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A review: composition, use and bioactive properties of ginger (*Zingiber officinale* L.) rhizoms

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Abstract

Ginger (rhizome of *Zingiber officinale*) belongs to the Zingiberaceae family, is widely used and is most popular as a culinary spice and in Traditional medicines to add flavor for more than thousands of years and tuberose plant thatgrows in humid locations. The rhizome can be macerated in ethanol and used as a tonic and a stimulant. It is also used in pharmaceuticals, nutraceuticals and in cosmetics. Ginger contains a fusion of an aroma oils both volatile (zingiberene) and non-volatile (oleoresin) oils and phenolic compounds (gingerol and shogaol, zingerone and paradol). In ginger rhizomes, also contains starch, saccharides, proteins, colouring matter and trace minerals that plays a huge role as a spice ingredient. Ginger is available in fresh, dried, pickled, preserved, crystallized, candied and powdered or ground form. The extractsand isolated metabolites of *Z. officinale* have exhibited the following properties: anti-inflammatory, antioxidant, antidiabetic, anticancer, antimicrobial, analgesic and antiviral. The aim of this review is to provide a overview about the main aspects related with pharmacognosy and pharmacology of *Z. officinalis* published in the literature over the last decade. Ginger has shown various pharmacological effects such antioxidant, anti-inflammatory, gastro protective, anti-bacterial, anti-diabetic.

Keywords: Ginger, functional food, bioactive components, pharmacological properties

1.Introduction

Ginger (*Zingiber ocinale* Roscoe), which belongs to the Zingiberaceae family and the *Zingibe*r genus, has been commonly consumed as a spice and an herbal medicine for a long time [1]). It is known as “Adrak” widely used in Pakistani and Indian cuisines over 2500 years [2]. It is a flowering plant whose rhizome or root is commonly used in folk medicine and as a spice. Common names are Ginger, African ginger, Black ginger, Cochin ginger, Gan jiang, Gegibre, Ingwer, Jamaican ginger, Race ginger [3]. In addition, ginger is closely related to two other cooking spices, turmeric and cardamom. Also, it is a 2 - 4 foot tall perennial with grass like leaves up to a foot in length. It is the underground root or rhizome that is used for culinary and medicinal purposes digestive [4]. Ginger rhizome is obtained from the underground stems that surrounded by the sheathing bases of the two-ranked leaves.

It is normally an erect perennial growing plant that grown in ground from 1 - 3 feet in height. Rhizomes are 7-15 cm long and 1-1.5 cm broad and laterally compressed. The branches arise obliquely from the rhizome are about 1-3 cm long and terminate in depress scars or in undeveloped buds.

The outer surface is buff colored and longitudinally striated or fibrous [5]. Fractured surface shows a narrow cortex, a well-marked endodermis and a wide stele [6]. It belongs to family “Zingiberaceae” which is very famous due its medicinal herbal plants like, cardamom and turmeric [7]. It has been cultivated in South-East Asia from thousands of years. After that it gains much popularity in European and African countries due to its therapeutic effects. Currently, the ginger and its products are used in many traditional medicinal systems, due to its rich phytochemistry and diseases preventive properties [8].

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Ginger is reported to originate from the tropical rainforests of the Indian subcontinent to Southern Asia where ginger plants show some genetic variation [9]. The oil from ginger is believed to be very medicinal. The major active ingredients in ginger oil are reported to be the sesquiterpenes, which include bisapolene, zingiberol and zingiberene [10]. In recent times, ginger has been introduced into various tropical countries where diverse chemotypes have been developed [11]. Ginger is one of the most widely used natural products consumed as a spice and medicine for treating nausea, dysentery, heartburn, flatulence, diarrhea, loss of appetite, infections, cough, and bronchitis. Experimental studies showed that ginger and its active components including 6-gingerol and 6-shogaol exert anticancer activities against GI cancer [12]. Ginger is a common and widely used spice. It is rich in various chemical constituents, including phenolic compounds, terpenes, polysaccharides, lipids, organic acids, and raw fibers. The aromatic constituents include zingiberene and bisabolene, while the pungent constituents are known as gingerols and shogaols [13]. Although the medicinal properties of ginger have been known for thousands of years, a significant number of *in vitro*, *in vivo*, and epidemiological studies further provide substantial evidence that ginger and its active compounds are effective against wide variety of human diseases including GI cancer. Ginger has been found to be effective against various GI cancers such as gastric cancer, pancreatic cancer, liver cancer, colorectal cancer, and cholangiocarcinoma [12]. Ginger root is used to attenuate and treat several common diseases, such as headaches, colds, nausea, and emesis. The health benefits of ginger are mainly attributed to its phenolic compounds, such as gingerols and shogaols. Accumulated investigations have demonstrated that ginger possesses multiple biological activities, including antioxidant, anti-inflammatory, antimicrobial, anticancer, neuroprotective, cardiovascular protective, respiratory protective, antiobesity, antidiabetic, antinausea, and antiemetic activities. In this review, we summarize current knowledge about the bioactive compounds and bioactivities of ginger, and the mechanisms of action are also discussed. We hope that this updated review paper will attract more attention to ginger and its further applications, including its potential to be developed into functional foods or nutraceuticals for the prevention and management of chronic diseases [14].

