

**SRI LANKAN MEDICINAL PLANT
MONOGRAPHS AND ANALYSIS
VOL - 10**

ALPINIA GALANGA



***Lakshmi Arambewela
Aravinda Wijesinghe***



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Preface

Studies on medicinal plants of Sri Lanka have been carried out in the Herbal Technology Division of Industrial Technology Institute (former Ceylon Institute of Scientific and Industrial Research) for almost two decades. This monograph which is the tenth in this series incorporates information collected from literature surveys, researches and also experiences of the Herbal Technology Division staff. This monograph is intended for a varied reading public, herbal drug manufacturers who need to identify their herbal raw materials, Ayurvedic physicians who need some scientific information on medicinal plants, research workers requiring some quick background information on a plant, industrialists or entrepreneurs pondering on commercial ventures and the inquiring lay readers. We hope this monograph fulfils some requirements of each of them.

The authors wish to thank the members of the Herbal Technology Division for their contribution, the Information Service Center for providing information, Department of Plant Sciences and Department of Zoology of the University of Colombo for assisting in anatomical studies, Food Technology Division of the Industrial Technology Institute for helping in the analysis of powdered plant materials and the Microbiology Laboratory for photographing the slides. They also gratefully acknowledge the sponsor National Science Foundation for the research grant (RG / 2004 / TM / 01).

Herbal Technology Division
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Colombo 07
Sri Lanka.

Alpinia galanga (L.) Willd

Family

Zingiberaceae

Synonyms

Alpinia galanga (L.) Sw ^{1,2}

Amomum galanga (L.) Lour ^{2,3,4}

Alpinia viridiflora Griff ¹

Maranta galanga (L.) ^{1,2}

Languas galanga (L.) Stuntz ^{1,2,3}

Languas vulgare J.Koenig ^{2,3}

Selected Vernacular Names

Sinhala	- Aratta, Mahaaratta, Kaluwala ¹
Indonesia	- Langkuas (general) ³
Malaysia	- Lengkuas, Puar ³
Philippines	- Languas (general), Pal-la (Mandaya) ³
Burma (Myanmar)	- Padagogi ³
Cambodia	- Rumdeng, Pras ³
Thailand	- Kha, kha yuak (northern) ³
Vietnam	- Ri(eeF)ng ³
Tamil	- Perarattai ^{1,4}
Telugu	- Peddadumparashtram ⁴
Marathi	- Koshtkulayan ⁴
Malayalam	- Arratta, peraratta, kol-inji ⁴
Gujarati	- Kulinjan ⁴
Kanarese / Kannada	- Dumparrasmi ⁴
Bengali, Hindi,	
Sanskrit & Urdu	- Barakulanjar, Kulanjan ^{1,4}
French	- Galanga ^{1,3}
English	- Greater galangal ^{1,4}

Pharmacopoeia

Ayurveda Pharmacopoeia

Chinese Pharmacopoeia

European Pharmacopoeia

Distribution

It is found in Indonesia, India, China, Saudi Arabia, Malaysia, Egypt and Sri Lanka. It grows in open sunny places, forests and brushwood. It is commonly cultivated in the mid and low-country in Sri Lanka.^{1,3,4,6}

Morphology¹

A perennial tuberous herb with elongate leafy stems and slightly aromatic rootstock; leaves cauline, 22.5-45 cm long, 3.7-11.2 cm broad, oblong-lanceolate, acute, glabrous, green above, paler beneath with slightly callous white margins, sheaths long, glabrous, ligule about 1 cm long and rounded; flowers irregular, bisexual, greenish white in dense-flowered panicles 15-30 cm long, branches short, rachis pubescent, pedicels 0.3-0.4 cm long, bracts 1 cm long, ovate-lanceolate; calyx 1 cm long, tubular, irregularly 3-toothed; corolla gamopetalous, 3cm long, tube 1.2 cm long, lobes oblong, obtuse, subequal, 0.6 cm broad, lip 2.1 cm long, claw green, 6 mm long, 2.5 mm broad, blade white striated with red, about 1.2 cm long, broadly elliptic, shortly 2-lobed at apex with a pair of subulate glands at the base of the claw; stamen 1, perfect, 1.8 cm long, filament flattened, anther cells diverging at the top occasionally with an orbicular crest, lateral staminodes minute or obsolete; ovary inferior, 3-locular, ovules few on an axile placenta, style filiform, stigma subglobose; fruit orange red, indehiscent.

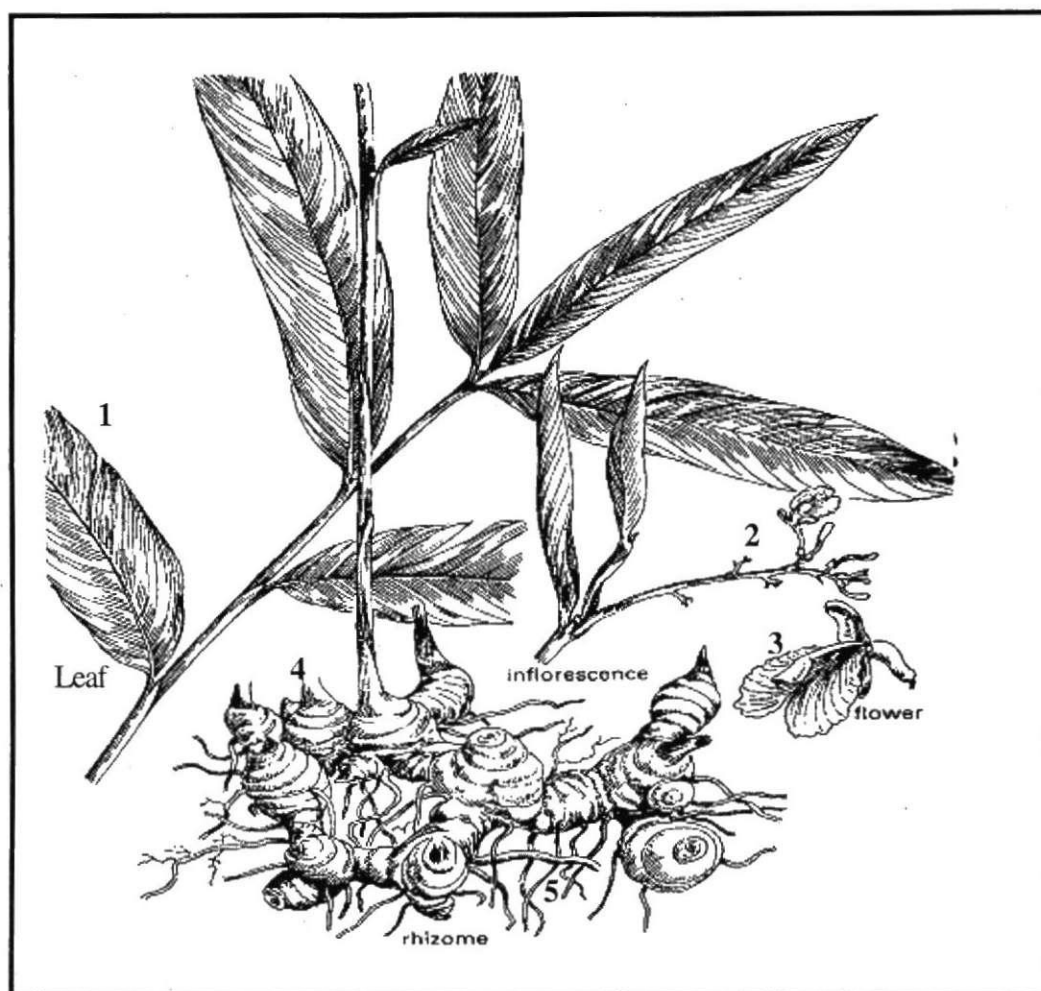


Fig-1. *Alpinia galanga* plant

1. Leaf 2. Inflorescence 3. Flower 4. Rhizome 5. Roots.

(Source - *Indian Medicinal Plants. A Compendium of 500 species I*, Orient Longman. p. 107)

