PHARMACOLOGICAL ACTIVITIES OF GINGER (ZINGIBER OFFICINALE): A REVIEW

Sabahat Saeed and Perween Tariq

Department of Microbiology, University of Karachi, Karachi-75270, Pakistan

ABSTRACT

Zingiber officinale (ginger) has been used for thousands of years as a culinary spice and medicinal herb. It has long been used for the treatment of migraine, bacterial dysentery, toothache, cold and diarrhea. Besides, it also has antibacterial, antifungal, antiparasitic, antiviral, antidiabetic, anti-inflammatory, antioxidant and anti-hypercholesterolaemic properties. It contains a wide variety of biologically active compounds. The major pharmacological activities of ginger appear to be due to gingerols and shogaols. It has not been associated with any significant adverse effects.

Key words: Ginger, antibacterial, antifungal, antiparasitic, gingerols, shogaols.

INTRODUCTION

The rhizome of Zingiber officinale, is a common constituent of diet worldwide (Penna et al., 2003). Ginger has a long history of both culinary and medicinal use in Chinese, Japanese and Indian medicinal care with many claims about its usefulness (Leung, 1984). It has been reported that its extracts present many pharmacological activities (Penna et al., 2003; Wang and Wang, 2005).

ACTIVE CONSTITUENTS

Ginger rhizome contains a wide variety of biologically active compounds (Duke and Beckstrom-Sternberg, 1999). The primary pungent agent of ginger is gingerol (Mishra et al., 2004), with other gingerol analogues such as the shogaols (Shadmani et al., 2004). Other constituents include ginger proteases, capsaicin and several sesquiterpenes for example zingiberol and zingiberenol. The major pharmacological activity of ginger appears to be due to the gingerol and shogaols (Suekawa et al., 1984; Wohlmuth et al., 2006).

Gingerols are biologically active compounds of ginger rhizome that make a significant contribution towards medicinal applications of ginger (Wohlmuth et al., 2006). 6-gingerol, 8-gingerol and 10-gingerol are responsible for antifungal activity of ginger (Ficker et al., 2003). Gingerols, however, are thermally labile due to the presence of a β-hydroxyketo group in the structure, and undergo dehydration readily to form the corresponding shogaols (Bhattarai et al., 2001). 6-shogaol is also one of the active constituent of ginger (Hashimoto et al., 2002; Murata et al., 2002). Ginger oil, obtained by steam distillation of the rhizome of ginger, displays considerable compositional diversity, but is typically characterized by a high content of sesquiterpene (Wohlmuth et al., 2006).

ANTIBACTERIAL ACTIVITY

Ginger has been found to be effective against the growth of both Gram-positive and Gram-negative bacteria (Martins et al., 2001), including Escherichia coli, Salmonella typhimurium (Jaetia et al., 2003), Proteus vulgaris, Staphylococcus aureus (Ekwenye and Elegalarn, 2005) and Streptococcus viridans (Schulick, 2001; Mascolo et al., 1989).

Akoachere et al., (2002) investigated the antibacterial activity of ginger on four respiratory tract pathogens viz., Staphylococcus aureus, Streptococcus pyogenes, Streptococcus pneumoniae and Haemophilus influenzae. They reported the minimum inhibitory concentration (MIC) of ginger extract as 0.0003-0.7 µg/ml and minimum bactericidal concentration (MBC) from 1.35-2.04 µg/ml. On the other hand, in a study extract of ginger was found only effective against Bacillus cereus whereas, Staphylococcus aureus, Listeria monocytogenes, Escherichia coli and Salmonella infantis were found resistant (Alzoreky and Nakahara, 2002). In contrast in another study ginger was found effective against Escherichia coli O157:H7 at 8°C (Gupta and Ravishankar, 2005).

