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Unveiling The Effects Of Medicinal Plants In Various Cardiac Diseases: A Comprehensive Review

Debashish Borah[1], Montaz Ali[2], Vishal Tatwal[3], Yukta Sarma[4], Shabana Jabi[5], Chetan[6], Abhishek Tiwari[7], Harmandeep[3], Ayush[8]
[1,2,3,4,6]NIMS Institute of Pharmacy, NIMS University, Jaipur, Rajasthan
[5]School of Basic and Applied Sciences, Shri Guru Ram Rai University, Dehradun-248001
[7]Faculty of Pharmaceutical Sciences, Guru Kashi University, Talwandi Sabo
[8]Faculty of Pharmaceutical Sciences, PDM University, Bahadurgarh, Haryana

Abstract
Cardiovascular diseases (CVDs) remain the leading cause of morbidity and mortality globally. In recent years, medicinal plants have gained significant attention due to their cardioprotective potential and minimal side effects. This comprehensive review explores the therapeutic effects of various medicinal plants on cardiac conditions such as myocardial infarction, hypertension, atherosclerosis, and heart failure. Phytochemicals like flavonoids, alkaloids, saponins, and polyphenols play key roles in exerting antioxidant, anti-inflammatory, antihypertensive, and lipid-lowering effects. The review highlights evidence from in vitro, in vivo, and limited clinical studies, emphasizing the need for further investigation. These plant-based therapies may offer promising adjunct or alternative strategies for conventional cardiac treatments.
Keywords: *Medicinal plants, cardiovascular diseases, Phytochemicals, Cardioprotection, Herbal therapy*

INTRODUCTION

1.1. Global burden of cardiac diseases

The main cause of death worldwide and a significant contribution to a worse quality of life are cardiovascular diseases (CVDs), which include peripheral artery disease, heart failure, ischemic heart disease, stroke, and many other cardiac and vascular illnesses [1,2]. An estimated 17.8 million deaths globally were attributed to CVD in 2017, which translates to 330 million years of lost life and an additional 35.6 million years of impairment [1, 2]. Cardiologists, other doctors, and public health specialists may benefit greatly from these summary indicators of health when combined with information on the prevalence of CVD and risk factors. They provide vital population-level data that may direct global, regional, national, and subnational efforts to prevent, treat, and manage CVD and risk factors.

These data's trends provide a helpful indicator of where progress has halted and where CVD mortality and burden are rising or falling globally. For instance, low- and middle-income countries (LMIC) account for about 80% of all deaths from CVD worldwide, and their burden of risk factors and CVD is increasing due to a continuing epidemiological change [3, 4, 5]. Compared to high- or low-income nations, middle-income countries have a higher rate of CVD mortality.

1.2 Limitations of conventional cardiac therapeutics

The inaccuracy and unreliability of symptom categorization, which is now dependent on a doctor's consultation, is one of the primary drawbacks of a symptom-driven therapy approach [6]. A poor concordance of just 54–56% was seen when two cardiologists were asked to describe the NYHA class of patients with mild to moderate symptoms. [7, 8] Others have proposed using self-reported NYHA classification, which would let the patient choose their own classification; however, a research found that this classification did not correlate well with physician classifications [9]. This problem can be resolved by using more objective measures of activity tolerance, such the 6-minute walk test (6MWT) or the cardiopulmonary exercise test, which is now the gold standard. However, these tests might be challenging to get on a regular basis.

There is significant variability between 6MWT distance and NYHA class, according to a comprehensive meta-analysis. Additionally, research demonstrated that class III and IV functional capacity could be distinguished more clearly by the NYHA categorization system than class I and II functional capacity [10]. While there was no discernible correlation in a retrospective analysis from the Evaluation Study of

Congestive Heart Failure and Pulmonary Artery Catheterization Effectiveness (ESCAPE) trial, there was only 42% agreement between the NYHA classification and the more sophisticated and precise VO2 max levels in cardiopulmonary exercise testing in another study with 145 participants. [11,12] Although a more standardized method of gathering a patient's medical history or the use of a particular questionnaire may assist increase accuracy and dependability, it is impossible to overlook the fact that a number of variables unrelated to heart failure may affect how symptoms are perceived. Therefore, emerging technologies, such as activity monitors and innovative sensors that offer continuous, real-time activity information, may be a superior measure. However, these devices must be verified in carefully planned clinical studies.