Many bioactive compounds in ginger have been identified, such as phenolic and terpene compounds. The phenolic compounds are mainly gingerols, shogaols, and paradols, which account for the various bioactivities of ginger [15,16]. Ginger has rich phytochemistry and several health promoting perspectives. Ginger has been used commonly to treat diarrhea, stomach upset, indigestion and nausea. It also has anti-inflammatory and antioxidant properties. It is concluded that, ginger has potential to treat numerous disorders including cancer due to its anti-inflammatory and anti-oxidant properties [17].

In recent years, ginger has been found to possess biological activities, such as antioxidant [18], anti-inflammatory [19], antimicrobial [20], and anticancer [21] activities. In addition, accumulating studies have demonstrated that ginger possesses the potential to prevent and manage several diseases, such as neurodegenerative diseases [22], cardiovascular diseases [23], obesity [24], diabetes mellitus [25], chemotherapy-induced nausea and emesis [26], and respiratory disorders [27]. In this review, we focus on the bioactive compounds and bioactivities of ginger, and we pay special attention to its mechanisms of action. Ginger is widely recognized that popular knowledge about the useof medicinal plants in the treatment of several diseases needs tobe confirmed. The traditional use of medicinal plants contributesto the spread of this knowledge and serves as a basis for scientific research seeking evidence of such pharmacological activities [28]. In Chinese and Indian alternative medicines, ginger was used as a dietary supplement as well as a spice and as a flavoring agent for foods and beverages. For centuries, it has been widely used for the treatment of nausea, vomiting, emetic, arthritis, rheumatism, sprains, muscular aches, pains, sore throats, cramps, fever, infectious diseases and helminthiasis [29].

Bioactive Components Ginger is abundant in active constituents, such as phenolic and terpene compounds [12,16]. The phenolic compounds in ginger are mainly gingerols, shogaols, and paradols. In fresh ginger, gingerols are the major polyphenols, such as 6-gingerol, 8-gingerol, and 10-gingerol. With heat treatment or long-time storage, gingerols can be transformed into corresponding shogaols. After hydrogenation, shogaols can be transformed into paradols [15].

There are also many other phenolic compounds in ginger, such as quercetin, zingerone, gingerenone-A, and 6-dehydrogingerdione [30, 31]. Besides these, polysaccharides, lipids, organic acids, and raw fibers are also present in ginger [12, 32]. In ginger family, *Zingiber officinalis* is one of most widely used species and it is found in several foods and beverages. Ginger constituents are 80% moisture, 2% protein, 2% fiber, 1% mineral, 0.9% fat, and 12% carbohydrate. The chemistry of ginger is well documented with the respect to the oleoresin and volatile oil. It is also useful in controlling the process of aging.

This scientific review favors ginger due to its rich phytochemistry, and it is recommended to conduct clinical trials of ginger with sound protocol design before claiming its efficacy [17]. The chemical composition and antioxidant activity (in aqueous and solvent extracts) of Ginger root were determined. The antioxidant components analysed were polyphenols, vitamin C, β carotene, flavonoids and tannins. Antioxidant assays such as free radical scavenging activity, reducing power and total antioxidant activity were carried out for ethanol, methanol, acetone, 80% methanol and 80% ethanolic extracts [33]. The aim of this review is to provide a overview about the main aspects related with composition, bioactive properties, pharmacognosy and pharmacology and pharmacological effects of *Z. officinalis* published in the literature over the last decade.

Composition of Ginger rhizom

Ginger, a member of the Zingiberaceae family, is a popular spice used globally especially in most of the Asian countries [34]. Chemical analysis of ginger shows that it contains over 400 different compounds. Fresh ginger contains 80.9% moisture, 2.3% protein, 0.9% fat, 1.2% minerals, 2.4% fibre and 12.3% carbohydrates. The minerals present in ginger are iron, calcium and phosphorous. It also contains vitamins such as thiamine, riboflavin, niacin and vitamin C. The composition varies with the type, variety, agronomic conditions, curing methods, drying and storage conditions [4,35]. Nutritional composition of ginger (per 100g): Moisture 15.02 ± 0.04, Ash (g) 3.85 ± 0.61 (4.53), Protein (g) 5.087 ± 0.09(5.98), Calcium (mg) 88.4 ± 0.97 (104.02), fat (g) 3.72 ± 0.03 (4.37), Phosphorous (mg) 174±1.2 (204.75), Insoluble fibre (%) 23.5 ± 0.06 (27.65) , Iron (mg) 8.0 ± 0.2 (9.41), Soluble fibre (%) 25.5 ± 0.04 (30.0), Zinc (mg) 0.92 ± 0 (1.08), Carbohydrate (g) 38.35 ± 0.1, Copper (mg) 0.545 ± 0.002 (0.641), Vitamin C (mg) 9.33 ± 0.08 (10.97), Manganese (mg) 9.13 ± 001 (10.74), Total carotenoids (mg) 79 ± 0.2 (9296), Chromium (µg) 70 ± 0 (83.37) [33]. Protein and fat content was found to be 5.98 and 4.37 g /100 g DW. The reported values for composition of ginger by various authors are in the following range; for protein, 7.2 to 8.7, fat, 5.5 to 7.3 and ash, 2.5 to 5.7 g/100 g DW [36-38]. In our study, ash, iron, calcium and phosphorous contents were 4.53 g, 9.41 mg, 104.02 mg, 204.75 mg/100 g DW, respectively.

