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A Review on Pharmacological and Phytochemical Properties of *Zingiber officinale* Roscoe (Zingiberaceae)

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ABSTRACT

Zingiber officinale is one of the most widely used herbs and food flavouring agent and commonly known as ginger. *Z. officinale* is belonging to Zingiberaceae family which includes more than 1200 species in 53 genera. *Z. officinale* is known for various medicinal properties in traditional medicinal system and use to cure a variety of diseases. In last few decades, *Z. officinale* is extensively studied for its medicinal properties by advanced scientific techniques and a variety of bioactive compounds have been isolated from the plant and were analysed pharmacologically. The medicinal properties of this plant represent it as a valuable source of medicinal compound. This study is a collective information concerning the ethnobotany, pharmacology, phytochemistry and biological activities of the *Z. officinale*.

Key words:*Zingiber officinale*, ethnobotany, pharmacology, phytochemistry

INTRODUCTION

Herbs and plants have been in use as a source of therapeutic compounds in traditional medicinal system since ancient time. Medicines plants play an important role in traditional health care systems as well as in international herbal and pharmaceutical markets. The medicinal value of these plants lies in some chemical substances that produce a definite physiological action on the human body. The most important of these bioactive constituents of plants are alkaloids, tannins, flavonoids and phenolic compounds [1, 2].

Z. officinale (Zingiberaceae) is an important plant with several ethnomedicinal and nutritional values therefore, used extensively worldwide as a spice, flavouring agent and herbal remedy. Traditionally, *Z. officinale* is used in Ayurveda, Siddha, Chinese, Arabian, Africans, Caribbean and many other medicinal systems to cure a variety of diseases viz, nausea, vomiting, asthma, cough, palpitaion, inflammation, dyspepsia, loss of appetite, constipation, indigestion and pain [3]. In last few decades, *Z. officinale* is extensively studied for its medicinal properties by advanced scientific techniques and a variety of bioactive compounds have been isolated from the different parts of the plant and were analysed pharmacologically. The plant is reported for antimicrobial activity, anticancer activity, antioxidant activity, antidiabetic activity, nephroprotective activity, hepatoprotective activity, larvicidal activity, analgesic activity, anti-inflammatory activity and immunomodulatory activities [4-12].

The present review is focused an overall outline of the morphology, distribution, phytochemistry and medicinal properties of *Z. officinale* and its future prospects for the further scientific investigation for the development of effective therapeutic compounds

Table 1: Taxonomy of ginger plant

Taxonomy	
Kingdom	: Plantae
Division	: Magnoliophyta
Order	: Zingiberales
Family	: Zingiberaceae
Genus	: *Zingiber*
Species	: *Z. officinale*

Figure 1: Rhizome of *Zingiber officinale*

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The plant

Ginger plants can grow to about 1 m tall. The upright shoots sprout from the rhizome at the base of the plant. Rhizomes are aromatic, thick lobed, knobbly and fleshy, covered in ring-like scars (Figure 1). The rhizome grows underground and it appears pale yellow in colour. Leaves are green, long and 2-3 cm broad with sheathing bases, the blade gradually tapering to a point. The flowering spikes sprout directly from the rhizomes and are about 30 cm long and which begin to dry when the plant matures [13].

Distribution

Z. officinale is a tropical plant and highly adapted to grow in sub-tropical areas also. *Z. officinale* grows well in warm and humid conditions from sea level up to 1500 m above MSL. The plant is cultivated in China, Nepal, US, India, Bangladesh, Taiwan, Jamaica, Nigeria and some other parts of world [14]. India is the biggest producer of *Z. officinale* in the world. In India, it is been cultivated in almost all the states. Some reports suggests that the climate conditions of Orissa, West Bengal, North Eastern states and Kerala are more suitable for the growth of *Z. officinale* in India [15]. *Z. officinale* is known by different names in different parts of world, some of them are mentioned in Table 2.

