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Review Article

A Review on Phytochemical and Pharmacological Potential of *Alpinia galanga*

Anirban Chouni, Santanu Paul*

ABSTRACT

Introduction: From the ancient Vedic era, green plants are being used for their medicinal properties to treat several diseases. Green plants represent a big source of bioactive compounds. *Alpinia galanga* (Linn.) of Zingiberaceae family is one amongst those medicinally important plants. Different parts of the plant are used in the treatment of many diseases for its anti-fungal, anti-tumour, antimicrobial, anti-inflammatory, anti-diabetic, antioxidant, anti-ulcer and many other properties. Several active compounds such as 1′S-1′-acetoxychavicol acetate, 1′S-1′-acetoxyeuginol acetate, 1, 8-cineol, α-fenchyl acetate, β-farnesene, β-bisabolene, α-bergamotene, β-pinene, β-Sitosteroldiglucoside (AG-7), β-sitsteryl Arabinoside (AG-8), 1′-acetoxychavicol acetate (galangal acetate), p-hydroxycinnamaldehyde has been extracted from the plant. **Methods:** Relevant information was collected from scientific journals, books, and reports via electronic search using Medline, PubMed, Science Direct and Scopus. **Results:** This review provides a comprehensive report on *Alpinia galanga* having anti-proliferative, apoptotic, anti angiogenic as well as cytotoxic efficacy and their mode of action *in vitro* as well as *in vivo* condition. **Conclusion:** Considering the ability of the golden treasure present in *Alpinia galanga*, this review is aimed to summarize the information of the chemical constituents, pharmacological and therapeutic effects of the plant.

Key words: *Alpinia galanga,* 1′s′-1′- *Acetoxychavicolacetate*, Anticancer, Antimicrobial, Bioactivity.

Anirban Chouni, Santanu Paul*

Laboratory of Cell and Molecular Biology, Department of Botany, University of Calcutta, Kolkata 700019, West Bengal, INDIA.

Correspondence

Santanu Paul

Laboratory of Cell and Molecular Biology, Department of Botany, University of Calcutta, Kolkata 700019, West Bengal, INDIA.

Phone No: 91-033-24614849

E-mail: spaul_1971@yahoo.com

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INTRODUCTION

Medicines derived from plant sources are widely used in traditional cultures globally and now-a-days they are getting popular as natural alternatives to synthetic chemicals. In the last few decades the use of herbal medicine has increased exponentially. Recently it is getting popular in developing and developed countries owing to its natural origin and lesser side effects. *Alpinia galanga* belongs to the family *Zingiberaceae*. The plant bears underground stems called rhizomes which have a strong aromatic smell with conspicuously nodes and internodes.[1] The seed of *A. galanga* is used in emaciation and cleaning of the mouth, it stimulates the digestive power and appetite. It is also used as a purgative. Usually the rhizome is used as a spice and a source of essential oil. Young shoots and flowers are used as vegetable or as spice.[2] The plant is broadly used in dietary intake as well as in the traditional system of medicine viz. Ayurveda, Unani, Chinese and Thai folk medicine.[3] Along with an aromatic ginger like odour, it has a pungent hot and spicy taste. As the rhizome has a characteristic fragrance as well as pungency, it is widely used as a condiment for foods and local medicine in China and Thailand.[4]

From the leaves, stems, rhizomes and roots of *Alpinia galanga*, presence of essential oil is reported. Those are mono and sesquiterpene as well as (E) - methyl cinnamate in nature. They are responsible for the characteristic odour as well as for the reported use in (folk) medicine and in food products of *A. galangal*.[5] *Alpinia galanga* contained flavonoids and volatile oils.[6,7] The previous studies, the plant possessed many pharmacological activities, including antibacterial, antifungal, antiviral, Antiprotozoal,[8,9] immunomodulatory, antioxidant effect, antidiabetic, antiplatelet, hypolipidemic and many other pharmacological effects. This review is a combination of chemical constituents, pharmacological and therapeutic effects of *Alpinia galanga* based on various current studies.

