Chapter

GINGER: A FUNCTIONAL HERB

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GENERAL DESCRIPTION

Ginger (*Zingiberofficinale* Roscoe)belongs to the familyZingiberaceae (Wagner, 1980) and genus *Zingiber*. Other names of ginger are African ginger, Black ginger, Cochin ginger, GanJiang,Gegibre, Ingwer, Jamaican ginger, and Race ginger. Turmeric, cardamom, and galangal are other notable members of the ginger family. The English botanist William Roscoe (1753-1831) gave the plant the name *Zingiber*, derived from a Sanskrit word *singabera* which means horn-shaped due to the protrusions on the rhizome (Katzer, 1999). The genus includes about 85 species of aromatic herbs from East Asia and tropical Australia.

Ginger is an erect perennial plant growing from one to three feet in height. The stem sticks up about 12 inches above ground and is surrounded by the sheathing bases of the two-ranked leaves. It produces clusters of white and pink flower buds that bloom into yellow flowers. Ginger grows horizontally, laterally flattened with branching pieces,a configuration known as rhizome. The whole rhizome has a firm, striated texture. It is 5 to 15cm long, 1.5to 6cm wide, 2cm thick and depending on the variety can be yellow, white, or red in color.

Warm, humid climate is the most ideal for ginger cultivation. It grows best in rich soil and shady places. Ginger can be grown both under rain fed and irrigated conditions. It is usually cultivated vegetatively, meaning pieces

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of rhizome are planted in the soil and each sprouts to form a new plant. Modern micropropagation is also being used where new plants are cloned from cells taken from a single plant. The cloned offspring are then planted out in a field. Carefully preserved seed rhizomes are cut into small pieces of 2.5-5.0 cm length weighing 20-25 g, each having one or two good buds. The seed rate varies from region to region and depends upon the adopted method of cultivation. Worldwide, over 25 varieties of ginger are grown. *Zingiber, ISR- Varada 2, Suprabha, Suruchi, Suravi,Himagiri, IISR Mahima, IISR Rejatha, Rio-de-Janerio, Nadia,*and *China* are some of the important cultivars grown across the world (**Shasikaran et al,** 2008). Ginger is also grown as a decorative plant. Patterned foliage, deliciously perfumed flowers in a rainbow palette of colors and surprising seedpods make the ginger plant an interesting and noteworthy ornamental plant.*Cautleya, Globba, Roscoea, Kaempferia,* and *Siphonochilus*are grown for ornamental and medicinal purpose but not for spice (Branney, 2005, Byers, 1999).

Soft root, bacterial wilt, leaf spot, nematode pests, shoot borer, and rhizome scale are some common diseases that can infest ginger. The pests affect both the ginger plant and rhizomes. When the leaves turn yellowand start withering gradually, it indicates that crop is ready to harvest. Depending on the variety and their intended use it takes about 8 to 9 months after planting. Fresh ginger might be harvested about 5 months after planting. Preserved ginger are usually dug up 5 to 7 months after planting, before they are fully mature but while they are still tender and mild. Dried ginger, mature rhizomes with a full aroma, flavour, and pungency, are harvested 8 to 9 months after planting. The essential oil content within rhizomes increases with age, so plants used for this might be harvested even later. Harvesting is done either by hand with a spade or digging fork or by mechanical diggers. The clumps are lifted carefully and the rhizomes are separated from the dried up leaves, roots and adhering soil. They are immediately scalded, or washed and scraped, to prevent sprouting. Mature ginger roots are fibrous and nearly dry. For seed material, bold and healthy rhizomes from disease free plants are selected immediately after harvesting and stored properly in pits under shade. Depending on the variety and location where the crop is being grown the yield of dry ginger is 19-25% of fresh ginger (**Shasikaran et** al, 2008). Ginger is grown throughout South Eastern Asia, China and in parts of Japan, Austria, Latin America, Jamaica and Africa. India is the top producer of Ginger, followed by China, Indonesia, Nepal and Thailand, but the most expensive and high quality varieties come from Jamaica, Australia, and South India (Gilani and Gayur, 2005, Ali and Gilani, 2007).

HISTORY, POPULAR AND TRADITIONAL USES

Ginger is native to Southeastern Asia (Wagner, 1980). It is mentioned in ancient Chinese, Indian, and Middle Eastern periodicals and has long been valued for its aromatic, culinary, and medicinal properties (Langner, 1998). Confucius wrote about ginger in his Analects and the Greek physician Dioscorides listed ginger as an antidote to poisoning, as a digestive, and as being warming to the stomach in De MateriaMedica (Langner, 1998). Many religious holy books—the Quran, the Talmud, the Bible, Ayurveda, CharakSushutra, Vagbhatta and CharakDutta—have mentioned ginger (Gajnavi, 1996, Hrdayam of Srimadvagbhat, 1999). The medicinal properties ofginger were known in ninth century **in** Germany and France and in tenth century **in** England**.** Records suggest that ginger was highly valued as an article of trade during the 13th and 14th century in England; one pound of ginger had the same worth as that of sheep. Ginger migrated westward to Europe by Greek and Roman times. History shows that ancient Romans imported ginger from China almost two thousand years ago. By the middleAges it was a very popular spice in the Mediterranean region and had spread throughout other countries. Medieval writing from many European countries indicates that ginger was a standard ingredient in recipes for the kitchen and the apothecary (Widmaier, 1986). In an attempt to make it more available, Spanish explorers introduced ginger to the West Indies, Mexico, and South America in the 16th century and these areas began exporting this precious herb back to Europe. Ginger plants grown in pots were carried abroad onlong sea voyages to prevent scurvy. The Eclectic physicians of the 19th century relied on ginger to induce sweating, improve the appetite, and curb nausea and as a topical counterirritant. Ginger is an integral part of Ayurveda, the traditional medicine of India, and is known as sunthi in Ayurveda (Hrdayam of Srimadvagbhatt, 1999). It was used to block excessive clotting of blood in arteries and veins, to reduce cholesterol, and to fight against arthritis. In Traditional Chinese Medicine (TCM) ginger is considered a pungent, dry, warming herb to be used for ailments triggered by cold and damp weather. It was also used as a digestive aid and antinausea remedy and to treat bleeding disorders, rheumatism, baldness, toothache, snakebite, and respiratory conditions. The Romans added ginger to the oil in lamps to render an aroma in the air. Meanwhile in England ginger was added to spice up beer. The Greeks wrapped ginger in bread and ate it after meals as

