



E-ISSN: 2321-2187

P-ISSN: 2394-0514

www.florajournal.com

IJHM 2022; 10(6): 04-09

Received: 11-07-2022

Accepted: 20-08-2022

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An overview on chemical constituents and biological activities of *Zingiber officinale*

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DOI: <https://doi.org/10.22271/flora.2022.v10.i6a.836>

Abstract

Ginger (*Zingiber officinale*) is a common kitchen spice that belongs to the family Zingiberaceae. It is rich in phytochemistry that is promoting health benefits. It is used as a home remedy to support the common cold, headaches, and pharmacological properties such as anti-inflammatory, antioxidant, antiemetic, antiulcer, and anti-cancer, antiplatelet, anti-diabetic and lipid-lowering activities. Gingerols are key ingredients found in ginger that convert into zingerone, shogaol, and paradols, giving flavor and odor. Zingerone and shogaol are present in limited quantities in fresh ginger and more in dried or extracted goods. Especially 6-gingerol and 6-shogaol are pharmacological properties that are effective in antipyretic, analgesic and hypotensive. The present review is about different therapeutic properties of ginger, including antioxidant properties, anti-diabetic properties, anti-cancer properties etc.

Keywords: Ginger, antioxidant, analgesic, anti-inflammatory, anti-diabetic

1. Introduction

Ginger (*Zingiber officinale*) rhizome belongs to the family Zingiberaceae widely used as an important cooking spice for various food and beverages around the world, specifically in the Southern Eastern Asian countries, Central, South Africa and United States of America [1]. Ginger rhizome's flesh can be white, yellow, and red in color, depend upon its variety. Its cover either be thick or thin brown skin, depending upon the harvesting when it was a young and mature plant. In India and China, fresh ginger use as a flavoring agent in beverages and the preparation of vegetables and meat products [2].



Fig: *Zingiber officinale* rhizome

Usually, ginger is consumed as a fresh paste and dried powder. In traditional medicine, the rhizome was used for the treatment of some diseases, including inflammatory disease, and proven various pharmacological activities such as antiemetic, antiulcer, anti-inflammatory, antioxidant, antiplatelet, glucose and lipid-lowering, cardiovascular, anti-microbial, gastro protective, respiratory protection and neuro-protection effects and anti-cancer activities [3]. It is also believed to support the common cold, headaches and even helpful in menstrual periods. Ayurveda practitioners commend ginger as a powerful digestive aid; it stimulates the appetite and clears the body's micro-circulatory channels. It also helps to improve the digestion and transportation of nutrients to targeted body tissues. Furthermore, it is also used as a remedy for joint pain, nausea and motion sickness [4].

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2. Taxonomic classification

1. Domain: Eukaryota
2. Kingdom: Plantae
3. Phylum: Spermatophyta
4. Subphylum: Angiospermae
5. Class: Monocotyledonae
6. Order: Zingiberales
7. Family: Zingiberaceae
8. Genus: *Zingiber*
9. Species: *Officinale*

3. Chemical composition

The active ingredients in ginger are thought to reside in its volatile oils, which comprise approximately 1 - 3% of its weight. The major active ingredients in ginger oil are the sesquiterpenes: bisabolene, zingiberene, and zingiberol [5]. The concentrations of active ingredients vary with growing conditions. Ginger's active ingredients have a variety of physiologic effects. For example, the gingerols have analgesic, sedative, antipyretic and antibacterial effects *in vitro* and in animals. The characteristic odor and flavor of ginger is caused by a mixture of zingerone, shogaols and gingerols, volatile oils that composed one to 3% of the weight of fresh ginger. In laboratory animals, the gingerols increase the motility of the gastrointestinal tract and have analgesic, sedative, antipyretic and antibacterial properties. Shogaols, shogaol have a number of different beneficial effects. These include anti carcinogenic, anti-oxidative, antimicrobial, anti-inflammatory, anti-diabetic, anti-obesity, anti-gastric ulcer and antiallergenic effects. In addition, it has also been reported that the bioactivity of shogaols is stronger than that of gingerols. Ginger oil has been shown to prevent skin cancer in mice and a study at the University of Michigan demonstrated that gingerols can kill ovarian cancer cells. Gingerol (1-[4'-hydroxy-3'-methoxyphenyl]-5-hydroxy-3-decanone) is the major pungent principle of ginger. The chemo preventive potentials of gingerol present a promising future alternative to expensive and toxic therapeutic agents. Ginger contains up to 3% of a fragrant essential oil whose main constituents are sesquiterpenoids, with (-)-zingiberene as the main component. Smaller amounts of other sesquiterpenoids (β -sesquiphellandrene, bisabolene and Farnesene) and a small monoterpene fraction (β phellandrene, cineol, and citral) have also been identified. The pungent taste of ginger is due to nonvolatile phenylpropanoid-derived compounds, particularly gingerols and shogaols, which are formed from gingerols when ginger is dried or cooked. Zingerone is also produced from gingerols during this process; this compound is less pungent and has a spicy-sweet aroma. Ginger is also a minor chemical irritant, and because of this was used as a horse suppository by pre-World War I mounted regiments for feaguing. Ginger has a sialagogue action, stimulating the production of saliva which makes swallowing easier [6].

