

Active Compounds in Gingers and Their Therapeutic Use in Complimentary Medication

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ABSTRACT

The rhizome of ginger is used widely both as a seasoning and herbal medicine. The active compounds contained in ginger are divided into two groups: volatile essential oils and fragrant or harsh phenol compounds. Two types of gingers, fresh and dried, are used in the herbal medicine. There exist differences in the chemical composition between fresh and dried gingers that might result in differences in medicinal functions of the herbs. The therapeutic functions, which include lowering cholesterol, relieving allergies and asthma, arthritis, colds, and nausea, protecting the digestive tract and liver against toxins and parasites, and avoiding gallstone, cerebral vascular and cardiovascular diseases, are reviewed and the toxicity and safety issues are also discussed in this article.

Keywords: antimicrobial, phenol compounds, therapeutic uses, volatile oil, *Zingiber officinale*

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INTRODUCTION

Herbal or plant medicines make up an important component of alternative or complimentary medications. Demands for herbal medicines have resulted in a big market. With a broad range of therapeutic claims, herbal drugs have attracted many patients, especially those who are faced with chronic conditions. Benefits of herbal medicine range from enhancement of the immune system to cures of cancers and other life-threatening syndromes. Ginger is one of the important herbs used in alternative medications. The perennial plant *Zingiber officinale* has a knotted, thick and underground stem, the rhizome, and grows underground about 18 cm with long, narrow, ribbed and green leaves above ground (Voravuthikunchai 2007).

Ginger is a kind of herbal plant that can strengthen the body and treat disease. Its use in traditional Chinese, Indian and Arabic herbal medicine goes for centuries. It is now used universally in traditional herbal medicine as well as in modern medicine. Scientists have found evidence to support a wide range of medicinal functions of gingers. These functions include lowering cholesterol, relieving allergies and asthma, arthritis, colds, and nausea, and protecting the digestive tract and liver against toxins and parasites. A few preliminary studies suggest that ginger may protect blood vessels from blockage such as atherosclerosis, which can lead to a heart attack or stroke. Randomized controlled trials have shown that ginger is as effective as the reference drug like placebo and vitamin B6 in relieving the severity of nausea and vomiting in pregnancy (Bergner 2001; Kea-

ting and Chez 2002; Pongrojapaw and Chiamchanya 2003; Smith *et al.* 2004; Borrelli *et al.* 2005; Ensiyeh and Sakineh 2008). Ginger is effective in reducing hyperglycemia-evoked gastric dysrhythmias (Gonlachavit *et al.* 2003) and plasma vasopressin release (Lien *et al.* 2003), increasing fibrinolytic activity (Verma and Bordia 2001). Its anti-inflammatory properties help relieve pain and reduce inflammation associated with rheumatoid arthritis, osteoarthritis, rheumatism and muscle spasms (Srivastava and Mustafa 1992). Ginger is believed to relieve the common cold, flu-like symptoms, headaches, and even painful menstrual periods. Today, ginger root is widely used as a digestive aid for mild stomach upset and is commonly recommended by professional herbalists to help prevent or treat nausea and vomiting associated with motion or morning sickness, pregnancy without causing drowsiness, and may even be used in chemotherapy for cancer (Lien *et al.* 2003; Smith *et al.* 2004; Zhu *et al.* 2006).

Usually, ginger is used either fresh or dried in traditional Chinese and Japanese herbal formula. The herb is available in extracts, tinctures, capsules and oils (Hawkins and Ehrlich 2007). Fresh ginger is used to relieve dryness and heat, while dried ginger is used to relieve dampness and chill, warm the energy channels and stop bleeding, especially the uterine bleeding. The important active components of the ginger root are thought to be volatile oils and pungent phenol compounds such as gingerols and shogaols, which are believed to be the active ingredients responsible for the action of ginger (Yahya and Rafutullah 1990). However, some of the constituent chemicals may be absent in either fresh or dried ginger, and the concentrations of the chemicals may differ between fresh and dried gingers. In this article, the active chemical constituents in fresh and dried gingers and their therapeutic uses as well as the possible relations with the function and safety are reviewed.

