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REVIEW

Antihypertensive Plants Used by the Anak Dalam Tribe in Jambi, Indonesia: Ethnobotanical Insights and Pharmacological Potential as Alternatives to Conventional Medicine

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Abstract: Hypertension represents a significant health burden worldwide, and traditional medicinal plants historically used by indigenous communities such as the Anak Dalam tribe to manage blood pressure offer promising ethnopharmacological opportunities for developing accessible and culturally acceptable antihypertensive therapies. This review summarizes the traditional uses of 34 well-known and promising medicinal plants utilized by the Anak Dalam tribe and assesses their potential for treating hypertension-related diseases. The results revealed that nine medicinal plants used by the Anak Dalam tribe in Jambi, Indonesia, in developing antihypertensive therapies. In this study, the medicinal properties of the following species are discussed briefly, and their benefits are highlighted: turmeric (*Curcuma longa* Linn). garlic (*Allium sativum* Linn). noni (*Morinda citrifolia* Linn). lime (*Citrus aurantiifolia* (Christm). Swingle), celery (*Apium graveolens* Linn). starfruit (*Averrhoa bilimbi* Linn). cat's whiskers (*Orthosiphon aristatus* var. *aristatus*), soursop (*Annona muricata* L). and ginger (*Zingiber officinale* Roscoe). According to the review of the literature, these plants were tested using various methods: turmeric and partially celery on male Wistar rats induced with deoxycorticosterone acetate (DOCA); garlic in a randomized clinical trial; noni with 8% NaCl and prednisone induction; lime in a heated palm oil model; bilimbi with 0.8% NaCl induction and human patients; cat's whiskers in phenylephrine-induced rats and a clinical cohort; soursop on normotensive and ethanol/sucrose/epinephrine-induced rats; and ginger by an unspecified invasive method. Data from the references suggest that the extracts reliably show notable decreases in blood pressure and adjustments in heart rate, mainly due to their elevated levels of flavonoids, phenolics, organosulfurs, coumarins, phthalides, and acetogenins compounds known for their antihypertensive effects. Although encouraging, additional studies are needed to create safe and effective pharmaceutical products derived from these plants. They have the potential to serve as a natural alternative to synthetic antihypertensive medications, possibly providing comparable results with fewer adverse effects. Furthermore, this review serves as an important reference for future studies on ethnomedicines that contain phytochemicals.

Keywords: antihypertension, herbal medicine, traditional medicine, phytochemicals, anak dalam tribe

Introduction

Hypertension represents a major global health problem and contributes significantly to mortality worldwide. The World Health Organization (WHO) reported that approximately 1.3 billion adults aged 30–79 years live with hypertension.[1,2] The 2023 Indonesian Health Survey (*Survei Kesehatan Indonesia*) showed that 34% of Indonesians aged 15 years and older suffer from hypertension. With this prevalence, Indonesia ranks fifth worldwide.[3] According to the 2018 Basic Health Research (Indonesian: *Riset Kesehatan Dasar* (RISKESDAS)) report, about 63.3 million Indonesian adults have

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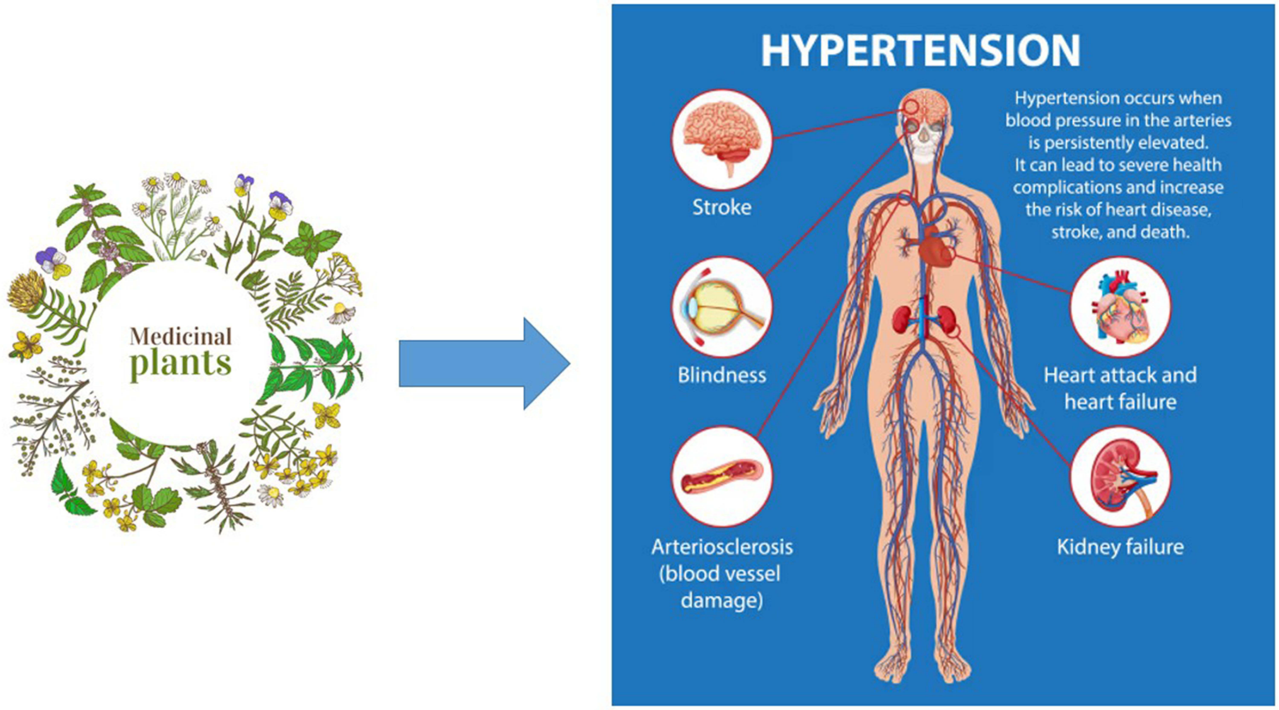
Graphical Abstract



hypertension, yet only 8.8% have received a diagnosis.[4] The undiagnosed prevalence remains particularly high among men (55%) and women (44%) aged 26–35 years.[5] The main challenge of hypertension lies in the fact that many individuals remain unaware of their condition. Without proper management, this often results in severe complications such as stroke, heart attack, kidney failure, or even sudden death due to irregular use of antihypertensive medication.[6,7] In addition, unhealthy modern lifestyles, including high-salt diets, physical inactivity, chronic stress, and excessive alcohol consumption, further worsen the prevalence of hypertension worldwide.[6,8] Limited public awareness and inadequate access to treatment remain critical obstacles in controlling hypertension globally, which accounts for an estimated 8.5 million deaths annually.[2]

Hypertension does not result only from excessive salt intake, stress, or lack of exercise. Genetic predisposition can also increase vascular resistance and cardiac workload.[9,10] Hypertension develops when blood vessels narrow or stiffen, forcing the heart to work harder to circulate blood, thereby elevating blood pressure. In severe cases, hypertension can cause stroke through ruptured cerebral vessels or trigger sudden heart attacks. Over time, uncontrolled hypertension may progress to chronic kidney failure, often requiring lifelong dialysis.[9] For this reason, strict blood pressure control in hypertensive patients remains crucial, especially through conventional treatment.

Conventional antihypertensive therapies, including ACE inhibitors, beta-blockers, and diuretics, effectively control blood pressure and prevent complications such as stroke and myocardial infarction. However, long-term use of these drugs may produce adverse effects, including dry cough, fatigue, dizziness, electrolyte imbalances, and impaired renal function.[11] These side effects can reduce patient quality of life, lower adherence to therapy, and raise concerns about dependency on synthetic drugs. As a result, many patients turn to natural treatment approaches.[12] To ensure safe and effective therapy, regular blood pressure monitoring by patients and medical personnel is essential.

Regular blood pressure monitoring by healthcare professionals, adjusting drug type and dosage to fit each patient's condition, and providing education about potential side effects represent key strategies for managing the adverse effects of conventional medications.[12] Counseling also plays a central role in hypertension management, particularly in reinforcing the importance of taking medication consistently, even in the absence of symptoms.[13] Because hypertension is often asymptomatic yet carries life-threatening risks of complications, an individualized therapeutic approach supported by family involvement and healthcare professionals is essential to improve long-term treatment adherence.[12]

Therefore, hypertension control at the community level should not rely only on conventional drugs but also incorporate traditional, effective, and self-reliant treatment practices. Traditional therapies rooted in local wisdom provide an integrative approach that can broaden the reach of hypertension control.[2] When combined with healthy lifestyle modifications, complementary therapies based on natural ingredients can reduce the side effects of conventional drugs while maintaining stable blood pressure. The use of natural ingredients, validated empirically and scientifically, as alternative or complementary therapies also helps minimize dependence on synthetic pharmaceuticals.[14,15]

In rural areas of Jambi Province, where healthcare infrastructure is limited—characterized by low facility density, inadequate physician-to-population ratios, and barriers to medication access—traditional medicine plays a vital role in primary healthcare.[15–20] Regular blood pressure monitoring and individualized treatment plans remain essential, but many individuals rely on local, culturally embedded practices. Community-based education and engagement are critical to improving hypertension management outcomes.

The Anak Dalam tribe, an indigenous community in Jambi Province, exemplifies this reliance on traditional medicine.[17] With an estimated population of around 3,198 to 3,205 people, they are geographically distributed across several regions within Jambi. The population of Anak Dalam tribe in Jambi is mainly spread across lowland forest areas, with the largest concentration in Bukit Duabelas National Park, which includes Batanghari, Tebo, and Sarolangun Regencies. They also live in Bukit Tiga Puluh National Park, as well as in Merangin, Bungo, and Muaro Jambi Regencies.[17] Their cultural practices deeply incorporate ethnobotanical knowledge, particularly in managing health conditions like hypertension. The tribe traditionally prepares decoctions from forest plants—boiled roots, leaves, or barks—that are believed to reduce blood pressure. This knowledge, passed down through generations, remains an integral part of their natural health practices, especially given the limited access to modern healthcare services in their remote settlements.

According to the 2012 Research on Medicinal Plants and Herbal Medicine (RISTOJA), the Anak Dalam tribe utilizes 34 species of medicinal plants with potential antihypertensive properties. Among these, nine species are most widely used: *Curcuma longa* Linn., *Allium sativum* Linn., *Morinda citrifolia* Linn., *Citrus aurantiifolia* (Christm). Swingle, *Apium graveolens* Linn., *Averrhoa bilimbi* Linn., *Orthosiphon aristatus* var. aristatus, *Annona* muricata L., and *Zingiber officinale* Roscoe. These plants contain bioactive compounds—such as flavonoids, saponins, and alkaloids etc.—that may contribute to blood pressure reduction.[14,15] Similar ethnobotanical practices are observed among other Indonesian tribes such as the Dayak (in Borneo), Baduy (in Java) and Toraja (in Celebes), suggesting that some antihypertensive remedies are either widespread or culturally specific within the region.[18,19] They utilize roots, leaves, and bark for medicinal purposes, guided by local knowledge.

The use of these medicinal plants is supported by their bioactive constituents, which act synergistically to relax blood vessels, promote sodium excretion, and inhibit angiotensin-converting enzyme (ACE) activity.[15] Such combinations, often prepared as decoctions, are considered safer alternatives with fewer side effects than synthetic drugs, especially in areas with limited healthcare access.[21] However, the empirical nature of these traditional practices necessitates scientific validation, including safety assessments, standardization, and efficacy studies.

Standardization challenges involve variability in extraction methods, plant harvest timing, plant part used, and geographical influences, all of which affect the consistency and quality of herbal preparations. Addressing these challenges is essential before such remedies can be developed into pharmaceutical products. Currently, scientific evidence supporting these species ranges from in vitro studies to animal trials, with limited human clinical trials—highlighting the need for a comprehensive evaluation of their translational potential.[22] A summary table categorizing the level of evidence in this review for each species would clarify their readiness for clinical development.

Furthermore, understanding Indonesia's regulatory pathway—from traditional Jamu formulations to standardized herbal products, phytopharmaceuticals, and registered drugs—is crucial for translating ethnobotanical knowledge into formal healthcare options.[23] Navigating this pathway requires adherence to national policies and international agreements like the Nagoya Protocol, ensuring ethical use and benefit-sharing with indigenous communities.

This review aims to synthesize ethnobotanical data from the Anak Dalam tribe, evaluate the safety and efficacy of their antihypertensive remedies, and explore the prospects for pharmaceutical development. Recognizing the cultural, ethical, and scientific dimensions of this traditional knowledge is essential for fostering responsible and sustainable integration of indigenous medicine into broader healthcare strategies.

Methods

The methodology involved the following key stages:

Search Strategy and Database Selection

A comprehensive search was performed across several prominent scientific databases to gather relevant literature. The primary databases accessed include:

- PubMed/MEDLINE: For biomedical and life sciences research.
- Scopus: A multidisciplinary abstract and citation database of peer-reviewed literature.
- Web of Science: Another multidisciplinary citation database covering science, social sciences, arts, and humanities.
- Google Scholar: To broaden the search and capture potentially relevant gray literature or less indexed publications.
- Indonesian National Library (Perpusnas) and Garuda: For local Indonesian research and publications.

The search strategy employed a combination of keywords and their synonyms, using Boolean operators (AND, OR) to refine the search queries. Key search terms included:

- “Children in tribe” OR “Kubu tribe” OR “Orang Jungle”
- “Jambi”
- “Ethnobotany” OR “Traditional medicine” OR “Folk medicine”
- “Medicinal plants” OR “Herbal medicine” OR “Phytotherapy”
- “Antihypertensive” OR “Blood pressure lowering” OR “Hypertension” OR “Cardiovascular disease”
- “Indonesia”

The search was not limited by publication date, aiming to capture historical knowledge alongside contemporary research. However, the primary focus was on literature published from 2000 to the present to ensure the inclusion of modern scientific investigations.

Inclusion and Exclusion Criteria

To ensure the relevance and quality of the selected literature, the following inclusion and exclusion criteria were applied:

Inclusion Criteria:

- Studies focusing on medicinal plants used by the Anak Dalam tribe in Jambi, Indonesia.
- Studies that investigate the antihypertensive properties of these plants, either through ethnobotanical surveys reporting their use for hypertension, or through scientific investigations (in vitro, in vivo, or clinical trials) demonstrating antihypertensive effects.
- Publications in English and Indonesian.
- Peer-reviewed journal articles, scientific reports, and relevant theses/dissertations.
- Studies that identify specific plant species, their parts used, preparation methods, and reported pharmacological mechanisms or active compounds related to blood pressure regulation.

