The Role of Herbal Medicine/Plant-based Medicine for the Prevention of Cardiovascular Diseases

Amina Hussain[1], Meesum Muneer[2], Rafia Yasmeen[3], Kinza Javed Iqbal[4], Khansa Adeel[5], Zia Ullah[2], Shanza Riaz[1] and Hafiza Saira Jafar[3,*]

[1]Department of Biochemistry, University of Agriculture, Faisalabad, Pakistan
[2]Doctor of Veterinary Medicine, Faculty of Veterinary Animal Sciences, Gomal University, Dera Ismail Khan, Khyber Pakhtunkhwa, Pakistan
[3]Radiography and Imaging Technology, Dr Yahya Institute of Medical Sciences, Layyah, Pakistan
[4]Department of National Institute of Food Science and Technology, University of Agriculture, Faisalabad, Pakistan
[5]Department of Microbiology, Government College University Faisalabad, Pakistan
Corresponding author: hafizasairajafar2002@gmail.com

Abstract

Cardiovascular disease, or CVD, is the leading cause of mortality globally. Cardiovascular disease (CVD) is the general term for conditions affecting the heart muscle and the circulatory system, which provides blood to the heart, brain, and other vital organs. It is anticipated that 62 million people in this country suffer from cardiovascular diseases, and 50 million have hypertension. Aging and cardiovascular disorders are caused by the breakdown of basic biomolecules (DNA, proteins), which is largely caused by reactive nitrogen metabolites (RNMs) and reactive oxygen metabolites (ROMs). Antioxidants that are naturally present in humans often fail to prevent the negative effects of reactive species. The demand for natural products as dietary supplements, particularly those made from plants, is growing every day worldwide. A variety of heart disorders have been successfully treated with cardiac glycosides, including cardenolides and their derivatives. Many other plants, such as Curcuma longa, Allium sativum, Camellia sinensis, Ocimum sanctum, and chemical groups known as flavonoids, have been studied as possible remedies for heart disease. In these chapters, we discuss the role of plants and their active constituents in cardiac diseases. Further study is needed to improve the therapeutic indications and efficacy of these plants and compounds.

Keywords: Cardiovascular disease, Antioxidants, Dietary supplements, Cardiac glycosides, Flavonoids

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Introduction

Environmental exposure is one important but poorly understood risk factor that influences the development and severity of cardiovascular diseases (CVDs). The heart and vascular system are especially vulnerable to ambient air pollution, and the most prevalent and thoroughly researched metals are lead, cadmium, and arsenic (Münzel *et al.*, 2022). By encouraging or starting pathophysiological processes associated with cardiovascular disease (CVD), such as blood pressure regulation, lipid and carbohydrate metabolism, the vascular system, and atherogenesis, these exposures raise the risk of contracting diseases and dying, much like traditional risk factors like smoking and diabetes mellitus (Izzo *et al.*, 2021). Although a higher cardiovascular system is associated with living in highly polluted areas, cardiovascular health can also be negatively impacted by exposure levels below existing restrictions. Even a slight increase in the risk of CVD can have a big effect on population health since exposure is so widespread. The worldwide burden of death and disability from CVD could be considerably decreased by lowering environmental exposures from their current level through evidence-based clinical and public health measures (Cosselman *et al.*, 2015).

Globally, cardiovascular disease (CVD) is the primary cause of death. Increased platelet aggregation, increased blood-clotting time, decreased fibrinolysis, raised cholesterol, and hypertension are the hallmarks of cardiovascular disease, a complex and complex illness (Vilahur and Fuster, 2025). An imbalance in cardiac function that prevents the heart from pumping blood at a rate suitable for the needs of the metabolizing tissues causes heart failure, a pathophysiologic condition in which the heart only pumps blood from an abnormally high diastolic filling pressure. Conditions affecting the heart muscle and the blood circulation that supplies the heart, brain, and other essential organs are included in the broad category of cardiovascular disease (Gaziano *et al.*, 2006). Peripheral vascular disorders, coronary heart disease (CHD), heart failure, myocardial infarction, stroke, cardiomyopathies, dyslipidemias, and hypertension are examples of cardiovascular diseases (CVDs). Vascular dysfunction is the most common cause of CVDs, which ultimately results in organ damage. Sometimes a brain stroke or heart attack might be caused by vascular dysfunction. High blood pressure (BP), thrombosis, and

