Current pharmacological and phytochemical studies of the plant *Alpinia galanga*

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**Abstract:** Traditional medicine systems consist of large numbers of plants with medicinal and pharmacological importance and hence represent an invaluable reservoir of new bioactive molecules. *Alpinia galanga* (family Zingiberaceae) is commonly known as galangal and has been used for its emmenagogue, aphrodisiac, abortifacient, carminative, antipyretic and anti-inflammatory qualities and used in the treatment of various diseases such as bronchitis, heart diseases, chronic enteritis, renal calculus, diabetes, rheumatism and kidney disorders. It was reported to contain, among other components, essential oils, tannins, phenol, glycosides, monoterpenes and carbohydrates. In the last few years, new compounds such as gallic acid glycoside, galangoids, sitosterol, galangin, alpinin, zerumbone and kampferide have been isolated from various parts of *A. galanga*. Therefore, the present review is aimed to summarize the information regarding *A. galanga* concerning the new phytoconstituents and pharmacological uses that have appeared in recent years.

**Keywords:** *Alpinia galanga*; rhizome; plant extracts; pharmacology; review

Since the rise of human civilization, plants have been used as one of the most important sources of medicines. *Alpinia galanga* (family Zingiberaceae) syn. *Langium galangal*, known as greater galangal in English, and either kulanjan* or barakulanjan in Hindi, has been widely cultivated in Sri Lanka, India, Malaysia, Indonesia, Egypt and Saudi Arabia and is found abundantly in Thailand. The rhizomes are extensively used for flavouring food. In India, most of the South Indian physicians of traditional Ayurveda and Siddha medicine systems use *A. galanga* to treat various kinds of diseases including diabetes mellitus. In China and Thailand, it is used as a folk medicine for stomach health. *A. galanga* has been used in traditional medicine systems for its carminative, emmenagogue, aphrodisiac, abortifacient, antipyretic, anti-inflammatory and antispasmodic activities. *A. galanga* was also found to be beneficial in the treatment of bronchitis, heart diseases, chronic enteritis, renal calculus, diabetes and rheumatism, etc. The young inflorescences and leaves are

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consumed as ulam or salad. A. galanga possesses many therapeutic activities such as antifungal, antiucler, antiflatulent, antiallergic, treating brain disorders, nerve tonic, and stimulant.

1 Phytochemistry

A. galanga has been studied by various researchers and a number of active constituents from the plant have been isolated and reported. Phenolic compounds such as flavonoids and phenolic acids are found abundantly in this plant. The dominant components isolated from the rhizomes were galangin flavonol[13], β-sitosterol diglucosyl caprate[14], methylugenol, p-coumarial diacetate, 1’-acetoxyugenol acetate, trans-p-aceoxicinamylic alcohol, trans-3, 4-dimethoxyxycinnamyl alcohol, p-hydroxybenzaldehyde, p-hydroxycinamaldehyde, trans-p-coumaryl alcohol, galangin, trans-p-coumaric acid, and galanganol B[15]. The major phytoconstituents which have been isolated from the rhizomes are acetoxyxavicol acetate (ACA) and hydroxycavicol acetate (HCA).[16] Rhizomes are lowest in fat but richiest in carbohydrate.

The chemical investigation of A. galanga has led to the isolation of b-caryophyllene (17.95%), and b-selinene (10.56%), terpinen-4-ol[17], 4-allylphenyl acetate and β-bisabolene, 5-hydroxymethyl furural (59.9%), benzyl alcohol (57.6%), methylcinnamate (9.4%), 3-phenyl-2-butanone (8.5%) and 1,2-benzenedicarbonylic acid (8.9%)[18]. A new phenylpropanoid, 4,4’[(2E, 2′E)-bis(prop-2-ene)-1,1’-oxy]-1-diphenyl-7,7’-diaceteta[19], as well as p-coumaryl alcohol-γ-O-methyl ether (CAME) and p-coumaryl diacetate (CD), has also been isolated from the plant.[17, 18]

Volatile oil of plant from Sri Lanka contained zerumbone (44.9%) and those from Malaysia, India and Indonesia were found to be β-farnesene, myrcene and 1,8-cineole, respectively[4, 19]. Bicyclo (4.2.0) oct-1-ene, 7-exoethenyl (58.46%), trans-caryophyllene (7.05%), α-pinene (14.94%) with camphene (2.15%), germacrene (1.78%) and citronellyl acetate (1.41%) were reported in A. galanga as major components[20].

