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Medicinal Plants with Antihypertensive Activity: A Review

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Authors' contributions

This work was carried out in collaboration between all authors. Author FKA designed the study, and wrote the first draft of the manuscript. Authors UOC and AIJ managed the literature searches. All authors read and approved the final manuscript.

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Review Article

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ABSTRACT

The medical term for elevated blood pressure is hypertension (HTN). It is risky because it puts too much strain on the heart and causes atherosclerosis, which is the hardening of the arteries, in addition to raising the risk of heart disease and stroke. Other diseases like, congestive heart failure, renal disease, and blindness can also arise due to HTN. Standard antihypertensive drugs frequently have a number of adverse effects. About 75-80%of the world's population, mostly in underdeveloped nations, use herbal medicines for primary health care because of its higher tolerance by the human body and fewer adverse effects. Research on native plants with hypotensive and antihypertensive therapeutic benefits has received a lot of focused attention during the past three decades. It has been prove by previous researchers that some of these medicinal herbs have hypotensive and antihypertensive properties. To evaluate the efficacy and clarify the safety profile of such herbal treatments for their antihypertensive potential, more scientific study along with Ayurveda expertise must combined with modern medicine.

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1. INTRODUCTION

Hypertension (HTN) is a medical disorder marked by a persistent increase in arterial blood pressure. In the world, high blood pressure is the main reversible risk factor for cardiovascular disease (CVD) and all-cause mortality [1,2]. There were 1.39 billion adults worldwide in 2010, and hypertension affected 31.1% of them [3,4]. HTN is defines as when the systolic and/or diastolic blood pressures are greater than 140 mmHg and 90 mmHg, respectively. The aging of the population and increased exposure to lifestyle risk factors, such as bad diets (high salt and low potassium intake and lack of physical activity), are both contributing to an increase in the prevalence of hypertension globally [3,5]. Globally, the prevalence of hypertension has changed, although not consistently. High-income nations (HICs) had a little decline in the prevalence of hypertension during the past two decades, while low- and middle-income nations (LMICs) saw large rises [6,7].

These differences in hypertension prevalence patterns indicate that LMIC health care systems may have to deal with a significant burden of infectious diseases as well as a fast rising burden of cardiovascular diseases caused by high blood pressure. One billion people worldwide suffer from hypertension, the most prevalent cardiovascular disease, which continues to be the main cause of 9.4 million deaths each year and contribute significantly to the global burden of disease [8,9]. The number of people with hypertension is expected to increase to 1.5 billion by 2025 from an estimated 972 million in 2000, 65% of whom resided in the developing countries [8]. If hypertension is not treated, it can have devastating complications, including heart attack, stroke, cardiac failure, and renal failure, among others. Many studies suggest that hypertension is a major issue in sub-Saharan Africa (SSA), where it has been reported to be as high as 38% in some groups [8,10]. Ten to twenty million of the over 650 million people in SSA are thought to suffer hypertension [11,12,8]. But many SSA nations still lack comprehensive fundamental information on the prevalence of hypertension and how it is spread among the various SSA populations [8]. Several studies have also examined the prevalence of pre-hypertension and the percentage of people with hypertension who are aware of their condition. In Nigeria, there were an estimated 20.8 million cases of hypertension among adults aged at least 20 in 2010. The prevalence was 28.0% (24.6, 31.9), with men and women experiencing 30.7% (24.9, 33.7) and 25.2% (22.7, 31.9), respectively, of the disease [13,14]. Also, it is predicted that by 2030 there will be 39.1 million cases of hypertension among adults aged at least 20 years, with prevalence rates of 30.8% (24.5, 33.7) for both sexes - 32.6% (27.3, 38.2) for men and 29.0% (21.9-32.2) for women [13]. Thus, the urgent need for a long-term solution. The majority of deaths from non-communicable diseases (NCDs) are attributable to cardiovascular disorders (48%) in the US. Raised blood pressure is one of the top physiological and behavioral risk factors for mortality, and it is responsible for 13% of all deaths worldwide. According to reports, hypertension ranks fourth among causes of early death in industrialized nations and seventh in underdeveloped nations. According to earlier studies, hypertension is one of the main causes of death and disability and is fast becoming more common in emerging nations. Hypertensionis classified as either primary (essential) or secondary. Essential or primary HTN is the most common type of HTN, affecting 90 to 95% of hypertensive patients [15,16]. Despite the lack of a clear cause, there are numerous contributing factors, including a sedentary lifestyle, stress, visceral obesity, and potassium deficiency (hypokalemia) [17]. Age-related risk is also higher [18], the presence of certain inherited genetic variants and a family history of HTN [19,17]. An additional risk factor is an increase in renin, an enzyme released by the kidney [20] similar to overactive sympathetic nervous system [21]. Insulin resistance may also influence HTN, which is a part of syndrome X, generally known as the metabolic syndrome. High fructose corn syrup-containing diets may raise one's risk of acquiring HTN [22,23].The other 5 to 10% of instances, known as secondary HTN, are brought on by additional disorders that affect the kidneys, arteries, heart, or endocrine system [17]. By definition, secondary HTN has a known cause. Since this type is treated differently from essential HTN by addressing the underlying cause of the raised BP. The pathophysiological mechanisms that control blood plasma volume and cardiac function, including the hormone-regulatory endocrine systemare compromisedin HTN. Some common and well-known secondary causes of HTN include Cushing's syndrome, in which the adrenal glands generate too much of

