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REVIEW ARTICLE

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GINGER (*ZINGIBER OFFICINALE*) IN TRADITIONAL CHINESE MEDICINE: A COMPREHENSIVE REVIEW OF ITS ANTI-INFLAMMATORY PROPERTIES AND CLINICAL APPLICATIONS

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ABSTRACT: Introduction: Traditional Chinese medicine has widely used ginger (*Zingiber officinale*) for its anti-inflammatory properties and various clinical applications. This comprehensive review aims to explore the phytochemical properties of ginger, focusing on its antioxidant components and active ingredients such as shogaols, gingerols, and zingerone. The unique composition of ginger, including terpenoids, flavonoids, and volatile oils, contributes to its therapeutic potential in managing various health conditions. **Methodology:** We conducted a thorough examination of existing literature to gather information on the anti-inflammatory properties and clinical applications of ginger in traditional Chinese medicine. We reviewed studies examining ginger's effects on conditions like osteoarthritis, rheumatoid arthritis, irritable bowel syndrome, and asthma to gain insights into its efficacy and mechanisms of action. We analysed the phytochemical composition of ginger, including its antioxidant compounds and active ingredients, to understand how these components contribute to its therapeutic effects. **Results:** The review revealed that ginger possesses antioxidant properties attributed to compounds like shogaols, gingerols, and zingerone. Additionally, the terpenoids, flavonoids, and volatile oils found in ginger play a crucial role in its anti-inflammatory and health-promoting effects. Clinical studies have demonstrated the effectiveness of ginger in reducing pain and inflammation in conditions such as osteoarthritis, rheumatoid arthritis, and irritable bowel syndrome. Furthermore, studies have shown that supplementing with ginger can improve lung function and mitigate airway inflammation in asthma patients. **Conclusion:** Ginger emerges as a valuable botanical remedy in traditional Chinese medicine due to its diverse phytochemical profile and therapeutic properties. The antioxidant components and active ingredients present in ginger contribute to its anti-inflammatory effects and clinical applications in managing various health conditions. We need to conduct further research and clinical trials to fully explore the potential of ginger for promoting health and well-being.

Keywords: Ginger, *Zingiber officinale*, Traditional Chinese medicine, Anti-inflammatory, Gingerols, Shogaols, Clinical applications

I. INTRODUCTION

Ginger (*Zingiber officinale*) has a long history of use in Traditional Chinese Medicine (TCM) for its versatile therapeutic properties, particularly its potent anti-inflammatory effects. This rhizome, known for its distinct flavour and aroma, has been a staple in TCM formulations for centuries, playing a crucial role in addressing a wide range of health concerns [1]. The bioactive compounds found in ginger, such as gingerols, shogaols, and paradols, are believed to underlie its medicinal benefits, including its anti-inflammatory, antioxidant, and digestive properties. TCM philosophy classifies ginger as a warming herb, particularly suitable for conditions characterized by cold or dampness in the body. People commonly use it to treat digestive disorders, colds, arthritis, and various inflammatory conditions [2]. People believe that ginger's warming nature stimulates circulation, dispels cold pathogens, and alleviates stagnation in the body's energy pathways, known as meridians. Modern scientific research has increasingly focused on validating the traditional uses of ginger in TCM and shedding light on its mechanisms of action and therapeutic potential [3]. Studies have elucidated the anti-inflammatory properties of ginger, demonstrating its ability to modulate inflammatory pathways, inhibit pro-inflammatory cytokines, and reduce oxidative stress. These findings have paved the way for the integration of ginger into mainstream healthcare practices as a natural remedy for inflammatory conditions. This comprehensive review aims to delve into the phytochemical properties of ginger, highlighting its antioxidant components and active ingredients that contribute to its anti-inflammatory effects [4]. By synthesising evidence from both traditional knowledge and contemporary research, this review seeks to provide a holistic understanding of ginger's role in TCM and its clinical applications in promoting health and well-being [5, 6].

2. Methodology

We conducted a systematic approach to explore the anti-inflammatory properties and clinical applications of ginger in traditional Chinese medicine (TCM). We conducted a comprehensive literature search across reputable databases such as PubMed, ScienceDirect, and Google Scholar, article from the

years 2011 to 2024 covering the knowledge regarding *Zingiber officinale* were included using relevant keywords such as "ginger," "*Zingiber officinale*," "Traditional Chinese Medicine," "anti-inflammatory," and "clinical applications." The selection criteria were to find English-language peer-reviewed articles, clinical trials, and review papers that talked about the phytochemical makeup of ginger, its antioxidants, and active ingredients like gingerols and shogaols in the context of TCM. A total of 152 articles were retrieved out of which a total of 70 articles were considered. An effort was made to compile pertinent writings that were only concerned with *Zingiber officinale*.

