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Review Article

Botanical Advancements in Hypertension Control: A Phytochemical Perspective

Mahak Joshi*, Abhijeet Ojha, Arun Kumar Singh, Navin Chandra Pant, Divya Negi

Faculty of Pharmaceutical Sciences Amrapali University, Haldwani, 263139 Uttarakhand.

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ABSTRACT

The interest in herbal remedies for the management of hypertension stems not only from their ready availability and relatively low cost but also from their fewer side effects compared with conventional drugs. According to a number of research, using medicinal plants can help control blood pressure. Some herbs include garlic (Allium sativum), ginger (Zingiber officinale), hibiscus (Hibiscus sabdariffa), and celery (Apium graveolens), which may be used to reduce blood pressure by causing vasodilation, producing diuresis, or through antioxidants. Researchers have focused on validating the traditional use of herbs and explored their bioactive compounds that act on the most significant physiological pathways related to hypertension. For instance, it has been documented that polyphenols and flavonoids are involved in the enhancement of vascular health. Some plants are used either solely as medications or along with other drugs for a better therapeutic effect. This knowledge in herbal interventions has contributed much from the different cultural practices, including traditional Chinese, and African medicine in treating hypertension. The natural alternatives have proved to be useful across various populations worldwide and offer a complement to conventional treatments for hypertension, even though there remains the ongoing study to learn better extended safety and efficacy of these herbs in the clinical conditions.

INTRODUCTION

Cardiovascular disease is the world's biggest cause of death. Hypertension is a major heart condition developing countries. A major public health concern including both the disease affects both sexes and is becoming more common in younger patients. The most common of the so-called "non-communicable diseases" (NCDs) group, hypertension is one of the leading causes of death worldwide. It is estimated that hypertension accounts for 57% of all stroke deaths and 24% of all coronary artery disease deaths.[10] Hypertension or high blood pressure is a chronic

***Corresponding Author:** Mahak Joshi
Address: Faculty of Pharmaceutical Sciences Amrapali University, Haldwani, 263139 Uttarakhand.
Email ✉: mahijoshi317@gmail.com
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medical condition, arises when the force that the blood enforces on the artery walls is steadily too high.[3] It is a major risk factor for kidney disease, heart attacks, spasms, or other heart events. Systolic pressure and hypertension when the heart beat higher than diastolic pressure, when the heart is at rest in between beats is measured in millimetres of mercury (mmHg). In general, a blood pressure measurement of 120/80 mmHg is considered as normal. The term "silent killer" is usually used to describe hypertension because, even at dangerously high blood pressure levels, it generally shows no indications. Regular monitoring and control are crucial for efficient detection. Primary (essential) hypertension, which makes up 90–95% of all instances of hypertension, is the most common type of patient. Although it is impacted by several variables, including age, lifestyle, genetics, and environmental factors, this kind of hypertension arises progressively over time and lack a known etiology. As individuals age, it seems to turn increasingly common, and medications and dietary alterations are typically prescribed to manage it. Globally, hypertension ranks as the third leading cause of death. Although hypertension is becoming more common, little is known about it, and it is not well controlled or treated. [4]

Types Of Hypertensions: -

1.Primary Hypertension

90 - 95 percent of persons have primary high blood pressure, sometimes referred to as essential high blood pressure.[11]Even though no specific cause is currently identified, it is expected that a combination of genetic, environmental, and lifestyle factors is responsible.