Ash content was in the range of reported values and calcium content, that, 104.02 mg/100 g DW was very close to the value reported for Indian foods [39]. Trace minerals namely zinc, copper, manganese and total chromium were estimated with atomic absorption spectrophotometer and found to be 1.08 mg, 0.641 mg, 10.74 mg and total chromium was 83.37 µg/100g DW, respectively. Vitamin C and total carotenoids content were found to be 10.97 and 92.96 mg/100 g, respectively [33]. Total polyphenols were highest in aqueous extract with almost similar amounts at different temperatures (840 and 830 mg/g) [33]. Ash, minerals namely iron, calcium, phosphorous, zinc, copper, chromium and manganese) and vitamin C were 3.85 (g), 8.0 (mg), 88.4 (mg), 174 (mg), 0.92 (mg), 0.545 (mg), 70 (µg), 9.13 (mg) and 9.33 (mg) per 100 g of sample, respectively. Antioxidant components (polyphenols, flavonoids and total tannin) were higher in hot water (100°C) extract than other solvent extracts and 30°C water extract. The rhizome of ginger plant has been used as a spice since several years across the globe. It was found that, ginger was one of wildly used herbs in traditional Chinese, Ayurveda, Europe and America [40-48]. The major constituents in ginger rhizomes are carbohydrates (50–70%), lipids (3–8%), terpenes, and phenolic compounds [48]. Terpene components of ginger include zingiberene, β-bisabolene, α-farnesene, β-sesquiphellandrene, and α- curcumene, while phenolic compounds include gingerol, paradols, and shogaol. These gingerols (23–25%) and shogaol (18–25%) are found in higher quantity than others. Besides these, amino acids, raw fiber, ash, protein, phytosterols, vitamins (e.g., nicotinic acid and vitamin A), and minerals are also present [8, 41]. Ginger also contains amadaldehyde, paradole, gingerdiols, gingerdiacetates, gingerenones, 6-gingersulfonic acid, diterpense, gingerglycolipids A, B and C [49-

53]. Ginger rhizome is also composed up of extractable oleoresin, fats, carbohydrate, vitamins, minerals, and some other bioactive components [8]. The extract is a combination of gingerols, shogaols, zingerone, monoterpenic, and sesquiterpenic compounds constituting about 3-7% of the total weight of fresh ginger. In the ginger oil gingerols are the main pungent and concentrated molecules. Gingerols are very sensitive towards heat on high temperature they are converted into a homologous series of degraded compounds (6, 8, 10 shogaols) that hold strong antioxidant activity [54].

2.Volatile Oils

Volatile compounds are those components which have very low boiling point and can easily evaporate from the commodity even at room temperature. In the ginger, concentration of these compounds is about 1-3%. The main moieties in the volatile oil of ginger include zingiberene, curcumene, and farnesene having respective percentages 35%, 18%, 10%. In addition, about 40 different molecules are present among which most abundant compounds are 1, 8-cineole, linalool, borneol, neral, and geraniol [5,55]. The pungent aroma and taste of the ginger is mainly depends on these volatile constituents [8]. The flavoring properties of the ginger oil are affected by processing conditions; different constituents are degraded into less flavoring compounds [5]. The concentration of volatile oils in the ginger ranges 1-3% and the aroma and flavour are also dependent on these compounds. The volatile aromatic compounds of ginger are lost during drying or thermal processing due to which aroma and flavour of dry ginger is different form fresh ginger [8]. Moreover, there are several terpene components in ginger, such as bisabolene, curcumene, zingiberene, farnesene, and sesquiphellandrene, which are considered to be the main constituents of ginger essential oils [32]. Mainly the bioactive ingredients, like gingerol, shogaols, zingerone and many others, serve as a source of aroma and flavor; the baking conditions of bread are very adverse for aromatic compounds. They are easily decomposed with heat. Generally, liquid flavors are not recommended in baked goods, such as crackers and hard type of sweet. Thus ginger extract may be better for texture than the powder of ginger. In recent years, in view of their advantageous effects, use of spices has been progressively rising in developed countries as well as used in phytotherapy especially in Europe [41]. In Pakistan, the use of functional and nutraceutical foods is growing rapidly. Although ginger is a regular ingredient of Pakistani foods yet little or no efforts have been made to use this health ingredient in commercially available processed foods.

Nutritional Profile and General uses

Fresh ginger contains numerous phytochemicals that are known to have antioxidant, antimicrobial, gastro protective and anti-inflammatory properties. The rhizome of ginger is an excellent source of dietary fibers that contain certain health benefits, essential oils, moisture, protein, fat, minerals, vitamins and carbohydrates. The composition and nutritional profile of ginger are varies with the type, variety, extraction and curing methods, drying and storage conditions [56]. Ginger is used in cooking to flavor foods and also as a spice. It is also used to lower blood sugar, reduce seizures, strengthen bones, and treat the eye, cough, colic, heart palpitation, swellings, dyspepsia, loss of appetite, and rheumatism [57,58]. Ginger used to increase and maintain the long shelf life of bread through moisture adsorption characteristics of ginger that keeps bread below 12- 15% dry basis (60-64% of RH) at room temperature. Ginger have also used for the composition of ginger pudding, contains ginger powder (1.6-4 % w/w), milk protein (31-62 % w/w), wheat protein (7-15 % w/w), calcium lactate (1.6-5.5 % w/w), carrageenan (0. 8-2. 4 % w/w) and lactic acid bacteria (0.4-1.6 % w/w) and these all ingredients mixed with cow milk and heated in a microwave oven. Powdered and dry form of ginger is classically used as a flavor for gingerbread, cookies, crackers and cakes, ginger ale, and ginger beer [59].