3. Botany

Ginger (*Zingiber officinale*) is a flowering plant belonging to the Zingiberaceae family, known for its rhizomatous root system that is widely utilised for culinary, medicinal, and therapeutic purposes. This perennial herbaceous plant typically grows to a height of about 3 to 4 feet and features narrow, lance-shaped leaves that arise from the base of the stem [7]. The plant's inflorescence consists of cone-shaped spikes with small yellow-green flowers enclosed by bracts in various colours, including green, yellow, and red. The most distinctive and valuable part of the ginger plant is its underground rhizome, which serves as a storage organ rich in bioactive compounds responsible for its characteristic flavour and medicinal properties. The rhizome is knobby and irregularly shaped, with a pale yellowish-brown skin and a yellow flesh that emits a strong, aromatic fragrance when cut or crushed [8]. The plant uses this fleshy rhizome in various forms such as fresh, dried, powdered, or for essential oil extraction. Ginger plants thrive in tropical and subtropical regions, preferring well-drained, moist soil and partial shade for optimal growth. We propagate them by either dividing the rhizomes or planting rhizome cuttings in suitable soil conditions. The plant requires warm temperatures and high humidity to flourish, making it well-suited for cultivation in regions with a tropical climate. Ginger cultivation involves regular watering, fertilisation, and protection from pests and diseases to ensure a healthy yield of rhizomes rich in bioactive compounds [9]. In addition to its culinary uses as a popular spice and flavoring agent in various cuisines worldwide, ginger has a long history of medicinal and therapeutic applications in traditional systems of medicine, including Traditional Chinese Medicine (TCM) [10]. The bioactive compounds found in ginger, such as gingerols, shogaols, and zingerone, contribute to its anti-inflammatory, antioxidant, and digestive properties, making it a versatile botanical remedy for a wide range of health conditions. The unique botanical characteristics of ginger, coupled with its rich phytochemical profile, underscore its significance as a valuable herb in both traditional and modern herbal medicine practices [11, 12].

4. Phytochemical Properties

Antioxidant properties are known to be possessed by all of the main active components of ginger, including shogaols, gingerols, zingerone, and gingerdiol. The polyphenol chemicals (6- gingerol and its derivatives) found in ginger are responsible for its antioxidant properties. Terpenoids, ginger flavonoids, paradol, zerumbone, 1-Dehydro-(10) gingerdione, Shogaols, Diarylheptanoids, and Volatile Oil (zingiberene, curcumene, farnesene, zingiberol, D-camphor) are the main active ingredients in ginger [13]. Essential oils that are volatile and non-volatile pungent chemicals like oleoresin are the sources of aroma or pungency. Ginger gets its distinct fiery flavour from these chemicals. Ginger oil is made from oleoresin and terpenes found in ginger. Additionally, ginger contains 1%–3% volatile oils as well as non-volatile, spicy components called oleoresin. Among ginger's phenylalkylketones, or vanillyl ketones, is 6-gingerol. 10- and 8-gingerol, 6- and 8-shogaol, 10- and 6-shogaol, and zingerone. There has also been identification of 6-paradol, 6- and 10-dehydrogingerdione, and 6- and 10-gingerdione. Significant anti-microbial and antioxidant properties were shown by *Zingiber officinale's* oleoresin and essential oil [14]. It was shown that the primary active ingredients in the fresh ginger rhizome were gingerols, namely 5-hydroxy-1-(4-hydroxy-3-methoxy phenyl) decane-3-one. is the component of the gingerol family that is most prevalent. The presence of bioactive phytochemicals such as gingerols, shogaols, paradols, gingerdiols, and zingerone is thought to be the cause of ginger's many health benefits. One significant route by which the body gets rid of cholesterol is by the conversion of cholesterol into bile acids, which ginger may promote [15]. In rats, superoxide dismutase, catalase, and glutathione peroxidase activity were maintained by ginger, which dramatically reduced lipid peroxidation. There was a significant rise in intestinal and pancreatic lipase when ginger was added to animal diets [16].

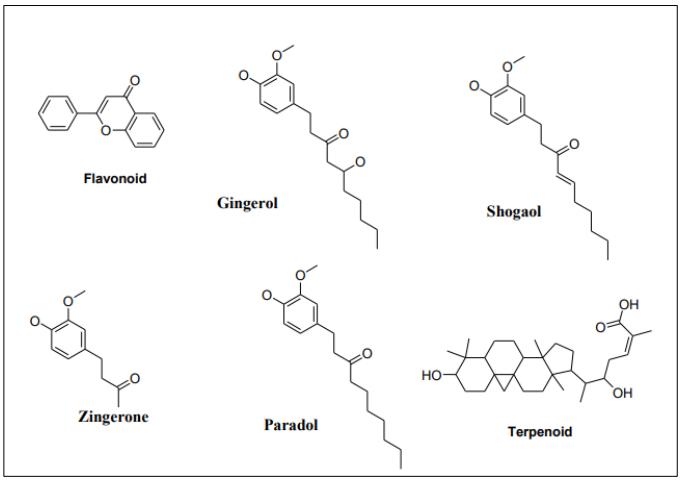

Figure 1: Phytochemical structures of Ginger (*Zingiber officinale*)

Ginger rhizome contents are believed to be as follows: 60–70% carbs, 9% protein, around 3- 8% crude fibre, 8% ash, 3-6% fatty oil, and 2-3% volatile oil. Soluble sugar, cellulose, and polysaccharides make up the carbohydrates. Aspartic acid, serine, glutamate, alanine, glycine, threonine, methionine, cysteine, valine, tyrosine, leucine, isoleucine, histidine, lysine, phenylalanine, proline, tryptophan, and arginine are among the many amino acids included in the protein [17]. The distinctive flavour of ginger is attributed to a few chemicals, particularly

zingerone, shogaols, gingerols, and volatile (essential) oils, which make up up to 3% of the mixture and are mostly alfa-zingiberene, βsesquiphellandrene, β-phellandrene, camphene, cineol, geraniol, and citral [18].