Exclusion Criteria:

- Studies not related to the Anak Dalam tribe or Jambi region.
- Studies on plants with no reported use or no scientific investigation for antihypertensive properties.
- Publications that are not in English or Indonesian.
- Opinion pieces, editorials, conference abstracts without full papers, and non-scientific articles.
- Studies focus solely on general ethnobotany without specific reference to antihypertensive applications.
- Studies on synthetic drugs or non-plant-based treatments.

Study Selection Process

The retrieved articles were initially screened by title and abstract for relevance to the research question. Potentially relevant articles were then retrieved in full text. A further manual review of the full texts was conducted to assess their eligibility based on the defined inclusion and exclusion criteria. Any discrepancies in study selection were resolved through discussion among the authors.

Data Extraction and Synthesis

Data from the included studies were extracted using a standardized data extraction form. The extracted information included:

- Plant Identification: Scientific name, family, local name (if available), and common name.
- Plant Part(s) Used: Leaves, roots, stems, fruits, flowers, etc.
- Traditional Preparation Methods: Boiling, decoction, maceration, chewing, etc.
- Reported Traditional Use for Hypertension: Specific indications and anecdotal evidence.
- Scientific Investigation:
  - Phytochemical Analysis: Identification of key bioactive compounds (eg., flavonoids, alkaloids, saponins, tannins).
  - Pharmacological Studies: In vitro assays (eg., ACE inhibition, vasodilation), in vivo animal studies (eg., blood pressure measurements in hypertensive models), and any available clinical data.
  - Mechanism of Action: Proposed pathways for antihypertensive effects (eg., vasodilation, diuretic effects, renin-angiotensin system inhibition, antioxidant activity).
- Potential for Conventional Treatment Replacement: Evidence supporting efficacy, safety, and feasibility.

The extracted data were then synthesized and organized thematically to identify common trends, promising plant species, and knowledge gaps. The review aims to provide a narrative synthesis of the findings, highlighting the potential of these plants as sources for novel antihypertensive drug development and their role in complementing or replacing conventional treatments.

There is nine medicinal plant species most frequently used for treating hypertension include *C. longa, A. sativum, M. citrifolia, C. aurantiifolia, A. graveolens, A. bilimbi, O. aristatus, A. muricata*, and *Z. officinale*. These species generally contain bioactive compounds such as alkaloids, flavonoids, and phenolics, which exhibit antioxidant, anti-inflammatory, and immunomodulatory activities. They also demonstrate strong inhibitory potential, with an IC_{50} value of 28.91 ± 13.42 μg/mL, categorized as highly potent.[21] Based on these findings, the nine plant species hold significant potential for development into pharmaceutical formulations, particularly in the form of antihypertensive tablets and capsules derived from their extracts. Such preparations may offer safer alternatives to conventional therapies by minimizing side effects, reducing drug interactions, and improving patient adherence to long-term treatment.

Antihypertensive Herbals

The availability of natural ingredients with antihypertensive properties offers opportunities for safer and more effective alternative therapies within the community. Indonesia, rich in biodiversity, provides a wide range of plants containing bioactive compounds known to lower blood pressure, including flavonoids, alkaloids, saponins, and polyphenols.[22] These compounds act through multiple mechanisms: direct vasodilation, inhibition of angiotensin converting enzyme (ACE), increased sodium and water excretion via the kidneys, blockade of angiotensin II receptors, inhibition of β-adrenergic receptors in the heart, reduction of calcium ion entry into vascular and cardiac smooth muscle cells, inhibition of α-adrenergic receptors in blood vessels, and suppression of sympathetic activity.[23] Beyond their pharmacological activity, these natural ingredients also align with local wisdom, supporting independence in traditional medicine.[24]

Replacing conventional drugs with herbal plants can reduce side effects and minimize drug interactions commonly encountered in long-term hypertension therapy. When properly processed, herbal plants can serve as effective, safe, and culturally acceptable therapeutic alternatives for patients.[25] Moreover, advancing research and development on herbal antihypertensives creates significant opportunities for sustainable therapy and supports the global shift toward natural products. Thus, exploring the therapeutic potential of natural antihypertensives represents a strategic effort to improve public health through a safe, effective, and culturally rooted approach.[26]

The Anak Dalam community in Jambi Province has long relied on local herbal medicinal plants as an alternative therapy for hypertension within their daily traditional practices. They cultivate herbs from the foothills and surrounding forests, preparing them with simple methods such as leaf or root decoctions in accordance with their ethnomedical knowledge.[17] This practice not only strengthens community self-reliance in health care but also provides a safer, more natural, and more sustainable therapeutic option for managing hypertension, particularly in areas with limited access to conventional medicine.[24]

Generations of Anak Dalam members have passed down empirical knowledge of hypertension treatment using medicinal plants believed to lower blood pressure. This tradition forms part of the community's trusted natural medicine system that continues to hold cultural significance today.

Based on the RISTOJA report, the Anak Dalam community in Jambi Province relies on approximately 34 medicinal plant species that have potential antihypertensive properties. These plants play a significant role in traditional medicine practices within the community, particularly for managing blood pressure. The study highlights the importance of these medicinal plants, many of which are abundant in the region's natural forests.[14]

Specifically, the plants with antihypertensive activity that grow abundantly in the Bukit Duabelas National Park and Bukit Tigapuluh National Park regions of Jambi, Indonesia, are of notable interest.[17] These species are not only plentiful in these protected areas but are also widely used by the Anak Dalam community for traditional healing purposes. The diversity and widespread use of these plants underscore their cultural and medicinal significance.

To provide a clearer understanding, the data on these plants, including their names, uses, and potential benefits, are summarized in Table 1. This table offers detailed information on the species that are most commonly utilized by the Anak Dalam community for hypertension management. Overall, this research emphasizes the rich ethnobotanical knowledge of the Anak Dalam people and highlights the potential of these local medicinal plants for further scientific investigation and possible development of natural antihypertensive therapies.

Interestingly, some of these medicinal plants are also used by different ethnic groups and communities in other countries for similar purposes. For example, certain species known locally in Jambi are also employed in traditional medicine practices in Indian subcontinent, Southeast Asia, South Asia, sub-Saharan Africa, Northeast Africa, Africa, tropical Americas and South America to treat hypertension or related cardiovascular conditions. This cross-cultural use suggests that these plants may contain active compounds with genuine antihypertensive properties, making them valuable candidates for further scientific research.

This review explores the use of medicinal plants by the Anak Dalam tribe in Jambi, Indonesia, focusing on those employed for managing hypertension. The authors compiled a list of 34 plant species, highlighting their traditional use in this community. However, it is important to inform that not all listed species are native or grow abundantly in the Bukit Duabelas National Park and Bukit Tiga Puluh National Park region or the surrounding Sumatran forests. Some plants, such as *Rauvolfia serpentina* (originally from the Indian subcontinent), *Lagenaria siceraria* (native to Africa), *Cassia fistula* (South Asia), *Citrullus lanatus* (Africa), and *Muntingia calabura* (Americas), are introduced or cultivated species rather than indigenous flora of the local environment. Their inclusion in the list reflects traditional or commercial use rather than natural abundance in the local ecosystem. This distinction is critical because it affects the ethnobotanical

Table 1 Indonesian Herbal Plants as Antihypertensives

No.	Latin Name	Family	Native (Introduced)	Simplicia/ Extract/ Fraction/ Isolate	Solvent	Bioactive Phytochemical Compounds	Activity	Method	Bioavailability	Ethnobotany	Ref.
1	*Curcuma longa* Linn. (Turmeric)	Zingiberaceae	India	Isolate	Ethanol	Curcumin	Antihypertensive	The antihypertensive effect of curcumin nanoemulsion (SNEC) targets the renin-angiotensin-aldosterone system (RAAS) and reduces oxidative stress in deoxycorticosterone acetate (DOCA) salt-induced hypertensive rats.	Molecular docking analysis demonstrated strong binding of curcumin to the ACE active site. Oral administration of SNEC significantly lowered systolic, diastolic, and mean arterial pressure compared with the DOCA-induced hypertensive group.[25]	Traditionally, turmeric is brewed in hot water to alleviate chronic inflammation. It is also consumed as capsule supplements to manage systolic blood pressure in lupus nephritis patients.[26]	[25,26]
2	*Lagenaria siceraria* (Molina) Standl. (Bottle Gourd)	Cucurbitaceae	Cameroon, Central African Republic, Congo, Ethiopia, Gambia, Ghana, Kenya, Liberia, Niger, Nigeria, Senegal, Sierra Leone, Somalia, Sudan, Tanzania, and Uganda	Simplicia	Ethanol	Flavonoids, sterols, saponins, terpenoids, vitamins, choline, minerals, proteins, and other phytochemicals	Antihypertensive	Male Wistar rats were divided into four groups: control (2% gum acacia p. o)., L-NAME (40 mg/kg p. o)., LS (500 mg/kg p.o). + L-NAME (40 mg/kg p.o)., and L-arginine (100 mg/kg p.o). + L-NAME (40 mg/kg p.o). Treatment lasted for 4 weeks.[27]	L-NAME significantly increased systolic blood pressure ($p < 0.001$). Both treatment groups significantly reduced systolic and diastolic blood pressure compared with L-NAME ($p < 0.001$).[27]	In Indonesia, bottle gourd is typically steamed, squeezed, and processed into juice for consumption.	[27]
3	*Allium sativum* L. (Garlic)	Amaryllidaceae	Iran, Kazakhstan, Kyrgyzstan, Tajikistan, Turkmenistan, and Uzbekistan	Extract	Ethanol	S-allyl cysteine (SAC) and allicin	Antihypertensive	A randomized, triple-blind, placebo-controlled parallel trial evaluated the antihypertensive effect of an optimized extract of aged black garlic containing low doses of SAC in Grade I hypertensive patients under drug treatment. Participants received daily supplementation of 0.25 mg/day SAC for 12 weeks.[28]	Supplementation reduced systolic blood pressure by 1.8 mmHg (95% CI: 0.7–4.1) and diastolic blood pressure by 1.5 mmHg (95% CI: 0.3–3.0).[28]	Traditionally, 3–4 cloves of garlic are crushed or finely chopped, boiled in 3 cups of water, and simmered until the volume reduces to one-quarter, then consumed as a decoction.	[28]
4	*Rauvolfia serpentina* Benth. (Indian Snakeroot)	Apocynaceae	Indian subcontinent, particularly India, predominantly in areas near the Himalayas	Extract	Methanol	Reserpine alkaloid and ajmalicine	Antihypertensive	Administration of methanol extract of *R. serpentina* demonstrated hypotensive and hypolipidemic effects in albino mice.	In vitro analysis confirmed that alkaloids identified through phytochemical screening contribute to managing cardiovascular disease and anxiety.[29]	Traditionally, the root of *R. serpentina* is used in decoctions for calming effects and to manage high blood pressure.	[29]

(*Continued*)

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Table 1 (Continued).

No.	Latin Name	Family	Native (Introduced)	Simplicia/ Extract/ Fraction/ Isolate	Solvent	Bioactive Phytochemical Compounds	Activity	Method	Bioavailability	Ethnobotany	Ref.
5	*Morinda citrifolia* L. (Noni)	Rubiaceae	Widely distributed across Bangladesh, Borneo, Cambodia, southeastern China, Hainan, India, Java, Lesser Sunda Islands, Malaya, Maldives, Maluku, Myanmar, Nansei-shoto, New Guinea, Nicobar Islands, Northern Territory, Ogasawara-shoto, Philippines, Queensland, Santa Cruz Islands, Solomon Islands, South China Sea, Sri Lanka, Sulawesi, Sumatra, Taiwan, Thailand, Vietnam, and Western Australia	Extract	Ethanol	Scopoletin	Antihypertensive	Antihypertensive activity was assessed in 25 male Wistar rats divided into five groups: (1) normal; (2) negative control (NaCl 8%); (3) positive control [NaCl 8% + amlodipine (1 mg/kg BW)]; (4) Treatment-1 [NaCl 8% + MCFE (45 mg/kg BW)]; and (5) Treatment-2 [NaCl 8% + MCFE (45 mg/kg BW) + amlodipine (1 mg/kg BW)]. MCFE and amlodipine were administered orally from day 22 to 35. Blood pressure was measured on days 0, 7, 21, 28, and 35. A 28-day repeated-dose oral toxicity test was conducted to evaluate sub-chronic toxicity.	Administration of noni ethanol extract reduced systolic and diastolic blood pressure in male Wistar rats induced by prednisone.[30] The reduction in blood pressure in Treatment-2 was not significantly different from that in the positive control or Treatment-1 ($p > 0.05$).[31,32] Noni fruit extract from Bogor also exhibited ACE inhibitory activity with an IC_{50} value of 206.26 µg/mL.[33]	Traditionally, three ripe noni fruits are grated, infused with boiled water, and strained before consumption.	[30–33]
6	*Phyllanthus niruri* L. (Meniran)	Phyllanthaceae	Argentina, Belize, Bolivia, Brazil, Colombia, Costa Rica, Dominican Republic, Ecuador, Haiti, Honduras, Leeward Islands, Mexico, Nicaragua, Panama, Paraguay, Puerto Rico, Texas, and Uruguay	Infusion	Aqueous	Flavonoids, saponins, tannins, quinones, steroids or triterpenoids, coumarins, and essential oils	Antihypertensive	A quasi-experimental, pre–post control design (noncomparative) was conducted at the Saintification of Jamu Clinic, Hortus Medicus, over 8 weeks. Sixty volunteers meeting the inclusion and exclusion criteria participated. Serum uric acid levels and renal and liver function were evaluated at baseline, mid-point, and the end of the study.	A statistically significant difference was observed in mean serum uric acid levels between baseline and week 8 in patients with mild hypertension and hyperuricemia ($p = 0.023$; 95% CI: 0.15–1.64). However, the proportion of hyperuricemic subjects increased slightly from 21.6% to 23.3% at day 56.[34] Administration of meniran extract also significantly reduced blood pressure in male SHR rats.[35]	Traditionally, meniran leaves are boiled in four glasses of water, cooled, and the decoction is strained before drinking.	[34,35]

7	*Cucumis sativus* L. (Cucumber)	Cucurbitaceae	Assam, Bangladesh, South-Central China, Southeast China, Eastern Himalayas, Myanmar, Nepal, Thailand, and Western Himalayas	Infusion	Aqueous	Steroids, terpenoids, alkaloids, phenolics, flavonoids, tannins, and saponins	Antihypertensive	Administration of 21% cucumber juice combined with 71% goldenberry juice effectively reduced blood pressure in NaCl-induced Sprague–Dawley rats.[36]	Clinical studies demonstrated that cucumber juice significantly lowered blood pressure in hypertensive patients aged > 60 years,[37] reduced mean arterial pressure in hypertensive women aged 31–60 years,[38] and significantly decreased systolic and diastolic blood pressure in patients with mild hypertension.[36]	Cucumbers are consumed raw or processed into juice as a traditional remedy for hypertension.	[36–38]
8	*Citrus aurantiifolia* (Christm). Swingle (Key Lime)	Rutaceae	Bangladesh, Bolivia, Costa Rica, Cuba, Dominican Republic, Eastern Himalayas, El Salvador, Ethiopia, Haiti, India, Laos, Malaya, Pakistan, Sri Lanka, Venezuela, and Vietnam	Extract	Ethanol	Flavonoids such as naringin, hesperidin, naringenin, hesperitin, rutin, nobiletin, and tangeretin	Antihypertensive	Supplementation with lime leaf extract reduced hypertension induced by heated palm oil in male Sprague–Dawley rats.[34,39]	In overweight or obese participants aged 10–18 years, supplementation led to slight reductions in body mass index (BMI), low-density lipoprotein cholesterol (LDL-C), and systolic blood pressure.[39]	Traditionally, lime juice mixed with warm water is consumed to manage blood pressure and support general health.	[34,39]
9	*Averrhoa carambola* L. (Starfruit)	Oxalidaceae	Java, Maluku, New Guinea, Sulawesi, and Vietnam	Extract	Aqueous	Flavonoids, tannins, and saponins	Antihypertensive	Intravenous administration of starfruit aqueous extract (AEAc, 10 mg/kg) decreased mean arterial blood pressure in male Wistar rats induced by Nω-nitro-L-arginine methyl ester hydrochloride. The extract reduced peripheral vascular resistance through Ca^{2+} channel blockade.[40]	Clinical studies showed that daily consumption of 200 mL of starfruit juice for 2 weeks decreased blood pressure in pregnant women with gestational hypertension during the second trimester. Another study reported reductions in blood pressure in hypertensive individuals who consumed starfruit juice.[41]	Traditionally, starfruit juice is prepared by consuming 150 g of fresh starfruit blended into juice, with or without added water or sugar, for seven consecutive days.	[40,41]

(*Continued*)

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Table 1 (Continued).

