Biointerface Research in Applied Chemistry
Open-Access Journal (ISSN: 2069-5837)

Review
Volume 14, Issue 1, 2023, 5
https://doi.org/10.33263/BRIAC141.005

The Phytochemistry, Ethnobotany, and Cardioprotective Potential of the Medicinal Plants *Zingiber officinale* Roscoe Var Rubrum, *Curcuma domestica* Val. and *Allium sativum*

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Scopus Author ID 57203138845
Received: 7.12.2022; Accepted: 9.02.2023; Published: 2.02.2024

Abstract: *Zingiber officinale* Roscoe var rubrum (red ginger), *Curcuma domestica* Val. (turmeric) and *Allium sativum* L. (garlic) is traditionally used to treat various cardiovascular protective conditions. This study reviewed the phytochemistry, ethnobotany, and cardioprotective potential of the three plants. A literature search of relevant papers (2000-2022) was performed using Google Scholar and PubMed databases. For this review, only publications written in English were utilized. The review found that red ginger, turmeric, and garlic contain chemicals that have the potency to treat various cardiovascular conditions. The three plants demonstrated anti-inflammatory, antioxidant, antihypertensive, antiplatelet, anti-myocardial, and antihyperlipidemic properties; hence they can be referred to as cardioprotective.

Keywords: red ginger; turmeric; garlic; cardioprotective; traditional use

1. Introduction

The abrupt ischemia death of cardiac tissue is known as a myocardial infarction. Myocardial infarction is often brought on in a clinical setting by a thrombotic blockage of a coronary artery brought on by the rupture of a vulnerable plaque [1]. An infarction may occur for several reasons. Cardiovascular illnesses, including hypertension, hyperlipidemia, atherosclerosis, and oxidative stress, are additional variables that speed up the incidence of infarction in addition to inflammatory conditions in the heart organ. Therefore, it is not unexpected that the number of patients is extremely significant [2]. Several risk factors and the pathophysiology of myocardial infarction are presented in Figure 1. In affluent nations, acute myocardial infarction is one of the main causes of mortality. Over one million people die in the United States annually from this disease, affecting nearly three million globally [3]. To treat infarction, a variety of pharmaceuticals, both synthetic and natural, can be utilized. Red ginger, turmeric, and garlic are natural medications that can be employed [4-6].

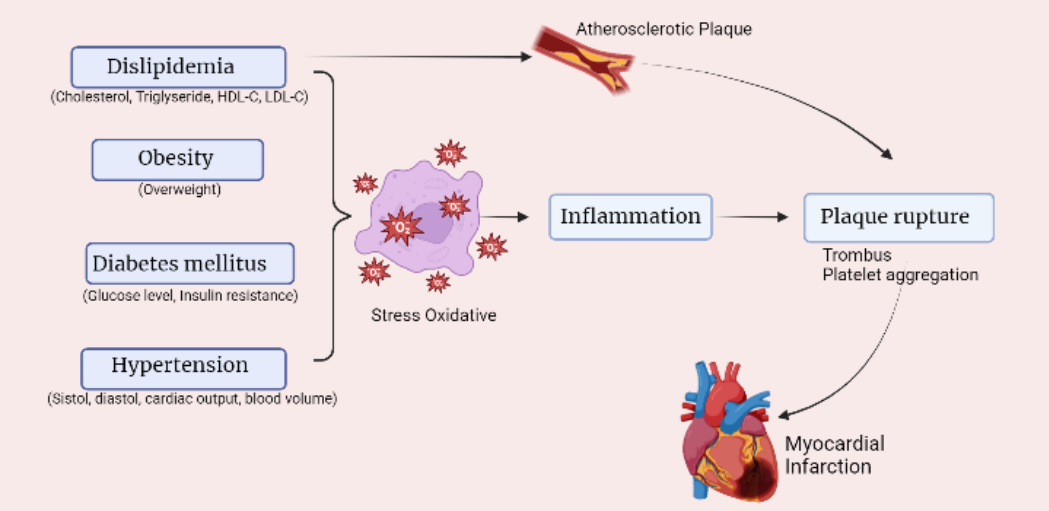


Figure 1. Risk factor and pathophysiology of myocardial infarction.

