INTERNATIONAL JOURNAL OF PHARMACEUTICAL SCIENCES
[ISSN: 0975-4725; CODEN(USA): IJPS00]
Journal Homepage: https://www.ijpsjournal.com

OPEN ACCESS

Review Article

Natural Hypertension Remedies: A Review of Medicinal Plant Efficacy

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ARTICLE INFO

Published: 08 April. 2025
Keywords:
Hypertension, Medicinal Plants, Antihypertensive Therapy, Vasodilation, ACE Inhibition, Traditional Medicine.
DOI:
10.5281/zenodo.15173728

ABSTRACT

Background: Hypertension is a significant global health concern and a major risk factor for cardiovascular diseases. While conventional antihypertensive drugs are widely used, they often cause side effects, leading to an increasing interest in plant-based alternatives. Traditional medicine has long utilized medicinal plants for managing hypertension, with various species demonstrating promising blood pressure-lowering effects. Objective: This review examines medicinal plants with antihypertensive properties, emphasizing their therapeutic potential, mechanisms of action, and pharmacological significance. Methods: A systematic review of the literature was conducted to identify medicinal plants with documented hypotensive effects. Studies investigating their bioactive compounds and mechanisms, including diuretic action, calcium channel blockade, nitric oxide (NO) modulation, and angiotensin-converting enzyme (ACE) inhibition, were analysed. Key Findings: Several medicinal plants, such as Allium sativum (garlic), Nigella sativa (black cumin), Bidens pilosa (black-jack), and Tribulus terrestris, exhibit significant antihypertensive effects. Their mechanisms of action include vasodilation, inhibition of ACE, and antioxidant activity, contributing to improved vascular health. These plants offer potential as complementary or alternative therapies for hypertension, with fewer side effects compared to conventional medications. However, further clinical trials are needed to confirm their safety, efficacy, and optimal dosages.

INTRODUCTION

Cardiovascular diseases (CVDs) remain a major public health concern, contributing significantly to morbidity and premature mortality worldwide. Among these, hypertension (HTN), often termed the "silent killer," is one of the most prevalent risk factors for cardiovascular complications. It arises due to a complex interplay of genetic predisposition and environmental influences, disrupting the body's natural mechanisms for

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Relevant conflicts of interest/financial disclosures: The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

blood pressure regulation [1,2]. Hypertension is a primary contributor to acute myocardial infarction and is responsible for a substantial percentage of global deaths annually. Clinically, it is defined as a systolic blood pressure (SBP) of ≥140 mm Hg and a diastolic blood pressure (DBP) of ≥90 mm Hg, based on multiple seated BP measurements. Although a wide range of antihypertensive medications is available—including diuretics, calcium channel blockers, renin inhibitors, beta-blockers, and vasodilators—these drugs are often associated with adverse effects such as fatigue, dizziness, kidney dysfunction, and electrolyte imbalances [3,4,5,6,7]. The increasing interest in alternative medicine has led to a renewed focus on herbal therapies for cardiovascular conditions. A significant portion of the global population, particularly in developing countries, relies on medicinal plants due to their affordability, biocompatibility, and lower risk of side effects compared to synthetic pharmaceuticals. Traditional systems of medicine, such as Persian medicine, have long recognized the therapeutic potential of natural products. Historical figures like Avicenna and Rhazes documented numerous herbal treatments for cardiovascular ailments, many of which have contributed to modern drug development [8,9,10,11]. This review aims to explore various medicinal plants with antihypertensive properties, highlighting their potential role in managing hypertension and providing insight into their mechanisms of action.

Pathophysiology of Hypertension

Hypertension (HTN) primarily develops due to increased vascular resistance, which results from vascular contraction and arterial remodeling. Several physiological and molecular mechanisms contribute to its progression, including activation of the renin-angiotensin-aldosterone system (RAAS), overactivity of the sympathetic nervous system, vasopressin release, and dysregulation of G protein-coupled receptor signaling. Additionally, inflammatory processes, T-cell dysfunction, and the release of vasoactive peptides from endothelial and smooth muscle cells further exacerbate blood pressure elevation [12,13]. Endothelial dysfunction plays a crucial role in HTN pathogenesis, often involving an imbalance between pro-oxidant enzymes and endothelial nitric oxide synthase (eNOS). This imbalance leads to increased arterial reactivity and reduced vasodilatory capacity. Additionally, elevated intracellular calcium levels through calcium channels, along with vascular smooth muscle cell (VSMC) hyperplasia and hypertrophy, contribute to excessive vasoconstriction [14]. Another key factor in HTN progression is increased vascular stiffness, which is strongly associated with complications such as atherosclerosis. This highlights the importance of therapeutic strategies that target vascular compliance in addition to reducing peripheral vascular resistance. Angiotensin II (Ang II), a central component of RAAS, promotes cell cycle progression and vascular remodeling, further intensifying arterial changes. Moreover, genetic mutations affecting renal sodium excretion, abnormalities in Na+/Ca2+ exchange within arterial smooth muscle cells, and neurohormonal vasoconstrictive mechanisms have been identified as additional contributors to hypertension development [15,16,17,18].