No.	Latin Name	Family	Native (Introduced)	Simplicia/ Extract/ Fraction/ Isolate	Solvent	Bioactive Phytochemical Compounds	Activity	Method	Bioavailability	Ethnobotany	Ref.
10	*Apium graveolens* Linn. (Celery)	Apiaceae	Afghanistan, Albania, Algeria, Austria, Azores, Balearic Islands, Belgium, Bulgaria, Canary Islands, Corsica, Cyprus, Denmark, France, Germany, Great Britain, Greece, Gulf States, Iran, Iraq, Ireland, Italy, Kazakhstan, Crete, Crimea, Lebanon-Syria, Libya, Madeira, Morocco, Netherlands, North Caucasus, Nova Scotia, Oman, Pakistan, Palestine, Poland, Portugal, Romania, Sardinia, Saudi Arabia, Sicily, Southern European Russia, Spain, Tajikistan, Transcaucasia, Tunisia, Turkey, European Turkey, Turkmenistan, Ukraine, Uzbekistan, Western Himalaya, Yemen, and former Yugoslavia	Extract	Ethanol, *n*-hexane, methanol, aqueous, and ethyl acetate	Flavonoids (apiin and apigenin), saponins, essential oils (olein) and oleoresin, phthalides (*n*-butyl phthalide and sedanolide), falcarinol, and falcarindiol	Antihypertensive	In rabbits, celery ethanol extract at 11 mg/kg produced the greatest blood pressure reduction. In rat atria, ethanol extract showed stronger hypotensive and cardio-depressant effects than aqueous extract.[42] In male Wistar rats, ethyl acetate extract strongly inhibited norepinephrine-induced contraction and significantly reduced $CaCl_2$-induced contraction.[43] Celery leaf extract prevented blood pressure elevation in fructose-induced Sprague-Dawley rats.[44] *N*-hexane, methanol, and aqueous-ethanol extracts lowered blood pressure and increased heart rate in DOCA-induced Wistar rats, with *n*-hexane extract showing the most significant effect.[45]	Administration of celery seed extract capsules (71 mg) twice daily significantly reduced blood pressure at weeks 3 and 6 in hypertensive patients.[46]	Celery leaves are added to hot water and steeped for 5–10 minutes, or celery leaf juice is consumed at least once daily.	[42–46]
11	*Cassia fistula* Linn. (Golden Shower Tree)	Fabaceae	Assam, Bangladesh, East Himalaya, India, Myanmar, Nepal, Sri Lanka, and West Himalaya	Isolate	Ethanol	Germichrysone, benzeneacetic acid, flavan-3-ol, 5,7,3′,4′-tetrahydroxy-6,8-dimethoxyflavon, dihydrokaempferol, and epiafzelechin	Antihypertensive	Top hub genes identified included TLR4, MMP9, MAPK14, AKT1, VEGFA, and HSP90AA1. Three compounds (ie, dihydrokaempferol, flavan-3-ol, and germichrysone) showed strong binding affinities of −7.1, −9.0, and −8.0 kcal/mol, respectively.	MD simulation validated the structural flexibility of the flavan-MMP9 and germich-TLR4 complexes through hydrogen bonds, root mean square deviations, and interaction energies. The study concluded that *C. fistula* (dihydrokaempferol and flavan-3-ol) and *C. occidentalis* (germichrysone) possess potential antihypertensive constituents for future drug development.	A preparation uses 1.6 g of trengguli fruit powder (*Cassia fistula*) brewed in 150 mL of warm water every morning for 14 days.	[47]

12	*Averrhoa bilimbi* Linn. (Bilimbi)	Oxalidaceae	Maluku and Sulawesi	Extract	Aqueous	Flavonoids, saponins, triterpenoids, alkaloids, tannins, amino acids, minerals, ascorbic acid, essential oils, and vitamins	Antihypertensive	Male Wistar rats induced with 0.8% NaCl showed a significant decrease in systolic blood pressure when given bilimbi extract.[48]	Mild-to-moderate hypertensive patients aged 10–61 years experienced a significant reduction in systolic blood pressure after consuming boiled bilimbi water.[49]	A regimen involves drinking 100 mL of bilimbi juice once daily for 14 days.	[48,49]
13	*Orthosiphon aristatus* var. *aristatus* (Cat's Wiskers)	Lamiaceae	Bangladesh, Borneo, Cambodia, China (South-Central, Hainan), India, Java, Laos, Lesser Sunda Islands, Malaya, Maluku, Myanmar, Philippines, Sri Lanka, Sulawesi, Sumatera, Taiwan, Thailand, and Vietnam	Extract	Ethanol	Polyphenols, alkaloids, and terpenoids	Antihypertensive	A combination of celery extract, cat's whiskers leaves, and noni fruit significantly reduced blood pressure in phenylephrine-induced hypertensive Sprague-Dawley rats and normotensive rats.[50]	Hypertensive-dyslipidemic patients receiving CCB or ACEI therapy showed a significant reduction in blood pressure after administration of nutraceuticals containing cat's whiskers leaf extract.[51]	A preparation involves boiling 4–5 cat's whiskers leaves in one glass of water until boiling, and drinking the decoction up to three times daily.	[50,51]
14	*Centella asiatica* (L). Urb. (Gotu Kola)	Apiaceae	Gambia, Ghana, Guinea, Guinea-Bissau, Gulf of Guinea Islands, India, Iran, Ivory Coast, Japan, Java, Kenya, Korea, KwaZulu-Natal, Laos, Lesotho, Lesser Sunda Islands, Liberia, Madagascar, Malawi, Malaya, Mali, Maluku, Mariana Islands, Marshall Islands, Mauritania, Mauritius, Mozambique, Myanmar, Namibia, Nansei-shoto, Nepal, and New Caledonia	Extract	Ethanol, hexane, ethyl acetate, and butanol	Asiaticoside, asiatic acid, madecassoside, madecassic acid	Antihypertensive	Renin inhibitor activity was assessed using a renin inhibitor screening assay kit. Total phenolics and flavonoid contents were measured spectrophotometrically with Folin-Ciocalteu and aluminum chloride, respectively.	Ethanol, hexane, ethyl acetate, and butanol extracts showed renin inhibitory activity with IC_{50} values of 1.329, 23.73, 53.76, and 61.38 μg/mL, respectively. Asiaticoside, asiatic acid, madecassoside, and madecassic acid showed IC_{50} values of 2.09, 63.65, 48.2, and 38.12 μg/mL, respectively. Aliskiren, as a reference, exhibited an IC_{50} of 3.56×10^{-3} μg/mL. Total phenolic contents of ethanol, hexane, ethyl acetate, and butanol extracts were 61.03 ± 3.44, 45.75 ± 0.77, 49.60 ± 2.33, and 76.78 ± 3.44 mg GAE/g, respectively. Furthermore, flavonoid contents were 51.95 ± 0.74, 70.01 ± 0.50, 50.46 ± 0.53, and 72.95 ± 1.28 mg QE/g, respectively.	*Centella asiatica* leaves serve as dried or fresh material. The leaves enter a glass, and hot water covers them. The infusion cools before consumption.	[52]

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Table 1 (Continued).

No.	Latin Name	Family	Native (Introduced)	Simplicia/ Extract/ Fraction/ Isolate	Solvent	Bioactive Phytochemical Compounds	Activity	Method	Bioavailability	Ethnobotany	Ref.
15	*Swietenia mahagoni* (L). Jacq. (Mahogany)	Meliaceae	Bahamas, Cayman Islands, Cuba, Dominican Republic, Florida, Haiti, Jamaica, Turks, and Caicos Islands	Extract	Aqueous	Flavonoids, saponins, alkaloids, steroids, and terpenoids	Antihypertensive	Rats received NaCl and aqueous extracts of mahogany seed (100 mg and 200 mg), ethanolic extracts of mahogany seed (100 mg and 200 mg), and aqueous extracts of purple sweet potato tuber (100 mg and 200 mg) for 4 weeks. Systolic blood pressure (SBP) and malondialdehyde (MDA) levels were measured before treatment. SBP was measured every 3 days during the treatment period.	After 4 weeks, blood superoxide dismutase (SOD) and MDA levels were examined. All treatment groups showed significant reductions in SBP and MDA, and significant increases in SOD levels ($p < 0.05$).	A dose of 1/4 teaspoon mahogany seed powder enters a glass of warm water or honey, and stirring produces a uniform mixture for consumption.	[53]
16	*Solanum nigrum* Linn. (Black Nightshade)	Solanaceae	Native to Southeast Asia; now widely distributed in temperate and tropical regions of Europe, Asia, and America.	Extract	Ethanol	Steroidal saponins, alkaloids, phenols, and polysaccharides	Antihypertensive	Not yet reported.	Not yet reported.	Water heats, and *Solanum nigrum* leaves enter the hot water to prepare a traditional decoction for consumption.	[53]
17	*Citrullus lanatus* (Thunb). Matsum. and Nakai (Watermelon)	Cucurbitaceae	Egypt, Ethiopia, Libya, and Sudan	Extract	Ethanol	Alkaloids, flavonoids, saponins, and tannins	Antihypertensive	Researchers use in vitro vasoconstriction and atrium models, in vivo invasive blood pressure measurement, and ISO-induced cardiac hypertrophy in rats, and analyze serum and heart samples using LC-MS/MS metabolomics.	Cl.EtOH produces vasorelaxant, negative chronotropic, and inotropic effects in vitro and induces a potent hypotensive effect in normotensive rats.	Watermelon juice provides 250 mL per dose and lowers blood pressure when consumed once daily for 7 days.	[54,55]

18	*Sonchus arvensis* Linn. (Perennial Sow Thistle)	Asteraceae	Albania, Altay, Austria, Belgium, Bulgaria, Buryatiya, Central European Russia, Denmark, East Aegean Is., East European Russia, Finland, France, Germany, Great Britain, Hungary, Ireland, Italy, Kamchatka, Kazakhstan, Khabarovsk, Kirgizstan, Magadan, Mongolia, Netherlands, North North European Russia, and Northwest European Russia	Extract	Aqueous	Flavonoids and potassium	Antihypertensive	*S. arvensis* at 50–100 mg/kg body weight lowers blood pressure in rats, and the CODA® system measures the effect.	The combination of *A. cordifolia* 50 mg/kg and *S. arvensis* 50 mg/kg achieves the highest inhibition of systolic and diastolic blood pressure.	Boiling fresh tempuyung leaves in water for 10–15 minutes produces a decoction, and the decoction lowers blood pressure when consumed 1–2 times daily.	[56]
19	*Terminalia catappa* L. (Indian Almond)	Combretaceae	Bangladesh, Borneo, Cambodia, Caroline Is., China Southeast, East Himalaya, Fiji, Hainan, India, Jawa, Lesser Sunda Is., Madagascar, Malaya, Maldives, Maluku, Myanmar, Nauru, Nepal, New Northern Philippines, Queensland, South China Sea, Sulawesi, Sumatera, Taiwan, Thailand, and Vietnam	Extract	Ethanol	Flavonoids, diterpenes, saponins, triterpenes, tannins, and phenolic compounds	Antihypertensive	Forty-two Wistar rats divided into seven groups receive 40 mg/kg L-NAME for 21 days to induce hypertension, and treatment with T. catappa fruit diet or sildenafil evaluates antihypertensive effects.	L-NAME increases blood pressure and heart rate significantly.	Boiling Indian almond leaves in water produces a decoction, which serves as medicine or is consumed.	[57]
20	*Blumea balsamifera* (L). DC. (Ngai Camphor)	Asteraceae	Bangladesh, Borneo, China, East Himalaya, Hainan, India, Jawa, Laos, Lesser Sunda Is., Malaya, Maluku, Myanmar, Nepal, New Pakistan, Philippines, Sri Lanka, Sulawesi, Sumatera, Taiwan, Thailand, and Vietnam	Extract	Ethanol	Essential oil 0.5% (cineol, borneol, landerol, camphor), flavanol, tannin, resin, and xanthoxylin	Antihypertensive	Ethanol extract lowers blood pressure in male white mice induced with NaCl and prednisone, with the most effective dose at 100 mg/kg BW.	Four weeks of treatment improve SOD and MDA levels, decrease SBP and blood MDA significantly, and increase SOD.	Boiling about five ngai camphor leaves in three glasses of water until reduced by one-fourth produces an infusion, which reduces hypertension when consumed.	[34]

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Table 1 (Continued).

