±0.022[ab] (33.55)	0.985±0.031[ab] (24.83)	1.025±0.016[ab] (28.31)	0.978±0.028[ab] (22.32)
	1200 mg/ kg po	0.780±0.006	0.228±0.008[a] (42.314)	0.520± 0.008[ab] (39.71)	0.665±0.016[ab] (44.195)	0.952±0.021[ab] (27.489)	0.990±0.011[ab] (30.81)	1.08±0.010[ab] (14.25)
aspirin	100 mg/ kg po	0.551±0.006	0.185±0.045[a] (54.96)	0.271± 0.01[a] (68.46)	0.363±0.009[a] (69.59)	0.415±0.011[a] (68.45)	0.480±0.008[a] (66.48)	0.481±0.008[a] (61.85)

[a]P<0.001 vs Control, [b]P<0.001 vs aspirin, (n=6/group), One-way ANOVA; SEM = Standard error of mean.

Figure 13: Anti inflammatory effect of alcoholic extract of *Kaempferia galanga* on carrageenan-induced rat paw edema.

Drugs	Dose/ route	Reaction time in s (mean±SEM)				
		Basal	30 min (% elongation)	60 min (% elongation)	120 min (% elongation)	180min (% elongation)
gum acacia	2 ml po	4.56±0.03	5.183±0.03* (13.66)	5.42±0.031* (18.84)	6.067±0.012* (33.03)	6.23±0.014* (36.60)
K. galanga	300 mg/ kg po	4.780±0.016	5.360±0.01* (12.14)	5.60±0.014* (17.16)	6.083±0.008* (27.27)	6.313±0.009* (32.08)
	600 mg/ kg po	5.052±0.016	7.29±0.04*[ab] (44.28)	7.68±0.033*[ab] (52.04)	6.96±0.017*[a] (37.78)	7.04±0.01*[ab] (39.43)
	1200 mg/ kg po	4.917±0.024	7.022±0.02*[ab] (42.83)	7.69±0.04*[ab] (56.56)	7.29±0.02*[ab] (48.31)	7.15±0.008*[ab] (45.37)
codeine	5 mg/ kg po	4.334±0.030	7.890±0.05*[a] (82.16)	7.25±0.04*[a] (67.40)	7.02±0.015*[a] (61.80)	6.81±0.011*[a] (57.20)

*P<0.01 vs Baseline value of the respective drug group, [a]P<0.001 vs Control, [b]P<0.001 vs codeine, (n=6/ group), One-way ANOVA; SEM = Standard error of mean.

Figure 14: Analgesic effect of alcoholic extract of *Kaempferia galanga* by hot plate method in rats.

Drugs	Dose/ route	Reaction time in s (mean±SEM)				
		Basal	30 min (% elongation)	60 min (% elongation)	120 min (% elongation)	180min (% elongation)
gum acacia	2 ml po	4.25±0.015	4.37±0.015 (2.95)	4.61±0.021* (8.39)	4.79±0.006* (12.78)	4.65±0.033* (9.49)
K.galanga	300 mg /kg po	4.39+0.006	4.44±0.020 (1.10)	4.71±0.048* (7.20)	4.86±0.009* (10.77)	4.72±0.009* (7.58)
	600 mg/ kg po	4.81±0.008	6.91±0.016*[ab] (43.66)	6.34±0.015*[ab] (31.86)	5.89±0.033*[ab] (22.36)	5.46±0.007*[ab] (13.43)
	1200 mg/ kg po	4.78±0.006	7.02±0.012*[ab] (46.76)	6.66±0.020*[ab] (39.23)	5.85±0.01*[ab] (22.43)	5.55±0.013*[ab] (16.09)
codeine	5mg/ kg po	4.93±0.008	8.87±0.033*[a] (80.08)	7.88±0.035*[a] (59.90)	6.64±0.077*[a] (34.75)	6.11±0.008*[a] (23.93)

*P<0.01 vs Baseline value of the respective drug group, [a]P<0.001 vs Control, [b]P<0.001 vs codeine, (n=6/ group), One-way ANOVA; SEM = Standard error of mean.

Figure 15: Analgesic effect of alcoholic extract of K.galanga on radiant heat tail-flick response in rats.

Antinociceptive and anti - inflammatory activities of the aqueous extract of *Kaempferia galanga*Linnleaves in animal models

Sulaiman MR *et al* (2008)[20] This study was performed to determine the antinociceptive and anti-inflammatory activities of aqueous extract of *Kaempferia galanga* leaves using various animal models. The extract, in the doses of 30, 100, and 300 mg/kg, was prepared by soaking (1:10; w/v) the air-dried powdered leaves (40 g) in distilled water for 72 h and administered subcutaneously in mice/rats 30 min prior to the tests. The extract exhibited significant ($P < 0.05$) antinociceptive activity when assessed using the abdominal constriction, hot-plate and formalin tests, with activity observed in all tests occurring in a dose-dependent manner. Furthermore, the antinociceptive activity of *Kaempferia galanga* extract was significantly ($P < 0.05$) reversed when prechallenged with 10 mg/kg naloxone. The extract also produced a significantly ($P < 0.05$) dose-dependent anti-inflammatory activity when assessed using the carrageenan-induced paw-edema test. In conclusion, this study demonstrated that *Kaempferia galanga* Linn leaves possessed antinociceptive and anti-inflammatory activities and thus supports the Malay's traditional uses of the plant for treatments of mouth ulcer, headache, sore throat.

Bioactivity-Guided Isolation of Ethyl-*p*-methoxycinnamate, an Anti-inflammatory Constituent, from *Kaempferia galanga* L Extracts

Muhammad Ihtisham Umar*et al* (2012)[21] This study evaluated the anti-inflammatory effect of *Kaempferia galanga L* using an activity-guided approach. KG rhizomes were serially extracted with petroleum ether, chloroform, methanol and water. These extracts (2 g/kg each) were tested for their ability to inhibit carrageenan-induced rat paw edema. The chloroform extract was found to exert the highest inhibition (42.9%) compared to control ($p < 0.001$), hence it was further fractionated by washing serially with hexane, hexane-chloroform (1:1) and chloroform. The chloroform fraction (1 g/kg) showed the highest inhibitory effect (51.9%, $p < 0.001$) on carrageenan-induced edema. This chloroform fraction was further fractionated with hexane-chloroform (1:3) and chloroform, and of the two fractions, the hexane-chloroform sub-fraction was the most effective in inhibiting edema (53.7%, $p < 0.001$). GC-MS analysis of theactive sub-fraction identified ethyl-*p*-methoxycinnamate (EPMC) as the major component, which was re-crystallized. EPMC dose-dependently inhibited carrageenan-induced edema with an MIC of 100 mg/kg. Moreover, in an *in vitro* study, EPMC non-selectively inhibited the activities of cyclooxygenases 1

and 2, with IC_{50} values of 1.12 µM and 0.83 µM respectively. These results validate the anti-inflammatory activity of KG which may be exerted by the inhibition of cyclooxygenases 1 and 2. EPMC isolated from this plant may be the active anti-inflammatory agent.

Anti-bacterial Effect Of *Kaempferia galanga*L Extract On *Lactobacillus AcidophilusIn Vitro*

Saraswati J *et al* (2013)[22] *Lactobacillus acidophilus* is one of the bacteria causes dental caries. Study has shown that *Kaempferia galanga*L extract has a potential to inhibit the growth of Lactobacillus acidophilus.*Kaempferia galanga L* is extracted in 3 different solvents:dichlormethane, ethanol, and aquades. For each solvent, 0.2 Î¼l *Kaempferia galanga L* extractdroped into 6 mm sterile paper disc 0.1 ml Lactobacillus acidophilus inoculated on MRS agar. Each disc contains extract were impragnated into the agar media, then incubated at 370C for 24 hours, and inhibition zone measured.Mean scores of *Kaempferia galanga L* extract in 3 different solvents are*Kaempferia galanga L* (dichlormethane) is 1.6400; *Kaempferia galanga* (ethanol) is 1.7440; *Kaempferia galanga extract* is 1.6600; boiled *Kaempferia galanga*L is 1.7000. Using Mann-Whitney Test, the results are negative controls have no inhibition effect on Lactobacillus acidophilus compaired to *Kaempferia galanga* extract, comparation of those 4 *Kaempferia galanga* treatments shows no significant difference, those 4 *Kaempferia galanga* treatments compaired to erythromycin antibacterial effect shows significant difference, otherwise *Kaempferia galanga* treatments compared to penicillin shows no significant difference except *Kaempferia galanga* (ethanol).*Kaempferia galanga* extract can kill Lactobacillus acidophilus. Inhibition effect of *Kaempferia galanga* extract has no significant difference to penicillin but lower inhibition effect than erythromycin. The *Kaempferia galanga* extracts showed better antibacterial activity than penicillin.

***In vitro* antimicrobial evaluation of *Kaempferia galanga* L. rhizome extract**

Kochuthressia K. P *et al* (2012)[23] The antimicrobial activity of *Kaempferia galanga* rhizome was investigated using methanol, ethanol, chloroform, petroleum ether and aqueous extracts of it. Ten bacterial pathogenic species (*Staphylococcus aureus, Streptococcus faecalis, Bacillus cereus, Bacillus subtilis, Enterobacter aerogenes, Salmonella typhi, Escherichia coli, Klebsiella pneumoniae, Pesudomonas aeruginosa and Vibrio cholerae)* and four fungal species (*Aspergillus niger, A. flavus, A.fumigatus and Candida albicans*) were assayed using disc diffusion method and then the zone of inhibition was analysed. All the extracts showed good to moderate antifungal and antibacterial activity although ethanolic extract depicted most prominent antibacterial activity against S.*aureus*.