For a long time, red ginger (*Zingiber officinale* Roscoe var rubrum), a member of the Zingiberaceae family and the Zingiber genus, has been widely used as a spice and herbal medicine [6]. Red ginger has immunomodulatory, anti-inflammatory, anti-tumorigenic, anti-apoptotic, anti-lipidemic, anti-hyperglycemic, antioxidant, and antiemetic properties [7]. Similar to red ginger, turmeric (*Curcuma domestica* Val.) has also been used extensively as a remedy. It is mostly distributed in India, Thailand, China, Malaysia, Indonesia, and Northern Australia. It is naturally found in tropical and subtropical environments [8]. Turmeric is believed to have antioxidant, anti-inflammatory, anti-thrombotic, and anti-apoptotic actions [10-11]. Additionally, systemic antihypertensive, MI prevention, and diabetic cardiomyopathy have all been documented as additional therapeutic outcomes [11]. Another plant that is also widely used by the people of Indonesia is garlic (*Allium sativum* L), family Amaryllidaceae. It is a fragrant annual spice that has been used in traditional medicine for thousands of years [13-14]. Garlic has been shown to lower the risk of diabetes and cardiovascular diseases, protect against infections by boosting immune function, and have antifungal, antimicrobial, anti-aging, and anti-cancer properties, which have been supported by epidemiological data from human clinical studies [14]. Clinical experiments have recently demonstrated the viability of using red ginger, turmeric, and garlic in medicine. This review article will examine issues directly related to the three plants' cardioprotective benefits.

2. Materials and Methods

Articles published between 2000 and 2022 were selected from Pubmed (https://pubmed.ncbi.nlm.nih.gov/) and Google Scholar (https://scholar.google.com/) databases. The articles for review were filtered using keywords "myocardial infarction" OR "red ginger" OR "cardioprotective of *Zingiber officinale* Roscoe" OR "bioactive of red ginger" OR "anti-inflammatory of red ginger" OR "myocardial infarction of red ginger" OR "ethnobotany of red ginger" OR "Turmeric" OR "cardioprotective of *Curcuma domestica* Val." OR "cardioprotective of *Curcuma longa*" OR "bioactive of turmeric" OR "anti-inflammatory of turmeric" OR "myocardial infarction of turmeric" OR "ethnobotany of turmeric" OR "garlic" OR "cardioprotective of *Allium sativum* L." OR "bioactive of garlic" OR "myocardial infarction of garlic" AND "ethnobotany of garlic". The title, abstract, and effect size of the publications found were carefully studied to see if they contained relevant studies on the phytochemistry, ethnobotanical, and cardiovascular activities of red ginger, turmeric, and garlic. For this review,

only English-language publications were used. All publications between 2000-2022 that discussed the pathophysiology of myocardial infarction, phytochemicals, ethnobotany, and cardioprotective effects were selected. In addition, publications that discussed medicinal plants, where red ginger, turmeric, and garlic are discussed in these publications, were also used in this article review.

3. Results and Discussion

The original keywords red ginger, turmeric, and garlic were entered into the PubMed and Google Scholar databases to look for articles published between 2000 and 2022. There were 197 articles about red ginger, 6,713 publications about turmeric, and 6,087 articles about garlic in the PubMed search results. In the meantime, we found 84,700 articles about red ginger, 83,300 articles about turmeric, and 305,000 papers about garlic on Google Scholar. The following search is concentrated on using the PubMed database based on the outcomes found. 13 red ginger articles, 2,466 turmeric articles, and 277 garlic articles were found after the articles that were received were screened using the keywords "anti-inflammatory of" "myocardial infarction of" or "cardioprotective of" Then, every article was reviewed again. The 63 publications used in this review were chosen based on the titles and abstracts of journals that examine plant composition, plant consumption, the pathophysiology of myocardial infarction, and the cardioprotective benefits of the three plants.

3.1. Ethnobotanical uses of Zingiber officinale Roscoe var rubrum, Curcuma domestica Val. and Allium sativum L.

In Indonesia, medicinal plants and herbs used for the treatment of health problems are known as Jamu [15]. Indonesia has more than 1300 species of medicinal plants [15], and three of them are *Zingiber officinale* Roscoe var rubrum, *Curcuma domestica* Val. and *Allium sativum* L. These three plants are utilized by nations throughout the world besides Indonesia. In Algeria, red ginger (*Zingiber officinale* Roscoe var rubrum) is used to treat gastrointestinal system diseases, cancer, respiratory tract diseases, and sexual-reproductive problems [16]. Red ginger decoctions are often utilized in the Siddha, Unani, and Ayurvedic medical systems in India [17]. These concoctions can be used for a broad range of purposes, such as stimulants, contraceptives, aphrodisiacs, abortion, hypoglycemia and hypolipidemic agents, tonics, carminatives, and stomach pain relievers [17]. In addition to treating the flu, arthritis, pneumonia, infertility, helminth infections, toothache, tuberculosis, afternoon throat, diarrhea, headaches, wound infections, and malaria, fresh ginger is also used to treat vomiting, coughing, asthma, and bronchitis [17]. For more than 2000 years, ginger has been utilized in Chinese medicine to heal illnesses. This rhizome has antioxidant, anti-inflammatory, and anti-apoptotic properties [18]. Its rhizome is a frequently used component in folk medicine (jamu) in Malaysia for treating stomach discomfort, and tumors, easing rheumatic aches, and as a postpartum remedy [19].