No.	Latin Name	Family	Native (Introduced)	Simplicia/ Extract/ Fraction/ Isolate	Solvent	Bioactive Phytochemical Compounds	Activity	Method	Bioavailability	Ethnobotany	Ref.
21	*Alternanthera sessilis* (L). R. Br. ex DC. (Sessile Joyweed)	Amaranthaceae	India, Iran, Iraq, Jamaica, Japan, Java, Laccadive Is., Laos, Lebanon-Syria, Leeward Is., Lesser Sunda Is., Malaya, Maluku, Mexico Gulf, Mexico Northeast, Mexico Southeast, Mexico Southwest, Myanmar, Nansei-shoto, Nepal, New Guinea, Nicaragua, Northern Territory, Pakistan, Paraguay, Peru, Philippines, Puerto Rico, Queensland, Saudi Arabia, Solomon Is., Sulawesi, and Sumatera	Extract	Ethanol	Flavonoid	Antihypertensive	The crude ethanolic extract of *Alternanthera sessilis* (As.Cr) and its fractions underwent in vitro testing on isolated rabbit tissue preparations, including the jejunum, trachea, and aorta, as well as in vivo testing on ketamine–diazepam-anesthetized normotensive rats. We recorded the responses using isotonic and isometric transducers connected to the PowerLab data acquisition system.	Solvent–solvent fractionation showed that the dichloromethane fraction produced stronger spasmolytic effects than the aqueous fraction. Intravenous administration of As.Cr reduced mean arterial blood pressure, systolic blood pressure, and diastolic blood pressure in ketamine–diazepam-anesthetized normotensive albino rats in a dose-dependent manner within the range of 1–10 mg/kg. Our findings indicate the presence of Ca^{2+} channel blocking (CCB) activity in As.Cr, which supports the traditional medicinal use of *Alternanthera sessilis* for managing diarrhea, asthma, and hypertension.	The plant is commonly consumed either as brewed tea or in capsule form.	[55]

22	*Annona muricata* L. (Soursop)	Annonaceae	Belize, Bolivia, Colombia, Costa Rica, Ecuador, French Guiana, Guatemala, Guyana, Honduras, Mexico Southeast, Nicaragua, Panamá, Peru, Suriname, and Venezuela	Extract	Aqueous and ethanol	Acetogenins (annonacin, muricapentocin, etc)., flavonoids, alkaloids, tannins, saponins, and vitamin C	Antihypertensive	(1) The researchers evaluated the effects of aqueous extracts (1:100 w/v) from different parts of the soursop fruit (pericarp, pulp, and seed) on hypertension by targeting angiotensin-I converting enzyme (ACE). (2) The researchers measured systolic and diastolic blood pressure (SBP and DBP), mean arterial pressure (MAP), and heart rate (HR) in normotensive Sprague-Dawley rats treated with 50–150 mg/kg of AME, PAE, or CAPE to determine their hypotensive effects. They calculated the "combination index" to assess the interaction between AME and PAE. They further evaluated the antihypertensive effect of CAPE by measuring SBP, DBP, MAP, and HR in ethanol-, sucrose-, and epinephrine-induced hypertensive rats. Additionally, they performed full blood counts, liver and kidney function tests, and urinalysis in ethanol/sucrose-induced hypertensive rats to assess safety for use.	(1) The extracts inhibited α-amylase, α-glucosidase, and ACE activities in a dose-dependent manner. The effective concentration causing 50% inhibition (EC_{50}) revealed that the pericarp extract exhibited the highest inhibitory activities for α-amylase (0.46 mg/mL), α-glucosidase (0.37 mg/mL), and ACE (0.03 mg/mL), whereas the seed extract showed the lowest activities [α-amylase (0.76 mg/mL), α-glucosidase (0.73 mg/mL), and ACE (0.20 mg/mL)]. (2) AME, PAE, and CAPE significantly ($p \le 0.001$) reduced blood pressure in both normotensive and hypertensive animals. The effects of CAPE 1, CAPE 2, and CAPE 3 were synergistic, with combination indices of 0.65 ± 0.07, 0.76 ± 0.09, and 0.87 ± 0.07, respectively. Treatment with 100 mg/kg CAPE 1 and 75 mg/kg CAPE 2 produced a significant decrease ($p \le 0.01$–0.001) in systolic blood pressure (SBP) and mean arterial pressure (MAP) in hypertensive rats, comparable to nifedipine treatment ($p \le 0.001$).	The practitioner boils eight soursop leaves in three glasses of water to prepare a decoction. The patient consumes one glass of the resulting decoction per dose. The patient takes the decoction in the morning and evening, three times per week.	[58,59]

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Table 1 (Continued).

No.	Latin Name	Family	Native (Introduced)	Simplicia/ Extract/ Fraction/ Isolate	Solvent	Bioactive Phytochemical Compounds	Activity	Method	Bioavailability	Ethnobotany	Ref.
23	*Moringa oleifera* Lam. (Drumstick Tree/Moringa)	Moringaceae	India and Pakistan	Extracts	Aqueous	Alkaloids, flavonoids, and polyphenols	Antihypertensive	Fifty male Wistar rats were randomly divided into five groups of 10 rats each and subjected to $N\omega$-nitro-L-arginine methyl ester (L-NAME) exposure. Group A served as the control and received normal saline only. Group B received L-NAME (40 mg/kg) only. Group C received L-NAME (40 mg/kg) combined with 10% Moringa oleifera (MO) feed. Group D received L-NAME (40 mg/kg) combined with 20% MO feed. Group E received L-NAME (40 mg/kg) combined with Lisinopril (10 mg/kg). Treatments were administered daily for 5 weeks. Blood pressure and electrocardiographic measurements were obtained using a non-invasive tail-cuff device and a 6/7 lead computer ECG system, respectively. Heart and kidney tissues were analyzed for oxidative stress parameters. Immunohistochemistry and histopathology of the heart and kidney were conducted following standard methods.	Co-treatment with MO and Lisinopril significantly increased nitric oxide levels. The combination significantly reduced malondialdehyde (MDA) concentrations in cardiac and renal tissues, whereas L-NAME alone caused a marked increase in MDA concentration. L-NAME alone also significantly increased the expression of cardiac and renal caspase-3, while co-treatment with MO and Lisinopril significantly reduced caspase-3 expression. Overall, co-treatment with MO effectively reduced arterial pressure and hypertension indices in rats and mitigated L-NAME–induced oxidative stress and apoptosis.	The practitioner washes the Moringa leaves and places them in a pot of boiling water. The leaves boil for 5–7 minutes.	[59]

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24	*Cymbopogon citratus* (DC). Stapf (Lemongrass)	Poaceae	India and Sri Lanka	Extracts	Aqueous	Essential oils (eg., citronellal, citronellol, geraniol, and geranyl acetate) alkaloids, flavonoids, saponins, tannins, and terpenoids	Antihypertensive	Rats were divided into eight groups of six rats each and treated daily for 5 weeks. The control group received distilled water (1 mL/kg). Rats in groups 2, 3, and 4 received ethanol 40° (3 g/kg/day), 10% sucrose as drinking water, and the two substances, respectively. The remaining groups received, in addition to sucrose and ethanol, the aqueous extract (50, 100, and 150 mg/kg) or nifedipine (10 mg/kg), respectively. Hemodynamic, biochemical, and histopathological parameters were assessed at the end of the study.	The results indicate that the aqueous extract exhibits antihypertensive activity against ethanol- and sucrose-induced hypertension in rats by improving biochemical and oxidative status and protecting the liver, kidney, and vascular endothelium from damage caused by chronic ethanol and sucrose consumption.	The practitioner washes 2–3 stalks of lemongrass, crushes them to release the aroma, and boils them in 2 cups of water until 1 cup of decoction remains.	[60]
25	*Andrographis paniculata* (Burm.f). Wall. ex Nees (King of Bitters)	Acanthaceae	Assam, Bangladesh, India, Nepal, Sri Lanka, and West Himalaya	Extracts	Ethanol	Andrographolide, flavonoids, and phenolics	Antihypertensive	Antihypertensive activity was evaluated using the CODA Non-Invasive Blood Pressure (NIBP) system with the Volume Pressure Recording method. High blood pressure was induced using an alpha-adrenergic receptor agonist, phenylephrine (0.9 mg/kg BW). EEAP was administered at doses of 45, 90, and 180 mg/kg BW and compared to nifedipine (10.8 mg/kg BW). Blood pressure measurements were performed three times: before induction (baseline), 15 minutes after, and 45 minutes after phenylephrine administration.	Based on TLC-densitometric data, andrographolide, total flavonoids, and total phenolics in EEAP were 12.85 ± 0.46%, 0.72 ± 0.01%, and 1.66 ± 0.01%, respectively. EEAP exhibited potent antihypertensive activity in phenylephrine-induced hypertensive rats, reducing systolic and diastolic blood pressures by up to 120% and 150%, respectively. EEAP fractions have potential for development as hypotensive agents in hypertension therapy.	The practitioner boils 10–20 g of dried herbs or grinds the dried herbs into powder and brews the decoction. The patient consumes it three to four times daily.	[61]

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Table 1 (Continued).

No.	Latin Name	Family	Native (Introduced)	Simplicia/ Extract/ Fraction/ Isolate	Solvent	Bioactive Phytochemical Compounds	Activity	Method	Bioavailability	Ethnobotany	Ref.
26	*Muntingia calabura* L. (Jamaica cherry)	Muntingiaceae	Northwest Argentina, Belize, Bolivia, North Brazil, Central American Pacific Islands, Colombia, Costa Rica, Ecuador, El Salvador, Guatemala, Honduras, Central Mexico, Gulf Mexico, Northeast Mexico, Southeast Mexico, Southwest Mexico, Nicaragua, Panamá, Peru, and Venezuela	Fraction / Extract	n-butanol soluble, methanol	Flavonoids and phenolics	Antihypertensive	The n-butanol soluble fraction (BSF) from methanol leaf extract of *M. calabura* was evaluated in spontaneously hypertensive rats (SHR) to determine its underlying mechanisms. Intravenous bolus administration of BSF (10–100 mg/kg) produced biphasic, dose-related antihypertensive and bradycardic effects in SHR.	The initial cardiovascular depressive effects lasted for 10 minutes, while the delayed effects began at 40 minutes and persisted for at least 120 minutes post-injection. These cardiovascular effects were more pronounced in SHR than in normotensive Wistar-Kyoto (WKY) rats. Both the initial and delayed antihypertensive and bradycardic effects of BSF (25 mg/kg, i.v). in SHR were significantly blocked by pretreatment with a nonselective nitric oxide (NO) synthase (NOS) inhibitor and a soluble guanylyl cyclase (sGC) inhibitor.	Fresh cherries can be consumed directly. A few fresh or dried cherry leaves are washed thoroughly and boiled in sufficient water until boiling. The decoction is then strained, and natural sweeteners, such as honey or palm sugar, can be added to taste. The patient consumes the cherry leaf tea regularly.	[62]
27	*Zingiber officinale* Roscoe (Ginger)	Zingiberaceae	Assam, South-Central China, East Himalaya, and India	Extracts	Methanol	Gingerol, shogaol, and essential oils	Antihypertensive	The researchers measured antihypertensive effects using an invasive method.	The scavenging percentage of TZ ranged from 78.5% to 80.4%, with an IC_{50} value of 1166.7 µg/mL. Tyrosinase inhibition reached 72% compared with 93% for kojic acid. Doses of 100, 250, and 500 mg/kg did not increase serum biomarkers of liver or renal function. Hemoglobin, erythrocytes, hematocrit, white blood cells (WBC), and lymphocytes significantly increased, while platelet count remained unchanged. Blood pressure significantly decreased.	The practitioner washes, crushes, and slices the ginger thinly. The ginger is placed in a teapot or directly in a glass. Boiling water is poured over the ginger, and the resulting decoction is consumed warm.	[63]

28	*Coriandrum sativum* L. (Coriander)	Apiaceae	Afghanistan, Iran, Lebanon-Syria, North Caucasus, Pakistan, Palestine, Saudi Arabia, Sinai, Transcaucasus, and Turkey	Fraction / Extract	Ethyl acetate	Alkaloids, flavonoids, steroids, and tannins are present. The specific flavonoids include pinocembrin, apigenin, pseudobaptigenin, galangin-5-methyl ether, quercetin, baicalein trimethyl ether, kaempferol dimethyl ether, pinobanksin derivatives, apigenin and quercetin glycosides, rutin, and isorhamnetin-3-O-rutinoside. Additional flavonoids include daidzein, luteolin, pectolinarigenin, apigenin-C-glucoside, kaempferol-3,7-dimethyl ether-3-O-glucoside, and apigenin-7-O-(6-methyl-β-D-glucoside).	Antihypertensive	The researchers explored the mechanism of action of *Coriandrum sativum* as an angiotensin-converting enzyme (ACE) inhibitor.	Only the flavonoid-rich fraction exhibited high ACE inhibition potential, with an IC_{50} value of 28.91 ± 13.42 μg/mL.	The practitioner boils coriander seeds in water and consumes the resulting decoction.	[21]
29	*Hibiscus sabdariffa* L. (Roselle)	Malvaceae	Central African Republic, Chad, Congo, DR Congo, Gabon, Ghana, Nigeria, and Sudan–South Sudan	Extracts	Ethanol and aqueous	Anthocyanins and flavonoids	Antihypertensive	Rats were administered 40 mg/kg body weight of N-nitro L-arginine methyl ester (L-NAME) via the intragastric route. *H. sabdariffa* extract was administered orally at varying doses (250, 500, and 1000 mg/kg). The hypolipidemic, antioxidant, and antihypertensive potentials of the extracts were evaluated using standard validated methods.	L-NAME significantly ($p < 0.05$) increased total cholesterol, triglyceride, and LDL levels, decreased HDL levels, increased LPO/MDA and H_2O_2 levels, and decreased GPx and SOD activities. L-NAME significantly ($p < 0.05$) increased diastolic and systolic blood pressures, ACE and arginase activities, and glucose level, while nitric oxide activity significantly decreased.	The practitioner prepares dried rosella flower petals with hot water or boils them, and consumes 1–2 glasses per day regularly.	[64]

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Table 1 (Continued).