Table 1. Antibacterial activity of rhizome extract of *Kaempferia galanga* - Disc diffusion method

Microorganisms	Ethanol extract 5mg/disc	Methanol extract 5mg/disc	Petroleum ether extract 5mg/disc	Chloroform extract 5mg/disc	Aqueous extract 5mg/disc	Standard antibiotic 30µg/disc
Bacteria	Diameter of inhibition zone in mm (mean)					
Staphylococcus aureus	21.3±0.08	18.1±0.30	12.3±0.36	10.4±0.25	9.2±0.91	23
Streptococcus faecalis	19.7±0.37	16.4±0.34	13.4±0.62	11.1±0.20	10.1±0.29	22
Bacillus cereus	18.4±0.41	14.2±0.13	14.3±0.29	14.5±0.32	9.3±0.26	23
Bacillus subtilis	19.7±0.20	15.1±0.57	11.3±1.12	12.6±0.26	10.3±0.25	20
Enterobacter aerogenes	16.2±0.37	15.6±0.26	10.9±0.67	10.8±0.46	9.5±1.20	20
Klebsiella pneumoniae	14.9±0.95	12.3±0.30	10.1±0.24	9.2.1±0.92	9.3±0.5	25
Salmonella typhi	15.5±0.17	11.4±0.50	12.7±0.23	10.7±0.56	8.8±1.39	20
Escherichia coli	17.8±0.55	12.8±0.34	12.4±0.25	10.4±0.98	8.2±0.92	20
Pseudomonas aeruginosa	12.1±0.40	12.4±0.40	9.3±0.49	9.2±0.19	8.9±1.30	23
Vibrio cholerae	12.3±0.16	12.4±0.05	9.3±0.25	8.2±1.30	8.2±1.30	24
Mean of three replicate determination ±S D ; Standard antibiotic- Kanamycin						

Table 2. Antifungal activity of rhizome extract of *Kaempferia galanga* -disc diffusion method

Microorganisms	Ethanol extract 5mg/disc	Methanol extract 5mg/disc	Petroleum ether extract 5mg/disc	Chloroform extract 5mg/disc	Aqueous extract 5mg/disc	Standard antibiotic 30µg/disc
Fungus	Diameter of inhibition zone in mm (mean)					
Aspergillus niger	16.3±0.45	14.2±0.26	12.4±0.39	11.5±0.38	9.3±0.27	24
Aspergillus flavus	15.3±0.36	13.2±1.20	11.4±0.21	9.24±0.91	9.2±1.10	23
Aspergillus fumigatus	14.0±0.48	10.8±1.89	10.3±0.46	9.6±1.29	9.2±1.5	25
Candida albicans	12.2±0.45	11.3±1.39	9.7±0.39	9.5±0.49	8.3±0.28	24
Mean of three replicate determination ±S D ; Standard antibiotic- Nystatin						

Figure 16: Anti bacterial activity and Antifumgal activity of rhizome extract of *kaempferia galanga*- disc diffusion method.

Antibacterial tests against acne *in vitro*, the physical stability and patch test using cream containing ethyl p-methoxycinnamate extracted from *Kaempferia galanga* L, rhizome

Elya B*et al* (2016)[24] Rimpang kencur (*Kaempferia galanga* L.) has an antibacterial agent from compound ethyl p-methoxycinnamate (EPMC).The antibacterial activity using EPMC against *P. acne*, *S. aureus* and *S. epidermidis* with the physical stability of the cream. The antibacterial activity and minimum inhibitory concentration of EPMC are 0.3, 0.6, 1.2 and 2.4% was done using disc diffusion method and broth dilution test. Data obtained from *in vitro* test of bacterial activity was analyzed using descriptive analysis and Complete Randomized Design (CRD) with 99% level of confidence. The result shows that all EPMC concentration has significant anti bacterial activity respectively gaining clear zone against *P. acne* (9.00, 11.50, 14.50 and 16.00 mm), *S. aureus* (9.00, 11.50, 16.50 and 22.00 mm) and *S. epidermidis* (10.50, 12.50, 20.50 and 27.00 mm). The EPMC compound with the 0.6, 1.2 and 2.4% concentration is proven to have MIC against *P. acne* bacterias, while on the *S. aureus* and *S. epidermidis* reaches up to 1.2 and 2.4% concentration.

Antimicrobial activity of *Kaempferia galanga* L against plant pathogen on rice

Suharti *et al* (2023)[26] *Rhizoctonia solani* and *Xanthomonas oryzae* are two main pathogens in rice plants that cause sheath blight and bacterial leaf blight disease. Controlling these two diseases using plant extracts is an alternative, environmentally friendly method. Plant extracts are known to have the ability to inhibit microbial growth. It is to determine the ability of *Kaempferia galanga* (aromatic ginger) extract to inhibit the growth of *Rhizoctonia solani* and *Xanthomonas oryzae* in-vitro and to determine the antimicrobial compounds contained in the extract. *Kaempferia galanga* was extracted using a maceration technique with 96% ethanol, followed by an antifungal test on *Rhizoctonia solani*with a diffusion well technique and an antibacterial test with a disc agar technique against *Xanthomonas oryzae* using two types of solvents (water and 96% ethanol) to obtain a concentration gradient (2, 4, 6, 8, and 10%). Then, the content of *Kaempferia galanga* compounds was examined using GC-MS. The results showed that *Kaempferia galanga* could inhibit the growth of pathogenic fungi and bacteria. In addition, several compounds withantimicrobial activity were found in the *Kaempferia galanga* extract,including germacrene-D, 1,8-cineol, borneol, caryophyllene, jasmone, and heptadecane.

***In vivo* cytotoxic and *In vitro* antibacterial activities of *Kaempferia galanga*Linn**

Pritesh Ranjan Dash *et al* (2014)[25] The *in vitro* antibacterial activities of *Kaempferia galanga* leaves and rhizomes was performed by disc diffusion method and determination of zone of inhibition of living microorganisms. Antibacterial activity were tested against gram positive bacteria such as *Staphylococcus aureus (S.aureus*), Bacillus cereus (B. cereus) and gram negative bacteria such as *Escherichia coli (E.coli), Pseudomonas aureus (P. aureus), Shigella dysenteriae (S. dysenteriae) and Klebsiella pneumoniae (K. pneumoniae). All* the extracts showed moderate activity against all the strains of bacteria mentioned except Klebsiella pneumoniae (K. pneumoniae).

Microorganism	Determination of zone of inhibition in mm					
	Cipro 5 µg/disc	ACR 400 µg/disc	PEF 400 µg/disc	CHF 400 µg/disc	MEF 400 µg/disc	ACL 400 µg/disc
Gram positive						
Staphylococcus aureus	22±0.71	10±1.47 (20.66%)	15±1.47 (46.48%)	13±1.47 (34.91%)	10±1.22 (20.66%)	14±1.47 (40.49%)
Bacillus cereus	15±0.82	8±0.71 (28.44%)	7±0.41 (21.77%)	10±0.41 (44.44%)	10±0.41 (44.44%)	6±0.41 (16.00%)
Gram negative						
Escherichia coli	21±1.08	13±1.08 (13.32%)	13±1.63 (38.32%)	15±0.71 (51.02%)	13±0.82 (38.32%)	14±0.82 (44.44%)
Pseudomonas aureus	21±1.08	8±0.41 (14.51%)	10±1.22 (22.67%)	10±0.82 (22.67%)	9±0.41 (18.36%)	10±0.71 (22.67%)
Shigella dysenteriae	21±0.41	12±0.82 (32.65%)	13±0.82 (28.32%)	10±0.41 (22.67%)	12±0.71 (32.65%)	12±0.82 (32.65%)
Klebsiella pneumonia	15±1.63	0	0	0	0	0

Values of the observed diameter zone of inhibition (mm). Incubation conditions for bacteria- 24 hours at 37 °C. The assay was performed in triplicate and the results are the mean of three values ± SEM. Within a bracket indicate the relative percentage of inhibition. ACR =Acetone extract of rhizome, PEF= Petroether fraction of rhizome, CHF=Chloroform fraction of rhizome MEF=Methanol fraction of rhizome and ACL=Acetone extract of leaf, 0= No Zone of Inhibition, Cipro = Ciprofloxacin.

***Figure 17: Antibacterial activity of different extracts of* Kaempferia galangal.**

Chemical components and biological activities of volatile oil of *Kaempferia galanga* Linn

Supinya Tewtrakul *et al* (2005)[27] The volatile oil of *Kaempferia galanga* exhibited marked activity against Gram-positive and Gram negative bacteria and also against a fungus, *Candida albicans*. by using agar disc diffusion method. The result revealed that the oil of this plant possessed marked antimicrobial activity against Gram-positive bacteria with the inhibition zones from 12.0-16.0 mm. and 8.0-12.0 mm. against Gram-negative

bacteria; whereas it potently inhibited *Candida albicans* with an inhibition zone of 31.0 mm., which was stronger than that of standard antifungal Clotrimazole (diameter = 25.0 mm.). It is suggested that the essential oil of this plant may be useful for treatment of the diseases caused by these bacteria and fungi, such as skin diseases and diarrhea. For brine shrimp lethality assay, the volatile oil of *Kaempferia galanga* give appreciable activity against brine shrimp lethality test with LD50 of 26.84 µg/ml. The results of bioactivities suggest that the essential oil of *Kaempferia galanga* could to be used for treatment of some microbial infections,whichalso agrees with the traditional use of this plant in treatment of those fungal- and bacterial-derived skin diseases.

Microbes	Diameter of inhibition zone (mm)	
	Essential oil of *K. galanga*	**Tetracycline (30 µg/disc)**
A) *Gram-positive bacteria*		
1. *Staphylococcus aureus* ATCC 25923	+ve, ϕ 12 mm.	+ve, ϕ 31 mm.
2. *Streptococcus faecalis*	+ve, ϕ 14 mm.	+ve, ϕ 15 mm.
3. *Bacillus subtilis*	+ve, ϕ 16 mm.	+ve, ϕ 18 mm.
	Essential oil of *K. galanga*	**Tetracycline (30 µg/disc)**
B) *Gram-negative bacteria*		
4. *Salmonella typhi*	+ve, ϕ 9 mm.	+ve, ϕ 21 mm.
5. *Shigella flexneri*	+ve, ϕ 12 mm.	+ve, ϕ 10 mm.
6. *Escherichia coli ATCC 25922*	+ve, ϕ 8 mm.	+ve, ϕ 23 mm.
	Essential oil of *K. galanga*	**Clotrimazole (2.5 µg/disc)**
C) *Fungi*		
7. *Candida albicans*	+ve, ϕ 31 mm.	+ve, ϕ 25 mm.

Figure 18: Antimicrobial activity of *Kaempferia galanga* essential oil and standard antibiotics by agar disc diffusion assay.

Anti-neoplastic potential of ethyl-p-methoxycinnamate of *Kaempferia galanga* on oral cancer cell lines

SolachuddinJ.AIchwan *et al* (2019)[28] The plant extract has also been reported to possess *in vitro* anti-cancer activities on various cancer cell lines such as human colon cancer SW620, cervical cancer C33A, and breast cancer MCF-7 cell lines. Ethyl-p-methoxycinnamate (EPMC), a major constituent of volatile oil of *Kaempferia galanga* has been attributed to its medicinal benefits.The anticancer potential of EPMC on oral cancer cells derived from human oral cavity, HSC-3 and Ca922 lines. MTT assay results showed that EPMC markedly induced cytotoxicity on HSC-3 (IC50 0.075 mg/mL) and Ca922 (IC50 0.085 mg/mL) cell lines. The apoptotic activity induced by EPMC was detected in both cell lines by flow cytometry and confirmed with Caspase 3/7 assay. Quantitative RT-PCR analysis revealed that EPMC-induced apoptosis in both lines elevated the mRNA levels of pro-apoptotic genes *caspase-9* and *PUMA*. It suggest that EPMC may be a potential candidate for oral cancer treatment.