Antioxidant Activity

Ginger oil has scavenging effects due to volatile oils and same has been proved in many studies [40, 42, 46, 59-61]. Ginger has preventive effect on lipid peroxidation and it inhibits or breaks its chain [40, 47, 62]. It has been known that overproduction of free radicals, such as reactive oxygen species (ROS), plays an important part in the development of many chronic diseases [63]. It has been reported that a variety of natural products possess antioxidant potential, such as vegetables, fruits, edible flowers, cereal grains, medicinal plants, and herbal infusions [64-70]. Several studies have found that ginger also has high antioxidant activity [31,71]. However, when dried ginger was further heated to obtain stir-fried ginger and carbonized ginger, the antioxidant activity decreased, because the processing could

change gingerols into shogaols [72]. Additionally, a fraction of the dried ginger powder abundant in polyphenols showed high antioxidant activity based on data from FRAP, oxygen radical absorbance capacity, and cellular antioxidant activity assays [16,73]. Several studies have indicated that ginger was effective for protection against oxidative stress. The underlying mechanisms of antioxidant action were investigated in cell models [31,74]. Several herbs and spices have been developed into natural effective antimicrobial agents against many pathogenic microorganisms [75].

In recent years, ginger has been reported to show antibacterial, antifungal, and antiviral activities [76,77]. The compounds in ginger essential oil possess lipophilic properties, making the cell wall as well as the cytoplasmic membrane more permeable and inducing a loss of membrane integrity in fungi [78]. Ginger essential oil had efficacy in suppressing the growth of *Aspergillus flavus* as well as aflatoxin and ergosterol production [78]. Moreover, a crude extract and methanolic fraction of ginger inhibited biofilm formation, glucan synthesis, and the adherence of Streptococcus mutans by downregulating virulence genes [79]. Free radicals are the highly reactive moieties produced during food processing and in biological systems in result of many generative and degradative reactions. Many health problems linked with advancement in food processing, dietary habits and free radicals production. In such conditions of imbalance, extra antioxidant supplementation through dietary modules is essential for organism vitality [80]. Antioxidants are those compounds which eliminate these active moieties by binding them with own active sites and reduce the risk of different health complications. In this scene, plant based foods are considered as good source of antioxidants. Among vegetables ginger has many therapeutic effects to mitigate such kind of health discrepancies [81]. In many in vitro studies ginger exhibit strong antioxidant activities, due to its active constituents like gingerols [82]. The use of ginger in diet improves the body defense system. It has been proved in many in vitro studies that many chronic diseases are associated with oxidative stress, to prevent these conditions ginger have protective effects due to high antioxidant activity of active components [80-83]. If oxidative stress retained for a longer period of time it leads to DNA damage [83]. The gingerols are considered as the enzyme inhibitor. It hinders the activity of different enzymes e.g Xanthine oxidase. Which are involved in the production of reactive radicals [84]. Among the ginger active components gingerols are considered as strongest antioxidant nutraceutical components. They have proven substantial antioxidant activity in different antioxidant assay [85]. The nutraceutical ingredients of ginger like gingerols possess substantial antioxidant activity as determined by various antioxidants assays. In the DPPH assay 6, 8, 10-gingerol and 6-shogaol shows significant scavenging activity with IC50 values of 26.3, 19.47, 10.47, and 8.05 muM respectively. IC50 values of 4.05, 2.5,1.68, and 0.85 muM against superoxide radical and IC50 values of 4.62, 1.97, 1.35, and 0.72 muM against hydroxyl radical, respectively [85]. It was documented that the extracts of ginger have shielding consequence against ethanol-induced hepatotoxicity in the rats by suppressing the age-related oxidative stress markers [86,87]. Chrubasik et al. [88] investigated that the oxidative stress in Chinese hamster ovary AS52 cells and promyelocutic leukemia (HL)-60 cells of humans can easily be suppressed by the use of ginger and its constituents. In the several studies, it was reported that gingerols have a significant inhibitory activity on superoxide production, restrain lipid peroxidation and defend the levels of reduced glutathione [89]. Ippoushi et al. [90] find out that the nitrogenous free radicals like “nitric oxide” (NO) are the key moieties which manipulate different health issues through signal transduction and DNA damage. These reactive molecules are produced by the action of enzyme nitric oxide synthase (iNOS) excreted in the stress conditions. The action of this enzyme and production of nitric oxide can be significantly reduced by the 6-gingerol administration on dose dependent manner. Like gingerols the other elements (6-Shogaol, 1-dehydro-10-Gingerdione, and 10-Gingerdione) of ginger also significantly trim down LPS-induced NO production, and 6-shogaol and 1-dehydro-10-gingerdione efficiently lessen iNOS expression [91]. El-Sharaky et al. [89] documented that the oral administration of ginger at 100mg/kg of body weight efficiently decreased the glutathione level and normalizes the nitric oxide (NO) generation in bromobenzene (BB)-induced hepatotoxicity model. In a study, it was described that the activities of superoxide dismutase and catalase, as well as GSH and glutathione peroxidase, glutathione reductase, glutathione-S-transferase, and lipid peroxidation in animal models have been reduced by the use of ginger [92].