ACTIVE COMPOUNDS IN GINGERS

Usually, the chemical constituents of ginger include 1, 8-cineole, 6-gingerol, 6-shogaol, 8-shogaol, acetic acid, α -linolenic acid, α -phellandrene, α -pinene, α -terpineol, arginine, ascorbic acid, β -bisolene, β -carotene, β -pinene, β -sitosterol, boron, caffeic acid, camphor, capsaicin, chlorogenic acid, curcumene, gingerols, sesquiphellandrene, zingiberene, resins, starches, fats, and proteins (Tyler 1994; He *et al.* 1998; Kemper 1999; Antonious and Kochhar 2003; Singh *et al.* 2005; Zhao and Xu 2006).

Differences in active compounds between fresh and dried gingers

Gingers that are used in herbal medicine are of two types, fresh and dried. Research has shown that there exist differences in the chemical compositions between the fresh and dried gingers. The active compounds contained in ginger are divided into two groups: volatile essential oils and fragrant or harsh phenol compounds. Volatile oils can be easily measured by gas chromatography. Phenolic compounds can be analyzed with spectrophotometers. In our research (Zhao and Xu 2006), a chromatographic analysis of the extract of fresh ginger (*Zingiber officinale* Rosc. 'Da-Huangjiang') showed that 77 peaks and 38 compounds were detected, while that for the dried ginger showed 82 peaks and 43 compounds were detected. Dried ginger contains seven more compounds that are absent in fresh ginger, for example, linalool and terpinen-4-ol, α -terpineol, citronellol, β -neral, δ -elemene and neryl acetate (Table 1). However, neral and *trans*-farnesal that are present in fresh ginger are not detected in dried ginger. Fresh ginger contained essential oils at relatively high concentrations compared to dried ginger (Table 2). Both the total quantity and concentrations of phenol compounds were much higher in dried ginger than in fresh ginger. We believe that the unstable compounds (alkenes) in fresh ginger changed into stable compounds (alcohols and phenols) during the drying process. Therefore, the concentrations of alkenes compounds were low in dried ginger but the stable new-born chemical compounds like linalool, terpinen-4-ol and α -terpineol that were absent in fresh ginger were found in dried ginger. Shi *et al.* (1999) also found that the Supercritical CO₂ Fluid Extraction (SFE-CO₂) contained 49 constituents, such as 6-paradol, while the ginger peppery component amounted to 22.90%. These changes might explain the differences in herbal medicinal functions between fresh and dried gingers.

Differences in herb medicinal functions between the fresh and dried gingers

In Chinese medical science, fresh and dried gingers are used for different clinical purposes. Fresh ginger, charac-

Table 2 Concentrations (%) of essential oils and phenols in fresh and dried gingers. (Data from Zhao and Xu 2006).

Sample	Essential oils	Phenols
Fresh ginger	0.267 ± 0.027	0.249 ± 0.027
Dried ginger	0.147 ± 0.034	1.605 ± 0.068

Table 1 The relative concentrations on percentage (%) basis of essential oils in fresh and dried gingers. (Data from Zhao and Xu 2006).