2 Pharmacological activities

2.1 Anti-inflammatory and analgesic actions

Several authors have studied the anti-inflammatory and analgesic effects of A. galanga in a variety of rheumatologic conditions. Min et al.[21] isolated chavicol analogues, namely, ACA and HCA from A. galanga, in which ACA exhibited potent antioxidant activity, increased cell apoptosis and decreased cytokines production by T helper cells: whereas, HCA suppressed T-bet expression. CAME, a phenylpropanoids from A. galanga suppressed interferon-γ production in CD4+ T helper cells by decreasing T-bet expression.[17]. p-Hydroxycinnamaldehyde from A. galanga extract inhibited the interleukin-1β-stimulated cartilage matrix degradation.[21, 22]

2.2 Anti-aceethylcholinesterase activity

Methanolic extracts of A. galanga showed acetylcholinesterase-inhibitory activity at a concentration of 100 μg/mL.[22]

2.3 Anticancer and antimalonogenic potentials

A. galanga extract at a dose of 300 μg/mL caused apoptosis of all cell lines including normal and p53-inactive fibroblasts, normal epithelial and tumour mammary cells and a lung adenocarcinoma cell line[23]. A. galanga and Curcuma aromatica extracts at non-cytotoxic concentrations (3.8 to 30.0 μg/mL) suppressed tyrosinase activity, mRNA levels and ultraviolet A (16 J/cm²)-mediated melain production[24].

2.4 Platelet-activating factor antagonist and hepatoprotective activity

Methanolic extract from the rhizome of A. galanga at the concentration of 18.2 μg/mL showed 73.9% platelet-activating factor (PAF)-inhibitory activity[24]. A. galanga extract at 200 and 400 mg/kg caused significant reduction in the number of necrotic cells of the liver of rats with paracetamol-induced hepatotoxicity.[25]

2.5 Antileishmanial activity

Hexane, chloroform and ethyl acetate extracts of A. galanga rhizomes, exhibited significant in vitro activity against promastigotes of Leishmania donovani due to the presence of phenylpropanoid compounds[26].

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2.6 Antimicrobial activities
2.6.1 Antiplasmid activity 1'-Acetoxychavicol acetate from A. galanga showed antiplasmid activity against various multi-drug resistant bacteria. Crude acetone extract of the rhizomes of A. galanga exhibited antiplasmid activity against Salmonella typhi, Escherichia coli and vancomycin-resistant Enterococcus faecalis with an efficiency of 92%, 82% and 8%, respectively at 400 µg/mL subinhibitory concentration[8].

2.6.2 Antibacterial activity Indian gooseberry (Phyllanthus emblica Linn.) and galangel (A. galanga) extracts were investigated against Staphylococcus aureus for their antimicrobial activities. Minimal inhibitory concentration (MIC) values of Indian gooseberry and galangel extracts were found to be 13.97 and 0.78 mg/mL and the minimum biocidal concentration (MBC) values were 13.97 and 2.34 mg/mL, respectively. Extracts from A. galanga flowers showed the activity against Micrococcus luteus[9]. The ethanolic extracts of galangel were evaluated for antimicrobial qualities on S. aureus 209P and E. coli NIHJ JC-2 by using an agar disc diffusion assay. The extract had the strongest inhibitory effect against S. aureus with MIC at 0.325 mg/mL and MBC at 1.3 mg/mL using the broth dilution method[7]. Methanolic, acetone and diethyl ether extracts of A. galanga have been evaluated against pathogens such as Bacillus subtilis MTCC 2391, Enterobacter aerogenes, Enterobacter cloacae, Enterococcus faecalis, E. coli MTCC 1563, Klebsiella pneumoniae, Pseudomonas aeruginosa MTCC 6642, Salmonella typhimurium, S. aureus and Streptococcus epidermidis using the agar well diffusion method. Methanolic extract of the plant showed an excellent ability to fight all pathogens with MIC and MBC values ranging from 0.04 to 1.28 mg/mL and 0.08 to 2.56 mg/mL, respectively[10]. Also the hexane and ethanolic extracts of A. galanga showed strong antimicrobial functions against S. aureus and/or Listeria monocytogenes[27].

