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Nature's Remedy: A Comprehensive Review Of Anti-Hypertensive Drugs

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Abstract: Hypertension, a chronic condition defined by blood pressure levels surpassing 140/90 mmHg, plays a significant role in worldwide health issues. Traditional antihypertensive treatments, including diuretics, calcium channel blockers, ACE inhibitors, and beta-blockers, while effective, frequently come with side effects such as fatigue, dizziness, and gastrointestinal problems. In contrast, herbal remedies have attracted interest due to their affordability, easy access, and minimal adverse effects. The use of medicinal plants is on the rise for hypertension management, offering safer therapeutic alternatives without triggering typical side effects like fatigue, sleeplessness, or irregular heartbeats. This review underscores the causes, symptoms, prevention methods, and treatment options for hypertension, highlighting the role of medicinal plants as a natural substitute for pharmaceuticals. It acts as a reference for examining the effectiveness of herbal treatments in controlling high blood pressure.

Index Terms – Hypertension, Beta blockers, ACE inhibitors, Garlic, Hibiscus.

INTRODUCTION

Hypertension, or high blood pressure, is a serious condition with readings of 140/90 mmHg or higher. It is often called the "silent killer" as it usually has no symptoms but increases the risk of heart diseases and strokes. About 26.4% of adults were affected globally in 2000, with estimates rising to 29.2% by 2025, and it is becoming a growing issue in India. Traditional medicinal plants are being recognized for their potential to help manage hypertension. Examples include Rauwolfia serpentina, which contains reserpine, and Hibiscus sabdariffa, which may lower blood pressure. Garlic and certain herbs are also noted for their benefits. While herbal remedies are gaining popularity, their use must be approached with scientific caution regarding dosage and interactions with other medications. This review aims to discuss hypertension causes, symptoms, treatments, and the role of herbal therapies in managing the condition.[1-6]

Causes and symptoms of hypertension: [7-9]

Hypertension is broadly categorized into primary (essential) and secondary hypertension based on its underlying causes.

Primary hypertension	Secondary hypertension
Increased sympathetic nervous system activity: Persistent stress or anxiety can lead to excessive activation of the sympathetic nervous system, causing elevated blood pressure.	Kidney disorders: Chronic kidney disease, polycystic kidney disease, or glomerulonephritis.
Sodium retention: A high-sodium diet increases blood volume and pressure by retaining more water in the body	Endocrine conditions: Cushing syndrome, hyperthyroidism, hypothyroidism, and primary aldosteronism.
Hormonal imbalances: Elevated levels of hormones like angiotensin II and aldosterone may lead to vasoconstriction and sodium retention.	Medications and substances: Use of oral contraceptives, nonsteroidal anti-inflammatory drugs (NSAIDs), or excessive alcohol consumption.

Symptoms of hypertension:[10]

Hypertension is commonly known as a "silent killer" since it usually presents no symptoms until complications occur. Nevertheless, when symptoms eventually manifest, they could consist of:

- Continual headaches.
- Feeling dizzy or faint.
- Difficulty breathing.
- Tiredness or overall weakness.
- Visual disturbances, like blurred vision.
- Pain in the chest or irregular heartbeat.
- Nosebleeds in extreme situations.

If hypertension is not addressed, it may result in serious complications, including:

- Cardiovascular diseases: Myocardial infarction, heart failure, and aortic aneurysm.
- Neurological conditions: Stroke, transient ischemic attacks, or cognitive deterioration.
- Renal damage: Chronic kidney disease and renal failure.
- Vision loss: Hypertensive retinopathy caused by damage to the blood vessels in the eyes.

Treatment options for hypertension:[11-12]

Hypertension can be controlled through a mix of medication, changes in lifestyle, and complementary therapies. These methods seek to decrease blood pressure to a secure level, minimize the likelihood of complications, and enhance overall quality of life.

Pharmacological Treatments: Traditional medications are frequently prescribed to control hypertension. Some of the main categories of antihypertensive medications consist of:

1. Diuretics:

These drugs assist the kidneys in eliminating excess sodium and water from the body, thus decreasing blood volume. Instances include thiazide diuretics, loop diuretics, and potassium-sparing diuretics. However, potential side effects may comprise dehydration, muscle cramps, and dizziness.