4. Areas of use

It has been used as a prominent spice and medicinal plant across the world since ancient times. The ginger we consume in fresh or dried form is *Rhizoma zingiberis* drug obtained from *Z. officinale* rhizomes. Ginger use is fairly high in USA, England and Scandinavian countries apart from the countries it is cultivated today. Some 2500 years ago, its forms of use in China included digestive aid, nausea remover, toothache reliever, bleeding regulator, rheumatic effective, remedy against baldness, anti-snakebite medicine and breathing

regulator. Moreover, ginger bears a great significance in traditional Chinese medicine in our day, too. It occupies a large area of production and use in India as well. It has been used as an anticoagulant and cholesterol preventers, and remedy for arthritis in traditional Indian medicine. Its form of use in Arab culture is an aphrodisiac. Some Africans also believe that mosquitoes are repelled when they eat ginger on a regular basis. Epstein-Barr virus infection is among the reasons of cancer. It is reported that ginger inhibits this virus infection and thereby prevents cancer. Direct effect of ginger on humans is in the form of a nausea reliever in the gastrointestinal system [7].

5. Traditional use

Ginger is carminative, pungent, stimulant, used widely for indigestion, stomachache, malaria and fevers. It is chiefly used to cure diseases due to morbidity of Kapha and Vata. Ginger with lime juice and rock salt increases appetite and stimulates the secretion of gastric juices. It is said to be used for abdominal pain, anorexia, arthritis, atonic dyspepsia, bleeding, cancer, chest congestion, chicken pox, cholera, chronic bronchitis, cold extremities, colic, colitis, common cold, cough, cystic fibrosis, diarrhoea, difficulty in breathing, dropsy, fever, flatulent, indigestion, disorders of gallbladder, hyperacidity, hypercholesterolemia, hyperglycemia, indigestion, morning sickness, nausea, rheumatism, sore throat, throat ache, stomach ache and vomiting. Ginger forms an important constituent of many pharmacopoeial Ayurvedic formulations [8].

6. Therapeutic effect of ginger

6.1. Antioxidant effect

In rats, ginger consumption reduces lipid peroxidation and restores the activities of superoxide dismutase and catalase, glutathione, and glutathione reductase, and glutathione peroxidase glutathione-S-transferase [9]. Before ischemia, supplementation of ginger resulted in a higher total antioxidant capacity that regularized glutathione peroxidase and superoxide dismutase activities and low total oxidants levels (lower tissue malondialdehyde, NO, and protein carbonyl contents) in comparison to an untreated group of Wistar albino rats. Overall experience fed of ginger (5%) show less kidney damage due to oxidative stress induced by ischemia [10]. The phytochemistry-rich ginger contains scavenges free radicals components that are produced in biological systems. For energy production generated during the process of oxidation, some free radicals are essential [11]. Increases in the production of free radicals show oxidative stress that can lead to damage to DNA [12].

6.2. Anti-nausea effect

Throughout history, ginger is commonly utilized for relieving nausea and vomiting. It is also an antiemetic; it is attributed as a carminative effect that helps break up and expel intestinal gas. Researchers compared the effectiveness of ginger and Vitamin B6 and reported that they were equally effective for reducing nausea and limit vomiting episodes during pregnancy [13].

6.3. Analgesic and anti-inflammatory effects

Ginger suppresses prostaglandin synthesis through inhibition of cyclooxygenase-1 and cyclooxygenase-2. It also suppresses leukotriene biosynthesis by inhibiting 5-lipoxygenase. His pharmacological property distinguishes ginger from NSAID (Non-Steroidal Anti-Inflammatory Drugs). Dual inhibitors of

cyclooxygenase and 5-lipoxygenase may have a better therapeutic profile and have fewer side effects than NSAID [14]. For the human being, the consumption of fresh ginger demonstrated promising results for the decrease of arthritis-induced pain. However, more studies are necessary before concluding on a real effect of the consumption of ginger for the prevention and treatment of pain caused by chronic inflammatory disorders [15]. Ginger has a strong analgesic action which in many cases act by cyclooxygenase-1 (COX-1) inhibition. Gingerol and their derivatives, especially paradol, have been reported to be more potent anti-platelet and cyclooxygenase-1 (COX-1) inhibitors than aspirin [16].