Besides red ginger, turmeric also has many benefits. The ethnobotanical uses of *Curcuma domestica* Val are quite diverse, and it is frequently used as a condiment, food preservative, and coloring agent [20]. It is also a well-known ethnomedicinal herb that is employed in several traditional cultures throughout the globe, particularly in Asian nations. The rhizome of *Curcuma domestica* Val is ground into a powder in traditional Pakistani medicine and used to treat wounds and pimples [21]. In Bhutan, the rhizome of *Curcuma*

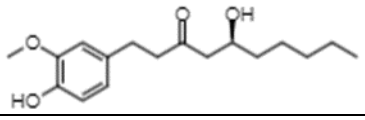
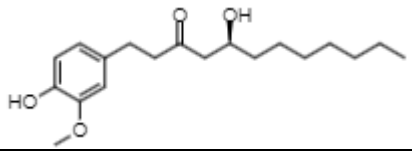
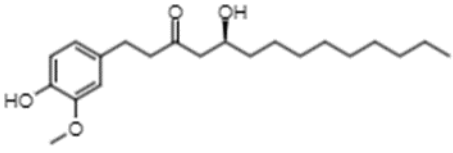
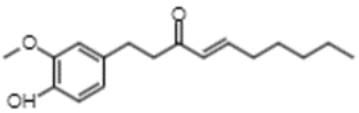
domestica Val is referred to as yung-ba, and traditional healers there advise it as a tonic, antidote, anti-inflammatory, antiseptic, and an excellent preservative [22]. In Colombia, it has long been used as a liver cleaner, circulatory stimulant, wound healer, thrombosis treatment, immune system booster, indigestion, high cholesterol, diabetes, obesity, kidney infection, and arthritis, as well as a condiment [23]. In addition, based on the results of research conducted, *Curcuma domestica* Val is also used to treat cardiovascular disorders, including myocardial infarction conditions [11,24]. Another ingredient that is also used as a medicine is garlic bulbs.

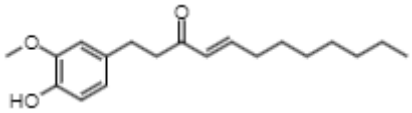
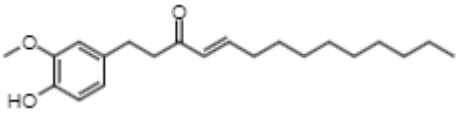
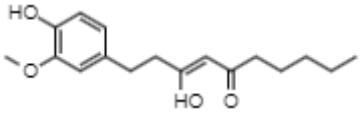
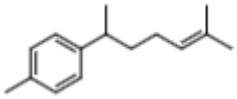
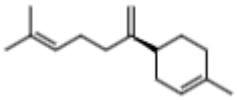
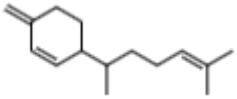
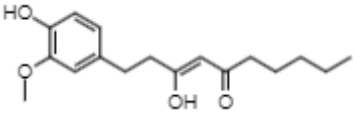
In China, garlic has a long history of use as a traditional medicine and is widely consumed there [25]. The amazing biological effects of garlic, including its anti-inflammatory, antibacterial, anti-diabetic, anti-cancer, and cardiovascular protective qualities, have been extensively studied in recent decades [27-28]. Garlic is utilized in Yoruba culture as a potent remedy for all poisons and dispelling spells. Garlic is a common ingredient in remedies for various viral and bacterial diseases in Northern Nigeria, including colds, coughs, toothaches, ringworm, candida, dysentery, typhoid, and malaria. Garlic also can assist in improving the amount of insulin that is accessible in the bloodstream, decrease cholesterol, and regulate blood pressure in addition to decreasing blood sugar and keeping it steady [28].

3.2. Phytochemistry/bioactive compounds of Zingiber officinale Roscoe var. rubrum, Curcuma domestica Val. and Allium sativum L.

Zingiber officinale Roscoe var. rubrum or red ginger has a lot of active ingredients, such as phenolic and terpene chemicals [29]. Mostly gingerols, shogaols, and paradols make up ginger's phenolic components. The primary polyphenols in fresh red ginger are gingerols, including 6-, 8-, and 10-gingerol [31-32]. Gingerols can be changed into matching shogaols by heat treatment or extended storage. Shogaols can become paradols after being hydrogenated [30]. Other phenolic components contained in red ginger are quercetin, zingerone, gingerenone-A, and 6-dehydrogingerdione. The terpenes in red ginger include α-farnesene, α-curcumene, β-bisabolene, β-sesquiphellandrene, and zingiberene. Red ginger additionally contains lipids, polysaccharides, organic acids, and raw fibers in addition to these [29]. The main chemical structure of red ginger content is presented in Table 1.