Essential oil	Fresh	Dried	Essential oil	Fresh	Dried
β -bisabolene	4.140	2.755	Limonene	12.708	16.720
Borneol	2.415	3.040	Linabool	0.000	0.095
Bornylacetate	0.207	0.361	<i>v</i> -muurolene	9.476	9.025
Camphene	17.365	12.635	Myrcene	1.748	2.233
Camphor	0.161	0.247	Neral	4.140	0.000
δ -3-carene	0.035	0.038	β -neral	0.000	2.803
1,8-cineole	5.083	16.910	Nerolidol	0.265	0.171
Citronellol	0.000	0.266	Neryl acetate	0.000	0.143
Citronellyl acetate	0.575	0.532	α -phellandrene	0.299	0.323
Copanene	0.207	0.380	α -pinene	5.405	3.534
α -curcumene	6.210	4.427	β -pinene	0.541	0.124
Dibutylphthalate	0.035	0.019	Sabinene	0.173	0.105
α -elemene	0.115	0.190	β -sesquiphellandrene	5.750	4.275
β -elemene	0.299	0.143	Tau-cadinol	0.644	0.285
δ -elemene	0.000	0.133	Ticyclene	0.311	0.076
τ -epi- α -selinene	1.334	0.855	<i>v</i> -terpinene	0.035	0.029
<i>Trans</i> , <i>trans</i> -farnesal	0.276	0.000	α -terpineol	0.000	1.672
2-farnesene	0.127	0.437	Terpinen-4-ol	0.000	0.342
Geranial	6.613	4.513	Terpinolene	0.288	0.532
Helanal	0.023	0.143	2-undecanone	0.403	0.428
2-heptanol	0.035	0.010	α -zingiberene	9.476	8.930
Lerpinen-4-ol	0.342	0.325			

terized by mild warmth and mild pungency, cures cold symptoms and stops cough and phlegm, while dried ginger, characterized by strong warmth and strong pungency, warms energy channels and raises positivity on the basis of Chinese medicine philosophy. Fresh ginger is used to relieve dryness and heat, and treat colds accompanied by chills but with no fever, while dried ginger is used to relieve dampness, chill and stop bleeding, especially uterine bleeding. Dried ginger, which is known as “*Gan-jiang*” in Chinese medicine, is much “hotter” than the fresh one and used to dissolve phlegm associated with colds or chronic bronchitis, treat asthma and cough due to a cold and coldness associated with shock, cure digestive disturbances arising from deficient spleen energy, including diarrhea and vomiting accompanied by cold extremities and faint pulse (Bensky and Gamble 1986).

Since the presence or absence and concentration of some of the constituent chemicals vary from fresh to dried gingers, it is scientifically logical that fresh ginger and dried ginger differ in their medicinal functions and the dosage safeties. According to the American Herbal Products Association (AHPA), fresh ginger root is of a class 1 safety, indicating that it is a safe herb with a wide dosage range and few side effects. However, the AHPA gives dried ginger root a class 2b rating, indicating that it should not be used during pregnancy (Borrelli *et al.* 2005).

Other types of ginger and their uses

In addition to medical uses, ginger has been valued as an important cooking spice and flavoring like salt and pepper for over thousands years. Ginger products are made from fresh or dried ginger root, or steamed from oil distillation in ginger root. These products, such as ginger bread, ginger snaps, ginger candy and ginger ale, can be found in a variety of foods and drinks. Fresh ginger are often cooked as an ingredient in many dishes, for example, pickled in vinegar or sherry as a snack or stewed in boiling water to make ginger tea (Moore 2006). Preserved ginger and crystallized ginger are cooked in sugar syrup (McGee 2003). Ginger juice is often used as a spice in Chinese cuisine to flavor dishes such as seafood or mutton. Ginger powder is typically used as spiciness or a flavoring for gingerbread, cookies, crackers, cakes and other recipes (From Wikipedia®, <http://en.wikipedia.org/wiki/Ginger> and http://www.herbs2000.com/herbs/herbs_ginger.htm). Ginger is also made into beverage like ginger ale and ginger beer, which have been recommended as “stomach settlers” for generations in countries (Langner 1998).

THERAPEUTIC USES

In addition to food uses, ginger is also a kind of herbal plant that can strengthen the body and treat disease. It has been extensively used in China, India and Arab countries as a traditional herbal medicine. It is now used universally in both traditional herbal medicine and modern medications.