Plant Material of Interest

Mainly rhizome but seeds and fruits are also used.^{1,3,4}

Official Drug

Dried rhizomes, rhizome oil, powder and seeds.^{1,3,4,5}



Pharmacognostic Features*

Anatomy



Fig- 2. Cross section of *Alpinia galanga* rhizome (stained with safranin (10x10))
1. Ground tissue (parenchyma) 2. Secretion cells 3. Sclerenchyma cells 4. Phloem 5. Xylem

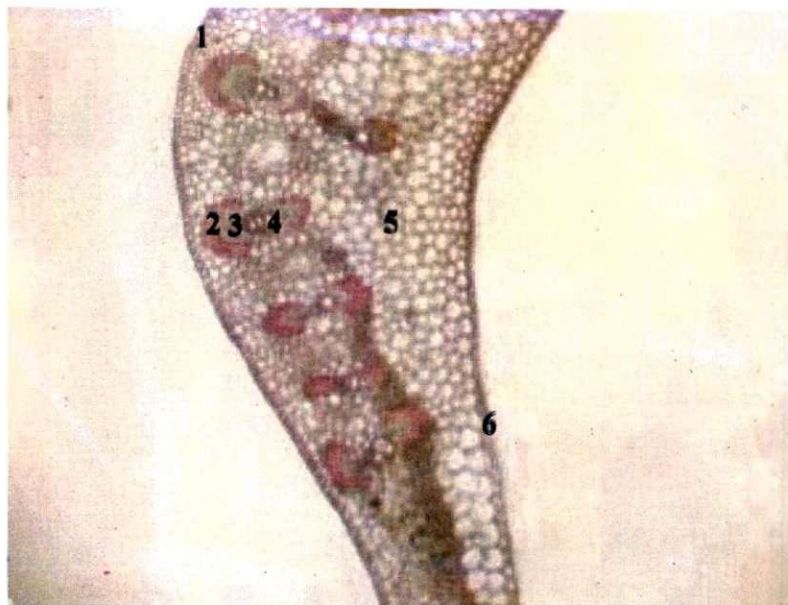


Fig- 3. Cross section of *Alpinia galanga* leaf (stained with safranin (10x10))
1. Lower epidermis 2. Sclerenchyma cells 3. Phloem 4. Xylem 5. Parenchyma cells 6. Upper epidermis

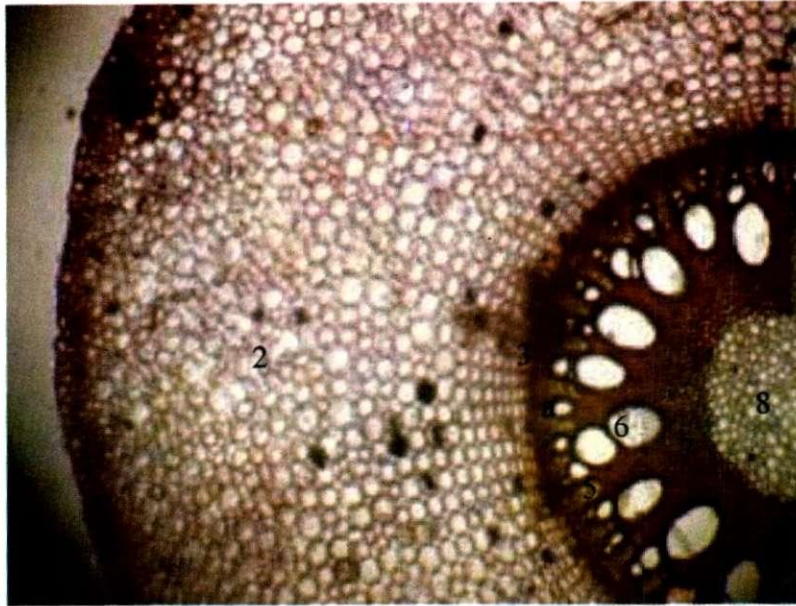


Fig- 4. Cross section of *Alpinia galanga* root (stained with safranin (10x10))

1. Epidermis 2. Cortex 3. Endodermis 4. Pericycle 5. Phloem 6. Xylem 7. Sclerenchyma cells 8. Pith

Powder analysis

Analyzed part – Rhizome

Organoleptic properties

Colour - Brown

Odour - Aromatic

Taste - Pungent

Microscopic characters

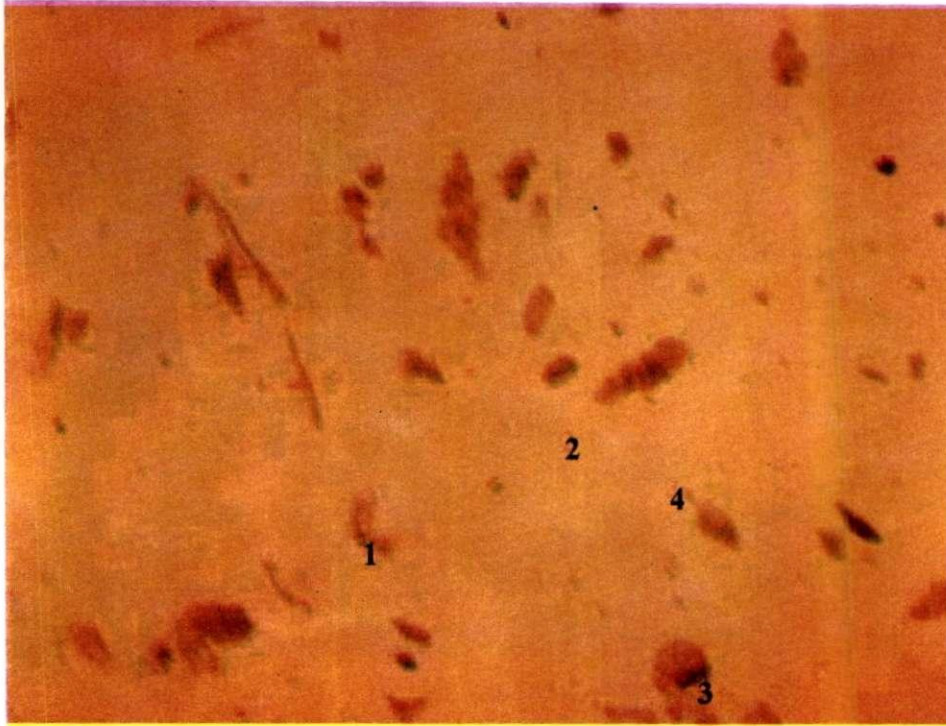


Fig- 5. Powder of *Alpinia galanga* rhizome under the microscope (10x4)