6.4. Cardiovascular effect

The studies show the effect of ginger on blood lipids in both animals and humans. The results show that ginger significantly decreases plasma cholesterol in animals, but not in patients who are suffering from any heart disease such as coronary artery disease. Research shows ginger has exhibit antithrombotic activity, *in vitro* study, its extract inhibits platelet aggregation and thromboxane-B2 (TXB2) production. Furthermore, gingerdione and shogaol also inhibit the formation of 5-hydroxyeicosatetraenoic acid (5-HETE) and prostaglandin-E2 (PGE2) from arachidonic acid, gingerol and dehydroparadol favored the inhibition of cyclooxygenase. Ginger is used as antiplatelet therapy, and it prevents coronary heart disease [17]. In this approach, ginger has less potent than aspirin, but in contrast, it has lesser side effects than aspirin. The function of aspirin is inhibiting arachidonic acid-induced platelet release and aggregation and COX activity; ginger also works as same as the mechanism of action. So suggested that the development of effective gingerol analogs has been used as a substitute for aspirin therapy to prevent ischemic heart disease [18].

6.5. Anti-cancer effect

Ginger and its constituents show a vital effect in the control of tumor development through up-regulation of tumor suppressor gene, induction of apoptosis and inactivation of VEGF pathways. Angiogenic factors such as VEGF (Vascular Endothelial Growth Factor) and FGF (fibroblast growth factor) play a significant role in the development and progression of tumor. Therefore, inhibition of VEGF and FGF is an important step in the prevention of tumor development/management [19]. The active ingredient 6-

gingerol has considerable role in the suppression of neoplastic transformation, hyper proliferation, and inflammatory processes that involve in various steps of carcinogenesis, angiogenesis and metastasis [20]. Several studies have shown that ginger has promising effect for liver cancer, breast cancer, prostate cancer and colorectal carcinomas through its diverse pharmaceutical mechanisms [21].

6.6. Anti-diabetic effect

In diabetes, many studies show that ginger and other plants have effective both preventively and therapeutically [22]. In Australia, the University of Sydney found ginger was effective in glycemic control for people with type 2 diabetes. A study showed that ginger extracts could increase the uptake of glucose into muscle cells without using insulin; hence, it may help control high blood sugar levels. Another clinical trial in diabetic patients that consumed three grams of dry ginger for 30 days shows that blood glucose, triglyceride, and total and LDL cholesterol levels significantly reduced [23]. A study of ethanolic extract of *Zingiber officinale* fed orally for 20 days produced a significant anti-hyperglycaemic effect ($p < 0.01$) in diabetic rats. Furthermore, in high-fat diets, the ethanolic extract of ginger was found to reduce body weights, total cholesterol, LDL cholesterol, triglycerides, free fatty acids, glucose, insulin and phospholipids [24]. Overall, ginger works on diabetes by increasing insulin release and sensitivity, inhibiting carbohydrate metabolism enzymes and improving lipid profiles. Ginger has a very low glycemic index (GI), which means it gradually breaks down to shape glucose and thus does not raise blood sugar levels as high GI foods do. Some other investigations established ginger has a preventive effect against diabetes complications. Ginger can also protect a diabetic's liver, kidneys, and central nervous system and reduce the risk of cataracts a common side effect of the disease [25].

6.7. Fertility enhancer

Ginger exerts a beneficial effect on the reproductive system of male rats. It causes increased sperm count, motility enhancing activity and testosterone while decreased malondialdehyde level. These all parameters improve the fertility capacity of semen [26]. Gentamycin handles the reduction of sperm count and also causes apoptosis in testis. The ginger extract showed inhibition of toxic effects of gentamycin on the reproductive system and also reduce apoptosis in testes [27].