a digestive aid. Subsequently, ginger was incorporated directly into bread and confectionaries such as gingerbread. As ginger resembles fingers, pregnant women in China are advised to avoid ginger during pregnancy, as they might give birth to babies with more than five fingers. But after birth a woman may take it for strength, to clean out all poison from her body, and to protect the newborn (Wong, 2001). In Malaysia and Indonesia, ginger soup is given to new mothers for 30 days after their delivery to help them sweat out impurities. In Arabian medicine, ginger is considered an aphrodisiac. Some Africans believe that eating ginger regularly will help repel mosquitoes and women of central Africa make belts of ginger roots to attract the attention of their husbands. Ginger flowers are traditionally worn by Hawaiian dancers (Gilani, 2005).

Culinary Use

Ginger is consumed worldwide as spice, flavoring agent, garnish, medicine, and food preservative and is used either fresh, in a fresh paste, or dry, in a dry powder. Fresh ginger can be substituted for dried ground ginger, although the flavors of fresh and dried ginger are somewhat different. Powdered dry ginger is typically used as a flavoring for recipes such as gingerbread, cookies, crackers and cakes, ginger ale, and beer. The fragrance of ginger is penetrating and aromatic. It tastes spicy, hot, and biting and is an integral part of almost all the cuisines of the world. The pungent, spicy sweetness of ginger adds a unique taste to many recipes ranging from sweet to savory.

In the subcontinents (India and Pakistan) ginger is called *Adrak*(local name) and is an essential ingredient of many dishes. Fresh ginger is one of the main spices used for making pulse, vegetablecurries and meat preparations. Fresh as well as dried ginger is used to spice tea and coffee, especially in winter. In Burma, it is consumed as a salad dish called *Gyin-thot*, which consists of shredded ginger preserved in oil, and a variety of nuts and seeds. In Indonesia, a beverage called *wedangjahe* is made from ginger and palm sugar. In the Philippines, it is brewed into a tea called *salabat*. In Vietnam, the fresh finely chopped leaves can also be added to shrimp-and-yam soup (*canhkhoaimở*) as a top garnish and spice to add a much subtler flavor of ginger than the chopped root. In China, sliced or whole ginger is often paired with savory dishes such as fish, and chopped ginger root is commonly paired with meat, when it is cooked. In Japan, ginger is pickled to

make *BeniShoga* and gari or grated and used raw on tofu or noodles. It is also used to make candy called *Shoga no satozuke*. In the traditional Korean*Kimchi*, ginger is finely minced and added to the ingredients of the spicy paste just before the fermenting process (Kim et al, 2005).

In the Caribbean, ginger is a popular spice for cooking and making drinks such as *sorrel*, a seasonal drink made during the Christmas season. Jamaicans make ginger beer both as a carbonated beverage and also fresh in their homes. Ginger tea is often made from fresh ginger, as well as the famous regional specialty Jamaican ginger cake.

In Arabic, ginger is called *Zanjabil*, and in some parts of the Middle East, ginger powder is used as a spice for coffee and for milk. In the Ivory Coast, ginger is ground and mixed with orange, pineapple, and lemon to produce a juice called *Nyamanku*. Yemenite Jews add ginger powder in *Hawaij*, a spice mixture used mostly for soups and coffee (Roden, 1996).

NUTRITIONAL COMPOSITION OF GINGER

Chemical Composition

Ginger contains approximately 50% carbohydrates, 9% protein and free amino acids, 6-8 % fatty acids and triglycerides, 3-6% ash, and 3-6% crude fiber (on dry matter basis) depending on variety, geography, and climatic conditions (Leung, 1984, Tang, 1992). Some African ginger varieties contain 5.98 and3.72g /100 proteins and fat (Shrin Adel, 2010). Soluble and insoluble fibers are also found in ginger. Ginger is a good source of essential micronutrients such as potassium, magnesium, copper, manganese and silicon. Potassium and manganese help to build resistance to disease and protect the lining of heart, blood vessels and urinary passages. Silicon promotes healthy skin, hair, teeth, and nails and helps to assimilate calcium. Small amount of vitamins A, E and some amounts of B- vitamins and Vitamin C are also found in ginger rhizome (Adel and Prakash, 2010).

Phytochemical Composition

Ginger is a complex substance consisting of more than 60 compounds (Srivastava et al, 2000). The ginger rhizome contains an essential oil and resin known collectively as oleoresin. The composition of the essential oil varies according to the geographical origin, but the chief constituents

aresesquiterpene hydrocarbons, which are responsible for the characteristic aroma. Gingerole is the main phenolic compond and once degraded gives shogaols, zingerone, and paradol. Zingerone and shogaols are found in small amounts in fresh ginger and in larger amounts in dried or extracted products. Zingerone is also produced from gingerols during this process; this compound is less pungent and has a spicy-sweet aroma. Smaller amounts of other sesquiterpenoidsbisabolene, geranyl acetate, terpeneol, terpanes, geraniol, alpha pinene, limonene, zigerbene, batabeasabolene, alpha paradol, farnesene, and monoterpenoid fraction (β-phelladrene, cineol, and citral) have also been identified. Ginger contains a special group of compounds called diasyleheptanoids, which includesgingerenone. A very small amount of curcumin is also found in ginger. In addition to that it also contains small amounts of alkaloids, tannins, carotenoids, saponins, flavonoids, steroids, and cardinolides (Shrin Adel, 2010).