Effects of Rhizoma *kaempferia* volatile oil on tumor growth and cell cycle of MKN-45 human gastric cancer cells orthotopically transplanted in nude mice

Xiao Y *etal* (2006)[29]The effects of Rhizome*kaempferia* volatile oil on tumor growth and cell cycle of MKN-45 human gastric cancer cells orthotopically transplanted in nude mice. One hundred and five nude mice orthotopically transplanted with MKN-45 human gastric cancer cells were randomly divided into seven groups: untreated group, normal saline-treated group, dissolvant-treated group, cyclophosphamide (CTX)-treated group and high-, medium-, and low-dose Rhizome *kaempferia*volatile oil-treated groups. Corresponding interventions were implemented in each group except the untreated group. The antitumor effects in vivo were evaluated. Cell cycle distribution and apoptosis of MKN-45 human gastric cancer cells were determined by using flow cytometry (FCM). The ultrastructure of MKN-45 gastric cancer cells was observed by a transmission electron microscope. In the high-, medium-, and low-dose Rhizome *kaempferia*volatile oil-treated groups, the growth inhibition rates of gastric cancer were 57.2%, 28.0% and 5.0% respectively, and the gastric cancer cells were arrested at G(0)/G(1) phase. This antitumor effect was dose-dependent. The apoptotic cells occurred more frequently in the high-dose Rhizome *kaempferia*volatile oil-treated group and the CTX-treated group than those in the medium- and low-dose Rhizome *kaempferia*volatile oil-treated groups. The Rhizome *kaempferia*volatile oil is an effective composition for growth inhibition of gastric cancer, and its mechanism may be related to regulating the cell cycle and inducing apoptosis.

Anticholangiocarcinoma activity and toxicity of the *Kaempferia galanga* Linn. Rhizome ethanolic extract

Asmare Amuamuta *et al*(2017)[2] The ethanolic extract of *Kaempferia galanga L* rhizome, ethyl-p-methoxycinnamate (EPMC) and 5-fluorouracil (5-FU) were evaluated for their cytotoxic activities against CCA cell line (CL-6) using MTT cell proliferation assay. Acute and subacute toxicity of the extract were evaluated in ICR (Imprinting Control Region) mice according to the OECD (International Organization for Economic Co-operation and Development) Guideline. Anti-CCA activity was evaluated in CCA- xenografted nude mice: Toxicity testing revealed no overt toxic effect up to the maximum single oral dose of 5000 mg/kg body weight and up to daily dose of 1000 mg/kg body weight for 30 days. The extract at the maximum tolerated dose level of 1000 mg/kg body weight for 30 days exhibited promising anti-CCA activity in CL6-xenografted nude mice as determined by inhibitory activity on tumor growth (58.41%) and lung metastasis (33.3%), as well as prolongation of survival time (62 days). The *Kaempferia galanga* rhizome extract and its bioactive compoundEPMC exhibited moderate cytotoxic activity against human CCA tumor (CL-6) cell line. Results of toxicity testing suggest that the extract was well tolerated up to the maximum single oral dose of 5000 mg/kg body weight and daily dose of 1000 mg/kg body weight for 30 days. The extract exhibited promising anti-CCA activity in CL6-xenografed nude mice as determined by significant inhibitory activity on tumor growth and lung metastasis, as well as prolongation of survival time.

***In vivo* cytotoxic and *In vitro* antibacterial activities of *Kaempferia galanga* Linn.**

Pritesh Ranjan Dash *et al* (2014)[25] Cytotoxicity was determined against *Artemia salina*brine shrimp nauplii. In the brine shrimp lethality bioassay all the extracts shows moderate cytotoxic activity when compared with the standard drug vincristine sulphate . For example, LC50 value of ACL was 4.78 µg/ml while the LC50 of the standard anticancer drug vincristine sulphate was 0.52 µg/ml .Control group nauplii remained unchanged (no lethality/mortality), is indicative of the cytotoxicity of all the extracts. The inhibitory effect of the extract might be due to the toxic compounds present in the active fraction that possess ovicidal and larvicidal properties. The metabolites either affected the embryonic development or slay the eggs . So the cytotoxic effects of the plant extracts enunciate that it can be selected for further cell line assay because there is a correlation between cytotoxicity and activity against the brine shrimp nauplii using extracts.

Sample	LC_{50} (µg/ml)	Regression equation	R^2
Vincristine Sulphate	0.52	Y = 32.61x+59.22	0.942
ACR	9.77	Y = 19.93x+30.18	0.943
PEF	6.76	Y = 20.20x+33.15	0.977
CHF	7.24	Y = 17.99x+34.36	0.923
MEF	9.77	Y = 23.25x+26.96	0.962
ACL	4.78	Y = 20.76x+35.76	0.954

ACR =Acetone extract of rhizome, **PEF**= Petroether fraction of rhizome, **CHF**=Chloroform fraction of rhizome **MEF**=Methanol fraction of rhizome and **ACL**=Acetone extract of leaf.

Figure 19: Result of *Kaempferia galanga* against on *Artemia salina.*

Study of Antinociceptive Activity of *Kaempferia galanga* Linn from Bangladesh in *Swiss albino Mice*

Pritesh Ranjan Dash *et al* (2015)[31] The antinociceptive activity was evaluated by using acetic acid-induced writhing, hot plate and tail immersion tests in *Swiss albino mice* at the doses of 100 and 200 mg/kg body weight p.o. The acetone extract of rhizome as well as petroether fraction ,chloroform fraction , methanol fraction and acetone extract of leaves were examined for antinociceptive activity. All the extracts displayed significant antinociceptive action in a dose dependent manner. In acetic acid induced writhing method, chloroform and methanol extract of rhizome (200 mg/kg) showed 81.22% and 70.12% writhing inhibition, respectively the standard drug Diclofenac-sodium (25 mg/kg) and Aspirin (100 mg/kg) exhibited 80.72% and 61.94% inhibition. In hot plate and tail immersion tests, the petroether extract of rhizome and acetone extract of leaves (200 mg/kg) produced maximum 69.41% and 81.69% nociception inhibition of thermal stimulus respectively. In this study Morphine (5 mg/kg) was used as standard. The acetone extracts and fractions of rhizome and leaves of *Kaempferia galanga* possess an anti nociceptive property which supports its use in traditional medicine.

Antinociceptive Activity of the Methanolic Extract of *Kaempferia galanga* Linn and Its Possible Mechanisms in Experimental Animals

Chutha Sae-wong *et al*(2008)[32] The methanolic extract of *Kaempferia galanga* Linn. (Zingiberaceae) was investigated for its antinociceptive activity and its possible mechanisms in mice and rats using acetic acid-induced writhing, formalin, hot plate and tail-flick tests. The extract at test doses of 50, 100 and 200 mg/kg PO clearly demonstrated antinociceptive activity in all tests. This activity was dose and time-dependent. The extract administered at 200 mg/kg PO had a stronger antinociceptive effect than aspirin (100 mg/kg PO) but less than morphine (5 mg/kg SC) in the formalin test in mice. Naloxone (2 mg/kg IP) abolished the antinociceptive activity of both morphine (5 mg/kg SC) and the extract (200 mg/kg PO) by reducing the reaction time of rat in the tail-flick test and in the mice hot plate test. The antinociceptive mechanisms appear to be both peripherally and centrally-mediated actions. The LD50

value of the extract given orally was estimated to be more than 5 g/kg in mice.

Antinociceptive activity of the methanolic extract of *Kaempferia galanga* Linn. in experimental animals
Wibool Ridtitid *et al* (2008)[32] The antinociceptive activity in mice and rats using acetic acid-induced writhing, formalin , hot plate and tail-flick tests. The extract at test doses of 50, 100 and 200 mg/kg, p.o. clearly demonstrated antinociceptive activity in all tests. This activity was dose- and time-dependent. The extract administered at 200 mg/kg, p.o. had a stronger antinociceptive effect than aspirin (100 mg/kg, p.o.) but less than morphine (5 mg/kg, s.c.). Naloxone (2 mg/kg, i.p.) abolished the antinociceptive action of both morphine (5 mg/kg, s.c.) and the extract (200 mg/kg, p.o.) in a similar manner. The methanol extract of *Kaempferia galanga* markedly demonstrated the antinociceptive action in experimental animals. The antinociceptive mechanisms appear to be both peripherally and centrally mediated actions and the opioid receptors are probably involved. In traditional medicine *Kaempferia galanga* was used against pain caused by various disorders.

Phenolics from the Rhizomes of *Kaempferia galanga L*and their Antioxidant Activity
Fazhuang Yao *et al* (2018)[33] Phenolics were isolated and identified from the rhizomes of *Kaempferia galanga L.*and purified by silicagel, ODS middle pressure liquid chromatography (MPLC) and high-performance liquid chromatography (HPLC), identified utilizing 1D, 2D nuclear magnetic resonance (NMR) and mass spectrum (MS). The radical scavenging ability of the isolated compounds was investigated via DPPH method.Ten phenolics were isolated from the rhizomes of sand ginger (*Kaempferia galanga* L.). DPPH radical scavenging was carried out to assess their antioxidant activity. some phenolics showed moderate antioxidant activity compared to those of ascorbic acid in DPPH. And these also demonstrated that phenolics may be partially responsible for the rhizomes of sand ginger's antioxidant activity.

Antioxidant and antineoplastic activities of methanolic extract of *Kaempferia galanga*Linn. Rhizome against Ehrlich ascites carcinoma cells
Hanif Ali *et al* (2017)[34] The antioxidant activities of methanol extract of *Kaempferia galanga* rhizome *In vitro* models and MTT assay.Membrane blebbing, chromatin condensation, nuclear fragmentations were observed after treatment with methanolic exract of *kaempferia galanga*. Methanolic exract of *Kaempferia galanga* exhibited strong antioxidant activity. TPC (Total phenolic content) and TFC (Total flavonoid content) were found strongly correlated ($P < 0.05$) with antioxidant activities of methanolic exract of *kaempferia galanga*.It may provide a natural source of antioxidant activity.