2. Beta-Blockers:

Beta-blockers decrease blood pressure by reducing the heart rate and lowering cardiac output. They are often given to individuals with heart-related issues. Possible side effects may encompass fatigue and cold extremities.

3. Calcium Channel Blockers:

These medications inhibit calcium from entering the walls of the heart and blood vessels, leading to the relaxation of blood vessels. Typical side effects include headache, swelling, and constipation.

4. ACE Inhibitors:

Angiotensin-converting enzyme (ACE) inhibitors relax blood vessels by blocking the production of angiotensin II, a hormone that prompts vasoconstriction. Side effects may involve a persistent dry cough and kidney dysfunction.

5. Angiotensin II Receptor Blockers (ARBs):

ARBs obstruct the effects of angiotensin II, resulting in blood vessel relaxation. They serve as an alternative for individuals who are unable to tolerate ACE inhibitors.

6. Lifestyle Modifications: Implementing sustainable lifestyle changes is fundamental to hypertension management. Essential modifications comprise:

7. Dietary Changes: A heart-healthy eating plan like the DASH (Dietary Approaches to Stop Hypertension) diet focuses on fruits, vegetables, whole grains, and low-fat dairy, while restricting sodium, saturated fats, and added sugars.

8. Regular Exercise: Participating in moderate physical activity, such as brisk walking or cycling, for no less than 30 minutes on the majority of days can considerably decrease blood pressure.

9. Weight Management: Shedding excess weight, especially around the waist, can alleviate pressure on the heart and help lower blood pressure.

10. Stress Management: Strategies such as meditation, yoga, or deep breathing can assist in reducing stress-related elevations in blood pressure.

11. Limiting Alcohol and Tobacco Use: Minimizing alcohol intake and refraining from smoking is vital for cardiovascular health.

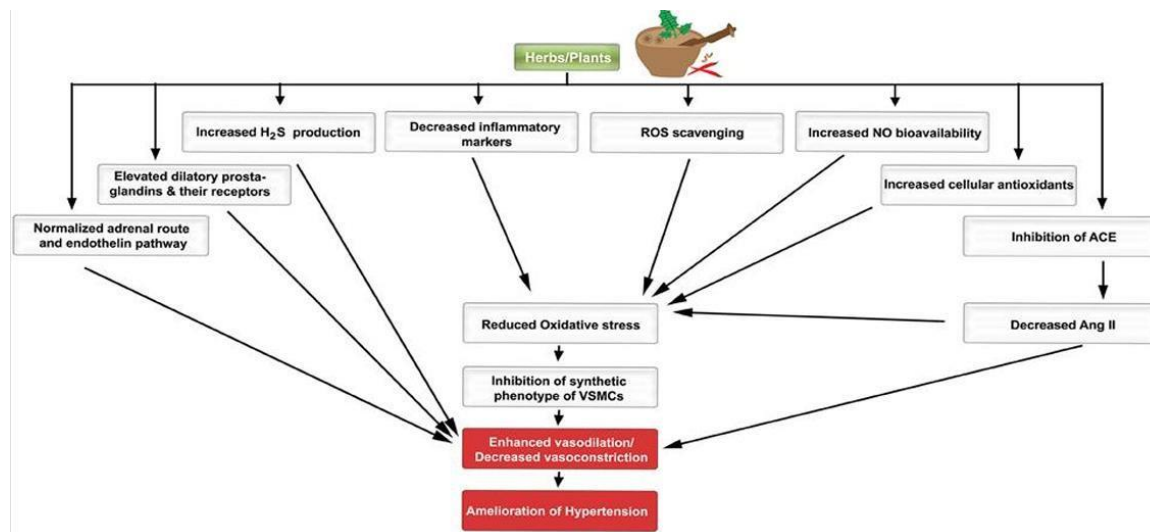


Figure 1. A schematic diagram indicating the favorable effects of plants/herbs on the molecular pathogenesis of hypertension. Different molecular, biochemical, and cellular pathways are favorably modulated by herbs/plants or their extracts.