Digestive aid

Ginger is considered as a pungent, dry and warming herb in Traditional Chinese Medicine. It has been used as a digestive aid and for ailments triggered by cold, damp weather for at least 2500 years (Kemper 1999). Ginger has a wonderful warming effect over the digestive system by invigorating the stomach as well as the intestines. It helps stimulate a weak appetite by encouraging secretion of different digestive enzymes inside the stomach. The consequent accumulation of metabolic toxins by the stagnation of food particles in the intestinal tract can be cleared away (http://www.herbs2000.com/herbs/herbs_ginger.htm).

Diaphoretic

Ginger has been recorded as a plague medicine by using its

diaphoretic qualities in mediaeval Europe (McGee 2003). Ginger helps in perspiration in the body and reduction in elevated body temperature during fevers. Ginger soup can help warm new mothers for 30 days after their delivery and help them sweat out impurities (Kemper 1999).

Nausea and vomiting

As described in the following paragraphs, several studies published in the last two decades have confirmed the traditional claims for use as an anti-vomiting or anti-motion sickness agent.

Vomiting associated with motion or morning sickness. In herbal medicine, ginger is regarded as an excellent carminative that promotes the elimination of intestinal gas, and intestinal spasmolysis that relaxes and soothes the intestinal tract. A clue to success of ginger uses in eliminating gastrointestinal distress is offered by double-blind studies. Ginger appeared to reduce the severity of the nausea and also the number of attacks of vomiting associated with motion or morning sickness by avoiding the development of gastric dysrhythmias and the elevation of plasma vasopressin (Lien *et al.* 2003). Although no side effects of ginger on reduction in vomiting were reported (Grontved *et al.* 1988; Bertolucci and DiDario 1995), the study on comparing ginger to placebo notes that ginger is not a panacea for morning sickness. Unwanted side effects associated with nausea such as dry mouth and drowsiness are often caused by conventional prescription and non-prescription medicines. Considering the safety, many people find ginger remedy a welcome alternative to relieve their motion sickness. Ginger tea made by steeping one or two slices of fresh ginger in hot water will likely be all you need to settle your stomach. The potential mechanism for ginger to reduce motion sickness is on the stomach rather than on the central nervous system (Holtmann *et al.* 1989). It is attributed to the ability to enhance intestinal motility by increasing digestive fluids, absorbing and neutralizing toxins and stomach acid (Yamahara *et al.* 1990).

Nausea and vomiting in pregnancy. Randomized controlled trials have showed that ginger is as safe and effective as the reference drug like placebo and vitamin B₆ in relieving the severity of nausea and vomiting in pregnancy (Sripamote and Lekhyananda 2003; Smith *et al.* 2004). Some herbalists suggest either caution during pregnancy or outright contraindication. Some Chinese texts give no contraindications for fresh ginger root, while say that dried ginger should be used with caution in pregnancy (Bensky and Gamble 1986). However, no reports appear in the scientific literature of miscarriage or birth defects or major fetal malformations from the use of ginger in pregnancy (Portnoi *et al.* 2003). A review published by Borrelli *et al.* (2005) has confirmed the absence of significant side effects or adverse effects on pregnancy outcomes. However, long-term use during pregnancy is not recommended.

Chemotherapy nausea. There is evidence from a few studies that suggests ginger reduces the severity and duration of nausea (but not vomiting) during chemotherapy (Ernst and Pittler 2000). Cancer patients often suffer from serious weight loss and nausea after chemotherapy. Researches on clinical analysis of cancer cases indicated that patients who took one piece of ginger before chemotherapy for one year suffered little nausea and weight loss. Another use of ginger in chemotherapy, point injection of antiemetics combined with ginger application, has also shown great efficiency in relieving nausea after chemotherapy (Zhu *et al.* 2006). However, long-term studies should be performed to confirm these results and to establish safety.