Hasham-hisam et al. [93] screened samples of fresh ginger which were boiled for one hour and baked for 15 min. The extraction of oleoresin was performed using a Soxhlet extractor with different solvents and different extraction times. For the determi-nation of antioxidant activity, the β-carotene-linoleic acid assay was used. The antioxidant activity of the extracts was compared to that of butylated hydroxytoluene (BHT-positive control). The combination of fresh sample with a polar solvent (acetone) with 12 h of extraction resulted in higher antioxidant activity. Ginger supplementation before ischemia/reperfusion resulted in a higher total antioxidant capacity (i.e., normalized glutathione peroxidase and superoxide dismutase activities) and lower total oxidant (lower tissue malondialdehyde, NO, and protein carbonyl contents) status levels compared to an untreated group of Wistar albino rats [94]. Total antioxidant activity was highest in methanolic extract at 98822 µmol/g followed by ethanolic extract at 91176 µmol/g [33]**.** Chen et al. [80], the reducing power of methanolic extract of 18 different species of ginger ranged from 0.34 to 1.6 nm in 100 mg of sample. In our study, methanolic extract of sample showed much higher activity of 0.208, 0.393, 0.558, 0.681 nm for 2.0, 4.0, 6.0 and 8.0 mg of sample [33]. Antioxidants are the neutralizer substances that can neutral the oxidative stress and free radicals. Oxidative stress is an alteration of reactive oxygen species (ROS) generation and neutralizer defense body system [95,96]. In our body, the production of free radicals can be balanced by intake of various antioxidants or by body defense system [97]. Various medicinal plants and their constituents are currently available that are a rich source of antioxidant and also played a significant role in prevention of disease. Ginger is a good example of antioxidant that reduces the level of oxidative stress and free hydroxyl radical production [98]. Many food industries like meat, dairy and baking use the extract of different plants and spices to increase the sensorial attributes and their antioxidant potential. These extracts have a great impact on the shelf life of different food products especially bakery items like crackers, cookies, bread, and biscuits are of great economic benefits. Reddy [99] reported the antioxidant response of many plants extract and their ultimate use in food items.

Antimicrobial effects

Ginger has strong antibacterial and to some extent antifungal properties. In vitro studies have shown that active constituents of ginger inhibit multiplication of colon bacteria. These bacteria ferment undigested carbohydrates causing flatulence. This can be counteracted with ginger. It inhibits the growth of *Escherichia coli, Proteus* sp., *Staphylococci, Streptococci* and *Salmonella*. The ginger extract has antimicrobial action at levels equivalent to 2000 mg/ ml of the spice. Ginger inhibits aspergillus, a fungus known for production of aflatoxin, a carcinogen 23,24. Fresh ginger juice showed inhibitory action against *A.niger, S.cerevisiae, Mycoderma* spp. and *L. acidophilus* at 4, 10, 12 and 14% respectively at ambient temperatures [100]. Due to the presence of some phenolic compounds in it, ginger has shown great antimicrobial activities and effectiveness in controlling certain viral, bacterial and fungal diseases. Ginger is used in many countries for the preservation of foods.

Ginger acts as anti-parasitic. Some studies reported the *in vivo* potential of methanolic extract of *Zingiber officinale* in the treatment of trypanosomiasis [51, 60, 101, 102]. Gingerols and Gingerdiol are the main anti-fungal principles, and extract of ginger powder is effective against several antifungal diseases [103]. Ginger has shown antiviral effect; however, more published literature is needed to prove this efficacy [104, 105]. Ginger is reported to be effective in management of hepatitis C virus infection where viral clearance is affected [51, 106, 107]. Due to phenolic compounds, ginger has shown excellent antimicrobial properties and effective in controlling virus, bacteria, fungal disease. In many countries, ginger is used to preserve food [105, 108, 109]. Ginger has shown good antimicrobial effect against both Gram positive and negative bacteria; however, severally, this effect is reduced due to heating 51, [104, 110-112]. Gingerols and Gingerdiol are the main anti-fungal principles and extract of ginger powder is effective against several antifungal diseases [87, 103, 108, 113]. Ginger and its constituents prevented the growth of bacteria and fungi and have both cidal and static activity. Ginger showed antimicrobial activity against *E coli*, *Salmonella typhi* and *Bacillus subtilis* [114,115] Ginger and its important constituent's gingerol and shogalol are identified antibacterial agent against periodontal bacteria *Candida albicans* [80, 115, 16, 117, 118]. Ginger extract and gingerol also showed antifungal properties [117].

Kader et al. [119] studied the inhibition potential of extracts from dried rhizomes. These extracts were used to determine antimicrobial activity by being tested with five gram positive (*Bacillus cereus, Bacillus megaterium, Bacillus subtilis, Staphylococcus aureus*, *Sarcina lutea*), eight gram negative (*Escherichia coli, Salmonella paratyphi, Salmonella typhi, Vibrio parahemolyticus, Vib-rio mimicus, Shigella dysenteriae, Shigella boydii, Pseudomonas aeru-ginosa*) and three pathogenic fungi (*Candida albicans, Aspergillus niger, Saccharomyces cerevisiae*). The ether and chloroform fractions showed moderate activity against the bacteria and fungi that were tested. The ethanol extract (400 mg/disk) showed the best antimicrobial activity against Vibrio parahaemolyticus (inhibition zone: 10 mm), and all the tested fungi. The data showed the antimicrobial and antifungal potential of the compounds present in *Z. zerumbet* extracts.