5. Anti-Inflammatory Properties of Ginger

Herbs were the main focus of ancient medical practitioners' efforts to strengthen the body's immune systems. Products made from ginger boost immunity in several nations. Through the inhibition of 5 lipoxygenase or prostaglandin synthetase, gingerol, shogaol, and other structurally similar compounds in ginger prevent the formation of prostaglandins and leukotrienes [19]. Furthermore, they have the ability to prevent the manufacture of proinflammatory cytokines such IL 1, TNF α, and IL 8. In a different study, Pan et al. demonstrated that shogaol can suppress the expression of the inflammatory iNOS and COX 2 genes in macrophages. According to Jung et al., *Z. officinale*'s rhizome hexane fraction extract prevented the overproduction of NO, PGE (2), TNF alpha, and IL 1beta [20].

Ginger rhizome has strong chemicals that might decrease allergic responses, which makes it potentially helpful for treating and preventing allergic illness. Ginger extract has been shown by Habib et al. to lower the increased production of TNF α and NFκB in rats with liver cancer. Numerous inflammatory disorders, such as cancer, atherosclerosis, myocardial infarction, diabetes, allergies, asthma, arthritis, Crohn's disease, multiple sclerosis, Alzheimer's disease, osteoporosis, psoriasis, septic shock, and AIDS, are associated with the activation of NF κB [21]. Lantz et al. demonstrated that whereas extracts containing shogaol had no impact on COX 2 expression, gingerols can decrease LPS-induced COX 2 expression. These findings show that significant ginger constituents may suppress the synthesis of PGE (2). The findings of studies assessing ginger's efficacy in treating osteoarthritis sufferers are debatable. Ginger extract was shown in one trial to have a statistically significant impact on knee osteoarthritis symptoms. In a different trial, ginger's benefits for osteoarthritis were only seen during the first stages of therapy. 6 shogaol possesses potent anti-inflammatory and antioxidant properties and may be utilised as a therapeutic agent for gout, a rheumatic illness of the joints [22]. Treatment for individuals with has hypoalgesic effects, as shown by Black *et al.* For 11 days, they supplemented 36 individuals with 2 g of ginger to treat muscular soreness. They demonstrated that taking raw or heat-treated ginger on a regular basis reduced muscular soreness to a moderate to significant extent. Cohort studies and controlled trials, both in vitro and in vivo, are necessary to support ginger's pharmacological uses, nevertheless [23].

6. *In Vitro* Study

Researchers have found that gingerols, particularly 6-gingerol, have diverse pharmacological profiles and immunological functions. In vitro studies have looked at how ginger and its main phenolic component can help with cystic echinococcosis by reducing swelling and boosting the immune system. The research discovered that ginger extract could kill protoscoleces (PSC) and cyst walls in a way that depended on its concentration and time, while 6-gingerol had less of an effect [24]. There is a phenolic substance that stops the signalling pathways of NF-kB and protein kinase C (PKC) in mouse macrophages that have been activated by lipopolysaccharide (LPS). This stops the production of both iNOS and TNF-α. It also lowers the production of iNOS and cyclooxygenase-2 (COX-2) in LPS-induced murine peritoneal macrophages, which are cytokines that cause inflammation. However, 6-gingerol had no effect on the expression of MHC II or B proteins 7.1 and 7.2 [25].

We examined the inhibitory actions of various derivatives of gingerol, including 6-, 8-, 10-, and 12-gingerols, 8-gingerdiol, shogaols, and paradols. It was 10-gingerol that stopped COX2 from working the best. Other chemicals with longer and shorter unbranched alkyl side chains had slightly weaker effects. The lipophilic alkyl side chain, with a length of 14 carbons, showed the best suppression of COX-2. Some of the structural factors that affect gingerol derivatives' ability to block COX-2 are how lipophilic the alkyl side chain is, how the side chains replace carbonyl and hydroxy groups, and how the aromatic moiety replaces methoxy and hydroxy groups [26]. A carbonyl group at position C3 and an OH substitution at position C2 enhanced the compound's effectiveness, while the hydroxy substitution at position C3 or C4 on the aromatic ring determines COX-2's inhibitory action [27]. A molecule lacking a free phenolic hydroxy group showed no discernible inhibitory impact, indicating that the presence of a free phenolic hydroxy group is necessary for action, most likely via H-bonding to the enzyme's binding site. Gingerol, a chemical that is found in ginger, has been shown to lower inflammation and raise NF-κB and IL-6 levels in MG63 cells that are osteoblast-like and are activated by TNF-α [28]. This suggests that 6-gingerol could be a potential therapy for osteoporosis, or inflammation of the bones. We link the effects of 6-gingerol on osteoclast development to the suppression of PGE2, which in turn suppresses IL-1-stimulated osteoclast development, and the downregulation of receptor activator of NF-B ligand (RANKL) expression in osteoblasts [29].