Nausea and vomiting following surgery. Research has produced mixed results regarding the use of ginger in the treatment of nausea and vomiting following surgery (Pongroj-

paw and Chiamchanya 2003). Herbal remedies made from ginger have proved far more effective in relieving postoperative nausea since the 1990's. One gram of ginger root before surgery reduced nausea as effectively as a leading medication. Among six randomized controlled clinical trials reviewed on postoperative nausea and vomiting suggested that ginger was superior to placebo and equal to metoclopramide in preventing postoperative gastrointestinal symptoms (Bone *et al.* 1990; Ernst and Pittler 2000). Other studies, however, have failed to find the same positive incidence of postoperative nausea and vomiting and revealed that ginger is not a clinically relevant antiemetic (Eberhart *et al.* 2003; Morin *et al.* 2004). In fact, one study found that ginger may actually increase vomiting following surgery. For this reason, further studies are needed to determine whether ginger is really safe and effective for the prevention and treatment of nausea and vomiting following surgery.

Anti-inflammation

Ginger is primarily used to treat nausea, but it is also used as an anti-inflammatory, a pain remedy and a warming remedy herb. Some active components in ginger, such as zingiberol, gingerol, zingiberene, have good effects on antibacterial, anti-inflammation and analgesia. These substances are believed to explain why so many people with osteoarthritis or rheumatoid arthritis experience reductions in their pain levels and improvements in their mobility when they consume ginger regularly. Many health care professionals today use ginger to help treat health problems associated with inflammation, such as arthritis, headache and ulcerative colitis. A 42 years old woman with a 16-year history of migraines experienced enormous relief after supplementing her diet with 1.5-2 grams of dried ginger daily (Mustafa and Srivastava 1990). As suggested by Wigler *et al.* (2003), regularly spicing up meals with fresh ginger may help arthritis-related problems with aging knees.

How does ginger work its anti-inflammatory function? One reason is the free radical protection afforded by one of active phenolic constituents, 6-gingerol (Ippoushi *et al.* 2003). Another study sheds further light on the mechanisms that ginger suppresses the pro-inflammatory compounds (cytokines and chemokines) produced by synoviocytes, chondrocytes and leukocytes (Phan *et al.* 2005). The discovery that a ginger extract (EV.EXT.77) inhibits the induction of several genes involved in the inflammatory response provided the first evidence that ginger modulates biochemical pathways activated in chronic inflammation (Grzanna *et al.* 2005).

Anti-senilism and antioxidation

Recently nutritionists have reported that ginger contains an anti-senile substance. The chemical structure is similar to Aspirin. This special component can be effective in preventing the convergency of platelets, avoiding thrombosis.

The pungent component, gingerol, from ginger has been reported to restrain the Malondialdehyde (MDA) produced by lipid peroxidation in brain tissue, increase superoxide dismutase (SOD) and Na⁺-K⁺-ATPase activities, reduce cell membrane permeability of brain and effectively protect catalase activity after brain ischemia reperfusion (Kuang *et al.* 2007). It can also improve metabolism of ischemic organs, reduce lactic acid, consequently alleviating metabolic acidosis within the body (He *et al.* 2002). German scholars reported that the antioxidation of gingerol was better than the most widely used antioxidant Vitamin E and butylhydroxyanisole. After the gingerol is absorbed by the body, it can produce SOD, restrain lipid peroxide and lipofuscin pigment- age pigment. There is a phrase in Chinese folk sayings that "three pieces of ginger in the morning better than ginseng soup." Actually, since Spring and Autumn Times, Chinese people have known that eating ginger results in greatly anti-senile effect. In China, ginger was given

a name "revived grass", and ginger soup was named "revived soup". It is recorded in Song Dynasty in ancient China that one 80 year-old person who took ginger for 40 years looked like a child.