the hormone cortisol [17]. Furthermore, pre-eclampsia during pregnancy, aortic coarctation, kidney disease, sleep apnea, obesity are common secondary causes of hypertension [24,25]. Chronic HTN is a major contributor to chronic kidney failure and one of the risk factors for stroke, heart attack, heart failure, and arterial aneurysm [17,26]. Life expectancy is decreased with moderate arterial BP increase. Changes in food, lifestyle, and medication can all help to control blood pressure better and lower the chance of any ensuing health issues. The systolic and diastolic BPs are another factor used to categorize HTN. The blood pressure in vessels while the heart is beating is known as systolic blood pressure. The pressure between heartbeats is known as diastolic BP. A person is categorized as having pre-HTN or HTN if their systolic or diastolic blood pressure readings are higher above the considered normal ranges for their age. HTN is divided into a number of subcategories, including stage I, stage II, and isolated systolic HTN [17]. Individual systolic HTN, which is frequent in senior people, is defined as having a high systolic pressure with a normal diastolic pressure. A patient's resting blood pressure readings from two or more clinic visits are averaged to arrive at these groupings. If a person's blood pressure is continuously at least 140 mmHg systolic or 90 mmHg diastolic and they are older than 50, they are considered to have HTN. Further treatment is necessary for patients whose blood pressure is greater than 130/80 mmHg and who alsohave diabetes or kidney disease.

2. PATHOPHYSIOLOGY OF HYPERTENSION

Most people understood the majority of secondary HTN-related processes; on the other hand, symptoms linked with essential (primary) HTN less characterized. What is known is that early in the disease's progression, cardiac output is elevated with normal total peripheral resistance (TPR). Eventually, cardiac output returns to normal levels, while TPR rises. Three theories have been put out to explain this, and they are as follows:

- Lack of sodium excretion by the kidneys causes the release of natriuretic factors like atrial natriuretic factor, which raises TPR as a side effect [27,17].
- Vasoconstriction, salt and water retention, and hyperactivity of the renin-angiotensin system occur. HTN is brought on by an increase in blood volume [28].
- Heightened stress responses due to an overactive sympathetic nervous system [29,30].

Another well-known fact about HTN is that it is highly heritable and polygenic (produced by multiple genes), and a few potential genes have been proposed as the disease's etiological factors [31,17]. The study of the connection between prolonged endothelium injury and essential HTN has gained favor recently among experts on the disease. To what extent long-term increased BPs or whether they occur before the onset of HTN is yet unknown cause endothelial alterations. For coronary artery disease, stroke, and renal failure, HTN is a significant independent risk factor. The risk of a fatal coronary event doubles for every 20 mmHg rise in systolic blood pressure and 10 mmHg rise in diastolic blood pressure over the range of 115/75 to 185/115 mmHg [31,32]. In attempt to lessen these negative effects, the American Heart Association and other groups are now urging more aggressive BP goals for many persons with HTN. Diuretics, calcium channel blockers, angiotensin converting enzyme inhibitors, angiotensin receptor blockers, vasodilators, and other medications are frequently used to treat HTN.

3. ANTI-HYPERTENSIVE DRUGS

There are both pharmaceutical and non-pharmacological methods for managing hypertension. While non-pharmacologic therapies involve changing one's way of life to manage high blood pressure, pharmacologic treatment involves the use of anti-hypertensive medications to lower blood pressure. To obtain optimal blood pressure control, one must alter one's lifestyle and take the right prescription combinations and dosages of antihypertensive medications [33,34]. The severity and prevalence of the disease have led to the development of numerous synthetic medications for the management of hypertension. Although the majority of these medications have shown to be more effective, they are not without negative effects as shown in Table 1. Therefore, scientific research suggests a different approach to managing hypertension through dietary changes and the use of the right phytomedicine [13,35]. A growing number of people are turning to herbal remedies due to their accessibility, cultural acceptance, safety, efficacy, lack of adverse

effects, and cost-effectiveness. Herbal remedies have recently received attention as alternate medicines for the treatment and prevention of cardiovascular issues [36,37,38]. Despite the availability of many modern antihypertensive medications, the majority of individuals still rely on complementary and alternative therapies, but some believe that combining these therapies with conventional therapies improves outcomes [39]. Intensive study into local plants with hypotensive and antihypertensive therapeutic benefits has been conducted over the past three decades. Due to the lack of socioeconomic resources, low-income individuals in developing nations, particularly those who live in rural areas, have turned more and more to herbal remedies in an effort to manage HTN and its complications [40]. However, additional scientific investigation is required to confirm the efficacy and clarify the safety profile of such herbal therapies. An overview of the naturally occurring medicinal plants that have been investigated scientifically, and found tohave hypotensive or antihypertensive properties is given in this review. Table 2 summarizes the information on the types of extracts, as well as the mechanisms of action, and references pertaining to the plants that have been studied or reported to have antihypertensive activity in animal studies.

