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Medicinal Importance of Ginger (*Zingiber officinale*): A Systematic Review

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Abstract

Ginger (*Zingiber officinale*) is a medicinal plant that has been used for centuries in Ayurvedic and traditional Chinese medicine for its therapeutic properties. The rhizome is the edible part of the plant and contains bioactive compounds like gingerols, shogaols, paradols and zingerone that contribute to its pharmacological effects. This review summarizes the bioactive components and pharmacological activities of ginger related to cardioprotection, anti-infective, neuroprotective, analgesic, anti-cramping, gastrointestinal, antineoplastic, anti-Parkinson's, anti-aging, anti-COVID-19, anti-osteoarthritic, antimicrobial, antiobesity and antidiabetic effects. Ginger demonstrates cardioprotective effects by lowering blood pressure, cholesterol, triglycerides and platelet aggregation. It exhibits antiviral, antibacterial and antifungal properties against various pathogens. Neuroprotective abilities are evidenced through protection of dopamine neurons and anti-inflammatory effects in models of Parkinson's disease. Analgesic and anti-cramping activities are mediated through modulation of serotonin receptors. Ginger improves chemotherapy-induced nausea and vomiting, and gastrointestinal motility. It has shown synergistic anticancer effects and reduced tumor size when combined with chemotherapy drugs. Topical application protects against UV-induced skin aging. Inhibitory effects against COVID-19 viral proteins and anti-inflammatory effects make it a potential adjuvant therapy. Through antioxidant and anti-inflammatory properties, ginger reduces osteoarthritis pain and improves mobility. Antimicrobial effects are exerted through disruption of bacterial membranes, biofilm and microbial virulence. Antiobesity effects are mediated by inhibition of adipogenesis and enhancement of lipid metabolism. Antidiabetic abilities are demonstrated through reduction in glucose, glycated hemoglobin and insulin levels. Ginger possesses a diverse range of pharmacological activities, largely attributed to its bioactive compounds, which make it a multi-target functional food and potential therapeutic for numerous conditions associated with aging. Further clinical research can help validate its traditional uses and reveal additional therapeutic applications.

Keywords: Antiobesity; Antimicrobial; Gastrointestinal effects; Ginger; Cardioprotective Activity

1. Introduction:

Ginger (*Zingiber officinale*) is a Zingiberaceae family annual plant endemic to Southeast Asia. For centuries, Asia's indigenous peoples have used ginger in a number of ways, chiefly as a spice and sweetener in their diet and as a natural treatment for curing a range of maladies. In conventional Chinese, Indian, and

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Ayurvedic medicine, ginger is thought to have remedial qualities. Ginger (*Zingiber officinale*) is a popular spice and therapeutic herb (Malik and Kumar, 2023). Ginger has a range of aqueous and polar active compounds, each with its own distinct properties (Akhlaghi and Najafpour-Darzi, 2023). Ginger (*Zingiber officinale Roscoe*) is a widely used dietary

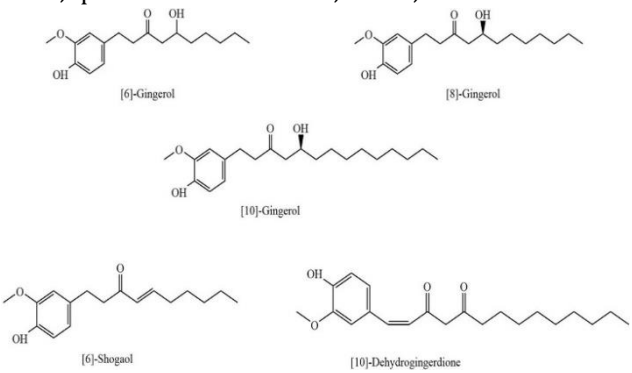
It can be utilized as a cough cure owing to its invigorating impact on loosening and releasing mucus. Ginger can be employed to treat nausea, upset stomachs, and toxic exposure, as well as to improve digestion (Liu *et al.,*2019). Numerous scientific studies have demonstrated that ginger has antiviral, antibacterial and anticancer properties, as well as its utility in the prevention and treatment of digestive, cardiac, and neurological disorders (Semwal, 2015). The rhizome is the plant's edible component. Ginger's therapeutic properties are primarily assigned to its aromatic factors, especially ginger compounds and shogaols (Paswan *et al.,* 2023).