Table 1. Chemical structure of red ginger content*.

Structure	Name
	6-Gingerol[31-32]
	8-Gingerol[31-32]
	10-Gingerol[31-32]
	6-Shogaol[31]

Structure	Name
	8-Shogaol[31]
	10-Shogaol[31]
	6-Gingerdione[30]
	ar-Curcumene[30]
	β-Bisabolene[30]
	β-sesquiphellandrene[30]
	(-)-Zingiberene[30]

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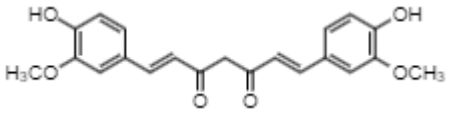
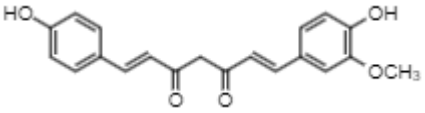
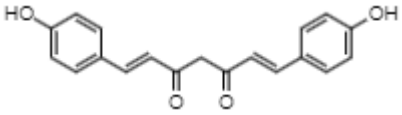
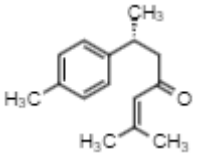
Thin-layer chromatography (TLC), high-performance thin-layer chromatography (HPTLC), and column have all been used in a number of investigations to separate gingerols [32]. HPTLC and HPLC were used to characterize *Zingiber officinale* Roscoe var rubrum cultivars. The ginger cultivars' HPTLC fingerprints revealed chemical homogeneity with minor qualitative variations in the intensities of the gingerol and shogaol zones [32]. The overall pungency of these chemicals varied significantly among the cultivars, as determined by high-performance liquid chromatography (HPLC)[32]. The quantitative measurement of 6-Gingerol in red ginger by the RP-HPLC technique was carried out in recent research by Ashraf and his colleagues. He reported extremely excellent 6-Gingerol separation in isocratic mode on mobile phase acetonitrile and water [33]. The response surface approach was used by Ghasemzadeh et al. in an experiment to optimize the reflux extraction conditions for obtaining high 6-Gingerol and 6-Shogaol contents as well as strong antioxidant activity [34].

Besides red ginger, another rhizome that has been studied chemically is *Curcuma domestica* Val. or turmeric. At least 235 different compounds, mostly phenolic and terpenoids, have been discovered so far [35]. These include diarylheptanoids, diarylpentanoids, monoterpenes, diterpenes, sesquiterpenes, triterpenoids, sterols, and alkaloids [35]. Curcuminoids are diarylheptanoids (also known as diphenylheptanoids) with an aryl-C7-aryl structure. Most of these polyphenols, curcumin, are typically found in 3–15 percent of turmeric rhizomes. Apart from curcumin, turmeric also contains demethoxycurcumin,

bisdemethoxycurcumin, and ar-turmerone [36]. The chemical structure of turmeric contents is presented in Table 2.

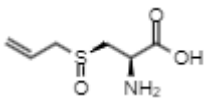
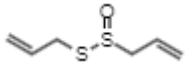
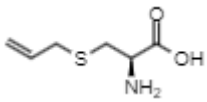
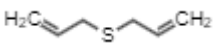
Table 2. Chemical structure of turmeric contents.

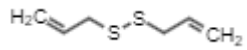
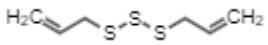
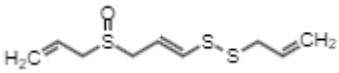
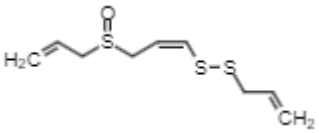
Structure	Name
	Curcumin[36]
	Demethoxycurcumin[36]
	Bisdemethoxycurcumin[36]
	ar-Turmerone[36]

*Note : personal documentation,
created by: https://chemdrawdirect.perkinelmer.cloud/js/sample/index.html#