3. Pharmacological effects:

Antiobesity Activity

Obesity is a risk factor for many chronic diseases, such as diabetes, hypertension, and cardiovascular diseases [120]. Several studies have reported that ginger is effective in the management and prevention of obesity [24, 121]. Ginger and its bioactive constituents, including gingerenone A, 6-shogaol, and 6-gingerol, have shown antiobesity activity, with the mechanisms mainly related to the inhibition of adipogenesis and the enhancement of fatty acid catabolism.

Protective Effects against Respiratory Disorders

Natural herbal medicines have a long history of application in the treatment of respiratory disorders such as asthma, and ginger is one of these remedies [27, 122]. Ginger and its bioactive compounds have exhibited bronchodilating activity and antihyperactivity in several studies [123].

Healing effect

Ginger is commonly used spices which are important in medicine due to the presence of many important phytochemical constituents and nutrients which are biologically active substances. In literatures, some of the documented properties of garlic and/or ginger include antioxidant, anti-inflammatory, rheumatologic, blood circulation and anti-cramp, anti-ulcer, anticholinergic, analgesic, antimicrobial, anti-stress, anti-cancer, immunity booster, anti-diabetic, regulation of blood pressure and treatment of cardiovascular diseases. Ginger is used worldwide as a cooking spice, condiment and herbal remedy [59,124]**.** Ginger has preventive effect on lipid peroxidation and also inhibits or breaks its chain [40, 47, 62]. Ginger has been identified as an herbal medicinal product with pharmacological effect. Ginger suppresses prostaglandin synthesis through inhibition of cyclooxygenase- 1 and cyclooxygenase- 2. In traditional Chinese and Indian medicine, ginger has been used to treat a wide range of ailments including stomach aches, diarrhea, nausea, asthma, respiratory disorders [48]. As ginger is widely used both as a spice and for its medicinal properties, the present study was undertaken to determine the nutritional composition of dry ginger as well as its antioxidant activity and components. An attempt was also made to investigate association between the antioxidant activities and components of dry ginger extracted in different solvents.

Ginger has many biologically active components like polyphenols and flavonoids contain health related properties including anticancer, antiviral and antihypertensive [125]. This review will cover all the aspects of bioactive components of ginger and their healthbenefits especially hypocholesterolemic and hypoglycemic role [125]. In medicinal plants, *Zingiber officinale* commonly known as Ginger or ‘Adrak’ has gained much importance. Ginger has been used in foods and medicines from ancient times. From previous few decades, massive research has been done to explore the pharmacological characteristics of a delicate and attractive spicy herb known as scientific name *Zingiber officinale*. Ginger rhizome is a product of Zingiberofficinale plant. It is a monocotyledon herbaceous plant of the tropical and subtropical region. It belongs to the sub-family Zingiberoideae, which is also very famous for two spice crops i.e. turmeric and cardamom. The genus Zingiber Boehm consists of 80-90 species of rhizomatous perennial herbs, very ordinary in South-East Asia, Japan, India, Nepal, China, Bangladesh, Queensland, Jamaica, Mexico, Hawaii and Pakistan [126]. The minerals present in ginger are sodium, potassium, calcium, magnesium iron, and phosphorous [127].

Anti-ulcer and anticholinergic

Ginger acts and protect gastric mucosa against several ulcerogenic agents and is very useful in cases of ulcerogenesis because of its antioxidant properties [85,128]. his has both many benefits and

drawbacks. Prostaglandin has been shown to have housekeeping and gastro-protective function by maintaining gastric mucosal integrity [40, 44, 89, 101, 129].

Effects on the gastrointestinal tract

Ginger is used in Mexican traditional medicine, mainly for gastrointestinal complaints. The active components of ginger is reported to stimulate digestion, absorption, relieve constipation and flatulence by increasing muscular activity in the digestive tract. The effectiveness of ginger (940 mg) in motion sickness was compared to that of dimenhydrinate (100 mg) in 18 male and 18 female college students, who were self rated as having extreme or very high susceptibility to motion sickness [130]. The study concluded that ginger was superior to dimenhydrinate in preventing motion sickness. Ginger administration (1g) prior to elective gynaecologic laparoscopy was also found to be effective in preventing postoperative nausea and vomiting. The effect of ginger was similar to that observed with 100 mg metoclopramide. In addition, a double blind study in 27 pregnant women suffering from morning sickness demonstrated that oral administration of 250 mg of powdered ginger 4 times daily over 4 days significantly reduced symptoms of nausea and vomiting [131]. Ginger is very useful in the treatment of several gastrointestinal diseases including peptic and duodenal ulcer. Ulcer is generally caused due to imbalance between defensive and offensive factors like acid, pepsin and *Helicobacter pylori*; and in this case, ginger is useful due to its anti-inflammatory properties. Ginger acts and protects gastric mucosa against several ulcerogenic agents. Ginger is also very useful in cases of ulcerogenesis due to its antioxidant activities [85,128, 132, 133].

Effects on cardiovascular system

In traditional Chinese medicine, ginger is used to improve the flow of body fluids. It stimulates blood circulation throughout the body by powerful stimulatory effect on the heart muscle and by diluting blood [134]. Several pieces of evidence, mainly from rat studies, have suggested that ginger exerts many direct and indirect effects on blood pressure and heart rate. More recently, Ghayur et al. [135] reported that the crude extract of ginger induced a dose-dependent (0.3–3 mg/kg) fall in the arterial blood pressure of anesthetized rats.