Table 1. Some conventional antihypertensive drugs

S/N	Classification	Types / Examples	Common Side effects
1.	Diuretics:	• Loop diuretics(Furosemide)	Dry mouth, Headache, Dizziness, Nausea and vomiting.
		• Thiazide diuretics(Hydrochlorothiazide)	Hypokalemia, frequent urination, constipation, diarrhea, headache, erectile dysfunction, vision problems, and weakness/ muscle spasms.
		• Potassium-sparing diuretics(Spironolactone)	Hyperkalemia, Nausea and vomiting, Abdominal discomfort. Headache, Drowsiness, Confusion. Ataxia (loss of control on bodily movements due to lack of coordination between muscles and brain).
2.	Adrenergic receptor antagonists:	• Beta blockers(Atenolol, Metoprolol)	weakness, dizzy or lightheadedness (these can be signs of a slow heart rate), Difficulties sleeping or nightmares. Erectile dysfunction.
		• Alpha-blockers(Prazosin, Doxazosin).	Dizziness, headaches, drowsiness, weakness, palpitations, and nausea, Swollen feet, ankles or fingers, Urinary tract infection (UTI) or cystitis.
		• Mixed Alpha + Beta-blockers(Carvedilol, Labetalol).	Fatigue, dizziness, nausea, and constipation, erectile dysfunction
3.	Adrenergic receptor agonists:	• Alpha-2 agonists(Clonidine, Methyldopa).	Drowsiness, headache. lack of energy
4.	Calcium channel blockers:	• Dihydropyridines (Amlodipine, Nifedipine)	Constipation, Dizziness, Fast heartbeat (palpitations) Fatigue, Flushing, Headache, Nausea, Rash.
		• Non-dihydropyridines (Diltiazem, Verapamil).	Chest pain, Coughnoisy breathing, dizziness, faintness, or lightheadedness dizziness.

S/N	Classification	Types / Examples	Common Side effects
5.	ACE inhibitors:	• Captopril, Enalapril, Fosinopril, Lisinopril.	Dry cough, hyperkalemia, Fatigue, Dizziness, Headache, Loss of taste.
6.	Angiotensin II receptor antagonists:	• Valsartan, Candesartan, Losartan, Telmisartan.	Headache, fainting, Dizziness, Fatigue, vomiting and diarrhea, back pain, Leg swelling.
7.	Aldosterone antagonists:	• Eplerenone, Spironolactone.	Cough. Dizziness, Headache, Diarrhea, hyperkalemia.
8.	Vasodilators:	• Sodium nitroprusside, Hydralazine.	Rapid heartbeat (tachycardia), Heart palpitations. Fluid retention (edema), Nausea, Vomiting. Headache.
9.	Centrally acting adrenergic drugs:	• Clonidine, Guanabenz, Methyldopa, Moxonidine.	Slow heart rate, Constipation, Dizziness. Drowsiness, Dry mouth, Fatigue, Fever, Headache.

Table 2. Some medicinal plants with anti-hypertensive activity

S/N	Names of plants	Family	Part used	Mechanism of action	References
1	*Achillea millefolium*	Asteraceae	Flower	Calcium channel blockers and ACE inhibitors	[41]
2	*Allium sativum*	Alliaceae	Rhizome	Enhance nitric oxide production	[42,43]
3	*Andrographis paniculata*	Acanthaceae	Herbs	Increases NO, Inhibit ACE, Block calcium channels	[44,45]
4	*Annona muricata*	Annonaceae	Leaves, fruits	Reduce peripheral vascular resistance	[46,47]
5	*Apium graveolens*	Apiaceae	Seeds	Calcium channels blocker.	[48]
6	*Aristolochia manshuriensis*	Aristolochiaceae	Leaves	Diuretic	[17]
7	*Artocarpus altilis*	Moraceae	Leaves	ACE Inhibitors	[49]
8	*Blond psyllium*	Plantaginaceae	Roots / leaves	Lower systolic blood pressure	[31]
9	*Camellia sinensis (green Tea extracts)*	Theaceae	Leaves	Inhibits ACE (AT1 receptor), Increases NO	[50]
10	*Capparis cartilaginea*	Capparaceae	Shrub	Calcuim channels blocker	[51,17]
11	*Carum copticum*	Umbelliferae	Seeds	Increase NO production, Calcium channels blocker	[52]
12	*Cassia absus*	Caesalpiniaceae	Seeds	HR reduction through increased NO synthesis	[53]

S/N	Names of plants	Family	Part used	Mechanism of action	References
13	*Cassia occidentalis*	Caesalpiniaceae	Leaves	An active diuretic. preventing Ca2+ influx via voltage-sensitive and receptor-operated channels as well	[54]
14	*Coleus forskohlii*	Lamiaceae		Relaxation of the vascular smooth muscle (enhance NO synthesis)	[55]
15	*Commelina virginica*	Commelinaceae	Leaves	Calcium channels blockers	[56]
16	*Coptis chinensis*	Ranunculaceae	Leaves / roots / stem	Calcium channels blocker	[45]
17	*Coriandrum sativum*	Apiaceae or Umbelliferae	Leaves	Diuretic action. By stimulating B-adrenoceptors, ROS generation is inhibited.	[57]
18	*Crataegus pinnatifida*	Rosaceae	Leaves / roots.	Activates eNOS and inhibits platelet aggregation and thrombosis.	[58]
19	*Crinum glaucum*	Amaryllidaceae	Leaves	Boost NO production. Reduce systolic and diastolic pressure.	[59]
20	*Crocus sativus*	Iridaceae	Roots / leaves	Blocks Ca2+ Channels	[60,61]
21	*Cymbopogon citratus*	Poaceae or Gramineae	Leaves	Inhibits Ca2+ Influx. Increases NO bioavailability	[62]
22	*Daucus carota*	Umbelliferae	Arial part	Blockade of calcium channels	[63]
23	*Desmodium styracifolium*	Leguminosae	Leaves	Stimulate of cholinergic receptors.	[17]
24	*Fuchsia magellanica*	Onagraceae	Leaves	ACE inhibitor. Acts as a diuretic.	[64,65]
25	*Gossypium barbadense*	Malvaceae	Leaves	Reduced the tension in an isolated guinea pig aorta induced by phenylephrine. Anti oxidant activity.	[66,67,68]
26	*Hibiscus sabdariffa*	Malvaceae	Leaves	Increases NO, Blocks Ca2+ channels. Decrease plasma Na+Levels. Direct	[67,17]

