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REVIEW article

Using common medicinal plants to treat high blood pressure: An updated overview and emphasis on antihypertensive phytochemicals

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Abstract: The primary cause of many fatalities is hypertension (high blood pressure). Many hypertensive patients are not even aware that they have the condition. As a result, hypertension is sometimes referred to as a silent killer. Until the harmful effects of high blood pressure, such as myocardial infarction, stroke, renal abnormalities, and vision problems, are identified, hypertension is typically asymptomatic. Without the use of herbs and dietary control, conventional medication therapy could not be enough to treat hypertension. The growing number of persons with high blood pressure can be effectively treated using alternative medicine. Numerous alternative therapies, such as diet, exercise, stress management, vitamins, and herbs, have been proven to be effective in lowering high blood pressure. There are several medications available to treat this disorder however popular antihypertensive medications typically have a long list of adverse effects. Numerous active ingredients with pharmacological and preventative qualities found in medicinal plants can be used to treat hypertension. This review discusses an overview of important medicinal plants and phytochemicals with hypotensive or antihypertensive effects.

Introduction

The two main causes of cardiovascular diseases are atherosclerosis and hypertension (HPT). One of the 21st century's most discussed and heavily prescribed diseases is HPT [1]. HPT is referred to be the silent killer since it frequently exhibits no symptoms and is easily missed. When the diastolic blood pressure exceeds 90 mmHg or the systolic blood pressure exceeds 140 mmHg, the National Institutes of Health describes the condition as HPT [2]. Many variables, including stress, a high-salt diet, family history, increased belly fat, and excessive alcohol use, might raise the chance of developing HPT. Chronic illnesses including renal disease, diabetes, and sleep apnea can further raise your risk of high blood pressure [3, 4]. Systemic arterial blood pressure that is higher than normal is known as HPT, a persistent and frequently asymptomatic medical disease. As a result, the heart and arteries are put under stress as it must work harder to pump blood to tissues despite the elevated systemic pressure. Congestive heart failure, myocardial infarction, pulmonary embolism, cerebral aneurysm, and renal failure are all primarily caused by the extra strain, which over time results in cardiovascular dysfunction [5]. An individual may prevent and treat HPT in a variety of ways, including by

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changing their lifestyle by losing extra weight, exercising more, and implementing good eating practices [3, 6, 7]. Before prescribing any drug, a health expert would often advise the patient to make certain lifestyle adjustments. Currently, the Dietary Approaches to Stop Hypertension (DASH) diet is advised by medical professionals as a way to reduce the risk of HPT. It emphasizes limiting dietary intake of saturated fat, cholesterol, and total fat in addition to the significance of lowering salt intake. It promotes a diet rich in fruits, vegetables, lean meats and poultry, fat-free and low-fat dairy products, nuts, seeds, and legumes, as well as vitamins and minerals [8]. The conventional approach has not done much to reduce the number of patients with this deadly condition in recent years. The growing patient ratio with HPT might be decreased with the use of natural therapies. Several strategies are effective in treating high blood pressure, including diet, exercise, stress management, vitamins, and herbs. Many studies on natural remedies for high blood pressure have been conducted each year [4, 9]. Natural remedies have greatly aided the development of industrial medication formulations. Natural plants contain several phytochemicals that act as potential hypotensive and might be used for pharmaceutical applications in the future (**Table 1**). Today, traditional medicines are giving way to new synthetic treatments that researchers and medical professionals claim are more reliable and effective [10-12]. Numerous natural herbs, including barberry, garlic, ginger, ginseng, and arjuna, are used to cure it. These plants can be carefully used as medications for HPT [13]. The herbs that have been scientifically shown to be effective in treating HPT are highlighted in this review.

Materials and methods

To find appropriate studies and literature published up until January 2025, a comprehensive literature search was conducted using Scopus, Google Scholar, PUBMED, and the NIH research website. The search approach included the following keywords: natural herb, anti-hypertensive plants, medicinal herbs' ability to decrease blood pressure, the pathophysiology of HPT, hypotensive phytoconstituent, non-pharmacological treatment for high blood pressure, etc. The search was limited to publications written in English. To discover all the results, full-text publications were examined, and subjective data was succinctly collected.