No.	Latin Name	Family	Native (Introduced)	Simplicia/ Extract/ Fraction/ Isolate	Solvent	Bioactive Phytochemical Compounds	Activity	Method	Bioavailability	Ethnobotany	Ref.
30	*Artocarpus altilis* (Parkinson) Fosberg (Breadfruit)	Moraceae	Caroline Islands and Marianas	Extracts	Aqueous	Flavonoids, tannins, saponins, and hydrocyanic acid	Antihypertensive	The researchers investigated the mechanisms of action of the aqueous extract and its effects on cytochrome P450 (CYP) enzyme activities. Intravenous administration of the extract (20.88–146.18 mg/kg) was performed, and mean arterial pressure and heart rate were recorded via carotid artery cannulation in anesthetized normotensive Sprague-Dawley rats. Contractile activity of aortic rings to the extract (0.71–4.26 mg/mL) was studied using standard organ bath techniques. Inhibitions of human CYP3A4 and CYP2D6 enzyme activities were evaluated using a fluorometric assay with heterologously expressed microsomes in 96-well plates.	The extract produced moderate inhibition of CYP3A4 and CYP2D6 enzyme activities, with IC_{50} values of 0.695 ± 0.187 and 0.512 ± 0.131 mg/mL, respectively.	The practitioner prepares 2–3 old, dark green breadfruit leaves, washes them thoroughly with running water, and places them in a pan with five glasses of water. The leaves are boiled until the water reaches a boil.	[65]

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31	*Persea americana* Mill (Avocado)	Lauraceae	Northeast and South Argentina, Belize, Bolivia, North, Northeast, South, Southeast, West-Central Brazil, Canary Islands, Central and South Chile, Colombia, Costa Rica, Cuba, Dominican Republic, Ecuador, El Salvador, French Guiana, Guatemala, Guyana, Haiti, Honduras, Jamaica, Leeward Islands, Madeira, Mexico, Nicaragua, Panamá, Peru, Puerto Rico, Suriname, Trinidad and Tobago, Venezuela, and Windward Islands	Extracts	n-Hexane and hydroethanol	Flavonoids, quercetin, and other phenolic compounds	Antihypertensive	The researchers investigated antihypertensive effects in high-salt diet-induced hypertensive rats. The extracts at doses of 100, 200, and 400 mg/kg showed a dose-dependent reduction in blood pressure. At 100 mg/kg, the systolic and diastolic blood pressures (SBP/DBP) for n-hexane and hydroethanol extracts were 124.28/103.83 mmHg and 122.72/104.78 mmHg, with pulse pressures (PP) of 20.45 and 17.94 mmHg, respectively.	The highest dose of the n-hexane extract (400 mg/kg) reduced blood pressure comparable to the standard drug nifedipine, suggesting a similar mechanism. The reduction in blood pressure may be attributed to the secondary metabolites identified in the plant.	The practitioner boils 5 dried avocado leaves in three glasses of water.	[66]
32	*Theobroma cacao* L. (Cacao)	Malvaceae	North Brazil, Colombia, Costa Rica, Ecuador, French Guiana, Guyana, Peru, Suriname, and Venezuela	Fraction	Ethyl acetate	Theobromine, phenethylamine, and anandamide	Antihypertensive	The researchers investigated the antihypertensive activity of the ethyl acetate fraction of *Theobroma cacao* pod husk (EAF-TCPH) in L-nitro-arginine-methyl-ester (L-NAME)-induced hypertensive male rats.	The elevated systolic and diastolic blood pressures (180.17 and 125.79 mmHg) in hypertensive rats decreased to 125.33 and 88.00 mmHg, respectively.	The pods can be consumed directly.	[67]
33	*Carica papaya* L. (Pepaya)	Caricaceae	Belize, Colombia, Costa Rica, El Salvador, Guatemala, Honduras, Gulf of Mexico, Southeast and Southwest Mexico, Nicaragua, Panamá, and Venezuela	Extracts	Ethanol	Papain, chymopapain, cystatin, flavonoids, ascorbic acid, cyanogenic glucosides, and glucosinolates	Antihypertensive	Researchers evaluated ACE and Angiotensin II Receptor Type 1 (AT1R) inhibition in silico to assess potential development as oral drugs and their safety.	Papaya leaves demonstrated the potential to reduce blood pressure in hypertensive rat models via ACE inhibition.	The practitioner boils papaya leaves and consumes the decoction.	[68]
34	*Syzygium polyanthum* (Wight) Walp. (Indonesian bay leaf)	Myrtaceae	Andaman Islands, Borneo, Cambodia, Java, Laos, Lesser Sunda Islands, Malaya, Myanmar, Nicobar Islands, Philippines, Sumatra, Thailand, and Vietnam	Fraction	n-Hexane, ethyl acetate, methanol, and aquenos	Polydatin, sesamol, brazilin, eugenol, ellagic acid, kukoamine A, and cyclocurcumin	Antihypertensive	Researchers intravenously administered crude extracts and derived fractions into pentobarbital-anaesthetized spontaneously hypertensive rats (*n* = 5) to record blood pressure parameters.	ASP had the highest total phenolic content (TPC), whereas F2ASP had the lowest. All fractions exhibited significant antihypertensive activity, with F2ASP being the most active. Few phenolics contributed to the antihypertensive effect.	The practitioner boils 10–15 fresh or dried bay leaves in three glasses of water until two glasses remain and consumes it twice daily, morning and night.	[69]

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interpretation and the contribution of the review. Emphasizing native species with established presence in the area provides a more accurate picture of the local ethnobotanical knowledge and plant availability. Conversely, recognizing the use of introduced plants underscores the influence of trade, migration, and cultural exchange in shaping traditional medicinal practices.

Based on the data presented in Table 1, the Anak Dalam community in Jambi Province has traditionally used around 34 different medicinal plant species that are believed to have potential antihypertensive effects. These plants form an essential part of their ethnomedical practices and are relied upon for managing high blood pressure, a common health concern in many communities. Among these 34 species, only about nine are most frequently used and considered the primary herbal remedies within the community. These nine species include *Curcuma longa* L. (turmeric), *Allium sativum* L. (garlic), *Morinda citrifolia* L. (noni fruit), *Citrus aurantiifolia* (Christm). Swingle (key lime), *Apium graveolens* L. (celery), *Averrhoa bilimbi* L. (bilimbi fruit), *Orthosiphon aristatus* var. aristatus (cat's whip), *Annona muricata* L. (soursop), and *Zingiber officinale* Roscoe (ginger). These plants are not only vital to the traditional health practices of the Anak Dalam tribe but are also well-known for their medicinal properties in other cultures and regions.

The use of these plants has been passed down through generations, forming an integral part of the community's cultural and ethnomedical knowledge. The Anak Dalam community typically prepares these medicinal plants by boiling specific parts of the plant—such as roots, leaves, or fruits—and then consuming the resulting decoctions regularly. This preparation method is rooted in their traditional belief that these herbal remedies can effectively lower blood pressure and improve overall cardiovascular health. The community's reliance on natural herbal medicine underscores their deep understanding of local flora and their trust in traditional healing methods.

Interestingly, some of these medicinal plants with antihypertensive potential are also used by different ethnic groups and communities in other parts of Indonesia and neighboring countries for similar health purposes. For example, garlic (*Allium sativum*) and ginger (*Zingiber officinale*) are widely recognized worldwide for their cardiovascular benefits, including blood pressure regulation, *Curcuma longa* (turmeric) and *Orthosiphon aristatus* are popular in traditional medicine systems across Southeast Asia for their anti-inflammatory and antihypertensive properties. The widespread use of these plants across diverse cultures highlights their potential efficacy and the universal importance of herbal remedies in managing hypertension.

Overall, the ethnobotanical knowledge of the Anak Dalam community demonstrates a rich tradition of using local plants to promote health and treat specific ailments. The data summarized in Table 1 emphasizes the significance of these nine key species, which are most commonly utilized in their daily health practices. Recognizing the potential anti-hypertensive effects of these plants, further scientific research could explore their active compounds and mechanisms of action. Such studies might contribute to developing natural, plant-based therapies for hypertension that could benefit not only local communities but also broader populations worldwide, especially as the global demand for herbal and alternative medicine continues to grow.

The ethnomedicinal use of *Curcuma longa* has been documented historically. Approximately 427 chemical compounds have been identified from Curcuma spp. *Curcuma longa* L., a yellow rhizome, is traditionally used to address conditions such as palpitations, hypertension, and blood circulation disorders.[70] Hypertension, characterized by elevated systolic and/or diastolic blood pressure, is a common global health concern. Long-term use of synthetic antihypertensive medications can cause adverse effects, leading some individuals to seek alternative treatments. *Curcuma longa*, particularly its active compound curcumin, has shown potential cardiovascular effects, including blood pressure regulation.[71] Among the Anak Dalam community, turmeric is prepared by cleaning, grinding or grating the rhizomes into a paste, boiling in water, and filtering to produce a decoction, which is consumed regularly as an herbal remedy. This traditional practice suggests community trust in turmeric's role in blood pressure management.

Similarly, The traditional use of celery root (*Apium graveolens* L). and turmeric rhizome (*Curcuma longa* L). for antihypertensive by the Anak Dalam tribe reflects their cultural and therapeutic significance. In Ayurvedic and broader Asian practices, turmeric has been incorporated into functional food formulations using modern methods. Studies evaluating different dosages of these plant mixtures have assessed total phenolic content, antioxidant activity, and sensory properties, combining traditional knowledge with scientific validation. The addition of turmeric enhanced the antioxidant potential of the celery–parsley mixture and showed moderate antihypertensive activity, with ACE inhibition of 62% and hydroxymethylglutaryl coenzyme A (HMG-CoA) reductase inhibition of 55%. These findings suggest potential applications in developing multifunctional food ingredients for antihypertensive and nutraceutical purposes.[71]

Scientifically, the use of several plants by the Anak Dalam tribe has been supported by several research center. The Tawangmangu Center for Research and Development of Traditional Medicinal Plants has identified several herbal species with potential antihypertensive effects, including leaves of *Apium graveolens, Centella asiatica, Phyllanthus niruri, Orthosiphon aristatus, Curcuma longa* Roxb., and *Curcuma xanthorrhiza* Roxb. Extracts from these plants administered orally at 72 mg/kg body weight effectively reduced blood pressure in rats. However, oral delivery faces challenges such as poor taste, unpleasant aroma, and the need for frequent dosing. Transdermal patches may offer an alternative delivery method. Optimization studies determined that the ideal proportion of HPMC to sodium CMC is 219.7:180.3 mg, with a desirability value of 0.98. The patches released an average of 30.89% of total flavonoids over 5 hours, with a total transported amount of 117.57 mg across the cellophane membrane and a cumulative release of 66.57 g/cm². Membrane permeability was calculated at 3.29×10^{-6} cm/s, and the flux was 3.7×10^{-6} mg/s/cm².[71] Additionally, the Anak Dalam community traditionally use fresh celery (*Apium graveolens*) as an antihypertensive remedy. The leaves and stems are harvested, washed, boiled in water, cooled, and consumed regularly as a decoction. This ethnomedicinal practice reflects the community's traditional belief that celery promotes vasodilation, improves circulation, and helps maintain blood pressure.

Allium sativum Linn. and *Apium graveolens* Linn. are herbal plants that can reduce elevated blood pressure in prehypertensive and hypertensive conditions when used alone or in combination with lifestyle modifications and antihypertensive drugs. Clinical studies have reported reductions in systolic and diastolic blood pressure with *A. sativum* (−18.1/-9 mmHg) and *A. graveolens* (−37.9/-15.4 mmHg). These findings highlight the importance of conducting more consistent clinical trials in humans to accurately confirm the efficacy and safety of these herbal treatments for hypertension.[72] Additional studies identified S-1-Propenyl-L-cysteine (S1PC), a stereoisomer of S-Allyl-L-cysteine (SAC), as a sulfur-containing amino acid that contributes to the pharmacological activity of *Allium sativum* extracts. This compound demonstrated the ability to lower blood pressure in animal models of hypertension.[73] The Anak Dalam community has long relied on *Allium sativum* (garlic) as a traditional antihypertensive remedy. Fresh garlic bulbs are crushed into a paste and consumed either raw or mixed with warm water. This ethnomedicinal practice, passed down through generations, reflects the community's cultural knowledge of garlic's role in maintaining cardiovascular health and managing hypertension naturally.

Noni (*Morinda citrifolia*) contains bioactive compounds such as scopoletin and flavonoids that contribute to lowering blood pressure. Its mechanism of action involves dilating blood vessels and improving blood circulation, thereby stabilizing blood pressure levels. For this reason, the Anak Dalam community often uses noni as a safe and natural antihypertensive remedy. Other studies also support this traditional use. Administration of *Morinda citrifolia* Linn. ethanol extract significantly reduced systolic and diastolic blood pressure in prednisone-induced male Wistar rats.[30] In another study, the blood pressure reduction observed in treatment group 2 did not differ significantly from the positive control group or treatment group 1 ($p > 0.05$) (31,32). Furthermore, noni fruit extract from Bogor demonstrated angiotensin-converting enzyme (ACE) inhibitory activity with an IC_{50} value of 206.26 μg/mL.[74] The Anak Dalam community prepares noni fruit by cutting ripe fruits into pieces, boiling them in water until fully cooked, and filtering the liquid before drinking it regularly as an herbal remedy. Despite its bitter taste and strong aroma, this traditional practice reflects local ethnomedicinal knowledge and has been culturally trusted to help manage high blood pressure.

With the increasing public interest in natural products, along with the practices of the Anak Dalam tribe, here are some potential plants that have been used as antihypertensive agents. Citrus species have gained attention as traditional remedies for managing hypertension symptoms. Citrus species and their phytoconstituents, such as flavonoids, limonoids, and carotenoids, show therapeutic potential in regulating key metabolic parameters. Preclinical studies using essential oils and extracts, as well as clinical studies, demonstrate that *Citrus aurantiifolia* (Christm). Swingle possesses antihypertensive activity through its bioactive phytoconstituents.[75] The major bioactive compounds found in citrus species include d-limonene, β-pinene, neral, citronellal, thymol, β-sitosterol, oleic acid, limonene, linalool, citral, α-pinene, coumarin, hexadecenoic acid, hesperidin, neohesperidin, eugenol, geraniol, and p-cymene. These compounds have also been reported to exert anti-obesity, antidiabetic, antihypertensive, antidyslipidemic, and cardiovascular-protective effects.[75] In cultural practice, the Anak Dalam tribe uses lime (*Citrus aurantiifolia*) as a natural remedy. They pick the fruit, cut it open, and squeeze out the juice. Consuming the juice directly or mixing it with a glass of warm water is believed to dilate blood vessels and reduce blood pressure.

Starfruit leaves (*Averrhoa bilimbi* Linn). serve as a functional food with potential as a non-pharmacological antihypertensive. When prepared as tea and administered to patients with hypertension, starfruit leaves significantly reduce blood pressure ($p < 0.05$).[76] In addition, Methylripariochromene A (MRC), isolated from *Orthosiphon aristatus* (Lamiaceae) leaves, demonstrates several pharmacological actions linked to antihypertensive activity. Studies show that MRC lowers blood pressure through vasodilatory effects, reduced cardiac output, and diuretic properties. These findings confirm that the traditional use of *O. aristatus* in hypertension therapy can effectively reduce blood pressure.[77] In cultural practice, the Anak Dalam tribe prepares a traditional herbal remedy by combining starfruit and cat's whiskers (*Orthosiphon aristatus*) leaves. They cut the starfruit into small pieces, boil it together with washed cat's whisker leaves, and reduce the mixture to half its volume. After straining, they consume it regularly as a herbal medicine to reduce the heart's workload and maintain stable blood pressure.