The naturopathic benefits of ginger can also be ascribed to chemical substances present in the rhizome, like ginger compounds (GNs), shogaols (SGs), paradols, or zingiberene (Liu *et al.,* 2019). Fresh ginger rhizomes possess reactive phenolic agents, principally 6-GN, as well as 4-, 8-, 10-, and 12-GNs, which contribute to ginger's strong fragrance and characteristic perfume. These molecules are highly reactive to both temperature and pH alterations, and high-temperature operations like drying & roasting swiftly transform gingerols to its equivalent 6-, 8-, and 10-SGs. The molecule content and related qualities of rhizome preparations and following processing procedures might vary significantly, with the dehydrated root constituting an essential ingredient in antioxidant activity. Sonth in Hindi, Sonti in Telugu, Soonth in Gujarati, Suntha in Marathi, and Shunti in Kannada are all names for pulverised spicy ginger. The newly harvested ginger is mostly composed of gingerols, the key phenolic chemicals in ginger. Multifunctional phytonutrients that include sabresparadols, zerumbone, zingerone, gingerols, and 1-dehydro-(10) gingerdione surpass another significant quercetin. Heat and prolonged preservation are able to separate shogaols using ginger. After hydrogenation, which causes paradols are able to convert to shogaols. Beyond it, ginger raw fibre provides healthy carbohydrates, fatty acids, and organic acids. Ginger active ingredients have been related to a wide range of biological effects, including anti-allergic, tumor prevention, antiseptic, and antiviral characteristics (Semwal and colleagues, 2015). As a consequence, the dried ginger plant is among the most significant ingredients in 6-SG, a water-soluble byproduct (Ok and Jeong, 2012). Past research has revealed indicated 6-SG possesses

item in Eastern civilizations (Mustafa and Chin, 2023). Ginger (*Zingiber officinale Rosc*.) is a traditional condiment crop valued for its taste as well as its therapeutic properties (Zhao *et al.,* 2023). Ginger is a prominent spice used in many cuisines and foods (Paul *et al.,* 2023).

greater impact on emotional responses than 6-GN (Bhattarai *et al.,* 2007; Pan *et al.,* 2008) absolutely no negative effects, and as a result, shuntha is said to have qualities that are more powerful for wellness purposes than unprocessed ginger (Mao *et al.,* 2019 and Rahmani, 2014).

Ginger (*Zingiber officinale*) is used in many meals across the world. It had been used for several decades as an alternate approach of controlling mellitus and other health conditions. Fakhri *et al.,* 2018 and pour masoumi *et al.,* 2018, performed comprehensive reviews to investigate the influence of ginger consumption affects lipid levels, nevertheless their results were contradictory. Fakhri *et al.,* 2018, reported that ginger intake greatly lowered TC, TG, and LDL-C while having no effect on HDL-C; on the other hand, pour masoumi *et al*., 2018, discovered that



ginger consumption dramatically reduced TG and LDL-C levels while having no effect on TC. Another recent metaanalysis focused on the effects of ginger supplementation on lipid profiles in patients who did not have mellitus (Ebrahimzadeh *et al.,* 2022). Ginger (*Zingiber officinale*) has been studied for its ability to treat a variety of chronic diseases in humans (Crichton *et al.,* 2023). Ginger is one of a number of commonly used herbs in the healing process of many ailments (Garza-Cadena *et al.,* 2023). Global demand for ginger, alongside its usage in manufacturing processes that include aromatic oil and lubricating extraction, is increasing. In the future years, there will be a rise in the overall amount of ginger debris (rhizomes, stems, and leaves) (Inthalaeng *et al.,* 2023). Ginger's antibacterial and anti-inflammatory abilities have been demonstrated to improve diabetes management (Diakos *et al.,* 2023). Upon separating, commercial use from ginger generates a substantial volume of agro waste (Liang *et al.,* 2023). Ginger (*Zingiber officinale Rosc*; Zingiberaceae family) serves as a condiment that

is also used as a medicine treating a variety of ailments. Ginger vital oil is a powerful antioxidant, anti-inflammatory, and bactericidal agent (Kamal *et al.,* 2023). Ginger is a valuable spice crop with pharmaceutical characteristics, and ginger oils constitute among the more frequent fragrant flavonoids found in ginger, accounting for the majority of its medicinal uses (Sreeja *et al.,* 2023). Because of its cancer-fighting, antiviral, antibacterial, and known to inhibit-ulcer properties, ginger components, particularly essential oily substances (GEO), have lately acquired favour. The vital oil derived from the ginger rhizome is also commercially recognised and utilised throughout the medicine and food sectors of the world (Uddin *et al.,* 2023). 6-gingerol is the main reactive hydroxyl substance found in ginger (*Zingiber officinale Rosc*.) rhizome, and it has various sensory and medicinal characteristics. Ginger has a substantial global market because of its antibacterial, known to inhibit-biofilm, militant-cancer, and calming properties (Sahoo *et al.,* 2023).