Table 1: Herbal antihypertensive drug

General Name	Botanical Name	Mechanism of Action	Active Constituents
Garlic	<i>Allium sativum</i>	Improves nitric oxide levels, causing vasodilation and reducing blood pressure.	Allicin, Sulfur compounds
Hibiscus	<i>Hibiscus sabdariffa</i>	Acts as a natural ACE inhibitor and diuretic.	Anthocyanins, Hibiscus acid
Olive Leaf	<i>Olea europaea</i>	Enhances vasodilation and reduces oxidative stress.	Oleuropein, Hydroxytyrosol
Indian Snakeroot ⁴	<i>Rauwolfia serpentina</i>	Depletes norepinephrine stores, reducing peripheral vascular resistance.	Reserpine, Ajmalicine
Hawthorn	<i>Crataegus spp.</i>	Improves coronary blood flow and decreases vascular resistance.	Flavonoids, Procyanidins
Ginger	<i>Zingiber officinale</i>	Acts as a calcium channel blocker and improves circulation.	Gingerol, Shogaol
Celery Seed	<i>Apium graveolens</i>	Promotes vasodilation and has diuretic properties.	Phthalides, Flavonoids
Green Tea	<i>Camellia sinensis</i>	Enhances endothelial function and reduces vascular stiffness.	Catechins, Epigallocatechin gallate (EGCG)

Cinnamon	<i>Cinnamomum spp.</i>	Enhances insulin sensitivity and reduces peripheral resistance.	Cinnamaldehyde, Polyphenols
Pomegranate	<i>Punica granatum</i>	Acts as an antioxidant, improving endothelial function.	Punicalagins, Ellagic acid
Fenugreek	<i>Trigonella foenum-graecum</i>	Reduces cholesterol and enhances nitric oxide production.	Diosgenin, Alkaloids
Ashwagandha	<i>Withania somnifera</i>	Acts as an adaptogen, reducing stress-induced hypertension.	Withanolides, Alkaloids
Turmeric	<i>Curcuma longa</i>	Improves endothelial function and acts as an anti-inflammatory agent.	Curcumin, Volatile oils

Cardamom	<i>Elettaria cardamomum</i>	Promotes diuresis and improves vascular tone.	Cineole, Terpinyl acetate
Lemon Balm	<i>Melissa officinalis</i>	Reduces stress and promotes vasodilation.	Rosmarinic acid, Flavonoids
Valerian Root	<i>Valeriana officinalis</i>	Promotes relaxation and reduces stress-induced hypertension.	Valerenic acid, Sesquiterpenes
Ginseng	<i>Panax ginseng</i>	Improves endothelial function and enhances nitric oxide synthesis.	Ginsenosides, Polyphenols
Indian Gooseberry	<i>Phyllanthus emblica</i>	Acts as an antioxidant and improves vascular health.	Emblicanin, Gallic acid
Black Cumin	<i>Nigella sativa</i>	Reduces vascular resistance and improves nitric oxide production.	Thymoquinone, Alkaloids
Moringa	<i>Moringa oleifera</i>	Contains bioactive compounds that improve vascular function.	Quercetin, Isothiocyanates
Roselle	<i>Hibiscus rosa-sinensis</i>	Reduces blood pressure by acting as a diuretic and antioxidant.	Flavonoids, Hibiscus acid
Holy Basil	<i>Ocimum sanctum</i>	Acts as an adaptogen and reduces oxidative stress.	Eugenol, Ursolic acid
Baikal Skullcap	<i>Scutellaria baicalensis</i>	Reduces oxidative stress and improves endothelial function.	Baicalin, Baicalein

Lavender	<i>Lavandula angustifolia</i>	Promotes relaxation and improves vascular health.	Linalool, Camphor
Coriander	<i>Coriandrum sativum</i>	Acts as a diuretic and reduces peripheral resistance.	Linalool, Terpenes
Passionflower	<i>Passiflora incarnata</i>	Reduces stress and relaxes smooth muscles.	-Flavonoids, Harman alkaloids
Arnica	<i>Arnica montana</i>	Reduces inflammation and improves circulation.	Helenalin, Flavonoids