The composition of fresh ginger oil contains more oxygenated compounds compared to dry ginger oil, making it more potent than dry ginger oil. There are more hydrocarbon compounds in dry ginger oil compared to fresh ginger oil. Monoterpene compounds are more active than sesquiterpene compounds. Dry ginger oil also has higher content of sesquiterpene hydrocarbons and they are reported to have less activity compared to oxygenated compounds (Srivastava, et al, 2000 and Sinha, et al, 1990, Sasidharan and Menon, 2010). Ginger oil (GEO) has been characterized to have a high content of sesquiterpene hydrocarbons, including β-sesquiphellandrene (27.16%), caryophyllene (15.29%), zingiberene (13.97%), *α*-farnesene (10.52%) and *ar*-curcumin (6.62%) (El-Baroty et al, 2010).

Table 1. Active Chemical Constituents of ginger

Phenols	**Volatile oils**	
	Sesquiterpenes	**Others**
Gingerols and shogoals	bisapolene, zingiberene, zingiberol, sesquiphellandrene, curcurmene	6-dehydrogingerdione, galanolactone, gingesulfonic acid, zingerone, geraniol, neral, monoacyldigalactosylglycerols, gingerglycolipids

Kathi, J Kemper, 1999.

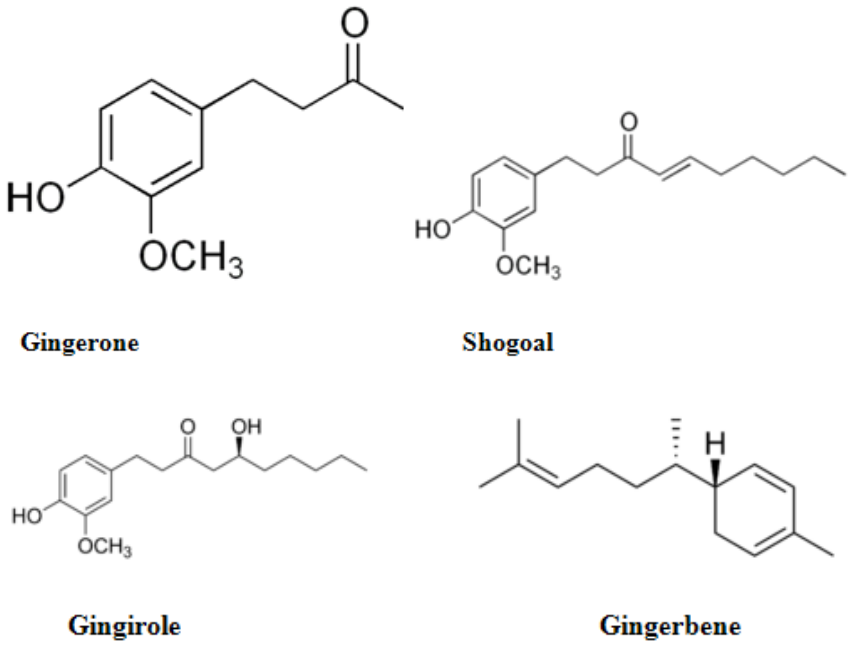

Figure 1. Chemical structure of important phytochemicals present in ginger.

HEALTHBENEFITS

Ginger is a potential herb used worldwide for its immense phytotherapeutic properties. In Ayurveda it is known as *Mahaaushdi*which means use of this herb improves body functions and helps to eliminates toxins from the body (Nadkarni, 1976). Modern scientific research has revealed that ginger possesses numerous therapeutic properties including antibiotic, antimicrobial, and antioxidant effects, an ability to inhibit the formation of inflammatory compounds, and direct anti-inflammatory effects. Besides this, ginger is also effective against some kinds of cancers, stimulates blood circulation, controls blood pressure and hypertension, helps in lowering cholesterol, and is associated with combating heart problems.

1. Digestive System

1.1. Gastrointestinal Relief

Historically, ginger has a long tradition of efficacy in alleviating symptoms of gastrointestinal disorders. In herbal medicine, ginger is regarded as an excellent carminative (a substance which promotes the elimination of intestinal gases) and intestinal spasmolytic (a substance which relaxes and soothes the intestinal tract). It reduces colon spasms and cramps, is excellent for nausea, vomiting, and motion sickness, stimulates production of digestive juices, helps bowel disorders, and acts as a colon cleanser. Ginger has a sialagogue action, stimulating the production of saliva, which makes swallowing easier (Bhagyalakshmi and Singh, 1988). In addition to that, it acts as an appetizer and stomachic. The main stomachic constituents present in ginger are zinzibereine and gingeirol. A famous Ayurvedic drug *trikatu,* which is used against digestive disorders, contains ginger as the main constituent (Malhotra et al, 2003). Ginger acts as a purgative. Fresh ginger helps to remove constipation while dry ginger powder is a fecal astringent, meaning it dries up the watery portion of the feces and causes constipation (Malhotra et al, 2003).

1.2. Dyspepsia

Ginger stimulates the flow of saliva, bile, and gastric secretions and therefore is traditionally used to stimulate appetite, reduce flatulence, colic, and gastrointestinal spasms, and generally act as a digestive aid (Blumenthal et al, 2000). Gingerols inhibit the growth of *Helicobacter pylori* associated with dyspepsia, peptic ulcer disease, and the development of gastric and colon cancer (Mahady et al, 2005).

1.3. Anti-ulcerogenic

Frequent use of non-steroidal anti-inflammatory drugs (NSAID) like Aspirin, Indomethacin, and Reserpine may cause gastric ulcer and hypothermic restraint stress. Many studies have proven ginger is a cytoprotective and anti-ulcerogenic agent. The main anti-ulcerogenic constituents present in ginger are 6 gingesulfonic acid, 6 gingerol,6 shogoal, beta-sesquiphellandrene, beta-bisabolene, gingesulfonic acid,curcumene, and 6 gingglycoprotein A, B and C(Yamahara et al, 1988). Of the anti-ulcerogenic constituents, 6 gingesulfonicacid is the most potent. These constituents protect gastric mucosa against alcohol, non-steroidal anti-

inflammatory drugs,and hydrochloric acid (Yamahara et al, 1992).In mice, zingiberene and gingerol significantly reduced gastric ulceration experimentally induced by ethanol and hydrochloric acid (Yamahara et al, 1988).