S/N	Names of plants	Family	Part used	Mechanism of action	References
				vasorelaxant actions that mediate through acetylcholine and histamine-like dependent mechanism.	
27	*Jatropha gossypiifolia*	Euphorbiaceae		Calcium channels blocker.	[69,70]
28	*Laelia autumnalis*	Orchidaceae	Roots	Calcium channels blocker	[71]
29	*Lavandula stoechas*	Lamiaceae	Leaves	The crude extract's antihypertensive and bradycardia effects may be mediated by a mechanism or mechanisms that are comparable to those of acetylcholine.	[67,17,72].
30	*Lepechinia caulescens*	Lamiaceae	Roots	Nitric oxide liberation	[73]
31	*Lepidium latifolium*	Cruciferae	Leaves	It exert diuretic action in rat	[74]
32	*Lumnitzera racemose*	Combretaceae	Leaves	Calcium channels blocker. Enhance NO synthesis	[75,76]
33	*Lycopersicon esculentum*	Solanaceae	Tomato fruits	Antioxidants activity. Slow the progress of atherosclerosis.	[77]
34	*Mammea africana*	Calophyllaceae	Bark	Ca2+ antagonists	[78]
35	*Moringa oleifera*	Moringaceae	Leaves	Diuretic action, ACE inhibitor	[79,80,81]
36	*Musangacecropiodes*	Cecropiaceae	Leaves	Vasorelaxant action,	[65]
37	*Ocimumbasilicum*	Lamiaceae	Leaves	. Eugenol's effects on the cardiovascular system are linked to its ability to inhibit calcium channels.	[67,17]
38	*Olea europaea*	Oleaceae	Leaves	Angiotensin II inhibition	[82,83]
39	*Phyllanthus niruri.*	Euphorbiaceae	Leaves	Vasorelaxation and a drop in blood pressure are both mediated by -adrenoceptor activation.	[84]
40	*Pinus pinaster*	Pinaceae	Bark	ACE I	[85]

S/N	Names of plants	Family	Part used	Mechanism of action	References
41	*Pueraria lobate*	Fabaceae	Roots	Vasodialation and antioxidant action	[86,87]
42	*Punica granatum*	Lythraceae	Fruits	Reduces ACEI action	[88]
43	*Rauwolfia serpentine*	Apocynaceae	Leaves / Roots	Deplete catecholamine	[89,90]
44	*Rhaptopetalum coriaceum oliver*	Scytopetalaceae	Stem bark	Calcium channel blocker	[17]
45	*Salvia cinnabarina*	Lamiaceae	Leaves	Nitric oxide production	[36]
46	*Sesamum indicum*	Pedaliaceae	Seeds	Antioxidant activity	[91,92]
47	*Solanum sisymbriifolium*	Solanaceae	Roots	Diuretics	[93]
48	*Tanacetum vulgare*	Asteraceae	Leaves	Diuretic action. NO production enhancer	[94]
49	*Theobroma cacao*	Malvaceae	Cacao powder	Antioxidant and calcium channels blocker	[95]
50	*Uncaria rhynchophylla*	Rubiaceae	Herbs	Calcium channel blocker	[96,97]
51	*Viscum album*	Santalaceae	Leaves	Enhances NO production	[98]
52	*Zingiber officinale*	Zingiberaceae	Rhizome	Calcium channel blocker. Inhibits lipid peroxidation	[99,100]

4. CONCLUSION

In recent years, there has been a resurgence of interest in the quest for novel medications derived from natural sources, particularly plant sources. Tropical rain forests have grown to be a key area of this activity, mostly because of the abundant biodiversity they support, which promises a wide variety of compounds with potentially unique structures. Nonetheless, only a small percentage of this diverse biodiversity has been investigated for its potential as medicine. As a result, in the future, we may be able to treat HTN with medications derived from plants and herbs that are naturally occurring and have fewer side effects and greater absorption.

5. SIGNIFICANCE OF THE STUDY

The study highlights the efficacy of "herbal" which is an ancient tradition, used in some parts of India. This ancient concept should be carefully evaluated in the light of modern medical science and can be utilized partially if found suitable.

CONSENT

It is not applicable.

ETHICAL APPROVAL

It is not applicable.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

REFERENCES

1. Li W, Zhao J, Song L, Chen S, Liu X, Wu S. Combined effects of carotid plaques and hypertension on the risk of cardiovascular disease and all-cause mortality. Clin Cardiol. 2020;43(7):715–22.
2. Ge Z, Hao Y, Cao J, Li J, Chen J, Huang J, et al. Does cigarette smoking exacerbate the effect of blood pressure on the risk of cardiovascular and all-cause mortality among hypertensive patients? J Hypertens. 2012;30(12):2307–13.
3. Mills KT, Stefanescu A, He J. The global epidemiology of hypertension. Nat Rev Nephrol. 2020;16(4):223–37.
4. Mills KT, Bundy JD, Kelly TN, Reed JE, Kearney PM, Reynolds K, et al. Global