Table 2: Names of *Zingiber officinale* in different languages [16]

Name	Language
Ginger	: English
Sheng jiang	: Chinese
Aduwa, sutho	: Nepali
Gember	: Dutch
Gemeiner ingber/ingwer	: German
Gengibre/jengibre	: Spanish
Gingembre	: French
Gingimbre	: Caribbean
Imbir lekarski	: Polish
Jahe	: Indonesian
Khing	: Thai
Saenggang	: Korean
Shokyo	: Japanese
Katubhadra, Srngavera	: Sanskrit
Adarakha	: Hindi
Ada	: Bengali
Adu	: Gujarati
Alla, Hasishunti	: Kannada
Inchi	: Malayalam
Ardrak, Ale	: Marathi
Adi, Adrak	: Punjabi
Injee, Allam, lakottai, Inji	: Tamil
Allamu, Allam	: Telugu
Adrak	: Urdu

Traditional uses of *Z. officinale*

Uses in Ayurveda

Ginger is used widely in Ayurveda to cure a many of the illness such as indigestion, tastelessness, loss of appetite, flatulence, intestinal, biliary colics, nausea, vomiting, allergic reactions, acute and chronic cough, common cold, fever, allergic rhinitis, sinusitis, acute and chronic bronchitis, respiratory troubles, pain, headache, backache or any kind of muscular catch, painful tooth and swelled gum [16-18].

Uses in Siddha

Ginger possess several important medicinal properties and used extensively in Siddha for the treatment of cough, nausea, pain and diarrhea. In combination with other herbal products, Ginger is used to cure several diseases such as vomiting, pitha diseases, indigestion, tastelessness, gastritis, vomiting, loss of appetite, dyspepsia, head ache, cough, back pain, abdominal pain, hepatomegaly, sinusitis, gingivitis, otitis, pharyngitis, peptic ulcer, dysmenorrhoea and toxic fever [19].

Phytochemical composition of *Zingiber officinale*

The phytochemical composition of the *Z. officinale* has been extensively studied in the past studies. *Z. officinale* is reported to possess essential oils, phenolic compounds, flavonoids, carbohydrates, proteins, alkaloids, glycosides, saponins, steroids, terpenoids and tannin as the major phytochemical groups.

These phytochemicals plays an important role in the medicinal property of this plant [20-22].

Chemicals

A variety of chemicals have been isolated from *Z. officinale* and extensively studied for their chemical structure by using advanced analytical techniques such as gas chromatography-mass spectroscopy (GC-MS) and high performance liquid chromatography (HPLC). The fresh and dried *Z. officinale* extracts have been reported to possess [6]- gingerols, [8]- gingerols, [10]-gingerols, 1,7-bis-(40-Hydroxy-30-methoxyphenyl)-3,5-heptadione, adenine, 1-Dehydro-3-dihydro-[10]-gingerdione, Acetoxy-6-dihydroparadol, [4]-Isogingerol, 5-Methoxy-[6]-gingerol, Methyl diacetoxy-[4]-gingerdiol, Methyl diacetoxy-[10]-gingerdiol, 1-Dehydro-[3]-gingerdione, Acetoxy-[4]-gingerol, [4]-Shogaol, [6]-Shogaol, [8]-Shogaol, [10]-Shogaol, [12]-Shogaol, [6]-Paradol, [7]-Paradol, [8]-Paradol, [9]-Paradol, [10]-Paradol, [11]-Paradol, [13]-Paradol, 1-(40-Hydroxy-30-methoxyphenyl)- 7-octen-3-one, 1-(40-Hydroxy-30-methoxyphenyl)-7-decen-3-one, 1-(40-Hydroxy-30-methoxyphenyl)-7-dodecen-3-one, beta-sitosterol palmitate, isovanillin, glycol monopalmitate, hexacosanoic acid 2,3-dihydroxypropyl ester, maleimide-5-oxime, p-hydroxybenzaldehyde and 1-(omega-ferulyloxyceratyl) glycerols [23-25].

Nutrient Composition

Ginger is used widely in a variety of foods because of its nutritional composition and flavouring compounds. Fresh ginger is reported to contains protein, fat, minerals, fibers, carbohydrates, lipids (including glycerides, phosphatidic acid, lecithins, and fatty acids), protease, iron, calcium, magnesium, potassium, and phosphorous. It also contains vitamins such as thiamine, riboflavin, niacin and vitamin C [26, 27].