2. Respiratory System

Ginger can be used for throat infections and to relieve congestion in sinusitis. It reduces fever in colds and flu and suppresses a dry, irritating cough in laryngitis by increasing human bronchial smooth muscle cell (BSMC) migration and proliferation and reversing phthalate ester-mediated airway remodeling. Moreover, (6)-shogaol, (6)-gingerol, (8)-gingerol, and (10)-gingerol, which are major bioactive compounds present in ginger, suppress phthalate ester-mediated airway remodeling, which shows that ginger is capable of preventing phthalate ester-associated asthma.

3. Circulatory System

Ginger stimulates circulation, may help prevent heart attacks, has natural blood thinning properties, lowers blood cholesterol levels, cleanses and stimulates blood supply, prevents internal blood clots, may prevent TIA's (mini strokes), acts therapeuticallyto reduce hypertension, and prevents oxidation of LDL which contributes to cholesterol deposits on artery walls. Ginger has a tonic effect on the heart, and may lower blood pressure by restricting blood flow in peripheral areas of the body. Further studies show that ginger can lower cholesterol levels by reducing cholesterol absorption in the blood and liver.

3.1. Cardiovascular Effect

Fresh ginger exhibits hypotensive properties by endothelium dependent (cholinergic) and endothelium-independent (CCB) vasodilator pathways. Fresh ginger extract lowers blood pressure through cholinergic and calcium blocking (CCB) properties and posseses a combination of cardio-suppressant and cardio-stimulant action in experimental animals. Cholinergic compounds are known to cause a fall in blood pressure by activation of muscarinic receptors located on the epithelium of blood vessels (Furchgott and Zawdski, 1980). Furthermore, the pungent components of ginger, namely 6-gingerole, 8-gingerole, 10-gingerole and 6-shogoal, exhibit a vasodilator effect through

a combination of a nitric oxide releasing and calcium antagonist mechanism. Ginger also contains saponins, terpenoids, flavonoids, amino acids/peptides, secondary amines, and alkaloids. These compounds demonstrate hypotensive and vasodilator properties and could be the causative agents in thereduction in blood pressure (Gilani et al, 1994, Ajay et al, 2003).

3.2. AntithromboiticActivity

Ginger has been shown to exhibit antithrombotic activity because it inhibits platelet aggregation and thromboxane –B2 (TXB2) production *in vitro*. Besides this, gingerdione has been shown to inhibit the production of 5-hydroxyeicosatetraenoic acid (5-HETE) and prostaglandins-F2(PGF2) from arachidonic acid.Shogoal appeared to be a preferential inhibitor of 5-HETE formation, whilegingerol and dehydroparadol favored the inhibition of cyclooxygenase (Nurtjahja-Tjendraputra et al, 2003, Thomson et al, 2002).

4.Nervous System

4.1. Alzheimer'sDisease

6-Gingerol attenuates amyloid-induced oxidative cell death via fortifying cellular antioxidant defense systems. Amyloid is involved in the formation of senile plaques (Tiraboschet al, 2004, Ohnishi, and Takano, 2004), the typical neuropathological marker for Alzheimer's disease (AD), and has been reported to cause apoptosis in neurons via oxidative and/or nitrosative stress. 6-Gingerol pretreatment can protect cytotoxicity and apoptotic cell death such as DNA fragmentation, disruption of mitochondrial membrane potential, elevated Bax/Bcl-2 ratio, and activation of caspase-3. 6-Gingerol is also known to suppress intracellular accumulation of reactive oxygen and/or nitrogen species and to restore depleted endogenous antioxidant glutathione levels. In addition, 6-gingerol treatment up-regulates the mRNA and protein expression of antioxidant enzymes such as glutamylcysteine ligase (GCL) and heme oxygenase-1 (HO-1), the rate limiting enzymes in glutathione biosynthesis and heme degradation, respectively.Therefore, 6-gingerol exhibits preventive and/or therapeutic potential for the management of AD via augmentation of antioxidant capacity (Lee et al, 2011).

4.2. Anti-InflammatoryProperties

Ginger is useful in treating inflammation, pain, and rheumatism. The anti-inflammatory properties of ginger have been known and valued for

centuries (Mascolo et al, 1989, Young, et al, 2005). It is believed that consuming ginger regularly can reduce pain level and increase mobility in osteoarthritis or rheumatoid arthritis patients. Although no one single constituent seems to be responsible for the anti-inflammatory effects of ginger,shogaol has exhibited the most potent antioxidant and anti-inflammatory properties which can be attributed to the presence of its alpha,beta-unsaturated ketone moiety. The carbon chain length has also played a significant role in making 10-gingerol the most potent among all the gingerols. An acetone extract containing gingerols, shogaols, and minor compounds like gingerenone A, [6]-gingerdiol, hexahydrocurcumin, and zingerone have been shown synergistically to produce dose-dependent anti-inflammatory effects (Young et al, 2005).