In a previous study, ginger rhizome only inhibited Micrococcus luteus while Escherichia coli, Salmonella typhimurium, Vibrio parahaemolyticus, Pseudomonas aeruginosa, Proteus vulgaris, Staphylococcus aureus, Mycobacterium phlei, Streptococcus faecalis and Bacillus cereus were found resistant. It was also reported that its antibacterial activity was heat labile and lost within 20 minutes at 100°C (Chen et al., 1985). Furthermore, the
antimicrobial activity of extracts and essential oil of ginger was evaluated against five strains of *Listeria monocytogenes* and four strains of *Salmonella typhimurium* DT104. It was found that aqueous and ethanolic extracts of ginger had no effect whereas ginger oil only inhibited the strains of *Listeria monocytogenes* while all strains of *Salmonella typhimurium* DT104 were found resistant (Thongson et al., 2005). In another study five *Listeria monocytogenes* isolates were tested against ginger oil, all (100%) isolates were found to be resistant (Byrd et al., 2002).

Ginger oil was tested for antibacterial activity against *Staphylococcus aureus* ATCC 25923, *Escherichia coli* ATCC 25922 and *Pseudomonas aeruginosa* ATCC 27853. It was to be weakly effective against only *Staphylococcus aureus* ATCC 25923 while showed no activity against *Escherichia coli* ATCC 25922 and *Pseudomonas aeruginosa* ATCC 27853 (Ontengo et al., 1995). The essential oil of ginger was found to be weakly effective against 4 Gram positive bacteria (*Staphylococcus aureus*, *Bacillus cereus*, *Enterococcus faecalis*, *Listeria monocytogenes*) and 4 Gram negative bacteria (*Escherichia coli*, *Yersinia enterocolitica*, *Salmonella choleraesuis*, *Pseudomonas aeruginosa*). It was found that Gram positive strains were more sensitive as compared to Gram negative strains (Lopez et al., 2005). Ginger extract also inhibits the growth of *Helicobacter pylori* which is a primary etiologic factor associated with the development of gastritis and peptic ulcers (Mahady et al., 2003; Mahady et al., 2005; O’Mahony et al., 2005).

**ANTIFUNGAL ACTIVITY**

Ginger has pronounced antifungal activity against a wide variety of fungi (Martins et al., 2001), including strains that were highly resistant to amphotericin B and ketoconazol (Ficker et al., 2003). An antifungal protein, isolated from ginger, exerted antifungal activity towards various fungi including *Botrytis cinerea*, *Fusarium oxysporum*, *Mycosphaerella arachidicola*, and *Physalospora piricola* (Wang and Ng, 2005). In another study antifungal activity of ginger oil was investigated against yeast and molds and concluded that ginger oil possesses antifungal activity against *Candida albicans* (yeast), *Penicillium islandicum* and *Aspergillus flavus* (molds) (Lopez et al., 2005).

**ANTIPARASITIC AND ANTIHELMINTIC ACTIVITY**

In 1990 a Japanese study showed that the gingerol and shogaol components of ginger could kill Anisakis larvae. Anisakis being one of the principle parasite, which find host in millions of people around the globe (Goto et al., 1990). In a study it was found that ginger possesses *in vitro* antihelmintic activity in sheep, naturally infected with mixed species of gastrointestinal nematodes (Iqbal et al., 2006).

**ANTIVIRAL ACTIVITY**

The inhibitory effect of ginger on the growth of influenza A/Aichi/2/68 (Aichi) virus was investigated in Madin-Darby Canine kidney (MDCK) cells. Direct addition of ginger to infected cells did not have any inhibitory effect. However, the ginger induced conditioned medium of a murine macrophages (Mphi) cell line exhibited an apparent inhibitory effect on MDCK cells without cytotoxicity. These findings suggested that ginger itself has no inhibitory effect on the growth of influenza virus, but could exert its effect via macrophage activation leading to production of tumor necrosis factor alpha (TNF-α) (Imanishi et al., 2006).

**ANTITUMOR ACTIVITY**

A few studies have been conducted on the effect of ginger on carcinogenesis. *In vitro* ginger has selective anticancer activity (Surch et al., 1999; Murakami et al., 2003; Leal et al., 2003; Kim et al., 2005; Manju and Nalini, 2005). The results from a study, carried out by Miyoshi et al. (2003) provide biological evidence that ginger specific constituents, galanals A and B, are potential anticancer agents. Ginger also improves immunological functione tumors (Liu and Zhu, 2002).