Causes of hypertension: Enhanced activity of the Sympathetic Nervous System, boosted production of hormones that retain sodium and vasoconstrictors, lack of vasodilators like prostacyclin and nitric oxide, improper and enhanced secretion of renin which results from raised fabrication of angiotensin-II and aldosterone, genetic disposition, Cushing syndrome, raised intracranial pressure, brain tumors, encephalitis, respiratory acidosis, thyrotoxicosis, congenital adrenal hyperplasia, polycystic disease, diabetic nephropathy, and cardiovascular disease. The function of herbs in the treatment of high blood pressure**:** In many regions of the world, traditional medicines have been used for thousands of years to address a variety of health issues. Developing nations continue to use these medicines today. In many developing nations, the use of herbal medicine has been growing [14-16]. Due to popular discontent with the high expense of pharmaceutical medications and a desire to revert to natural cures, industrialized nations have also demonstrated a greater interest in and usage of herbal medications [11, 12, 17-19]. A substantial contribution to the advancement of cardiovascular research has been made by herbal medications. Patients with HPT, congestive heart failure, angina pectoris, atherosclerosis, cerebral insufficiency, and arrhythmia have all been treated using herbal remedies for cardiovascular conditions [20]. Due to their many biological and medicinal properties, ease of availability, higher safety margins, and lower cost, herbal medicines have become increasingly important in the treatment of HPT in recent years and are in high demand for primary healthcare in both developed and developing nations. Herbal plants would have been significant and long-lasting alternative sources of treatment for high blood pressure given the rising trend of HPT prevalence and burden, severe adverse side effects, treatment failure, lack of affordable mono-therapeutic anti- HPT medications in use, and their severe adverse side effects [21, 22].

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Table 1: Important medicinal plants with their antihypertensive phytochemical contents

Medicinal plant	Antihypertensive phytochemicals	Medicinal plant	Antihypertensive phytochemicals
Tea (*Camellia sinensis*)	catechin, epicatechin, epicatechin gallate	Cardamom (*Elettaria cardamomum*)	1,8-cineole, terpinyl acetate, limonene, and terpinolene
Basil (*Ocimum basilicum*)	linalool and eugenol	Roselle (*Hibiscus sabdariffa*)	anthocyanins and polyphenols
Garlic (*Allium sativum*)	allicin, diallyl disulfide, and ajoene	Cocoa Bean (*Theobroma cacao*)	procyanidins, catechins, and epicatechin
Arjuna (*Terminalia arjuna*)	triterpenoids, flavonoids, and oligomeric proanthocyanidins	Sweet lime (*Citrus limetta*)	limonene, flavonoids
Beetroot (*Beta vulgaris*)	betalains (betacyanins and betaxanthins), polyphenols	Saffron (*Crocus sativus*)	crocin, safranal, and crocetin
Ginger (*Zingiber officinale*)	gingerols and shogaols	Turmeric (*Curcuma longa*)	Curcumin, demethoxycurcumin and bisdemethoxycurcumin
Ginseng (*Panax ginseng*)	ginsenoside Rg3 and arginine-fructose (Arg-Fru)	Brahmi (*Centella asiatica*)	bacosides (specifically bacoside A3, bacopaside II, bacopaside X, and bacopasaponin C)
Parsley (*Petroselinum crispum*)	apigenin and its glycosides	Black Cumin (*Nigella sativa*)	thymoquinone, thymol, and dithymoquinone
Onion (*Allium cepa*)	quercetin, organosulfur compounds	Coriander (*Coriandrum sativum*)	linalool
Goldthread (*Coptis chinensis*)	berberine (BBR)	Ashwagandha (*Withania somnifera*)	withanolides, alkaloids, flavonoids, and glycosides
Coconut (*Cocos nucifera*)	flavonoids, phenols, and alkaloids	Bitter melon (*Momordica charantia*)	charantin, polypeptide-p, alkaloids, saponins, and phenolic compounds
Star fruit (*Averrhoa carambola*)	kaempferol, luteolin, naringenin	Ashoka (*Polyalthia longifolia*)	quercetin and kaempferol, β-Sitosterol
Yarrow (*Achillea millefolium*)	leucodin, achillin, artemetin, and various flavonoids like apigenin and rutin	Jatamansi (*Nardostachys jatamansi*)	jatamansone, nardostachone, and valeranal, as well as (-)-aristolone and kanshone H.
Oats (*Avena sativa*)	beta-glucan, avenanthramides, and phenolic acids	African mammee (*Mammea africana*)	xanthones, coumarins, and flavonoids
Garden cress (*Lepidium sativum*)	lepidine, semilepidinoside A, and semilepidinoside B	Sea thistle (*Cirsium japonicum*)	apigenin, acacetin, diosmetin, and luteolin
Tagara (*Valeriana wallichii*)	iridoids, sesquiterpenes	Large-flowered sword plant (*Echinodorus grandiflorus*)	diterpenoids and flavonoids
Chokeberry (*Aronia mitschurinii*)	anthocyanins, flavonols, and phenolic acids	Turkey berry (*Solanum torvum*)	flavonoids, alkaloids, and steroidal glycosides
Celery (*Apium graveolens*)	3-n-butylphthalide (NBP) and apigenin	Lemongrass (*Cymbopogon citratus*)	quercetin, luteolin, and apigenin
Olive tree (*Olea europaea*)	oleuropein	Nasturtium (*Tropaeolum majus*)	isoquercitrin and quercetin
Virgin bladder (*Commelina virginica*)	octadecanoic acid, 9,12-octadecadienoic acid, and phenol, 4-ethenyl- acetate	Carrot (*Daucus carota*)	coumarin glycosides (DC-2 and DC-3), phenolic compounds, carotenoids, and polyacetylenes
Coin leaf (*Desmodium styracifolium*)	shaftoside and styracifoline	Lavender (*Lavandula stoechas*)	flavonoids, catechic tannins, sterols, and coumarins
Tomato (*Lycopersicon esculentum*)	lycopene, chlorogenic acid, caffeic acid, and rutin	Sesame seeds (*Sesamum indicum*)	sesamin, sesamol, and sesamolin
Mistletoe (*Viscum album*)	Chlorogenic acid, caffeic acid, phenylpropanoids	Pomegranate (*Punica granatum*)	ellagic acid, ellagitannins, punicalagin, and anthocyanins