Ginger can modulate the biochemical pathways of prostaglandin synthesis through inhibition of cyclooxygenase-1 and cyclooxygenase-2 and leukotriene biosynthesis through inhibition of 5-lipoxygenase. **Thus,** it functions as a dual inhibitor of eicosanoid biosynthesis (Grzanna, et al, 2005). This pharmacological property distinguishes ginger from non-steroidal anti-inflammatory drugs. The dual inhibitors of cyclooxygenase and 5-lipoxygenase may have a better therapeutic profile and have fewer side effects than non-steroidal anti-inflammatory drugs. One of the features of inflammation is increased oxygenation of arachidonic acid which is metabolized by two enzymic pathways—the cyclooxygenase (CO) and the 5-lipoxygenase (5-LO)—leading to the production of prostaglandins and leukotrienes respectively. Amongst the CO products, PGE_2, and amongst the 5-LO products, LTB_4, are considered important mediators of inflammation. Ginger extract and *Alpinagalanga* inhibits the induction of several genes involved in the inflammatory response (Grazanna, et al, 2005). These include genes encoding cytokines, chemokines, and the inducible enzyme cyclooxygenase-2. In one experiment Srivastava and Mustafa (1992) utilized powdered ginger to treat 56 patients of different musculoskeletal disorders (28 with rheumatoid arthritis, 18 with osteoarthritis, and 10 with muscular discomfort) against their afflictions. Amongst the arthritis patients more than three-quarters experienced to varying degreesof relief in pain and swelling. All the patients with muscular discomfort experienced relief in pain. None of the patients reported adverse effects during the period of ginger consumption which ranged from 3 months to 2.5 years. The investigators suggested that at least one of the mechanisms by which ginger shows its ameliorative effects could be related to inhibition of prostaglandin and leukotriene biosynthesis (i.e. it works as a dual inhibitor of eicosanoid biosynthesis).

Another mechanism used by ginger compounds to inhibit inflammation is attenuation of NF-kappaB-mediated iNOS gene expression. Inducible nitric oxide synthase (iNOS), a proinflammatory enzyme responsible for the generation of nitric oxide (NO), has been implicated in the pathogenesis of inflammatory diseases. Gingerols have anti-inflammatory properties *in vitro*. The active phenolic constituent, 6-gingerol, can inhibit the production of nitric oxide, a highly reactive nitrogen molecule that quickly forms a very damaging free radical called peroxynitrite. The resulting peroxinitrites are responsible for inflammation, pain, and associated diseases. 6-gingerol increases blood supply to the damaged areas and speeds up the healing and detoxification process. Udea et al, (2010) investigated the ability of ginger extract to induce an immune response in RAW-264 cells after repeated oral administration to mice. They revealed that ginger extract augmented the serum corticosterone level and gradually induced tolerance and anti-inflammatory activity in mice. Several oral administrations of squeezed ginger extract augment the immune resistance, but the repeated administration led to an anti-inflammatory effect. The effect of ginger on immune response can be reversed by oral administration period and by some host factors.It has been identified that serum corticosterone levels significantly increased after oral administration of ginger extract over 1-5 days. This augmentation may have been the cause of TNF-α inhibition which was observed after repeated administration of ginger extract. C**orticosterone has been reported to decrease the cytokine production and further the immune response**. The phosphoestrase-4 inhibitor has been reported to decrease TNF-α production and has shown dramatic anti-inflammatory efficacy that was dependent on release of corticosterone from adrenal glands (Pethipher et al, 1996).

4.3. Ginger and Migraine

Migrainesare a recurrent episodic disorder characterized by headache associated with other symptoms such as nausea, sensory sensitivity, muscle pain, and cognitive dysfunction. Migraine headaches are fundamentally different from tension headaches that are caused by accumulated stress and constriction of muscles in the neck, head, and face. It is thought that migraine headaches are caused by a cycle of dramatic constriction of the arteries that supply the brain with blood and nutrients. This constriction is followed by rapid dilation, then again by constriction, during which nerve pathway changes and brain chemistry imbalances cause the blood vessels to become inflamed. It leads to the instability of blood vessels in the brain and to a

reduction in blood flow during a migraine attack. Additionally, the platelets of migraine sufferers are different from normal platelets both during and between migraine attacks. Platelets are small blood cells that clump together to form blood clots. The difference between platelets results in migraine sufferers having a significant increase in spontaneous clumping of platelets as well as in a reduction in the release of a chemical called serotonin. Ginger has been shown to significantly reduce the effects of migraines by reducing inflammation and platelet aggregation. Ginger's ability to help fight nausea, inflammation, pain, and anxiety makes it an ideal addition to formulas designed to prevent and manage migraines.

High doses of ginger have also been found to significantly reduce migraine intensity. It plays a role as a circulatory stimulant, peripheral vasodilator, and antispasmodic. Ginger may exert abortive and prophylactic effects in migraine headaches without any side effects. Ginger and its constituents inhibit the metabolism of arachidonic acid through both the cyclooxygenase and lipoxygenase pathways, thus reducing the accumulation of prostaglandins and leukotrienes that contribute to pain and inflammation. This is important because other compounds that are prophylactic against migraine attacks are postulated to work through the same pathways. Additionally, ginger extract inhibits the induction of several genes involved in the inflammatory response, including those that encode cytokines and chemokines. Studies indicate that certain cytokines are overproduced in migraine sufferers. The ability of ginger to inhibit thromboxane A2 and exert antihistamine, anti-inflammatory, and gastric actions makes it a theoretically attractive choice in migraine therapy (Mustafa &Srivastava 1990b).

4.4. ReducesAnxiety

Ginger can also help to reduce anxiety. Anxiety is frequently associated with migraine and is correlated with poorer responses to migraine treatment. Ginger fractions bind to a serotonin receptor and reduce levels of anxiety in animals. The bioactive compounds of ginger extract interact with the human serotonin 5-HT (1A) receptor with significant to moderate binding affinities (K(i)=3-20 microM).S-GTP gamma S assays indicated that 10-shogaol, 1-dehydro-6-gingerdione, and particularly the whole lipophilic ginger extract (K(i)=11.6 microg/ml) partially activate the 5-HT(1A) receptor (20-60% of maximal activation). In addition, the intestinal absorption of gingerols and shogaols interact with P-glycoprotein and offer a favorable pharmacokinetic profile for the 5-HT (1A) active compounds. A combination of ginger and *Ginkgo biloba* has been shown to reduce anxiety in an animal model

(elevated plus-maze test). The effect was similar to diazepam (an allopathic medicine used for anxiety treatment) (Hasenohrl et al, 1996). A highly non-polar fraction of a ginger extract has been shown to possess anticonvulsant, anxiolytic, and anti-emetic activities in animals (Vishwakarma et al, 2002).