1.1. Objectives:

- To review and summarize the pharmacological activities and mechanisms of action of ginger.

2. Bioactive Components:

Ginger has a lot of potent ingredients, such as flavonoid and methoxy chemicals (Tyagi and Prasad, 2015). Ginger's chemical constituents include mostly ginger extracts, synthetic and paradols. Gingerols, that include 6-gingerol, 8-gingerol, and 10-gingerol, constitute the most abundant flavonoids in fresh ginger. Ginger extracts can be converted into shogaols by exposure to heat or prolonged storage. Shogaols can be converted into paradols after hydrogenation. (Stoner, 2013). Ginger contains several additional phenolic ingredients, including quercetin, zingerone, gingerenone-A, and 6-dehydrogingerdione (Ji *et al.,* 2017 and Schadich *et al.,* 2016). Furthermore, ginger possesses various terpene sections, Within the principal constituents of ginger vital fats are -bisabolene, -curcumene, zingiberene, -farnesene, and –sesquiphellandrene. Ginger additionally comprises mixed lipids, natural acidic substances, and raw cellulose. (Prasad & Tyagi, 2015 and Yeh *et al.,* 2014). Bioactive components of ginger with positive effects on inflammatory bowel diseases (IBD) (Zhang *et al*., 2016; Shayesteh *et al.,* 2020).

3. Medicinal Properties:

3.1. Cardioprotective Activity:

Age is a major contributory factor towards acquiring coronary artery disease. Dylipidemia and hyperglycemia are well-known risk factors for a variety of cardiovascular diseases, notably heart attacks, strokes, and stroke. Recent study data indicates that ginger and certain of its key components could prove beneficial in decreasing blood lipids and arterial pressure, as well as avoiding the accumulation of platelets.

The pure extract of ginger has been demonstrated to reduce hypertension in anaesthetized rodents through the use of injections, and this action was related to its regulatory impact on channels that depend on voltage (Ghayur and Gilani, 2005). In a rat model of hypertension induced via the NOS blocker L-NAME, and arginase activities were enhanced, as were pulmonary plasma nitric oxide (NO) levels (Akinyemi *et al.*, 2015). Another study discovered that 6-GN lowers blood vessel bypass graft type 1 receptor expression (Liu *et al*., 2013). As previously stated, ACE converts angiotensin I to angiotensin II, a powerful relaxant peptide that has been primarily involved in the aetiology of hypertension. (Liu *et al.,* 2013). As mentioned before, ACE converts angiotensin I to angiotensin II, a powerful relaxant peptide that has been involved in the disorders of hypertension and operates via angiotensin II type 1 receptors. In a study including several in vitro cell cultures, 6-GN was demonstrated to normalise the expression of critical biomarkers associated with diabetes through an approach utilising peroxisome proliferator-activated receptor delta (PPAR). In a rat bp model caused by L-NAME, (Lee and colleagues, 2018) discovered that *Zingiber officinale* increased both the systolic effectiveness and plasma levels of losartan, a hypertension drug and an angiotensin II type 1 transmitter antagonist. (Ahad *et al.,* 2020). The results imply whether ginger may also have an effect on liver intestinal enzymes that facilitate the absorption and utilization of several medications that treat hypertension.

According to a systematic review of clinical studies, ginger intake at a dosage of >3 g daily for a period of time is helpful in decreasing blood pressure in individuals (Hasani *et al.,* 2019). Elevated blood lipids are thought to be the major cause of atherosclerosis. The simultaneous administration of physical activity and ginger extract demonstrated an important decrease in circulating triglycerides (TG), In rodents given a diet rich in fat, there was a significant increase in LDL and total cholesterol amounts, as well as a significant increase in HDL concentrations; these findings suggest that ginger may provide shields against coronary artery disease. (Khosravani *et al.,* 2016). It is worth noting that degradation of apoA-I, an essential part of HDL, has been linked to the formation

of defective HDL in hyperlipidemic conditions in the last few decades. In a single research investigation, extracted ginger proved to boost functional HDL synthesis in rodents fed a diet that was high in fat via improving apoA-I activity through stress-related oxidative inhibition. Ginger also appeared to boost faecal lipoprotein output in the exact same analysis (Barbalata *et al.,* 2019).