atherosclerosis are the main causes of vascular dysfunction (Lockhart and Sun, 2021). High levels of low-density lipoprotein cholesterol (LDL), declining levels of high-density lipoprotein cholesterol (HDL), diabetes mellitus, hyperlipidemia, smoking, poor nutrition, and hypertension are some of the main risk factors for CVDs (Acuna *et al.*, 2015). Conditions affecting the heart or blood vessels are known as cardiovascular diseases (CVDs). Nearly 17 million deaths globally are attributed to CVDs each year. Consequently, cardiovascular diseases (CVDs) remain the world's top cause of mortality and pose a substantial financial and health burden. The World Health Organization (WHO) estimates that cardiovascular diseases (CVDs) account for 31% of all deaths globally. Cardiovascular diseases (CVDs) are conditions that affect the heart or blood vessels (Shaito *et al.*, 2020).

Medicinal Plants with Cardiovascular Benefits

The ability of medicinal plants to produce bioactive substances that can prevent, treat, or cure a wide range of disorders makes them an essential component of both traditional and modern medicine (Abbas *et al.*, 2025). Alkaloids, flavonoids, terpenes, and glycosides are examples of secondary metabolites found in these plants that have analgesic, antibacterial, antioxidant, and anti-inflammatory qualities. One of the most significant sources of medications is thought to be plants (Alamgir and Alamgir, 2018). People have been using plants as medicine for thousands of years. Medicinal plants are important for several reasons: natural and safe, cost-effective, and a diverse range of uses. These treatments were initially unrefined herbal concoctions. Over 80,000 of the 2,50,000 higher plant species that are known to exist on the globe are utilized medicinally. More than 80% of people worldwide are believed to only use traditional medicine, mostly plant-based, to treat their fundamental medical needs, according to a World Health Organization (WHO) study. Furthermore, it is estimated that medicinal plants account for about 40% of the pharmaceutical sector (Monib, 2024).

Turmeric (*Curcuma longa*)

Turmeric is an evergreen herbaceous plant that is a member of the Zingiberaceae (ginger) family. It is mostly grown in China and India, although it is grown all around Asia. Since it has been used for at least 2500 years, turmeric is probably an Indian invention. Ayurvedic and traditional Chinese medicine have long utilized turmeric, the rhizome of the Curcuma longa plant, which belongs to the Zingiberaceae family of gingers, to treat long-term ailments, including metabolic and cardiovascular problems (CVD). Curcumin, a polyphenol, is what gives turmeric, a curry spice, its yellow color (diferuloylmethane). Curcumin, the primary bioactive component of turmeric, has been used extensively in traditional medicine across numerous nations to prevent and treat a variety of illnesses. Because of its pleiotropic effects in CVDs, curcumin (1,7-bis(4-hydroxy-3-methoxyphenyl)-1,6-heptadiene-3,5-dione) is a very attractive treatment choice (Li *et al.*, 2020).