disparities of hypertension prevalence and control: a systematic analysis of population-based studies from 90 countries. Circulation. 2016;134(6): 441–50.
5. Samadian F, Dalili N, Jamalian A. Lifestyle modifications to prevent and control hypertension. Iran J Kidney Dis. 2016;10(5).
6. Schutte AE, Srinivasapura Venkateshmurthy N, Mohan S, Prabhakaran D. Hypertension in low-and middle-income countries. Circ Res. 2021;128(7):808–26.
7. Bowry ADK, Lewey J, Dugani SB, Choudhry NK. The burden of cardiovascular disease in low-and middle-income countries: epidemiology and management. Can J Cardiol. 2015;31(9): 1151–9.
8. Guwatudde D, Nankya-Mutyoba J, Kalyesubula R, Laurence C, Adebamowo C, Ajayi I, et al. The burden of hypertension in sub-Saharan Africa: a four-country cross sectional study. BMC Public Health. 2015;15:1–8.
9. Bedane SN. Out of pocket expenditures among hypertensive patients and their households who visit public hospitals in Addis Ababa, Ethiopia, 2016. Heal Econ Outcome Res Open Access. 2018;4(1): 1–7.
10. Ogah OS, Rayner BL. Recent advances in hypertension in sub-Saharan Africa. Heart. 2013;99(19):1390–7.
11. Desormais I, Amidou SA, Houehanou YC, Houinato SD, Gbagouidi GN, Preux PM, et al. The prevalence, awareness, management and control of hypertension in men and women in Benin, West Africa: the TAHES study. BMC Cardiovasc Disord. 2019;19(1):1–12.
12. Mv SP, Mwinuka VJ. Prevalence of Controlled Systemic Hypertension and its Associated Risk Factors among Hypertensive Patients at Mbeya Zonal Referral Hospital, Tanzania. Syst Rev Pharm. 2021;12(11):3686–90.
13. Ajayi TO, Moody JO, Anthony CS. Ethnobotanical survey of plants used in the management of hypertension in Ibadan North Local Government Area of Oyo State, Nigeria. Niger J Pharm Res. 2019; 15(1):61–73.
14. Adeloye D, Basquill C, Aderemi A V, Thompson JY, Obi FA. An estimate of the prevalence of hypertension in Nigeria: a systematic review and meta-analysis. J Hypertens. 2015;33(2):230–42.
15. Princewel F, Cumber SN, Kimbi JA, Nkfusai CN, Keka EI, Viyoff VZ, et al. Prevalence and risk factors associated with hypertension among adults in a rural setting: the case of Ombe, Cameroon. Pan Afr Med J. 2019;34.
16. Khan QA, Khan AA, Jabeen A, Jahangir U, Khalid M, Ansari S. Essential hypertension: a co relational approach in Unani medicine. Int J Pharmacogn. 2016; 3(6):240–5.
17. Tabassum N, Ahmad F. Role of natural herbs in the treatment of hypertension. Pharmacogn Rev. 2011;5(9):30.
18. Barton M, Husmann M, Meyer MR. Accelerated vascular aging as a paradigm for hypertensive vascular disease: prevention and therapy. Can J Cardiol. 2016;32(5):680–6.
19. Zhu Y, Gu X, Xu C. Mitochondrial DNA 7908–8816 region mutations in maternally inherited essential hypertensive subjects in China. BMC Med Genomics. 2018;11(1):1–11.
20. Nandhini S. Essential hypertension-a review article. J Pharm Sci Res. 2014; 6(9):305.
21. Saxena T, Ali AO, Saxena M. Pathophysiology of essential hypertension: an update. Expert Rev Cardiovasc Ther. 2018;16(12):879–87.
22. Ferder L, Ferder MD, Inserra F. The role of high-fructose corn syrup in metabolic syndrome and hypertension. Curr Hypertens Rep. 2010;12:105–12.
23. Le MT, Frye RF, Rivard CJ, Cheng J, McFann KK, Segal MS, et al. Effects of high-fructose corn syrup and sucrose on the pharmacokinetics of fructose and acute metabolic and hemodynamic responses in healthy subjects. Metabolism. 2012;61(5): 641–51.
24. Hegde S, Ahmed I, Aeddula N. Secondary hypertension. StatPearls. 2023;
25. Zhang M, Wong HS, Malakar RD, Puar TH. Secondary Causes of Hypertension: An Overview. Hypertens Cardiovasc Dis Asia. 2022;197–207.
26. Anthony J, Sliwa K. Decompensated heart failure in pregnancy. Card Fail Rev. 2016;2(1):20.
27. Singh M, Mensah GA, Bakris G. Pathogenesis and clinical physiology of hypertension. Cardiol Clin. 2010;28(4): 545–59.