2.6.3 Antifungal activity and anti-amoebic activity
Extracts of A. galanga were studied for their inhibitory activity against mycelial growth of Phytophthora capsici KACC 40157, Rhizoctonia solani KACC 40146, Fusarium solani KACC 40384, Colletotrichum gloeosporioides ATCC 32097, and Botrytis cinera KCTC 6973. The extracts showed inhibitory activity against all the five fungi[18]. Extract from A. galanga rhizome showed antifungal activity toward Aspergillus niger[10]. Crude ethanolic extract of the rhizome suppressed the growth of zoonotic dermatophytes (Microsporum gypseum and Trichophyton mentagrophyte) and yeast-like Candida albicans in a concentration-dependent manner (0.5 to 256 mg/mL)[15]. Chloroform extract of A. galanga at a concentration of 1000 µg/mL showed good anti-amoebic activity against Entamoeba histolytica strain HTH-56: MUTM and strain HMI: IMSS with 50% inhibitory concentration (IC_{50}) value of 55.2 µg/mL. The same extract showed the highest activity against Giradia intestinalis with MIC at 125 µg/mL with an IC_{50} at 37.73 µg/mL[30].

2.7 Antioxidant activity Different extracts (methanolic and aqueous) and volatile oils from rhizomes of A. galanga were assessed for free radical-scavenging activity against 1,1-diphenyl-2-picrylhydrazyl radical. Gas chromatography/mass spectroscopy analysis showed that trans-3-acetoxy-1,8-cineole was detected as a main compound in A. galanga, responsible for the antioxidant activity. The novel compound, p-coumaryl-9-methyl ether, was isolated from methanol extract of A. galanga[14]. It was reported that A. galanga leaves and flowers showed the highest chelating and β-carotene-bleaching ability[10].

2.8 Apoptosis activity 4'-Hydroxycinnamaldehyde (4'-HCA) isolated from A. galanga was cytotoxic to human leukemic HL60 and U937 cell lines in a dose-dependent manner[10].

3 Conclusion
A. galanga is a rhizomatous medicinal plant of mammoth importance with a diverse pharmacological spectrum. Besides having the above mentioned pharmacological properties, it has been used as a constituent of many herbal formulations for the treatment of various diseases, in particular the respiratory diseases and rheumatism. The plant could be further exploited, in order to fulfil the need of quality-control aspects and standardization of various constituents and extracts.

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5 Conflict of interest statement
The authors declare that there are no conflicts of interests and no agency is involved for financial support for this research work.

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大高良姜的药理学及植物化学研究综述

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摘要：传统医学使用大量具有医用及药用价值的植物治疗疾病，因此是生物活性物质的一个宝库。姜科植物
大高良姜通常被用作调味剂、催欲剂、堕胎药、驱风剂、退热剂和抗炎药等，可用于治疗支气管炎、心脏病
、慢性肠炎、肾结石、糖尿病、风湿病及肾脏疾病。大高良姜含有精油、鞣酸、苯酚、苷类、单萜及糖类等。过去
几年，有报道大高良姜各部位提取物中还含有没食子酸、生姜异黄酮、β-谷甾醇、高良姜素、良姜素、花姜酮、
山姜素等。本文总结了近年来有关大高良姜的研究中新的植物化学成分及药理学的研究内容。
关键词：红豆蔻；根茎；植物提取物；药理学；综述