1. Fibers 2. Part of a tracheid 3. Parenchyma cells 4. Parenchyma cells with oil secretion cell

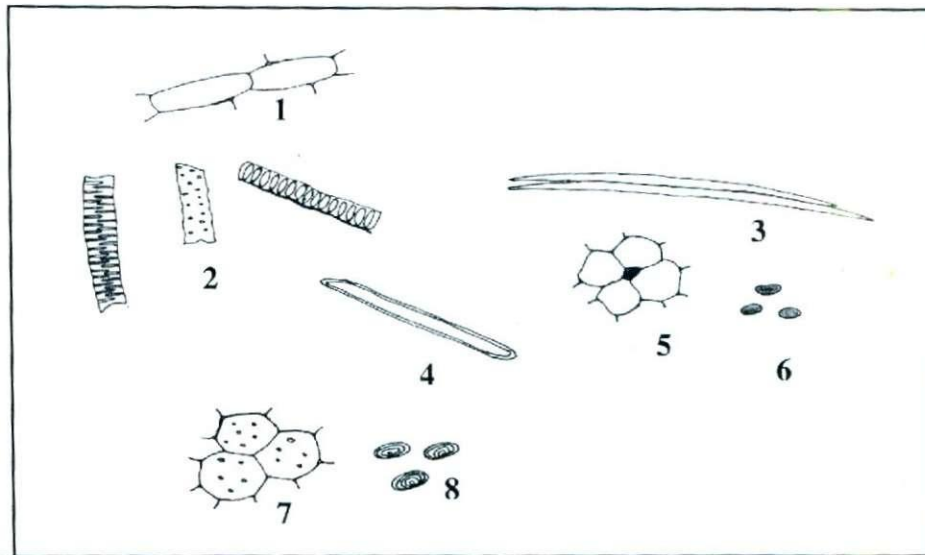


Fig- 6. Schematic diagram of powder microscopy

1. Parenchyma cells 2. Xylem vessel segments with different thickenings 3. Fibers 4. Tracheid 5. Parenchyma cells with oil secretion cell 6. Oil secretion cells 7. Parenchyma cells with starch granules 8. Starch granules

* These analysis were carried out by the authors at Industrial Technology Institute and the Dept. of Plant Sciences and Dept. of Zoology of University of Colombo.

Physico-chemical Analysis⁹⁸

Extractable matter

Crushed, dried plant material (about 4 g) was weighed to a glass-stoppered conical flask. Solvent (100 mL) was added, weighed, shaken well and allowed to stand for 1h. It was then boiled for 1h and cooled. The weight was readjusted with specified solvent and filtered. Filtrate (25 mL) was taken, solvent was evaporated and oven dried at 105 °C for 6 h, cooled in a desiccator and weighed.

Total ash

Crushed, air dried plant material (about 4 g) was weighed to a previously ignited crucible. The material was ignited by gradually increasing the temperature to 550 °C until free from carbon. The crucible was cooled and weighed.

Acid insoluble ash

Hydrochloric acid (25 mL, conc. ~70 g/L) was added to the crucible containing total ash, covered with a watch glass and boiled gently for 5min. The insoluble matter was collected on an ashless filter paper and washed with hot water until the filtrate was neutral. The filter paper containing the insoluble matter was transferred to the original crucible and ignited to a constant weight.

Water soluble ash

Water (25 mL) was added to the crucible containing total ash, covered with a watch glass and boiled gently for 5min. The insoluble matter was collected on an ashless filter paper and washed with hot water. The filter paper containing the insoluble matter was transferred to the original crucible and ignited for 15 min. at a temperature not exceeding 450 °C. Water soluble ash is the calculated difference in weight between the total ash and the residue remaining after treatment of the total ash with water.

Moisture content of the samples was estimated and all the calculations were done on dry weight basis.

Table I. Physico-Chemical parameters of *Alpinia galanga* rhizome**

Physico-chemical parameter	Amount (%)
Ethanol extractive of rhizome	9.8-10.5
Water extractive of rhizome	11.3-13.6
Acid insoluble ash	3.8-5.8
Water soluble ash	4.3-5.9
Total ash	8.3-11.9

(Results are expressed as percentages on dry weight basis)

Thin Layer Chromatographic Profile**

Alpinia galanga ethanol extract of rhizome

Sample preparation : *A. galanga* rhizome (4 g) was boiled with 95% ethanol (100 mL) for 1h and the extract was filtered and evaporated to dryness. Ten microliters (10 μ L) of the diluted extract (0.1 g in 5 mL) was spotted on TLC plate.

Adsorbent : Silica gel-GF₂₅₄

Solvent system : Cyclohexane : Chloroform : Ethyl acetate (2.8 : 2.0 : 0.2)

Detection

Direct evaluation : UV_{254 nm}, R_f values - 0.13, 0.22, 0.33, 0.56, 0.65, 75, 0.86
UV_{366 nm}, R_f values - 0.13, 0.56

Scanning : Densitometer at 254 nm (before spraying) and 450 nm (after spraying)

Spray reagent : Vanillin sulphate

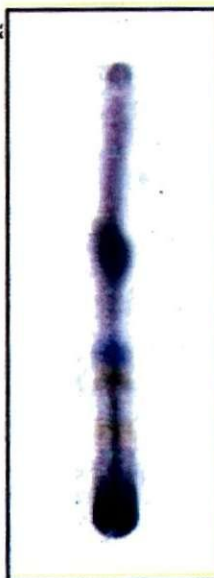


Fig- 7. TLC finger print profile of ethanol extract of *Alpinia galanga* rhizome

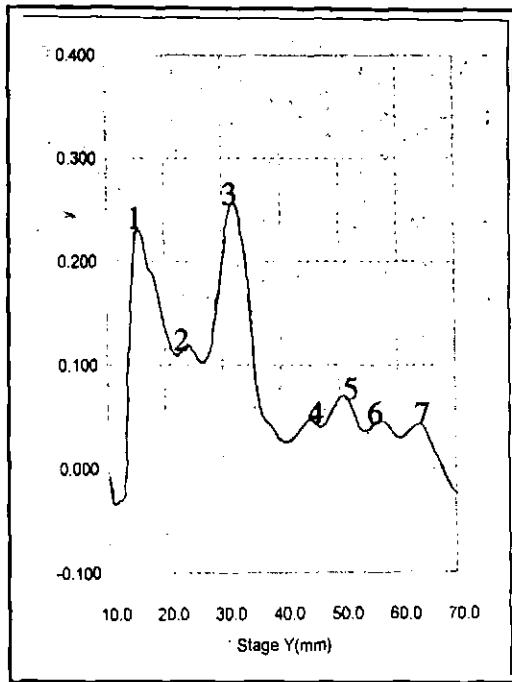


Table 2. Description of densitogram (Fig-8)

