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Medicinal uses and bioactivities of Ginger – A detailed review

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Abstract

Ginger belongs to family Zingiberacae and genus Zingiber that has widely been used as medicine in traditional, modern and ayurvedic system of medicines since ages. It is also an essential ingredient of different food items and extensively grown in many countries but mostly found native to China and India. Ginger has many varieties and cultivars but most of the properties of ginger depend on the geographical location. Ginger contains many chemical compounds among which highest percentages are of zingerone, gingerol and shogaol. Ginger contains upto three percent of fragrant essential oil whose main chemical constituents are sesquiterpenoids having zingiberene. Minerals present in ginger are iron, calcium and phosphorous however this plant also contains vitamins such as thiamine, riboflavin, niacin and vitamin C. Ginger rhizome has long been used in ayurvedic system of medicines owing to its anti-emetic, anti-pyretic and anti-inflammatory potentials. In traditional Chinese medicines, ginger is used to improve the flow of body fluids. Its major active components are gingerol, paradol and shagaol while the aromatic components are bisabolene and zingiberene. Some active chemical constituents of ginger are reported to stimulate the digestion, absorption, relieve constipation and flatulence by increasing muscular activity in digestive tract. Ginger has strong anti-bacterial properties and to some extent anti-fungal potentials as well. Various in-vitro studies have shown that active constituents of ginger significantly inhibit the multiplication of colon bacteria.

Key words: Ginger, zingerone, shogaol, zingiberene, riboflavin, niacin, vitamin C, anti-emetic, anti-pyretic, anti-inflammatory, anti-bacterial, anti-fungal

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1. Introduction

Ginger belongs to family *Zingiberacae* in which caradom, galangal and turmeric are also included. It has been used as a traditional medicine or as a spice. The genus *Zingiber* is native to China, Southeast Asia, New Guinea and the Indian Subcontinent. Ginger plant is widely grown all around the globe owing to its culinary usage and medicinal applications. Since then only *Amomum* L. has been studied in depth, which results in the exploration of eleven new species [1]. There have been many recent descriptions about new species by contrast from Indochinese floristic region which showed that large number of ginger biodiversity is yet to be documented. Following three species of ginger that are described in detail in this review are found to be new during the broad investigations of the Indochinese regions. The types and original descriptions of all the species in their particular genera subgenera have been consulted, particularly that are from adjacent territories [2].

The most well-known specie of ginger is *Zingiber officinale* that is commonly named as garden ginger. Ginger has different names depending upon where you are in the world. In Chinese, it is commonly called "jeung", "sang keong", "chiang", "jiang", "keong" and "shen jiang". In India and Indonesia, specifically in Hindi it is called "adi", "adrack" in fresh form and "sonth" in dried form. In Vietnamese, it is commonly termed as "ung" and "sinh khuong" while in Malayasam it is known as "inchi" (fresh/plant) and "chukku" (dried). It is known as "gember" in Dutch, "gingembre" in French, "ingwar" in German, "zenzero" in Italy, "jengibre" in Spanish in various European countries. Pharmacological name of ginger is *Rhizoma zingiberis* [3].

The most familiar specie of ginger is *Zingiber officinale Roscoe*. However, this has a wide range of varieties and cultivars varying in flavor, scents and uses. Some common species of ginger are African ginger, Black ginger, Cochin ginger, Gan jiang, Gegibre, Ingwer, Jamaican ginger and Race ginger. Ginger has close resemblance with two other culinary spices cardamom and turmeric. The approximate length of ginger plant is 2-4 feet just like that of commonly grown wild grasses.

Approximately 50 cultivars in addition to seven better quality varieties have been reported in India [4]. In order to determine the quality of ginger cultivars, some deciding factors are essential oil and their specific pungent smell. It consists of rhizome or underground roots that are used for number of medicinal and culinary purposes. Ginger is native to warm tropical climates and is widely grown in Africa, Asia, Jamaica, India, Hawaii and Mexico [5]. The species *Zingiber pseudosquarrosum* is new to present scientific community as it belongs to genus *Zingiber* and has already been used by local particularly vulnerable tribal groups (PVTGs) of the andamans owing to its medicinal importance.