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Pathophysiology of hypertension: The pathophysiological factors (**Figure 1**) linked to the development of HPT include increased vascular resistance, which is primarily identified by decreasing vascular diameter due to increased arterial remodeling and vascular contraction [23]. The pathophysiology of HPT is caused by a variety of factors, such as increased renin-angiotensin-aldosterone system (RAAS), sympathetic nervous system stimulation, vasopressin, disrupted G protein-coupled receptor signaling, inflammation, various T-cell functions, and the variety of vasoactive peptides released by other endothelial cells and smooth muscle cells [24]. Enhanced vasoconstriction may result from increased basal and activated calcium levels via calcium channels, increased arterial reactivity due to dysregulation in pro-oxidant enzymes and endothelial nitric oxide synthase (eNOS), and co-occurrence of vascular smooth muscle cell (VSMC) hyperplasia and hypertrophy [25]. HTN and its complications, including atherosclerosis, are promoted by increased vascular stiffness, suggesting that treatment should target vascular stiffness rather than only peripheral vascular resistance regulation [26]. Other potential causes of HPT include hereditary disorders of renal sodium secretion, genetically related disorders of the Na/Ca^{2+} exchange in artery smooth muscles, and hormonal-neurogenic vasoconstriction [27].

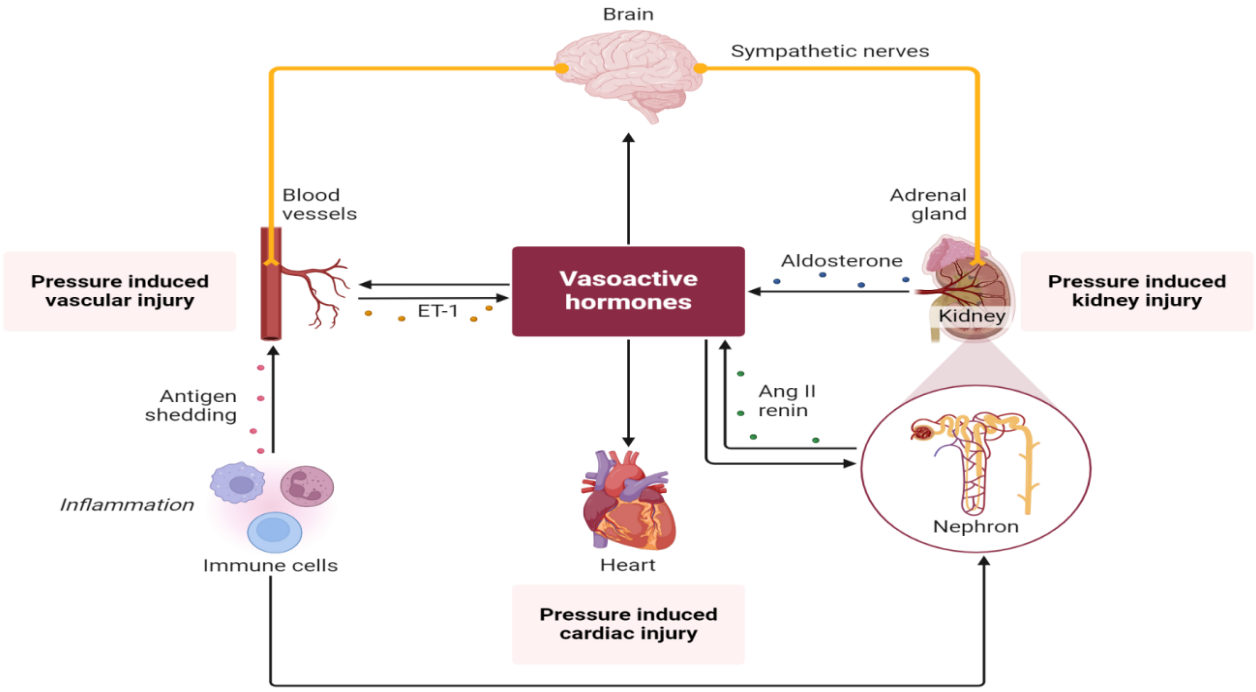

Figure 1: Pathophysiology of hypertension [37]

Treatment of hypertension with medicinal plants: Products derived from plants, animals, and minerals serve as the foundation for the treatment of a number of different illnesses. Nearly 80.0% of people in developing nations rely on natural herbs to cure a variety of illnesses, according to a new estimate. Additionally, these natural herbs are derived from a variety of plants and animals. Natural medications have become more and more popular in recent years. Approximately 500 plants and their therapeutic uses have been documented in