METHODOLOGY

The study of the literature review was carried out by searching on the electronic databases including PubMed, Science Direct, Scopus and Google Scholar for studies focusing on the biological and pharmacological activities of *Alpinia galanga*. All English-language articles published between 1976 and 2017 were searched using the terms '*Alpinia galanga*', 'greater galangal', 'Thai galangal'. The list of references of all the relevant articles was also studied to include all reports and reviews related to the subject.

TAXONOMY

Alpinia galanga belongs to the Tribe Alpinieae of Alpinioideae subfamily under the *Zingibera-*

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ceae family of *Zingiberales* order. *Alpinia galanga* is known by several synonyms such as *Amomum galangal*, *Alpinia viridiflora, Maranta galangal, Languas galangal, Languasvulgare*.[2] It is known by several common names such as Kulanjan in Hindi, Dhumarasmi in Kannada, Kulingjan in Bengali, Kulinjan in Gujrati, Arattha in Malayalam, Pera-rattai in Tamil, Dhoomraasmi in Kannad, Pedda-dhumpa in Telugu, Mahabaracach, SugandhaVacha, Rasna in Sanskrit, Greater galangal in English.

BOTANICAL DESCRIPTION

The plant is a perennial herb. It grows up to a height about 5 feet. Leaves are *oblong-lanceolate*, tuberous root, slightly aromatic. The rhizome is from 3.5-7.5 cm in length, and seldom more than 2 cm thick. The leaves are long, *oblong-lanceolate,* acute, *glabrous,* ligules are short and rounded. Flowers are greenish white in colour, *bracteate,* bracts are ovate lanceolate. Tubular calyx, Corolla lobes oblong, claw green, blade white, striated with red, rather more than 1 cm long, broadly elliptic, shortly 2-lobed at the apex, with a pair of subulate glands at the base of the apex, with a pair of subulate glands at the base of the claw. Fruit the size of the small cherry, orange red.[10]

GEOGRAPHICAL DISTRIBUTION

Alpinia galanga commonly found in Indonesia, India, China, and Arabic gulf areas, 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.[2] In India the plant is distributed in the Himalaya and Southern region of Western Ghats.[11]

TRADITIONAL USE

Alpinia galanga is an important medicinal plant in different traditional systems of medicine to treat several diseases, including microbial infections, inflammations, rheumatic pains, chest pain, and dyspepsia, fever, burning of the liver, kidney disease, tumours, diabetes and even HIV.[12] The plant has an active role in the treatment of eczema, bronchitis, coryza, mobile, pityriasis versicolor, otitis internal, gastritis, ulcers, and cholera. The seed is used for emaciation and to clean the mouth. It stimulates the digestive power, appetite and acts as a purgative. The rhizome is generally used as a spice. It is also a good source of essential oil. The flowers and young shoots are also used as a vegetable or as a spice.[2]

ACTIVE COMPOUNDS

1'S-1'-acetoxychavicol acetate (ACE), isolated from *Alpinia galanga* is the major compound so far reported with various biological activities.[13] About 80% of *Alpinia galanga* rhizome aqueous acetone extract were found to inhibit the release of b-hexosaminidase, as a marker of antigen-IgE-mediated degranulation in RBL-2H3cells. Nine known phenylpropanoids and p-hydroxybenzaldehyde were isolated from the extract. Among them, 1'S-1'-acetoxychavicol acetate and 1'S-1'-acetoxyeugenol acetate exhibited potent inhibitory activity with IC_{50} values of 15 and 19 mM[14] Table 1. Four isomers of acetoxy cineoles (trans and cis)-2-and 3-acetoxy-1, 1, 8-cineoles has been isolated from the isolated plant of rhizome. Their structures were confirmed by comparing the retention indices by GC and the mass spectra with those of synthesized compound[15] Figure 2 1'-acetoxychavicol acetate (galangal acetate) has been extracted and isolated from rhizome of *Alpinia galanga*. Galangal acetate was identified as the pungent principal of galangal rhizomes. The identification was done by the Gas Chromatography Analysis.[16] *β-Sitosteroldiglucoside* (AG-7) and β-*sitsteryl Arabinoside* (AG-8), has been isolated from the rhizome of *Alpinia galanga* and characterized by their spectral value.[17]