In addition to red ginger and turmeric, garlic bulbs have many chemical components. Garlic contains a range of bioactive substances, such as polysaccharides, saponins, phenolic compounds, and organosulfur compounds [40]. Garlic's organosulfur compounds include E/Z-ajoene, S-allyl-cysteine sulfoxide, S-allyl-cysteine (SAC), alliin, diallyl thiosulfonate (allicin), diallyl disulfide (DADS), diallyl sulfide (DAS), diallyl sulfide (DAS) and diallyl trisulfide (DATS) [41-43]. Garlic also contains saponins [38], and more than 20 phenolic compounds were found in garlic determined by the off-line SFE-SFC-MS/MS method. According to the findings, garlic contains the following phenolic compounds such as ferulic acid, p-coumaric acid, apigenin, naringenin, protocatechuic acid, isorhamnetin, phthalic acid, luteolin, and quercetin [42]. According to reports, garlic's polysaccharide component contains 85% fructose, 14% glucose, and 1% galactose [43]. The chemical structure of the main garlic content is presented in Table 3.

Table 3. Chemical structure of garlic contents [41-42].

Structure	Name
	Alliin
	Allicin
	S-allyl-cysteine
	Diallyl sulfide (DAS)

Structure	Name
	Diallyl disulfide (DADS)
	Diallyl trisulfide (DATS)
	E-ajoene
	Z-ajoene

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3.3. Pharmacological activities of Zingiber officinale Roscoe var. rubrum, Curcuma domestica Val. and Allium sativum L.

Red ginger (*Zingiber officinale* Roscoe var. rubrum), turmeric (*Curcuma domestica* Val), and garlic (*Allium sativum* L.) have been reported as potential cardioprotective. A summary of red ginger, turmeric, and garlic's cardioprotective activities is given in Table 4.

Table 4. Cardioprotective activities of red ginger, turmeric, and garlic

Sample	Dosage	Activity	Methode	Inductor/ Intervention	Result	Ref
6-Gingerol	6 mg/kg BW	Anti-inflammatory	*In vivo*	Thoracotomy, LAD was ligated and then reperfused	Decrease TNF-α, IL-1β and IL-6	[18, 41]
		Cardioprotective	*In vivo*	Thoracotomy, LAD was ligated and then reperfused	PI3K/Akt signaling pathway inhibitor	[18]
	20 mg/kg BB	Antioxidant	*In vivo*	As_2O_3 (5 mg/kg, ip)	• Increase SOD, GSH, and CAT level • Decrease MDA level	[44]
		Anti-inflammatory	*In vivo*	As_2O_3 (5 mg/kg, ip)	• considerably reduced unfavorable alterations such as mitochondrial swelling and mitochondrial • Decrease TNF-α and IL-6 level • Reduce apoptosis	[44]
		Cardioprotective	*In vivo*	As_2O_3 (5 mg/kg, ip)	The AMPK/SIRT1/PGC-1 pathway may be activated by 6G membrane rupture	[44]
8-Gingerol	10 and 20 mg/kg/ day	Antioxidant	*In vivo*	Isoproterenol (ISO) (85 mg/kg, sc)	• Increase SOD, GSH, and CAT level • Decrease MDA level	[45]
		Antimyocardial infarction	*In vivo*	Isoproterenol (ISO) (85 mg/kg, sc)	• Decrease heart rate and Ca level • Decrease protein expression of Bax and Caspase-3 and the ratio of Bax/Bcl-2 • Increase Bcl-2 expression • Decrease protein expression of p38, JNK, and ERK1/2	[45]