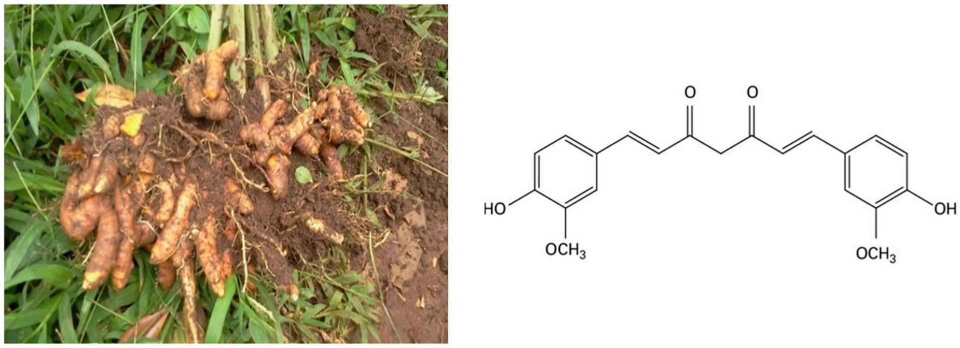
Consistent with the practice of the Anak Dalam tribe using plants to treat various illnesses, particularly hypertension. In Thailand, hypertension continues to rise and carries ethnopharmacological relevance, as it is the most dominant risk factor for cardiovascular, kidney, and eye diseases. In response, many Thais have turned to herbal medicines for health care. Researchers have documented 62 plant species traditionally used to treat hypertension, most belonging to the Asteraceae, Piperaceae, Rutaceae, and Zingiberaceae families. *Annona muricata* remains a preferred remedy, typically prepared by boiling (78%) and consumed as tea before three daily meals (26%).[78] Certain plant species employed are identical to those utilized by the Anak Dalam tribe.

Among these species, *Zingiber officinale* demonstrates strong antihypertensive activity. It shows a TZ scavenging percentage ranging from 78.5 to 80.4, an IC_{50} value of 1166.7 µg/mL, and tyrosinase inhibition of 72% compared to 93% for kojic acid. At doses of 100, 250, and 500 mg/kg, no changes in serum biomarkers for liver and kidney function were detected. However, hemoglobin, erythrocytes, hematocrit, white blood cells (WBCs), and lymphocytes increased significantly, while platelet counts remained stable Importantly, blood pressure decreased significantly in all tested doses.[63] In cultural practice, the Anak Dalam tribe also relies on *Zingiber officinale* (ginger) as a natural antihypertensive remedy. They wash fresh rhizomes thoroughly, then bruise or slice them thinly before boiling in water. After boiling, they strain the decoction and drink it warm regularly as a herbal medicine. To improve palatability and enhance its benefits, some add a small amount of honey.

Phytochemistry

Aromatic medicinal plants, such as *Curcuma longa*, exhibit diverse pharmacological properties, including antidiabetic, anticancer, antihypertensive, anticardiovascular, and antileprosy effects, because they synthesize a wide range of therapeutic bioactive secondary metabolites. These metabolites with antihypertensive activity include alkaloids, steroids, terpenoids, peptides, polyketides, flavonoids, quinones, and phenols.[79] Turmeric (*Curcuma longa*), often referred to as the "golden powder," is widely recognized as a culinary spice. However, experimental and clinical studies have demonstrated its potential in disease treatment due to its curcuminoid content. Curcuminoids display antioxidant, antidiabetic, anti-inflammatory, antimicrobial, anticoagulant, cardiovascular, and central nervous system activities.[80] The genus *Curcuma longa* L. contains a rich profile of flavonoids, tannins, anthocyanins, phenolic compounds, essential oils, organic acids, and inorganic constituents. Among these, curcumin stands out as one of the primary active compounds, known for its potent anti-inflammatory and antioxidant properties. Pharmacological studies have further confirmed that *Curcuma* exhibits hepatoprotective, antifungal, antihypertensive, and neuroprotective effects.[70] Figure 1a shows *Curcuma longa* plant and Figure 1b shows the chemical structure of curcumin.

Allium sativum (garlic) is an aromatic plant widely consumed and used in traditional medicine as an antihypertensive agent and as a cooking spice worldwide. Belonging to the Amaryllidaceae family, *A. sativum* is rich in sulfur-containing compounds such as alliin, allicin, and ajoene, along with flavonoids such as quercetin.[81,82] Although garlic has long been recognized for its therapeutic properties, comprehensive studies on Tunisian garlic remain limited. Extracts of Tunisian *A. sativum* are rich in bioactive compounds, including phenolic acids, flavonoids, and vitamins, highlighting their potential antifungal, antioxidant,

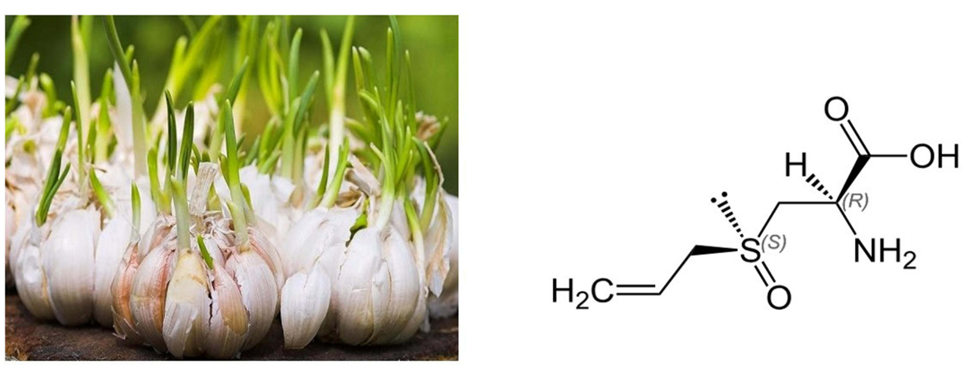


(a) (b)

Figure 1 (**a**) *Curcuma longa* plant and (**b**) the chemical structure of curcumin compound.

and cytotoxic bioactivities. Thus, *A. sativum* continues to emerge as a functional food source with diverse pharmacological properties.[83] Beyond red ginger and turmeric, garlic bulbs also contain numerous chemical constituents. These include polysaccharides, saponins, phenolic compounds, and organosulfur compounds. The organosulfur compounds in garlic consist of E/Z-ajoene, S-allyl-cysteine sulfoxide, S-allyl-cysteine (SAC), alliin, diallyl thiosulfonate (allisin), diallyl disulfide (DADS), diallyl sulfide (DAS), and diallyl trisulfide (DATS). Garlic also contains saponins and more than 20 phenolic compounds, as identified using offline SFE-SFC-MS/MS methods. These phenolic compounds include ferulic acid, p-coumaric acid, apigenin, naringenin, protocatechuic acid, isorhamnetin, phthalic acid, luteolin, and quercetin. Furthermore, the polysaccharide components of garlic consist of approximately 85% fructose, 14% glucose, and 1% galactose.[84] Figure 2a shows *Allium sativum* plant and Figure 2b shows chemical structure of the allin.

Morinda citrifolia L., commonly known as noni, has served as a traditional medicinal plant for more than 2,000 years due to its richness in antioxidant phytochemicals. These include flavonoids (kaempferol and rutin), iridoids (aucubin, asperulosidic acid, deacetylasperulosidic acid, and asperuloside), polysaccharides (nonioside A), and coumarins (scopoletin). Researchers have highlighted the pharmacological properties and molecular mechanisms of noni, emphasizing its potential antioxidant activity.[85] The Rubiaceae family, which comprises more than 13,100 species, primarily grows in tropical regions and includes *Adina cordifolia, Anthocephalus cadamba, Cinchona officinalis, Coffea arabica, Morinda citrifolia*, and *Paederia foetida*. To date, researchers have identified over 100 compounds from the Rubiaceae family with diverse chemical structures, including alkaloids, glycosides, flavonoids, triterpenoids, phenols, and volatile components. Crude extracts and isolated compounds from this family exhibit broad pharmacological activities (eg., antimalarial, antibacterial, antihypertensive, antidiabetic, antioxidant, and anti-inflammatory), confirmed through biological screening guided by traditional healers' knowledge.[86] Figure 3a shows *Morinda citrifolia* plant and Figure 3b shows chemical structure of the scopoletin.



(a) (b)

Figure 2 (**a**) *Allium sativum* plant and (**b**) the chemical structure of the allin compound.

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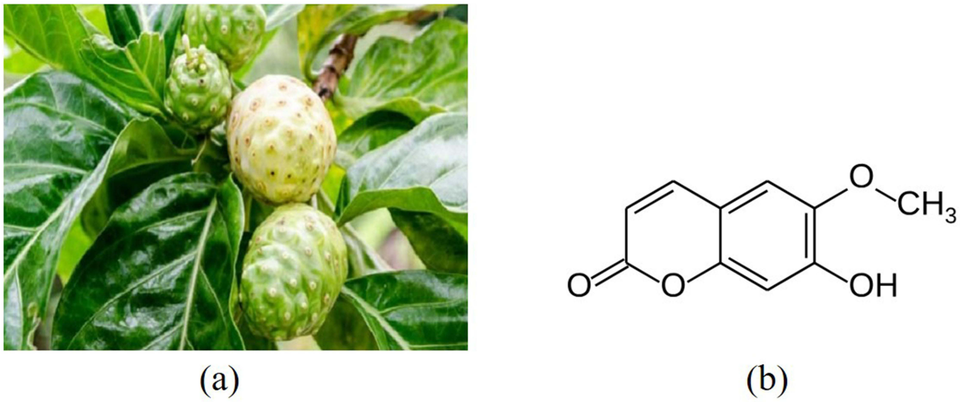


Figure 3 (**a**) *Morinda citrifolia* plant and (**b**) the chemical structure of the scopoletin compound.

Citrus aurantiifolia (Christm). Swingle, native to tropical and subtropical regions worldwide, is widely cultivated for its nutraceutical value. Limonene emerged as the major constituent across three extraction methods, with yields of 98.86% (SD), 98.68% (HD), and 99.23% (MAHD). Citrus essential oil and its components demonstrated strong antioxidant, anticholinesterase, antimelanogenesis, antidiabetic, and antihypertensive activities. The presence of linalool and α-terpineol acetate likely accounts for the superior activity observed in oil isolated by HD, particularly in radical scavenging, AChE inhibition, and enzyme inhibition assays.[87] From an ethnopharmacological perspective, hypertension remains the most prominent risk factor for cardiovascular, renal, and ocular diseases. In Thailand, the prevalence of illness and hospitalization caused by high blood pressure continues to rise in the modern public health system. Despite this trend, many Thais have increasingly turned to herbal medicines as part of their healthcare practices.[78] Figure 4a shows *Citrus aurantiifolia* plant and Figure 4b shows chemical structure of the limonene.

Apium graveolens Linn. is a medicinal plant rich in natural bioactive compounds with therapeutic potential, widely used in the synthesis of various drug formulations. High-performance liquid chromatography (HPLC) analysis revealed a diverse phytochemical composition in its extract.[88] *Apium graveolens* L., a member of the Apiaceae family, has been valued as a spice and a medicinal plant since Ancient Greece. Celery possesses mild laxative, diuretic, antiseptic, antihypertensive, antiallergic, anti-inflammatory, enveloping, and wound-healing properties. A quantitative assessment of fragrant celery roots cultivated in the North Caucasus demonstrated the following biologically active compound content:

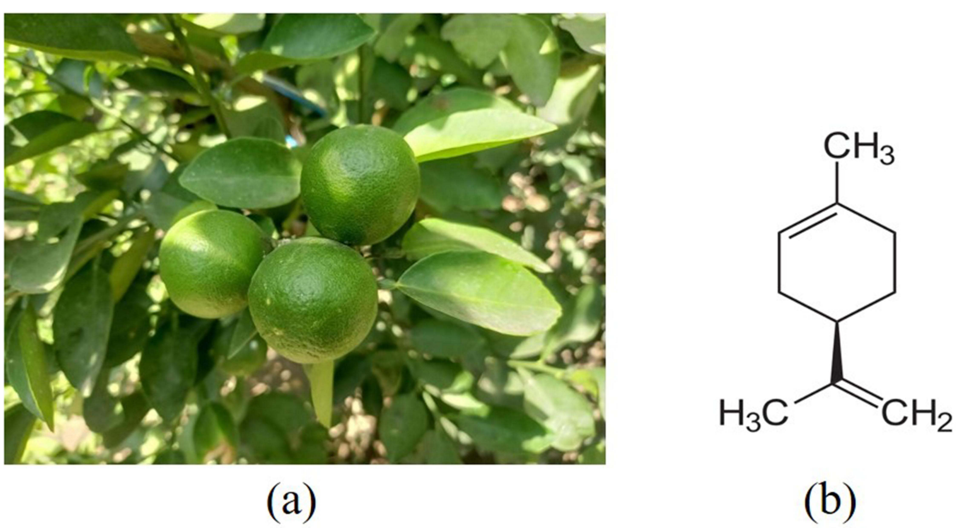


Figure 4 (**a**) *Citrus aurantiifolia* plant and (**b**) the chemical structure of the limonene compound.

essential oils (2.04 ± 0.01%), flavonoids (1.44 ± 0.01%), lipophilic substances (4.05 ± 0.01%), carotenoids (3.03 ± 0.02%), free organic acids (2.38 ± 0.02%), tannins (8.06 ± 0.01%), water-soluble polysaccharides (8.33 ± 0.01%), pectin substances (3.45 ± 0.01%), hemicellulose A (1.54 ± 0.01%), and hemicellulose B (1.47 ± 0.01%).[89]

Other studies report that the phytochemical composition of celery (*Apium graveolens* L). includes flavonoids, organic acids, hydroxycinnamic acids, terpenoids from essential oils, tannins, vitamins, and microelements, all of which serve as biologically active substances (BAS) of *A. graveolens*. The rich BAS composition contributes to a wide range of biological and pharmacological effects of herbal raw material extracts, primarily due to their antioxidant activity. In addition, the extract demonstrates neuroprotective, anti-inflammatory, hypolipidemic, antihypertensive, and antibacterial properties. *A. graveolens* exhibits a broad spectrum of pharmacological activities and remains a non-toxic plant.[90] *Apium graveolens* Linn. has long been used in traditional medicine systems to treat diseases such as bronchitis, asthma, liver and spleen disorders, gout, anuria, amenorrhea, kidney and vesicular stones, renal colic, stranguria, and hypertension. Celery contains several medicinally important chemical compounds, including flavonoids, alkaloids, glycosides, and steroids. The main flavonoid compounds identified in celery are apiin and apigenin, both of which play a significant role in its therapeutic effects, particularly in lowering blood pressure. In addition to flavonoids, celery also contains tannins, saponins, and steroids.[91] Figure 5a shows *Apium graveolens* plant and Figure 5b shows chemical structure of the apiin.