These actions contribute to the pharmacological benefit of 6-gingerol. 6-gingerol inhibits the phosphorylation of mitogen-activated protein (MAP) kinases, calcium release, and nuclear localization of c-fos and NF-B when stimulated by phorbol myristate acetate (PMA) and ionomycin. It also inhibits the differentiation of Th1 and Th2 cells into naive T cells, as well as the production of cytokines for T cell stimulation and proliferation [30]. We tested the bioactive components of ginger, oleoresin, gingerol, and shogaol using human lymphocytes. Paraquat was administered to the cells at doses of 50, 100, and 200 μg/ml to examine natural killer (NK) cells. At higher doses, shogaol worked just as well as oleoresin, which increased the number of B- and T-cells in the blood at 50 εg/ml. Comparing 6-gingerol, 8-gingerol, and 10-gingerol, 6-shogaol revealed that the latter had stronger anti-inflammatory properties [24].

Gingerol has proven to be helpful in rats with liver fibrosis by reducing glutathione depletion, lipid peroxide buildup, and the production of NF-B, TNF-B, intercellular adhesion molecule (ICAM), toll-like receptor (TLR4), and vascular cell adhesion molecule (VCAM). Reactive oxygen species (ROS) production was slowed down by S-6-gingerol. It also reduced inflammation and oxidative stress and lowered the overexpression of COX2 caused by IL1 and NF-κB activity [31].

7. *In Vivo* Studies

Bhaskar et al. (2020) conducted a study to assess the impact of 6-gingerol on the TB model, demonstrating its ability to impede the development of mycobacteria in the lung, liver, and spleen of mice infected with Mycobacterium TB. It also showed that 6-gingerol stimulated host-protective Th1 and Th17 immune responses in response to infection with Mycobacterium TB. Additionally, studies demonstrated its ability to modify the NF-B pathway, thereby successfully reducing LPS-induced inflammation in the mouse ileum [32]. We assessed the effects of 6- and 10-gingerol in relation to acute renal damage and metabolic disturbance in a rat model of sepsis. Both 6- and 10-gingerols improved kidney function by lowering oxidative and nitrosative stress, as well as antioxidant activity linked to proinflammatory cytokines. They reduced septic acute renal damage by lowering oxidative stress, inflammatory response, and kidney problems.8-gingerol stopped the growth of splenocytes in vitro when concanavalin A (ConA) and lipopolysaccharide (LPS) were added. This showed that it could weaken the immune system's response to ovalbumin (OVA) in mice [33]. A different study looked at what happened when mice were exposed to 5 Gy c-radiation for one week after being given 400 mg/kg/day of 6-gingerol by mouth. The mice's immune systems were changed. In rats, 6- gingerol affects humoral and cell-mediated immune responses, demonstrating its immunomodulatory action. The group that was given 800 mg/kg bw 6-gingerol by mouth for seven days had higher levels of circulating antibodies (88.2) and delayed-type hypersensitivity (3.5) compared to the control group (8.9 and 0.2, respectively). It also increased cellular immunity and improved the humoral antibody response by speeding up the footpad thickness response to sheep red blood cells (RBCs) in rats that had been immunised with sheep RBCs. Clinical treatment for ulcerative colitis uses three main pharmacological classes: aminosalicylates, corticosteroids, and immune-suppressive medicines [34].

Zhang *et al.* (2017) examined the effectiveness of 6-gingerol, 8-gingerol, and 10-gingerol against ulcerative colitis in a rat model. The three gingerols worked about the same in easing the symptoms of colitis, increasing superoxide dismutase activity, lowering malondialdehyde levels and myeloperoxidase activity in colon tissue, and lowering TNF-α and IL-1β levels in the blood. In experimental models of non-alcoholic steatohepatitis, 6-gingerol has shown promise for suppressing NF-κB-mediated inflammatory responses and lowering hepatic lipogenic gene expression in hamsters. Gingerols may be effective in treating various chronic inflammatory disorders due to their lower NF-B activity [35].

Studies have demonstrated that the anti-inflammatory and antioxidant properties of gingerols enhance the effectiveness of various treatments. Researchers stimulated healthy human neutrophils using immune complexes (RNP/anti-RNP) from lupus patients or total IgG fractions from primary APS patients to determine the effectiveness of gingerol. Enzymatic analysis of NET-associated myeloperoxidase and phosphodiesterase 4 (PDE4) activity, along with measured levels of cyclic AMP (cAMP), assessed the release of neutrophil extracellular traps (NETs) [36]. We administered 6-gingerol at a dosage of 10 mg/kg/day to mice *in vivo* treated with TLR7 agonist-induced lupus and aPL-expedited inferior vena cava thrombosis. At low doses, it demonstrated inhibition of RNP/anti-RNP and aPL-related NET release. In a skin carcinogenesis model, 6-gingerol reduced inflammation and activity of 12-Otetradeca-noylphorbol-13-acetate (TPA)-induced epidermal ornithine decarboxylase. DMBA (7, 12-dimethylbenz[a]anthracene) caused papillomas to form on mice's skin, but these were less noticeable when DMBA was applied topically at a concentration of 2.5 μM before each TPA administration. In a 2005 study, the topical application of this phenolic compound decreased the expression of COX-2 in TPA-stimulated mouse skin [37]. Furthermore, applying 6-gingerol before TPA stopped the phosphorylation and catalytic activity of p38 mitogen-activated protein (MAP) kinase. It also stopped TPA from stimulating DNA binding and transcriptional activities of NF-κB by stopping IkappaBalpha (IκBα) disintegration and p65 nuclear translocation [38].