The yellow-pigmented portion of turmeric contains curcuminoids, which are chemically related to curcumin, the primary component of turmeric. The primary curcuminoids in turmeric are demethoxycurcumin (curcumin II), bisdemethoxycurcumin (curcumin III), and the recently identified cyclocurcumin. Previous research has demonstrated curcumin's protective effects on the cardiovascular system and its potential as a therapeutic agent to reduce cardiovascular disease and other vascular dysfunctions. Curcumin may have a membrane-stabilizing role that guards against cardiac injury, as evidenced by the fact that it prevented the Adriamycin-induced ECG changes. Another study has also shown that phenylbutyrate, an inhibitor of histone acetyltransferases, protects against heart damage brought on by Adriamycin. This is partly because it raises cardiac manganese superoxide dismutase's protein level and activity (Wongcharoen and Phrommintikul, 2009). Maintaining a healthy cholesterol level is essential for preventing cardiovascular diseases and other serious health problems. Because high cholesterol may be detrimental to one's health, people are always looking for ways to lower it. Studies have shown that including turmeric in one's diet can significantly lower blood cholesterol levels. Turmeric may help prevent atherosclerosis, a buildup of plaque that can obstruct arteries and cause a heart attack or stroke, according to preliminary research (Verma *et al.*, 2018). The development of cholesterol plaques, which narrow or stiffen coronary arteries and result in atherosclerosis associated with CVD, is brought on by an increase in serum oxidized low-density lipoproteins (LDL). By stimulating enhanced production of low-density lipoprotein (LDL) receptors in mouse macrophages and the cultured human liver cancer cell line HepG2, curcumin helps to improve LDL absorption, a critical step in avoiding atherosclerosis (Zhang and Kitts, 2021).

Garlic (*Allium sativum*)

Garlic (Allium sativum), a member of the Alliaceae family, is thought to have originated in Central Asia. Garlic seems to have come from central Asia, then to China, the Near East, and the Mediterranean, before heading west to Mexico, northern Africa (Egypt), and central and southern Europe. Garlic is produced practically everywhere in the world. Garlic has been used as medicine for thousands of years. Chinese medicine has been utilizing it for at least 3,000 years, and Sanskrit sources claim that its therapeutic use extends back 5,000 years. The Greeks, Romans, Babylonians, and Egyptians all used garlic as medicine. After Pasteur identified garlic's antibacterial qualities in 1858, During World Wars I and II, it served as an antiseptic to stop gangrene. In addition to its widespread usage as a flavoring agent, traditional medicine, and a functional food to improve mental and physical health, garlic's main medicinal applications now include preventing and treating cardiovascular disease by decreasing blood pressure and cholesterol. Garlic's dry weight, which is mostly made up of water (65%), is mostly made up of carbohydrates that contain fructose. Protein, fiber, sulfur compounds, and free amino acids come next. Garlic also contains minor amounts of calcium, magnesium, salt, iron, manganese, and B-complex vitamins, and substantial amounts of selenium, phosphorus, potassium, sulfur, zinc, and saponins (Rahman and Lowe, 2006).

A high-fat diet can increase plasma fibrinogen and serum cholesterol levels while also lowering fibrinolytic activity and blood coagulation time. Increased serum cholesterol levels are a major factor in the development of atherosclerosis and cardiovascular disease, whereas changes in blood coagulation time are associated with the production of thrombin in atherosclerotic arteries. Cardiovascular disease is also associated with elevated LDL levels; in particular, it has been shown that LDL particle oxidation is probably a crucial stage in the formation of atherosclerotic plaques. It has been demonstrated that higher platelet activity is present in smokers, people with vascular injury, people with

hyperlipidemia, and those with hypertension. Plaques may form as a result of these circulating platelets coating the innermost lining of the arteries. The blood arteries narrow as a result of the artery walls being thicker. These plaques can develop and block blood vessels by mixing lipoproteins, lipids, and cholesterol. A heart attack brought on by coronary artery blockage is followed by a myocardial infarction. People who regularly eat more onions and garlic have lower lipid and cholesterol levels than people who don't eat these vegetables (Rahman, 2001).