ancient texts, and roughly 800 plants have been used in regional medical systems [28]. Because of the negative impacts of allopathic treatment, there is also a growing need for organic products in Western nations. Consequently, several pharmaceutical companies are increasingly concentrating on the production of natural (phytopharmaceutical) medications [29]. There are about 20,000 known plants with therapeutic qualities. The development of novel medicines derived from medicinal plants has been greatly impacted by the ease with which chemical standards from natural resources can now be established. Numerous natural medications have

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been used to treat HPT; a few of these are described here. The effectiveness of common herbs in treating HPT is reviewed in this article, including *Allium sativum*, Arjuna, Beetroot, Cardamon, *Hibiscus sabdariffa*, Ginger, *Panax spp*., Turmeric, basil, tea sweet lime are summarized in (**Table 2**). Plants that have been researched or reported to have antihypertensive activity in animal experiments with possible mechanisms are listed in (**Table 3**), along with information on their families, modes of action, and references.

Table 2: Brief overview of common medicinal plants used to treat hypertension

Medicinal plant	Part used	Dose	Reference
Garlic (*Allium sativum*)	Fruits	300-1200 mg/day	[43]
Arjuna (*Terminalia arjuna*)	Bark	-	[31]
Beetroot (*Beta vulgaris*)	Root powder juice	3-6 g/day	[44]
Cardamom (*Elettaria cardamomum*)	Crude	3 g/day	[34]
Roselle (*Hibiscus sabdariffa*)	Flower	250 mg-10 g/day	[45]
Ginger (*Zingiber officinale*)	Root	70-140 mg/kg	[38]
Ginseng (*Panax ginseng*)	Root	3 g/day	[40]
Turmeric (*Curcuma longa*)	Root	50-100 mg/kg/day	[42]
Brahmi (*Centella asiatica*)	Leaves	-	[47]
Saffron (*Crocus sativus*)	Stigma	400 mg	[48]
Tea (*Camellia sinensis*)	Leaves	-	[49]
Sweet lime (*Citrus limetta*)	Fruits	-	[50]
Basil (*Ocimum basilicum*)	Whole plant	-	[51]
Cocoa Bean (*Theobroma cacao*)	Bean	40-100 g	[52]
Black Cumin (*Nigella sativa*)	Seed oil	200 mg/kg	[53]