Sample	Dosage	Activity	Methode	Inductor/ Intervention	Result	Ref
					(onMAPK signaling pathway) • 8G inhibited I_{Ca-L}, cell contraction, and Ca^{2+} transients in isolated rat myocytes.	
Zingiberene	10 mg/ kg BW	Antimyocardial infarction	*In vivo*	Isoproterenol (ISO) (85 mg/kg, sc)	Decrease CK-MB, CK, cTn I, and cTn T level	[46]
		Antioxidant	*In vivo*	Isoproterenol (ISO)	• Decrease TBARS level • Increase GSH, SOD, Catalase (CAT), and GPx level	[46]
Red Ginger (*Z. officinale* Roscoe var rubrum Theilade)	Ethanolic fresh ginger extract 100, 200 and 400 mg/kg BW	Antioxidant	*In vivo*	Isoproterenol (ISO) (85 mg/kg, sc)	Increase catalase (CAT), superoxide dismutase (SOD), and glutathione peroxidase (GPx) level	[47]
	-	Antihypertension	*In silico*	ACE reseptor interaction	Bond energy at docking ACE-beta sesquiphellandrene is very low	[48]
	Combina-tion with common ginger	Anti-inflammatory	*In vitro*	Griess reagent PGE_2 enzyme-linked immunosorbent assay	inhibitor of NO production inhibited PGE_2 production	[6]
	Ginger in feed	Cardioprotective	*In vivo*	Isoproterenol (ISO) (20 mg/kg, ip)	Decrease CK-MB, creatine kinase (CK), LDH , ALT and myocardial necrosis	[49]
	Warm compress (200 g)	Antihypertension	Clinical research	Red ginger warm compress placed on the neck and back of the respondents	Decrease blood pressure	[50]
Pungent constituents of ginger ([6]-, [8]-, [9]-, [10]- and [12]-gingerols ; [6]- and [8]-gingerdiol, ; [6]- and [8]-shogaols; paradols)	-	Antiplatelet	*In vitro*	Arachidonic acid	• Inhibit platelet formation with IC_{50} values ranging from 3 to 7 μM • Inhibit COX-1. [8]-paradol exhibited the strongest COX-1 inhibitory activity, with IC_{50} values of 4 ± 1 μM	[51]
Curcumin	50 mg/kg BW	Antimyocardial infarction	*In vivo*	Isoproterenol (ISO) (100 mg/kg, sc)	• Decrease LDH and CK • reduction in the heart organ index	[52]
		Antioxidant	*In vivo*	Isoproterenol (ISO) (100 mg/kg, sc)	Decrease MDA and SOD level	
		Anti-inflammatory	*In vivo*	Isoproterenol (ISO) (100 mg/kg, sc)	Reduce apoptotic cell	
	100 mg/kg/day, po	Antifibrotic and antiinflammatory	*In vivo*	permanent left anterior descending coronary	• Decrease collagen I, collagen III, and TgF-β1 • Increase SIRT1 expression	[11]

Sample	Dosage	Activity	Methode	Inductor/ Intervention	Result	Ref
				artery ligation (in vivo)	• Decrease collagen deposition and degradation of extracellular matrix (ECM)	
		Anti-inflammatory	*In vitro*	Ang II (in vitro)	inhibits the proliferation and migration of cardiac fibroblasts (CFs)	
	100 mg/kg BW	Antidislipidemic and Antioxidant	*In vivo*	Dexamethasone (10 mg/kg bw, sc)	• Decrease total Cholesterol, Triglycerides, and LDL level • Increase HDL • 3-hydroxy-3-methylglutaryl coenzyme A (HMG-CoA) reductase activity is reduced by curcumin. • Decrease atherogenic index • Decrease AST, ALT level • Decrease MDA level	[54-55]
	150 mg/kg/day, intragastric	Cardioprotective	*In vivo*	CME-model group was established by injecting microspheres into the apex of the left ventricle	• Decrease C troponin I and the expression of cleaved caspase-3 • Increase the Bcl-2/Bax ratio • Decrease IL-1β and TNF-α • Inhibited the activation of TLR4/MyD88/NF-κB	[55]
Curcumin nanoparticel (Cur-NPs)	Variation concentration (0-100 µM)	Anti-inflammatory and antimyocardial infarction	*In vitro*	A Palmitate (PA)	• inhibited the apoptosis of cardiomyocytes • inhibited of PERK/eIF2α/ATF4 pathway	[56]
	100, 150, 200 mg/kg BW	Antimyocardial infarction	*In vivo*	Isoproterenol (ISO) (100 mg/kg, sc)	• Increase RR interval • Decrease heart rate • Prevented the elevation of AST, ALT, LDH, and glycemia	[57]
		Antioxidant	*In vivo*	Isoproterenol (ISO) (100 mg/kg, sc)	• Decrease MDA, NOx, TOS (Total oxidative status) level • Increase total antioxidant capacity (TAC)	[57]
Turmeric (*Curcuma domesticae* Val)	Ethanolic extract 100, 300, and 500 mg/kg BW	Cardioprotective	*In vivo*	Doxorubicin (5 mg/kg, ip)	• Decrease CK-MB and LDH level • Reduce bleeding, kariolisis, piknosis and fragmentation of heart cell	[58]
	Ethanolic extract 300, 600, 1200 mg/kg BW	Antidislipidemic	*In vivo*	PTU	• Decrease total Cholesterol, triglycerides and LDL level • Increase HDL level	[59]
	Water extract of turmeric leaf	Antioxidant	*In vitro* (vero cell)	H_2O_2	• Decrease intracellular ROS Generation in Vero Cells • Reduction in the percentage of cells in the sub-G1 phase • Inhibit cell death	[60]
			In vivo (zebrafish)	H_2O_2	• Inhibit lipid peroxidation in zebrafish	[60]
	turmeric, black cumin, and their combination in diet feed	Hypoglycemic and Antidislipidemic	*In vivo*	Streptozotocin 50mg/kg	• Decrease blood glucose levels, insulin level, total cholesterol, triglyceride, and LDL-C level • Increase HDL-C	[61]
Garlic oil	75 mg/kg bW	Antioxidant	*In vivo*	Isoproterenol (ISO) 20 mg/100 g, sc	Decrease lipid peroxidation, and increase SOD, CAT, GPx, GST, and GRD level	[62]