It is evident that symptomatic HF patients get insufficient treatment, notwithstanding the limitations of the symptomatic evaluation of HF. Providers may mistakenly think that patients with more severe illness may be "beyond help," whereas those with milder symptoms have minimal morbidity and death. [13]

The scope of HF undertreatment is shown by recent findings from the Change the Management of Patients with Heart Failure (CHAMP-HF) experiment. Just 1% of patients were getting all GDMT at target dosages in real-world settings, while 27%, 33%, and 67% of patients were not administered beta-blockers, MRAs, or ACEI/ARB/ARNIs, respectively. [14] It is widely recognized that poorer results result from underusing prescribed pharmaceutical classes and from failing to uptitrate these medicines. [15, 16] Even in patients with severe heart failure, GDMT and other cutting-edge treatments have shown positive benefits on the cellular and myocardial levels. [17, 18] However, the existing treatment alternatives can only alter the underlying pathophysiology in the absence of scar and fibrosis, since rejuvenative therapies, including stem cells, have not been able to provide long-term, sustained effects.

Reverse remodeling is an option for some individuals with viable but malfunctioning myocardium. Based on cardiac MRI with gadolinium imaging, a small investigation of patients with ischemic heart failure revealed that 19% and 60% of patients with NYHA I or II, respectively, exhibited a dysfunctional but viable myocardium [19]. The condition may not advance as quickly or may even regress with proper medical care and reduction of risk factors that affect contractility, preload, and/or afterload, resulting in remission or recovery [20].

1.3 Role of medicinal plants in cardiovascular health

Traditional drugs that are often used to treat CVDs are costly and have adverse effects [21, 22]. Therefore, a more effective, affordable, and safe substitute is needed. Accordingly, the most important treatment option for cardiovascular illness is medicinal plants. CVDs are more likely to be treated using medicinal herbs. Because more people are aware of how herbs enhance health and quality of life, herbal therapy has been widely accepted in the medical community [23]. An alternate and potential method of preventing CVD is the use of phytochemicals and plant-based whole meals, according to mounting data [24]. Arrhythmia, congestive heart failure, cerebral and venous insufficiency, atherosclerosis, angina pectoris, and systolic hypertension have all been treated with herbal remedies [25, 26]. In addition to therapeutic herbs, exercise is believed to provide cardioprotective effects [27].

Important cardiovascular disease markers including oxidative stress and inflammatory mediators may be effectively prevented, controlled, or blocked by natural substances, according to recent research [28]. The qualities of the bioactive chemicals that medicinal plants possess are what give them their therapeutic qualities [29]. Carotenoids, tocotrienols, polyphenols, sulforaphane, catechin, quercetin, resveratrol, diosgenin, isoflavones, and flavonoids are among the plant bioactive substances that have been shown to protect CVD [30]. A healthy diet lowers the incidence of cardiovascular diseases, according to epidemiological research and some clinical trials [31]. In contrast to diets rich in saturated fat, a research found that diets high in polyunsaturated and monounsaturated fat protect CVD [32]. According to a different research, eating more foods high in phytochemicals is substantially linked to a decreased risk of having a high LDL-C/HDL-C ratio, which is a predictor of CVD risk. Consuming insoluble polyphenols may lower the LDL-C/HDL-C ratio, according to a randomized clinical research conducted on hypercholesterolemia patients [33].