The essential oil contents of ginger is equally variable between species and cultivars and is thought to be related to growing conditions, geographic origins, genetic factors, chemo-types and differences in the nutritional status of plants. The yield of essential oil from gorubuthane, shingboi and thringia cultivars is 3.8%, 3% and 1.8% respectively. The main ingredients of shingboi ginger oil (20.07%) were arcurcumene (6.56%) and neral (9.44%). The gorubathane oil was rich in sequiphellandrene (10.9%), zingeberene (32.2%) and geranial (5.86%). However, thingria oil primarily contains zingiberene (12.58%). Majority of essential oil is present in rhizome of ginger. It is clear that the morphological and chemical variations of ginger appear to be strongly influenced by environment. The origin, source and growing condition of ginger have an impact on the plants usage, flavors, aromas and medical uses [6].

2. Historical Perspective

Ginger is found native to China and India. Its name has been taken from Sanskrit word "stringa-vera" which has meaning "with a body like a horn", as in antlers. It has great importance in Chinese medication for many centuries and is stated in the literatures of Confucius. It is also named in the Koran, the sacred book of the Moslems, which clearly shows it was known in Arab countries since 650 A.D. Ginger is one the most primitive spice that is known in Western Europe and has been using since the 9th century [7]. The ginger history is approximately 5000 years old when the ancient Indians and Chinese considered it as a tonic root for all ailments. Ginger is originated in Southeast Asia but it has an extensive history of being cultivated in other countries. At an early age it was transferred from India to ancient Rome. Romans used ginger extensively but it was almost vanished from the pantry when downfall of Roman Empire occurred. Arabs took control of the spice import and export from east, after the downfall of the Roman Empire. Like numerous other spices, ginger became relatively expensive. Ginger was used to make sweets and generally imported in preserved form in medieval times. In nineteenth century, English taverns and pubs, barkeepers put out small bottles of ground ginger, for people to sprinkle into their beer, the origin of ginger ale. In order to gee up a lazy horse, it is the time honoured practice of Sussex farmers that they apply a pinch of ginger on backside of animals [8].

3. Demography/Location

Ginger is a perennial herb that grows in a humid, warm climate and in filtered sunlight. Although it is a tropical plant but can still be grown in areas that receive light frost if the rhizome is not exposed to freezing temperatures. Ginger is usually grown from rhizome and is often grown in a container so it can be moved indoor easily when there is danger of frost. Ginger is widely grown in Japan, Saudia Arabia, Malaysia, United States, Singapore, Netherlands, Canada, Germany, France, Pakistan, Australia, Mexico, Poland, Switzerland and South Africa [9]. Ginger is a horticulture crop that is commercially produced in Ethiopia and SNNPS. In SNNPRS, producing areas are known to be ginger belts of Ethiopia where most of the country's marketing and production activities are located. These areas of country are known as the major suppliers of the ginger, not full attention has been given to expand production for improvement of small-holder farmers that are involved in marketing and production activities.

The global statistics for production of ginger are hard to obtain. India produces 702,000 metric tonnes that is about 34.6% of the world total. China produce 388,886 metric tonnes that is about 19.1% of worlds total, Nepal produce 216,289 metric tonnes that is 10.6% of world total and Nigeria produces 160,000 metric tonnes that is almost 7.9% of world's total [10]. These production countries indicate the availability of gingers types to spice importers such as Chinese, Indian (Calicut and Cochin), Jamaican, African (Sierra Leone and Nigeria) and Australian. The reputation of high quality ginger is owned by Jamaican and Indian which have delicate flavor and light color. Calicut ginger is more reddish-brown while Cochin ginger has a light yellow color; both of them have a delicate flavor and odor, they have some lemon-like aroma; ginger of India is mostly exported, dried and washed, roughly peeled or unpeeled. Ginger of Africa has dark color and relatively higher content of monoterpene which gives it more pungent aroma with camphoraceous notes as it has a high level of pungency and oil contents thus it is generally preferred for oleoresins and oils production. Dried ginger of China is exported as sliced unpeeled and whole peeled with two grades. Chinese ginger is whiter than the Indian ginger and it tends to be more bitter and more fibrous [11].