Sample	Dosage	Activity	Methode	Inductor/ Intervention	Result	Ref
	28 mg / kg. BW, combination with L-carnitine 200 mg/kg. BW	Antioxidant and Antidislipidemic	*In vivo*	high cholesterol diets	Reduce serum lipid profile, FFAs, MDA, glucose, insulin, insulin resistance, liver lipid percent, and oxidized glutathione Increase HDL-C level	[63]
Garlic (*Allium sativum)* extract	Aqueous Extract, Methanol Extract, Ethanol Extract (20 and 50 mg/kg BW)	Anti-inflammatory	*In vivo*	1% carrageenan suspension	Increase the percentage of edema inhibition relative	[26]
	Variation concentration	Antioxidant	*In vitro*	Cadmium (Cd)	• The levels of DPPH, ABTS, FRAP, superoxide, and hydroxyl in pickled garlic extracts were considerably higher. • IC_{50} of $CdCl_2$ was 135.8 lmol/L • Both fresh and pickled garlic extracts showed a small amount of cell damage.	[64]
Combination	Garlic, ginger and lemon fresh juice 200 mg/kg bw	Antidislipidemic	*In vivo*	Experimental diet	• Feed intake per day is directly proportional to body weight • Inhibits increase in TC, TG, and LDL-C levels but increases HDL-C levels • Serological markers such as total protein, albumin, AST, ALT, creatinine, urea, and bilirubin should be within normal ranges. • Increase the number of hemoglobin, leucocyte, erythrocytes, neutrophils, monocytes, and lymphocyte	[65]
	Aged Garlic Extract (AGE) and S-allyl-L-cysteine	Cardioprotective	*In vivo*	isoproterenol (ISO)	• Decrease LDH, CK-MB, and TBARS level • Increase SOD, CAT level • The musculature of the cardiac cell → normal • Reduce cardiac necrosis cell	[66]

3.3.1. Anti-inflammatory effects.

According to Tongtong Xu's research, 6-G may be used to treat atherosclerosis by lowering levels of the inflammatory markers TNF-, IL-6, and IL-1 [18,44]. In rats with ISO-induced MI, ZBN pretreatment dramatically decreased the level of inflammatory markers (TNF-a, IL-6, NF-kB, and IL-1b) [46]. Red ginger extract is also known to decrease PEG2 synthesis and lower NO generation [6]. Garlic and turmeric are also recognized for their anti-inflammatory properties. Both of these plants have the ability to stop the death of cells and the development of edema in the mouse foot [26,56].

3.3.2. Antioxidant effects.

Zingiberen (ZBN), one of the ingredients of red ginger, treatment substantially decreased ISO-induced TBARS. ZBN is an antioxidant. When compared to animals in the control group, ZBN was able to lower GSH levels and considerably lower SOD, catalase, and GPx enzyme levels [46]. When compared to the MI-induced group alone, the administration of red ginger extract containing ZBN, 6-gingerol, or 8-gingerol significantly decreased ISO-induced TBARS and LOOH. Red ginger extract pretreatment increased the activity of enzyme antioxidants such SOD, catalase, and GPx, preventing the ISO-induced loss of antioxidants.

Additionally, it has the capacity to raise GSH levels [18,46,67]. The benefits of garlic oil are mediated through the modulation of lipid peroxidation and enhancement of antioxidant and detoxifying enzyme systems. In hearts with isoproterenol-induced myocardial necrosis, the activities of antioxidant enzymes such SOD, CAT, GPX, GST, and GRD were markedly reduced [62]. Curcumin from *Curcuma domestica* Val. also has antioxidant activity. In rats given isoproterenol, it was able to lower the levels of malondialdehyde (MDA), nitrogen oxides (NOx), and TOS (total oxidative status). Curcumin can also raise the value of the body's overall antioxidant capacity (TAC) [57]. The antioxidant activity of turmeric leaves is also well recognized. It has the power to stop cell death, lower the percentage of cells in the sub-G1 phase, and minimize intracellular ROS generation in Vero cells [60]. Garlic also contains antioxidants, along with red ginger and turmeric. In rats exposed to isoproterenol, it can reduce lipid peroxidation and raise levels of SOD, catalase, and glutathione [62,64]. Additionally, the findings demonstrated that administering garlic extract to rats reduced the quantity of MDA in their serum, which was brought on by a high-fat diet [63].