Kava	<i>Piper methysticum</i>	Promotes relaxation and reduces stress-related hypertension.	Kavain, Dihydrokavain
Bitter Melon	<i>Momordica charantia</i>	Improves glucose metabolism and reduces oxidative stress.	Charantin, Alkaloids
Sage	<i>Salvia officinalis</i>	Enhances vascular relaxation and acts as an antioxidant.	Rosmarinic acid, Thujone
Fennel	<i>Foeniculum vulgare</i>	Promotes diuresis and improves vascular tone.	Anethole, Fenchone
Lemongrass	<i>Cymbopogon citratus</i>	Acts as a vasodilator and reduces oxidative stress.	Citral, Myrcene
Aloe Vera	<i>Aloe barbadensis</i>	Improves vascular health and reduces inflammation.	Aloin, Polysaccharides
Indian Kudzu	<i>Pueraria tuberosa</i>	Enhances nitric oxide production and reduces vascular resistance.	Puerarin, Isoflavonoids
Chinese Rhubarb	<i>Rheum palmatum</i>	Acts as an anti-inflammatory and promotes vascular health.	Anthraquinones, Tannins
Burdock Root	<i>Arctium lappa</i>	Improves circulation and reduces oxidative stress.	Lignans, Inulin
Dandelion	<i>Taraxacum officinale</i>	Acts as a diuretic and improves vascular tone.	Sesquiterpene lactones, Flavonoids
Gotu Kola	<i>Centella asiatica</i>	Improves circulation and enhances endothelial function.	Asiaticoside, Madecassoside

Bilberry	<i>Vaccinium myrtillus</i>	Enhances vascular health and reduces oxidative stress.	Anthocyanins, Flavonoids
Red Clover	<i>Trifolium pratense</i>	Acts as an antioxidant and improves vascular relaxation.	Isoflavones, Coumarins
Chamomile	<i>Matricaria chamomilla</i>	Promotes relaxation and reduces stress-related hypertension.	Chamazulene, Apigenin

Devil's Claw	<i>Harpagophytum procumbens</i>	Reduces inflammation and improves circulation.	Harpagoside, Iridoid glycosides
Nettle	<i>Urtica dioica</i>	Acts as a diuretic and reduces vascular resistance.	Flavonoids, Phytosterols
Milk Thistle	<i>Silybum marianum</i>	Acts as an antioxidant and improves endothelial function.	Silymarin, Flavonolignans
Licorice	<i>Glycyrrhiza glabra</i>	Reduces inflammation and improves vascular health.	Glycyrrhizin, Flavonoids
Rhodiola	<i>Rhodiola rosea</i>	Acts as an adaptogen and reduces stress-induced hypertension.	Rosavin, Salidroside
Echinacea	<i>Echinacea purpurea</i>	Enhances immune function and reduces oxidative stress.	Cichoric acid, Polysaccharides
Cat's Claw	<i>Uncaria tomentosa</i>	Acts as an anti-inflammatory and promotes vascular relaxation.	Oxindole alkaloids, Flavonoids
Senna	<i>Senna alexandrina</i>	Promotes diuresis and improves vascular tone.	Sennosides, Glycosides
Slippery Elm	<i>Ulmus rubra</i>	Reduces inflammation and promotes vascular health.	Mucilage, Tannins
Thyme	<i>Thymus vulgaris</i>	Acts as an antioxidant and promotes vasodilation.	Thymol, Carvacrol
Blueberry	<i>Vaccinium corymbosum</i>	Improves vascular health and reduces oxidative stress.	Anthocyanins, Flavonoids
Peony Root	<i>Paeonia lactiflora</i>	Promotes relaxation and reduces vascular resistance.	Paeoniflorin, Tannins

Angelica	<i>Angelica sinensis</i>	Acts as a vasodilator and improves endothelial function.	Ligustilide, Ferulic acid
Chicory	<i>Cichorium intybus</i>	Promotes diuresis and improves vascular tone.	Sesquiterpene lactones, Inulin

Marshmallow Root	<i>Althaea officinalis</i>	Reduces inflammation and promotes vascular relaxation.	Mucilage, Flavonoids
Guggul	<i>Commiphora mukul</i>	Reduces cholesterol and enhances vascular health.	Guggulsterones, Steroids
Brahmi	<i>Bacopa monnieri</i>	Acts as an adaptogen and promotes vascular relaxation.	Bacosides, Alkaloids
Neem	<i>Azadirachta indica</i>	Reduces vascular resistance and improves endothelial function.	Azadirachtin, Limonoids
Dong Quai	<i>Angelica sinensis</i>	Enhances nitric oxide production and reduces oxidative stress.	n-Butylidenephthalide, Z-ligustilide