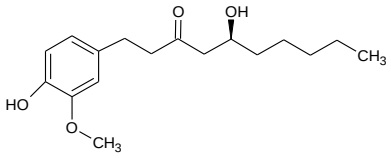
4. Botanical Description and Ecological Features

The plant of ginger can grow from one to three feet in height having sheating bases of two ranked leaves that surrounds the plant. This plant has a club like spike of yellowish, purple-lipped flowers that has showy greenish yellow bracts just beneath the plant. Unfortunately, in cultivation of ginger, rarely few flowers are found to grow. It has thick scaly underground stems, which has branch with thick thumb-like protrusion, hence individual division of rhizome is known as hands. Rhizome is 1-1.5 cm broad and

7-15 cm long and laterally compressed. The branches of ginger that arise obliquely from rhizome are about 1-3 cm long and end in the undeveloped buds and in depress scars. The surface is longitudinally striated or fibrous and has buff color. The surface that is fractured surface shows a well-marked endodermis, narrow cortex and a wide stele in all plants [12].

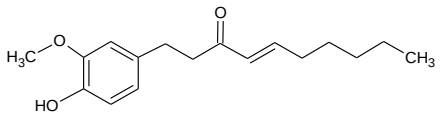
5. Essential Phytochemicals and Nutritive Components

Ginger has pungency due to the presence of gingerol which is an oily liquid and consists of homologous phenols. In plants, it is formed from alonate, phenylalanine and hexonate. In rhizoe of fresh ginger, major active constituent is gingerols that is found in appreciable amount. The powder of rhizome contains 60-70% carbohydrates, 9% proteins, 3-6% fatty oil, 2-3% volatile oil, about 8% ash, 3-8% crude fiber and 9-12% water. The volatile oil consists of mainly caphene, monoterpenes and sesquiterpenes, curcuemene, β-phellandrene, geranyl acetate, cineol, terpenes and terpenol. In powder of dried ginger, shogaol is dehydrated product of gingerol and a predominant pungent constituent naturally produced by biosynthesis. It contains 5-8% acrid resinous substances. The approximate yield of ginger essential oil is 3% whose major chemical constituent is a sesquiterpene named zingiberene. A small fraction of monoterpene and other sesquiterpene have also been determined. From ginger extract, a novel component amaldehyde has also been isolated. The rhizome has other pungent principles that are gingerdiols, paradols and gingerdiacetates etc. The rhizome also contains diterpenes and ginger glycolipids A, B and C_{18}. Other minor compounds are methylegingediol, gingediacetates, methlegingediacetates and C_{20}-dialdehyde [13].



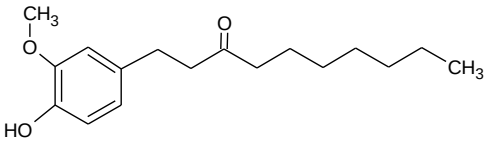
Gingerol

(A) Gingerol



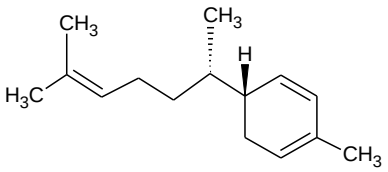
Shogaol

(B) Shogaol



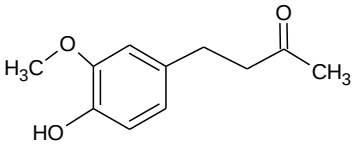
Paradol

(C) Paradol



Zingiberene

(D) Zingiberene



Zingerone

(E) Zingerone

Fig 1 Chemical structures of ginger (A) gingerol (B) shogaol (C) paradol (D) zingiberene and (E) zingerone