2. Secondary Hypertension

About 5–10% of individuals suffer from secondary hypertension. The causes include diseases of the kidneys, arteries, and endocrine system, as well as diseases of the muscles.[11]

Causes Of Hypertension: -

Inherited characteristics, poor lifestyles (like consuming excessive salt, gaining weight, and physical inactivity), and physiological mechanisms such as sympathetic nervous system hyperactivity and RAAS dysfunction all cause hypertension. Insomnia, endocrine imbalances, and renal disease are symptoms of secondary causes. [15

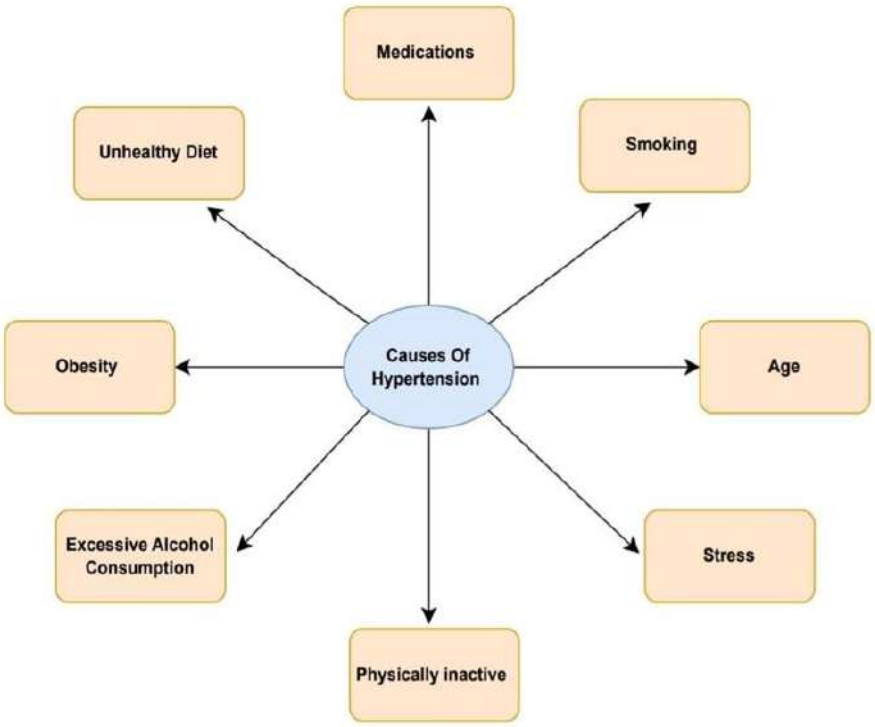

Fig. 1 Causes of hypertension

Symptoms Of Hypertension: -

It is also referred to as the "silent killer" because it usually does not present with symptoms.[14] Symptoms might be present if they are headaches, dizziness, blurred vision, chest pain, and nosebleeds, particularly if the blood pressure is extremely high. In order for it to be diagnosed early, regular check-ups should be conducted.[11]