MARKET SURVEY:

The worldwide demand for herbal antihypertensive medications is increasing rapidly due to the rising prevalence of hypertension, a major risk factor for cardiovascular diseases across the globe. Changes in lifestyle, stress, and poor dietary habits have greatly contributed to the growth in hypertension cases, prompting consumers to seek safer, natural alternatives to synthetic drugs. Herbal antihypertensive medications, originating from plants such as garlic, hawthorn, hibiscus, and olive leaves, are becoming more popular because of their limited side effects, bioavailability, and therapeutic benefits. Areas like Asia Pacific, especially India and China, lead the market owing to their rich heritage in herbal medicine and growing investments in herbal research and development. Furthermore, Europe and North America are experiencing a rise in consumer interest, driven by awareness campaigns and the inclusion of herbal remedies into conventional healthcare.

The market for herbal antihypertensive medications is also being enhanced by the rising inclination towards preventive healthcare and natural wellness products. The worldwide herbal medicine market is anticipated to expand at a compound annual growth rate (CAGR) of 8.17%, achieving over \$437 billion by 2032. Major factors driving this growth include improvements in extraction methods, governmental support for traditional medicine, and the integration of herbal treatments into functional foods and dietary supplements. Despite the optimistic forecast, the market encounters obstacles such as the absence of standardized regulations, issues with quality control, and the necessity for more rigorous clinical trials to confirm efficacy and safety. Nevertheless, with increasing research and consumer confidence in natural health solutions, herbal antihypertensive medications are poised to play a crucial role in global healthcare strategies.

CURRENT MARKET SCENARIO:

Table 2: The **10** mostly commonly used herbal drugs for hypertension and their market share in the Global Market is as follows:

Herbal Drug	Percentage Used	Market Share (in USD)
Garlic (<i>Allium sativum</i>)	25%	\$2 billion
Hawthorn (<i>Crataegus spp.</i>)	17%	\$1.5 billion
Olive Leaf (<i>Olea europaea</i>)	16%	\$1.2 billion
Hibiscus (<i>Hibiscus sabdariffa</i>)	9%	\$1 billion
Celery Seed (<i>Apium graveolens</i>)	8%	\$800 million
Green Tea (<i>Camellia sinensis</i>)	13.5%	\$1 billion
Ginger (<i>Zingiber officinale</i>)	8.7%	\$800 million
Flaxseed (<i>Linum usitatissimum</i>)	9%	\$700 million
Ashwagandha (<i>Withania somnifera</i>)	8.6%	\$500 million
Fenugreek (<i>Trigonella foenum-graecum</i>)	5%	\$500 million

Table 3: Comparative table of 10 most marketed herbal anti hypertensive formulations

Herbal Drug	Brand Name	Content	Manufacturer	Dosage Form	Pack Size
Garlic (<i>Allium sativum</i>)	Wakunaga Kyolic Aged Garlic Extract	Aged Garlic Powder	Wakunaga America Co.,Ltd, USA.	Tablets	100 tab./bottle
Hawthorn (<i>Crataegus spp.</i>)	Allen Nutraceuticals	Hawthorn Berry Extract, standardized for 1.8-2.2% Vitexin	Allen Homeo & Herbal Products, West Bengal, India.	Capsules	50 cap./bottle
Olive Leaf (<i>Olea europaea</i>)	Trexgenics Olive Leaf Extract Veg Capsule	Olive Leaf Extract and 20% Oleuropein	Trexgen Pharmaceuticals Pvt., Ltd., Ahmedabad, Gujarat.	Capsules	60 cap./bottle
Hibiscus (<i>Hibiscus sabdariffa</i>)	Traditional Medicinals Organic Hibiscus Tea	Hibiscus Flower	Traditional Medicine, California.	Tea Bags	16 Tea Bags/box
Celery Seed (<i>Apium graveolens</i>)	Swanson Celery seed	Celery seed Extract	Swanson Health Products, USA	Capsules	180 cap./bottle
Green Tea (<i>Camellia sinensis</i>)	Life Extension Mega green Tea Extract	Decaffeinated Green tea Extract, 98% polyphenols, 45% EGCG	Life Extension, USA.	Capsules	100 cap./bottle
Ginger (<i>Zingiber officinale</i>)	NOW Supplements Ginger root	Ginger Root Extract, standardized to 5% gingerols	NOW Foods, Illinois, USA.	Capsules	90 cap./bottle