Peak no.	Y (mm)	Relative area %
1	15.46	19.99
2	24.03	7.97
3	31.88	27.65
4	45.21	5.05
5	50.74	8.30
6	56.91	5.82
7	63.89	8.11

Fig- 8. Densitogram of TLC finger print profile of ethanol extract of *Alpinia galanga* rhizome at 254 nm

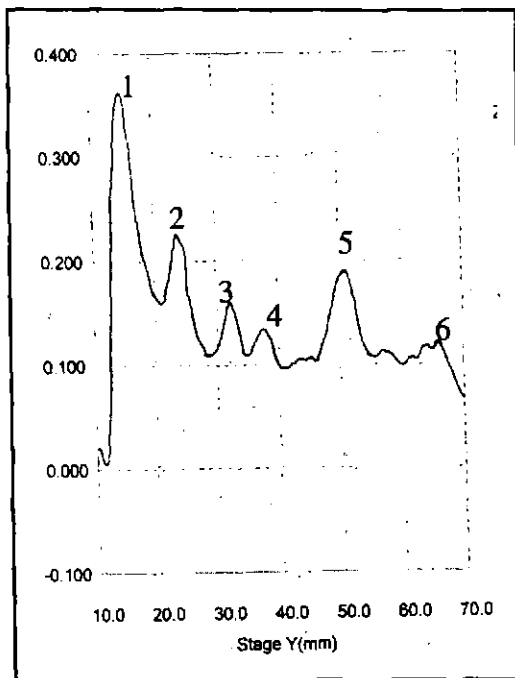


Table 3. Description of densitogram (Fig-9)

Peak no.	Y (mm)	Relative area %
1	14.77	25.15
2	23.70	14.47
3	32.17	9.51
4	37.48	8.87
5	50.72	15.69
6	63.92	14.16

Fig- 9. Densitogram of TLC finger print profile of ethanol extract of *Alpinia galanga* rhizome at 450 nm

***Alpinia galanga* water extract of rhizome**

Sample preparation : *A. galanga* rhizome (4 g) was boiled with water (100 mL) for 1h and the extract was filtered and evaporated to dryness. Ten microliters (10 μ L) of the diluted extract (0.09 g in 5 mL) was spotted on TLC plate.

Absorbent : Silica gel-GF₂₅₄

Solvent system : Butanol : Water : Ammonia (4.6 : 0.3 : 0.1)

Detection

Direct evaluation : UV_{254 nm}, R_f values - 0.14, 0.39, 0.80

Scanning : Densitometer at 254 nm (before spraying) and 450 nm (after Spraying)

Spray reagent : Vanillin sulphate

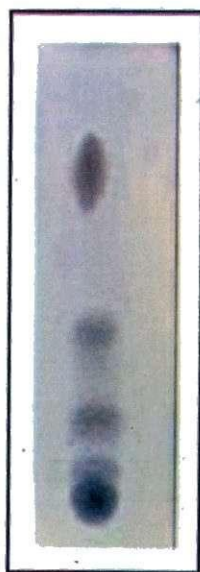


Fig- 10. TLC finger print profile of water extract of *Alpinia galanga* rhizome

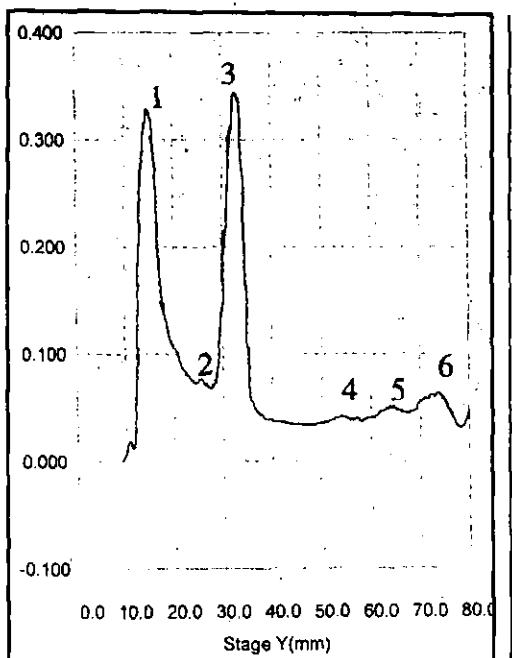


Table 4. Description of densitogram (Fig-11)

Peak no.	Y (mm)	Relative are %
1	14.82	27.68
2	25.80	2.82
3	32.82	23.73
4	54.41	2.62
5	64.06	3.02
6	73.87	3.45

Fig- 11 Densitogram of TLC finger print profile of water extract of *Alpinia galanga* rhizome at 254 nm

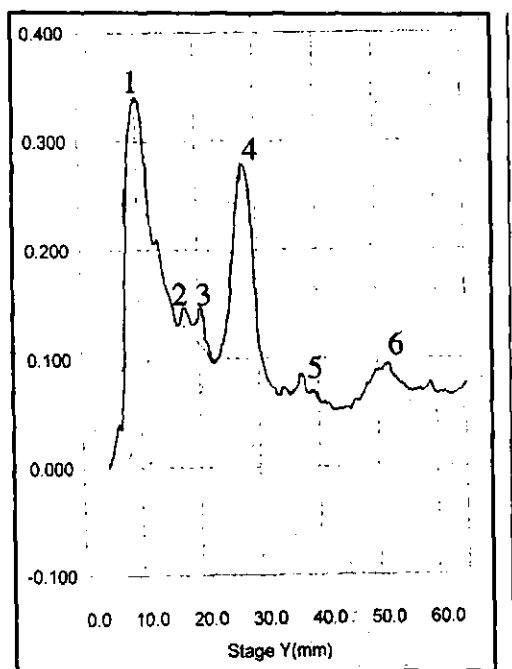


Table 5. Description of densitogram (Fig-12)

Peak no.	Y (mm)	Relative area %
1	9.99	38.72
2	17.64	5.17
3	20.41	6.55
4	27.84	23.93
5	37.32	3.48
6	51.67	4.92

Fig- 12. Densitogram of TLC finger print profile of water extract of *Alpinia galanga* rhizome at 450 nm

High Pressure Liquid Chromatographic Profile**

Alpinia galanga water extract of rhizome

Sample preparation : *A. galanga* rhizomes (4 g) were boiled with water (100 mL) for 1h and the extract was filtered and evaporated to dryness.

The diluted extract (8.5 mg in 5mL) was purified using Sep-pak C18 cartridge.

Injection volume : 20 μ L

Apparatus : Shimadzu LC - 10 ADvp pumps and Shimadzu SPD - M 10 Avp uv / vis photodiode array detector.