Antitumor and anticancer

Laboratory studies have found that components in ginger may have antitumor and anticancer activities. The 6-gingerol and 6-paradol had inhibitory effects on the viability and DNA synthesis of human promyelocytic leukemia cells (Lee and Surh 1998; Surh *et al.* 1998). Animal researchers showed that topical application of 6-gingerol to rats significantly inhibited epidermis papilloma, indicating that 6-gingerol had tumor stimulatory activity (Katiyar *et al.* 1996; Surh *et al.* 1999; Huang *et al.* 2005). Moreover, research from the University of Minnesota strongly suggests that ginger compounds may be effective chemopreventive and/or chemotherapeutic agents for human colorectal carcinomas and has already applied for a patent on the use of gingerol as an anti-cancer agent (Bode 2003). Recently, Lee *et al.* (2008) elucidated the mechanisms of 6-gingerol in human colorectal cancer. Lab experiments show that gingerols, the active phytonutrients in ginger, kill ovarian cancer cells by inducing apoptosis and autophagocytosis (Rhode 2006). Lee *et al.* (2008) showed that 6-gingerol inhibited cell adhesion, invasion, motility and activities of MDA-MB-231 human breast cancer cell. Another effective composition, polyprotic acid panoxitrol, as proved by some studies, has an inhibitory effect on proliferation of cancer cells (Kuang *et al.* 2007). However, more research needs to be performed to determine the effects of ginger on various cancers in humans.

Improvement of gastrointestinal symptoms

Ginger has been widely used for centuries to improve upper gastrointestinal symptoms like dyspepsia and gastrointestinal hemorrhage (Gong *et al.* 1989). It has been used historically as a carminative, to enhance digestion and reduce intestinal gas and flatulence. Animal data demonstrated that ginger significantly reduced gastric ulceration experimentally induced by ethanol, non-steroidal anti-inflammatory drugs and hydrochloric acid (Al-Yahya *et al.* 1989; Yamahara *et al.* 1992, 1998). The information about the effects of ginger on gastric motor function is reported by some studies. A study by Ghayur and Gilani (2005) indicates that a cholinergic, spasmogenic component provides a possible mechanistic insight for the prokinetic action of ginger, and may explain its use in hyperactive states of gut like colic and diarrhea. Wu *et al.* (2008) reported the effects of ginger on gastric emptying, antral motility, proximal gastric dimensions, and postprandial symptoms. Their results indicate that ginger accelerates gastric emptying and stimulates antral contractions and could potentially be beneficial in symptomatic patient groups.

Cerebral vascular diseases

The efficiency of ginger on cerebral circulation includes relieving cerebral vasospasm, reducing blood flow velocity and improving ischemia metabolism and hypoxia, thereby positively protecting brain. This manifests that the pharmacological effects on cerebral vascular diseases are mainly shown on anticoagulant, antithrombosis and the improvement of cerebral circulation. Some scholars believe that gingerol and its analogs are inhibitors of blood platelet activity which play a potential value in curing diseases of cardiovascular system (Kuang *et al.* 2007).

Stimulation of blood circulation

One therapeutic property of ginger is its ability to stimulate the circulatory system that makes ginger an important herbal remedy for the treatment of chilblains and impaired cir-

ulation along the hands and feet (Hutch 2008). It helps in nourishing the skin by increasing blood flow to the surface of the skin, removing toxins from the body, and cleansing the bowels and kidneys (McGee 2003). Ginger also effectively helps in controlling high blood pressure that directly affects blood circulation (Hutch 2008).

Cardiovascular disease and antiplatelet

A few preliminary studies suggest that ginger may decrease the threat of heart attack or stroke. Although it is much too early to tell whether it will benefit those with heart disease, it suggests that ginger may protect the blood vessels from the damaging effects of blockage such as atherosclerosis, which can lead to a heart attack or stroke (Fuhrman *et al.* 2000).

Ginger is estimated by experimental studies as a cardiotoxic for cardiovascular diseases. Powdered or dried ginger administered to the patients with coronary artery disease (CAD) significantly inhibited the platelet aggregation induced by adenosine diphosphate (ADP) and epinephrine (Bordia *et al.* 1997). Fibrinolytic activity and fibrinogen level, however, remained unchanged. Another study showed that fresh or cooked ginger did not affect thrombotic activity or platelet thromboxane production (Janssen *et al.* 1996).