It has been shown that the cardioprotective properties of medicinal plants lessen harm to endothelial cells, vascular smooth muscle cells, cardiomyocytes, and macrophages and monocytes [34]. Certain medications, including diuretics, hypolipidemic, anticoagulants, antioxidants, and anti-inflammatory drugs, may have an impact on the cardiovascular system [35]. For example, by lowering the quantity of free radicals in the body, antioxidant mechanisms of action are the main way to lessen the impact of cardiovascular disease [36]. Modification of inhibitor kappa B kinase-beta (IKK-β) kinase activity may be useful in reducing inflammatory activities, which effectively protect against cardiovascular disease. By phosphorylating IB and activating the transcription factor nuclear factor-kappa B (NF-B), IKK causes inflammation. IKK is thus a prospective target for cardiovascular disease prevention and treatment [37]. It is advised to employ anticoagulant activity to avoid thrombotic events in a variety of cardiovascular conditions, such as atrial fibrillation stroke prevention, acute coronary syndrome secondary prevention, and therapy [38]. Any substance that lowers blood levels of lipids and lipoproteins (lipid-protein complexes) is known as hypolipidemic activity, or lipid-lowering medication. Elevated levels of some lipoproteins, namely low-density lipoprotein (LDL) and very low-density lipoprotein (VLDL), have been linked to an increased risk of heart attacks, strokes, and coronary artery disease [39]. Nevertheless, no research has been done on the scientific foundation for elucidating the molecular mechanism of herbal medicines' possible cardioprotection by cell and molecular technology [36]. It is important to pay attention to the negative effects of herbal remedies and medication interactions; no herbal remedy regimen should be started without carefully weighing the possible outcomes [40]. Additionally, the scientific study of phytochemicals in nanoforms is insufficient. Current research shows that natural-based nanoformulations are very successful in preventing and treating CVD, either by themselves or in conjunction with other synthetic or herbal medications.

2. Phytochemicals in Cardioprotection

2.*1 Phytochemicals Derived from Plants in the Prevention and Management of CVD*

Research on the prevention or treatment of cardiovascular disease has focused a lot of emphasis on natural products and herbal therapies [41]. This urge is driven by several reasons. Specifically, the possibility of cost-effective therapy has been contrasted with the widely held perception that existing conventional therapies are safe and effective. Numerous medicinal plants have been utilized to treat cardiovascular disease as a result of these findings. Examples of plants that have been used to treat cardiovascular diseases include the aerial parts of *Achillea arabica [42], the root, leaf, and stem part of Ageratum conyzoides [43], Artemisia absinthium leaves, stalks, and stems [44], Chrysanthemum x morifolium flowers [45], and Clerodendrum volubile leaves [46]. Ajuga integrifolia (Ethiopia) [47], Leonurus cardiaca (Europe) [48], Pogostemon elsholtzioides (Eastern Himalaya) [49], Ballota glandulosissinia (Turkey) [50], and Clerodendrum volubile (Nigeria)* [51] are among the Lamiaceae plant species that are also used as medicinal plants for cardiovascular treatment [52] (Figure 1). Cardioprotective properties have been discovered in a number of terrestrial plants, including *Terminalia arjuna, Ocimum sanctum L., Allium cepa (onion), Curcuma longa L., Commiphora mukul, Trigonella foenum-graecum L., and Allium sativum L. (garlic*) [53]. *Daucus carota* contains bioactive substances that are utilized to treat cardiovascular disease, such as daucoside, sesquiterpenoids, carotene, xanthophylls, and daucosol [54]. By monitoring the activity of cardiac enzymes such lactate dehydrogenase (LDH), cardiac protein, lipid peroxidises, and transaminases, Muralidharan et al. [55] investigated cardiac protection. Additionally, the investigation demonstrated the cardioprotective effects of *Nerium oleander (*NO) concentrate [56]. Similarly, NO flowers had remarkable cardioprotective action, according to a research by Gayathri et al. [57] that examined the cardioprotective capacity of NO flowers in rats that were given isoproterenol to produce oxidative myocardial stress. A research was carried out to evaluate the cardioprotective potential of *Amaranthus viridis Linn* [58], and the findings revealed that it has cardioprotective effect by reducing cardiac enzyme levels in the rat population treated with the plant. According to some research, the seeds and leaves of Ginkgo biloba have a cardioprotective effect. Panda and Naik [59] used extracts of *Ginkgo biloba* and Ocimum sanctum in rats with isoproterenol-induced cardiac necrosis for comparative research. Serum enzyme levels in normal rats were found to be lower than those in rats with myoproterenol-induced cardiac necrosis. Ginkgo biloba dosages of 50 mg/kg body weight and 100 mg/kg body weight when compared to the combination administration of 50 mg/kg body weight of Ocimum sanctum and 100 mg/kg body weight of Ginkgo biloba, Ocimum sanctum showed significant protection against cardiovascular disease. Extracts from the roots, fruit, and stem of *Tinospora cordifolia* were discovered to possess cardioprotective qualities. *Tinospora cordifolia's* cardioprotective qualities are attributed to a variety of phytoconstituents [60, 61]. Among the plants used to prevent CVD are *Nerium oleander, Amaranthus viridis, Ginkgo biloba, Terminalia arjuna, Daucus carota, Picrorhiza kurroa, Salvia miltiorrhiza, Tinospora cordifolia, Mucuna pruriens, Andrographis paniculata*, and *Hydrocotyle Asiatica.*