Column : Inertsil 5U ODS - 2 reverse phase column, (250 mm x 2.6 mm)

Solvent system : Acetonitrile : Water (50 : 50)

Flow rate : 1 mL/min

Detection : 254 nm

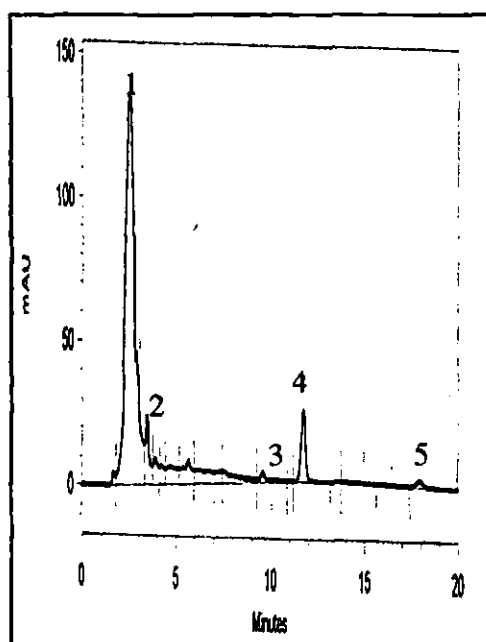


Table 6. Retention times of main peaks

Peak no.	Retention time(min)	Relative area %
1	2.52	52.95
2	3.47	11.56
3	9.60	6.03
4	11.74	6.74
5	17.95	3.46

Fig- 13. HPLC finger print profile of water extract of *Alpinia galanga* rhizome

***Alpinia galanga* ethanol extract of rhizome**

Sample preparation : *A. galanga* rhizomes (4 g) were boiled with 95% ethanol (100 mL) for 1h and the extract was filtered and evaporated to dryness.

The diluted extract (8.1 mg in 5mL) was purified using Sep-pak C18 cartridge.

Injection volume : 20 μ L

Apparatus : Shimadzu LC – 10 ADvp pumps and Shimadzu SPD – M 10 Avp uv / vis photodiode array detector.

Column : Inertsil 5U ODS – 2 reverse phase column, (250 mm x 2.6 mm)

Solvent system : Methanol : Water (75 : 25)

Flow rate : 0.7 mL/min

Detection : 254 nm

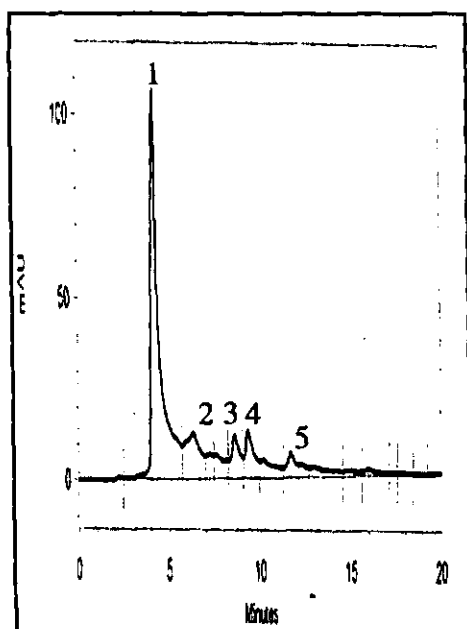


Table 7. Retention times of main peaks

Peak no.	Retention time(min)	Relative area %
1	4.21	56.56
2	6.35	4.85
3	8.63	1.12
4	9.38	5.83
5	11.70	0.82

Fig- 14. HPLC.finger print profile of ethanol extract of *Alpinia galanga* rhizome

** These analysis were carried out by the authors at Industrial Technology Institute.

Phytochemistry

The rhizome contains essential oils, the constituents of which are methyl cinnamate, p-methane-1,8-epoxy-acethoxychavicol acetate, alpinin, kaempferide, 3-dioxy 4-methoxy flavone, pinene, camphor, pineol, galangin, (1'S)-1'-acetoxychavicol acetate, (1'S)-1'-acetoxyeugenol acetate, 1'-acetoxychavicol acetate (7), 1'-acetoxyeugenol acetate (8), D-camphor, chavicol, chavicol acetate, 1,8-cineole (13), 3-hydroxy-1,8-cineole glucopyranosides, (1R,2R,4S), (1S,2S,4R)-trans-2-hydroxy-1,8-cineole -D- glucopyranosides, (1R,3S,4S)- trans-3-hydroxy-1,8-cineole -D- glucopyranoside, trans coniferyl diacetate, trans -p-coumaryl diacetate, di-(p-hydroxy-cis-styryl) methane, eugenol acetate, trans β -farnesene, 7-hydroxy-3,5-dimethoxy flavone, 4-hydroxybenzyldehyde, 1'-hydroxychavicol acetate, p-hydroxycinnamaldehyde, isorhamnetin, kaempferol, kaempferol-4'-methylether, kaempferol-7'-methylether, methylcinnamate, methyleugenol, 3-carene, α -thujene α -pinene (6), β -pinene (5), camphene(11), myrcene, p-cymene (2), borneol (15), α -terpineol (1), 4-terpineol (17), fenchyl acetate, bornyl acetate, α -humulene (16), zerumbone. Two skeletal diterpenes, named galanga A (9) and B (10), and 2 labdane type diterpenes, named galanolactone and (E) - β (17), 12-labdene-15, 16-dial, were isolated from *A. galanga* together with (E)-(17) - β epoxyabd-12-ene15, 16-dial. One of the pungent principle of *A. galanga* rhizome was isolated and identified as 1'-acetoxychavicol diacetate.^{7, 8, 9, 10, 11, 12, 13, 14, 15, 16, 17, 18, 19, 20, 21, 22, 23, 24.}

Leaf oil contains mainly myrcene, β -ocimene, α -pinene (6), borneol (15), β -caryophyllene(12), β -bisabolene.²⁴

Flower oil contains α -pinene (6), sabinene, limonene (3), α -phyllandrene (14), 1,8-cineole (13), linalool (4), terpinen-4-ol (17), α -terpineol (1), methyl eugenol, α -patchoulene, caratol, α -caryophyllene (12), α -bergamotene,(E,E), α -farnesene, nerolidol, α - bisabolol and benzyl benzoate.²⁵

Fruits of *A. galanga* contain 1'-acetoxyeugenol acetate (8) and 1'-acetoxychavicol acetate (7).²⁶

Seed contains 1'-acetoxyeugenol acetate (8), 1'-acetoxychavicol acetate (7), caryophyllene oxide, caryophyllenol I, caryophyllenol II, pentadecane, 7-heptadecane, fatty acid methyl esters, galanga A (9), B (10), (E) and 8,17-epoxylabd-12-ene-15, 16-diol.²⁰