Pharmacological studies

Z. officinale is one of the most widely used herbs in the family Zingiberaceae. In recent history this plants is reported for various medicinal properties (Figure 2).

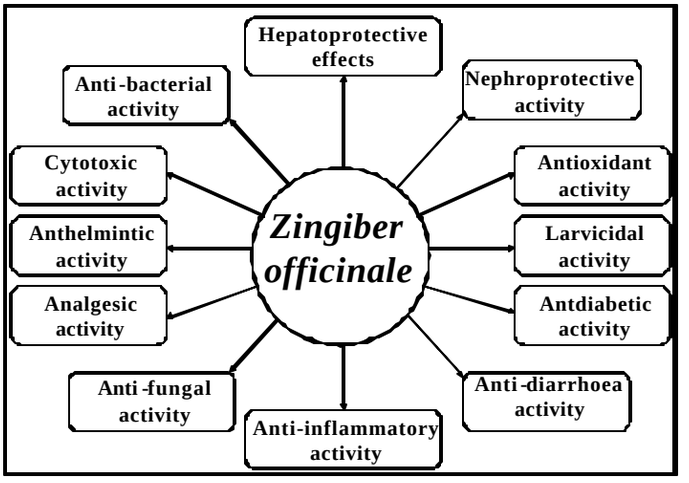

Figure 2: Medicinal properties of *Zingiber officinale*

Antimicrobial activity

Ginger has been traditionally used for the treatment of throat infections and been reported to inhibit the broad range of pathogenic microorganisms included gram positive, gram negative bacteria and fungi. Many in vitro studies proved the antimicrobial potential of *Z. officinale* extracts towards both gram positive and gram negative bacteria .

Antimicrobial activity of the different organic extracts (n-hexane, ethyl acetate, ethanol and water) of *Z. officinale* rhizome was reported against *Colliform bacillus, Staphylococcus epidermidis* and *Streptococcus viridians.* The study showed that all the extracts except the water extract have antibacterial activity and that the inhibition of bacterial growth. Among all, ethanol extract showed maximum antimicrobial activity [28].

Antibacterial activity of the different organic extracts of *Z. officinale* alone and in combination with honey (methanol extract, ethanol extract, Honey, Honey+ methanol extract, Honey+ ethanol extract) has been evaluated. All the five compositions exhibited efficient antimicrobial activity against *Staphylococcus aureus, Escherichia coli, Salmonella typhi, Bacillus cereus, Klebsiella pneumoniae* and *Pseudomonas aeruginosa* . However, the antimicrobial activity of the combination of honey and the extracts were much higher than that of the individuals [4].

Antibacterial activity of crude polysaccharides, flavonoids, aqueous and ethanol extracts of *Z. officinale* were reported. Antimicrobial activity of theses extracts were evaluated against *Escherichia coli* (ATCC25922), *Staphylococcus aureus* (ATCC25923), *Shigella fiexneri* (ATCC12022), *Proteus vulgaris* (ATCC13315), *Pseudomonas aeruginosa* (ATCC27853) and *Bacillus subtilis* (ATCC6633b). The ethanol extracts and crude flavonoids exhibit antibacterial activities against *Escherichia coli, Staphylococcus aureus, Shigella fiexneri, Proteus vulgaris* and *Pseudomonas aeruginosa*, while polysaccharides and aqueous extracts did not showed any activity [29].

Antifungal activity of the ethanol extract of *Z. officinale* was reported against two strains of *Candida albicans* (PTCC 5027 and ATCC 10231). The results revealed the efficient antifungal activity of the extract [30].

Anti-diabetic activity

Z. officinale is used to control diabetes in traditional medicinal system. Many in vivo scientific studies have been conducted in animal models to evaluate the ant-diabetic activity of different organic extracts and fresh juice of *Z. officinale*.

Hypoglycaemic potential of *Z. officinale* was reported in streptozotocin induced diabetic rats. Treatment with aqueous extract (500 mg/kg body weight, i.p.) of *Z. officinale* for a period of 7 weeks significantly decreased the serum glucose, cholesterol and triacylglycerol levels in the treated diabetic rats compared with the control diabetic rats [31].