Antiparasitic and Antiviral action

Ginger acts as anti-parasitic; study shows the *in vivo* potential of methanolic extract of *Zingiber officinale* in the treatment of trypanosomiasis [60, 61, 101, 112, 133, 136]. Ginger has shown antiviral effect; however, more published literature is needed to prove efficacy [52,104, 107,108, 139].

Headache

Ginger is used for the treatment of headache and havinggood effect on reducing symptoms of pain. This effect is due to reduction in prostaglandin synthesis. It also has been reported that ginger suppresses leukotriene biosynthesis by inhibiting 5-lipoxyganse [103,108,111].

Gingers Hyperglycemic/ Anti-Diabetic Effects

Previously, several human illnesses have been treated by using ginger rhizome extract. Functional and nutraceutical ingredients present in ginger rhizome have hypocholesterolemic and hypoglycemic effects especially antioxidants, fat-soluble vitamins, phytosterols and some pyrazanol containing moieties [140,141]. The gingerol shows antioxidant [142], and anti-inflammatory behavior [107]. 1 g of ginger powder on an average contained 2.56 mg, 0.47 mg 0.36 mg and 1.27 mg of 6-gingerol, 8-gingerol, 10-gingerol and 6-shogaols, respectively [143]. Pretreatment of ginger inhibits the induced hyperglycemia, hyperinsulinemia and hyperlipidemia [144]. Its contains zingiberol, the principal aroma contributing component as well as gingerol, shogaols, paradols, zingiberene, gingediol, diarylheptanoids, vitamins and phytosteroles [145]. The antioxidant activity of ginger extract is depend on the concentration of 6-gingerol in the extract. In a study, it was investigated the concentration 6-gingerol is highly related to the antihyperlipidemic effects of ginger extract in fructose induced hypolipidemic rats [146]. Diabetes is disorder of carbohydrate metabolism that leads to low blood insulin level [147-149]. Ginger and its constituents significantly controlled diabetes through decreasing blood glucose level86 and inhibition of oxidative stress and anti-inflammatory process. Studies have suggested that ginger may improve insulin sensitivity in body. The mineral element of ginger is effective for the same [61, 89, 136, 137, 150]. Ginger has been used as a spice and as natural additives for more than 2000 years [2]. Also, ginger has many medicinal properties.

Studies have shown that, the long term dietary intake of ginger has hypoglycaemic and hypolipidaemic effect [149]. The change in the dietary style and low physical activity generates many lifestyle related disorders like blood pressure, obesity, CVD and many others. Among these Diabetes mellitus is rapidly growing health complication and one of the foremost reasons of casualties in the world. In a survey, it has been estimated that if this diseases remain increasing with the current rate then in 2030 it will harm about 367 million peoples worldwide [151]. It is a persistent metabolic disorder occurs in result of lower physiological activity and high caloric intake [152]. In this context, scientist and doctors are trying to explore anti-diabetic activity of different plants based food items. In the past few years the effectiveness and anti-diabetic activity of ginger has been tested in many studies and it is proved as a safe herbal medicine. Bhandari and Pillai [153] studies on that the oral administration of ethanolic ginger extract in rabbits has significantly reduce the blood glucose level. Another study was conducted to explore the cholesterol reducing effect of ginger extract by Al-Qattan et al. [154] in which aqueous ginger extract was given at dose of 500 mg/kg of rats for 4 weeks. The hematological studies proved that ginger extract subsequently reduces the fasting blood glucose level. The anti-diabetic activity of ginger extract is depends upon the concentration of 6-gingerol. It enhances insulin-sensitive glucose uptake by stimulating the differentiation of 3T3-L1 preadipocytes [155]. Akhnai et al. [156] reported that the ginger juice significantly cures the 5-hydroxytryptamine-(5-HT-) induced acute hyperglycemia. It was also conclude from study that in STZ-induced diabetic rats oral glucose tolerance test shows that ginger consumption significantly reduces the area under the curve of serum glucose level and increases the area under insulin curve. Commonly conventional solvents are considered as best extraction medium for 6-gingerol. The methanol gives best results as compared to the other organic solvents. Kadnur and Goyal, [157] examined that the methanolic extract of ginger is also more effective in reducing lipid profiles, body weight, glucose and insulin levels in the fructose induced hyperglycemic rats. Its activity depends on the higher concentration of 6-gingerol present in it. Bhandari et al. [158] compared the anti-diabetic potential of dried ethanolic extract against the standard anti-hyperglycemic drug “Gliclzide”.

The ginger extracts oral administration for 20 days shows significant hypoglycemic effect comparison of drug. Likewise Han et al. [159] explored that aqueous extract of ginger reduces the hydrolysis of triolein emulsified with phosphatidylcholine by pancreatic lipase in vitro and reduced the elevation of rat plasma triacylglycerol levels after oral administration of a lipid emulsion containing corn oil. Recently, Al-Amin et al. [160] studied the hypoglycemic potentials of ginger in streptozotocin (STZ)-induced diabetic rats given an aqueous extract of raw ginger daily (500 mg/kg, intraperitoneally) for a period of 7 weeks. Blood serum from fasting animals was analyzed for glucose, cholesterol and triacylglycerol levels. The STZ-injected rats exhibited hyperglycemia accompanied by weight loss. At a dose of 500 mg/kg, raw ginger was significantly effective in lowering serum glucose, cholesterol and triacylglycerol levels in the ginger-treated diabetic rats compared with the control diabetic rats. The ginger-treated diabetic rats sustained their initial weights during the treatment period, decreased water intake. Thus, ginger may be of value in managing the effects of diabetic complications in human subjects.