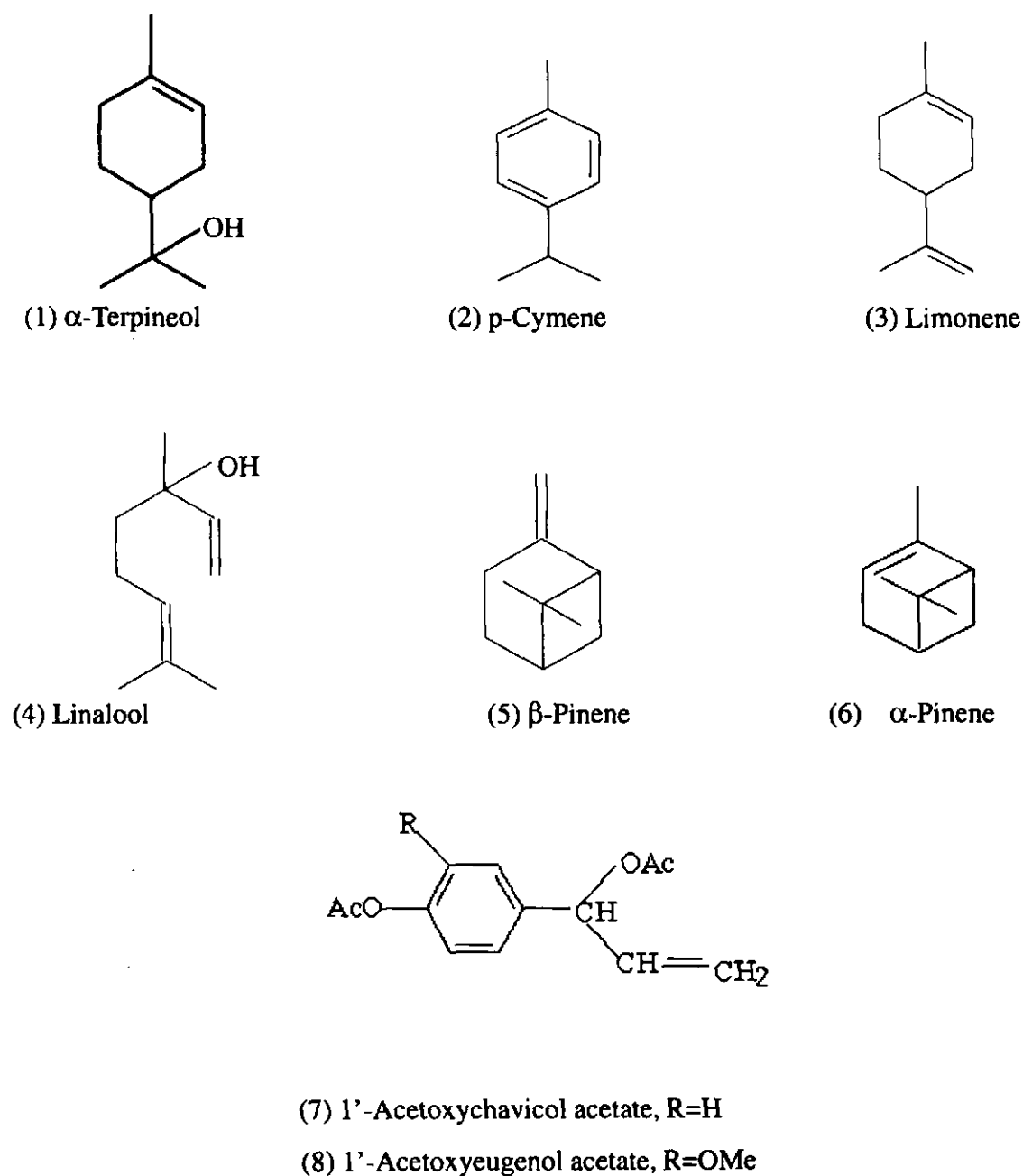
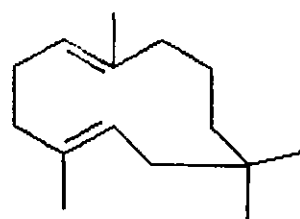
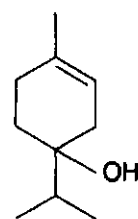


Fig- 15. Compounds in *Alpinia galanga*



(16) α -Humulene



(17) 4-Terpineol

Fig- 17. Compounds in *Alpinia galanga*

Gas Chromatographic Profile of Essential Oil of *Alpinia galanga*

Method of distillation of oil

Dried crushed rhizomes of *A. galanga* were hydrodistilled for 4 hrs using a Clevenger arm to obtain the rhizome oil (0.56%). The oil was subjected to GC analysis. The peaks were identified by peak enhancement experiments and mass spectral data. NMR data of the major compound was obtained. Quantitative data of the peaks were obtained from the GC.¹⁷ The oil contents are expressed on dry weight basis.

Details of the gas chromatograph operating conditions

The GC Instrument - H.P 5890-2 model, using a Restek RTX-5 column (30 m long and 0.25 mm id, with a coating thickness of 1 micron).

Initial oven temperature - 40 °C

Final oven temperature - 280 °C

Programmed rate - 10 °C/min

The concentration of the compounds was determined by comparing the peak area of the compound with the total area of the peaks in the chromatogram.

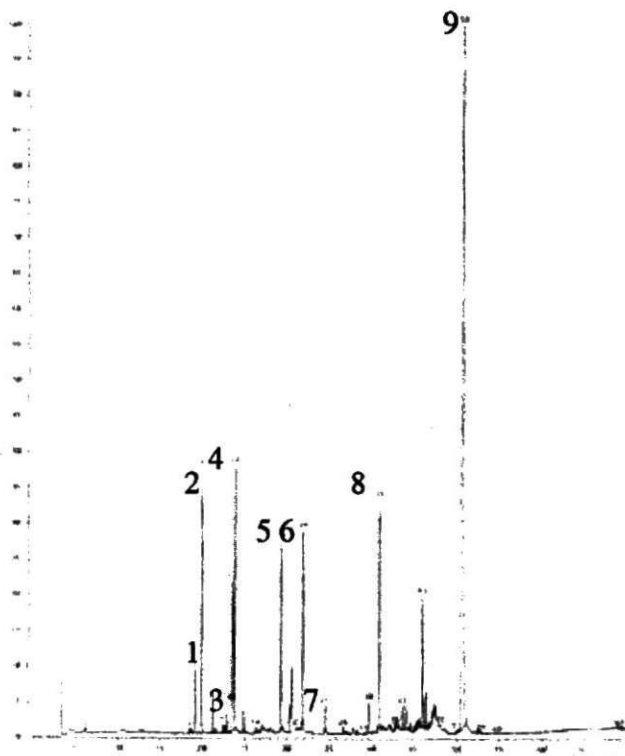


Fig- 18. Gas chromatogram of *Alpinia galanga* rhizome oil¹⁷

Table 8. Description of the gas chromatogram of *Alpinia galanga* rhizome oil¹⁷

Peak no.	Compound	Relative area % ¹⁷
1	α -Pinene	1.9
2	Camphene	6.4
3	β -Pinene	0.8
4	p-Cymene	6.5
5	Camphor	4.9
6	Fenchyl acetate ¹⁸	4.47
7	Bornyl acetate	0.6
8	α -Humulene	5.97
9	Zerumbone	44.84

Medicinal Uses

Uses described in pharmacopoeia and other traditional systems of medicine

The roots of *A. galanga* are used to rub on spots caused by “panu” a common skin fungus causing white blotches and for eczema, bronchitis, coryza, morbili, pityriasis versicolor, otitis interna, gastritis, ulcers, cholera, and the seed of *A. galanga* is used for emaciation.⁶

The drug is used as follows according to Ayurvedic pharmacopoeia.⁵

Nervous system- Used for nervous debility and nervous diseases and it stimulates and strengthens the nerves.⁵

In gastrointestinal system- The drug helps to clean the mouth, stimulates the digestive power, appetite and acts as a purgative. ‘Teekshana’ property helps to increase the mixing of food in the stomach, salivary secretion and digestive secretions. It also prevents anorexia and abdominal pain.⁵

In blood circulatory system - The drug increases the blood supply to the gastrointestinal system and as a result it reduces the cardiac contractions, cardiac output and blood supply to the vital organs. It is also used for ‘Vitaja’ heart diseases.⁵

In respiratory system-The drug reduces the sputum (Kapha) and dilates the bronchioles and reduces asthma. It strengthens the laryngeal folds. It can also be used for speech defects such as dysarthria, stammering and aphasia.⁵

In urinary system-It slightly reduces the ability of urine production and used for polyuria and other urine disorder formulations.⁵

In genital system-It is used for impotency. By keeping a piece of rhizome in the mouth, it is said to promote sexual desire.⁵

It also helps to protect from cold.⁵

External application of Rasana powder reduces hyperrespiration and coldness due to circulatory failure.