Patients with HPT frequently utilize garlic due to its purported ability to decrease blood pressure and prevent cardiovascular disease. Garlic's anti-inflammatory and cancer-prevention properties have also been touted. Research has indicated a wide range of physiological effects, such as elevated levels of antioxidant enzymes and suppression of platelet activity. In garlic formulations, there are most likely many active components. Not unexpectedly, a number of studies have been conducted to investigate its potential for treating hyperlipidemia and HPT. According to the Agency for Health Care Research and Quality's evidence study on garlic, which included 37 randomized studies, garlic preparations did, in fact, temporarily cut total cholesterol, but no decrease was shown after six months [30]. Arjun plant is found across India. Its bark is the portion that has been used as a medication for almost three centuries to cure various diseases. Gallic acid, triterpenoid saponins, magnesium, ellagic acid, phytosterols, flavonoids, calcium, zinc, and copper are among its constituent chemicals [31]. It lowers systolic blood pressure and is used to treat a variety of conditions, including cardiac conditions including coronary artery disease, HPT, congestive heart failure, stable angina, and more. It has no adverse effects on the liver, kidneys, or blood [32]. When 200-800 mg of nitrate from beetroot juice is consumed daily, it may lower clinical systolic blood pressure in hypertensive people who do not exhibit any symptoms of tolerance. Results should be viewed cautiously because the evidence is not very certain [33]. The fruit powder of *Elettaria cardamomum* has been evaluated for its potential to lower blood pressure. By raising the overall antioxidant status, it has been demonstrated to lower mean systolic and diastolic blood pressure in pre-hypertensive patients by 19- and 12-mm Hg, respectively, when taken as a powder (3.0 g) [34].

Hibiscus sabdariffa is used in traditional medicine to treat wounds, bronchitis, diabetes, heart and neurological conditions, calcified artery repair, antispasmodic, hypochlosterolemic, antibacterial, antifungal, anticancer, muscle relaxant, and more recently, antihypertensive [35]. This plant's extract has antihypertensive properties through at least three main specific mechanisms of action: diuretic, vasodilator, and angiotensin-converting enzyme inhibitor (ACE inhibitor). However, hibiscus also has long-term effects as an antioxidant and a hypocholesterolemic, which are thought to have a cardioprotective effect. As demonstrated by potassium K^+

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values, corresponding index, and the saluretic relationship of Na^+/K^+ [24], HS acts as a diuretic by inhibiting sodium and water reabsorption. This gives it an advantage over the loop diuretic furosemide in that it does not cause over-reactivation of the rennin-angiotensin aldosterone system and maintains the potassium concentration in the body [36].

Table 3: Common antihypertensive medicinal plants with their mechanism of action

Medicinal plant	Mechanism of action	Family	Reference
Garlic (*Allium sativum*)	Enhance the availability of hydrogen sulphide (H_2S) and nitric oxide (NO)	Alliaceae	[54]
Arjuna (*Terminalia arjuna*)	It can increase endothelial function, decrease oxidative stress, and cause vasodilation	Combretaceae	[31]
Beetroot (*Beta vulgaris*)	Its high nitrate content, which the body transforms into nitric oxide (NO), is the procedure	Amaranthaceae	[44]
Cardamom (*Elettaria cardamomum*)	Blockage of calcium channels, nitric oxide synthesis promotion, and antioxidant activity	Zingiberaceae	[34]
Roselle (*Hibiscus sabdariffa*)	Blocks the Ca^{2+} channels and raises NO. Reduce the levels of plasma Na^+	Malvaceae	[55]
Ginger (*Zingiber officinale*)	Blocks calcium channel and inhibits peroxidation	Zingiberaceae	[56]
Ginseng (*Panax ginseng*)	Boosting the production of nitric oxide (NO) in vascular endothelial cells	Araliaceae	[40]
Turmeric (*Curcuma longa*)	Reducing arterial stiffness, and improving vascular function	Zingiberaceae	[42]
Brahmi (*Centella asiatica*)	Possibly by affecting the RAAS (renin-angiotensin-aldosterone system)	Apiaceae	[47]
Saffron (*Crocus sativus*)	Activates eNOS and blocks Ca^{2+} channels	Iridaceae	[48]
Tea (*Camellia sinensis*)	Inhibits ACE (AT_1 receptor) as well as Increases NO	Theaceae	[57]
Sweet lime (*Citrus limetta*)	Through the inhibition of angiotensin II	Rutaceae	[50]
Basil (*Ocimum basilicum*)	The effects of eugenol on the cardiovascular system are associated with its capacity to block calcium channels	Lamiaceae	[58]
Cocoa Bean (*Theobroma cacao*)	Calcium channel blocker	Malvaceae	[59]
Black Cumin (*Nigella sativa*)	Increases the activity of cardiac heme oxygenase-1 and stops the loss of plasma nitric oxide	Ranunculaceae	[53]