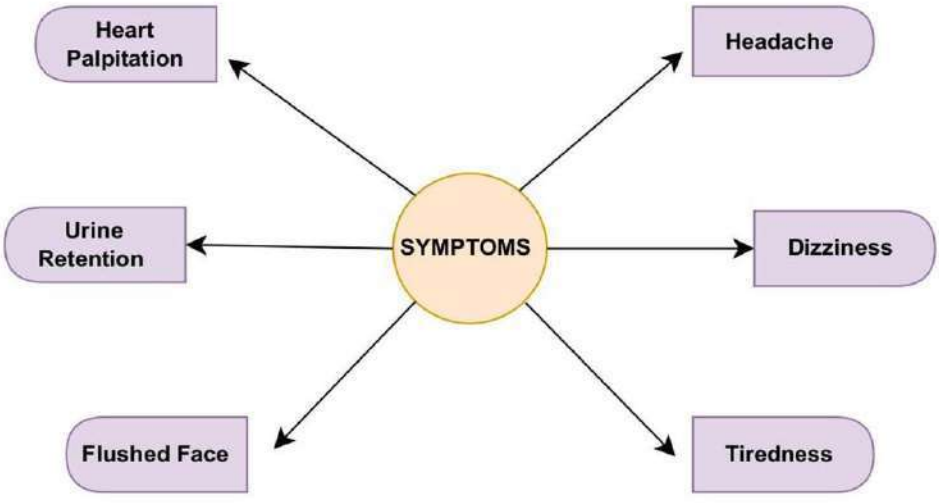

Fig. 2 Symptoms of hypertension

Pathophysiology Of Hypertension: -

The kidneys release renin when the sympathetic nervous system is stimulated, when sodium levels are low, or when renal perfusion is reduced. Renin breaks down the liver's angiotensinogen to angiotensin I, which is subsequently changed into angiotensin II by the lungs' angiotensin converting enzyme (ACE). [15] Vasoconstrictor angiotensin II induces the adrenal glands to release aldosterone, which increases salt and water retention.[3] As a result, blood volume and systemic vascular resistance increase. Chronic hypertension causes endothelial dysfunction and arterial changing, and it is a risk factor for chronic cardiovascular disease over the long run.[12]

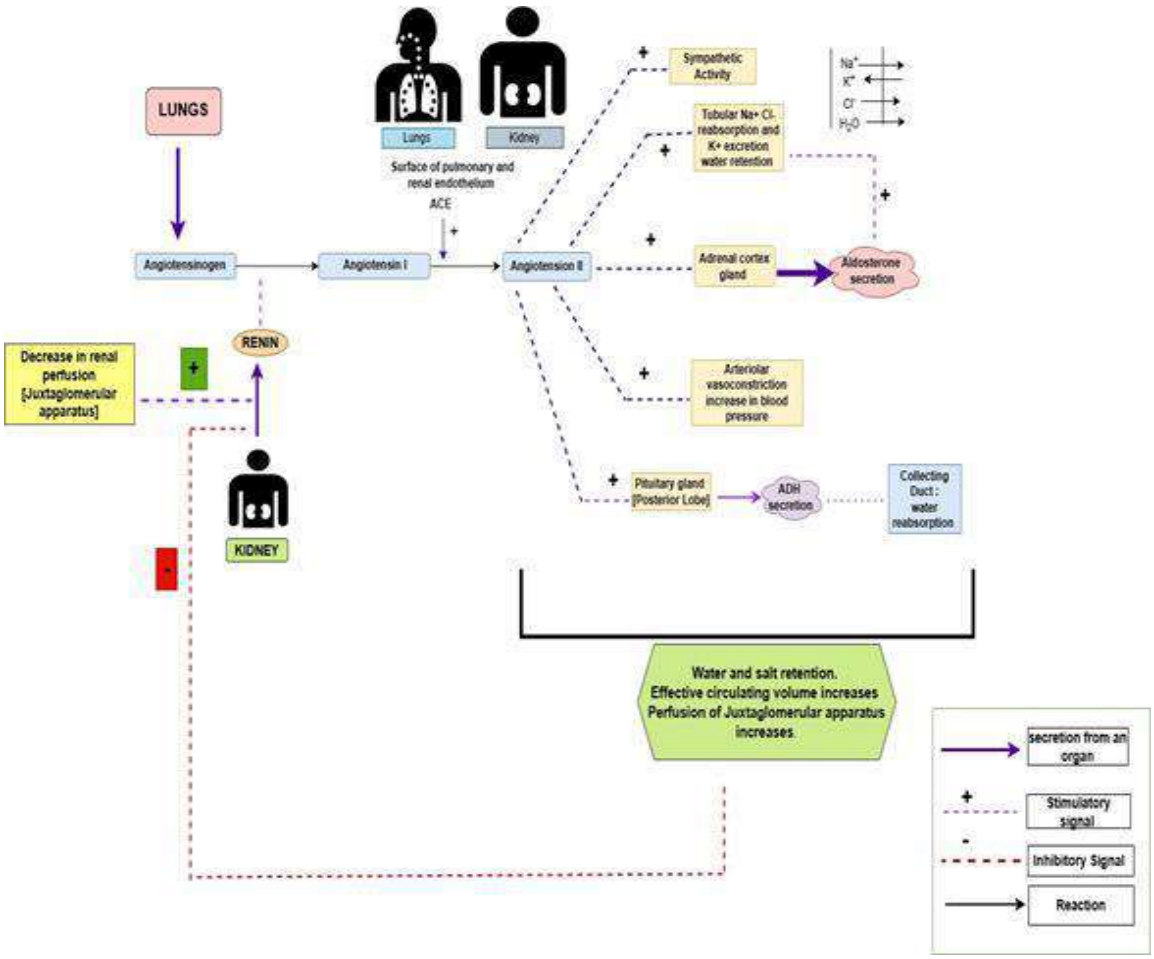

Fig: 3 Pathophysiology of Hypertension

Table 1: List Of Botanicals Used in Hypertension Control with Their Plant Families and Key Phytoconstituents: -