Herbal Medicines for The Treatment of Hypertension

While conventional antihypertensive medications effectively lower blood pressure, they are often associated with adverse effects, prompting interest in alternative therapeutic approaches. Scientific studies suggest that incorporating medicinal plants alongside lifestyle modifications may serve as a

complementary strategy for hypertension (HTN) management. Many herbs and spices contain bioactive secondary metabolites with antihypertensive properties. These compounds exert their effects through various mechanisms, including antioxidant, anti-inflammatory, and anti-apoptotic activities. Additionally, they enhance endothelial nitric oxide synthase (eNOS) activity, leading to increased nitric oxide (NO) production, which plays a crucial role in vasodilation. Some herbal medicines also regulate endothelial permeability and promote angiogenesis, further contributing to vascular health and blood pressure regulation [19,20]. The specific mechanisms by which medicinal plants or their extracts aid in hypertension management are illustrated in Figure 1

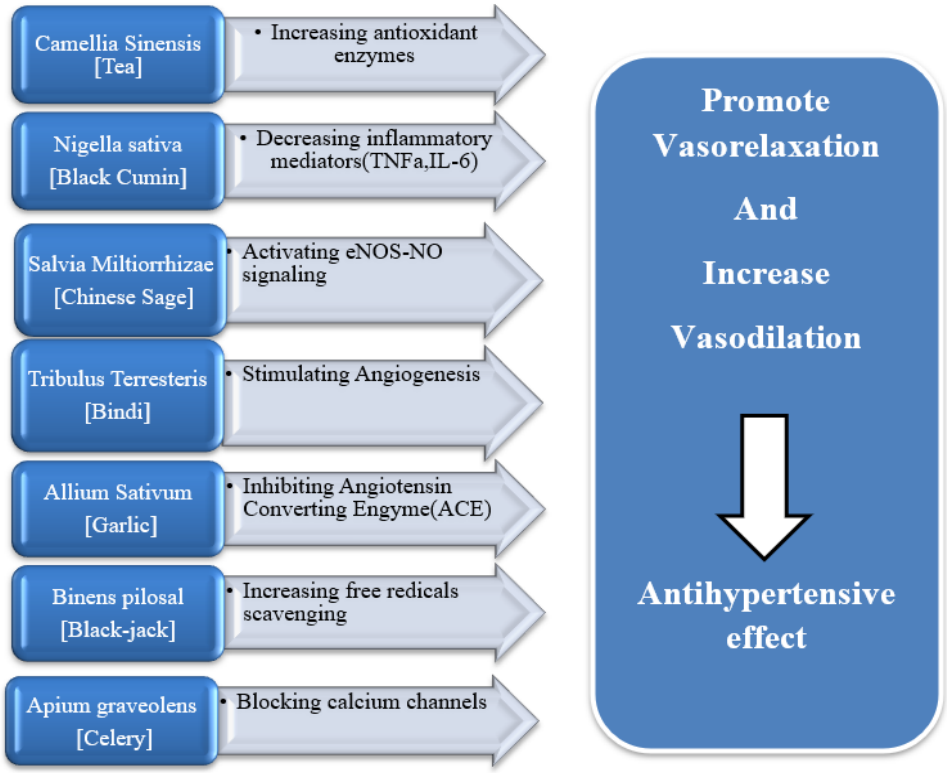

Figure 1 Schematic diagram showing the mechanism of some medicinal plant or their extract in the management of Hypertension.