A study in mice found that orally administered ginger significantly reduced the occurrence of mammary tumors without adverse effects (Nagasawa et al., 2002). Researches have found that extracts of ginger possess anti-skin tumor effects when placed directly on the skin of mice (Katiyar et al., 1996). In addition it has been found that gingerol from ginger inhibits the tumor promoter Epstein-Barr virus (EBV) activation (Ohigashi et al., 1994).
ANTIDIABETIC ACTIVITY

Ginger has been reported to be hypoglycaemic (Srinivasan, 2005). Akhani et al. (2004) studied the effect of ginger on streptozotocin-induced type I diabetic rats. They concluded that ginger has anti-diabetic activity. In another study aqueous extract of ginger rhizome was studied in streptozotocin and glucose-induced diabetic rats to evaluate its hypoglycaemic activity and concluded that aqueous extract of ginger rhizome exhibited hypoglycaemic activity in both streptozotocin and glucose-induced diabetic rats (Kalejaiye et al., 2002).

ANTIOXIDANT ACTIVITY

Ginger contains antioxidant properties (Schulick, 2001; Lako et al., 2004; Masuda et al., 2004; Kuo et al., 2005). Ginger has been found to inhibit lipid peroxidation in rat liver microcosms (Reddy and Lokesh, 1992) and successfully scavenge superoxide anions (Krishnakantha and Lokesh, 1993). In an American study 21 compounds were isolated from ginger. It was found that the most of the isolated compounds exhibited stronger antioxidative effect that alpha-tocopherol (Vitamin E) (Kikuzaki and Nakatani, 1994). The antioxidant powers of ginger have been proven in applications where ginger extract was added to meat products. The antioxidative effectiveness of ginger extract was further tested with fresh, frozen and precooked pork patties. The shelf life of all products was improved by the inclusion of ginger extract (Lee et al., 1986).

ANTIEMETIC AND ANTIMOTION SICKNESS ACTIVITY

Ginger is probably most well known for its ability to reduce nausea (Flake et al., 2004). It has been superior to placebo in studies on seasickness, morning sickness, motion sickness, chemotherapy-induced nausea, and pregnancy related nausea (Stewart et al., 1991; Ernst and Pittler, 2000; Keating and Chez, 2002; Pongrojpaw and Chiamchanya, 2003; Lien et al., 2003; Boone and Shields, 2005). Powdered ginger root has been compared to standard drugs used in combating postoperative nausea and vomiting (Morin et al., 2004; Chaiyakunapruk et al., 2006). Tests have shown that the requirement for postoperative antiemetics was lower in patients receiving ginger. Ginger is an effective and promising prophylactic antiemetic, which may be especially useful for day case surgery (Phillips et al., 1993).

It has been reported that ginger was effective in reducing post-operative nausea and vomiting (Bone et al., 1990; Betz et al., 2005). The ingestion of 1g of ginger in syrup in a divided dose daily may be useful in some patients experiencing nausea and vomiting in the 1st trimester of pregnancy (Keating and Chez, 2002).

A double-blind randomized clinical trial to investigate the effect of ginger on nausea and vomiting following gynaecological laparoscopic surgery was conducted by Arfeen et al. (1995). They found that ginger is effective in reducing nausea. Phillips et al. (1993) and Bone et al. (1990) reported that ginger is effective in reducing post-operative nausea and vomiting. In contrast Visalyaputra et al. (1998) found that ginger is ineffective in preventing the post-operative nausea and vomiting associated with diagnostic gynaecological laparoscopy.

Ginger is often advocated as beneficial for nausea and vomiting. Whether the herb is truly efficacious for this condition is, however, still a matter of debate (Ernst and Pittler, 2000). Ginger has long been used as an alternative medicine to prevent and treat motion sickness (Lien et al., 2003; Scurr and Zinopin, 2004). Pharmacological studies of the antimotion sickness of ginger would indicate that ginger is effective in controlling motion sickness by the direct action of ginger’s active compounds on the gastric system (Mowrey and Clayson, 1982; Holtmann et al., 1989).

A report on the effects of ginger on motion sickness was reported in the British medical journal-The Lancet. In this clinical trial, 39 men and women who reported very high susceptibility to motion sickness were tested. Motion sickness was induced by being subjected to a rotating, tilted chair while blind folded under controlled conditions. It was found that ginger was significantly effective in reducing motion sickness than the antihistamine dimenhydrinate and a placebo (Grontved et al., 1988). Some studies have, however, failed to show such an effect on either motion or sea sickness (Holtman et al., 1989).