Three hydroxy-l, 8-cineole glucopyranosides, (1R, 2R, 4S)-and (1S, 2S, 4R)-trans-2-hydroxy-1, 8-cineole β-D-*glucopyranoside*, and (1R, 3S, 4S)-trans-3-hydroxy-1, 8-cineole β-D- lucopyranoside, which are possible precursors of acetoxy-1, 8-cineole, has isolated and identified from the rhizome of the *Alpinia galangal.* The major active compounds found in *A. galanga* are 1, 8-cineol, Galangin, α-fenchyl acetate, β-farnesene, β-bisabolene, α-bergamotene, β-pinene, 1'S-1'-acetoxychavicol acetate, 1'S-1'-acetoxyeuginol acetate, β-*Sitosteroldiglucoside* (AG-7), β-*sitsteryl-Arabinoside* (AG-8), 1'-acetoxychavicol acetate (galangal acetate), p- droxycinnamaldehyde, [di-(p-hydroxy-cis-styryl)] methane. By using FAB-MS and NMR spectrometry the structures of the compounds were analyzed. The absolute configuration of each aglycone was determined by using a GC-MS analysis with a capillary column coated with a chiral stationary phase. By GC-MS analysis after preparing the trifluoroacetate derivatives of the glycosides it was found that the composition of the diastereomers of (1R, 2R, 4S)-and (1S, 2S, 4R)-trans-2-hydroxy 1,8-cineole β-D-*glucopyranoside*s in the rhizome was determined as 3:7.[18] *p-hydroxy-cinnamaldehyde* and [di-(p-hydroxy-cis-styryl)] methane has been isolated by the chloroform extract from the rhizome of the *Alpinia galangal.*[19] From the roots of *Alpinia galanga* some *endophyticactinomycetes* (120) has isolated. Based on the morphology and amino acid composition of the whole-cell extracts the identification of these endophytes has done. Most of them were classified as *Streptomyces sp.* (82). Others were identified as *Nocardia sp*. (11), *Microbispora sp*. (3), *Micromonospora sp.* (2). Eight isolated were unclassified and 14 were lost during subculture.[20] An antimicrobial diterpene was isolated from the rhizome of *Alpinia galanga.* The structure was elucidated by spectral data and identified as (E) -8 beta, 17- epoxylabd-12-ene-15, 16-dial[21] Table 1. Xanthine oxidase (XO) inhibitors were isolated from the rhizome of *Alpinia galanga.* The compound had been identified as *trans-p-coumaryldiacetate*, trans-coniferyldiacetate, [1'S] -1'-acetoxychavicol acetate, [1'S] -1'-acetoxy-eugenol acetate and 4-hydroxybenzaldehyde.[22] From the rhizomes of *Alpinia galanga* six phenylpropanoids were obtained and their structures were identified as (*S*)-1'-ethoxy chavicol acetate (**1**), (*E*)-4-acetoxy cinnamyl ethyl ether (**2**), (*E*)-4-*hydroxycinnamaldehyde* (**3**), (*E*)-4-acetoxy cinnamyl alcohol (**4**), 4-acetoxy cinnamyl acetate (**5**), and 4, 4'[(2*E*, 2′*E*)-bis(prop-2-ene)-1, 1′-oxy]-diphenyl-7, 7′-diacetate (**6**). By using various chromatographic methods and crystallization chemical constituents were isolated, and the chemical structures were elucidated on the basis of spectral analysis. Compounds **1** and **2** were two new phenylpropanoids. Compound **5** shows the selective cytotoxic activity on human lung adenocarcinoma cell A549 (IC_{50} 19.35 μmol·L^{-1}).[23]

BIOACTIVITY

Now-a-days, *Alpinia galanga* is gaining lots of interest, according to the researchers' point of view. Many pharmacological studies have been conducted recently on *Alpinia galanga* (Figure 1). A summary of the findings is presented below:

Antimicrobial Activity

The essential oils obtained from fresh and dried rhizomes of *Alpinia galanga* show antimicrobial activity against g-positive bacteria. An extract from the dried rhizome shows antimicrobial activity against *Trichophytonmentagrophytes*.[24] 1'S'-1'- acetoxychavicol acetate obtained from *Alpinia galanga* acts as an efflux pump inhibitor which provokes resistance in Mycobacterium and hence it acts as a new target for the discovery of anti-TB agents[25] Table 1. 1'-acetoxychavicol acetate from *Alpinia galanga* showed antiplasmid activity against multi-drug resistant bacteria. A crude acetone extract of the rhizomes of *Alpinia 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 micro g/ml SIC Table 1.[26] Using Agar well diffusion method,

Table 1: Table showing major bio molecules isolated from *Alpinia galanga* and their mechanism of action.