Table 1 Effective medicinal plants on Hypertension

Herb	Mechanism of Action	Part Used	Dose
Ajwain *(Carum copticum)*[26]	- Blocks calcium channels - Cholinomimetic effects - Vasodilation of coronary arteries - Lowers systemic blood pressure	Leaves, Seed-like fruit	1-30 mg/kg
Bindii (*Tribulus terrestris*)[27]	- Increases NO - Reduces ACE - Inhibits Ang II-induced proliferation	Leaves, Aqueous extract of fruits	0.3–15 mg/mL

Black Cumin (*Nigella sativa*)[28]	- Reduces cardiac oxidative stress - Decreases angiotensin-converting enzyme activity - Enhances cardiac heme oxygenase-1 activity - Prevents plasma nitric oxide loss	Seed oil	100 mg/kg, 200 mg/kg
Black-Jack (Bidens pilosa L.)[29]	- Acts as calcium channel antagonist	Leaves	75 and 150 mg/kg
Burdock (Arctium lappa)[30]	- Suppresses VCAM-1 in aortic endothelial cells - Promotes vasorelaxation	Root	100 and 200 mg/kg/day
Cardamom (Elettaria cardamomum) [24,31]	- Blocks calcium channels - Increases urine output - Enhances sodium and potassium excretion	Crude	3 g/day
Celery (Apium graveolens)[32]	- Lowers levels of circulating catecholamines - Reduces vascular resistance - Blocks calcium channels	Seeds	300 mg/kg
Chinese Sage (Salvia miltiorrhizae)[33]	- Increases NO - Opens KATP channels - Blocks calcium channels - Reduces ACE activity	Dried root	0–10 mg/mL
Cocoa Bean (Theobroma cacao)[34]	- Upregulates NO - Promotes vasodilation - Improves endothelial function	Cocoa bean	40 - 105 g
Garden Nasturtium (Tropaeolum majus L.)[35]	- Downregulates ACE - Increases NO - Decreases aldosterone - Reduces renal sodium/potassium pump - Increases urine volume	Seeds, Leaves, Flowers	10-300 mg/kg
Garlic (Allium sativum)[25,36]	- Relaxes blood vessels - Reduces blood clotting ability - Increases NO - Inhibits ACE - Prevents Ang-II-induced cell cycle progression	Fruits	300–1500 mg/day
Ginger (Zingiber officinale)[21,37,50]	- Blocks calcium channels - Promotes vasodilation	Root	70–140 mg/kg
Ginseng (genus Panax)[38]	- Enhances NO and cGMP levels - Has anti-proliferative effects on vascular smooth muscle cells (VSMCs)	Root	3 g/day
Japanese Thistle (Cirsium japonicum)[39]	- Induces vasorelaxation - Elevates NO levels - Acts as an antagonist for the AT1 receptor	Whole plant	0.05–0.4 mg/mL
Onion (Allium cepa)[40,47]	- Improves artery elasticity - Decreases blood viscosity - Interacts with the Renin-Angiotensin System	Fruits	400 mg/kg/day

	- Enhances endothelial and vascular function		
Pomegranate (Punica granatum)[41]	- Enhances endothelium-dependent coronary relaxation - Inhibits calcium influx - Reduces ACE activity	Fruits	50 mL/day
Radish (Raphanus sativus)[42]	- Increases NO production	Seeds, Leaves, Root	30 and 90 mg/kg
Roselle (Hibiscus sabdariffa)[43]	- Enhances NO production - Inhibits calcium channels - Opens KATP channels	Leaves, Flowers	250 mg–10 g/day
Saffron (Crocus sativus) [23,44]	- Activates eNOS - Blocks calcium channels	Stigma	400 mg
Sumac (Rhus coriaria)[45]	- Evokes endothelium-dependent vasorelaxation - Activates eNOS	Leaves, Fruits (red berries)	0.3–300 µg/mL
Tea (Camellia sinensis)[46]	-Inhibition of angiotensin converting enzyme -Blocks Ca2+ channels -Diuretic -Enhances eNOS activity	Leaves	3 cups/day
Turmeric (Curcuma longa) [22,47]	-Interference with Ca2+ concentration -Reduces ACE activity -Reduces AT1 receptor expression -Increase vasodilation -Increase No production	Root	50-100 mg/kg/d
Cucumber (Cucumis sativus)[48]	- Rich in potassium: helps regulate sodium balance and lower blood pressure - Contains magnesium and fiber: supports vascular health - Antioxidants reduce oxidative stress, a contributor to hypertension	Fruit (fresh/raw)	200–300g raw fruit daily - 200–250 ml fresh juice

Plants

1.Allium sativum (Garlic)[25,36]

Garlic (*Allium sativum L.*) belongs to the Amaryllidaceae family and is derived from its bulb. Native to Central Asia, it has long been used in traditional medicine for cardiovascular health.