ANTI-INFLAMMATORY ACTIVITY

Ginger possesses anti-inflammatory properties (Sharma et al., 1994; Raji et al., 2002; Thomson et al., 2002; Grzanna et al., 2005; Vendruscolo et al., 2006; Zhou et al., 2006). More than 200 drugs have been tested through the 1990’s in order to find a cure for rheumatism and musculoskeletal ailments. These have included non-steroidal anti-inflammatory drugs, corticosteroids, gold salt, anti-rheumatic drugs, methorexate and cyclosporin. None of these is
found to be safe (Srivastava and Mustafa, 1992). A common side effect of treating inflammation with modern drugs is that ulcers in digestive system can be created or their condition made worse. Ginger cannot only relieve the symptoms of inflammation, it also protects the creation of digestive ulcers (Schulick, 1993).

GINGER AND THE CIRCULATORY SYSTEM

Ginger also stimulates the immune system (Tan and Vanitha, 2004). Ginger has been found to be beneficial in reducing platelets aggregation, which leads to coronary artery disease (Bordla et al., 1997), therefore, decreases the risk of clotting, which may lead to either heart attack or stroke (Srivastava, 1964; Tognolini et al., 2006), while having no effect on blood lipids and blood sugar (Bordla et al., 1997). In other studies ginger was shown to be anti-hypercholesterolaemic (Giri et al., 1984; Bhandari et al., 2005). Similarly, Akhani et al. (2004) reported that treatment with ginger caused a decrease in serum cholesterol, serum triglyceride and blood pressure in diabetic rats. The effect of an aqueous extract of ginger on serum cholesterol and triglyceride levels as well as platelet thromboxane-B2 and prostaglandin-E2 production was examined. The result of this study concluded that ginger has cholesterol-lowering and antithrombic activities (Thomson et al., 2002).

OTHER ACTIVITIES

Fresh ginger has been used in eastern countries for many complains including rheumatism, bacterial dysentery, toothache, malaria and for cold and moist conditions such as excess mucus and diarrhea. In the west it is better known as digestive aid and for flatulence and colic (Geck, 2000). Respiratory disorders indicating ginger as a remedy are: asthma, chest trouble, pulmonary and catarrhal diseases, throat diseases and cold (Zaman and Khan, 1970). Ginger treatment has also been found to be useful in treatment of migrain, where it is proposed that pain relief from ginger may occur without any of the side effects that occur with standard treatments (Mustafa and Srivastava, 1990; Cady et al., 2005).

Ginger is eminently useful in habitual flatulency, atomic dyspepsia, hysteria and enfeebled and relaxed habits, especially for old individuals (Ghayur and Gilani, 2005). It is excellent to relieve nausea, pain and cramps of stomach and bowels, and to obviate tenesmus. Ginger is occasionally of value in fever, particularly pain and movement of gases within the intestine (Felter and Lloyd, 1898). Apart from these, it also finds use in piles and gout and used as diuretic, sedative to pain, in urinary incontinence, cholera and pneumonias (Nadkerni, 1976). Ginger oil obtained by steam distillation of the rhizome of ginger is also used in the beverages (Campanella et al., 2003) and fragrance industries (Wohlmuth et al., 2006).

Chinese medicine has incorporated ginger in remedies for the digestive system for centuries and it is regularly used as a calmative for stomach upsets. Other digestive benefits from ginger are the natural enzyme action on protein digestion (Thompson et al., 1973), stimulation of digestion, pro-biotic support of the natural gut flora, anti-diarreal properties and liver protection (Schulick, 1993).

CONTRAINDICATIONS

Ginger has not been associated with any significant adverse effects in trials which are associated with other antiemetic medication (Holtmann et al., 1989), except for some degree of heart burn sensation and rare cases of allergic reaction (Meyer et al., 1995; O’Hera et al., 1998). In some cases gastrointestinal upset is reported (Weidner and Sigwart, 2001). 6-gingerol is a potent mutagen, however, ginger juice also contains antimutagenic compounds that suppress 6-gingerol (Nakamura, 1982).

REFERENCES


*(Accepted for publication June 2006)*