Allicin, also known as diallyl thiosulfonate or allyl 2-propenethiosulfinate, is believed to be the main bioactive ingredient in raw garlic homogenate or aqueous garlic extract. Allicin is created when the enzyme alliinase, which is activated when garlic is chopped or crushed, mixes with alliin, which is found in intact garlic. γ-L-glutamyl-S-alkyl-L-cysteine, 1-propenyl allyl thiosulfonate, and allyl methyl thiosulfonate are other significant sulfur-containing substances found in garlic homogenate (Banerjee and Maulik, 2002). It has been shown that garlic increases antioxidant status, inhibits the angiotensin-converting enzyme, decreases platelet aggregation, prevents injured erythrocytes and LDL from undergoing lipid peroxidation, and inhibits the enzymes that produce lipids. To create AGE, raw garlic slices are preserved in 15%–20 % ethanol for 20 months. Several novel molecules, including S-allylcysteine (SAC), Nα-fructosyl arginine, selenium, allixin, and S-allylmercaptocysteine, are expected to become more active as a result of the entire process. These substances are all important antioxidants, stable, and highly bioavailable. Garlic's health advantages are primarily due to SAC. Aged garlic extract (AGE) slows the evolution of atherosclerosis while improving oxidative biomarkers and vascular function. AGE protects atherosclerotic lesions and reduces the absorption of oxidized LDL via altering the peroxisome proliferator-activated receptor γ (PPARγ) pathway and decreasing the creation of macrophage CD36.

HDL, oxidized phospholipids/apoB, and lipoprotein(a) significantly increased after garlic administration, but total cholesterol, LDL cholesterol, homocysteine, autoantibodies to malonyl dialdehyde-LDL, and apoB–immune complexes decreased. In addition to its antioxidant properties, allicin, one of the primary components of raw garlic, may affect atherosclerosis through a number of pathways, such as lipoprotein alteration and decreased LDL absorption. One possible explanation for garlic's ability to prevent atherosclerosis is that it inhibits LDL oxidation. Platelet activation results in a transient increase in free cytoplasmic calcium (Ca^{2+}), thromboxane A2, and glycoprotein IIb/IIIa receptor activation. Protein kinase C, NO, cAMP, lipoxygenase metabolites, and cyclic guanine monophosphate (cGMP) are other modulators that promote platelet aggregation. By reducing intraplatelet Ca^{2+} mobilization, raising cAMP and cGMP, and blocking cyclooxygenase activity and thromboxane A2 generation, garlic inhibits platelet aggregation. Additionally, garlic has potent antioxidant qualities and raises NO levels by activating platelets' nitric oxide synthase (NOS). Additionally, it may directly impact the glycoprotein IIb/IIIa receptors, decreasing platelets' capacity to bind fibrinogen. Garlic protects the heart through a variety of molecular pathways. Garlic, like several other pharmaceutical therapies, can reduce arrhythmia, prevent myocardial damage, and minimize the risk of coronary heart disease (CHD), acute MI, and sudden death in high-risk individuals (Khatua *et al.*, 2013).

Green Tea (*Camellia sinensis*)

The Camellia sinensis plant is the source of green tea, a popular beverage that has been linked in clinical trials to anti-atherosclerosis and has been shown to be an antioxidant. The polyphenol content is preserved when the plant's fresh leaves are dried and steam-cooked, which inactivates the polyphenol oxidase enzyme. Flavonoids, the primary polyphenols found in green tea, are believed to constitute the tea's active component and to be crucial in avoiding coronary artery disease. Epicatechin (EC), epicatechin gallate (EGCG), and epigallocatechin (EGC) are the four primary flavonoids present in green tea. Of them, EGCG is the most prevalent and potent derivative, making up 48–55% of the total catechin in green tea (Mak, 2012).