Figure 1 mportant plants used in the treatment and prevention of cardiovascular diseases: *(a) Daucus carota, (b) Nerium oleander, (c) Amaranthus Viridis, (d) Ginkgo biloba, (e) Terminalia arjuna, (f) Picrorhiza kurroa, (g) Salvia miltiorrhiza, (h) Tinospora cordifolia, (i) Mucuna pruriens, (j) Hydrocotyle asiatica, (k) Bombax ceiba, and (l) Andrographis paniculata*. [60]

3. Medicinal Plants and Their Mechanisms in Cardiac Disorders

Herbal extracts and their derivatives offer beneficial effects by modulating key molecular pathways involved in the development of hypertension and atherosclerosis—two major contributors to cardiovascular disease. These natural remedies are rich in multiple bioactive compounds and therefore exhibit a variety of cellular actions. Their therapeutic potential includes antioxidant, vasorelaxant, anti-inflammatory, anti-proliferative, and diuretic activities. Additionally, herbal medicines can prevent vascular smooth muscle cell (VSMC) phenotypic switching, mitigate endothelial dysfunction, inhibit platelet aggregation, suppress lipid peroxidation, reduce reactive oxygen species (ROS) formation, and counter macrophage-driven atherogenesis. Due to this extensive range of mechanisms, herbal preparations are valuable in managing multiple forms of cardiovascular disease.

For instance, *Salvia miltiorrhiza* (commonly known as Red sage), widely used in traditional Chinese medicine, is employed to treat various cardiovascular conditions such as coronary heart disease, myocardial infarction, atherosclerosis, and angina. Its dried root (Danshen) is the primary medicinal component. The plant contains both lipid-soluble compounds (Tanshinones) and water-soluble phenolics [61]. Extracts of S. miltiorrhiza demonstrate potent antioxidant properties and a strong capacity to neutralize free radicals, which contribute to its cardioprotective and vasoprotective effects [62].

One of its active constituents, *Salvianolic acid B*, has been found effective in preventing fibrosis and ischemia–reperfusion injury [63]. Danshen also appears to protect against the harmful effects of homocysteine, a known risk factor in vascular diseases [64]. When combined with Pueraria montana var. lobata (Kudzu), it demonstrates significant anti-hypertensive effects [65]. In clinical settings, administration of Danshen capsules (1000 mg twice daily for 12 weeks) significantly lowered systolic blood pressure and pulse rate in individuals with mild to moderate hypertension already on conventional treatment. It has shown good tolerability and safety in such populations [66].