A previous study concluded that the effect of ginger on thromboxane synthetase activity was dose dependent, or only occurring with fresh ginger; and dried ginger was unlikely to cause platelet dysfunction when used therapeutically (Lumb 1994). Because of some studies on platelet aggregation and thromboxane synthesis *in vitro*, some cautious physicians have advised that ginger may alter bleeding time and should not be used concurrently with anticoagulant medications (Backon 1986; Miller 1998). However, no adverse interactions have been reported. There may be differences in effects of ginger depending on whether fresh or dried preparations are used (Kemper 1999). Pungent constituents of ginger and related substances represent a potential new class of anti-platelet agents. Effie *et al.* (2003) studied the ability of pungent constituents of ginger and related substances to inhibit arachidonic acid (AA) induced platelet activation in human whole blood. Their findings showed that gingerol compounds and their derivatives, such as 8-Paradol, are more potent antiplatelet aggregation agents than aspirin, and the attenuation of COX-1/Tx synthase enzymatic activity may explain the mechanism that underlies AA-induced platelet aggregation inhibition. However, the therapeutic effects of gingers on platelet activation still bear further investigation for persons with atherosclerotic disease.

Prevention of gallstone

Gingerol can suppress excessive secretion of prostaglandin, decrease mucin contents in bile, stop excessive mucin combining with ion calcium and bilirubin. Patients who suffer cholecystitis can benefit from eating ginger frequently. Ginger should be taken carefully by patients with a history of gallstones after consultation with a nutritional doctor as side effects are possible (Blumenthal *et al.* 1998). Some herbalists advise against ginger for patients with gallstones, cardiac conditions or other biliary disease, or patients with diabetes or hypoglycemia (Newall *et al.* 1996; Brinker 1997; McGuffin *et al.* 1997). However, there are no reports of adverse effects of ginger on patients eating it as part of their diet or as a dietary supplement.

Relief of painful menstrual periods

Ginger is very effective in alleviating delayed or scanty menstrual periods, relieving the pain present during ovulation as well as blood clots associated with the menstrual cycle. And it is also useful in dealing with various other disorders affecting the uterus (Duke and Ayensu 1985).

Antimicrobial properties

Antibacterial activity of gingers is effective against numerous intestinal problems. Ginger is also used to avoid the formation of ulcers by eliminating the bacterium *Helicobacter pylori*, whose secretions of ammonia cause ulcers (Free Encyclopedia 2006). Ginger has the capacity to inhibit harmful bacteria, such as *Escherichia coli*, responsible for most of the diarrhea (Wood 1988). Ginger inhibits *Bacillus cereus*, which mainly causes diarrhea and nausea (Foster 2000). Sesquiterpenes in ginger show antirhinoviral effects (Denyer *et al.* 1994) and some chemical constituents in ginger, such as diarylheptenones, gingerenones A, B and C and isogingerenone B, have shown antifungal activity (Endo *et al.* 1990). Ginger extracts show antibacterial effects against both gram positive and gram negative bacteria, such as *Clostridium*, *Listeria*, *Enterococcus*, and *Staphylococcus* species (Kemper 1999). The antibacterial action of fresh ginger extractions at the concentrations of 0.0625-3.0% and pH 6-8 to common food contaminating bacteria proves to be widely effective (Smid and Gorris 1999). Heat treatment does not affect the antibacterial capacity of fresh ginger extractions (Yan 2005). Some studies demonstrated that ethanol extractions from dried ginger, including gingerols, showed obvious effect in killing *Oncomelania hupensis* and 6-gingerol inhibits the growth of other insects by causing anorexia, body contraction (Huang *et al.* 2005). Another kind of ginger, *Zingiber zerumbet*, is also active against *S. aureus*, the most common cause of staph infections (Voravuthikunchai *et al.* 2006) and other foodborne pathogens (Voravuthikunchai 2007). As reported by Gupta and Ravishankar (2005), ginger paste showed the strongest antimicrobial activity with complete inactivation of *E. coli* O157: H7 at 4°C and 8°C. Research by Azu and Onyeagba (2007) has also confirmed that ginger extract inhibits *E. coli* and *S. typhi* that are common causes of gastrointestinal tract infections.