Name of the compound	Type of the compound	Pharmacological activity	References
1'S-1'-acetoxychavicol acetate	Phenylpropanoid	Acts as efflux pump inhibitor which provokes resistance in mycobacterium and hence it acts as a new target for the discovery of anti-TB agents	[25]
		Inhibition of the constitutive activation of NF-κB through suppression of IKKα/β activation	[48]
		antitumour principles against Sarcoma 180 ascites in mice	[49]
		Antiplasmid activity against multi-drug resistant bacteria.	[26]
1'-acetoxychavicol acetate	Phenylpropanoid	Induces apoptosis in myeloid leukemic cells. In NB4 cells, ACA-induced apoptosis is in association with the loss of mitochondrial transmembrane potential (ΔΨm) and activation of caspase-9, hence, ACA-induced death signalling is mediated through a mitochondrial oxygen stress pathway. In addition, ACA activated Fas-mediated apoptosis by inducing of casapse-8 activity.	[51]
1′*S*-1′-acetoxyeugenol acetate	Phenylpropanoid	In RBL-2H3 cells, participate in the late phase of type I allergic reactions	[14]
(*E*)-8β, 17-epoxylabd-12-ene-15, 16-dial	Diterpene	Enhance antifungal activity of quercetin and chalcone against *Candida albicans*	[21]
p-hydroxycinnamaldehyde	Phenylpropanoid	Potential therapeutic agent for treatment of Osteoarthritis as it has an effect on human chondrocytes	[36]
1, 7-bis (4-hydroxyphenyl)-1, 4, 6-heptatrien-3-one (BHPHTO) and bisdemethoxycurcumin (BDMC)	Curcuminoid (natural phenols)	Inhibit proliferation of human melanoma A2058in the cell viability assay.	[53]

Figure 1: Several pharmacological properties of *Alpinia galanga*.

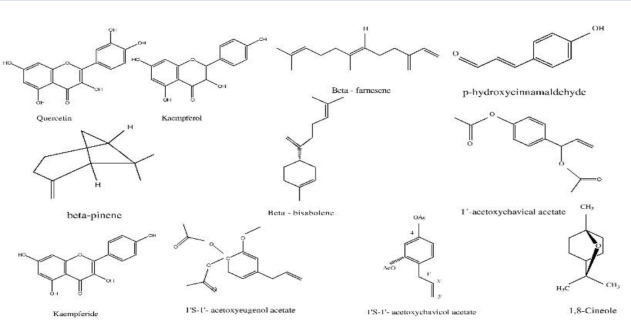

Figure 2: Chemical structures of the important bioactive molecules extracted from *Alpinia galanga*.

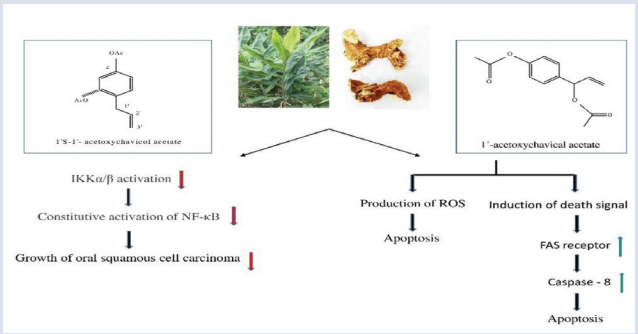

Figure 3: Diagrammatic outlining of the mechanism of action shown by 1′S-1′- ACA and 1′-ACA. Compound 1′S-1′- ACA inhibit the growth of oral SCC by inhibition of NF-κB and 1′-ACA induces apoptosis by ROS generation in mitochondria as well as caspase-8 activation by FAS receptor activation. Green arrows and red down arrows represent activation and inhibition respectively.