5. Endocrine System

5.1.Diabetes and Hyperglycemic

Diabetes mellitus can be defined as a group of metabolic diseases characterized by chronic hyperglycemia resulting from defects in insulin secretion, insulin action, or both resulting in impaired function in carbohydrate, lipid, and protein metabolism and is associated with markedly increased morbidity and mortality rate(Zhang et al,2006). Diabetes is known to increase ROS production and oxidative stress probably as a result of glucose auto-oxidation and non-enzymatic glycation (Gupta et al, 2007). Prolonged exposure to hyperglycemic conditions creates predominance of oxidative stress over antioxidative defense systems, leading to oxidative DNA damage, which possibly contributes to pancreatic beta-cell dysfunction (Song et al., 2007). Hence, compounds with both hypoglycemic and anti-oxidative properties would be useful anti-diabetic agents (Cemek et al., 2008). Ginger has already been proven as an antidiabetic agent and helps in reducing hyperglycemia and hypoinsulinemia conditions (**Akhaniet al,2004**, Sharma et al,1996,Ajithet al, 2007). Ginger may assist in prevention of the progression of type 2 diabetes through its hypoglycemic effects and by increasing insulin sensitivity. The hypoglycemic potentials of ginger were tested in streptozotocin (STZ)-induced diabetic rats (500 mg/kg, intra-peritoneally) daily for a period of 7 weeks. Ginger was found very effective in reversing the diabetic proteinuria andlowering serum glucose, cholesterol, and triacylglycerol levels in the ginger-treated diabetic rats compared with the control diabetic rats (Al-Amin et al, 2006). Singh et al, (2009) suggested that (6)-gingerol is an effective anti-diabetic agent via its ability to enhance insulin sensitivity and to decrease hyperlipidemia in type 2 diabetic animals. Furthermore, it is also beneficial against oxidative stress, thereby being helpful in delaying or preventing complications of diabetes and aging. Ginger ethanolic extract has shown insulinotropic action similar to chlorpropamide, a sulphonylurea drug, and enhanced insulin sensitivity atthe cellular level (Ojewole et al, 2006). Also, ethanolic ginger extract reduced plasma cholesterol and inhibited LDL oxidation in atherosclerotic apoE-deficient

mice (Fuhrman et al, 2000). Moreover, addition of ginger (1 %) to a normal diet prevented the formation of free radicals and maintained the integrity of rat erythrocytes (Ahemed et al, 2000). The antioxidant potency of ginger has been attributed to gingerols that prevent the production of reactive oxygen species (Ali et al, 2008). Aldose reductase inhibitors, which reduce sorbitol formation as well as its accumulation in human tissues such as erythrocytes and protect cells from osmotic damage, are considered to have remarkable potential for the treatment of diabetes mellitus and its complications. At least two active components, 2-(4-hydroxy-3-methoxyphenyl) ethanol and 2-(4-hydroxy-3-methoxyphenyl) ethanoic acid, of ginger have shown aldose reductase inhibitor properties (Ali et al, 2008). Also, ginger inhibited serotonin-induced hyperglycemia and hypoinsulinemia by blocking its receptors (Al-Amin et al, 2006). Madko et al (2011) reported that a ginger, garlic,and turmeric mixture significantly decreased serum total lipid and total cholesterol levels in healthy rats, which may be beneficial as a prophylaxis against hypercholesterolemia.

5.1.1. Cataract

Ginger not only prevents and cures diabetes but it is also preventive in the progression of cataracts. The aqueous extract of ginger possesses both antiglycating activity and ALR2 (aldolase reductase) inhibition (Saraswat et al, 2010, Saraswat et al, 2008). Regular consumption of ginger delays the progression and maturation of cataracts. This could be attributed to its ability to prevent the multiple changes associated with the accumulation of AGE (i.e., reduction in the carbonyl stress, inhibition of osmotic stress by reducing the activity of polyol pathway, and prevention of oxidative stress) (Saraswat, 2009).

5.2.2. Hypertension

Angiotensin I converting enzyme (ACE) is a metellopeptidease that catalyses two reactions, leading to constriction of blood vessels and hence blood pressure regulation (Schmaier, 2002).Ginger exhibited relevant ACE inhibitory activities indicating potential anti-hypertension activity likely related to non-phenolic compounds (Ranillaet al, 2010).

6. Immune System

The active constituents of ginger function as immunomodulators by increasing the body’s immunity through their antimicrobial and free radical

scavenging properties. Ginger extract raises the thymus index, spleen index, and percentage of phagocytosis significantly, thus improving immunologic function(Kathi, 1999, Schitteket al, 2001). Ginger cannot only be warming on a cold day, but can also help promote healthy sweating, which is often helpful during colds and flus. A good sweat may do a lot more than simply assist detoxification. Sweat contains a potent germ-fighting agent that may help fight off infections. Dermicidin is a protein manufactured in the body's sweat glands, secreted into the sweat, and transported to the skin's surface where it provides protection against invading microorganisms, including bacteria, such as *E. coli* and *Staphylococcus aureus* (a common cause of skin infections), and fungi, including *Candida albicans* (Alternative Medical Review,2003, Schitteket al,2001).

6.1.Antimicrobialand AntifungalProperties

Ginger extract and several of its constituents exhibit antimicrobial activity *in vitro* and *in vivo* and antischistosomal activity (Akoachere*et al*, 2002). Chemical constituents of ginger such assesquiterpenes, diarylheptenones, gingerenones A, B and C, and isogingerenone B, have shown antifungal activity *invitro*. It has been proposed that lipophilicity or hydrophobicity and chemical structure of essential oils or their main compounds such as the presence of functional polar groups and aromaticity could play an important role in the antimicrobial activity (Faraget al, 1989b; Dawet al, 1994).This activity enables partitioning between lipids of the bacterial or fungal cell membrane and mitochondria, disturbing the cell structures and rendering them more permeable, which will lead to cell death (Sikkemaet al, 1994). Some of the major components present in ginger oils can penetrate the membrane of the microorganisms and react with the membrane enzymes and proteins as well as phospholipid bilayer, which causes an impairment of the microbial enzyme system and/or a disturbance of genetic material functionality (Farag et al, 1989, Abd El-Baky and El-Baroty, 2008, Conner, 1993). Fresh ginger oil (FG) showed strong inhibition against *Aspergillusniger*and *Candida* and inactivity against *Pencilliumspp*and *Trichoderma spp*. At the same time, dry ginger oil (DG) was more active towards *Candida* andweaker against *Aspergillusniger*, *Pencilliumspp*, and *Saccharomyces cereviseae* (Sasidharan and Menon 2010).