Aldose reductase inhibitors are now considered to have remarkable potential for the treatment of diabetes and its complications without increased risk of hypoglycemia [161]. In a study concluded that ginger has glucose lowering effect in the normal rats after the 1 hour of administration [162]. In the STZ- induced diabetic rat models investigated that ethanolic extract of ginger (800mg/kg) significantly lower the blood glucose concentration after 1 hour of administration. Its highest activity was recorded after 4 hours, where it showed dose (100-800 mg/kg) dependent decrease in blood glucose level about 24-53% [162]. In the streptozotocin-induced diabetic rat model, rats that were fed ginger exhibited better glucose tolerance and higher serum insulin levels than untreated rats, suggesting that it could help control blood sugar levels [163]. Further-more, Nammi et al. [164] assert that the ethanolic extract of ginger at 100, 200, and 400 mg/kg body weight reduced body weights and levels of glucose, insulin, total cholesterol, LDL cholesterol, triglycerides, free fatty acids, and phospholipids in high-fat diets [162]. Recently, Heimes et al. [165] supported the hypoglycemic potential of ginger.

Islam and Choi [163] suggested that ginger has insulin optropic properties that are mainly attributed to its glucose-lowering potential [146, 155, 165]. Diabetes mellitus is known as a severe metabolic disorder caused by insulin deficiency and/or insulin resistance, resulting in an abnormal increase in blood glucose. Prolonged hyperglycemia could accelerate protein glycation and the formation of advanced glycation end products (AGEs) [166]. Many research works have evaluated the antidiabetic e_ect of ginger and its major active constituents [167]. An in vitro experiment resulted in both 6-shogaol and 6-gingerol preventing the progression of diabetic complications, and they inhibited the production of AGEs by trapping methylglyoxal (MGO), the precursor of AGEs [166]. Ginger is having powerful antioxidant activity due to its oil which has protective effect on DNA damage. They have demonstrated this effect in many cell culture [106,113,168-170]. The genus Zingiber contains approximately 85 species [171]. The main species of ginger consumed in Brazil is *Z. officinale* Roscoe, whose bioactive compounds gingerol, shogaol and other gingerones confer its characteristic flavor, aromaand anti-inflammatory properties. For these reasons it is mainlyused in medicines and for culinary purposes [172, 173].

Neuroprotective and Antiemetic effect

Ginger and its constituents showed neuroprotective effect through the inhibition of microglia by accelerating brain antioxidant defense mechanisms and decreasing the MDA levels to the normal levels in the diabetic rats [162, 174]. Ginger and its constituents such as gingerols, shogaols, galanolactone and diterpenoid illustrate a significant effect on nausea and vomiting [50, 175]. The extract of ginger also possessed 5HT3 receptor antagonism and anti-serotoninergic effect on animal model [50, 175, 176].

4.Conclusion

It can be concluded that ginger is a good source of antioxidant and most of the antioxidant components exhibit higher activities in alcoholic media as determined by different assays. Hence, apart from its medicinal properties, ginger can also be used as an antioxidant supplement. The present review sought to document and comment on the publications that have appeared on ginger and its constituents in the last 10 years or so.

The papers reviewed provide another example of how it may be possible to explain the action(s) of folk medicines in terms of conventional biochemistry and pharmacology. Ginger and many of its chemical constituents have strong anti-oxidant actions. Ginger and many of its chemical constituents have been shown, in numerous clinical studies, to be useful in combating postoperative vomiting and vomiting of pregnancy. More studies are also required on the kinetics of ginger and its constituents and on the effects of their consumption over a long period of time. Ginger is considered to be a safe herbal medicine with only few and insignificant adverse/side effects [4]. There are several evidences from literatures on the medicinal properties of ginger. Apart from their appreciable roles in nutrition, they have been reported to possess several medicinal properties such as antioxidant, anti-inflammatory, rheumatologic, blood circulation booster, anti-cramp, anti-ulcer, anticholinergic, analgesic, antimicrobial, anti-stress, anti-cancer, immunity booster and anti-diabetic.

The active components of ginger is reported to stimulate digestion, absorption, relieve constipation and flatulence by increasing muscular activity in the digestive. The rhizome of Ginger, Zingiberaceae family, is widely used and most popular as a culinary spice in cooking to add flavor and color in Traditional medicines for more than thousands of years. Ginger contains a number of chemical constituents such as gingerol, shogaol, paradol, oleoresins which are responsible to provide different pharmacological actions. Ginger used in beverage formulations, condiments, baby foods and in bakery products to enhance and create a spicy and crunch flavor. Many researchers have lot of interest in developing ginger as a less toxic and effective therapy for diseases and they have been proven about ginger's pharmacological activities such as cardio-protective activity, anti-inflammatory activity, anti-microbial activity, antioxidant property, anti-proliferative activity, neuro-protective activity and hepato protective activities. Even though from these activites of ginger, respiratory tract infection, cancer and tumor treatments are still remaining to be prove that extending the further and future research with a positive outcome [59].

Compliance with Ethics Requirements. Authors declare that they respect the journal's ethics requirements. Authors declare that they have no conflict of interest and all procedures involving human or animal subjects (if exist) respect the specific regulation and standards.

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