Uses in folk medicine

- In Java the fresh grated rhizomes with a little salt is given on an empty stomach for an enlarged spleen.³
- In Philippines the rhizomes are considered carminative and stimulative. A decoction of the leaves is used as an anti rheumatic and for stimulant baths.³
- In Indonesian traditional medicine, *A. galanga* is used as an ingredient in treatment of ear pain, cholera, skin disease, eczema and sprains.^{27, 28, 29}
- In Arabian countries the rhizomes are used as aphrodisiac and as a veterinary medicine.³
- In South-East Asian countries the rhizomes of *A. galanga* are used in the treatment of hyperlipidemia, obesity, haemorrhoid, menstrual disorder and acne. It is also used as a laxative, uric acid suppressant, and given during pregnancy and after child birth.³⁰
- The seeds are considered stomachic and sternutatory; they are prescribed in China for colic, diarrhoea and vomiting.^{1, 4}
- In tropical Asian countries the drug is widely used in rheumatism and bronchial catarrh. It is considered a tonic and used as a fragrant adjunct to complex preparations and also in cough and digestive mixtures. Its chief use is for clearing the voice. The drug has expectorant action and is useful in many respiratory ailments, especially for children suffering from whooping cough. It has an antispasmodic effect that alleviates asthma and also exhibits anti-amphetamine and diuretic properties. In affections of the gastro-intestinal tract, the drug may be useful like other volatile oils.^{4, 31}
- It is reported to be used as emmenagogue by rural people in Thailand and in Chile, abortifacient in Indonesia, anti pyretic, anti-inflammatory and in the treatment of heart diseases, chronic enteritis, dyspersia, gastralgia, antinauseant and uterine stimulant in Saudi Arabia, kidney diseases, diabetes and rheumatism etc in India.^{32, 33, 34, 35, 36, 37, 38, 40, 41}
- *A. galanga* has been used in traditional medicine for antifungal purposes in Thailand.³⁹
- In India the hot water extract is used for pain in the chest and a decoction used for Tuberculous glands and sore throat.^{42, 43}

Other Uses

- The rhizome is generally used as a spice or source of essential oil throughout its distribution area.^{2,3}
- The flowers and young shoots are used as a vegetable or as a spice.^{3,4}
- In Kerala, rhizomes are used for seasoning fish in pickling.⁴
- The rhizomes are used for insecticidal purposes as the essential oil has a high knockdown effect against houseflies and *Anopheles minimus*.⁴
- Galanga root oil is also used for perfumes and as a resinoid.⁴
- Dried rhizomes are used as a food in Thailand.^{2,4}

Ayurvedic / Traditional Medicinal Preparations

It is used as a constituent of the following Ayurvedic preparations.

Rasandi gugluva, Ashvaganda oil, Karpasadi oil, Maha naraya oil, Mahabala oil, Vishagana neela oil, Chyathya ghathya, Vruhathjagaladighathaya, Kakubdhadi powder, Ashvagandadi powder, Ranagigru kvathaya, Ranavishvadiya (Rasna dashamula), Rasna saphthayakaya, Bilvorasnadi kvathaya, Dashamul Iguruadi kvathaya, Dashamuladi kvathaya, Kumara guliya.^{5,44}

Activity Studies

- **Antifungal activity-** *A. galanga* extract has shown inhibition against the growth of three groups of fungi: yeast (*Saccharomyces* species, *Candida albican*), mold (*Aspergillus flavus*, *A. fumigatus*, *A. niger*) and dermatophytes (*Microsporum gypseum*, *Trichophyton mentagrophytes*). The crude extract of *A. galanga* showed effective fungal inhibition (60%) of *Trichophyton longifusus* while moderate inhibitory activity against *Aspergillus flavus*, *Microsporum canis* and *Fusarium solani* (30%, 50% and 40%, respectively) and low inhibitory action against *Trichophyton rubrum*, *Epidermophyton floccosum* and *Cryptococcus neoformans*.^{38, 45, 46, 47, 48, 49, 50, 51, 52, 53, 54, 55, 56}
- **Antibacterial activity-** Ethereal extract of *A. galanga* rhizomes has shown significant inhibition against *Staphylococcus aureus*, *Streptococcus* Gram A, *Streptococcus* Gram B, *Staphylococcus lutea*, *Bacillus subtilis*, *Mycobacterium smegmatics*, *Bacillus cereus*, *Bacillus megaterium*, *Pseudomonas aeruginosa*, *Aeromonas hydrophila*, *Escherichia coli*, *Shigella senteriae*, *Hemophilus pertussis*, *Vibrio cholera*, *Diplococcus pneumoniae*, *Salmonella paratyphi*, *Salmonella schottmuelleri*, *Staphylococcus albus* and antimycobacterial activity against *Mycobacterium tuberculosis*, *Mycobacterium Bovis*, *Mycobacterium avium* was also observed.^{42, 46, 57, 58, 59, 60, 61, 62, 63, 64}
- **Antiprotozoan activity-** Antiprotozoan activity against *Paramecium caudatum* and *Paramecium caudatum* have been observed.⁴²
- **Antitumor activity-** DL-1'-Acetoxychavicol acetate and acetoxyeugenol acetate isolated from *A. galanga*, have shown antitumor activity against sarcoma 180 (ascites) in mice. Investigation using rat showed that 1'-Acetoxychavicol acetate from *A. galanga* could inhibit the development of azoxymethane induced colonic aberrant crypt foci through its suppression of cell proliferation in the colonic mucosa and 1'-Acetoxychavicol acetate might be a possible chemopreventive agent against colon tumor ingenesis. 1'-Acetoxychavicol acetate was also proven to be a highly active anti-tumor promoter by an in vivo test on mouse skin. 1'-Acetoxychavicol acetate also acts as an inhibitor of xanthine oxidase, indicating that it may exhibit antitumor activity by inhibiting the generation of anions during the tumor promotion. The effect of *A. galanga* extracts on hepatocarcinogenesis was investigated in a medium term bioassay using male rats. *A. galanga* may contain agents augmenting the hepatocarcinogenicity of 2-amino-3,8-dimethylimidazo (4,5-f) quinoxaline. Hexane extract (dose 10 mg/kg) and methanol extract showed antitumor promoting activity against mouse.^{14, 18, 65, 66, 67, 68, 69, 70, 71, 72}
- **Antitrypanosomal activity-** Antitrypanosomal activity against *Trypanosoma cruzi* has been reported.⁷³