Another herb, *Astragalus membranaceus* (also listed as Astragalus propinquus), is recognized for its primary active compound, Astragaloside IV, which is known for its antioxidant activity and protective effects in ischemic heart conditions [67]. Extracts of this plant help preserve cardiac function by enhancing energy metabolism and limiting oxidative stress, as observed in ischemia-reperfusion models in rats [68]. It improves cardiac outcomes by reducing levels of oxidative stress markers like malondialdehyde (MDA), maintaining superoxide dismutase (SOD) activity, and lowering myocardial cell damage due to free radicals [69]. Furthermore, it promotes new blood vessel formation in ischemic tissue [70]. Astragaloside IV has also demonstrated positive inotropic effects, improving left ventricular ejection in congestive heart failure patients [71], while the plant's polysaccharides have been linked to reduced insulin resistance, as well as anti-obesity and lipid-lowering properties [72].

Allium sativum (Garlic) is a well-established herb in cardiovascular care due to its wide-ranging benefits, including reduction of hypertension, oxidative stress, inflammation, and lipid abnormalities [73]. By lowering total cholesterol and LDL levels, reducing lipid accumulation in arterial walls, and inhibiting VSMC proliferation, garlic contributes to atherosclerosis prevention and lipid control [74].

Crataegus oxyacantha (commonly known as Hawthorn) exerts antihypertensive effects via endothelial nitric oxide synthase (eNOS)-mediated vasorelaxation [75], while Crocus sativus (Saffron) acts as a vasodilator by blocking calcium channels in an endothelium-independent manner and activating eNOS [76]. Other plants, such as *Hibiscus sabdariffa (Roselle)*, lower blood pressure by inhibiting angiotensin-converting enzyme (ACE) [77], and *Camellia sinensis* (Tea) enhances vascular function by improving brachial artery flow-mediated dilation [78].

Rosmarinus officinalis (Rosemary) has been shown to protect against cerebral ischemia and stroke-related injuries by improving localized blood flow and reducing inflammation. It does so by suppressing the expression of inducible nitric oxide synthase (iNOS), cyclooxygenase-2 (COX-2), and other inflammatory mediators [79].

In addition to their use in treating hypertension and atherosclerosis, medicinal plants are also used in managing heart failure and arrhythmias. Digitalis, derived from the dried leaves of the foxglove plant, serves as a potent Na^+/K^+-ATPase inhibitor. By causing cellular depolarization, it promotes smooth muscle contraction and vasoconstriction, ultimately enhancing myocardial contractility [80].

4. Experimental and Clinical Evidence

4.1 In Vivo Preclinical Evaluations of Gynostemma pentaphyllum

The primary bioactive compounds in Gynostemma pentaphyllum, known as gypenosides, have demonstrated significant potential in preventing atherosclerosis. A study in Wistar rats evaluated a combination of G. pentaphyllum gypenosides and Fermentum rubrum (referred to as HG) and reported stronger anti-atherosclerotic effects than those of the statin simvastatin, underscoring the therapeutic promise of G. pentaphyllum [81]. In rats with fatty liver disease, this HG mixture also alleviated oxidative stress and reduced serum pro-inflammatory cytokines, revealing its protective effects against atherosclerosis [82].

Further research highlighted the anti-inflammatory and antioxidant properties of gypenosides in a rat model of ischemia–reperfusion injury, where treatment resulted in decreased apoptosis and improved cardiac function. This effect was achieved by blocking ER-stress and apoptosis pathways, particularly by inhibiting CHOP and activating the PI3K/Akt signaling cascade [83]. In another study using the same injury model, pretreatment with gypenosides reduced myocardial infarct size, improved left ventricular function, and prevented oxidative damage. Notably, mitochondrial integrity was preserved, preventing the release of cytochrome c and supporting the cytoprotective effects of gypenosides in acute myocardial infarction [84].

Since diabetes is closely associated with cardiovascular complications, G. pentaphyllum extracts were evaluated for their effects on blood glucose in diabetic mice. These extracts inhibited α-glucosidase activity and modulated GLUT2 protein expression, suggesting a potential role in glycemic control [85].