28. Pimenta E, Oparil S. Role of aliskiren in cardio-renal protection and use in hypertensives with multiple risk factors. Vasc Health Risk Manag. 2009;453–63.
29. Tuck ML. The sympathetic nervous system in essential hypertension. Am Heart J. 1986;112(4):877–86.
30. Takahashi H. Sympathetic hyperactivity in hypertension. Nihon Rinsho. 2008;66(8): 1495–502.
31. Sharma I, Parashar B, Dhamija HK, Sharma R. An ayurvedic arena for hypertension treatment. Asian J Pharm Res. 2012;2(2):54–8.
32. Ghadieh AS, Saab B. Evidence for exercise training in the management of hypertension in adults. Can Fam Physician. 2015;61(3):233–9.
33. Mancia G, Fagard R, Narkiewicz K, Redon J, Zanchetti A, Böhm M, et al. 2013 ESH/ESC practice guidelines for the management of arterial hypertension: ESH-ESC the task force for the management of arterial hypertension of the European Society of Hypertension (ESH) and of the European Society of Cardiology (ESC). Blood Press. 2014;23(1):3–16.
34. Düsing R. Overcoming barriers to effective blood pressure control in patients with hypertension. Curr Med Res Opin. 2006; 22(8):1545–53.
35. Singh P, Mishra A, Singh P, Goswami S, Singh A, Tiwari KD. Hypertension and herbal plant for its treatment: a review. Indian J Res Pharm Biotechnol. 2015; 3(5):358.
36. Sultana S, Muhammad Asif H. Medicinal plants combating against hypertension: A green antihypertensive approach. Pak J Pharm Sci. 2017;30(6).
37. Rastogi S, Pandey MM, Rawat AKS. Traditional herbs: a remedy for cardiovascular disorders. Phytomedicine. 2016;23(11):1082–9.
38. Nasri H, Baradaran A, Shirzad H, Rafieian-Kopaei M. New concepts in nutraceuticals as alternative for pharmaceuticals. Int J Prev Med. 2014;5(12):1487.
39. Abubakar MG, Ukwuani AN, Mande UU. Antihypertensive activity of Hibiscus Sabdariffa aqueous calyx extract in Albino rats. Sky J Biochem Res. 2015;4(3): 16–20.
40. Farnsworth NR, Akerele O, Bingel AS, Soejarto DD, Guo Z. Medicinal plants in therapy. Bull World Health Organ. 1985; 63(6):965.
41. Arias-Durán L, Estrada-Soto S, Hernández-Morales M, Millán-Pacheco C, Navarrete-Vázquez G, Villalobos-Molina R, et al. Antihypertensive and vasorelaxant effect of leucodin and achillin isolated from Achillea millefolium through calcium channel blockade and NO production: In vivo, functional ex vivo and in silico studies. J Ethnopharmacol. 2021;273: 113948.
42. Nwokocha CR, Ozolua RI, Owu DU, Nwokocha MI, Ugwu AC. Antihypertensive properties of Allium sativum (garlic) on normotensive and two kidney one clip hypertensive rats. Niger J Physiol Sci. 2011;26(2):213–8.
43. El-Saber Batiha G, Magdy Beshbishy A, G. Wasef L, Elewa YHA, A. Al-Sagan A, Abd El-Hack ME, et al. Chemical constituents and pharmacological activities of garlic (Allium sativum L.): A review. Nutrients. 2020;12(3):872.
44. Cahyawati PN. A Mini Review: Efek Farmakologi Andrographis Paniculata (Sambiloto). WICAKSANA J Lingkung dan Pembang. 2021;5(1):19–24.
45. Verma T, Sinha M, Bansal N, Yadav SR, Shah K, Chauhan NS. Plants used as antihypertensive. Nat Products Bioprospect. 2021;11:155–84.
46. Sokpe A, Mensah MLK, Koffuor GA, Thomford KP, Arthur R, Jibira Y, et al. Hypotensive and antihypertensive properties and safety for use of Annona muricata and Persea americana and their combination products. Evidence-Based Complement Altern Med. 2020;2020:1–13.
47. Adefegha SA, Oyeleye SI, Oboh G. Distribution of phenolic contents, antidiabetic potentials, antihypertensive properties, and antioxidative effects of soursop (Annona muricata L.) fruit parts in vitro. Biochem Res Int. 2015;2015.
48. Makarova EI, Bokov DO, Sergunova E V, Chevidaev V V, Kakhramanova SD, Bessonov V V, et al. Apium graveolens L.: A phytochemical and pharmacological review. Res J Pharm Technol. 2022;15(2):927–34.
49. Siddesha JM, Angaswamy N, Vishwanath BS. Phytochemical screening and evaluation of in vitro angiotensin-converting enzyme inhibitory activity of Artocarpus altilis leaf. Nat Prod Res. 2011;25(20):1931–40.
50. Xingfei L, Shunshun P, Wenji Z, Lingli S, Qiuhua L, Ruohong C, et al. Properties of