Mechanism of Action

Garlic lowers blood pressure through multiple pathways:

- **Vasodilation**: Enhances nitric oxide (NO) synthesis, relaxing blood vessels.
- **ACE Inhibition**: Reduces angiotensin-converting enzyme (ACE) activity, preventing blood vessel constriction.
- **Oxidative Stress Reduction**: Lowers inflammation and improves vascular function.
- **Calcium Channel Modulation**: Helps in blood vessel relaxation, further reducing pressure.

Therapeutic Benefits

Regular garlic intake helps reduce systolic and diastolic blood pressure, prevents cardiovascular diseases, and supports endothelial function.

Key Compounds

The antihypertensive effects are attributed to allicin (formed from alliin when crushed), diallyl disulfide (DADS), diallyl trisulfide (DATS), S-allyl cysteine (SAC), flavonoids, saponins, and essential minerals like selenium and manganese.

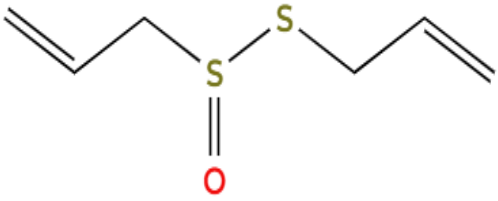

Figure 2. Structure of Allicin

Dosage

- **Supplements**: 600–1200 mg/day, divided into 2–3 doses.
- **Fresh Garlic**: 1–2 cloves per day (≈2–5 grams).

2.Carum copticum (Ajwain) [26]

Carum copticum (*Trachyspermum ammi*), from the Apiaceae family, is obtained from its dried seeds. Native to Egypt and the Eastern Mediterranean, it is widely cultivated in India, Iran, Pakistan, and Afghanistan.

Mechanism of Action

Ajwain helps lower blood pressure through:

- **Vasodilation**: Calcium channel blockade promotes blood vessel relaxation.
- **Antioxidant Effects**: Reduces oxidative stress, supporting vascular health.
- **ACE Inhibition**: May help regulate blood pressure by inhibiting angiotensin-converting enzyme (ACE).
- **Lipid Modulation**: May improve lipid levels and prevent arterial plaque formation.

Therapeutic Benefits

Ajwain is traditionally used in Ayurveda for cardiovascular and digestive health. It may reduce hypertension, support lipid metabolism, and prevent arterial damage.

Key Compounds

The active constituents include **thymol** (primary bioactive compound), p-cymene, γ-terpinene, β-pinene, limonene, carvacrol, flavonoids, and glycosides.

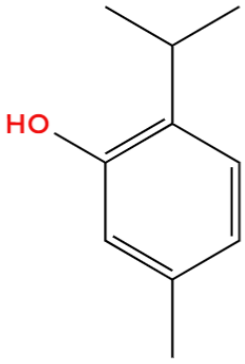

Figure 3. Structure of Thymol

Dosage

- **Traditional Use**: 1–2 grams of seeds daily.
- **Extract Form**: 50–100 mg/kg (requires further clinical validation).

3.Tribulus terrestris (Bindii) [27]

Tribulus terrestris, commonly known as Bindii or Puncture Vine, belongs to the Zygophyllaceae family. Native to warm temperate and tropical regions, it is widely found in India, China, the Mediterranean, and parts of Africa and Australia.

Mechanism of Action

- **Vasodilation**: Enhances nitric oxide (NO) production, improving blood flow.
- **ACE Inhibition**: Helps lower blood pressure by reducing vascular resistance.
- **Diuretic Effect**: Reduces blood volume, further aiding in blood pressure control.

Therapeutic Benefits

Tribulus terrestris is used in traditional medicine to manage hypertension, support cardiovascular health, reduce cholesterol, and enhance libido.

Key Compounds

The plant contains protodioscin (a steroidal saponin), tribulosin, flavonoids, alkaloids, steroidal glycosides, tannins, and resins.