The anti-oxidant activity and chemical composition of ginger root was determined in a scientific investigation. The analysed anti-oxidant components were vitamin C, polyphenols, tannins and flavonoids. Anti-oxidant assays such as reducing power, free radical scavenging activity and total anti-oxidant activities were performed for ethanolic, acetonic and methanolic extracts. Fats and proteins of sample were found to be 3.72 and 5.08/100g respectively. Ash and minerals such as iron, calcium, phosphorous, zinc, copper, chromium and vitamin C were 3.85g, 8.0mg, 88.4mg, 174mg, 0.92mg and 9.33mg respectively. Components of anti-oxidant were higher in hot water than aqueous and other solvent extracts. Three different methods showed higher anti-oxidant activity in solvent extract. Anti-oxidant activity order by free radical scavenging activity by DPPH and reducing power was as follows: 80% methanolic > 80% ethanolic > methanolic > ethanolic > acetonic extract. Some essential minerals present in ginger are calcium, iron and phosphorous. It also contains vitamins such as riboflavin, niacin, thiamine and vitamin C. The variation in the composition occurs with the variety, agronomic conditions, type, curing methods, storage conditions and drying. Over 2000 years, ginger has been used as a spice. Polyphenyl compounds which have high anti-oxidant activity are present in its extracts and roots [14].

Since the early 19th century, chemistry of ginger has been the subject of sporadic study. In common with other pungent spices, considerable advances were made in the early part of the 20th century, but it has only been in recent years that a fairly clear understanding of relationship of its chemical composition to its organoleptic properties has emerged. Organoleptic properties of two classes of chemical constituents are (a) steam volatile compounds constituting essential oils and (b) non-steam volatile compounds including oleoresins. Steam distillation process is used to produce essential oil from dried ginger as it is obtained as a pale yellow to light amber mobile liquid, its

viscosity increases on exposure to the air or on aging. Organoleptic properties of ginger oil vary on the basis of geographical location of the dried ginger. Ginger oil of Africa shows more fatty sweetness and tends to be darker in color while the Jamaican oil generally has obvious odor freshness and has very pale color. The composition of steam volatile oil of ginger, which mostly contains sesquiterpene hydrocarbons, determines the flavor and aroma of ginger [15]. The fatty acid composition of different parts of essential oils are listed in table [16].

Table 1 Fatty acid composition in ginger

Fatty Acids	Total Fatty Acids (%)
Caprylic Acid	1.4
Capric Acid	4.1
Lauric Acid	7.6
Myristic Acid	3.5
Pentadecanoic Acid	0.4
Palmitic Acid	23.2
Heptadecanoic Acid	1.3
Stearic Acid	3.3
Oleic Acid	22.9
Linoleic Acid	23.2
Linolenic Acid	6.6
Arachidic Acid	1.1

6. Post-Harvest Management and Commercial Products

Rhizomes of mature ginger are harvested when the top of plants start to wilt and die. Rhizomes should be plump with a dry, bright yellow-brown skin color. The sheen is soon lost and the skin darkens. Rhizomes are sold in full telescoping cartons with filled bags. Mature ginger rhizoe can be stored in different ways. Superficial mold growth can occur if condensation collects on rhizomes, especially on the broken ends. Young ginger rapidly loses water and wilt in few days. When rhizome is infested by this, it becomes watery and soft. Use of fungicides is not permitted on ginger, but reasonable control can be obtained if the rhizome is effectively cured. On the injured areas and cut ends, saprophytes grows although not parasitic but they give surface and the cut ends an unsightly outlook and it may cause production of mycotoxins [17].

Rhizome of *Zingiber officinale Roso* plant is the main source of ginger. Basically, it was originated in South East Asia and is valued for the preserved crystalline ginger and dried ginger spice. It is recommended that before the ginger processing, market survey should be carried out. This will be helpful for information collection on the basis of availability of processing materials and equipment availability along with the availability of raw materials and demands and access of ginger products in market. The information collected through this survey will provide clue whether your business plan would be successful or not. Generally, ginger is available in three different forms; dried ginger spice, fresh ginger or preserved ginger in brine or syrup. Mostly fresh ginger is eaten in areas where it is produced however there is possibility of transportation of fresh roots internationally. Mature and immature rhizomes of ginger are used as a fresh vegetable. It is not simple to make preserved ginger, for this a lot of attention and quality care is required, only the most tender and youngest stems of ginger should be used. Competition with the well-established Australian and Chinese producers is difficult [18].