G. pentaphyllum is also frequently used in China for managing metabolic conditions like hyperlipidemia, fatty liver, and obesity. The plant showed the ability to regulate lipid metabolism, elevate phosphatidylcholine levels, and reduce trimethylamine N-oxide concentrations in both plasma and liver tissues of rats [86]. In another experiment, heat-processed ethanol extracts of the plant significantly reduced obesity in mice by activating AMP-activated protein kinase (AMPK), indicating its usefulness as a fat-reducing supplement [87].

Anti-hyperlipidemic activity of gypenosides was confirmed in rats with poloxamer P407-induced hyperlipidemia. Gypenosides administered orally (250 mg/kg) for 4 and 12 days significantly reduced plasma triglyceride levels by 53% and 85%, respectively, and total cholesterol levels by 10% and 44%. LDL levels were also lowered while HDL levels increased. These effects were comparable to atorvastatin and were linked to the reversal of lipoprotein lipase inhibition [88]. Similar lipid-lowering effects were noted in obese Zucher rats [89].

A novel extraction method yielded a G. pentaphyllum extract rich in gypenoside L, gypenoside LI, and ginsenoside Rg3. In a high-fat diet-induced obesity model, this extract significantly suppressed body weight gain, fat accumulation, and adipocyte hypertrophy. Lipid profiles improved, including reductions in triglyceride, total cholesterol, and LDL cholesterol without changes in HDL cholesterol. Mechanistically, the extract activated AMPK and downregulated key adipogenic markers including C/EBPα, PPARγ, SREBP-1c, and others while upregulating fat oxidation genes such as CPT and HSL [90].

4.2 *G. pentaphyllum* in Clinical Research

Currently, clinical studies involving G. pentaphyllum remain limited. A search of clinicaltrials.gov reveals only four registered studies using its extract—three on diabetes and one on obesity.

Actiponin, a proprietary G. pentaphyllum extract used as a dietary supplement, was tested in a randomized, double-blind trial involving 80 obese individuals. Administered at a dose of 450 mg/day for 12 weeks, the supplement significantly reduced body weight with no reported side effects compared to placebo [91].

In another study, a water extract of G. pentaphyllum (1 mg/kg) was given to cardiovascular disease patients and healthy controls. The extract significantly inhibited platelet aggregation, suggesting a role in preventing cardio-cerebrovascular events. However, caution is needed for use in individuals with bleeding disorders or low platelet counts [92].

Given the link between anxiety and cardiovascular disease risk, G. pentaphyllum's anti-anxiety potential was evaluated. In animal studies, its ethanol extract reduced stress-induced anxiety-like behavior. These findings were validated in a double-blind clinical trial involving 72 stressed individuals. Participants receiving 200 mg of the extract twice daily for 8 weeks showed decreased anxiety without any side effects, pointing to its safety and efficacy [93].

Although preclinical findings are promising, human studies remain sparse. Nevertheless, several trials involving individuals with type 2 diabetes have demonstrated beneficial effects. In one study, 24 drug-naïve patients consumed 6 g of G. pentaphyllum tea daily for a week, resulting in significant improvements in fasting glucose, insulin, and HbA1c levels [94]. A follow-up trial with 16 patients confirmed these findings, and another study showed enhanced glycemic control when G. pentaphyllum was combined with sulfonylurea drugs [95]. These results suggest the plant may improve insulin sensitivity both as monotherapy and adjunct therapy [96].

4.3 Safety, Toxicity, and Side Effects

Safety studies conducted in rats have shown high tolerance to G. pentaphyllum. Single doses up to 5000 mg/kg and repeated doses of 1000 mg/kg/day for 90 days did not induce any mortality or signs of toxicity. While some blood chemistry parameters differed from controls, all remained within physiological ranges [97]. Another long-term animal study using up to 750 mg/kg reported no toxicity [98].

In a Phase I clinical trial, healthy participants were given 50, 200, or 400 mg of G. pentaphyllum extract twice daily for two months. No significant immune or biochemical disturbances were observed, indicating good safety at these doses [99]. In a separate study involving 537 patients with bronchitis, mild adverse effects such as gastrointestinal discomfort, dizziness, blurred vision, and tinnitus were reported but were not severe enough to discontinue treatment [100]. Most recently, a placebo-controlled clinical trial with 72 healthy individuals confirmed the absence of side effects from ethanolic extract use [101].