S. No.	Common Name	Botanical Name	Family	Phytoconstituent
1.	Garlic	*Allivum sativum*	Liliaceae	Allicin
2.	Cinnamon	*Cinnamomum verum*	Lauraceae	Cinnamaldehyde
3.	Roselle	*Hibiscus sabdariffa*	Malvaceae	Cyanidin diglucoside
4.	Rauwolfia	*Rauwolfia serpentina*	Apocynaceae	Methylajmaline
5.	Maidenhair Tree	*Ginkgo biloba*	Ginkgoaceae	Bilobetin
6.	Ginseng	*Panax ginseng*	Araliaceae	Ginosenosides

7.	Celery	*Apium graveolens*	Apiaceae	Apiin
8.	Black cumin	*Nigella sativa*	Ranunculaceae	Nigellicine
9.	Barberry	*Coptis chinensis*	Berberidaceae	Berbine
10.	Tea	*Camelia sinensis*	Theaceae	Caffeine
11.	Saffron	*Crocus sativus*	Iridaceae	Crocin
12.	Lemongrass	*Cymbopogon citrate*	Gramineae	Citral
13.	Ginger	*Zingiber officinalis*	Zingiberaceae	Zingiberene
14.	Hawthorns	*Crataegus species*	Rosaceae	Flavonoids (Hyperoside)
15.	Coriander	*Coriandrum sativum*	Umbelliferae	Linalool
16.	King of bitter	*Andrographis paniculata*	Acanthaceae	Andrographolide
17.	Arjuna	*Terminalia arjuna*	Combretaceae	Arjunic acid
18.	Cardamom	*E.cardamomum*	Zingiberaceae	a-terpineol
19.	Blackjack	*Bidens pilosa*	Asteraceae	Phytosterols
20.	Chinese sage	*Salviae miltiorrhizae*	Lamiaceae	Tanshinones

Botanical Advancements in Hypertension Control:

1.*Allivum sativum*

Common name: Garlic

Family: Liliaceae

Allicin, the main constituent, is a powerful antioxidant, antibacterial, and lipid-lowering agent. It also lowers serum glucose, high blood cholesterol, and blood pressure.[12]Garlic relaxes smooth muscles and dilates blood vessels, which lowers high blood pressure.[11]Studies proved that it is an effective agent of hypertension in addition treatment wherein the blood pressure is significantly lowered by nearly 10 mm Hg systolic and 8 mm Hg diastolic from its standard drug therapy levels. The well-known hypocholesteraemia, antibacterial antioxidant, anti-inflammatory and anti-cancer property bearing herb.[15]

2. *Cinnamomum verum*

Common name: Cinnamon

Family: Lauraceae

This is a small, evergreen tree native to Sri Lanka. Apart from commercial cultivation, it is still the source of the total world supply of cinnamon and represents 80–90%. It has blood pressure-reducing and blood sugar-reducing properties.[12] Cinnamon is a well-known functional food. Studies have shown that it has the ability to reduce blood glucose in people with type 2 diabetes and pre-diabetes, besides showing similar effects in different rat models.[5]The mechanisms of the action of cinnamon through its ability to reduce blood pressure include ACE inhibitory activity as shown by in vitro studies. An experimental study compared percentages of ACE inhibition in sheep lung, testis, and kidney tissues by using a reference drug, captopril, as the control while utilizing a methanolic extract of cinnamon zeylanicum (10:1) as a natural inhibitor.[18]