methanol extracts of *Alpinia galanga* have been evaluated against pathogens viz. *Bacillus subtilis* MTCC 2391, *Enterobacteraerogene, Enterobacter cloacae, Enterococcus faecalis, Escherichia coli* MTCC 1563, *Klebsiellapneumoniae, Pseudomonas aeruginosa* MTCC 6642, *Salmonella typhimurium, Staphylococcus aureus* and *Streptococcus epidermis.* Minimum inhibitory concentration (MIC) and minimum bactericidal concentration (MBC) were determined using the macrodilution method. The extracts have shown excellent activity towards all the pathogens with MIC and MBC values ranging from 0.04–1.28 mg/ml and 0.08–2.56 mg/ml, respectively.[27] An antimicrobial diterpene, was isolated from *Alpinia galanga*. The identified structure of the compound was (*E*)-8β, 17-epoxylabd-12-ene-15, 16-dial.[21] The activity of endophyti-

cactinomycetes obtained from root of *Alpinia galanga* against phytopathogenic fungi was tested against *Candida albicans*, and phytopathogenic fungi, *Colletotrichummasae* and *Fusariumoxysporum*. The strain, *Streptomyces aureofaciens*CMUAc130 was the most effective in antifungal activity amongst those investigated.[28] The essential oils obtained from dried *A. galanga* rhizomes showed effective against S*taphylococcus aureus*, *Bacillus subtilis*, *Streptococcus faecalis*[*Enterococcus faecalis*], *Escherichia coli*, *Proteus vulgaris*, *Salmonella enteritidis*, *Saccharomyces cerevisiae*and *Aspergillusniger* (the MIC values ranged from 1.25 to 12,5 micro l/ml) Essential oil obtained from dried rhizome is more effective than fresh one.[29] Hexane, ethyl acetate, acetone or methanol extract of the rhizome of *Alpinia galanga* shows the anti-*Phytopthoracapsici*activities and it has the potential antifungal activity.[30] In comparison of the antimicrobial potential of variety of extraction of *Alpinia galanga* extract such as hexane, ethyl acetate, ethanol and the essential oil respectively against swine pathogenic bacteria compose of *Escherichia coli ATCC, Staphilococcus aureus ATCC, Salmonella typhimurium ATCC, Salmonella enteritidis* and *Pasteurellamultocida,* essential oil of *Alpinia galanga* have the best antibacterial and bactericidal activities with minimum inhibition concentration (MIC) and minimum bactericidal concentration (MBC) to *Escherichia coli ATCC*, *Staphilococcus aureus ATCC*, *Salmonella typhimurium ATCC* and *Salmonella enteritidis*at 8 mg/cc and to *Pasteurellamultocida*at 16 mg/cc.[31] From various extracts of *Alpinia galanga antimicrobial* activity were screened against the common food borne bacteria such as *Escherichia coli*, *Salmonella enteriditis, Clostridiumperfringens, Staphylococcus aureus, Campylobacter jejuni, Bacillus cereus* and fungi such as *Saccharomyces cerevisiae, Hansenulaanomala, Mucormucedo, Candidaalbicans* using disc diffusion method. All the extracts showed significant antibacterial and antifungal properties.[32] Extracts from *Alpinia galanga* flowers shows the largest zone of inhibition of *Micrococcus leteus*.[33]

Antifungal activity

The ethanolic extracts of *Alpinia galanga* found to possess good antifungal activities against *Trichophytonlongifusus*.[34] Diterpene *compound,* (*E*)-8β, 17-epoxylabd-12-ene-15, 16-dialsynergistically enhanced the antifungal activity of quercetin and chalcone against *Candida albicans*.[21] Strong antifungal activities of n-Hex and DCM fractions of *Alpinia galanga* has been demonstrated by zone of inhibition assay. High phenolic and flavonoid content and strong free radical scavenging activity of the fractions of *A.galanga* has been observed.[35]