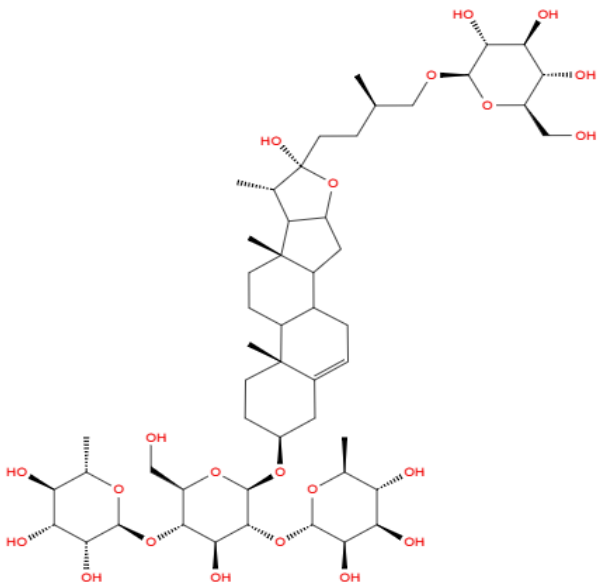

Figure 4. Structure of Protodioscin

Dosage

- **Extract Form**: 250–1,500 mg/day (standardized).
- **Dried Fruit Powder**: 500–1,000 mg/day or aqueous extract (traditional use).

4.Nigella sativa (Black Cumin) [28]

Nigella sativa, commonly known as Black Cumin, belongs to the **Ranunculaceae** family. It is native to South and Southwest Asia and cultivated in the Middle East, North Africa, Southern Europe, and India.

Mechanism of Action

- **Vasodilation**: Increases nitric oxide (NO) levels, promoting blood vessel relaxation.
- **Antioxidant Properties**: Reduces oxidative stress, protecting endothelial function.
- **ACE Inhibition**: Thymoquinone, a key compound, inhibits angiotensin-converting enzyme (ACE) and enhances diuretic effects.

Therapeutic Benefits

- Lowers systolic and diastolic blood pressure.
- Improves endothelial function and arterial flexibility.
- Reduces oxidative stress and supports cardiovascular health.

- Traditionally used for hypertension, hypercholesterolemia, and diabetes management.

Key Compounds:

Thymoquinone (main active component), nigellone, p-cymene, carvacrol, α-pinene, flavonoids, and fatty acids (linoleic & oleic acids).

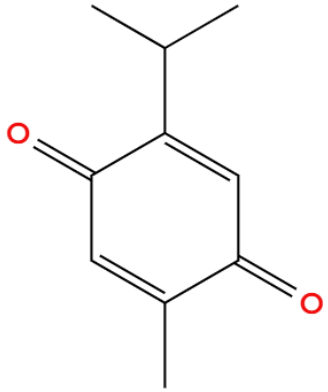

Figure 5. Structure of Thymoquinone

Dosage

- **Oil Form**: 100–200 mg/day.
- **Seed Powder**: 1–2 grams per day.
- **Standardized Extracts**: Also used in clinical settings.

5.Elettaria cardamomum (Cardamom) [31]

Cardamom, from the **Zingiberaceae** family, is native to India's Western Ghats and cultivated in Sri Lanka, Nepal, Tanzania, and Guatemala.

Mechanism of Action

- **Vasodilation**: Enhances nitric oxide (NO) production and inhibits calcium channels, promoting blood vessel relaxation.
- **Antioxidant Effects**: Reduces oxidative stress, protecting vascular function.
- **Diuretic Activity**: Aids in fluid removal, lowering blood volume and blood pressure.
- **Lipid Regulation**: May help improve cardiovascular health by modulating lipid metabolism.

Therapeutic Benefits

- Reduces systolic and diastolic blood pressure.
- Enhances vascular flexibility and reduces arterial stiffness.
- Traditionally used for hypertension, digestive disorders, and respiratory conditions in Ayurvedic medicine.

Key Compounds

Volatile oils (cineole, α-terpineol), flavonoids (quercetin, kaempferol), sterols, phenolic acids (caffeic acid), and alkaloids.

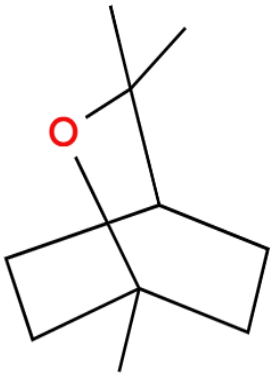

Figure 6. Structure of Cineole

Dosage

- **Cardamom Powder**: 1.5–3 grams daily for 12 weeks.
- **Extracts**: Used in supplements for blood pressure management.