3.*Hibiscus sabdariffa*

Common name: Roselle,gongura

Family: Malvaceae

There are several hundred species of Gongura, the flowering plant group that naturally grows in the warm tropical and subtropical regions around the world. The cyclopropane molecules and their derivatives-β-sitosterol, stigmasterol, and taraxeryl acetate -are present in the leaves and stems.[12]In patients with mild and pre-hypertensive states, 240 mL per day of hibiscus tea, taken in three divided doses for a period of six weeks was able to significantly reduce the SBP, DBP, and MAP by about 7.2, 3.1, and 4.5 mmHg, respectively. Its mechanisms were mediated through enhancements in NO generation, a Ca2+ channel-blocker, and an opened KATP channel.[15]

4.*Rauwolfia serpentina*

Common name: Rauwolfia, Indian snakeroot

Family: Apocynaceae

It is a tropical woody plant originating from Africa, South America, and Asia. In Hindu medicine, extracts of its various parts and of plants that generally resembled rauwolfia were used for snakebite, sleeplessness, insanity, and many others.This is the strongest plant in reducing blood pressure. This resperpine, the first effective drug used a lot for the long-term treatment of high blood pressure is R. serpentina pure alkaloid.[15]Its alkaloids reduce blood pressure by altering nerve signals and pathways that affect the heart and blood vessels. They also reduce catecholamines and serotonin from the nerves of the central nervous system.[11]It also contain ajmaline has anti-arrhythmic properties which suppress abnormal rhythms of the heart.[12]

5.*Ginkgo biloba*

Common name: Maidenhair tree

Family: Ginkgoaceae

The primary functions of plants are flavonoids and glycosides. Ginkgo is promoted as a single herbal preparation or combined. Angina pectoris, arteriosclerosis, thrombosis, and cardiac disorders. Clinical and experimental data have established the fact that ginkgo leaf extracts increase vascular blood flow and cause vasodilation, especially in the more distal medium and smaller artery regions.[13]The mechanism behind it involves vasodilation and antihypertensive effects, of which a growing number of research supports cardioprotective properties of Ginkgo biloba.Ginkgo biloba lowered SBP by 6% and DBP by 21% at the end of three months of daily follow up.[18]

6.*Panax ginseng*

Common name: ginseng

Family: Araliaceae

A variety of ginseng preparations including capsules, tablets, extracts, dried roots, oil, and tea are used for the treatment of hypertension. High levels of ginseng cause hypotensive effects, and low levels tend to be hypertensive. [15]According to research findings in English-language literature, Wood and associates were the first to show the blood pressure-lowering properties of Panax ginseng extract using animal experimental models in the 1960s and 1970s. Ginsenoside Rg3 is a well-studied and widely documented component of Panax due to its special influence in this respect. By inducing vasodilation and increasing the release of NO, ginsenoside Rg3 is thought to have a blood pressure-lowering effect. Furthermore, it has been noted that calcium-dependent potassium (K) channels are activated.[18]

7.*Apium graveolens*

Common name: Celery

Family: Apiaceae

It is characterized with its excellence in flavor, aroma, and slender stalks within the skin of the superior alternative cultivars. Stemming plants with a stronger flavor and aroma compared to other varieties.[12]The most studied compounds as regards to its hypotensive actions which actively relax the blood vessels are flavonoids; apigenin, luteolin and kaempferol (aided by phthalides; butylphthalide) moderate activity have monoterpenes. [18]

8.Nigella sativa

Common name: Black cumin, Black seed

Family: Ranunculaceae

According to clinical trial-based findings, it dilates the blood vessels because it lowers systolic as well as diastolic pressure through several mechanisms. Additionally, it has diuretic, calcium channel blocking as well as cardiac depressing features due to its properties in countering the impact of angiotensin II. It increases left ventricular end-diastolic pressure, reduces the MAP (mean arterial pressure) and HR (heart rate).[18]Its chemical compounds are t-anethole, carvacrol, thymoquinone, thymol 32, and 4-terpineol. The seeds essential oils contribute to the hypotensive effect. Since in vivo research has proven the fact that essential oils are centrally acting antihypertensive medications which are potent.[11]