Antiinflammatory activity

Antiallergic principles have reported from *Alpinia galanga* rhizome. 80% aqueous acetone extract of the rhizomes of *Alpinia galanga* expressed the inhibition of the release of beta -hexosaminidase, as a marker of antigen-IgE-mediated degranulation in RBL-2H3 cells. 1′*S*-1′-acetoxychavicol acetate and 1′*S*-1′-acetoxyeugenol acetate exhibit potent inhibitory activity. Additionally, ear passive cutaneous anaphylaxis reactions in mice and the antigen-IgE-mediated TNF-α and IL-4 production are inhibited by 1′*S*-1′-acetoxychavicol acetate and 1′*S*-1′-acetoxyeugenol acetate. In RBL-2H3 cells, both participate in the late phase of type I allergic reactions.[14] Purification of the acetone extract of *Alpinia galanga produces p*-hydroxy cinnamaldehyde, which is a potential therapeutic agent for treatment of Osteoarthritis as it influences human chondrocytes Table 1.[36] Ethanolic extract of *Alpinia galanga* rhizome has scientifically validated anti-inflammatory screening technique on rats by carrageenan induced pleurisy. The results obtained indicate that the ethanolic extract has significant activity in rats. Hence, the ethanolic extract of *A. galanga* rhizome has potential anti-inflammatory activity.[37] Anti-inflammatory activity of Petroleum ether, Chloroform, Methanolic and Aqueous methanolic (1:1) extracts of *Alpinia galangal.* Willd has been investigated in carrageenan induced paw edema in Wistar rats and compared to a positive control drug, Ibuprofen. Methanolic extract of *Alpinia galanga* showed maximum inhibition of 79.51 % on carrageenan induced rat paw edema.[38]

Hepatotoxicity

It has observed that the hepatoprotective effect of the crude extract of *Alpinia galanga* at 200 and 400 mg kg-1 treated paracetamol induced hepatotoxicity in rats.[39]

Immunomodulator

Hot water polysaccharide extracts of *Alpinia galanga* (L.) Willd. Shows marked stimulating effect on the reticulo-endothelial system (RES) and increased the number of peritoneal exudate cells (PEC), and spleen cells of mice. Hence, hot water polysaccharide extracts of *A. The challenge* has immuno-stimulating activity.[40]

Anti-Diabetic activity

The extracts of the rhizome of *Alpinia galanga* in rabbits show hypoglycemic activity on their blood glucose levels. In normal rabbits, powdered rhizome and its methanol and aqueous extracts significantly lowered the blood glucose.[41] Methanolic extract of aerial parts of *Alpinia galanga* was effective in controlling blood glucose level and improve lipid profile in euglycemic as well as diabetic rats.[42] The methanolic extracts of *Alpinia galanga* shows a considerable inhibition of the haemoglobin glycosylation. The extract of the plant inhibits the activities of α -amylase and α-glucosidase in a concentration dependent manner which indicate that the plant possesses considerable *in vitro* antidiabetic activity.[43]

Anti-Oxidant activity

Antioxidant activity has shown by extract of *Alpinia galanga*. 50% ethanol in water was studied for its antioxidant activity and composition in comparison with two other samples based on a water extract and the essential oil. By using 2, 2-diphenyl-1-picrylhydrazyl (DPPH) and oxygen radical absorbance capacity (ORAC) the antioxidant activities were measured. Highest DPPH free radical scavenging ability was reported from the ethanolic extract. Highest ORAC value observed when compared to the water extract and the essential oil.[44] Antioxidant activity of 1'-acetoxychavicol acetate and its related compounds has been reported from the rhizomes of *Alpinia galanga.*[45] Methanol extracts of *Alpinia galanga* has been evaluated for total phenolic content (TPC) and antioxidant activities (AOA). Using 1, 1-diphenyl-2-picrylhydrazyl (DPPH), reducing power (RP), ferrous ion chelating as well as β-carotene bleaching assays the AOA has been investigated. *A.galanga* leaves and flowers showed highest chelating and β-carotene bleaching abilities. So the leaves of the plant may serve as potential dietary source of natural antioxidant.[33]