About 150–200mg/g of catechins, including 90 mg of EGCG, are present in one cup of green tea prepared using a single tea bag. The most important active ingredient is thought to be epigallocatechin gallate. Due to the presence of catechins linked to green tea use, it is generally accepted that green tea may offer protection against mortality from all causes, particularly cardiovascular disorders (coronary heart disease and stroke) (Pang *et al.*, 2016). Green tea catechins have been shown to reduce CVD risk factors through a number of different mechanisms. Anti-inflammatory, anti-proliferative, lipid profile alteration, antioxidant activity, and endothelial function protection are some of these routes. The antioxidant qualities of polyphenol compounds are attributed to the phenolic hydroxyl group's ability to scavenge reactive oxygen species. The antioxidant properties of green tea polyphenols prevent LDL-C from undergoing oxidative alteration, which is a crucial step in the development of atherosclerosis. When LDL-C and free radicals interact, LDL-C oxidation takes place, which causes LDL-C to build up in the subendothelial area. By encouraging macrophage uptake, LDL-C oxidation produces a cholesterol-rich "foam cell" that can collect inside the artery and cause an atherosclerotic lesion. CVD is characterized by a buildup of atherosclerotic lesions that eventually obstruct blood flow or cause an artery to rupture. Another significant risk factor linked to CVD is hypertension. The activation of endothelial nitric oxide synthase has been linked to the vasculoprotective and antihypertensive effects of green tea. This increased generation of nitric oxide (NO) causes vasorelaxation, which in turn lowers blood pressure (Murray *et al.*, 2015).

Tulsi (*Ocimum sanctum*)

Modern research is increasingly confirming the health advantages of Tulsi (Ocimum sanctum), the most significant herb in Ayurveda and a member of the Lamiaceae family. The genus Ocimum includes between 50 and 150 species of tropical plants and shrubs. Because of its many complex healing benefits, the tulsi herb is extremely valuable to humanity. Tulsi features whorled flowers on thorny inflorescences, square stalks, and scented opposite leaves. The presence of essential or volatile oil, which is mostly concentrated in the leaf, is responsible for the distinctive fragrant scent of Ocimum sanctum, often known as tulsi. This aromatic volatile oil is mostly composed of aldehydes, terpenes, and phenols. Fatty acids make up the majority of fixed oil, which is the oil extracted from seeds. The plant also includes alkaloids, glycosides, tannins, and saponins in addition to oil. Ascorbic acid and carotene are also present in the leaves. At 30 to 60 cm in height, it is a well-proportioned, erect subbush with simple, inverted green leaves that are unmistakably aromatic and hairy stems. Tulsi is an upright, aromatic shrub that may reach a height of three to five feet. The essential oil from tulsi leaves and flavoring tips is obtained by steam distillation and

utilized in traditional medicines, rituals, dental and oral treatments, and scents (Chandra *et al.*, 2016).

Ocimum tenuiflorum, popularly known as Ocimum sanctum L., has two cultivars that differ in both botany and phytochemistry: Rama or Sri Tulsi (green leaves) and Krishna or Shyama Tulsi (purplish leaves). Tulsi, often called holy basil in English or Tulasi in Sanskrit, is considered the queen of plants and is used in herbal remedies for a variety of medicinal purposes. It has been in use for over 3,000 years on the Indian subcontinent. It is widely grown in warm climates in Asia, the Middle East, Malaysia, Australia, and Africa because it boosts immunity and improves health conditions. It is utilized in religious rites, food, cosmetics, herbal medicine, and many traditional medical systems. In order to strengthen the immune system and help cure, prevent, and manage COVID-19 infections, Tulsi was used as the main immune booster during the pandemic (Yadav *et al.*, 2024).

Basil is stomachic, galactagogue, carminative, appetizer, and antispasmodic. Constipation, intestinal catarrh, vomiting, gastric catarrh, stomach pains, and enteritis are among its uses. It has occasionally been used as an antispasmodic for whooping cough. Tulsi lowers blood sugar levels and has antioxidant qualities. Thus, diabetics can benefit from it. Tulsi lowers cholesterol levels overall. Patients with cardiac problems can also benefit from it. Blood pressure is lowered with tulsi.