TGF- induces the assembly of Protein peptides in the smooth muscle cells of arteries, which raises the binding ability of LDL. TGF- possesses proatherogenic qualities as the consequence of this action, thus plays a crucial part in the initiation of hypertension. According to one study, 6-GN could guard towards the progression of hypertension by decreasing peptide formation (Kamato *et al.,* 2013).

Recent research has shown that ginger supplementation lowers blood pressure in individuals. A substantial drop in blood was collected. In hyperlipidemic patients who underwent ginger core therapy at a dose of 3 g/day for 45 days elevated levels of cholesterol were noted for a single experiment and for a total of four weeks in another (Alizadeh-Navaei *et al.,* 2008; Zhao and Chen, 2018).

Accumulation of platelets has long been recognised as a predictive contributor to coronary cardiovascular disease and haemorrhage. In comparison to a pain reliever ginger has been shown to have significant in situ gastrointestinal effect in the accumulation of platelets triggered by nucleoside 5-diphosphate (ADP), bovine the coagulant and arachidonic acid, respectively (positive control) (Chen *et al.,* 2019).

3.2. Anti-Infective Actions:

Decreased innate immunity and complications associated with maturing elevate the probability of getting sick in the elderly. Ginger and its naturally occurring compounds are being proven in recent research to have antimicrobial, antifungal, or antiviral impacts. Ginger and/or the active ingredients in it have been shown to be effective against microbe with immunity to antibiotics including Escherichia coli, Salmonella typhi, staph aureus, Tuberculosis TB, and Enterococcus faecalis, and even against fungus like *Candida albicans* (Mao *et al.,* 2019; Bhaskar *et al.,* 2020 and Oyedemi *et al.,* 2019).

Interferon- (IFN-), a substance that is generated by immune cells and amplified by T lymphocytes, plays an important function in defending our bodies against infections such as viruses and bacteria. 6-SG was discovered to increase IFN-synthesis and translation among human T lymphocyte cells in a dose-related way (Ouyang *et al.,* 2021).

3.3. Neuroprotective Activity:

As we grow older, the frequency of neurological disorders that involve Alzheimer's, Parkinson's, and dementia rises. Recent investigation indicates that ginger could provide restorative benefits for many ongoing, incurable diseases through pathways different compared to the ones accountable for its renowned antiviral, anti-allergic, and malignant properties (Sahardi and Makpol, 2019).

3.4. Analgesic Effect:

Gingerols, the major component of ginger, is being demonstrated to exhibit several intriguing pharmaceutical properties. It is a widely accessible medicine with clinical trials supporting its usage. This activity is likely triggered by an increase in the receptors for serotonin such as 5-HT3. Ginger can help with headaches and other uncomfortable signs. The true outcome of this investigation is expected to be the avoidance of bothersome creating prostaglandin (Bind *et al.,* 2020; Dubey *et al.,* 2022).

3.5. Activities of Blood Circulation and Anti-cramp Effect:

Ginger has been studied for its ability to increase blood serum supply by activating the cardiac muscle and dispersing the human body's flowing blood. Light activity will be beneficial in this regard (Gull *et al.,* 2012).

3.6. Gastrointestinal Effects:

(Anh *et al.,* 2020; Khorasani *et al.,* 2020; Toth *et al.,* 2018; Hu *et al.,* 2020; Crichton *et al.,* 2019; Ozgoli and Naz. 2018; Saneei Totmaj *et al.,* 2019) described that Ginger's impact upon vomiting and feeling sick was investigated. In pregnant women, it showed convincing proof that ginger decreased nausea frequency and extent statistically substantially when compared to placebo (effect size: very big; GRADE level: high) but did not have a significant impact on vomiting prevalence (GRADE level: medium) (Hu *et al.*, 2020). Despite not being state of play-analyzed, all three (100%) main investigations that investigated grumbling occurrence in pregnant women revealed ginger to have a statistically substantial favourable impact (Anh *et al*., 2020; Khorasani *et al.*, 2020; Hu *et al.*, 2020). In subjects who had had an operation, there was reliable proof that ginger substantially lowered postoperative nausea severity when compared to control or an unnamed control. (Effect size: medium; GRADE level: low) However, there was not a statistically significant difference in the incidence of

nausea or vomiting or the necessity for emergency antibacterial medications (GRADE level: mild to moderate) (Toth *et al.,* 2018).