Anticancer property

An aqueous acetone extract from the fruit of *Alpinia galanga* demonstrated inhibitory effects on melanogenesis in theophylline-stimulated murine B16 melanoma 4A5 cells (IC_{50} = 7.3 μg/ml).[46] In the investigation of the potential of *Alpinia galanga* rhizomes to induce cytotoxic and apoptotic effects in the cultured human breast carcinoma cell line, (MCF-7) in comparison with the non-malignant (MRC-5) cells cultured in DMEM medium, the percentage of apoptotic cells was determined by flow cytometry using Annexin-V fluorescein isothiocyanate. It was found that *Alpinia galanga* induced apoptosis in MCF-7 cells, as determined by flow cytometry.[47] The active compound, 1'S'-1'- acetoxychavicol acetate were found to provide inhibition of the growth of oral squamous cell carcinoma in *in vitro* or *in vivo* by inhibition of the constitutive activation of NF-κB through suppression of IKKα/β activation Figure 3. The effect of the compound is also correlated with a down-regulation of NF-κB regulated

gene (FasL and Bim), including proinflammatory (NF-κB and COX-2) and proliferative (cyclin D1) biomarkers in tumor tissue Table 1.[48] *Alpinia galanga* was found to cause antitumor activity. Active compounds from *A. galanga* such as 1′-acetoxychavicol acetate and 1′-acetoxyeugenol acetate were isolated as antitumour principles against Sarcoma 180 ascites in mice Table 1.[49] The high dose of methanolic extract of *A. galanga* treated albino mice showed no estrogenic activity rather showed decrease uterine wet weight as well as morphologically constricted uterine horns which clearly suggests anti-estrogenic activity.[50] 1'-acetoxychavicol acetate (ACA) obtained from the rhizomes of *Alpinia galanga* induces apoptosis in myeloid leukemic cells via independent dual pathways. ACA has potential as a novel therapeutic agent for the treatment of myeloid leukaemia. It is evident that low-dose ACA dramatically inhibited cellular growth of leukemic cells by inducing apoptosis. NB4 promyelocytic leukemic cells are sensitive to ACA. Reactive oxygen species production triggers ACA-induced apoptosis. In NB4 cells, ACA-induced apoptosis is in association with the loss of mitochondrial *transmembrane* potential ($\Delta\Psi m$) and activation of caspase-9, suggesting that ACA-induced death signalling is mediated through a mitochondrial oxygen stress pathway. In addition, ACA activated Fas-mediated apoptosis by inducing of casapse-8 activity Table 1.[51] 1'S-1'-acetoxychavicol acetate (ACA) isolated from *A. galanga*, induced cytotoxicity in various cancer cells, including cervical cancer in combination with miR-629 and RSU1.[52] 1, 7-bis (4-hydroxyphenyl)-1, 4, 6-heptatrien-3-one (BHPHTO) and *bisdemethoxycurcumin* (BDMC) which has been isolated from *A. galanga* rhizome, were examined for their defectiveness on the human melanoma A2058 and showed that significantly inhibited the proliferation of melanoma cells in the cell viability assay Table 1. The research was also taken on the tests to B16-F10 cell line and showed minor inhibitory consequences of cellular tyrosinase activities and melanin contents.[53]

Anti-Ulcer property

Extract of *Alpinia galanga* has been studied on experimentally induced gastric ulcers in rats. At a dose of 500mg/kg of the ethanolic extract, the intensity of gastric mucosal damage induced by pyloric ligation and hypothermic restraint stress in rats significantly reduced. The experimental result shows significant antisecretory and cytoprotectively action of *A. galanga* which may be responsible for its antiulcer activity.[54] The potent anti-ulcer principles, 1'-acetoxychavicol acetate (1) and 1'-acetoxyeugenol acetate (2), were isolated from the seeds of *Alpinia galanga* and established by chemical syntheses.[55] The effects of 1'S-1'-acetoxychavicol acetate and related phenylpropanoids isolated from the rhizomes of *Alpinia galanga* on ethanol-induced gastric lesions in rats has been evaluated. It has been observed that, 1'S-1'-acetoxychavicol acetate and 1'S-1'-acetoxyeugenol acetate markedly inhibited the ethanol-induced gastric mucosal lesions.[56]