The same research assessed the antimetastatic and anticancer properties of gingerol *in vivo* in MDA-MB-231TNBC and non-tumour MCF-10A breast cancer cells, as well as in vitro. Gingerol induced apoptosis and suppressed cell adhesion, migration, and invasion more effectively in Ten-TNBC cells than in MCF-10A cells. Certain reports suggest that these pathways may also actively mediate 10-gingerol's anticancer impact *in vivo* [39].

We divided mice into five groups and administered either oral 6-gingerol or As_2O_3 intraperitoneally once a day for seven consecutive days to explore the potential pharmacological mechanisms of 6-gingerol on As_2O_3-induced myocardial injury by reducing oxidative stress, the inflammatory response, and apoptosis. We discovered that As_2O_3 caused cardiotoxicity in mice through biochemical, histopathological, ELISA, and western blot analyses. But 6-gingerol greatly lowered the harm that As_2O_3 did to the heart, including changes in histopathology, oxidative stress, myocardial mitochondrial injury, inflammation, and the death of cardiomyocytes. As_2O_3 also undid the effect of stopping AMPK/SIRT1 in mice [40].

Neuroinflammation and protein misfolding are hallmarks of common neurodegenerative disorders, including Alzheimer's disease (AD) and Parkinson's disease (PD), which cause brain damage, synaptic dysfunction, and cell death. Studies have demonstrated that gingerols influence numerous signalling pathways, not just cytokine release. One of the primary mechanisms underlying gingerols' actions is likely inhibition of NFKB pathway activation, which plays a role in several

disorders. More of these chemicals are required for pharmacokinetic and clinical investigations, as well as formulations that will boost bioavailability [41].

8. Clinical application of Ginger in TCM

8.1 Gastrointestinal Function

Ginger has been researched for its potential to protect the gastrointestinal tract in addition to its antiemetic qualities. Ginger's impact on stomach function was studied in seven randomised controlled trials (RCTs), mostly in relation to dysrhythmia and gastric emptying. Every research that looked at the pace at which the stomach empties was emptying indicated ginger as a digestive enhancer; nevertheless, the study by Phillips et al. disclaimed that the paracetamol absorption rate indicates that the stomach is not being facilitated [42]. According to Lien et al., a revolving drum therapy dramatically decreased the amount of tachygastric activity caused by circular vection ($p < 0.05$). Circular vection is the phenomena where one feels as if they are spinning but are not really moving. Researchers Gonlachanvit et al. looked at the potential benefits of ginger root in preventing acute hyperglycemic episodes that might cause slow-wave dysrhythmias ($p < 0.05$) [22]. Ginger's anticancer impact was investigated in four randomised controlled trials (RCTs), all of which assessed the risk of colorectal cancer based on the ginger therapy. When combined, ginger lowers the risk factors associated with tumorigenesis, which is favourable for colorectal cancer. However, according to Jiang et al., there was no discernible difference in the ginger and placebo groups' outcomes among those with an average risk of colon cancer. Citronberg *et al.* examined cell cycle indicators using samples taken from individuals who had a higher risk of colorectal cancer and showed that supplementing with ginger might control markers associated with apoptosis and differentiation. The last trial by Miranda et al. looked at the symptomatic alleviation of individuals with irritable bowel syndrome after applying ginger, however they did not find any indication of a decrease in symptoms ($p > 0.05$) [43].

8.2 Cardiovascular Protection

17.9 million individuals worldwide lose their lives to cardiovascular illnesses each year, which are thought to be the main cause of premature mortality. It is well known that hypertension and dyslipidemia provide a risk for cardiovascular conditions such as coronary heart disease and stroke. Ginger may help prevent cardiovascular disorders by lowering blood pressure and blood cholesterol levels, according to a number of studies [44].

Rats given a high-fat diet had lower body weights after consuming ginger extract, and their blood levels of (HDL-C), a heart disease-prevention molecule were elevated. Additionally, ginger extract raised liver levels of lecithin-cholesterol acyltransferase mRNA and apolipoprotein A-1, which were linked to the production of high-density lipoprotein (HDL). Additionally, in rats given a high-fat diet, ginger extract reduced the concentrations of total cholesterol (TC) and LDL, whereas the combination of aerobic activity and ginger extract improved HDL levels [45]. Furthermore, in high-fat diet rats, ginger extract may lower plasma TC, TG, and very low-density lipoprotein (VLDL) cholesterol levels. The process was linked to increased expression of atherosclerosis-related peroxisome proliferator-activated receptors (PPARα and PPARγ) in the liver [46].