Overall, G. pentaphyllum appears safe and well-tolerated at therapeutic doses used in both preclinical and clinical settings

5. Molecular Mechanisms of Action

Numerous medicinal plants have been shown to have cardio-protective qualities, and these effects have been linked to the bioactive chemicals found in these plants.

For generations, people have used medicinal plants to treat illnesses in humans [102]. Throughout their history, medicinal plants have made significant contributions to human health because they contain components that have therapeutic potential [102]. Conventional medications have shown promise in treating cardiovascular diseases, but they are not without adverse effects, which limits their usage [102] and calls for alternate searches.

The cardio-protective function of medicinal plants, which are thought to be inexpensive and safe, is due to their nutritional content, namely phytochemicals, which have the ability to restore and maintain a balanced bodily system [103]. Various studies have shown the cardio-protective properties of medicinal herbs, suggesting that the antioxidant potentials may be the mechanism. According to epidemiological, clinical, and experimental research, reducing the production of free radicals and increasing endogenous antioxidants may significantly reduce the risk of myocardial infarction [104]. Nonetheless, a number of studies have shown proof that medicinal plants have significant functions.

In addition to their antioxidant function, medicinal plants have been shown to have anti-inflammatory and cardioprotective properties.

5.1 The function of antioxidants

The body produces free radicals as a consequence of normal aerobic metabolic activities, radiation exposure, redox cycling materials, and other environmental factors [105]. As oxygen is gradually reduced in vivo, ROS such superoxide anion, hydrogen peroxide, and hydroxyl radical are created [105]. According to reports, ROS is a key mediator in the development of cardiovascular disorders as well as other illnesses including diabetes and neurological diseases [105]. Oxidative stress results in the progressive oxidation of macromolecules including DNA, proteins, and lipids when the generation of free radicals beyond the antioxidant defense system's threshold [106]. Enzymes including glutathione peroxidase, superoxide dismutase, catalase, and reduced glutathione are part of the human antioxidant defense system [107]. Nevertheless, the benefits of the endogenous antioxidant system may be enhanced by exogenous antioxidants like vitamin E and ascorbic acid.

Studies have shown that cardiovascular illness is associated with a decrease in the endogenous antioxidant enzyme [108]. In the pathophysiology of CVD, elevated ROS production is often accompanied by increased lipid peroxidation, which damages the vascular membrane [34,79]. Targeting oxidative stress would significantly enhance the therapy of CVD since ROS production is crucial to heart pathophysiology (Figure 3). Moreover, antioxidants may reduce cellular damage and apoptosis via a radical-scavenging mechanism when oxidative stress is the underlying cause [109]. For instance, cardiac dysfunction may be lessened by therapeutic intervention that suppresses the production of free radicals and/or increases the activity of endogenous antioxidant enzymes [109]. Antioxidants' use in pharmacology is the subject of much research. Because of their many health advantages, antioxidants have lately become more and more popular. It has been shown that they reduce the risk of heart disease.

CONCLUSION

Medicinal plants offer promising therapeutic potential in the prevention and management of various cardiovascular diseases due to their diverse bioactive constituents, such as flavonoids, alkaloids, tannins, and saponins. These phytochemicals exhibit cardioprotective actions including antioxidant, anti-inflammatory, antihypertensive, hypolipidemic, and antithrombotic effects. This review underscores the significance of integrating herbal remedies with conventional therapies to enhance treatment outcomes and reduce drug-related side effects. However, despite the wealth of preclinical evidence supporting the efficacy of medicinal plants, large-scale and well-controlled clinical trials are still needed to validate their safety and effectiveness. With proper standardization and scientific validation, medicinal plants could become a cornerstone in complementary and alternative cardiovascular care, offering accessible and sustainable solutions for global heart health challenges.

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