ACE inhibitory peptide prepared from protein in green tea residue and evaluation of its anti-hypertensive activity. Process Biochem. 2020;92:277–87.
51. Upadhyay RK. Kareel plant: A natural source of medicines and nutrients. Int J Green Pharm. 2011;5(4).
52. Gilani AH, Jabeen Q, Ghayur MN, Janbaz KH, Akhtar MS. Studies on the antihypertensive, antispasmodic, bronchodilator and hepatoprotective activities of the Carum copticum seed extract. J Ethnopharmacol. 2005;98(1–2):127–35.
53. Ahmad S, Hassan A, Abbasi WM, Rehman T. Phytochemistry and pharmacological potential of Cassia absus–a review. J Pharm Pharmacol. 2018;70(1):27–41.
54. Ntchapda F, Barama J, Azambou DRK, Etet PFS, Dimo T. Diuretic and antioxidant activities of the aqueous extract of leaves of Cassia occidentalis (Linn.) in rats. Asian Pac J Trop Med. 2015;8(9):685–93.
55. Shivaprasad HN, Pandit S, Bhanumathy M, Manohar D, Jain V, Thandu SA, et al. Ethnopharmacological and phytomedical knowledge of Coleus forskohlii: an approach towards its safety and therapeutic value. Orient Pharm Exp Med. 2014;14(4):301–12.
56. Khatoon T, Naskar A, Datta K, Kumar D, Kaur G, Karmakar P, et al. A Short Review on Role of Some Natural Herbs in the Treatment of Hypertension. Asian J Pharm Res Dev. 2022;10(3):88–93.
57. Mahleyuddin NN, Moshawih S, Ming LC, Zulkifly HH, Kifli N, Loy MJ, et al. Coriandrum sativum L.: A review on ethnopharmacology, phytochemistry, and cardiovascular benefits. Molecules. 2021;27(1):209.
58. Wang T, Zhang P, Zhao C, Zhang Y, Liu H, Hu L, et al. Prevention effect in selenite-induced cataract in vivo and antioxidative effects in vitro of Crataegus pinnatifida leaves. Biol Trace Elem Res. 2011;142:106–16.
59. Ndjenda Ii MK, Nguelefack-Mbuyo EP, Atsamo AD, Fofie CK, Fodem C, Nguemo F, et al. Antihypertensive Effects of the Methanol Extract and the Ethyl Acetate Fraction from Crinum zeylanicum (Amaryllidaceae) Leaves in L-NAME-Treated Rat. Evidence-Based Complement Altern Med. 2021;2021.
60. Hosseini A, Razavi BM, Hosseinzadeh H. Saffron (Crocus sativus) petal as a new pharmacological target: A review. Iran J Basic Med Sci. 2018;21(11):1091.
61. Srivastava R, Ahmed H, Dixit RK, Saraf SA. Crocus sativus L.: a comprehensive review. Pharmacogn Rev. 2010;4(8): 200.
62. Dzeufiet PDD, Mogueo A, Bilanda DC, Aboubakar B-FO, Tédong L, Dimo T, et al. Antihypertensive potential of the aqueous extract which combine leaf of Persea americana Mill.(Lauraceae), stems and leaf of Cymbopogon citratus (DC) Stapf.(Poaceae), fruits of Citrus medical L.(Rutaceae) as well as honey in ethanol and sucrose experiment. BMC Complement Altern Med. 2014;14:1–12.
63. Gilani AH, Shaheen F, Saeed SA, Bibi S, Sadiq M, Faizi S. Hypotensive action of coumarin glycosides from Daucus carota. Phytomedicine. 2000;7(5):423–6.
64. Hansen K, Nyman U, Smitt UW, Adsersen A, Gudiksen L, Rajasekharan S, et al. In vitro screening of traditional medicines for anti-hypertensive effect based on inhibition of the angiotensin converting enzyme (ACE). J Ethnopharmacol. 1995;48(1): 43–51.
65. Kamyab R, Namdar H, Torbati M, Ghojazadeh M, Araj-Khodaei M, Fazljou SMB. Medicinal plants in the treatment of hypertension: A review. Adv Pharm Bull. 2021;11(4):601.
66. Rawat P, Singh PK, Kumar V. Anti-hypertensive medicinal plants and their mode of action. J Herb Med. 2016; 6(3):107–18.
67. Baradaran A, Nasri H, Rafieian-Kopaei M. Oxidative stress and hypertension: Possibility of hypertension therapy with antioxidants. J Res Med Sci Off J Isfahan Univ Med Sci. 2014;19(4):358.
68. Mans DRA, Sallevelt SCEH, Soekhoe R, Bipat R, Toelsie JR. Evaluation of plants with presumed antihypertensive properties for their potential to decrease peripheral resistance using isolated guinea pig aortic rings pre-contracted with phenylephrine. Acad J Suriname. 2010;1(1):15–9.
69. Silva S do N, Abreu IC, Freire SM de F, Cartágenes M do S de S, Ribeiro RM, Castro AS de, et al. Antispasmodic effect of Jatropha gossypiifolia is mediated through dual blockade of muscarinic receptors and Ca2+ channels. Rev Bras Farmacogn. 2011;21:715–20.
70. Wu Q, Patocka J, Nepovimova E, Kuca K. Jatropha gossypiifolia L. and its biologically