- **Antiinflammatory activity**- The water soluble fraction of the alcoholic extract of the air dried plant is reported to exhibit a significant antiinflammatory activity in albino rats similar to that of β -methasone. Fruits of *A. galanga* contain 1'-acetoxychavicol acetate and acetoxyeugenol acetate which have antiinflammatory activity. ^{4,26}
- **Insect antifeedant activity**- Methanol extracts of *A. galanga* have strong effects on *Callosobruchus chinensis* adults and also on *Plutella xylostella* larvae. ⁸¹
- **Cancer chemopreventive**- Root oil contains ethyl trans cinnamate and ethyl 4-methoxy-trans-cinnamate. Ethyl trans cinnamate and ethyl 4-methoxy-trans-cinnamate exhibited significant chemopreventive activity in the mouse liver and intestines. Evaluation for inhibitory activities of the methanol extracts of *A. galanga* toward 12-O-hexadecanophenylphorbol 13-acetate induced Epstein-Barr virus activation suggested that this plant has high potentiality for cancer chemoprevention. 1'-Acetoxychavicol acetate showed powerful inhibitory effects on 4-nitroquinoline 1-oxide induced rat tongue carcinogenesis in the initiation or post initiation phase as well as on 12-O-tetradecanoylphorbol 13-acetate induced skin tumor promotion in ICR mice initiated with 7,12-dimethylbenz anthracene. 1'-Acetoxychavicol acetate may be recognized as an intrinsic antioxidant, which specifically blocks the xanthine oxidase and NADPH oxidase systems generating O_2 . ^{70,82}
- **Irritant activity**- The extract causes irritation to soft tissue of male rabbits. ⁷⁹
- **Smooth muscle stimulating activity**- An alcohol water (1:1) extract of rhizome was shown to have smooth muscle stimulating effects on the isolated guinea pig ileum. In moderate doses the rhizome oil has an antispasmodic action on involuntary muscle tissue, inhibiting excessive peristaltic movement of the intestines. ⁸³
- **Antioxidant activity**- *A. galanga* extract may be a possible natural antioxidant source for meat and meat products. (In raw beef, addition of *A. galanga* extract was as effective as α -tocopherol and butylated hydroxytoluene in inhibiting / minimizing lipid oxidation). Ethanol extracts of *A. galanga* showed higher antioxidative stability at neutral pH than that at acidic pH. The extracts also exhibited strong superoxide anion scavenging activity, Fe^{2+} chelating activity and reducing power in a concentration dependant manner and acted as a radical scavenger and a lipoxygenase inhibitor. ^{84,85}
- **Antiulcer activity**- Antiulcer agents were isolated from *A. galanga* seeds and they were identified as 1'-acetoxychavicol acetate and 1'-acetoxyeugenol acetate. Ethanol extracts showed antiulcer activity against hyperthermia induced ulcers ethanol induced ulcers, HCl induced ulcers, indomethacin induced ulcers, reserpine induced ulcers and pyloric ligation induced ulcers. ^{86,87,88}

- **Acaricides activity**- Acaricides are present in *A. galanga* seed extracts showed mortality against *Tyrophagus putrescentiae* and *Dermatophagoides pteronyssinus*.⁸⁹
- **Immunostimulating activity**- Hot water extract of *A. galanga* showed a marked stimulating effect on the reticulo-endothelial system (RES) and increased the number of peritoneal exudate cells (PEC), and spleen cells of mice.⁹
- **Inhibitory effects**- Methanol extracts of *A. galanga* showed significant inhibitory effects of more than 60% on platelet-activating factor (PAF) binding to rabbit platelets. 1'S-1'-acetoxychavicol acetate from the rhizomes of *A. galanga* showed inhibitory activity against production of nitric oxide (NO) in lipopolysaccharide (LPS)-activated mouse peritoneal macrophages and IFN- β mRNA expression as well as NF- κ B activation. 1'S-1'-acetoxychavicol acetate inhibited the lesions induced by 0.6 M HCl (ED_{50} =0.73 mg/kg) and aspirin (ED_{50} = 0.69 mg/kg).⁶² The 80% acetone extract of the *A. galanga* was found to inhibit release of hexosaminidase, as a marker of antigen-IgE-mediated degranulation in RBL-2H3 cells. 1'S-1'-acetoxychavicol acetate and 1'S-1'-acetoxyeugenol acetate inhibited ear passive cutaneous anaphylaxis actions in mice and the antigen-IgE-mediated TNF- α and IL-4 production in RBL-2H3 cells. Gastric secretory inhibition, prostroglanin synthesis inhibition, intracellular and vascular cell adhesion molecule-1 inhibition, phosphodiesterase inhibition and angiotensin conversion enzyme inhibition were also observed. Xanthine oxidase inhibitors were isolated from the rhizomes of *A. galanga* and were identified as trans p-coumaryl diacetate, trans coniferyl diacetate, 1'S-1'-acetoxychavicol acetate, 1'S-1'-acetoxyeugenol acetate and 4-hydroxybenzaldehyde. The type of inhibition by ether trans p-coumaryl diacetate or 1'S-1'-acetoxychavicol acetate with respect to xanthine as substrate was uncompetitive.^{21, 23, 91, 92, 93, 94, 95, 96}
- **Gastroprotective effects**- 1'S-1'-acetoxychavicol acetate and 1'S-1'-acetoxyeugenol acetate markedly inhibited the ethanol- induced gastric mucosal lesions (ED_{50} =0.61 mg/kg and ca. 0.90 mg/kg).²¹

Antihepatotoxic activity, Antiamphetamine activity, Antiascariasis activity, Aphrodisiac activity, Diuretic activity, Hypertensive activity, Insect repellent activity on *Anopheles minimus*, Insecticidal activity, Larvicidal activity, Antilithic activity, Cytotoxic activity, Urine stimulant and relaxation effect, Spermicidal effect on ox male, Anticlastogenic activity, Membrane stabilization effect and Mutogenic activity were also reported.^{74,75,76,77, 78, 79, 80}

Safety Evaluation

- **Toxicity**- Hematological studies revealed a significant rise in the RBC level of *A. galanga* treated animals as compared to the controls. The gain in weight of sexual organs and increased sperm motility and sperm counts were highly significant in treated male mice.⁹⁷
- **Cytotoxicity activity**- 1'-Acetoxychavicol acetate was isolated as the major cytotoxic component of *A. galanga* against human cancer cell lines and non cancer cell lines by sulforodamine B assay.²²

Propagation

A. galanga requires fertile soil and cool shady places. They are propagated by the divisions of rootstocks which are planted a meter apart at a permanent site in the garden or in pots. Liberal watering and application of foliage spray are beneficial during the growing period. The plants require thinning and clipping to keep them shapely and low. The rhizomes are washed, trimmed and carefully dried after harvesting.⁴

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