Starfruit (*Averrhoa bilimbi* L). leaf extract has been studied for its phytochemical components and evaluated for antibacterial and antihypertensive activities. Phytochemical screening revealed the presence of alkaloids, flavonoids, saponins, steroids, tannins, glycosides, and carbohydrates, with tannins absent in the aqueous extract.[92] Starfruit grows widely in tropical and subtropical regions and shows potential as a source of phytopharmaceutical compounds. The leaves and fruit contain phytochemicals such as alkaloids, saponins, tannins, flavonoids, phenols, and triterpenoids. These compounds are primarily obtained through extraction and exhibit pharmacological properties, including antibacterial, antiviral, antihypertensive, cholesterol-lowering, and antioxidant effects.[93] Natural phenolic compounds, in particular, demonstrate strong antioxidant potential and bioactivity as antihypertensive agents. Extracts from starfruit flower decoctions contain anthocyanins, saponins, flavonoids, and polyphenols. The methanol extract of starfruit contains flavonoids, oxalic acid, tannins, and triterpenes, while ethanol extracts of the leaves have been reported to contain polyphenols, tannins, and saponins, which function as antimicrobials, antibiotics, anti-inflammatory agents, and antioxidants.[94] Figure 6a shows *Averrhoa bilimbi* plant and Figure 6b shows chemical structure of the quercetin.

Orthosiphon aristatus (Blume) Miq. is a traditional herbal medicine with diverse biological activities. In silico screening of bioactive compounds derived from *O. aristatus* revealed that flavonoids (eg., sinensetin), polyphenols (eg., 2,3-O-dicaffeoyltartaric acid and rosmarinic acid), diterpenoids (eg., trans-ozidic acid), triterpenoids, and dipeptides (eg., acetate aurantiamide) exhibit strong binding affinity with 17β-HSD1, ErbB2/HER2, and PI3K-PKB/Akt proteins.[95]

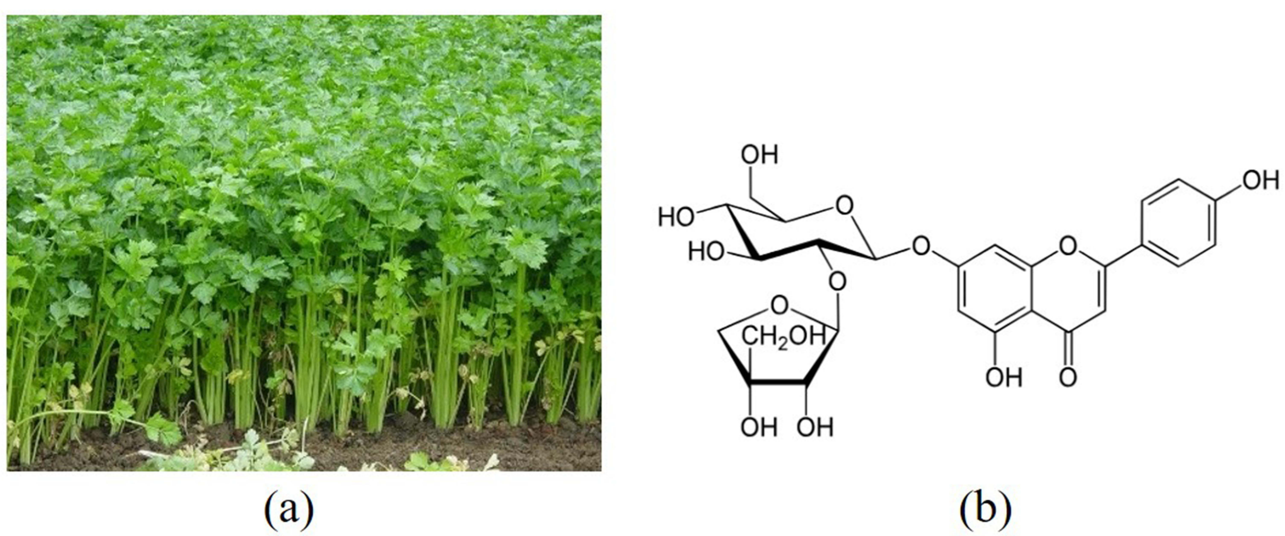
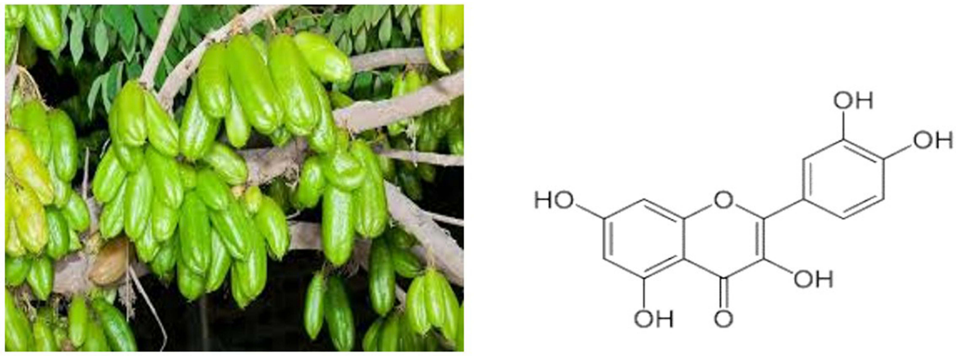


Figure 5 (**a**) *Apium graveolens* plant and (**b**) the chemical structure of the apiin compound.

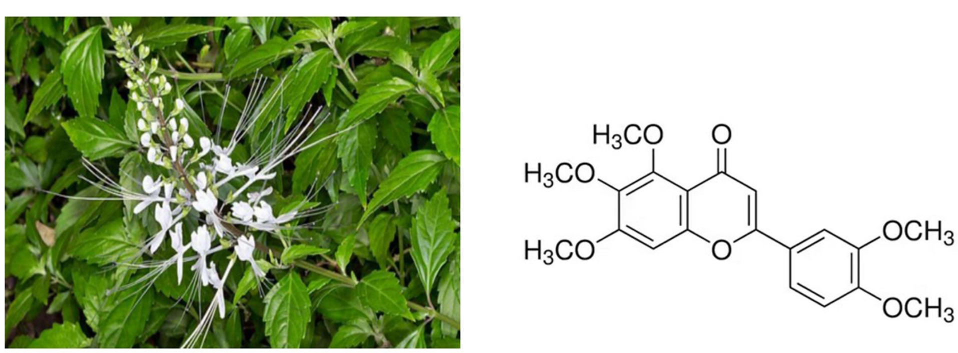


(a) (b)

Figure 6 (**a**) *Averrhoa bilimbi* plant and (**b**) the chemical structure of the quercetin compound.

Phytochemical profiling of cat's whiskers (*Orthosiphon aristatus*) using high-performance liquid chromatography (HPLC) with a mobile phase of 0.1% formic acid-acetonitrile confirmed the presence of active compounds such as rosmarinic acid, sinensetin, and eupatorin. The ethanol extract of purple-leaf varieties contained rosmarinic acid at the highest concentration (2.21% w/w). The ethyl acetate and ethanol extracts of purple-leaf varieties contained sinensetin at 2.13 and 3.07% w/w, respectively. By contrast, extracts from purple-white leaf varieties contained lower sinensetin levels, at 0.95 and 1.82% w/w, respectively. The ethyl acetate extract of the purple-white variety contained the highest eupatorin concentration, at 3.70% w/w. Although both extracts were obtained from the same species, the two *O. aristatus* varieties demonstrated significant compositional differences.[96] Figure 7a shows *Orthosiphon aristatus* plant and Figure 7b shows chemical structure of the sinensetin compound.

Annona muricata L. leaves contain abundant bioactive compounds with strong antioxidant potential. In Colima, Mexico, folk medicine traditionally employs ethanol extracts and infusions of *A. muricata* to treat various ailments, particularly hypertension. Both preparations contain high levels of alkaloids, flavonoids, tannins, and phenolic compounds. The infusion demonstrates superior antioxidant capacity, with DPPH inhibition values of 72.5%, 68.3%, and 65.1% in the northern, central, and southern regions, respectively, compared to 50.3%, 48.9%, and 45.0% for the ethanol extract.[97] Soursop leaves (*Annona muricata*) also contain acetogenins, annocatacin, annocatalin, annohexocin, annonacin, annomuricin, anomurine, anonol, caclourine, gentisic acid, gigantetronin, linoleic acid, and muricapentocin. The chemical constituents of the Annonaceae family are generally classified into non-alkaloids and alkaloids. Non-alkaloids include sucrose, glucose, fructose, and glycerides, which exhibit insecticidal properties. Alkaloids in *A. muricata* include several compounds from the benzyl-tetrahydroisoquinoline group, such as liriodine, which demonstrates antitumor,



(a) (b)

Figure 7 (**a**) *Orthosiphon aristatus* plant and (**b**) the chemical structure of the sinensetin compound.

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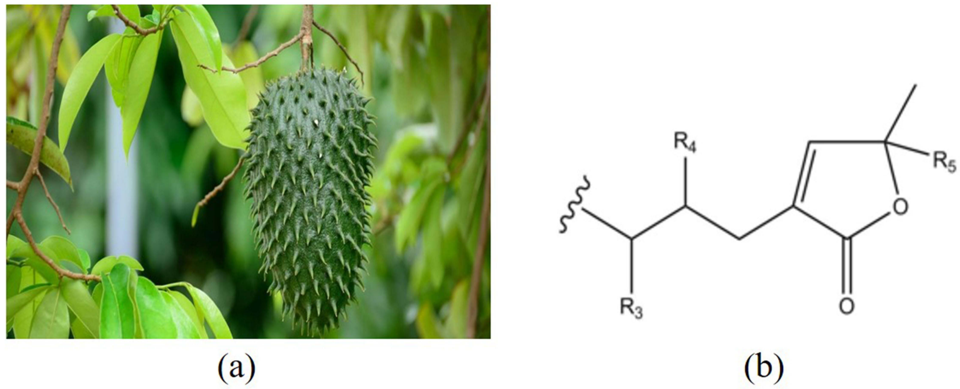

Figure 8 (**a**) *Annona muricata* plant and (**b**) the chemical structure of the acetogenin compound.

antibacterial, and antifungal activities.[98] Figure 8a shows *Annona muricata* plant and Figure 8b shows the chemical structure of the acetogenin compound.

The phytochemical profiles, antioxidant capacity, mineral composition, and antibacterial activity of *Zingiber officinale* and *Piper nigrum* have been evaluated using water, ethanol, and methanol extractions. The extracts were analyzed for polyphenols, flavonoids, and tannins, and their antioxidant potential was measured through the DPPH assay. UPLC-HRMS identified major bioactive compounds in *Z. officinale*, including 6-gingerol and shogaol. *Z. officinale* demonstrated stronger activity at lower concentrations, with a minimum inhibitory concentration (MIC) as low as 3.91 µg/mL against *Salmonella* and *Staphylococcus aureus*. Principal component analysis (PCA) revealed a strong correlation between phenolic content and biological activity.[99] Figure 9a shows *Zingiber officinale* plant and Figure 9b shows chemical structure of the gingerol.

Pharmacological Activity

Turmeric (*Curcuma longa*) has potential in hypertension therapy through its antioxidant and anti-inflammatory activities, its ability to inhibit vascular smooth muscle cell proliferation, and its modulation of β-adrenergic receptors. Its mechanisms of action include effects on the expression of eNOS, iNOS, ACE, AT1R, arginase, COX-2, Bcl-2, and Caspase-3 genes. The broad pharmacological benefits of *C. longa*, particularly its role in gene expression related to hypertension, warrant further investigation through clinical and preclinical trials.[99] Isometric voltage recording experiments on normotensive rats demonstrated the vasorelaxant effect of *C. longa* methanol extract. Intravenous administration at concentrations of 10, 20, and 30 mg/kg produced dose-dependent hypotension (2.0 ± 0.5%, 27.1 ± 5.0%, and 26.7 ± 4.6%), primarily due to the inhibition of extracellular Ca^{2+} influx and/or suppression of intracellular Ca^{2+}

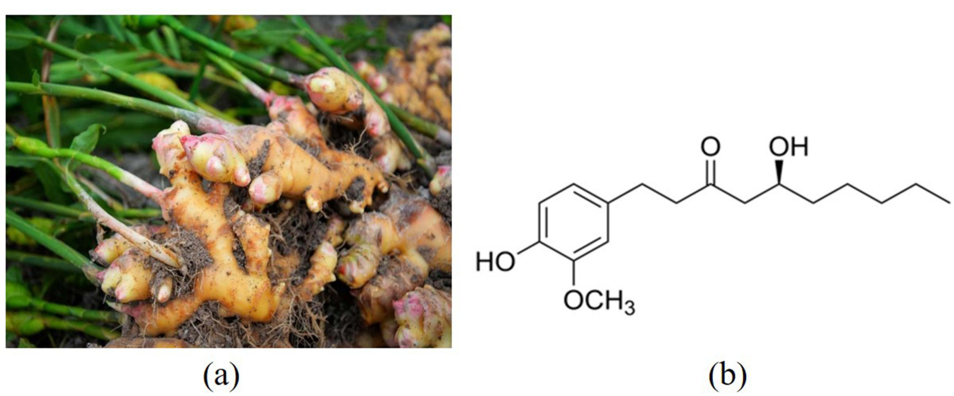

Figure 9 (**a**) *Zingiber officinale* plant and (**b**) the chemical structure of the gingerol compound.