6.1.1.Antibacterial

Ginger extracts have antibacterial effects against both gram-positive and gram-negative bacteria such as *Clostridium*, *Listeria*, *Enterococcus*,

Staphylococcus,*Streptococcus*,and *Haemophilus* species. The minimum inhibitory concentration of ginger ranged from 0.0003–0.7 µg/mL, and the minimum bactericidal concentration ranged from 0.135–2.04 µg/mLspecies, but some of this effect is destroyed by heating (e.g., cooking)(Mascoloet al, 1989 and Chenet al, 1985). Gingerols demonstrated antibacterial activity against *Bacillus subtilis* and *Escherichia coliin vitro* (Yamada et al 1992). Sasidharan and Menon(2010) found fresh ginger oil was inactive against *Bacillus subtilis*whereas dry ginger oil wasmore active towards *Pseudomonas aeruginosa*and weakeragainst *Bacillus subtilis.*

6.1.2 Antiviral

Ginger has been found very effective against the flu virus, due to its warm and bitter property. Several sesquiterpenes, but especially beta-sesquiphellandrene, isolated from ginger **has**also been shown to have antirhinoviral activity *in vitro* (Denyeret al 1994). Denyer also showed that shogaol and zingerone strongly inhibited *Salmonella typhi*, *Vibrio cholerae* and *Trichophytonviolaceum*.

6.1.3.AntiparasiticProperty

Gingerol (5.0 ppm) completely abolished the infectivity of Schistosoma spp. (blood flukes) in animal studies (Adewunmi et al 1990). Zingibain, another bioactive compound, dissolves parasites and their eggs. Gingerol and shogaol exhibited potent molluscicidal activity *in vivo* (Adewunmi*et al* 1990). Shogaol and gingerol have demonstrated anti-nematode activities; 6.25 µg/mL 6-shogaol destroyed *Anisakis* larvae within 16 hours *in vitro*, whereas the antinematodal medication pyrantelpamoate had no lethal effect at 1 mg/mL (Goto et al 1990).

6.2. As an Antioxidant

Ginger spares SOD (superoxide dismutase)–an important anti-oxidant, catalase which is essential for breaking down potentially harmful hydrogen peroxide in the cells to glutathione peroxidase. SOD also acts on hydrogen peroxide and helps maintain integrity of cell membranes (Brock, 2007). The active constituents of ginger have antioxidant properties. The chemical structure of zingerone makes it a potent free radical scavenger. The hydroxyl groups in the molecule are responsible for scavenging peroxynitrite (ONOO-), a very powerful pro-oxidant implicated in a number of neurodegenerative and pathophysiological processes. Zingerone can diffuse freely across phospholipid membrane bilayers to react with a wide variety of molecular

targets including lipids, proteins, and DNA, leading to cell death via necrosis or apoptosis. Since endogenous antioxidant enzymes are lacking to inactivate ONOO, it is imperative to include some article through the diet thathas this action. Zingerone not only cleans the peroxynitrite (ONOO-) from the system, but it is also involved in the inhibition of NO- and O_2- formation. Although the mechanism is not fully defined, the two possible pathways of nitration or electron donation have been suggested as a phenolic ONOO-scavenger interaction with ONOO-. Ginger is a good source of antioxidant and most of the antioxidant components exhibit higher activities in alcoholic media. Hence, apart from its medicinal properties, ginger can also be used as an antioxidant supplement (Adiland Prasad, 2010).

6.3.Cancer

Ginger constituents are regarded as chemopreventive dietary agents exhibiting inhibition of cyclooxygenase and lypoxygenase (LO) activities, induction of apoptosis, and antitumerogenic effects. Ginger inhibits 5-LO enzymes, the only food for prostate cancer cells. Prostate cancer cells die in one to two hours in absence of 5-LO enzyme. Ginger induces cell death in leukemic, skin, kidney, lung, and pancreatic cancer cells. The anticancer properties of ginger are attributed to the presence of certain constituents such as [6]-gingerol and [6]-paradol, as well as some other constituents like shogaolsand zingerone (Park et al., 2006). Therefore, it can safely be used for cancer therapy. Gingerol inhibits pancreatic cell growth,is beneficial to prevent constipation-related cancer, and is an effective anti-tumor agent in leukemia cells.

6.3.1. Colorectal Cancer

As suggested by Cancer Prevention Research, gingerols, the main active components in ginger, inhibit the growth of human colorectal cancer cells (Bode et al, 2003). In another experiment, Bode et al (2001) studied the effect of 6-paradol and 6-gingerol on the cell proliferation and DNA synthesis of HL-60 cells. They observed that their cytotoxicity was associated with induction of apoptosis and/or inhibition of activator protein-1(AP-1). Apoptosis can be defined as the cleavage of DNA into discontinuous mono- and oligonucleosomal size fragments that form a typical DNA ladder during gel electrophoresis. 6-gingerol, a natural product of ginger, has been known to possess anti-tumorigenic and pro-apoptotic activities. It has also been suggested that 6-gingerol stimulates apoptosis through up regulation of NAG-1 and G (1) cell cycle arrest through down

regulation of cyclin D1. Multiple mechanisms appear to be involved in gingerol action, including protein degradation as well as beta-catenin, PKCepsilon, and GSK-3beta pathways (Lee et al, 2008).