In addition to the therapeutic uses based on its antimicrobial properties, ginger has been widely applied in meat preservation and prevention of lipid rancidity. In many tropical countries, ginger is used to preserve foods that spoil easily such as fruits and meats (Kemper 1999). These are all based on the antimicrobial effects of ginger.

Other uses for health

In daily life, ginger can be used in many aspects of health care. Washing hair with hot water with ginger steeped is effective in treating baldness and suppressing dandruff (Leung 1984; Duke 2001). Ginger can detoxify the body against toxicosis like snakebite and poisonous juice from taros and wild herbs and fruits. Juice of fresh ginger with a little juice of fresh garlic, mixed with honey, is a popular remedy for cough and asthma (Leung 1984; Foster 2000). Ginger affects an expectorant action inside the lungs, clearing phlegm and helping relieve catarrhal coughs and related chest infections in patients (http://www.herbs2000.com/herbs/herbs_ginger.htm). Ginger is also used to treat toothache (Leung 1984), oral and gastric ulceration (Afzal *et al.* 2001; Minaiyan *et al.* 2006) and respiratory problems (Duke and Ayensu 1985), alleviate or eliminate ebriety or protect liver from the acute alcohol (Xu and Gao 2007), and avoid heat stroke.

According to Traditional Medical Theory, ginger has long been ascribed aphrodisiac powers, taken either internally or externally. There are some records in the *Karma Sutra*, Arabian medicine and the Melanesian Islands of the South Pacific. It is employed 'to gain the affection of a woman' (Qureshi *et al.* 1989).

TOXICITY AND SAFETY

Ginger as a food spice has been taken daily in significant amounts by millions of people around the world. This fact and the use of ginger for thousands of years have attested to

its safety. However, as the widely therapeutic uses of ginger in modern medication, some concerns over the safety of ginger have been raised that the presence of certain potent bioactive compounds in ginger could cause adverse effects like gas, bloating, heartburn, and nausea. For example, taking ginger remedies in large dose has the potential to cause depression of the central nervous system and cardiac arrhythmias (Solomon and Baker 2008), and to result in significant inhibition of blood platelet aggregation (Verma and Singh 1993; Lumb 1994). Excessive dose of ginger can also lead to gastric irritation and loss of protective gastric mucosa (Desai *et al.* 1990). Consuming ginger in large doses during pregnancy may result in mutations or abortion (Bryer 2005) and the effects of certain ginger components on fetal development are unknown (Backon 1991; Wilkinson 2000), although there seem no safety problem to treat the nausea and vomiting in the short-term use of ginger during pregnancy. However, additional research is needed to conform the safety and effectiveness of ginger as an anti-nausea remedy for longer periods of time during pregnancy. The 6-gingerol, the main active ingredient of ginger, which contributes to the pungent fraction (Yahya *et al.* 1990), has been reported to have the mutagenic potential (Namakura and Yamamoto 1982; Nagabhushan 1987; Weidner and Sigwart 2001). Powerful antimutagenic components like tryptophan pyrolysate and antioxidant activities in ginger should be taken into account for the antimutagenic action (Kada *et al.* 1978; Jitoe 1992). However, purified fractions or isolated compounds may have lost their anti-mutagenic protective components (Fulder 1996). As to the kinetics of ginger, more studies are required, at least, to elucidate its constituents and the effects of their consumption over a long period of time. Identification of the molecular targets of individual ginger constituents on specific biomarkers of inflammation will be useful for studies (Grzanna *et al.* 2005).

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