Ultrasound-enhanced subcritical water extraction of essential oils from *Kaempferia galanga* Linn and their comparative antioxidant activities
Qin Ma *et al* (2015)[35] The extraction of essential oils from *Kaempferia galanga* using ultrasound-enhanced subcritical water extraction (USWE) and antioxidant ability of the essential oils. The antioxidant activity of the essential oils was evaluated by the assays of the DPPH scavenging ability and the superoxide anion radical scavenging activity. The maximum yields (25.80 mg/g) of ethyl trans-p-methoxycinnamate were obtained at an extraction condition of temperature 120 °C, extraction time 20 min, extraction pressure 10 Mpa, ultrasonic power density 250 W/L, and ultrasound frequency 20 kHz. USWE was found to be superior to the other extraction methods in terms of its higher recovery yields of essential oil and its stronger anti-oxidant ability.

Chemical composition of the *Kaempferia galanga* Linn essential oil and its *in- vitro* and *in-vivo* antioxidant activities
Si-Yu Wang *et al* (2023)[36] The antioxidant activity was determined using the DPPH, ABTS, hydroxyl radical scavenging assays and reducing power assay *in vitro*. A *zebrafish* model was used to evaluate the protective effect of KGEO against H2O2-induced oxidative stress damage *in vivo* .*In vitro* pharmacological results shows that *Kaempferia galanga* essential oil had good free radical scavenging capacity in DPPH, ABTS, and hydroxyl radical scavenging assays and weak reducing capacity in the reducing power assay. In vivo z*ebrafish* experiments results indicated that the survival rate and heart rate increased, and ROS generation, cell death, and lipid peroxidation were attenuated after *Kaempferia galanga* essential oil treatment. In addition, a decrease in malondialdehyde (MDA) levels and increases in superoxide dismutase (SOD), catalase (CAT) and glutathione peroxidase (GSH-Px) activities were observed in the *Kaempferia galanga* essential oil treated groups.

Sedative activity of hexane extract of *Kaempferia galanga* Linn and its active compounds
Linfang Huang *et al* (2008)[37] The sedative effects of hexane extract of *Kaempferia galanga* L.and 2 active aromatic compounds (compound 1: ethyl trans-p-methoxycinnamate and compound 2: ethyl cinnamate) included in the extyract by means of inhalation in mice.Inhalation of hexane extract at the doses of 1.5 and 10mg showed significant reduction of locomotor activity, indicating considerable sedative and relaxant effects. Compound 1 and 2 were proved to possess sedative effects at 0.0014mg and 0.0012mg respectively.It suggest application of *Kaempferia galanga* L. and its constituents in aromatherapy.

Study of sedative activity of different extracts of *Kaempferia galanga* Linn in *Swiss albino mice*

Mohammad Shawkat Ali *et al* (2015)[38] The sedative activity of different extracts of rhizome and leaf of *Kaempferia galanga* was evaluated by using thiopental sodium induced sleeping time hole cross and open field tests in *Swiss albino mice* at the doses of 100 and 200 mg/kg body weight per oral (p.o). The acetone extract of rhizome as well as petroleum ether fraction, chloroform fraction, methanol fraction and acetone extract of leaf were examined for sedative activity.All the extracts exhibited significant 0reduction of onset and duration of thiopental sodium induced sleeping time, reduction of locomotor and exploratory activities in the hole cross and open field tests. In thiopental sodium induced sleeping time test, the chloroform extract of rhizome (200 mg/kg) shows maximum 358.55 % effect in duration of loss of righting reflex, whereas the standard drug Diazepam (2 mg/kg) produced 231.42 % effect. In hole cross and open field tests, maximum 95.09 % and 95.58 % suppression of locomotor activity were observed with the acetonic leaf extract (200 mg/kg) whereas suppression of locomotor activity of the standard drug Diazepam were 71.70 % and 70.58 % respectively. It indicates that the acetone extracts of rhizome and leaf of *Kaempferia galanga* including fractions possess central nervous system depressant properties which supports its use in traditional medicine.

Wound healing activity of alcoholic extract of *Kaempferia galanga* Linn in Wistar rats

Tara V Shanbhag *et al* (2006)[39] The wound healing effect of alcoholic extract of *Kaempferia galanga* and its effect in dexamethasone suppressed wound healing in Wistar rats. Three wound models viz. incision, excision and dead space wounds were used. The parameters were breaking strength in case of incision wounds, epithelialization and wound contraction in case of excision wound and granulation tissue dry weight, breaking strength and hydroxyproline content in case of dead space wound. The dexamethasone treated group showed a significant reduction in the wound breaking strength when compared to control group in incision type of wound model. Coadministration of *Kaempferia galanga* with dexamethasone had significantly increased the breaking strength of dexamethasone treated group. In excision wound model, the percentage of the wound contraction was significantly increased by *Kaempferia galanga* only on 16th day and it reversed the dexamethasone suppressed wound contraction on the 16 day. *Kaempferia galanga* significantly reduced the time required for epithelialization and reversed the epithelialization delaying effect of dexamethasone significantly.

Anti-Inflammatory Activity and Wound Healing Effect of *Kaempferia galanga*L. Rhizome on the Chemical-Induced Oral Mucosal Ulcer in Wistar Rats

Indah Suasani Wahyuni *et al* (2022)[40] This aimed to investigate anti-inflammatory activity and wound healing effect of the ethanol extract of *Kaempferia galanga* (EEKG)rhizome on the chemical-induced oral mucosal ulcer in Wistar rats. In this , 35 rats were divided into 7 groups (normal, negative, triamcinolone acetonide, and 4 EEKG groups). Acetic acid 70% was used as the oral mucosal ulcer inducer. Parameters observed were macroscopic and microscopic histopathological examinations.The results revealed that dose of 0.5% of the EEKG was effective in increasing the percent recovery of ulcer area and inflammation sign scores. Meanwhile, doses of 0.5–2% of EEKG were effective in reducing the histopathological score. Interestingly, topical EEKG was more effective compared with triamcinolone acetonide (the conventional therapy for oral mucosal ulceration).The EEKG has been confirmed its anti-inflammatory activity by accelerating the healing process on the chemical-induced oral mucosal ulcer in Wistar rats, based on the percent recovery of the ulcer area, the percent recovery of the inflammation sign score,and the histopathology score. *Kaempferia galanga* is very potential to be developed as a prospective phyto-pharmaceutical for the treatment of oral mucosal ulceration in human after clinical trials.

Wound healing properties of pharmaceutical gel containing isopimarane diterpene isolated from *Kaempferia galanga*Linn

Teeratad Sudsai *et al* (2022)[41] It is to investigate the wound healing properties of gel containing 6β-acetoxysandaracopimaradiene-1α, 9α-diol (KG6), a compound from *Kaempferia galanga*.KG6 gel formulations were prepared using 1.0% carbopol 940 as gelling agent. Three KG6 gel formulations (0.10, 0.25, 0.50% w/w) were subjected to heating-cooling test to determine their physical, chemical and biological stabilities. The wound healing properties of KG6 gel formulations were performed using RAW264.7 cells for anti-inflammatory effect, while their impact on cell proliferation and migration, collagen content and H2O2-induced oxidative stress was examined using human dermal fibroblasts (HDF).Gel containing 0.25% KG6 showed better chemical stability than other formulations. The 0.25% KG6 gel significantly increased cell viability (102.8%) and produced the highest HDF cell migration (91.9%) which was greater than that of Aloe vera gel (96.2, 78.4%, respectively). This gel exhibited anti-inflammatory activity via suppressing nitric oxide release and improved the viability of HDF cells against H2O2-induced oxidative stress. The 0.25% KG6 gels also increased collagen content in HDF cells.The gel formulation consisting of 0.25% KG6 with 1.0% of carbopol 940 found to be a promising pharmaceutical gel for wound treatments due to marked wound healing properties.

Standardization of*Kaempferia galanga L.* rhizome and vaso-relaxation effect of its key metabolite ethyl p-methoxycinnamate

Nupur Srivastava *et al* (2021)[42] Fresh rhizomes of *Kaempferia galanga* L. were procured from West

Bengal.The vasorelaxation effect of major phytochemical ethyl-p-methoxycinnamate(EPMC) and ethylcinnamate(EC) of *Kaempferia galanga* was evaluated on the main mesenteric arteries isolated from male *Wistar rats*. Specific BKca channel blocker tetraethylammonium,receptor antagonist, nitric oxide scavenging capacity, and antioxidant potential were also evaluated for its plausible mechanism.EPMC a dose-dependent relaxation in rat main mesenteric arteries (MMA) contracted. Similarly, in endothelium-denuded MMA rings, relaxation was also observed Moreover, relaxation response to EPMC has strongly inhibited when the tissue exposed to depolarizing high K+ containing buffer for the contraction. The point correlation dimension (pD2) values were also significantly decreased inhigh K+ treated arterial rings compared to control. Interestingly, when MMA rings incubated with a specific BKca channel blocker (TEA, 1 mM), the relaxation response to EPMC was also significantly blocked.The chemical standardization of *Kaempferia galanga* rhizome and EPMC is responsible for its vasorelaxation potential as demonstrated by the endothelium-independent response mediated by Ca2+ dependent potassium channels

Vasorelaxant effects of ethyl cinnamate isolated from *Kaempferia galangal* on smooth muscles of the rat aorta

Rozana Othman *et al* (2002)[43] From the rhizomes of *Kaempferia galanga*, ethyl cinnamate (EC) was isolated and its vasorelaxant effect was examined on the rat aorta. EC inhibited the tonic contractions induced by high K+ and phenylephrine (PE) in a concentration-dependent manner, with respective IC50 values of 0.30 +/- 0.05 mM and 0.38 +/- 0.04 mM. The relaxant effect against PE-induced contractions was greater in the presence of endothelium. Pre-treatment of the aorta with methylene blue and indomethacin significantly reduced the relaxant effect. The inhibitory effects of EC may involve inhibition of Ca2+ influx into vascular cells and release of nitric oxide (NO) and prostacyclin from the endothelial cells. Thus, the vasorelaxant effect of EC mediated through multiple pathways may explain the traditional use of the parent plant in treating hypertension.

Bioassay-guided isolation of a vasorelaxant active compound from *Kaempferia galanga L*

R. Othman *et al* (2006)[6] Bioassay-guided fractionation was performed on a crude dichloromethane extract of *Kaempferia galanga* L. using chromatography techniques. Screening of the extract for biological activity started with the brine shrimp lethality bioassay, followed by the study of its antihypertensive activity on anaesthetized rats, which involved monitoring of the extract's effect on mean arterial blood pressure. The components of the fractions obtainedfrom the separation procedures were analyzed using gaschromatography (GC). The yield of the CH2Cl2 extract was 0.29% of the crude plant extract. Analysis of the data for brine shrimp lethality test using the Finney computer program. Intravenous administration of the extract induced a dose-related reduction of basal mean arterial pressure (MAP) (130±5 mmHg) in the anaesthetized rat, with maximal effects seen after 5–10 min of injection. The gas chromatogram showed that the common compound in the active fractions obtained from the bioassay-guided fractionation of the CH2Cl2 extract was ethyl cinnamate. This vasorelaxant active compound, ethy l cinnamate, was isolated as a colorless oil. Ethyl p-methoxycinnamic acid was also isolated as white needles but did not exhibit any relaxant effect on the precontracted thoracic rat aorta.