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mobilization.[100] However, studies on turmeric as a traditional medicine remain within the category of standardized herbal medicines and have not yet advanced to the stage of phytopharmaceuticals. Curcumin exerts its therapeutic activity by modulating various molecular targets, either through direct physical interaction or by regulating transcription factors, enzyme activity, and gene expression.[70]

It is important to highlight that, beyond the Anak Dalam tribe, the application of plants for medicinal purposes is also common in different countries, including Morocco. According to various references, several of these plants are used to treat hypertension, and these same plants are often employed across different regions. In recent years, herbal medicine has experienced a global resurgence, particularly in Morocco, where phytotherapy remains central to traditional practices for treating hypertension and diabetes in the Laayoune Sakia El Hamra Region of Southern Morocco. A recent ethnopharmacological survey documented 81 plant species from 39 families used in the treatment of these diseases. For diabetes, the most frequently cited plants included *Coriandrum sativum, Lepidium sativum, Trigonella foenum-graecum*, and *Artemisia herba-alba*. For hypertension, the most common species were *Allium sativum, Ammodaucus leucotrichus, Acacia rhadiana*, and *Olea europaea*. The plant families with the highest representation were Apiaceae, Asteraceae, Fabaceae, and Lamiaceae. The most frequently used plant parts were leaves (30.87%), aerial parts (20.99%), and seeds (14.84%). In the Sahara region, the most common method of preparation was decoction (37%), followed by powder (22%) and infusion (18%). The oral route accounted for 98% of reported applications. This traditional knowledge represents a valuable cultural and therapeutic resource that must be preserved. Furthermore, pharmacological and phytochemical investigations of the identified plants are necessary to validate their efficacy and ensure safe clinical use.[101–103] Among these, *Allium sativum* is particularly well known for its therapeutic properties, including anticarcinogenic, antioxidant, antidiabetic, renoprotective, anti-atherosclerotic, antimicrobial, anti-obesity, and antihypertensive effects. Its active components, especially allicin, exhibit antibacterial, antiviral, antifungal, anti-inflammatory, and anticancer activities, contributing to its role in immunomodulation and cytokine regulation.[82]

The Anak Dalam tribe has traditionally used the noni (*Morinda citrifolia* L). plant for a long time to address health issues associated with hypertension. Interestingly, this plant is also utilized by communities in Malaysia. *Morinda citrifolia* L., commonly known as *mengkudu* in Malaysia, has been used for thousands of years as a medicinal plant to treat various health problems. It plays a significant role in traditional medicine, particularly among Malay communities. Phytochemical compounds, primarily from the phenolic and flavonoid groups, found in different parts of *M. citrifolia* L., exhibit diverse biological activities, including antibacterial, antioxidant, antidiabetic, anti-obesity, anticancer, and anti-hypertensive properties. Factors such as extraction conditions and solvents strongly influence the therapeutic potential of different plant parts.[104] A systematic review of previous studies reported that certain non-derived compounds display potent free radical scavenging activity (eg., inhibition of 2,2-diphenyl-1-picrylhydrazyl/2,2′-azino-bis(3-ethylbenzothiazoline-6-sulfonic acid) (DPPH/ABTS)) as well as enhancement of endogenous antioxidant enzymes (eg., superoxide dismutase (SOD), catalase (CAT), and glutathione peroxidase (GPx)). These compounds also modulate key signaling pathways, including nuclear factor erythroid 2-related factor 2/Kelch-like ECH-associated protein 1 (Nrf2/Keap1) and nuclear factor kappa-B (NF-κB). Notably, polysaccharides and iridoids demonstrate antioxidant and anti-inflammatory activities by regulating gut microbiota.[85,105]

Citrus aurantiifolia (Christm). Swingle is another medicinal plant commonly used traditionally to treat hypertension. Overall, 62 species have been recorded for this use, with many from the families Asteraceae, Piperaceae, Rutaceae, and Zingiberaceae, each comprising four species. Herbal remedies are most often prepared by boiling (78%) and are typically consumed as one cup of tea before three meals daily (26%). Of these species, 37 have been reported in ethnomedicinal practices, while 24 have been scientifically investigated for antihypertensive activity and 46 for toxicity. *C. aurantiifolia* (Christm). Swingle stands out as one of the plants examined for pharmacological efficacy and safety.[78]

A different study revealed the presence of over 554 phytochemicals, showing a wide variety of molecular structures. These bioactive compounds belong to several distinct chemical classes, including flavonoids, terpenoids, saponins, and volatile substances. They were extracted and identified from a total of 34 medicinal plants, highlighting the rich chemical diversity found in these botanical sources. The study emphasizes the complex nature of plant phytochemicals and their potential importance in medicinal applications. Such findings contribute to a better understanding of the chemical makeup of medicinal plants and underscore their value as sources of diverse bioactive compounds for future research and drug development. These compounds demonstrated a wide range of pharmacological activities, including anti-inflammatory, antimicrobial, wound healing, antimalarial, antihypertensive, and headache relief. Among these, five medicinal plants are widely used by traditional healers: *Garcinia mangostana, Apium graveolens, Cayratia clematidea, Drymocallis arguta*, and *Elaeocarpus longifolius*. Of these, only *A. graveolens* has demonstrated pharmacological evidence supporting its use in treating hypertension.[106]

Traditionally, communities have used *Averrhoa bilimbi* L., a member of the Oxalidaceae family, to treat various ailments such as itching, boils, syphilis, whooping cough, hypertension, fever, and inflammation. The fruit extract of *A. bilimbi* L. contains key phytochemicals. GC-MS analysis identified 151 compounds, of which 15 exhibited diverse biological activities. The extract also showed a high total phenolic content of 209.25 mg GAE/g.[105] The presence of phenolic compounds contributes to its antioxidant activity. This activity is evidenced by strong nitric oxide (NO) scavenging capacity, with a notable IC_{50} value of 108.10. These findings indicate that *A. bilimbi* L. fruit extract is a rich source of phytochemicals with multiple biological activities, including antihypertensive effects.[105]

In addition, *Averrhoa bilimbi* L. and *Averrhoa carambola* (Starfruit) belong to the same genus, which is Averrhoa. Both of these plants are part of the Oxalidaceae family and have closely related taxonomic characteristics, although their fruit morphology differs. Starfruit leaves, as a functional food, can serve as a non-pharmacological antihypertensive remedy. The leaves are processed into herbal tea, which is consumed as a traditional drink. Researchers conducted tests involving 15 semi-trained panelists and 30 consumer panelists. They stored the starfruit leaf tea for 14 days at 25°C, 35°C, and 45°C, measuring moisture content and total microbial parameters. In the hedonic quality test, semi-trained panelists gave the highest overall score to formula 4, although its taste parameter score was lower. In contrast, the consumer panelists rated formula 2 the highest, with a better score for taste parameters. Based on these findings, formula 2 (7 g/150 mL water) demonstrated greater consumer acceptance and the best shelf life when stored at 25°C.[76]

Four other studies on *Orthosiphon aristatus* reported significant pharmacological effects of the methanol rosmarinic compound (MRC). First, MRC caused a sustained decrease in systolic blood pressure and heart rate after subcutaneous administration in conscious male SHRSP rats. Second, MRC showed concentration-dependent suppression of contractions induced by high K^+, L-phenylephrine, or prostaglandin $F_2\alpha$ in endothelium-treated rat thoracic aorta. Third, MRC markedly suppressed contraction force without a significant decrease in pulse rate in isolated bilateral guinea pig atria. Finally, MRC increased urine volume and the excretion of Na^+, K^+, and Cl^- for three hours after oral administration with a saline load in fasting rats.[77] The fresh reddish-purple flowers of *O. aristatus* are thought to contain anthocyanin compounds, while the bitter taste of its leaves and flowers likely results from astringent polyphenols. Polyphenols act by inhibiting oxidized microbial enzymes, possibly through reactions with sulfhydryl groups or nonspecific interactions with microbial proteins. They can also denature microbial proteins. Scientific evidence further demonstrates that antioxidant compounds, including polyphenols, vitamins C, E, and A, as well as carotenes and phenolic acids, reduce the risk of chronic diseases caused by free radicals. The key characteristic of antioxidant compounds lies in their ability to capture and stabilize free radicals.[94]

Annona muricata is a medicinal plant traditionally used as an antihypertensive and antitoxic agent. Most traditional healers believe that hypertension arises from disturbances in the body's fire and wind elements. To address wind-related imbalances, they apply medicinal plants with mild, spicy flavors. A total of 37 species have been reported for use in traditional medicine, while 24 and 46 species have been studied for their antihypertensive activity and toxicity, respectively. Identifying medicinal plants that have been tested by experienced traditional healers offers communities opportunities to select and consume local herbs that are easily accessible in their regions.[78] Another study demonstrated that *A. muricata* extract inhibited α-amylase, α-glucosidase, and ACE activity in a dose-dependent manner. The effective concentration of extracts required to achieve 50% antioxidant activity (EC_{50}) revealed that pericarp extract had the highest inhibitory activity against α-amylase (0.46 mg/mL), α-glucosidase (0.37 mg/mL), and ACE (0.03 mg/mL). In contrast, seed extract exhibited the lowest inhibitory activity [α-amylase (0.76 mg/mL), α-glucosidase (0.73 mg/mL), and ACE (0.20 mg/mL)].[68] Furthermore, AME, PAE, and CAPE significantly ($p \leq 0.001$) lowered blood pressure in normotensive and hypertensive animals. The effects of CAPE 1, CAPE 2, and CAPE 3 were synergistic, with combination indices of 0.65 ± 0.07, 0.76 ± 0.09, and 0.87 ± 0.07, respectively. CAPE 1 (100 mg/kg) and CAPE 2 (75 mg/kg) treatments significantly reduced systolic blood pressure (SBP) and mean arterial pressure (MAP) in hypertensive models ($p \leq 0.01$–0.001), comparable to the reductions achieved with nifedipine treatment ($p \leq 0.001$).[68]

In another study, HPLC analysis identified quercetin as the main compound across all samples. Geographically, the northern region exhibited higher concentrations of bioactive compounds, particularly total flavonoid content (TFC) and ferric reducing power assay (FRPA). Both ethanol extract and infusion of *A. muricata* leaves demonstrated significant antioxidant activity, with the infusion showing superior performance.[101] These findings suggest that *A. muricata* infusion holds potential for managing diseases associated with oxidative stress, such as cancer, hypertension, and diabetes.[97] Furthermore, researchers can develop this formulation into a nanotechnology-based preparation, such as nanocapsules, to enhance its efficacy in lowering blood pressure.[101,102]

Inflammation plays a critical pathogenic role in the development of hypertension. Researchers therefore investigated the effects of ginger (*Zingiber officinale*) and turmeric (*Curcuma longa*) on purinergic and cholinergic system enzyme activities as well as inflammatory cytokine levels in Nω-nitro-L-arginine methyl ester hydrochloride-induced hypertensive rats. The rats were divided into seven groups (n = 10). Groups 1–3 consisted of normotensive control rats, hypertensive rats (Nω-nitro-L-arginine methyl ester hydrochloride), and hypertensive control rats treated with atenolol (a standard antihypertensive drug). Groups 4 and 5 included normotensive and hypertensive rats treated with a 4% turmeric supplement, respectively, while groups 6 and 7 included normotensive and hypertensive rats treated with a 4% ginger supplement. Researchers induced hypertension by orally administering Nω-nitro-L-arginine methyl ester hydrochloride at 40 mg/kg body weight. The results showed a significant increase in ATP and ADP hydrolysis, adenosine deaminase, and acetylcholinesterase activity in lymphocytes of hypertensive rats compared with control rats. In addition, hypertensive rats exhibited increased serum butyrylcholinesterase activity and elevated proinflammatory cytokines (interleukin-1, interleukin-6, interferon-γ, and tumor necrosis factor-α), accompanied by a decrease in the anti-inflammatory cytokine interleukin-10. However, dietary supplementation with both rhizomes effectively prevented these changes in hypertensive rats by reducing ATP hydrolysis, acetylcholinesterase, and butyrylcholinesterase activities as well as proinflammatory cytokine levels. These findings provide insight into the protective mechanisms of rhizomes against hypertension-related inflammation.[107]

The Anak Dalam tribe in Jambi, Indonesia, has traditionally utilized a variety of native plants for managing hypertension and other cardiovascular conditions. Ethnobotanical surveys have documented several species believed to possess antihypertensive properties, rooted in the tribe's indigenous knowledge systems. Recent pharmacological investigations have begun to substantiate these traditional claims, emphasizing the potential of these plants as alternative therapeutic agents. Preclinical studies, including in vitro and in vivo experiments, have demonstrated promising antihypertensive effects of several plants used by the Anak Dalam tribe. For example, *Allium sativum* Linn. and *Zingiber officinale* Roscoe had shown vasodilatory effects by modulating nitric oxide pathways, and exhibits ACE-inhibitory activity, contributing to blood pressure reduction. Notably, recent research has revealed that some of these plants also possess antidiabetic properties, indicating a multifaceted therapeutic potential, especially considering the common comorbidity of hypertension and diabetes.

Recent data from preclinical testing supports the safety and efficacy of these plants, showing significant reductions in systolic and diastolic blood pressures in animal models without observable toxicity. These findings provide a scientific basis for further clinical evaluation, which could lead to the development of ethnobotanical-based antihypertensive medications. Based on these promising preclinical results, interested researchers are encouraged to pursue clinical trials to evaluate efficacy and safety in human subjects. Such studies should adhere to rigorous protocols and consider local traditional knowledge, ensuring ethical standards are maintained throughout the research process.

To reinforce the ethical and legal framework of this research, it is essential to establish benefit-sharing agreements with the Anak Dalam community, acknowledging their traditional knowledge and contributions. Furthermore, compliance with the Nagoya Protocol on Access and Benefit-Sharing (ABS) must be prioritized, ensuring that any benefits arising from the utilization of these genetic resources and traditional knowledge are fairly shared with the indigenous community. This approach not only promotes ethical research practices but also supports the conservation of biodiversity and traditional cultural heritage.

Conclusions

This study documents the indigenous knowledge of antihypertensive medicinal plants utilized by the Anak Dalam tribe in Jambi, Indonesia. A total of 34 plant species are used by the community, with nine species being most widely employed: turmeric (*Curcuma longa* Linn)., garlic (*Allium sativum* Linn)., noni (*Morinda citrifolia* Linn)., lime (*Citrus aurantiifolia* (Christm). Swingle), celery (*Apium graveolens* Linn)., starfruit (*Averrhoa bilimbi* Linn)., cat's whiskers (*Orthosiphon aristatus* var. aristatus), soursop (*Annona muricata* L)., and ginger (*Zingiber officinale* Roscoe).

While these plants show promise as potential antihypertensive agents, it is crucial to thoroughly evaluate their safety profiles. Specific species, such as *Annona muricata* and *Orthosiphon aristatus*, carry the most significant safety risks and require careful assessment. Conversely, species like turmeric and garlic have a stronger evidence base supporting their efficacy and safety, making them more viable candidates for clinical development. Conducting comprehensive toxicity assessments, including identifying potential adverse effects and establishing therapeutic indices, is essential before these plants can be considered for clinical use. Such evaluation will help determine which species pose safety concerns and which hold the most promise for integration into modern hypertension treatment.

In addition to safety considerations, further research must validate the efficacy of these traditional medicines and elucidate their mechanisms of action. Beyond the scientific aspects, this work has broader public health implications for hypertension management in Indonesia, where hypertension prevalence is rising. Moreover, exploring the pharmaceutical potential of bioactive compounds derived from these plants could lead to new therapeutic options. Equally important is the preservation and promotion of indigenous ethnobotanical knowledge, which holds cultural significance and could inform sustainable medicinal plant use. Strengthening these areas will enhance the impact of this research and guide future efforts in medicinal plant development and public health strategies.

Data Sharing Statement

No datasets were generated or analysed during the current study.

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Author Contributions

All authors made a significant contribution to the work reported, whether that is in the conception, study design, execution, acquisition of data, analysis and interpretation, or in all these areas; took part in drafting, revising or critically reviewing the article; gave final approval of the version to be published; have agreed on the journal to which the article has been submitted; and agree to be accountable for all aspects of the work.

Disclosure

The authors declare no competing interests in this work.

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