Ocimum significantly affects the treatment and prevention of cardiovascular diseases by reducing blood cholesterol, preventing ischemia and stroke, lowering hypertension, and possessing greater antioxidant properties. The active components of Tulsi include phenols, terpenes, alkaloids, glycosides, and tannins. Ocimum sanctum leaves are the main source of volatile oils, including eugenol and methyl eugenol. Fresh leaves and stem extract of Ocimum sanctum have been shown to contain a variety of phenolic components, such as cirsilineol, circimaritin, isothymusin, rosameric acid, and trace levels of eugenol. Tulsi (Ocimum sanctum) also contains monoterpenes and sesquiterpenes, including β-sitosterol, cholesterol, stigmasterol, camphene, α and β pinene, and bornyl acetate. Minerals such as calcium, iron, zinc, and chlorophyll, together with vitamins A and C, are examples of nutritional components. By decreasing levels of phospholipids, triglycerides, total cholesterol, and low-density lipoprotein (LDL), Ocimum sanctum leaves demonstrated a hypolipidemic impact. High-density lipoprotein (HDL) cholesterol increased as a result. Furthermore, by increasing the levels of antioxidant enzymes and lowering the levels of ALT, AST, AP, and LDH in the blood, liver, and heart tissues, three weeks of treatment with an aqueous extract of Ocimum sanctum leaves decreased oxidative stress in rats given a high-cholesterol diet. Furthermore, by increasing antioxidant enzyme levels and lowering the production of free radicals, the administration of extracts from Ginkgo biloba and Ocimum sanctum showed a cardioprotective advantage by preventing ventricular dysfunction. In another study, Wistar rats were given a homogenate of Ocimum sanctum leaves for 30 days, which increased the level of endogenous antioxidants and reduced isoproterenol-induced cardiac necrosis. It has been demonstrated that the phytochemical ursolic acid, which was isolated from the leaves of Ocimum sanctum, has a cardioprotective effect against lipid peroxidation caused by Adriamycin (ADR). Additionally, the linoleic and linolenic acids in oil release PGI2 and PGI3, which results in the hypotensive effect (Singh *et al.*, 2013).

Conclusion

Strong antioxidant properties are followed by anti-hyperlipidemic, vasodilatory, antithrombotic, and diuretic actions. These processes are strongly linked to the treatment of cardiovascular disorders, including hypertension, coronary heart disease (CHD), atherosclerosis, and others. We shouldn't waste these resources by letting the medicinal plant grow wild and die instead of using it to further pharmaceutical development in the future, since it is useful in treating human ailments. Curcumin's medicinal properties have been well studied, especially in relation to the treatment of anti-inflammatory and cancerous conditions. Furthermore, curcumin has low toxicity, is inexpensive, and is well tolerated at doses up to 12 g per day. On the other hand, not much is known about how curcumin affects cardiovascular conditions. Curcumin may help protect against a number of cardiovascular disorders, according to mounting data. Curcumin's antioxidant properties have been demonstrated to reduce the cardiotoxicity caused by Adriamycin and may shield the cardiovascular system against diabetic consequences. A single clove of garlic may be able to treat a variety of illnesses by reducing the number of several bacterial and fungal strains. The use of garlic (Allium sativum) in cardiovascular treatment is much older, having been used for over 3,000 years. Several studies on animals have shown that garlic lowers cholesterol. The active component, allicin, is produced when fresh garlic is crushed. This allows the enzyme alliinase to work on the stable precursor Allin. CVD events can be prevented. A key factor in reducing the incidence of CVDs is daily living. Dietary consumption is not independent of our daily lives. As a result, tea and coffee are the most widely consumed beverages worldwide. Fresh C. sinensis leaves are dried and steam-cooked to deactivate the polyphenol oxidase enzyme and preserve the polyphenol content. Polyphenols, a healthy component of tea, are important in preventing coronary artery disease. The primary polyphenols in green tea are flavonoids. Tulsi is a safe herbal treatment that can assist with immunological and psychological stress, as well as normalizing blood pressure, cholesterol, and glucose levels. Further clinical study is necessary since these results also imply that including Tulsi into the diet on a regular basis and/or utilizing it as a complement to drug therapy may help prevent or decrease a variety of ailments. It has been demonstrated that the phytochemical ursolic acid, which was isolated from the leaves of Ocimum sanctum, has a cardioprotective action against lipid peroxidation caused by Adriamycin (ADR).

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