6.3.2. Ovarian Cancer

Ovarian cancer is often deadly since symptoms typically do not appear until late in the disease process, so by the time ovarian cancer is diagnosed, it has spread beyond the ovaries. More than 50% of women who develop ovarian cancer are diagnosed in the advanced stages of the disease. *Invitro* experiments have shown that ginger kills ovarian cancer cells by inducing apoptosis (programmed cell death) and autophagocytosis (self-digestion). Ginger extracts have been shown to have antioxidant, anti-inflammatory, and anti-tumor effects on cells (Rhode et al, 2006). A pro-inflammatory state is thought to be an important contributing factor in the development of ovarian cancer (Rhode et al, 2006). Ginger, containing a number of key indicators of inflammation (vascular endothelial growth factor, interleukin-8, and prostaglandin E2), can decrease ovarian cancer cells. Conventional chemotherapeutic agents also suppress these inflammatory markers, but may cause cancer cells to become resistant to the action of the drugs. However, ginger may be of special benefit for ovarian cancer patients because cancer cells exposed to ginger do not become resistant to its cancer-destroying effects(Rhode et al, 2006).

6.3.3. Breast Cancer

Ginger has been found to significantly inhibit mammary tumorigenesis and tumor growth in laboratory mice when fed in drinking water. [6]-gingerol, a component of ginger, has been shown to inhibit cell adhesion, invasion, and motility in ER-negative (estrogen independent) human breast cancer cells in the laboratory (Lee et al, 2007). Hence, ginger appears to have promise in fighting breast cancer and is safe to include in the diet.

7. Other Uses

Ginger is on the Food and Drug Administrations (FDA) list of generally recognized as safe (GRAS)(Alternative Medical Review, 2003).

7.1. ReducesCoughand Cold

Ginger also acts as an expectorant. It is believe to control common cold and flu symptoms. Ginger juice with honey is a common home remedy for cough. ***Rhinovirus*** is among those viruses which are responsible for common cold. The dried ginger has been found very effective against this virus. βsequiphellandrene, a sesquiterpene which is found in ginger, is effective against the rhinovirus. In addition, it helps eliminate congestion and ginger tea eases a sore throat.

7.2. PreventObesity

Ginger acts as fat and cellulite burning food. *Invitro* studies in Japan show that zingerone, an active component of ginger, prevents fat storage in rats by increasing fat burning and by reducing the absorption of fat from the small intestine.

7.3. As a MeatTenderizer

Ginger rhizome has been investigated as a source of plant proteolytic enzyme (Thompson et al, 1973,Ziauddinet al, 1995). The ginger protease is a thiol proteinase with an optimum activity at 60°C. Rapid denaturation of the enzyme occurs at 70°C. Its proteolytic activity on collagen appears to be many times greater than that on actomyosin and the combined proteolysis of these two muscle proteins resulted in significantly more tender meat. Ginger extract is an effective meat tenderizer and the tenderization is achieved through its action on both myofibrillar and connective tissue components of toughness. Improvement in color, appearance, juiciness, and tenderness of beef samples treated with ginger extract were also tested (Ziauddinet al,1995. The use of ginger extract for improving the qualities of tough meat could prove to be a boon to the meat industry (Naveen et al, 2001).

7.4. As a Food Preservative

Ginger and some other herbs like cinnamon are used as a food preservative and can increase food safety and shelf life of fatty and processed food products. El-Baroty et al (2010) reported that cinnamon and ginger essential oils can be used as a preventer of cellular damage due to spoilage bacteria and fungi. Both oils and bioactive components (at concentration levels 20 - 100 µg/ml) could be employed as natural food preservatives to prevent lipid peroxidation, which causes food spoilage.

7.5. Thermogenic

Ginger has traditionally been used in Asia as a warming remedy to treat chills associated with colds and flu. The shogaol compounds of ginger significantly inhibited serotonin (5-HT) induced hypothermia in rats. Within 30 minutes of oral administration, ginger raised the body temperature of rats by 0.5°C(Kanu et al, 1992). Gingerol increased body temperature and oxygen consumption in rats indicating an increased metabolic rate (Eldershaw et al, 1992).

7.6. Regulate Menstrual Irregularities and Dysmenorrhea

Ginger is useful when taken internally, if menstrual pain is due to ischemic cramp (lack of uterine blood supply) (Alternative Medical Review, 2003). It is also good in the form of hot compresses for abdominal cramps, headaches, and joint stiffness.

POSSIBLE INTERACTIONS

Ginger may alter the effects of some prescribed and nonprescribed medications. If blood-thinners such as warfarin (Coumadin) or aspirin, diabetes medicines,or high blood pressure medicines are being taken ginger therapy is not advisable.Ginger may lower blood sugar, raising the risk of hypoglycemia or low blood sugar, and may lower blood pressure, raising the risk of low blood pressure or irregular heartbeat. Ginger therapy is also not recommended in children less than two years (Heck et al, 2000 and Vaes et al, 2000).

CONCLUSION

Ginger is a rhizomatous plant grown throughout South-eastern Asia and China and in parts of Japan, Austria, Latin America, Jamaica, andAfrica. Ginger has been used as a spice and medicine in the Indian subcontinent since ancient times. Its medicinal values have been known for centuries.It is the most widely used condiment, flavoring, and garnishing agent. The herb serves as a stimulant and carminative and is used in dyspepsia and colic. It is known to have blood thinning and cholesterol lowering properties, due to which it is used in treating heart diseases.The major phenolic compounds and

essential oils act as potent antioxidant and exhibit free radical scavenging properties. The antimicrobial properties are due to the presence of componentssuch as thymol, eugenol, 1, 8- cineole, α- and β-pinenes, linalool, and α-terpineol. Ginger tea is considered a good home remedy for cold. The herb can also used to treat arthritis, diarrhea, motion sickness, diabetes, bronchitis, and rheumatism. It is a remedy for nausea due to seasickness, morning sickness, and chemotherapy. Overall, ginger is a versatile herb with phenomenal phytotherapeutic and medicinal properties. It would be difficult to find a place or nation on this globe that has not been benefited through this extraordinary aromatic herb.

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