6.Theobroma cacao (Cocoa) [34]

Cocoa, from the Malvaceae family, originates from the Amazon Basin and Central America and is widely cultivated in West Africa, Southeast Asia, and the Americas.

Mechanism of Action

- **Vasodilation**: Flavonoids (especially epicatechin) enhance nitric oxide (NO) production, promoting blood vessel relaxation.
- **Antioxidant & Anti-inflammatory Effects**: Reduces oxidative stress and inflammation, supporting cardiovascular health.
- **Metabolic Benefits**: Improves insulin sensitivity and lipid profiles, which indirectly aids blood pressure regulation.

Therapeutic Benefits

- Lowers blood pressure by improving endothelial function and circulation.
- Reduces oxidative damage, lowering cardiovascular risk.
- Commonly consumed as dark chocolate (70% cocoa or higher) for heart health.

Key Compounds

Flavonoids (catechins, epicatechin), **theobromine**, **caffeine**, **polyphenols**, **fatty acids** (stearic acid, oleic acid).

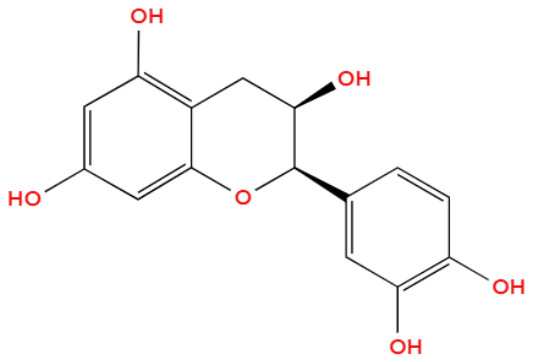

Figure 7. Structure of Epicatechin

Dosage

- **Dark Chocolate**: 30–60 grams daily (70% cocoa or higher).
- **Cocoa Powder**: 5–10 grams per day for cardiovascular benefits.

DISCUSSION:

Several medicinal plants contribute to hypertension management through diverse mechanisms such as nitric oxide (NO) enhancement, calcium channel inhibition, ACE suppression, and antioxidant properties. Ajwain (*Carum copticum*), garlic (*Allium sativum*), and ginger (*Zingiber officinale*) promote vasodilation and calcium channel blockade, leading to reduced vascular resistance. *Tribulus terrestris* and *Salvia miltiorrhizae* enhance NO levels and inhibit angiotensin-converting enzyme (ACE), while black cumin (*Nigella sativa*) and saffron (*Crocus sativus*) exert cardioprotective effects through oxidative stress reduction. Plants like celery (*Apium graveolens*), cardamom (*Elettaria cardamomum*), and garden nasturtium (*Tropaeolum majus*) exhibit diuretic properties, aiding sodium and potassium excretion. Similarly, tea (*Camellia sinensis*), cocoa bean (*Theobroma cacao*), and pomegranate (*Punica granatum*) improve endothelial function and promote vasodilation. *Onion (Allium cepa)* and *Roselle (Hibiscus sabdariffa)* regulate blood pressure by enhancing arterial elasticity and inhibiting calcium influx. These natural remedies highlight the therapeutic potential of phytochemicals in hypertension treatment, though further research is required for standardization and clinical validation.

CONCLUSION:

Medicinal plants offer promising alternatives for hypertension management through mechanisms like nitric oxide enhancement, calcium channel inhibition, ACE suppression, and diuretic effects. Herbs such as garlic, black cumin, cardamom, and hibiscus have shown significant antihypertensive potential, improving vascular health and reducing oxidative stress. While these natural remedies present fewer side effects compared to synthetic

drugs, further clinical studies are necessary to standardize dosages and establish their long-term efficacy. Integrating these plant-based therapies with conventional treatments could enhance cardiovascular health and provide holistic hypertension management.

ACKNOWLEDGMENTS:

We are thankful to Dr. Subhash University for providing guidance and support for this review work.

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HOW TO CITE: Dr. Payal Vaja *, Hiral Popaniya, Dilip Ghusar, Vivek Solanki, Siddhi Upadhyay, Harsh Madiya, Chetan Borkhataria, Natural Hypertension Remedies: A Review of Medicinal Plant Efficacy, Int. J. of Pharm. Sci., 2025, Vol 3, Issue 4, 871-883 https://doi.org/10.5281/zenodo.15173728