It was found a possibility that additive ginger usage empirically significantly reduced the possibility of severe bowel movements prevalence and feeling dizzy and nausea-related fatigue compared to placebo in individuals going through radiation therapy along with standard antiemetics (Crichton *et al.,* 2019). In contrast to a control group or typical treatment, ginger didn't have a substantial effect on the probability or extent of in general cancer treatment-induced symptoms such as severe vomiting, postponed feeling dizzy or diarrhea, or cancer treatment-induced bloating and feeling sick-related quality of life (GRADE level: very low to moderate). (Crichton *et al.*, 2019). Subgroup analyses increased variability but had no influence on the outcome sizes for nausea and vomiting related to chemotherapy.

In the reviews, there have been no systematic reviews of gastrointestinal distress or stomach emptying results. Ginger consumption, on the other hand, was found to have a statistically significant positive effect in two (67%) of three studies that analysed the probability of vomiting and/or dizziness associated with nausea and vomiting during motion sickness, and in one (50%) of two studies that analysed the consequences on being dizzy or motion sickness indications (vertigo and nystagmus) (Anh *et al.,* 2020). Ginger had a statistically significant positive influence in three (60%) of the five main research studies that looked at gastrointestinal emptying and two (67%) of the three key studies that looked at induced gastric dysrhythmia (Anh *et al.,* 2020).

4. Ginger in Antineoplastic Combination Therapies:

Chemotherapy using multiple medications and treatments has been shown to have a combinatorial and/or complementary impact on the management of cancer, as well as to minimise drug resistance and toxicity. With HT-29 & SW837 adult colon cancer cells, the simultaneous use of -tocotrienol and 6-GN has been shown to produce lethality and suicide (Yusof *et al.*, 2015). In another study, the same team of researchers observed that coupling a mixture of ginger extract and Gelam honey demonstrated a chemo preventive impact in HT29 colon cancer cells by modulating the Ras/ERK and PI3K/AKT channels in a way that was mutually advantageous. (Tahir *et al.,* 2015). Furthermore, an assortment of 6-GN and epigallocatechin gallate (EGCG), the former of which has antineoplastic effects, has been proven to simultaneously induce mortality and limit the expansion of cancer cells. Rahman *et al*., 2014 and Ashmawy *et al.,* 2018, found in a preclinical carcinoma of the breast model that combining extract of ginger with doxorubicin, or DOX, boosts mouse survival relative to the DOX alone group, lowers tumor bulk, and promotes apoptosis (Ashmawy *et al.,* 2018). Recently, 6-SG was demonstrated to strengthen the anticancer medications 5-fluorouracil, oxaliplatin, and irinotecan antineoplastic activity against SW480 through SW620 colon cancer cell lines by boosting their abilities to trigger necrosis and starvation (Woźniak *et al.,* 2020). According to the results, using extracts of ginger Antioxidant Toxicology and Mitochondrial Rejuvenation 7 or 6-SG in standard chemotherapy programs may enhance the effects of therapy (Ashmawy *et al*., 2018; Woźniak *et al.,* 2020).

4.1. Parkinson's Disease:

Parkinson's syndrome (PD) is a medical condition that causes a continuous decline in synapses that produce dopamine in certain parts of the brain as people age. (MohdSahardi and Makpol, 2019). In a murine model of Parkinson's disease (PD) caused by 2-methyl-4-phenyl-4-propionoxypiperidine (MPTP), the use of ginger extract has been demonstrated to help safeguard neurons compared to a mechanism called enhances the concentration of dopamine in the pallidus (globus pallidus) and striatum, as well as decrease TNF-, NO, and ROS levels, resulting in increased PD signs such as movement disorder and bradykinesia (Bassiouny *et al.,* 2016). In another study, 6-SG was discovered to have neuroprotective effects in Parkinson's disease models in situ (C57/BL cells) and in vitro (rat mesencephalic neuronal preparations) (Park *et al.,* 2013). Latest research has demonstrated that addressing bowel disturbance is critical in neurodegenerative diseases like Parkinson's. Ginger and 6-SG reduced the increase of NOS, TNF-, and Il-1 in C57BL/6J mice (i.e., vulnerable to audiogenic seizure) with MPTP-induced intestinal injury, displayed positive effects on dopamine-producing intestinal neurons, and restored intestinal consistency (Huh *et al.,* 2020).