Fresh juice of *Z. Officinale* was reported to carry hyperglycaemic activity. The Fresh juice of *Z. officinale* (4 ml/kg body weight) produced a significant time dependent decrease in blood glucose level in streptozotocin induced diabetic rats[32].

The juice of *Z. officinale* was reported to control type I diabetes. Treatment with *Z. officinale* juice in streptozotocin induced type I diabetic rats resulted in to a significant increase in insulin levels and a decrease in fasting glucose levels in diabetic rats. *Z. officinale* treatment also caused a decrease in serum cholesterol, serum triglyceride and blood pressure in diabetic rats[7].

Nephroprotective activity

Nephroprotective activity of the ethanol extract of *Z. officinale* was reported in mice. The mice were injected with cisplatin (single dose of 10 mg/kg body wt, i.p) in order to induced acute renal damage. The ethanol extract of *Z. officinale* alone and in combination with a-tocopherol significantly and dose dependently protected the nephrotoxicity induced by cisplatin. The protective effect of *Z. officinale* (250 mg/kg body weight) was found to be better than that of a-tocopherol (250 mg/kg body wt). The combination of *Z. officinale* (250 mg/kg) with a-tocopherol (250 mg/kg) showed a better protection compared to their 250 mg/kg alone treated groups [8].

Hepatoprotective activity

The antihepatotoxic effect of ethanolic extract of *Z. officinale* was reported against CCl_4 induced hepatotoxicity in Wister albino rats. The ethanolic extract of *Z. officinale* significantly reduced the serum glutamate pyruvate transaminase (SGPT) and serum glutamate oxaloacetate transaminase (SGOT) when ginger ethanolic extract was administered first (1000 mg/kg body weight) followed by CCl_4 24 h later. Injection of CCl_4 followed by ethanolic ginger extract gave a reduction in the serum enzymes but not as much as when ginger extract was first administered [33].

The hepatoprotactive activity of the *Z. officinale* extract was reported in male Sprague-Dawley rats. Hepatotoxicity was induced by an oral dose of paracetamol (1000 mg/kg body weight). The ethanol extract of *Z. officinale* was given orally to the rats at a dose of 200 mg/kg body weight and 300 mg/kg body weight. The results showed that ethanolic extract of *Z. officinale* rhizome (200 mg/kg body weight) significantly reduced the plasma SOD levels. At the higher dose (300 mg/kg body weight) it significantly reduced the plasma SOD, hepatic MDA, serum AST and increased the levels of plasma proteins [9].

Larvicidal activity

Larvicidal activity of *Z. officinale* was reported against *Angiostrongylus cantonensis* a round worm. *A. cantonens* is a parasitic nematode which causes angiostrongyliasis, the most common cause of eosinophilic meningitis in Southeast Asia and the Pacific Basin. In the study, [6]-gingerol, [10]-shogaol, [10]-gingerol, [6]-shogaol and hexahydrocurcumin were isolate from the roots of *Z. officinale* and screened for larvicidal activity against the larvae of *A. cantonensis*. Among all, [10]-gingerol showed higher larvicidal than hexahydrocurcumin, mebendazole and albendazole [10].

Larvicidal activities of the compounds isolated form the roots of *Z. officinale* were performed against the larvae of *Anisakis simplex. A. simplex* is a parasitic nematode, which present in fish and other marine mammals. Human get infected by consuming infected raw sea food and diseases is called anisakiasis. The study reveled that the compounds ([10]-shogaol, [6]-shogaol, [10]-gingerol and [6]-gingerol) isolated from the roots of *Z. officinale* kill or reduce spontaneous movement in *A. simplex* larvae. Among all, [10]-gingerol resulted in to 100% lethality against the larvae of *A. simplex* [34].

Larvicidal activity of isolated compounds from the rhizome of *Z. officinale* was reported against *Adese aegypti* and *Culex quinquefasciatus*. The study reported the larvicidal activity of (4)-gingerol, (6)-dehydrogingerdione and (6)-dihydrogingerdione against fourth instar larvae of *A. aegypti* (LC_{50} 4.25, 9.80, 18.20 ppm) and *C. quinquefasciatus* (LC_{50} 5.52, 7.66, 27.24 ppm), respectively [35].