9. *Coptis chinensis*

Common name: Barberry

Family: Berberidaceae

It is a well-known shrub for its edible and sour berries. In most of the places, it is consumed tangy and cool fruit. Barberry — has antioxidant properties and it kills bacteria. Another alkaloid found in barberry is berberine, which cures cardiovascular diseases well.[12]Meta-analysis found that when used as a monotherapy or an add-on to oral antihypertensive, taking berberine was significantly more effective than basic drug therapy if at least one thousand of the same antihypertensives in monotherapy and were compared with lifestyle only. In reference to the ability of berberines, in hypertension and diabetes, as you could see previously how beneficial it's nephroprotective effects can be due to its mechanism by means in which renal hemodynamic is improved via reducing inflammation/oxidative stress [may vary separately with each disease.[18]

10.*Camelia sinensis*

Common name: Tea

Family: Theacae

In addition to its antihypertensive, anti-inflammatory, and antidiabetic qualities, tea also exhibits pleiotropic effects. Many studies have revealed that tea significantly reduces blood pressure, although its antihypertensive effects are still being researched.[1] A more recent meta-analysis of randomized controlled trials, however, showed that green tea lowers SBP and DBP by 1.98 and 1.92, respectively.[2]Research suggests that black tea or fermented tea (*Camellia sinensis*) does not impact blood pressure, in individuals, with hypertension while a population study indicates that consuming unfermented green tea *(Camellia sinensis*) and partially fermented Oolong tea *(Camellia sinensis*) decreases the likelihood of developing hypertension.[3]

11.*Crocus sativus*

Common name: Saffron

Family: Iridaceae

The components of saffron include flavonoids, anthocyanins, crocin, picrocrocin, and safranal. These compounds have a variety of modes of action, such as vasodilatory and antihypertensive effects.[3]It was reported that because of its vasorelaxant properties, regular usage of saffron for seven days can result in a significant decrease in arterial pressure and SBP in healthy individuals.noted that the chemical components of saffron, primarily crocin, decreased guinea-pig heart rate and contraction by blocking Ca2+ channels, activating potassium channels, and antagonizing b-adrenoceptors.[14]

12.*Cymbopogon citrate*

Common name: Lemongrass

Family: Gramineae

Traditional medicine in a number of nations, notably Brazil, China, and Southern Asia, has made extensive use of lemongrass to treat hypertension because of its potent vasodilator, citral.[1]The ileum of rabbits, the aortic rings of rats, and the mesentery of rats are among the tissues where the relaxing effects of lemongrass have been shown. For example, phenylephrine-pre-constricted aortic rings from male WKRs or SHRs showed a dose-dependent vasorelaxation in response to citral or crude extracts of *C. citratus* (leaves, stems, or roots).[2]

13.*Zingiber officinale*

Common name: Ginger

Family: Zingiberaceae

It works to relax the muscles around blood vessels and enhance blood circulation. A dose-dependent (0.3–3 mg/kg) decrease in the arterial blood pressure of sedated rats was caused by the crude extract of ginger. The rate and force of spontaneous contractions in guinea pig paired atria showed cardio depressant effect.[3]According to certain research, ginger oils are a novel angiotensin IItype1 receptor antagonist that causes vasodilation. Zingiber offcinale (ZO) has been used traditionally for a very long time. It contains a variety of substances such as beta-carotene, capsaicin, curcumin, gingerdiol, gingerol, and gingerdione. Blood pressure-lowering, anti-inflammatory, cholesterol-lowering, hypoglycemic anticancer, antiplatelet aggregation, antimicrobial , cardiovascular, neuroprotective, antidiabetic characteristics are just a few of the biological activities that ginger has been shown to have by the literature review.[14]