4.2. Skin Ageing:

The epidermis serves essential aesthetic purposes as well as shielding the internal organs from a wide range of outside opponents. Dermal alterations are one of the most obvious indications of maturing. Wrinkles, flexibility reduction, and loosening of the skin are all signs of ageing. Particularly, permanent prolonged contact with UV rays from the sun is the leading cause of external premature ageing of the skin. Zhang and Duan, 2018, discovered that the form and

make-derived elastase enzyme contributes to wrinkle development by promoting elasticity loss in UV-B-exposed skin (Tsukahara *et al.,* 2006). When applied superficially onto mouse and rat skin, ginger extract, which has previously been demonstrated to block members, members-derived elastase, was shown to reduce UV-B10 Antioxidants Therapy and Biological Gerontology caused to decreased skin flexibility. (Tsukahara *et al*, 2006). Another study found that applying a ginger oil massage treatment for four weeks reduced the indications of skin ageing, which was likely due to the plant's antioxidant capacity (Leelapornpisid *et al.,* 2015).

4.3. Ginger and COVID-19:

Because of the high concentration of antiviral components in ginger, it has been demonstrated to have excellent antiviral activity (Mao *et al.,* 2019; Ahmed *et al.,* 2017) Coronavirus, disease 2019 (COVID-19) is a coronavirus-related acute respiratory illness caused by the coronavirus that causes SARS-CoV-2. Since its discovery in 2019, the influenza virus has propagated around the world, culminating in the COVID-19 pandemic. The illness has the potential to be fatal, especially in elderly infected patients with morbidities (Ünal Yavuzand, 2020). Despite there doesn't exist a cure or completely successful vaccine for COVID19, significant research is being conducted. Inflammatory nonstructural peptidase 15 (Nsp15) has evolved into a more promising therapeutic target for SARS-CoV-2 transmission. In a recent in vitro study using hydroxychloroquine (one of the few medications approved for the management of COVID-19) as a control group, gingerol was demonstrated to reduce virus transmission by clinging to the SARS-CoV-2 viral protein Nsp15 (Kumar *et al.*, 2021). Additionally, ginger extract may be used as an adjunct therapy for COVID-19 due to its demonstrated advantages in acute lung injury (ARDS), pulmonary fibrosis, coughing, and septicemia, all of which happen to COVID-19 patients (Thota *et al.,* 2020).

In Ahkam *et al.,*2020, Based on the connection of interacting ginger components that include antiviral spike (S) protein and major metalloproteinase (MPro), Ahkam *et al.,* 2020, did an insilco analysis to investigate the potential utility of ginger's antiviral capabilities in the treatment of SARS-CoV-2 illness. As a result, creating structure-dependent antiviral medications based on phytochemical compounds that inhibit essential SARS-CoV-2 proteins might be a viable therapy strategy.

4.4. Osteoarthritis:

Osteoarthritis is the most common kind of arthritis, defined by cartilage degeneration, discomfort, inflammation, decreased mobility, and dysfunction, especially in the aged. Despite the fact that osteoarthritis is not an inflammatory condition, it does include various types of stimulation in cartilage in joints and its surrounding tissues during its aetiology. The ageing process increases the likelihood of acquiring arthritis. Osteoarthritis has become one of the most prevalent causes of disability and chronic pain, especially in those over the age of 65.In one study, ginger extract reduced the production of inflammatory molecules including PGE2 and NO in osteoarthritic animal cell civilizations, and also decreased oxidative stress and mortality in IL-1-induced C28I2 human cartilage cells (Hosseinzadeh *et al.,* 2017 and Shen *et al.,* 2005).A current meta-analysis found that taking ginger orally is more effective than taking a placebo in reducing agony and improving joint function in persons with osteoarthritis of the knee, most likely owing to its anti-inflammatory and oxidative characteristic (Araya-Quintanilla *et al.,* 2020).