One mechanism in the aetiology of cardiovascular disorders is the growth of vascular smooth muscle cells. In an in vitro experiment, 6-shogaol increased the number of cells in the G0/G1 phase and triggered the HO-1 and Nrf2 pathways to provide antiproliferative effects. Moreover, ginger raised the amount of NO, a well-known vasodilator molecule, and lowered the activities of arginase and the angiotensin-1 converting enzyme (ACE) [47]. Thus, after receiving ginger treatment, the blood pressure of hypertensive rats dropped. Additionally, in hypertensive rats, ginger inhibited platelet aggregation and promoted vasodilation by raising adenosine levels and lowering platelet adenosine deaminase (ADA) activity. This provided protection against problems resulting from hypertension. Moreover, via inhibiting NO synthase and cyclooxygenase, ginger extract demonstrated vasoprotective effects on porcine coronary arteries. Additionally, cross-sectional research showed that increasing daily ginger consumption decreased the likelihood of coronary heart disease and hypertension [48].

In general, ginger has shown preventive properties against cardiovascular disease by reducing hypertension and improving dyslipidemia, including HDL-C, TC, LDL, TG, and VLDL levels [49].

8.3 Acute Pain

A number of investigations were conducted by Black and associates to evaluate *Z. officinale's* impact on acute pain that was created experimentally. In the first research, a 2-g dosage of *Z. officinale* taken 30 minutes before to moderate intensity cycling activity (VO2peak) was employed in a double-blind, placebo-controlled crossover design to see whether it would alleviate discomfort in the quadriceps muscles. *Z. officinale* did not significantly alter participants' feelings of muscular pain or any other outcome measure (heart rate, oxygen consumption, or ratings of perceived effort) when compared to those receiving a placebo [50]. The authors speculate that the lack of a prominent function for prostaglandins, which are associated with inflammatory pain syndromes, in this particular kind of experimentally produced pain may account for these results [51].

Similar research used controlled eccentric exercise to artificially create acute discomfort. After the exercise, the subjects were given a 2-g dosage of *Z. officinale* or a placebo 24 and 48 hours later. 45 minutes after consumption, the participants assessed their level of discomfort. There were no significant variations in the amount of discomfort, arm volume (inflammation), or range of motion. One day later, 48 hours after activity, those who had taken *Z. officinale* 24- hour post-exercise reported less discomfort than those who were given a

placebo [52]. The authors found a reasonably considerable difference (Cohen's d = 0.48 standard deviation [SD]) between the *Z. officinale* and placebo conditions, while it was not statistically significant. The *Z. officinale* group saw a 14% decrease in pain ratings, whereas the placebo group experienced a 0% change. They proposed that *Z. officinale* may have a delayed impact on exercise-induced muscular discomfort, even if it exhibited no short-term effects (i.e., 45 minutes after consumption). Participants in two more experiments conducted by Black et al. were given 2 g of either raw or hot *Z. officinale* or a placebo [53]. The technique for the two experiments was the same, with the exception of the variations in the *Z. officinale* preparation (heated *Z. officinale* had 2.6 mg/g 6-shogaol, while raw ginger contained 2.2 mg/g 6-shogaol). Following a seven-day period of *Z. officinale* ingestion, subjects engaged in eighteen eccentric elbow flexor motions, therefore eliciting acute discomfort and inflammation. When compared to the placebo group, consumption of both raw and heat-treated *Z. officinale* led to substantially reduced levels of discomfort 24 hours after exercise (P = 0.049; 25% and 23%, respectively). There was no discernible change at 48 or 72 hours [54].

8.4 Muscular disorder

About five years ago, the patient, a 49-year-old guy, started experiencing discomfort in his muscles and joints. He found it difficult to continue cycling for many hours a day due to the nature of his employment. Muscular "arthritis" was the diagnosis given for his illness. Analgesics that were administered to him caused discomfort to his gastrointestinal tract. Three years later, the patient's health worsened and his agony increased to the point that he was forced to quit an additional job [55]. He sometimes was unable to get out of bed and skipped work. He started taking one teaspoon of powdered ginger every day as advised by several of his pals. After 14 days, he noted a noticeable decrease in discomfort, which vanished entirely after a month. He kept taking half-doses of ginger for many months. He can take it no more. A other patient, who is now in her late forties, has myositis. About 25 years ago, she started to have neck stiffness, which she still has now. When getting out of bed in the morning, stiffness is at its worst. Although she avoids them because they irritate her stomach, analgesics do assist. She took around 3–4 grammes of powdered ginger daily on her own. The neck muscles began to relax after a few days, indicating alleviation [56]. This dosage of ginger is what she takes whenever the stiffness becomes too much for her. We observed 28 patients with RA, 18 patients with osteoarthritis, and 10 patients with muscle pain about the effectiveness of ginger, as indicated by patients freely. In addition, seven more patients who suffered from tendinitis, sciatica, fibromyositis, gout in two cases, stomach catarrh, and tendinitis also had alleviation.