When the ginger rhizomes are planted they can be harvested after months however they will be supposed to be quite immature at this stage. They are tender with a mild flavor. At that time, they are suitable for processing into preserved ginger or for fresh consumption. Rhizome after seven months become less tender and have too strong flavor for fresh use thus, they can be used only in dried form. For drying of mature rhizomes, they are harvested between the age of eight and nine months when they have a high flavor and strong aroma. Delayed harvesting tends to enhance fiber contents of this plant. Native properties of ginger such as flavor, color, aroma and taste depend on the place at which they are grown. These factors affect their suitability for processing. For preparation of dried ginger rhizomes with a strong aroma and flavor its proper processing is ultimately required and its size is another very important factor. Rhizomes of medium size are most suitable for drying while rhizomes of large size usually have high moisture contents thus it is difficult to dry them. Many forms of dried ginger are commercially available in market. The rhizomes may be used as a whole or they may be divided or sliced into smaller pieces to fasten the drying process. Rhizomes are sometimes killed by boiling for 10-15 minutes or by peeling. A black product is formed which can be bleached using sulphurous acid or lime. In UK market only cleanly peeled dried ginger product is accepted [19].

Ginger can be traded in processed form or dried form. Generally dried ginger occupies nearly 25% of the total ginger trade because it is the major value added product. Only small quantity of ginger is processed because the negligible quantity of processed form of ginger like candy and powder is traded. The second most traded ginger after fresh ginger is sutho or dried ginger. When fresh ginger is dried then dry ginger is obtained which can be preserved for long time. Mature rhizome is used to prepare dry ginger which has specific flavor, characteristic aroma and unique pungency and its harvesting is generally carried out from 8 to 9 months after plantation. Cultivars with medium sized rhizomes having high percentage of cure are preferred to make dry ginger [20]. Taste of ginger candy is hot and sweet. Processors that are producing candy are very limited. It is mostly produced by microenterprises run by cooperative from ginger pocket area. When fresh ginger is mixed with preservatives and water then ginger squash is prepared. However life of ginger squash is short and it damages very quickly. Ginger squash is not much popular thus its marketing linkages have not been created yet.

7. Medicinal Uses and Pharmacological Applications

Ginger is mostly used to treat nausea but it is also used as a pain remedy, as an anti-inflammatory, a cholesterol-lowering herb and a warming remedy. To prevent nausea, its randomized controlled trials support is used. Its usefulness is suggested by case study in treatment of inflammatory arthritis and migraines but no randomized trials have been reported yet. In animal studies, thermogenic effects have been suggested but there is no evaluation in humans. There is not sufficient data available for recommendation of ginger as a cholesterol-lowering supplement. From the ancient times ginger has been using as a food, thus it is supposed to be safe for supplemental use. Because ginger has effects on thromboxane synthesis *in vitro* and platelet aggregation, it is suggested by some herbalists that special caution is required for those patients that are scheduled for surgery or those taking anti-coagulants on the other hand clinically no significant anti-coagulant effects have been documented. There are no studies that have evaluated ginger's safety during lactation, pregnancy or during childhood, although it is on the Generally Recognized as Safe (GRAS) list. In animals related spices it has uterotonic effects, it is the reason that the German Commission E and some herbalists recommended to avoid the use of ginger during pregnancy [20].

In small quantities spices are added to other foods to improve their palatability and flavor as it add colour and pungency to other foods. Ginger is worldwide popular although it is mostly used in China and India; it is a main ingredient in masala mixes and blends of curry [21]. It also has uses in non-alcoholic and alcoholic beverages including ginger beer, ginger wine and ginger ale. It has uses in baking and it is very popular spice which adds flavor and aroma to biscuits and cakes. Gingerbread which is still popular, according to legend it was first baked in 240 BCE on the Isle of Rhodes from where it was introduced into Egypt. The Romans then circulated it in Britain and across the Roman Empire it was a sweet treat during middle ages. It was favorite at the court of Elizabeth 1 in 16th century, however it was perhaps more like the primitive version than product like cake known today [22]. Worldwide ginger is used as a condiment, cooking spice and herbal remedy. Ginger has been used by Chinese at least 2500 years as an anti-nausea remedy and digestive aid and for the treatment of rheumatism and bleeding disorders; it was also used for treatment of toothache, snake bite, baldness and respiratory conditions. In traditional Chinese medicine (TCM), ginger is considered as a dry warming, pungent, yang herb that is used for illnesses caused by damp weather and cold.