Study of anti-diarrheal activity of two medicinal plants of Bangladesh In castor-oil induced diarrhoea

Ali *et al* (2014)[44] Experimental animals were randomly selected and divided into four groups denoted as control, standard and test samples (group-I and group-II) and consisting of 6 mice in each group. Mice were fasted for 18h before the test with free access to water. Control (water 5ml/kg), standard (Loperamide 3mg/kg) and test samples *Kaempferia galanga* (100 and 200 mg/kg) were administered orally. Then 1 h later, 0.3ml castor oil was administered orally to each mouse to induce diarrhea. The total numbers of both dry and wet faeces excreted by the animals were counted every hour for a period of 4 h. The total number of diarrheal faeces of the control group was considered 100%. In this castor oil-induced diarrhea experiment, the mice group that did not receive the plant extracts showed typical diarrheal signs and symptoms such as watery and frequent defecation. The effects of *Kaempferia galanga* were found to be statistically significant($p < 0.05$-0.001) which shows it has the power to inhibit the severity of diarrhea induced by castor oil.

Diaryl heptanoids with hypoglycemic potency from the rhizomes of *Kaempferia galanga* Linn (Anti-diabetic activity)

Tian Wang *et al* (2023)[45] Five new diarylheptanoids, kaemgalangins A–E (1–5), and seven known ones were isolated from the rhizomes of *Kaempferia galanga*. The structures of new compounds were identified by spectroscopic analyses involving 1D and 2D NMR, HRESIMS, IR, UV, [α]D, ECD calculations, and chemical methods. All compounds were tested for their hypoglycemic effects against α-glucosidase, Gpa and PTP1B enzymes, and stimulative effects on GLP-1 secretion. Kaemgalangins A (1) and E (5) have significant inhibition on α-glucosidase with IC50 values of 45.3 and 116.0 μM; renealtin B (8) showed inhibition on GPa with an IC50 value of 68.1 μM; whereas all compounds were inactive to PTP1B. Docking study manifested that 1 well located in the catalytic pocket of α-glucosidase and OH-4″ played important roles in maintaining activity. Moreover, all compounds showed obviously stimulative effects on GLP-1 with promoting rates of 826.9%–1738.3% in NCI-H716 cells. This study suggests that the diarylheptanoids in *Kaempferia galanga* have antidiabetic potency by inhibiting α-

glucosidase and Gpa enzymes, and promoting GLP-1 secretion.

An *in vitro* analysis on the antioxidant and anti-diabetic properties of *Kaempferia galanga* rhizome using different solvent systems

Vishaka S *et al* (2022)[46] The *Kaempferia galanga* rizhome extract effectively inhibited alpha amylase and alpha‑glucosidase activity indicates that it have anti‑diabetic properties. Accordingly,it implies that *Kaempferia galanga* rizhome may be used to treat diabetes mellitus as well as to control oxidative stress and the illnesses associated with it.By observing *Kaempferia galanga* rizhomes alpha‑glucosidase and alpha‑amylase inhibitory activity,the *in vitro* diabetic activity was assessed.

Possible site of action of *Kaempferia galanga* Linn in killing Culex quinquefasciatus larvae.

D. Insun *et al*(1999)[47] Extracts of the rhizomes of *Kaempferia. galanga* were tested for their toxicity against *Culex quinquefasciatus larvae*. It is concluded that the ethanolic fraction has a specific site of action on the anal gills of the larvae, by destruction of the irregular ridge-like reticulum on the surface of gills which function as ionic regulators.

Repellent and Insecticidal Effects of the Essential Oil of *Kaempferia galanga* Linn Rhizomes to *Liposcelis bostrychophila* (Psocoptera: Liposcelidae)

Xin Chao Liu *et al* (2014)[48] It is to determine chemical composition and repellent and insecticidal activities of the essential oil of *Kaempferia galanga* rhizomes against the *booklouse, Liposcelis bostrychophila Badonnel*, and to isolate insecticidal or repellent constituents from the oil. The essential oil was obtained by hydrodistillation and analyzed by gas chromatography-mass spectrometry. Twenty-eight components of the oil were identified. The major compounds in the oil were ethyl-ρ-methoxycinnamate (38.6%), ethyl cinnamate (23.2%), 1,8-cineole (11.5%), trans-cinnamaldehyde (5.3%), and borneol (5.2%). On bioactivity-guided fractionation, four active constituents were isolated from the oil and identified as 1,8-cineole, ethyl cinnamate, ethyl ρ-methoxycinnamate, and trans-cinnamaldehyde. Trans-Cinnamaldehyde was strongly repellent to booklice, whereas ethyl cinnamate and ethyl ρ-methoxycinnamate were weakly repellent and 1,8-cineole did not repel booklice. It indicate that the essential oil and its constituent compounds have potential for development into natural insecticides or fumigants and repellents for control of insects in stored grains.

Larvicidal, Pupicidal* And Smoke Toxicity Effect Of *Kaempferia galanga* Linn To The Malarial Vector, *Anopheles Stephensi

Abirami Dhandapani *et al* (2011)[49] Laboratory investigation have been made to test the *larval* and *pupal* toxicity, smoke toxicity and repellent potential of methanolic extract of *Kempferia galanga* at different concentrations (0.25%, 0.5%, 1.0%, 2.0% and 4.0%) against the different instar (I, II, III and IV) larvae and pupae of *Anopheles stephensi*. Methanolic extract of *Kaempferia galanga* shows considerable toxicity effect against larvae and pupae of Anopheles stephensi. Lethal concentration (LC50 and LC90) has been worked out on different larval stages of *Anopheles stephensi*. The LC50 and LC90 values of *Kaempferia galanga f*or I instar larvae were 0.63 %,3.15 %, II instar 0.86 %, 3.66%, III instar 1.12%, 4.14%, IV instar 1.43%, 4.55%, respectively. The LC50 and LC90 values of pupae were 0.69%, 3.05%. The results of larvicidal and pupicidal activity of *Kaempheria galanga* are presented in the Table 1.The repellent activity of different concentrations of *K. galanga* (0.25, 0.5, 1.0, 2.0 and 4.0 %) on the malarial vector, *Anopheles stephensi* was shown in figure 18.

Concentration of extract (%)	Number of Adult Mosquito	No.of Mosquito landing(hrs)						% of repellency (After 6 hours)
		1/2	1	11/2	2	21/2	3	
0.25	50	6	8	10	12	14	16	68
0.5	50	4	6	10	13	14	15	70
1.0	50	0	0	5	6	10	12	76
2.0	50	0	0	4	4	6	8	84
4.0	50	0	0	0	0	3	5	90
control	50	12	17	22	29	35	47	6

Figure 19: Repellent potential of methanolic extract of *K.galanga* on the malarial vector ,*Anopheles stephensi.*

Study of anthelmintic and insecticidal activities of different extracts of *Kaempferia galanga* Linn

Pritesh Ranjan Dash*et al* (2017)[50] The Antihelminthic activity evaluated by using different extracts of the rhizome of *Kaempferia galanga*. *Pheretima posthuma* was selected as test animal while 25, 50, 100 mg/ml concentrations of samples were tested in the bioassay, from which time of paralysis and time of death of worms were estimate.In anthelmintic study, extracts exhibited its activity in dose-dependent manner showing higher the concentration, higher the effect. Extracts of ACR, PEF, CHF and MEF in case of 100 mg/ml concentration exhibited its paralytic effect followed by death within a short period of time among which ACRextract gave the best result which only took approx. 20 mins to show paralytic effect and 35 min for death sentence.

Hypo - pigmentary Effects of Ethyl P-Methoxycinnamate Isolated from *Kaempferia galanga* Linn

Hyun-Ju Ko *et al* (2013)[51] Isolation of crystals from the chloroform fraction of an ethanol extract of *Kaempferia galanga* and identified it as ethyl p-methoxycinnamate through nuclear magnetic resonance analysis. In this study, ethyl p-methoxycinnamate significantly decreased melanin synthesis in B16F10 murine melanoma cells stimulated with α-melanocyte stimulating hormone (α-MSH). In a cell-free system, however, ethyl p-methoxycinnamate did not directly inhibit tyrosinase, the rate-limiting enzyme of melanogenesis. Instead, it inhibited tyrosinase activity in B16F10 cells in a dose-dependent manner. Furthermore, Western blot analysis showed that ethyl p-methoxycinnamate decreased microphthalmia-associated transcription factor and tyrosinase levels in α-MSH-stimulated B16F10 cells. These pigment-inhibitory effect of ethyl p-methoxycinnamate results from downregulation of tyrosinase. Ethyl p-methoxycinnamate isolated from *Kaempferia galanga* would be developed as a skin whitening agent to treat hyperpigmentary disorders.

Hexane extract of *Kaempferia galanga L* suppresses melanogenesis via p38, JNK and Akt

In, Myung-Hee *et al* (2016)[52] In this study investigation of the inhibition of melanogenesis by hexane extract of *Kaempferia galanga L* (HKG) in B16F10 melanoma cells. Cell-free tyrosinase, melanin contents, intracellular tyrosinase activity and western blot analysis were performed to elucidate the effects on anti-melanogenesis. Cytotoxicity of the extracts was measured using 3-(4,5-dimethylthiazol-2-yl)-2,5-diphenyltetrazolium bromide (MTT) assay and determined the concentration of 12.5, 25 μg/ml. HKG significantly inhibited to activities of intracellular tyrosinase and melanin synthesis in the absence or presence of α-melanocyte stimulating hormone (α-MSH) with dose-dependent manner. And HKG inhibited the expression of tyrosinase, tyrosinase-related protein 1 (TRP-1) and tyrosinase-related protein 2 (TRP-2), regardless of the presence or absence of α-MSH. HKG also down-regulated phosphorylation of p38 and JNK, and up-regulated phosphorylation of Akt. These effects were not related to its cytotoxicity action. These results indicate that HKG has the potential to be a useful therapeutic agent for treating hyperpigmentation disorders and as a beneficial additive in whitening agents in cosmetics industry.