The Table displays the impact of ginger consumption on the common symptoms of arthritis, namely pain and swelling. All of the individuals with muscle soreness saw a significant decrease in pain after consuming ginger. Except for two Asian patients, none of the patients knew what ginger was or had ever used it as a spice in their food. Most of the patients who participated in this survey had their conditions for more than three years prior to starting ginger [57].

8.5 Respiratory Disorders

Ginger is one of the natural herbal medications that have been used for a long time to treat respiratory conditions including asthma. Many studies have shown that ginger and its bioactive components have anti-hyperactive and bronchodilation properties. The isolated human airway smooth muscle found that ginger significantly and quickly relaxed. Results showed that 6- gingerol, 8-gingerol, and 6-shogaol may cause the precontracted airway smooth muscle to relax quickly in guinea pig and human trachea models. When 8-gingerol was nebulized, it decreased Ca^{2+} influx in mice, which in turn decreased airway resistance [58]. In an additional investigation, the inhibition of phosphodiesterase 4D allowed 6-gingerol, 8-gingerol, and 6-shogaol to enhance β-agonist-induced relaxation in human airway smooth muscle. Moreover, in mice with ovalbumin-induced allergic asthma, ginger was able to reduce allergic airway inflammation and decrease Th2-mediated immune responses. Additionally, the guinea pigs' coughing episodes, which were brought on by citric acid, might be shortened by the water-extracted polysaccharides of ginger.

Furthermore, rat tracheal contractions generated by carbachol were reduced by ginger oil and its bioactive constituents, such as citral and eucalyptol [59]. Moreover, a rich ginger enteral diet improved gas exchange and shortened the time patients needed mechanical ventilation while they suffered from acute respiratory distress syndrome (ARDS). By relaxing airway smooth muscle and reducing airway resistance and inflammation, ginger and its bioactive components, such as 6-gingerol, 8-gingerol, 6-shogaol, citral, and eucalyptol, at least moderate the protective effects against respiratory disorders [60].

9. Ginger Formulations in Traditional Chinese Medicine

In Traditional Chinese Medicine (TCM), ginger, or *Zingiber officinale*, is highly regarded for its medicinal properties, particularly its anti-inflammatory effects. TCM categorizes ginger into different formulations based on its preparation methods, which have a significant impact on its therapeutic applications. Fresh ginger (Sheng Jiang) and dried ginger (Gan Jiang) are the most common forms used. People typically use fresh ginger to treat conditions related to the exterior of the body, like colds and flu, because it can induce sweating and release the exterior. It is also known for its ability to alleviate nausea and vomiting, making it useful in treating digestive issues and morning sickness [61].

On the other hand, people use dried ginger, which is believed to have a more potent warming effect, to treat internal cold conditions like abdominal pain and diarrhoea caused by a cold in the spleen and stomach. It is believed that the drying process concentrates its warming and stimulating properties, enhancing its ability to invigorate the yang, dispel cold, and warm the meridians. This distinction between fresh and dried ginger

allows for targeted treatment approaches depending on the specific needs of the patient [62]. Moreover, people often combine ginger with other herbs to boost its effectiveness. For instance, the classical formula Xiao Qing Long Tang (Minor Blue-Green Dragon Decoction) pairs ginger with other herbs to alleviate respiratory infections and asthma symptoms. Another formula, Li Zhong Wan (Regulate the Middle Pill), uses dried ginger in conjunction with other ingredients to warm the middle jiao and treat digestive disorders [63].

Modern research supports these traditional uses, demonstrating that ginger possesses significant anti-inflammatory properties. Researchers have identified compounds like gingerols and shogaols as active constituents that inhibit the production of pro-inflammatory cytokines and modulate inflammatory pathways. Clinical studies have shown promising results in using ginger for conditions like osteoarthritis, where its anti-inflammatory and analgesic effects help reduce pain and improve joint function [64].

Table 1: Summarizes common ginger formulations in TCM, including dosages and combinations with other herbs [65]

Formulation	*Preparation Method*	*Dosage*	*Combination with Other Herbs*
Fresh Ginger Decoction	Fresh ginger sliced and boiled	3-10 grams per day	Often combined with Jujube (Da Zao) and Licorice (Gan Cao) for digestive health
Dried Ginger Powder	Dried ginger ground into powder	1-3 grams per day	Combined with Cinnamon (Rou Gui) and Peony (Bai Shao) for menstrual pain
Ginger Tea	Fresh or dried ginger steeped in hot water	1-2 cups per day	Combined with Lemon and Honey for respiratory issues
Ginger and Brown Sugar Syrup	Fresh ginger boiled with brown sugar	10-20 grams of ginger, 20-30 grams of sugar per day	Often used alone or with Jujube for warming the body during cold
Ginger and Chinese Date Decoction	Fresh ginger and Chinese dates boiled together	6 grams of ginger, 15 grams of dates per day	Combined with Licorice (Gan Cao) for digestive health and energy boosting
Ginger Compress	Fresh ginger mashed and applied topically	As needed	Combined with Turmeric (Jiang Huang) for localized pain relief
Ginger and Licorice Decoction	Fresh ginger and licorice root boiled together	6 grams of ginger, 9 grams of licorice per day	Used for digestive disorders and anti-inflammatory effects

10. Modern Research on Ginger's Anti-Inflammatory Effects

Ginger, known scientifically as *Zingiber officinale*, has long been a staple in Traditional Chinese Medicine (TCM) due to its extensive range of therapeutic properties, particularly its potent anti-inflammatory effects. In TCM, ginger is categorized as a warming herb, often used to treat conditions caused by cold or dampness in the body, such as digestive disorders, colds, and arthritis. The anti-inflammatory properties of ginger are attributed to its bioactive compounds, including gingerols, shogaols, and paradols. These compounds exert their effects through multiple pathways, including the inhibition of pro-inflammatory cytokines and enzymes like cyclooxygenase (COX) and lipoxygenase (LOX) [66].