Ginger has extensive usage in ayurvedic system of medicines that is traditional Indian medicine, to reduce cholesterol, to block excessive clotting (i.e. heart disease) and fight arthritis. In Indonesia and Malaysia, ginger soup is given to new mothers for 30 days after their delivery to help them sweat out impurities and to warm them [23]. Ginger is considered an aphrodisiac in Arabian medicine. It is believed by some Africans that eating ginger regularly will prevent from mosquitos. Ginger transported westward to Europe by Roman and Greek times. The Greeks use ginger as a digestive aid they wrapped it in bread and ate it after meals. Subsequently, ginger was combined with bread and sweets such as gingerbread. Spanish gave so much value to ginger that in 1600's they established ginger plantations in Jamaica. In 19th century, eclectic physicians relied on ginger to improve the appetite, to induce sweating and curb nausea and as a topical counter irritant. Ginger is extensively cultivated now-a-days from Asia to Africa and Caribbean and is used internationally as an anti-spasmodic, as a nausea remedy and to promote warming in case of chills. Ginger is also largely consumed as a flavoring agent; in India it is estimated that average daily consumption of fresh ginger roots is 8-10 grams. Ginger roots are used as a prophylactic agent against motion sickness and for treatment of dyspepsia that was approved by the German Commission [24].

Ginger is extensively used all around the world in food as a spice. It is native to tropical Asia however ginger is a perennial plant that is cultivated in the tropical climates of China, Australia, Brazil, Jamaica, West Africa, India and all parts of the United States. The rhizome of ginger has a long history of use in Ayurvedic and Chinese medicine as an anti-inflammatory, anti-pyretic and anti-emetic agent. Here, the objective was to précis the most common and recent actions and beneficial application of ginger and its active components [25]. In modern times, the advancement has been witnessed in the treatment of rheumatoid arthritis. The severity of inflammation can be rapidly reduced by DMRAD's that are therapeutic agents. Now a days, the treatment has goal of complete remission [25]. Ayurveda is a time-tested health science which is serving the mankind since ages. Many remedies have been invented by the sages of ayurveda to combat this disease. It has been known from ancient times that essential oils from medicinal and aromatic plants have anti-bacterial, biological activity, anti-oxidant and anti-fungal properties.

There is increasing interest in the use of essential oils in both the pharmaceutical and the food industries because of which an organized study on these extracts of plants have become very important. Spices have extensive uses since the ancient times for different purposes that include keeping away the pests, flavoring and in perfumery. The plant of ginger is a rhizomatous that is grown throughout China, South-Eastern Asia and in parts of Japan, Latin America, Austria, Africa and Jamaica. Ginger has been used as a medicine and spice in China and India since ancient times. To carry the ginger plants to long distance countries via long sea journey they were grown in pots to prevent them from scurvy. This spice for its medicinal properties was known in France and Germany in the 9th century and in England in 10th century. Anti-microbial

properties are shown by many oils due to the presence of components such as α-terpineol, α-pinenes and β-pinenes, eugenol, thymol, 1,8-cineole and linalool [26]. Since these compounds and their relative concentration vary from oil to oil and from different oils which accounts for a varied anti-microbial activity.

7.1 Effects on Gastrointestinal Tract

It is reported that active components of ginger stimulate absorption, digestion and flatulence by increasing muscular activity in the digestive tract and relieve constipation. The efficiency of ginger (940 mg) in motion sickness was compared to that of dimenhydrinate (100 mg) in 18 female and 18 male students of college, who were self-rated as having very high or extreme susceptibility to motion sickness. The conclusion of study was that ginger was effective than dimenhydrinate for the prevention of motion sickness. The administration of ginger (1g) prior to elective gynecologic laparoscopy was also found to be more effective for the prevention of postoperative vomiting and nausea [18]. The ginger has same effects as was observed with 100mg metoclopramide. In addition, a double blind study in 27 pregnant women suffering from morning sickness proved that oral administration of 250 mg of ginger powder 4 times daily over 4 days have significantly reduced symptoms of vomiting and nausea.