14.*Crataegus species*

Common name: Hawthorns

Family: Rosaceae

For generations, traditional medicine has utilized hawthorns, which include thorn apple and hawberry, to treat cardiovascular diseases. When hawthorn extracts were used to treat hypertension patients, their blood pressure somewhat decreased.[1]A small number of human-based studies with a population of hypertension individuals have reported modest drops in blood pressure. There was a promising tendency for a reduction in DBP (by 13.1 mmHg) in a randomized, double-blind, placebo-controlled research in which 500 mg of hawthorn extract was administered for 10 weeks to participants with moderate hypertension.[2]

15.*Coriandrum sativum*

Common name: Coriander, Cilantro

Family: Umbelliferae

C. sativum is employed to cure various GI ailments, such as flatulence, diarrhoea, anorexia, dyspepsia, vomiting, and pain, as an antihypertensive, antibacterial, antiemetic, myorelaxant, antidiabetic, anti-inflammatory, emmenagogue, lipolytic, and nerve-soothing agent.[14] Coriander possesses a well-documented vasodilatory action. Intravenous infusion of an aqueous methanolic extract of powdered, dried coriander seeds (1-30 mg/ml) caused a dose-dependent reduction in mean arterial blood pressure (MABP), DBP, and SBP in normotensive Sprague-Dawley rats (40.84 ± 6.34%).[2]

16. *Andrographis paniculata*

Common name: King of bitter

Family: Acanthaceae

It has been discovered to possess antioxidant, antimicrobial, and anti-inflammatory activities. Andrographis paniculatia extracts were found to possess several labdane-type diterpenoid hypotensive compounds. [2] The antihypertensive effect is due to an inhibition of intracellular Ca2+ influx through voltage-gated calcium channels.[1]

17.*Terminalia arjuna*

Common name: Arjuna

Family: Combretaceae

Arjuna is a deciduous tree which grows all over India. For over three centuries, its bark has been utilized in Ayurvedic medicine. The active ingredients of Terminalia include phytosterols, calcium, magnesium, zinc, copper, gallic acid, ellagic acid, triterpenoid saponins, flavonoids, and OPCs.[40]It has also been demonstrated to be successful in lowering systolic blood pressure. It has no adverse effects on the liver, kidneys, or hematology. [11]

18. *E. cardamomum*

Common name: Cardamom

Family : Zingiberaceae

Additionally, it has a lot of potassium and magnesium, which are known to lower blood pressure and improve heart health. Twenty recently diagnosed patients with primary hypertension (stage 1) received approximately 3g of cardamom powder in two separate doses over the course of 12 weeks. This clinical trial conducted in India revealed that it significantly increased fibrinolytic activity and decreased systolic and diastolic blood pressure as well as mean blood pressure at the end of the 12th week.[12]

19.*Bidens pilosa*

Common name: Blackjack

Family: Asteraceae

The components of plants of B. pilosa are used in a variety of traditional remedies, including decoctions, macerations, dry powders, and tinctures. Its many health benefits and potential use in the treatment of bacterial, carcinogenic, obesity, hypertension, malaria, and cardiovascular disorders have made it a major plant today. Bidens pilosa contains a wide variety of beneficial chemical compounds, including no fewer than 60 flavonoids. As a result, preparations of this plant are used extensively in medicine to treat roughly 40 different types of disorders through a variety of expected mecha

nisms, including calcium blockers, lipid augment ation, vasodilation, free radical scavenging, and i nsulin sensitivity.[14]

20.*Salviae miltiorrhizae*

Common name: Chinese sage

Family: Lamiaceae

One of the most ancient and widely used Chinese traditional herbs, Salviae miltiorrhizae, also referred to as Danshen or red/Chinese sage, is extensively used to treat cardiovascular diseases.[2]Danshen relaxes the vascular both by endothelium-dependent and endothelium-independent strategies. Study have shown that administration of Danshen in combination with Gegen (Pueraria lobata) lowers blood pressure in SHRs and relaxes the rat aorta, basilar arteries, and pig coronary arteries.[2]

Table 2: List Of Botanicals with Therapeutic Potential In Hypertension Control: -