RESULTS AND DISCUSSION

Nowadays it has been recognized that several diseases are caused due to the oxidative stress. Oxidative stress generates inside the living system due to imbalance of the formation of Reactive Oxygen Species i.e. ROS and their endogenous neutralization by quenching of the free radicals. Formation of ROS is an inevitable natural process. To combat the generation of oxidative stress exogenous antioxidant is necessary to neutralize the ROS. From the above mentioned characteristics of *Alpinia galanga* it is clear that the plant is potentially rich in antioxidant property. Hence *Alpinia galanga* may be used as a good source of antioxidant. Generation of ROS is also related to cancer development. Again, it has been seen that the plant exhibits good anticancer properties in several cell lines. Apart from antioxidant and anticancer properties, the plant has anti-diabetic, anti-inflammatory, anti-microbial, anti-fungal, anti-ulcer properties. So, it is clear that *Alpinia galanga* possesses rich phytochemical and pharmacological potentials. Compiling all the current knowledge so far we have regarding *Alpinia galanga* it is evident that the plant is a potential powerhouse of several lead molecules which are responsible for numerous bioactivities. Hence, isolation and identification of those lead molecules are needed for opening a new window in therapeutics of cancer biology as well as several other diseases.

CONCLUSION

From the various scientific research based on *Alpinia galanga*, the plant has a huge biological potential. Several chemicals present in the plant shows a wide pharmacological and medicinal property. More research and evaluation needs to be done to isolate and identify different chemicals present in the plant which will be used for innumerable application for human welfare in the near future.

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CONFLICT OF INTEREST

The authors declare that they have no conflict of interest.

ABBREVIATION USED

ACE: 1'S-1'-acetoxychavicol acetate; **RBL:** Rat Basophilic Leukemia; **FAB-MS:** Fast Atom Bombardment Mass Spectrometry; **HIV:** Human immunodeficiency virus; **NMR:** Nuclear magnetic resonance; **GC-MS:** Gas chromatography–mass spectrometry; **TB:** Tuberculosis; **MIC:** Minimum inhibitory concentration; **MBC:** minimum bactericidal concentration; **DCM:** Dichloromethane; **TNF-α:** tumor necrosis factor alpha; **IL-4:** interleukin 4; **DPPH:** 2, 2-diphenyl-1-picrylhydrazyl; **ORAC:** oxygen radical absorbance capacity; **TPC:** total phenolic content; **AOA:** antioxidant activities; **NF-κB:** Nuclear factor-κB; **IKK-β:** inhibitor of nuclear factor kappa-B; **COX-2:** cyclooxygenase 2; **ROS:** Reactive Oxygen Species.

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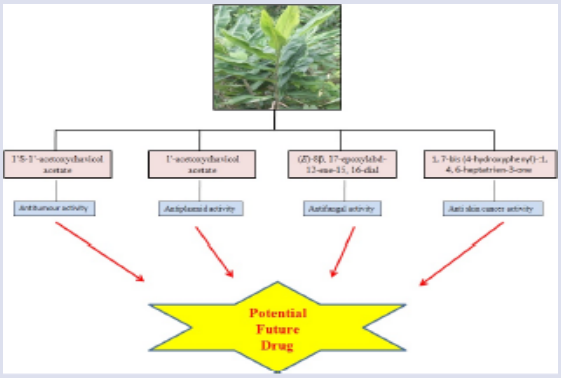
GRAPHICAL ABSTRACT



SUMMARY

- *Alpinia galanga* (Linn.) is a medicinally important plant belongs to Zingiberaceae family.
- Chiefly the rhizome part of the plant is used in the treatment of many diseases for its anti-fungal, anti-tumour, antimicrobial, anti-inflammatory, anti-diabetic, antioxidant, anti-ulcer and many other properties.
- Several active compounds has been extracted from the plant which shows bioactivity.
- Isolation and identification of the bioactive lead molecules may be used in therapeutics of cancer biology as well as several other diseases.

ABOUT AUTHORS

Dr. Santanu Paul is an Associate Professor at the Department of Botany; University of Calcutta; India.

Anirban Chouni is a Junior Research Fellow at the Department of Botany; University of Calcutta; India.

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