7.2 Anti-Microbial Effects

The anti-bacterial properties and to some extend anti-fungal properties of ginger are very strong. It has been shown in in-vitro studies that active components of ginger reduce the chances of multiplication of colon bacteria. These bacteria cause flatulence by fermenting undigested carbohydrates. This can be counteracted with ginger. It inhibits the growth of *Proteus* sp., *Escherichia coli, Streptococci, Staphylococci* and *Salmonella*. Anti-microbial action of ginger extract is at levels equivalent to 2000 mg/ml of spice. Ginger inhibits the growth of *Aspergillus*, a fungus that is known for production of aflatoxin, a carcinogen. Fresh juice of ginger showed inhibitory action against *Saccharomyces cerevisiae, Lactobacillus acidophilus, Aspergillus niger* and *Mycoderma sp.* at 10, 14, 4 and 12% respectively at ambient temperatures [27].

7.3 Effects on Cardiovascular System

In traditional Chinese medicine, ginger has used in the improvement of the flow of body fluids. It stimulates blood circulation throughout the body by diluting blood and by powerful stimulatory effect on the heart muscle. It is believed that improve circulation increase the cellular metabolic activity, thus it contribute to the relief of tension and cramps. In Japanese study it is shown that active components in ginger decreased cardiac workload and reduced blood pressure. Ginger reduced the formation of thromboxane and proinflammatory prostaglandins, thus it lowers the blood clotting ability. The platelet aggregation is inhibited by ginger more than the similar effects observed with onion and garlic. The increase in cholesterol levels due to intake of cholesterol-rich diet can be prevented by ginger. Ginger also possess anti-oxidant properties [8].

7.4 Effect on Blood Pressure

Numerous pieces of evidence, mostly from rat studies, have recommended that ginger have several direct and indirect effects on heart rate and blood pressure. Recently, Gilani and Ghayur reported that the ginger crude extract have induced a dose-dependent (0.3–3 mg/kg) fall in the arterial blood pressure of anesthetized rats. The crude extracts of ginger have exhibited a cardio-depressant activity on the force and rate of spontaneous contractions in the paired atria of Guinea pig. In preparation, thoracic aorta of rabbit, the crude extract relaxed the phenylephrine induced vascular contraction at a dose 10 times higher than that required against K-induced contraction [16]. The blocking activity of Ca^{2+} was confirmed when the Ca^{2+} dose–response curves was shifted to the right by crude extract that was similar to the effect of verapamil. The phenylephrine control peaks in normal Ca^{2+}-plus and Ca^{2+}-free solutions were also inhibited by it, which indicates that it acts at both intracellular Ca^{2+} channels and the membrane-bound. When tested in contraction of endothelium at 14 times less dose than that required for the relaxation PE-induced contraction. The crude extract, vasodilator effect was endothelium-independent because it was not blocked by either atropine or L-NAME (a non-selective inhibitor of nitric oxide synthase used experimentally to induce hypertension) and it was also reproduced in the preparation of endothelium-denuded in the same range of dose. These data shows that the ginger has blood pressure lowering effect and it is mediated through blockade of voltage dependent calcium channels. It was also concluded by the same group in another paper that aqueous ginger extract has blood pressure lowering action by a dual inhibitory effect mediated via stimulation of both blockade of Ca^{2+} channels and muscarinic receptors. Importantly, it was also noted that the different ingredients of ginger might have opposite effect on the blood vessels reactivity [15].

7.5 Effect on Blood Clotting

The impact of an aqueous extract of ginger on production of prostaglandin-E2 (PGE2) and platelet thromboxane-B2 (TBX2) has been examined after treating rats, either orally or intraperitoneally (IP) with a raw aqueous extract of ginger daily for a period of 4 weeks. When low dose of ginger (50 mg/kg) was administered either IP or orally, it did not significantly reduce the serum TBX2 levels [17].

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