S.no	Herbs	Effect On Hypertension
1.	Garlic	By acting as a natural ACE inhibitor, garlic lowers angiotensin II production.
2.	Cinnamon	Lower levels of angiotensin II cause the blood vessels to relax and secrete less aldosterone.
3.	Roselle	Vasodilation by enhanced NO production, blockade of Ca2+ voltage channels, opening of KATP channels, and ACE blockade.
4.	Rauwolfia	By reducing sympathetic stimulation of the kidneys, renin release, angiotensin II, and aldosterone levels, rauwolfia (reserpine) lowers blood pressure by producing vasodilation
5.	Maidenhair Tree	By possibly inhibiting ACE, improving blood vessel function, and lowering oxidative stress
6.	Ginseng	Decreased aldosterone, blockade of Ca2+ voltage channels, and enhanced production of NO all lead to vasodilation.
7.	Celery	Reducing the production of the vasoconstrictive angiotensin II and redu cing the secretion ofaldosterone could result in improved blood pressure control.
8.	Black cumin	Lowering oxidative stress and blocking Ca2+ voltage channels to cause vasodilation.
9.	Barberry	By possibly decreasing renin, angiotensin II, and aldosterone levels, lowering blood pressure, and improving fluid balance.
10.	Tea	Vasodilation caused by elevated NO levels derived from Camelia flavonoids.
11.	Saffron	By suppressing ACE activity, lowering the synthesis of angiotensin II, and encouraging vasodilation, saffron may reduce blood pressure.
12.	Lemongrass	By encouraging diuresis, decreasing oxidative stress, and reducing inflammation, blood pressure may be lowered.
13.	Ginger	Promote vasodilation, lower oxidative stress and inflammation, enhance circulation, possibly block ACE activity to lower hypertension.
14.	Hawthorns	Vasodilation caused by increased NO generation from procyanidins and flavonoids
15.	Coriander	By decreasing oxidative stress, raising vasodilation, suppressing ACE, and supporting fluid balance, blood pressure may be reduced.
16.	King of bitter	Reduce hypertension by having mild diuretic, anti-inflammatory, antioxidant, and vasodilatory actions.
17.	Arjuna	By decreasing the action of the hormone angiotensin II

18.	Cardamom	By increasing vasodilation and decreasing angiotensin II activity and renin secretion.
19.	Blackjack	Bioactive substances found in blackjack aid in blood vessel relaxation, enhancing blood flow and lowering blood pressure.
20.	Chinese sage	Lowering blood pressure and causing vasodilation by decreasing renin production, angiotensin II activity, and aldosterone levels.

CONCLUSION

Herbal medicine offers a potential and effective therapeutic and management choice for hypertension. A number of herbs like garlic, hibiscus, rauwolfia, cinnamon, and ginseng have shown remarkable antihypertensive activity by multiple mechanisms, including vasodilation, diuresis, inhibition of the renin-angiotensin system, and attenuation of oxidative stress. All the herbs are bioactive, containing bioactive compounds like allicin, cinnamaldehyde, as well as ginsenosides, which are responsible for the regulation of blood pressure. These herbal drugs are gaining global popularity as adjunct therapies due to their natural nature, reduced prices, and less side effects when compared to chemical medications. Though traditional practice and initial studies point to their efficacy, rigorous clinical trials and toxicological studies must be conducted to establish safety, identify appropriate dosages, and define their place in holistic therapeutic regimens in hypertension.

RESULT

This study considered how various medicinal plants can be used to control high blood pressure. A total of 20 herbs were examined, each of which possesses unique natural compounds that decrease blood pressure in various ways, including relaxing blood vessels, decreasing heart stress, and eliminating excess water in the body. The study revealed that garlic, hibiscus, rauwolfia, cinnamon, and ginseng herbs decrease systolic and diastolic blood pressure by a considerable extent. These effects are attributed to active compounds like allicin, ginsenosides, cinnamaldehyde and others. The natural compounds do this by increasing blood flow, decreasing hormone activity that increases blood pressure, and making the heart stronger.

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