Commonly known as ginger, *Zingiber officinale* has been used extensively in everyday diets and for a variety of medicinal uses. Potassium, which is abundant in ginger, helps to regulate blood pressure and heart rate. Two bioactive components of ginger, (6)-gingerol and (6)-shogaol, can be administered intravenously (1.75-3.5 mg/kg) or orally (70-140 mg/kg) to produce tri-phasic blood pressure profiles: a quick decrease in blood pressure followed by an intermediate increase and a protracted fall. (6)-gingerol is now thought to be a novel antagonist of the Ang II type 1 receptor [37]. Ginger has recently been shown to lower triglyceride, low-density lipoprotein, very low-density lipoprotein, and total cholesterol levels. Moreover, it suppresses ACE-1 activity [38].

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Ginseng has hypotensive properties and is utilized in a variety of forms, including tea, dried roots, extracts, pills, capsules, and oil. Higher dosages of ginseng are hypotensive, whereas smaller amounts raise blood pressure. Ginseng thereby lowers blood pressure in hypotensive individuals, most likely via altering arterial baroreflex, regulating autonomic nervous system activity, or changing vascular function [39]. Red ginseng, or ginsenoside Rg3, increases eNOS, cGMP, and NO levels, and activates Ca_2^+-gated K^+ channels. Additionally, ginseng exhibits antihypertensive and anti-atherosclerotic properties, as well as an anti-proliferative effect on VSMCs [40]. Turmeric, or *Curcuma longa*, is a plant native to Southeast India that is grown extensively across South Asia's tropical regions. The compound turmeric, often known as curcumin, has anti-inflammatory and anti-cancer effects [41]. Curcumin has positive benefits on cardiovascular diseases including HPT. Curcumin inhibits the progression of HPT by reducing AT_1R-mediated vasoconstriction and lowering AT_1R expression in arteries via disrupting SP1/AT_1R DNA binding [42].

Safety issues of natural products: When integrating natural products into their practices, practitioners should keep in mind a number of important factors: standardization, quality assurance, and clinical evidence from the appropriate authorities (**Table 4**). Customers and healthcare providers must seek products made by reliable companies that have earned third-party certification in order to guarantee that the health supplements on the market are safe, effective, and pure [11, 12, 64].

Table 4: Integration of natural products into hypertension therapies may raise questions and issues

Issues	Explanation	References
Standardization fact	Natural products' therapeutic efficacy varies depending on their source, content, and quality, which makes it difficult to combine them with conventional medications for HPT.	[60]
Possibility of drug interactions	Conventional cardiovascular drugs and natural items may interact, producing either antagonistic or synergistic results. For example, anticoagulants and omega-3 fatty acids shouldn't be used together because they can have serious side effects, such as bleeding.	[61]
Bioavailability issues	The majority of natural substances like curcumin, have low bioavailability and are therefore poorly absorbed by the body. Therefore, when used in combination with traditional therapy, they are less effective. Therefore, methods to improve their solubility are needed.	[62]
Lack of strong clinical evidence	The majority of natural items that show potential in the initial round of testing have not undergone extensive, double-blind scientific trials to ascertain their efficacy and safety when used in combination with traditional treatment for various diseases.	[63]

Conclusion: Medicinal plants are currently the subject of extensive conservation research to determine whether their traditional applications are based on folklore or real pharmacological properties. Comparing herbal remedies to synthetic pharmaceuticals, the herbal is less expensive and has fewer negative side effects. The most widely utilized plants for the treatment and control of hypertension are summarized in this review. Additionally, it is recommended that patients get appropriate education and information on the usage of herbs that have been used for a long time, such as garlic, basil, and beetroot.

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