Ethyl p-methoxycinnamate isolated from a traditional anti-tuberculosis medicinal herb inhibits drug resistant strains of*Mycobacterium tuberculae in- vitro*

Divya Lakshmanan *et al* (2011)[53] *Kaempferia galanga*, yielded an anti-TB molecule, ethyl p-methoxycinnamate (EPMC). By resazurin microtitre assay (REMA), EPMC was shown to inhibit M. tuberculae H37Ra, H37Rv, drug susceptible and multidrug resistant (MDR) clinical isolates (MIC 0.242–0.485 mM). No cross resistance was observed to any standard anti-TB drugs in the MDR strains. The compound did not inhibit any prototype bacteria tested. EPMC seems to be a potential anti-TB lead molecule.

Ultraviolet Radiation Protective and Anti-Inflammatory Effects of *Kaempferia galanga* L. Rhizome Oil and Microemulsion: Formulation, Characterization, and Hydrogel Preparation

Chuda Chittasupho *et al* (2022)[54] The UV protection of *Kaempferia galanga* rhizome oil and its microemulsion were investigated using an ultraviolet transmittance analyzer. The protective effect of *Kaempferia galanga* rhizome oil against LPS-induced inflammation was investigated via MTT and nitric oxide inhibitory assays. *Kaempferia galanga* rhizome oil and microemulsion demonstrated moderate sun protective activity and reduced the nitric oxide production induced by LPS in macrophage cells, indicating that microemulsion containing *Kaempferia galanga* rhizome oil may help protect human skin from UV damage and inflammation. The use of *Kaempferia galanga* rhizome oil as a natural sun-protective substance may provide a protective effect against inflammation on the skin. *Kaempferia galanga* rhizome oil microemulsion was successfully incorporated into the hydrogel and has the potential to be used as a topical sunscreen preparation.

Determination of sun protection factor and antioxidant properties of cream formulation of kencur *(Kaempferia galanga L)* and temu kunci (Boesenbergia pandurata (Roxb.) Schlecht

Shintia Lintang Charisma *et al* (2018)[55] *Kaempferia galanga* rhizome contain ethyl-p-methoxycinnamate (EPMS) which has sunscreen properties.This research used Simplex Latice Design (SLD) model with 2 components of kencur extract and temu kunci extract. Based on the SLD model obtained optimum formula design, then the SPF values and antioxidant activity were studied by UV spectrophotometric method and DPPH method respectively.Based on SLD model obtained optimum formula that containing kencur: temu kunci extract 80%: 20%(formula A) and 70%: 30%(formula B). The SPF values of kencur extract, formula A and formula B were 4.505, 5.024 and 4.511 respectively. The SPF value of the optimum formulations were higher than SPF value of kencur extract.

Antithrombotic Effect of *Kaempferia galanga* L. and *Curcuma xanthorrhiza* Roxb. on Collagen-epinephrine induced thromboembolism in Mice

Fadlina Chany Saputri *et al* (2018)[56] The ethanol extracts of *Kaempferia galanga* and *Curcuma xanthorrhiza* were orally administered with three different doses (7, 14 and 28 mg/20 g BW) in two experimental mouse models. Bleeding time prolongation was observed on mice tail that had been cut and the survival rate of mice was observed after thromboembolism induction by collagenepinephrine. These two experiments were observed after 7 days

extracts pre-treatment and compared to the positive control, aspirin.Both *Kaempferia galanga* and *Curcuma xanthorrhiza* extracts significantly protected mice from thromboembolic death.*Kaempferia galanga* and *Curcuma xanthorrhiza* extracts have a potential to be developed as antithrombotic agents against platelet thromboembolism.

PHYTOCHEMICAL REVIEW

Subhash Chandra Mishra *et al* (2021)[57] The objective of this study was to screen the phytochemicals, estimate the content of phenolic, flavonoids and alkaloid compounds of the rhizomes of *Kaempferia galanga* Linn. Qualitative analysis of various phytochemical constituents and quantitative analysis of total phenol, flavonoids and alkaloids were determined. Phytochemical analysis of ethanolic extract of the plant revealed the presence of flavonoids, alkaloids, saponins, phenolics, carbohydrate, and tannin. The total phenolic, flavonoids and alkaloids content of ethanolic extract of K. galanga rhizomes were 0.813, 1.146.

S. No.	Constituents	Chloroform extract	Ethyl acetate extract	Ethanol extract	Aqueous extract
1.	Alkaloids				
	A) Hager's Test:	-Ve	-Ve	-Ve	-Ve
2.	Glycosides				
	A) Legal's Test:	-Ve	-Ve	-Ve	-Ve
3.	Flavonoids				
	A) Lead acetate Test:	-Ve	-Ve	+Ve	+Ve
	B) Alkaline Reagent Test:	-Ve	-Ve	+Ve	-Ve
4.	Saponins				
	A) Froth Test:	-Ve	+Ve	+Ve	+Ve
5.	Phenolics				
	A) Ferric Chloride Test:	-Ve	-Ve	+Ve	+Ve
6.	Proteins				
	A) Xanthoproteic Test:	-Ve	-Ve	-Ve	-Ve
7.	Carbohydrate				
	A) Fehling's Test:	+Ve	-Ve	+Ve	+Ve
8.	Tannin				
	A) Gelatin test:	+Ve	+Ve	+Ve	+Ve

Figure 20: Result of phytochemical screening of extracts of *K. galanga L.*

S. No.	Extracts	Total phenolic content (mg/100mg of dried extract)	Total flavonoids content (mg/ 100 mg of dried extract)	Total alkaloid content (mg/ 100 mg of dried extract)
1	Chloroform	-	-	-
2	Ethyl acetate	-	-	-
3	Ethanol	0.813	1.146	-
4	Aqueous	0.572	0.490	-

Figure 21: Estimation of total phenolic, flavonoids and alkaloid content of *K. galanga L.*

Phyo moh moh zin*et al* (2019)[15] Preliminary phytochemical investigation on rhizomes from *Kaempferia galanga* L. was carried out to examine the plant constituents. The powdered rhizomes of *Kaempferia galanga*L. was tested qualitatively for the presence or absence of alkaloid, α-amino acid, carbohydrate, starch, reducing sugar, cyanogenic glycoside, glycoside, phenolic compound, saponin, tannin ,flavonoid, steroid and terpenoid were observed in the rhizomes. α-amino acids and cyanogenic glycoside were absent.

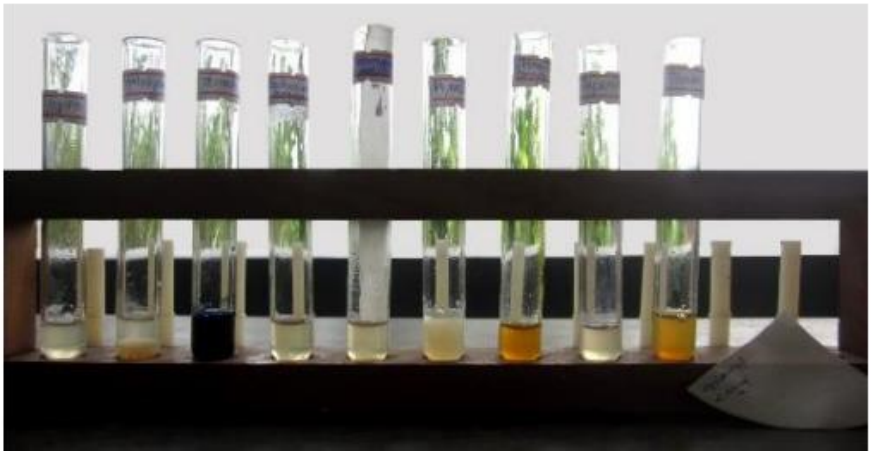


Figure 22: Phytochemical test.

No	Test	Extract	Test reagents	observation	
1	Alkaloid	1%HCL	(1)Mayer's Reagent (2)Wagner's Reagent (3) Dragendroff's Reagent	White ppt Brown ppt Orange ppt	+ + +
2	α-amino acids	H_2O	Ninhydrin solution	No change in colour	–
3	Carbohydrate	H_2O	10%α-naphthol+conc-H_2SO_4	Red ring	+
4	Starch	H_2O	I_2KI solution	Blue color	+++
5	Reducing sugar	H_2O	Benedict's solution	Brick red ppt	+
6	Cyanogenic glycoside	H_2O	(1)Conc-H2SO4 acid (2)Sodium picrate paper	No change in color	–
7	Glycoside	H_2O	10%lead acetate solution	White ppt	+
8	Phenolic compound	H_2O	Ferric chloride	Deep blue color	+
9	Saponin	H_2O	Distilled water	Frothing	+
10	Tannin	H_2O	Ferric chloride	Deep blue color	+
11	Flavonoid	EtOH	(1)Mg turning (2)Conc HCL	Pink color	+
2	Steroid	P.E	Acetic anhydride+conc- H2SO4	Blue green color	+
13	Terpenoid	P.E	Acetic anhydride+conc- H2SO4	Deep pink color	+

Puralae Channabasavaiah Jagadish*et al* (2016)[58] The petroleum ether (SKG-1), ethyl acetate (SKG-2) and alcohol (SKG-3) extracts yielded a golden yellowish oily liquid, dark brownish semi-solid residue and black semi-solid residue, respectively and yields were 3.5, 3, and 2.5% w/w with respect to dried powdered material of rhizome. Crude extraction of K. galanga rhizome with alcohol,designated as KG produced brownish black semisolid residue with the yield of 4% w/w. The preliminary phytochemical studies revealed the presence of flavonoids, phenolics, fixed oils, saponins, steroids, tannins and triterpenoids in K. galanga L rhizome.Among the extracts, petroleum ether extract (SKG-1) and crude alcoholic extract (KG) had the maximum quantity of ethyl-p-methoxycinnamate.The presence or absence of individual phytochemical in the respective extract is represented in Table 5.

Phytochemicals	SKG-1	SKG-2	SKG-3	KG
Carbohydrates	_	_	_	_
Alkaloids	_	_	_	_
Glycosides	_	_	_	_
Flavonoids	_	+	+	+
Phenolics	_	+	+	+
Fixed oils	+	+	+	+
Saponins	_	_	_	+
Steroids and sterols	+	_	_	+
Tannins	_	+	_	+
Triterpenoids	+	+	_	+

+ and – signs indicate the presence or absence of respective phytochemical in the extracts.

ANALYTICAL REVIEW

Supinya Tewtrakul *et al* (2005)[27] Volatile oil of dried rhizome of *Kaempferia galanga* obtained by water distillation was determined for its chemical components using gas chromatography and mass spectrometry (GC-MS). The major chemical constituents were identified as ethyl-p-methoxycinnamate (31.77%), methylcinnamate (23.23%), carvone (11.13%), eucalyptol (9.59%) and pentadecane (6.41%), respectively.