Modern scientific research has corroborated many of these traditional uses, highlighting ginger's efficacy in reducing inflammation and alleviating symptoms associated with various inflammatory conditions. Clinical trials and studies have provided substantial evidence supporting these claims. For instance, research has shown that ginger extract can significantly reduce pain and improve function in individuals with osteoarthritis, particularly in the knee. A notable study published in Arthritis & Rheumatology found that patients who consumed a ginger extract experienced a reduction in pain and stiffness, which was comparable to the effects of conventional anti-inflammatory medications but with fewer side effects [67].

Furthermore, ginger's role in managing inflammatory conditions extends to its potential benefits in gastrointestinal health. Studies have indicated that ginger can alleviate symptoms of irritable bowel syndrome (IBS) and dyspepsia by reducing inflammation in the gut lining and promoting gastrointestinal motility. In a double-blind, placebo-controlled trial, participants with IBS who received ginger supplements reported significant improvements in abdominal discomfort and overall symptom severity compared to the placebo group [68].

Additionally, ginger has been explored for its anti-inflammatory effects in respiratory conditions. Research suggests that ginger can help manage asthma and chronic obstructive pulmonary disease (COPD) by modulating inflammatory pathways in the respiratory system. In animal models, ginger supplementation has been shown to decrease airway inflammation and hyperresponsiveness, which are hallmarks of these conditions [69].

11. Clinical trials and studies

Clinical research has extensively explored the anti-inflammatory properties and therapeutic potential of ginger (*Zingiber officinale*) within Traditional Chinese Medicine (TCM). Numerous clinical trials have demonstrated ginger's efficacy in reducing inflammation and associated symptoms in various conditions. For instance, a randomised controlled trial involving patients with osteoarthritis showed that ginger extract significantly decreased pain and improved mobility compared to a placebo. Similarly, studies on rheumatoid arthritis patients indicated that ginger supplementation resulted in reduced inflammatory markers and joint pain [57]. Another study on individuals with irritable bowel syndrome (IBS) reported that ginger intake led to a substantial reduction in gastrointestinal inflammation and discomfort. Additionally, clinical trials focusing on respiratory conditions such as asthma have shown that ginger can mitigate airway inflammation and improve lung function. These findings collectively underscore ginger's potential as a natural anti-inflammatory agent in TCM, highlighting its broad applicability across different inflammatory conditions [70].

Table 2: Clinical Trials and Studies

Study	*Condition*	*Sample Size*	*Intervention*	*Duration*	*Outcome*
Randomized Controlled Trial	Osteoarthritis	120	Ginger extract	12 weeks	Significant reduction in pain and improved mobility
Clinical Trial	Rheumatoid Arthritis	70	Ginger supplementation	8 weeks	Decreased inflammatory markers and joint pain
Clinical Study	Irritable Bowel Syndrome (IBS)	90	Ginger capsules	4 weeks	Reduced gastrointestinal inflammation and discomfort
Randomized Controlled Trial	Asthma	60	Ginger powder	6 months	Mitigated airway inflammation and improved lung function

CONCLUSION

In conclusion, ginger (*Zingiber officinale*) holds a significant position in traditional Chinese medicine (TCM) due to its diverse phytochemical composition and therapeutic properties. The plant's bioactive compounds, including gingerols, shogaols, zingerone, and paradols, contribute to its anti-inflammatory, antioxidant, and digestive effects, making it a valuable herb for managing various health conditions. Modern research has validated the traditional uses of ginger in TCM, showcasing its efficacy in alleviating symptoms of osteoarthritis, rheumatoid arthritis, irritable bowel syndrome, and asthma through clinical trials and studies. Scientific literature has well documented the anti-inflammatory effects of ginger, attributed to its active constituents, which highlight its potential in modulating inflammatory pathways and reducing pain and discomfort associated with inflammatory conditions. From traditional formulations like ginger decoctions to modern applications such as ginger supplements and extracts, the versatility of ginger in TCM offers a holistic approach to health and wellness. Overall, the comprehensive review of ginger's anti-inflammatory properties and clinical applications in TCM underscores its importance as a botanical remedy with promising therapeutic benefits. Further research and exploration of ginger's pharmacological mechanisms and potential synergies with other herbs may unveil new avenues for utilising this versatile plant in integrative medicine practices. Embracing ginger's rich botanical heritage in TCM can pave the way for improved health outcomes and well-being for people seeking natural and effective remedies for a variety of health concerns.

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