active metabolites: A mini review. J Ethnopharmacol. 2019;234:197–203.
71. Vergara-Galicia J, Ortiz-Andrade R, Rivera-Leyva J, Castillo-España P, Villalobos-Molina R, Ibarra-Barajas M, et al. Vasorelaxant and antihypertensive effects of methanolic extract from roots of Laelia anceps are mediated by calcium-channel antagonism. Fitoterapia. 2010; 81(5):350–7.
72. Lim TK. Lavandula stoechas. In: Edible Medicinal and Non Medicinal Plants: Volume 8, Flowers. Springer; 2014. p. 192–201.
73. Talha J, Priyanka M, Akanksha A. Hypertension and herbal plants. Int Res J Pharm. 2011;2(8):26–30.
74. Wright CI, Van-Buren L, Kroner CI, Koning MMG. Herbal medicines as diuretics: a review of the scientific evidence. J Ethnopharmacol. 2007;114(1):1–31.
75. Das SK, Das B, Jena AB, Pradhan C, Sahoo G, Dandapat J. Therapeutic Potential and Ethnopharmacology of Dominant Mangroves of Bhitarkanika National Park, Odisha, India. Chem Biodivers. 2022;19(3):e202100857.
76. Manohar SM. A Review of the Botany, Phytochemistry and Pharmacology of Mangrove Lumnitzera racemosa Willd. Pharmacogn Rev. 2021;15(30).
77. Phachonpai W. Antihypertensive and vasoprotective effects of Clausena lansium fruits extract in L-NAME induced hypertensive rats. Pak J Pharm Sci. 2020;
78. Nguelefack-Mbuyo PE, Nguelefack TB, Dongmo AB, Afkir S, Azebaze AGB, Dimo T, et al. Anti-hypertensive effects of the methanol/methylene chloride stem bark extract of Mammea africana in L-NAME-induced hypertensive rats. J Ethnopharmacol. 2008;117(3):446–50.
79. Kumolosasi E, Wei CC, Abdullah AZ, Abd Manap NS, Lee WL, Yousuf MH, et al. Antihypertensive activities of standardised Moringa oleifera Lam.(merunggai) extracts in spontaneously hypertensive rats. Sains Malays. 2021;50(3):769–78.
80. Aekthammarat D, Pannangpetch P, Tangsucharit P. Moringa oleifera leaf extract lowers high blood pressure by alleviating vascular dysfunction and decreasing oxidative stress in L-NAME hypertensive rats. Phytomedicine. 2019; 54:9–16.
81. Ma K, Wang Y, Wang M, Wang Z, Wang X, Ju X, et al. Antihypertensive activity of the ACE–renin inhibitory peptide derived from Moringa oleifera protein. Food Funct. 2021;12(19):8994–9006.
82. Ivanov M, Vajic U-J, Mihailovic-Stanojevic N, Miloradovic Z, Jovovic D, Grujic-Milanovic J, et al. Highly potent antioxidant Olea europaea L. leaf extract affects carotid and renal haemodynamics in experimental hypertension: the role of oleuropein. EXCLI J. 2018;17:29.
83. Susalit E, Agus N, Effendi I, Tjandrawinata RR, Nofiarny D, Perrinjaquet-Moccetti T, et al. Olive (Olea europaea) leaf extract effective in patients with stage-1 hypertension: comparison with Captopril. Phytomedicine. 2011;18(4):251–8.
84. Bello I, Usman NS, Dewa A, Abubakar K, Aminu N, Asmawi MZ, et al. Blood pressure lowering effect and vascular activity of Phyllanthus niruri extract: The role of NO/cGMP signaling pathway and β-adrenoceptor mediated relaxation of isolated aortic rings. J Ethnopharmacol. 2020;250:112461.
85. Maimoona A, Naeem I, Saddiqe Z, Jameel K. A review on biological, nutraceutical and clinical aspects of French maritime pine bark extract. J Ethnopharmacol. 2011; 133(2):261–77.
86. Ng CF, Koon CM, Cheung DWS, Lam MY, Leung PC, Lau CBS, et al. The anti-hypertensive effect of Danshen (Salvia miltiorrhiza) and Gegen (Pueraria lobata) formula in rats and its underlying mechanisms of vasorelaxation. J Ethnopharmacol. 2011;137(3):1366–72.
87. Bebrevska L, Foubert K, Hermans N, Chatterjee S, Van Marck E, De Meyer G, et al. In vivo antioxidative activity of a quantified Pueraria lobata root extract. J Ethnopharmacol. 2010;127(1):112–7.
88. Mayasankaravalli C, Deepika K, Lydia DE, Agada R, Thagriki D, Govindasamy C, et al. Profiling the phyto-constituents of Punica granatum fruits peel extract and accessing its in-vitro antioxidant, anti-diabetic, anti-obesity, and angiotensin-converting enzyme inhibitory properties. Saudi J Biol Sci. 2020;27(12):3228–34.
89. Kaur A. Pharmacobotanical and pharmacological evaluation of ayurvedic crude drug: Rauwolfia serpentina (Apocynaceae). Int J Green Pharm. 2017;11(04).
90. Shah SMA, Naqvi SAR, Munir N, Zafar S, Akram M, Nisar J. Antihypertensive and antihyperlipidemic activity of aqueous

methanolic extract of Rauwolfia serpentina in albino rats. Dose-Response. 2020; 18(3):1559325820942077.

91. Elleuch M, Bedigian D, Zitoun A. Sesame (Sesamum indicum L.) seeds in food, nutrition, and health. In: Nuts and seeds in health and disease prevention. Elsevier; 2011. p. 1029–36.
92. Mushtaq A, Hanif MA, Ayub MA, Bhatti IA, Jilani MI. Sesame. In: Medicinal Plants of South Asia. Elsevier; 2020. p. 601–15.
93. Ibarrola DA, Arrua W, Gonzalez JE, Escobar MSS, Centurión J, Benitez AMC, et al. The antihypertensive and diuretic effect of crude root extract and saponins from Solanum sisymbriifolium Lam., in L-NAME-induced hypertension in rats. J Ethnopharmacol. 2022;298:115605.
94. Babich O, Larina V, Krol O, Ulrikh E, Sukhikh S, Gureev MA, et al. In Vitro Study of Biological Activity of Tanacetum vulgare Extracts. Pharmaceutics. 2023;15(2):616.
95. Ishaq S, Jafri L. Biomedical importance of cocoa (Theobroma cacao): significance and potential for the maintenance of human health. Matrix Sci Pharma. 2017; 1(1):1–5.
96. Loh YC, Ch'ng YS, Tan CS, Ahmad M, Asmawi MZ, Yam MF. Mechanisms of action of Uncaria rhynchophylla ethanolic extract for its vasodilatory effects. J Med Food. 2017; 20(9):895–911.
97. Ndagijimana A, Wang X, Pan G, Zhang F, Feng H, Olaleye O. A review on indole alkaloids isolated from Uncaria rhynchophylla and their pharmacological studies. Fitoterapia. 2013;86:35–47.
98. Poruthukaren KJ, Palatty PL, Baliga MS, Suresh S. Clinical evaluation of Viscum album mother tincture as an antihypertensive: a pilot study. J Evid Based Complementary Altern Med. 2014; 19(1):31–5.
99. Yeh H, Chuang C, Chen H, Wan C, Chen T, Lin L. Bioactive components analysis of two various gingers (Zingiber officinale Roscoe) and antioxidant effect of ginger extracts. LWT-Food Sci Technol. 2014; 55(1):329–34.
100. Dhanik J, Arya N, Nand V. A review on Zingiber officinale. J Pharmacogn Phytochem. 2017;6(3):174–84.

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