Peak number	Components	Retention time (min.)	Peak area %
1	pinene	3.32	1.28
2	camphene	3.50	2.47
3	carvone	4.19	11.13
4	benzene	4.32	1.33
5	eucalyptol	4.45	9.59
6	borneol	5.94	2.87
7	methyl cinnamate	8.89	23.23
8	pentadecane	9.00	6.41
9	ethyl-*p*-methoxycinnamate	11.21	31.77
	unidentified		9.94
	total		100.00

***Figure 23: Volatile oil components, retention time and peak area (%) of* Kaemferia galanga oil.**

Nonglang *et al* (2022)[59] Studies have investigated the percentage of extractive yield obtained from the freeze-dried ethanol extract of *K. galanga (*rhizome) was found to be 7.28% .Total polyphenol content (TPC) of 23.55±0.5 mg gallic acid equivalent (GAE)/g dry weight of extract and total favonoid content (TFC) of 100±1.414 mg rutin equivalents (RE)/g dry weight of extract were found. High-performance thin-layer chromatography (HPTLC) analysis shows the best separation of bands at diferent retention factor (Rf) values, when employing the solvent system 2-butanol/1-propanol/water in the ratio of 3:1:1 (v/v/v). Gas chromatography-mass spectroscopy (GCMS) analysis confrms the presence and identifcation of various phytocompounds, with ethyl p-methoxycinnamate identifed as the major active compound.

Peak#	Max Rf value	Max height	Area	Area%
1	0.359	0.0466	0.00192	2.63
2	0.510	0.2106	0.00845	11.58
3	0.556	0.1795	0.00594	8.13
4	0.776	0.7085	0.05666	77.65

***Figure 24: HPTLC fngerprinting of the ethanolic extract of* K.galanga.**

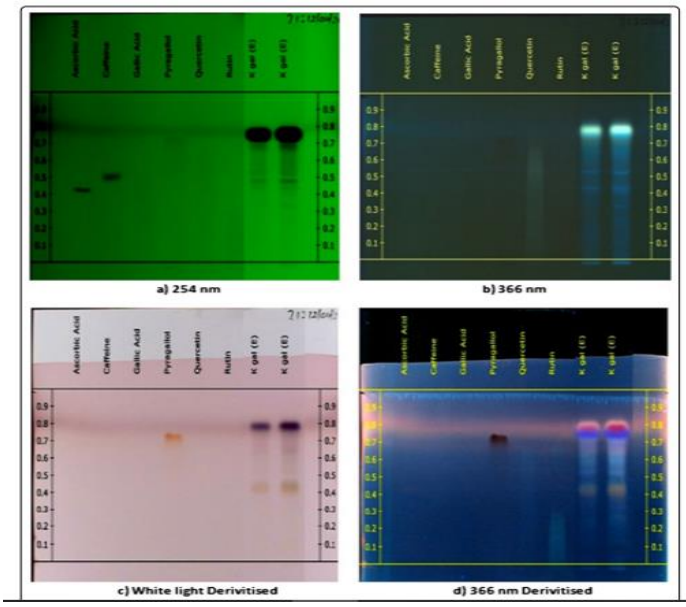


Figure 25: HPTLC band chromatogram of the ethanolic extract *of K. galangal.*

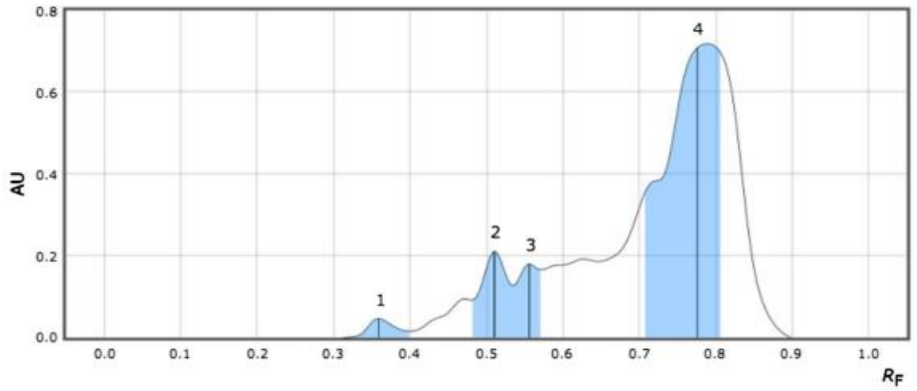


Figure 26: HPTLC spectrum peak chromatogram of the ethanolic extract of *Kaempferia galangal.*

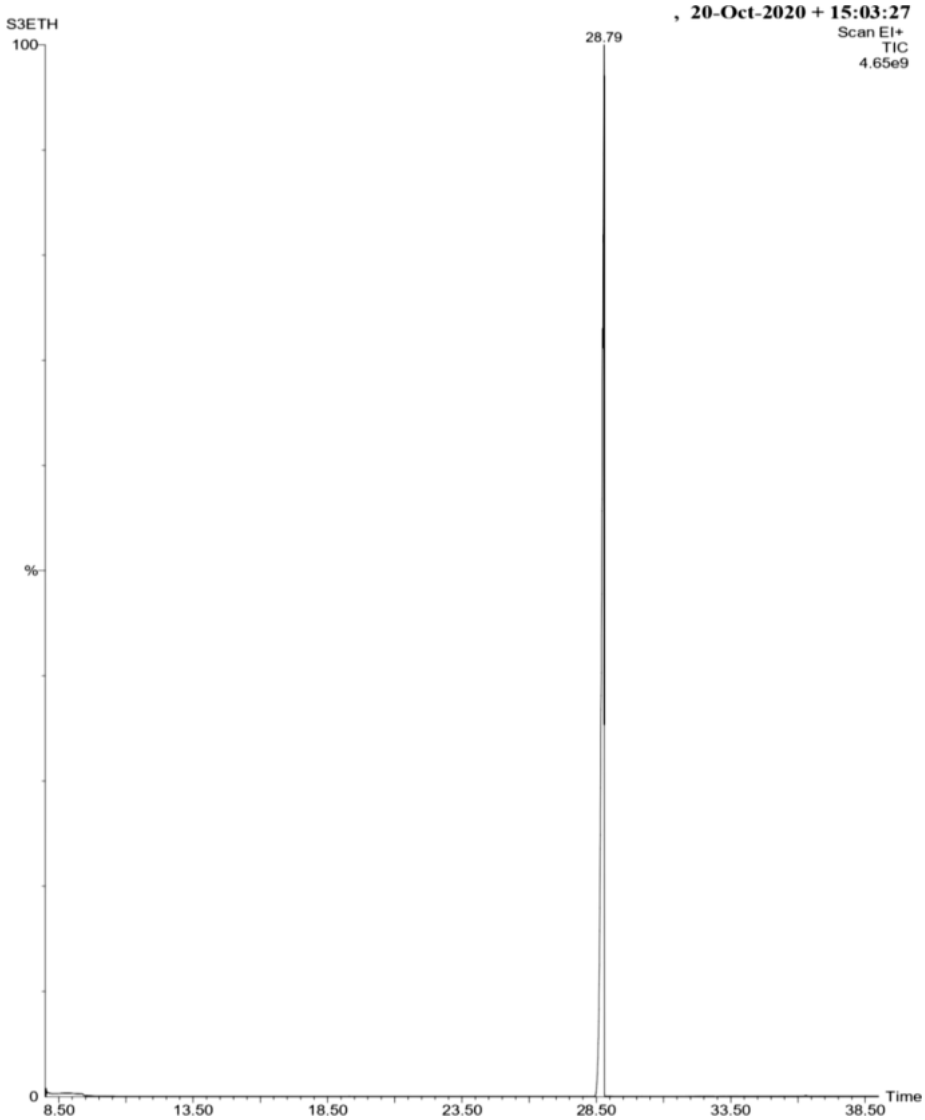


Figure 27: GCMS peak chromatogram of the ethanolic extract of *K. galangal.*

Bhuiyan *et al* (2008)[60] *Kaempferia galanga* Linn. leaf and rhizome oils, obtained by hydrodistillation, were analyzed by gas chromatography mass spectroscopy (GC-MS). One hundred and eight components were identified in the leaf oil. The major components were linoleoyl chloride (21.42%), caryophyllene oxide (11.75%), cubenol (9.66%) and caryophyllene (5.60%). Eighty one components were identified in rhizome oil with the main components being 2-propenoic acid, 3-(4-methoxyphenyl),-ethyl ester (63.36%), ethyl cinnamate (6.31%), 4-cyclooctene -1-methanol (4.61%), caryophyllene oxide (4.37%) and limonene (3.22%). The compositions of both oils varied qualitatively and quantitativelyGas chromatography mass spectroscopy

(GC-MS) was used to examine the hydrodistillation-obtained oils from the leaves and rhizomes of *Kaempferia galanga* Linn. In the leaf oil, one hundred and eight components were found. Linoleoyl chloride (21.42%), caryophyllene oxide (11.75%), cubenol (9.66%), and caryophyllene (5.60%) were the main constituents. Eighty-one constituents were found in rhizome oil, with 2-propenoic acid, 3-(4-methoxyphenyl),-ethyl ester (63.36%), ethyl cinnamate (6.31%), 4-cyclooctene -1-methanol (4.61%), caryophyllene oxide (4.37%), and limonene (3.22%) being the leading constituents. Both oils' constituents differed both qualitatively and quantitatively.

TOXICOLOGICAL REVIEW

Asmare Amuamuta *et al* (2017)[2] Studied that the *Kaempferia galanga* Linn. Rhizome extract and its bioactive compound EPMC exhibited moderate cytotoxic activity against human CCA tumor (CL-6) cell line. Although result of cytotoxicity test suggests relatively low selectivity of the extract on CCA cells, results of toxicity testing revealed no overt toxicity up to the maximum single oral dose of 5000 mg/kg body weight and daily dose of 1000 mg/kg body weight for 30 days. The extract at the maximum tolerated dose of 1000 mg/kg body weight for 30 days exhibited promising anti-CCA activity in CL6 x*enografed nude mice* as determined by significant inhibitory activity on tumor growth and lung metastasis, as well as prolongation of survival time. In an effort to develop an effective alternative treatment option against CCA, further studies should be carried out to confirm its tolerability profile following chronic dosing, as well as pharmacological activities, molecular and cellular mechanisms of action, and pharmacokinetics of the bio active compound EPMC. *In vivo* evaluation of anti-CCA activity of EPMC in animals may not be required considering the markedly low concentrations and equipotent cytotoxic activity of both the crude extract and the pure compound EPMC against CCA cells. It is likely that other unidentified constituents in the extract may act synergistically to produce anti-CCA.