7. Major effects

Table 1: Major effects

Major effects	Ref.
Effective treatment in rheumatoid arthritis.	[28]
Significantly reduce migraine attacks.	[29]
Relieve moderate to mild nausea and vomiting during pregnancy.	[30]
Effective for Chemotherapy-induced vomiting and nausea.	[31]
Anti-diabetic and Cardiovascular effect.	[32]
Effective in knee osteoarthritis patients.	[33]
Significantly improves breast milk volume.	[34]
Effective for weight loss.	[35]
Helpful to maintain the blood glucose level.	[36]
Significantly reduced the frequency of vomiting and nausea during chemotherapy.	[37]
Recover the muscle strength after intense exercise, no effect on muscle damage or delayed onset muscle soreness.	[38]
Significantly reduced menstrual blood loss.	[39]

8. Nutrient composition

The study reveals that mature ginger had higher in ash

(7.48%), fat (4.48%), crude fiber (9.75%) and protein (10.54%) content on dry weight bases. However tender ginger

had similar content of ash and fat i.e. 3.80%. Carbohydrate content was noted maximum in tender ginger. Among the processed products ginger candy noted 1.68% of crude fiber. Ginger sherbet was prepared by dilution and hence its significant impact on the nutrient composition was observed. Ginger precipitate was collected while the processing of ginger for juice and noted that it had 7.04% protein and 3.80% of ash content [40].

9. Ginger tea

In order to prepare ginger tea, a 2.5 cm tall fresh ginger root is sliced or used in powdered form. Next, half a dessertspoon of ginger refined using a grinder is added to a full glass of cold water, heated up to the boiling degree in a mild temperature, then boiled in a mild temperature for 5 to 6 min and drained. If necessary, a cup of freshly brewed tea is sweetened by

squeezing juice of half a lemon and adding honey; and drinks it before it cools down. There is no inconvenience in drinking 1 or 2 cups of freshly brewed tea a day. The tea is preferred especially in complaints related to digestive system. Tincture you may prepare ginger tincture using a proper dilution. Primary areas of use are digestive problems, asthma and complaints related to urinary tract. Drink it continuously or when necessary by adding 10 to 15 drops into half a tablespoon of lukewarm water for 2 or 3 times a day. Spice Ginger is such a spice that patients suffering from stomach ulcer may use it conveniently. Spices containing ginger with may be conveniently added into soups, grilled meat with the purpose of easing digestion, any kind of cheese, vegetables, fruit salad, rice pilaf, muffins or cakes. Spices with ginger are preferred mostly due to their aphrodisiac effect [41].

10. Methods of use in different diseases

Table 2: Methods of use in different diseases

Methods of use	Ref
If you have anorexia condition, mix 2 teaspoons of ginger juice and a little salt in a quarter cup of water and leave it in your mouth for a while for 10/15 minutes.	[42]
Chewing a little ginger with sea salt before eating increases appetite, eliminates mouth soreness, phlegm of tongue and throat and numbness.	
Ginger juice mixed with honey is useful for colds and fevers.	
When the body becomes swollen with wheels (commonly called hives), it is relieved by mixing ginger juice with old molasses.	
In case of chronic dysentery, it is beneficial to take one gram of dry powder with hot water.	
In case of pox, mix one teaspoon of ginger juice with one teaspoon of <i>Ocimum sanctum</i> leaf juice and eat it.	
To stop hiccups mix ginger juice with goat's milk and drink it.	
If it is cut in body, if you press a little bit of dry ginger powder there, the bleeding will stop and the cut wound will heal quickly.	
Ginger contains essential oil, so ginger juice is very popular in the treatment of flatulence, vomiting, sore throat, cough, constipation, earache and headache.	

11. Compound drugs

Jowarish komuni, Jowarish jalinush, Jowarish tamarhind, Jowarish bisbasa, Majoon falasafa, Majoon lana, Majoon mukil, Majoon suranjan, Majoon shohagsoot, Majoon suparipak, Arq faulin, Syrup carmina, Syrup jinsin, Kurs borchina, Habbe ambar momiyaye, Habbe kated nowshadori, Abe Hayat [43].

12. Warnings

Ginger should not be used together with blood diluent medicines like heparin, warfarin and aspirin because bleeding time may be prolonged in long-term use of ginger, which is also a strong inhibitor of thromboxane synthetase. It does not bear any known side effect except for its long-term use during pregnancy period (it may be used for short terms against pregnancy nausea) [44].

13. Conclusion

Ginger is well known as a condiment and spices used for flavoring food and also its use as a therapeutic purpose from a thousand years ago. Ginger and its bioactive components include gingerols, shogaol, and paradols are active/valuable ingredients which use as a novel therapeutic strategy against various degenerative diseases. This review appreciated natural products drugs (ginger), have beneficial effects for cardiovascular disorders, diabetes mellitus, and gastrointestinal health, and have anti-inflammatory and antibacterial effects. The application of ginger is safe and promising health benefits in the past as well as the future. It can be concluded that ginger is a good source of antioxidant and most of the antioxidant components exhibit higher

activities in alcoholic media as determined by different assays. Hence, apart from its medicinal properties, ginger can also be used as an antioxidant supplement.

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