3.3.3. Glucose, cholesterol, and other lipid-lowering effects.

ZBN taken orally reduced the levels of total cholesterol, triglycerides, phospholipids, free fatty acids, VLDL-C, and LDL-C that were caused by ISO to their baseline values [46]. Another study's findings demonstrated that curcumin, which is present in turmeric extract, has antihyperlipidemic properties. Giving turmeric extract lowers triglyceride, LDL, and total cholesterol levels while raising HDL levels [54-55,60]. The same effect was also found in garlic extract. It is able to improve blood lipid profile in animals induced by a high-fat diet [63] [65].

3.3.4. Antiplatelet effect.

Ginger's natural ingredients may act as COX-1 inhibitors and antiplatelet agents. Five phenolic substances, 8-gingerol, 8-paradol, 8-shogaol, and synthetic equivalents 1 and 5, were able to prevent platelet aggregation through various functional group substitution patterns on their alkyl side chains. 8-Paradol, whose action is three to seven times greater than ASA, is the most effective inhibitor [51].

3.3.5. Antihypertensive effect.

Blood pressure can be lowered with ginger extract. The red ginger ethanol extract can be proposed and investigated further by in-vitro and in-vivo technique as a clinical candidate for antihypertensive medications since the in silico test findings revealed that the bond energy at docking ACE-beta sesquiphellandrene was very low [48,50].

3.3.6. Myocardial injury protective effect.

The findings of the investigation on the effects of red ginger extract demonstrated that red ginger had a protective effect on the myocardium in ISO and MI-induced damage. Rats given ZBN with ISO showed a considerable reduction in CK, CK-MB, cTn T, and cTn I activity [46]. A cardioprotective effect has also been demonstrated for the presence of 6-gingerols (6-G). The expression levels of PI3K and p-Akt for the I/R group were considerably lower, according to the results of the Western blot experiment. The expression of PI3K and p-Akt may be increased by 6-G therapy. However, the PI3K/Akt signaling pathway inhibitor LY294002 may be able to counteract the activating function of 6-G through this route. These findings demonstrated that the PI3K/Akt-dependent mechanism of 6-G might regulate the myocardial inflammatory response and reduce MIRI [18]. Additionally, it has been demonstrated that red ginger extract can limit the rise in CK, CK-MB, and LDH levels and lessen the degree of necrosis seen in tests on the histopathology of heart muscle tissue [49]. Extracts of garlic and turmeric are also recognized to have cardioprotective properties [55-56] [66]. Both of these extracts were shown to prevent myocardial infarction in rats exposed to isoproterenol. The test findings demonstrate that administering turmeric extract or garlic extract can enhance cardiac enzyme parameters. A summary of the phytochemical and cardioprotective potential of red ginger, turmeric, and garlic is presented in Figure 2.

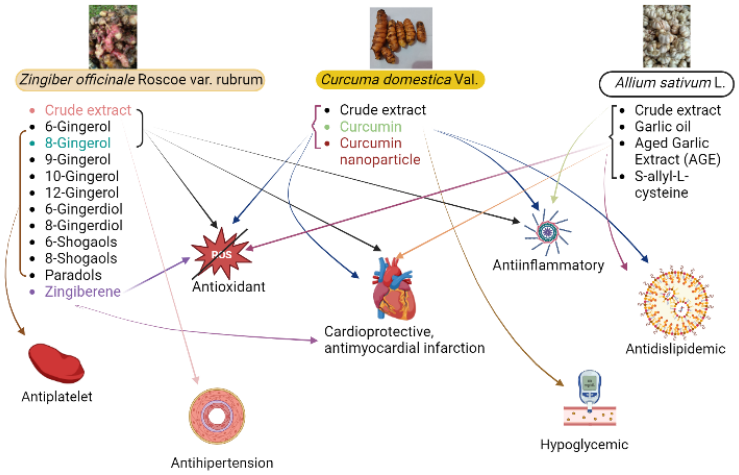

Figure 2. Summary of the phytochemistry and cardioprotective potentials of *Zingiber officinale* Roscoe var. rubrum, *Curcuma domestica* Val and *Allium sativum* L.

4. Conclusions

Red ginger, turmeric, and garlic are all utilized in cuisine and medicine. These three plants' medicinal potencies were confirmed through pharmacological testing. These three plants have cardioprotective potential due to their anti-inflammatory, antioxidant, antihypertensive, antiplatelet, anti-myocardial, and antihyperlipidemic activities.

Funding

No funding resources.

Acknowledgments

We appreciate the contributions of all the authors whose work was used in this article.

Conflicts of Interest

The authors declare that the publication of this article is not impacted by any conflicts of interest.

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