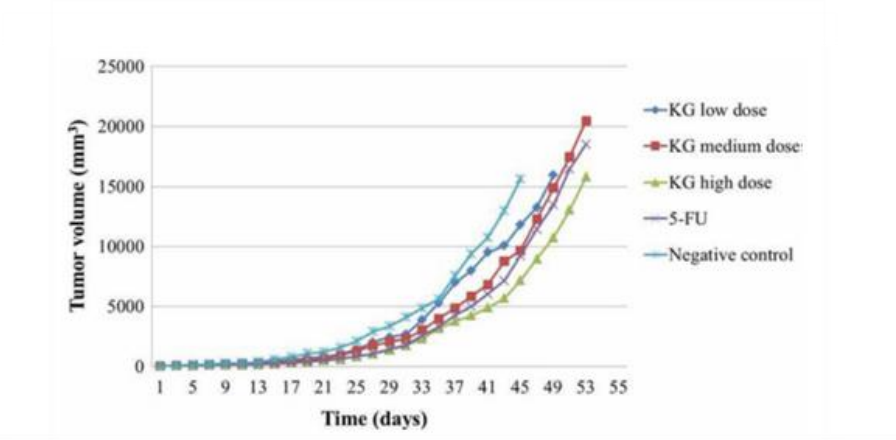


Figure 28: Anti-CCA activity and tumor volume (TV) progression (mm3) in CCA (CL6)-xenografted nude mice following initiation of treatment with K. galanga Linn. extract at high (1000 mg/kg body weight), medium (500 mg/kg body weight), and low (100 mg/kg body weight),medium (500 mg/kg body weight), and low (100 mg/kg body weight) dose levels versus the control groups (vehicle treated and 5-FU treated) during the investigation period. Treatment was started on day 7th after tumor transplant induction. Median survival time of the CCA-xenografted nude mice treated with the high dose extract [1000 mg/kg body weight: 62 (53.2–71.8) days] and 5-FU [59.0 (55.0–63.0) days] were significantly longer than the untreated control mice [49 (54.4–52.6) days]. Each data point is the median value of 6 tumors (from 3 male and 3 female mice) for each treatment group.

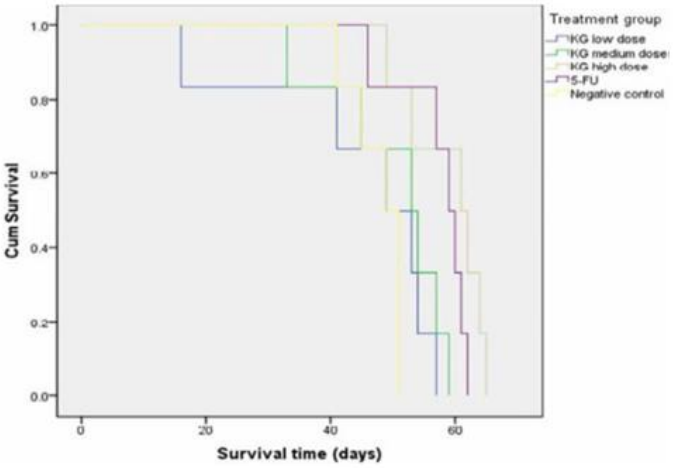


Figure 29: Anti-CCA activity and tumor volume (TV) progression (mm3) in CCA (CL6)-xenografted nude mice following initiation of treatment with *Kaempferia galanga* Linn. extract at high (1000 mg/kg body weight), medium (500 mg/kg body weight), and low (100 mg/kg body weight) dose levels versus the control groups (vehicle treated and 5-FU treated) during the investigation period. Treatment was started on day 7th after tumor transplant induction. Median survival time of the CCA-xenografted nude mice treated with the high dose extract [1000 mg/kg body weight: 62 (53.2–71.8) days] and 5-FU [59.0 (55.0–63.0) days] were significantly longer than the untreated control mice [49 (54.4–52.6) days]. Each data point is the median value of 6 tumors (from 3 male and 3 female mice) for each treatment group.

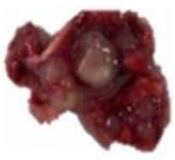
Treatment group	Time at autopsy (weeks)	Lung metastasis	
		Macrometastasis	Proportion of mice without metastasis
Low dose *K. galanga* Linn. extract (100 mg/kg body weight)	3–9		0/6 (0%)
Medium dose *K. galanga* Linn. extract (500 mg/kg body weight)	5–9		1/6 (16.7%)
High dose *K. galanga* Linn. extract (1000 mg/kg body weight)	7–10		2/6 (33.3%)
Untreated control	6–7		0/6 (0%)
5-FU treated (40 mg/kg body weight)	7–9		1/6 (16.7%)

***Figure* 30: Representative tumor metastasis and proportion of mice with metastasis in CL-6 xenografted nude mice treated with *Kaempferia galanga* Linn. extract and control (untreated and 5-FU) groups.**

S Siska*et al* (2022)[61] examined that acute toxicity of the ethyl acetate fraction of KG (EAFKG) with parameters of blood chemistry value, and liver and kidney histological morphology. 40 DDY strain mice, consisting of males and females with weights ranging from 20-35 g, were used in this study. The mice are divided into four groups for each sex. Groups 1, 2, 3, and 4 received the EAFKG at a dose of 0.128; 0.64; 3.2; and 16 g/Kg BW, respectively, and were administered orally. Observations are carried out for 24 hours. The levels of serum creatinine, AST, and ALT were detected with a clinical spectrophotometer. According to the test results, both male and female mouse groups had no fatalities. The EAFKG rhizome is practically non-toxic (LD50 > 15 g/Kg BW). There is no significant difference in AST, ALT, and serum creatinine levels at any dose group than the control group. EAFKG administration affects liver and kidney cells at high doses but does not cause lethality.

	Control	Dose 1 (D1)	Dose 2 (D2)	Dose 3 (D3)	Dose 4 (D4)
Male					
Creatinine (mg/dL)	0,44	0,41	0,39	0,45	0,36
AST (u/L)	141	136	162	181	201
ALT (u/L)	40	44	56	54	48
Female					
Creatinine (mg/dL)	0,30	0,38	0,31	0,35	0,40
AST (u/L)	130	128	120	135	160
ALT (u/L)	53	43	48	52	58

Figure 31: ***Blood chemistry value of mice treated with ethyl acetate fraction of Kaempferia galanga in an acute toxicity.***

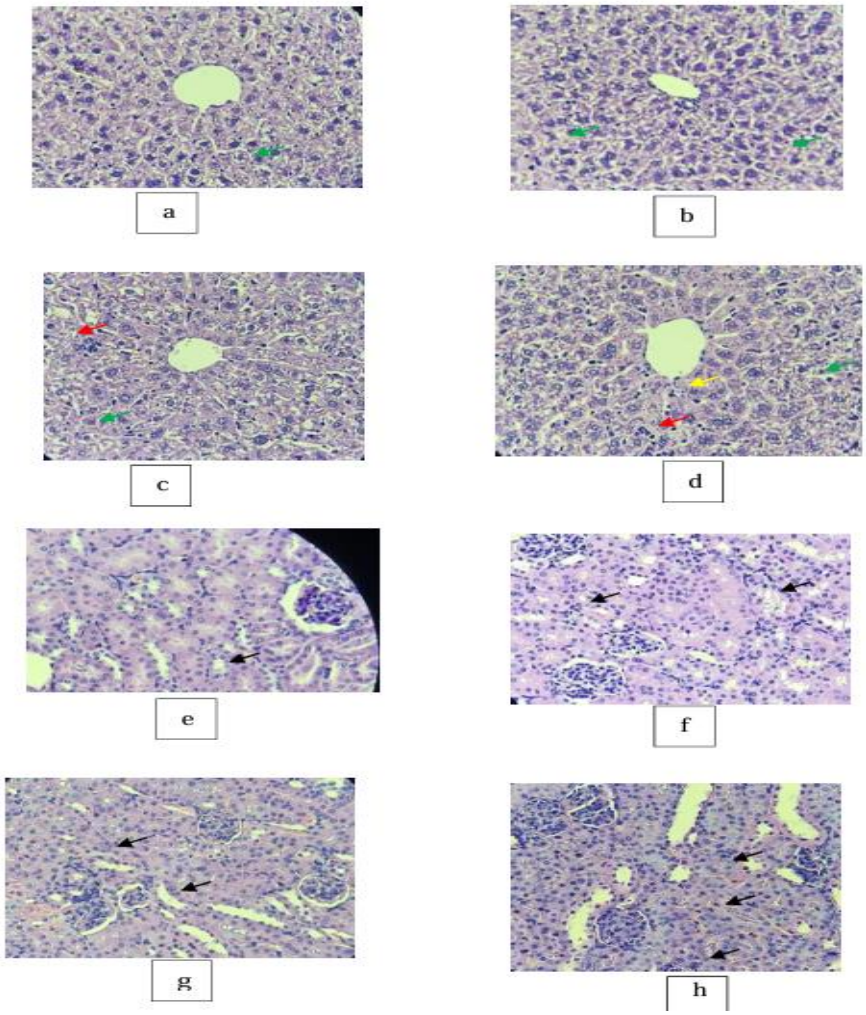


Figure 32: ***Histopathology of a representative internal organ (liver and kidney) in acute toxicity study of KG ethyl acetate fraction. 40 X magnification (hematoxylin-eosin stain). a=liver group D1; b=livergroup D2; c=liver group D3; d=liver group D4; e=kidney group D1; f=kidney group D2; g=kidney group D3; and h=kidney group D4.***

Kanjanapothi *et al*(2004)[13] Reported that the maximum tolerated dose (MTD) of ethanol extract of rhizomes of *K. galanga* was up to 5,000mg/kg and no death occurred in rats by oral administration. Hematological analysis showed no difference in any parameter tested between control and test group in male and female. Moreover, no abnormal in pathology and histopathology, and no irritation in the skin. Besides, in 28 days subacute toxicity studies, there was no death occurred when the ethanolic *K. galanga* extract was treated the dosage of 25, 50 or 100 mg/kg . Therefore, K. galanga is safe for the vital organs during treatment depending on the above toxicological studies.

CONCLUSION

To sum up, *Kaempferia galanga* Linn 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 Anti-bacterial,Analgesic and anti -inflammatory,anti-nociceptive, vaso-relaxant activity. In addition, further research on the use of *Kaempferia galanga* will increase the application of this plant in a wider and more suitable range.

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