Flaxseed (<i>Linum usitatissimum</i>)	Nature's Way Flaxseed Oil	Cold pressed Flaxseed oil, providing omega-3 fatty acids	Nature's Way, Miami, USA.	Softgels	100 softgels/bottle
Ashwagandha (<i>Withania somnifera</i>)	KSM-66 Ashwagandha	KSM-66 Ashwagandha Root Extract standardized to 5% withanolides	Rasanayam – Nature's Best, Faridabad, India.	Capsules	60 cap./bottle
Fenugreek (<i>Trigonella foenum-graecum</i>)	Amazing Formulas Fenugreek	Fenugreek Seed Powder	Amazing Nutrition, Patna, India.	Capsules	180 cap./bottle

CONCLUSION:

Hypertension is a widespread global health issue that greatly contributes to cardiovascular diseases and death. Although traditional pharmacological treatments are successful in controlling high blood pressure, their related side effects and challenges with adherence frequently impede optimal results. This has resulted in a growing interest in the application of medicinal plants as complementary or alternative therapies. Herbal remedies, such as *Allium sativum* (garlic), *Hibiscus sabdariffa* (roselle), and *Rauwolfia serpentina* (Indian snakeroot), have shown considerable antihypertensive capacity through mechanisms such as vasodilation, diuresis, and hormonal modulation. Their natural source, cost-effectiveness, and safety profile render them an appealing choice, particularly in settings with limited resources.

Furthermore, traditional herbal remedies correspond with a holistic perspective on health, targeting not just blood pressure control but also enhancing overall cardiovascular performance and reducing risks linked with complications from hypertension. In spite of their advantages, the application of medicinal plants requires careful consideration, ensuring appropriate dosages and taking into account potential interactions with conventional treatments. Future studies should aim at standardizing herbal therapies, pinpointing bioactive substances, and executing extensive clinical trials to confirm their effectiveness and safety. This will aid in the incorporation of herbal medicine into conventional healthcare frameworks, providing patients with a more all-encompassing and sustainable method for managing hypertension. By harnessing the healing capabilities of medicinal plants, we can augment contemporary medical approaches and support a comprehensive, patient-oriented strategy for addressing hypertension and its related complications.

The market survey, present market landscape, and comparative evaluation of the most widely sold herbal antihypertensive formulations underscore the increasing consumer inclination towards natural options in controlling hypertension. The rising interest in herbal medications is fueled by their cost-effectiveness, lower side effects, and societal acceptance, especially in areas with a deep-rooted heritage of herbal healing. The market for herbal antihypertensive products is growing swiftly, with major companies concentrating on enhancing product standardization, clinical validation, and regulatory adherence. The comparative evaluation of the leading 10 marketed herbal antihypertensive formulations demonstrates that Garlic (*Allium sativum*), Hawthorn (*Crataegus* spp.), Olive leaf (*Olea europaea*), and Hibiscus (*Hibiscus sabdariffa*) lead the international market owing to their well-documented effectiveness in reducing blood pressure. Companies have leveraged these herbal components by providing a variety of formulations, such as capsules, tablets, teas, and extracts, thereby making them available to a broad spectrum of consumers.

Despite the optimistic perspective, obstacles such as the absence of standardized regulations, issues with quality control, and the requirement for more comprehensive clinical trials remain. Tackling these obstacles through scientific validation and regulatory structures will be vital for incorporating herbal antihypertensive medications into conventional healthcare. Future studies should aim at refining dosage protocols, comprehending long-term impacts, and investigating synergistic mixtures of herbal substances to increase their antihypertensive effectiveness. In general, herbal antihypertensive medications offer a feasible and supplementary method for managing hypertension, resonating with the worldwide trend towards natural and preventive healthcare strategies.

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