4.5. Antimicrobial Activity:

Resistance to antibiotics has resulted in the worldwide distribution of infectious microbial, fungal, and viral diseases, a severe public health problem. Many medicinal herbs and spices have been transformed into natural antibacterial medicines which have been powerful towards a wide variety of pathogenic microbes (Awan *et al.*, 2017). In recent years, ginger has been found to have antibacterial, antifungal, and antiviral effects (Moon *et al.,* 2014; Nassan and Mohamed, 2014). Biofilm formation aids both infection and drug resistance. Based to preliminary research, ginger reduced the growth of a drug-resistant version of the bacterium Pseudomonas by modifying membrane integrity and lowering biofilm formation (Chakotiya *et al.*, 2017) Furthermore, ginger extract prevented biofilm formation in P. aeruginosa strains by decreasing the quantity of bis-(30-50)-cyclic dimeric guanosine adenosine (c-di-GMP) PA14. (Kim and Park, 2013). Furthermore, through suppressing virulence genes, the basic extract and a methanol-based component of ginger inhibited Streptococcus mutans the formation of biofilm glucan synthesis, and adhesion. A reduction in caries development caused by an isolate of Streptococcus mutans had been observed in a pretreatment group of rodents, a result that was consistent with the findings of the in vitro study (Hasan *et al.*, 2015) Furthermore, gingerenone-A and 6-shogaol were demonstrated to limit Staphylococcus aureus development by lowering the activity associated with the pathogen's 6-hydroxymethyl-7, 8-

dihydropterin pyrophosphokinase (Rampogu *et al.,* 2018). Ginger aromatic oil includes hydrophobic molecules that render the cell surface and cytoplasmic membrane accessible to oxygen, leading fungal membrane integrity to deteriorate (Nerilo *et al.,* 2016). An in vitro study found that ginger essential oil effectively reduced the growth of *Fusarium verticillioides* by reducing ergosterol synthesis and affecting membrane integrity. It may also inhibit the formation of fum B1 and a chemical called fum B2 (Garcia *et al*., 2013). Additionally, the crucial oil of ginger prevented the growth of Aspergillus flavus, and it also inhibited the formation of formaldehyde and ergosterol (Nerilo *et al.*, 2016). Furthermore, the antifungal properties of -terpinene with citronella in ginger oils have been found to suppress the expression of particular genes that contribute to aflatoxin synthesis. (Moon *et al.,* 2018). Moreover, fresh ginger was shown to be effective in inhibiting viral attachment and internalisation in respiratory tract cell lines that generate human breathing virus, or RSV (HRSV)Ginger was found to be effective in preventing viral adherence and incorporation. Chang *et al. (*2013) discovered that using ginger extract decreased HCV loads, the amount of -fetoprotein (AFP), and liver function indicators such as AST (aspartate aminotransferase) and alanine aminotransferase, or ALT, in Egyptian HCV patients (Abdel-Moneim *et al.,* 2013).

4.6. Antiobesity Activity:

Obesity increases the risk of a variety of chronic conditions, such as diabetes, high blood sugar levels, and coronary artery disease. (Misawa *et al.*, 2015). Multiple investigations have demonstrated that ginger can help cure and prevent obesity (Mahmoud and Elnour, 2013; Suk *et al.,* 2017). Gingerenone A reduced fat synthesis and lipid accumulation in 3T3-L1 preadipocyte cells more efficiently than gingerols and 6-shogaol. Gingerenone A has the ability to alter fatty acid metabolism in vivo by triggering AMPK, thereby reducing diet-induced obesity (Suk *et al.,* 2017). In cultured muscle from the skeleton myotubes, 6-shogaol and 6-gingerol may induce peroxisome proliferator-activated transmitter (PPAR)-dependent gene expression, resulting in enhanced cellular triglyceride catabolism. Furthermore, in a diet rich in fat rats, equivalent ginger and orlistat reduced body mass and lipid composition, with ginger having a larger effect on increasing levels of HDL-C than chloroquine (Mahmoud and Elnour, 2013). In a randomized, double-blind in placebo-controlled study conducted, resulted eobese women who took 2 g of ginger powder daily had a reduced body mass index (BMI) (Attari *et al.*, 2016). Furthermore, in humans, the administration of dried ginger powder may reduce cardiopulmonary transfer ratios while increasing fat utilization by increasing fat oxidation (Miyamoto *et al.*, 2015). Ginger and its bioactive ingredients, such as gingerenone A, 6-shogaol, and 6-gingerol, have anti-obesity properties, with the processes mostly including adipogenesis inhibition and fatty acid catabolism enhancement.