Anticancer activity

Ethanol and chloroform extracts of *Z. officinalis* were screened for their cytotoxic activity against human cervical cancer (HeLa) and mouse fibroblast (L929) cell-lines. These extracts showed significant cytotoxic activity against the test cell lines. Chloroform extract inhibit L929 and HeLa cells with IC_{50} values 87.28 µg/ml and 74.32 µg/mL, respectively, while the ethanol extract showed IC_{50} values at 101 µg/ml and 33.78 µg/mL, respectively [5]. Habib et al., 2008 reported the anticancer activity of the *Z. officinale* extract on ethionine-induced hepatoma Rats [36].

Analgesic activity

The analgesic activity of the *Z. officinale* oil was evaluated by the Acetic acid-induced writhing in mice and hot-plate test in mice. The study reported the significant analgesic effect against chemically and thermally-induced nociceptive pain stimuli in mice [37].

The analgesic activity of the *Z. officinale* extract was studied in the acetic acid induced writhing in Swiss albino mice. The rhizome extract (50 and 100 mg/kg body weight) significantly reduced the number of writhing induced by acetic acid in mice [11].

Anti-inflammatory activity

The anti-inflammatory activity of the *Z. officinale* extract was performed in the carrageenan - induced rat paw oedema in Wistar strain albino rats. The rhizome extract (50 and 100 mg/kg body weight) significantly reduced the carrageenan – induced rat paw oedema in rats [11].

Immunomodulatory activity

The immunomodulatory effect of *Z. officinale* essential oils was reported in mice. In the study, essential oil of *Z. officinale* was administered to mice (once a day, orally, for a week) previously immunized with sheep red blood cells. *Z. officinale* essential oil showed the improvement in humoral immune response in immune suppressed mice [12].

Anthelmintic property of ginger

Aqueous extracts of rhizome of *Z. officinale* was investigated for their anthelmintic activity against the earthworm *Pheretima posthuma.* The result reveled that the test extract (100mg/ml) possess significant anthelmintic activity [38].

Methanol extracts of *Z. officinale* was screened for their *in vitro* anthelmintic activity. Results revealed that *Zingiber officinale* killed all the test worms (*Haemonchus contortus*) within two hours post exposure being 100% effective [39].

Antioxidant activity

Antioxidant compounds are widely used compounds to counter the free radicals mediate oxidative stress in the cell. The antioxidant compounds can be derived from natural sources such as plants. Antioxidant activity of the plants is due to the presence of flavones, isoflavones, flavonoids, anthocyanin, coumarin lignans, catechins and isocatechins. *Z. officinale* is extensively reported to possess antioxidant activity against a variety of free radicals.

The antioxidant effect of *Z. officinale* was reported by DPPH radical scavenging activity. The total phenolic content in the alcoholic extract of the dried rhizome of *Z. officinale* was 870.1 mg/g of dry extract. Extract exhibited 90.1% of DPPH radical scavenging activity with the IC_{50} concentration of 0.64 µg/ml [40].

Toxicity

The ginger has been listed in "Generally Recognised as Safe" (GRAS) document of the US FDA. A dose of 0.5 – 1.0 g of ginger powder ingested 2-3 times for periods ranging from 3 months to 2.5 years did not cause any adverse effects. The British Herbal Compendium documents no adverse effects of ginger. The acute oral LD_{50} in rats of roasted ginger is 170 g/kg body weight. Dry ginger is more than 250 g/kg body weight [41-43].

CONCLUSION

Z. officinale is an important medicinal herb and extensively used in Ayurveda, Siddha, Chinese medicine etc. In recent years, ethnomedicinal studies received much attention as this brings to light the numerous little known and unknown medicinal virtues especially of plant origin. Pharmacological screenings of *Z. officinale* revealed its medicinal potential and represents it as a valuable medicinal plant with several medicinal properties. As the pharmacologists are looking forward to develop new drugs from natural sources, development of modern drugs from *Z. officinale* can be emphasized for the control of various diseases. A systemic research and development work should be undertaken for the development of products for their better economic and therapeutic utilization.

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