4.7. Antidiabetic Activity:

Diabetes, also called type 2 diabetes, is a serious metabolic disease distinguished by insulin deficiency and/or blockage, producing an unregulated spike in plasma glucose levels. Chronic diabetes has been associated with a boost in protein breakdown and the generation of advanced glycation end products (AGEs) (Zhu *et al.*, 2015). Many research have been undertaken to evaluate the anti-diabetic activity of hawthorn and its constituent ingredients (Sampath *et al.*, 2017). In an in vitro investigation, either 6-shogaol and 6-gingerol inhibited the progression of diabetic issues and decreased the manufacture of AGEs by predominantly trapping a compound called (MGO), the precursor of AGEs. (Zhu *et al.,* 2015). Additionally, 6-gingerol reduced plasma insulin and glucose levels in obese rats fed a high-fat diet. 6-gingerol inhibited N-carboxymethyl-lysine (CML), an AGE indicator, through activating Nrf2 (Sampath *et al.,* 2017). By enhancing AMPK phosphorylation, 6-paradol and 6-shogaol boosted glucose utilisation in 3T3-L1 adipocytes and C2C12 myotubes. Furthermore, 6-paradol significantly reduced blood glucose levels in a rat model fed a high-fat diet. (Wei and colleagues, 2017) 6-gingerol also increased the ability to tolerate glucose in type 2 diabetic mice by increasing the levels of glucagon-like peptide 1 (GLP-1). Moreover, 6-gingerol treatment activated glycogen synthase 1 and increased the appearance of the glucose transporter type 4 (GLUT4) on the cell membrane, as well as enhanced the preservation of glycogen in skeletal muscles (Bin Samad *et al*., 2017). Likewise, ginger consumption may reduce fasting plasma glucose, HbA1C, insulin, TG, and TC levels in persons experiencing type 2 diabetes mellitus (DM2) (Arablou *et al*., 2014). Moreover, ginger extract treatment enhanced the reaction to insulin in rats with metabolic syndrome, which might be connected to 6-gingerol's enhancement in energy metabolism (Li *et al.*, 2014). Furthermore, ginger extract reduced retinal microvascular abnormalities in streptozotocin-induced diabetic rats. Ginger extract had been demonstrated to reduce NF-B, TNF-, and the growth factor for vascular endothelial cells levels in retinal

tissue (Dongare *et al.,* 2016). Ginger consumption lowered insulin, LDL-C, and TG levels; dropped the biochemical simulation inspection score; and increased the measurable glycemic-responsiveness explore index in patients with DM2 in a randomised, blinded, wonder drug-controlled experiment (Mahluji *et al.,* 2013). Ginger and its active components have been demonstrated in experiments to protect against hyperglycemia and associated complications, most likely via reducing insulin levels while increasing insulin responsiveness.

5. Conclusion:

Ginger is an annual plant endemic to Southeast Asia that has been used for centuries in various ways, including as a spice and natural treatment for curing different ailments. Its remedial qualities have been recognized in conventional Chinese, Indian, and Ayurvedic medicine. Ginger contains various potent ingredients, such as flavonoid and methoxy chemicals, and its active compounds, including gingerols and shogaols, have been found to have pharmaceutical properties. Recent studies have shown that ginger has antimicrobial, antifungal, or antiviral impacts and can help with various medical conditions, including cough toxic exposure, and skin aging. Additionally, ginger can help prevent cardiovascular diseases, obesity, and hyperglycemia, and improve insulin responsiveness. Ginger is a widely accessible medicine with clinical trials supporting its usage, making it a valuable natural remedy with many potential health benefit Ginger, a plant from the Zingiberaceae family native to Southeast Asia, has been used for centuries by indigenous people in Asia as a spice, sweetener, and natural remedy for various ailments. It is believed to have medicinal properties in traditional Chinese, Indian, and Ayurvedic medicine and can be used to treat coughs, nausea, upset stomachs, and improve digestion. The health benefits of ginger are due to its chemical compounds, such as gingerols, shogaols, paradols, or zingiberene, which are found in the rhizome. These compounds contribute to ginger's fragrance and perfume, along with flavonoids, methoxy chemicals, mixed lipids, natural acidic substances, and raw cellulose. Recent studies suggest that ginger and its components may be beneficial in decreasing blood lipids, arterial pressure, and platelet accumulation, which are risk factors for cardiovascular diseases. Ginger has also been shown to have antimicrobial, antifungal, and antiviral effects against various microbes, including those resistant to antibiotics. Ginger can also help with headaches and other uncomfortable symptoms by activating receptors for serotonin such as 5-HT3. Ginger has been studied for its ability to increase blood serum supply, reduce skin aging, decrease inflammation and oxidative stress in osteoarthritis, prevent viral adherence and incorporation, and protect against hyperglycemia and associated complications.

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