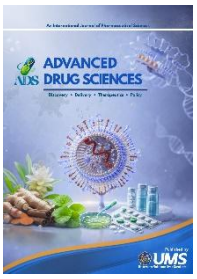
Advanced Drug Sciences

Volume 1 https://doi.org/to be assigned Issue 1

Journal Homepage: https://journals2.ums.ac.id/ads/index



REVIEW ARTICLE

Antihypertensive Herbal Medicines as Adjuncts to Guideline-Based Care: A Narrative Review of Clinical Evidence, Mechanisms, Safety, and Translational Challenges

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Citation: Ahamed, M. T., Ramadhana, I.H.A., & Purnama,.M.F. (2026). Antihypertensive Herbal Medicines as Adjuncts to Guideline-Based Care: A Narrative Review of Clinical Evidence, Mechanisms, Safety, and Translational Challenges. *Adv. Drug Sci., 1*(1), e000003. DOI: to be assigned

ABSTRACT

Hypertension is a leading modifiable cause of cardiovascular, cerebrovascular, and renal disease. Herbal medicines remain widely used because they are culturally familiar, perceived as safe, accessible in many communities, and biologically plausible. This narrative review synthesizes evidence on herbal products proposed for blood pressure management. The review focuses on clinical efficacy, mechanisms, safety, product quality, and translational readiness. Evidence from guidelines, randomized trials, systematic reviews, mechanistic studies, ethnobotanical reports, pharmacovigilance literature, and Indonesian regulatory sources was appraised qualitatively. A qualitative approach was used because studies differ in botanical identity, plant part, extraction method, dose, comparator, follow-up duration, blood pressure measurement, and adverse event reporting. The strongest clinically interpretable evidence is product-specific rather than plant-name-specific. Hibiscus sabdariffa (Roselle), Aged Allium sativum (Garlic) preparations, Olea europaea (olive leaf extract), and Camellia sinensis (Tea) derived products have randomized or synthesis-level signals suggesting modest blood pressure reduction whereas Apium graveolens (celery) and several ethnobotanical candidates remain preliminary or hypothesis generating. Proposed mechanisms include renin-angiotensin-aldosterone system modulation, nitric oxide-mediated vasodilation, antioxidant and anti-inflammatory activity, calcium-channel or sympathetic modulation, and mild natriuretic or diuretic effects. Herbal medicines should not replace validated lifestyle intervention, cardiovascular risk assessment, or pharmacotherapy in sustained, symptomatic, high-risk, or uncontrolled hypertension. Responsible integration requires standardized products, medication reconciliation, home or ambulatory blood pressure monitoring, adverse-event surveillance, and research designs that report botanical identity and product quality with the same precision expected for conventional medicines.

ARTICLE INFORMATION

Keywords:
Hypertension
Herbal medicine
Phytotherapy
Complementary medicine
Blood pressure
Traditional medicine
Pharmacovigilance

Received	18 May 2026
Revision	12 Jun 2026
Accepted	12 Jun 2026
Published	30 Jun 2026

1. INTRODUCTION

Hypertension is one of the most important modifiable causes of cardiovascular disease, stroke, heart failure, chronic kidney disease, cognitive decline, and premature mortality. The World Health Organization has emphasized that improved detection, treatment, long-term control, validated blood pressure devices, and reliable

access to quality-assured medicines are central to reducing the global burden of hypertension [1,2]. Contemporary European and international guidelines similarly emphasize accurate office measurement, confirmation with home or ambulatory monitoring when feasible, cardiovascular risk stratification, lifestyle intervention, and evidence-based pharmacotherapy [2-4]. Large-scale evidence also confirms that blood pressure lowering reduces the risk of major cardiovascular events and mortality, which is why adjunctive strategies must be evaluated against the standard of durable blood pressure control rather than short-term symptom relief alone [5].

Despite the availability of effective antihypertensive medicines, control remains suboptimal in many settings because of limited access, treatment inertia, adverse effects, polypharmacy, cost, health-system barriers, and variable adherence. These same pressures help explain the continued use of herbal medicines and traditional preparations as complementary strategies. In many communities, herbal products are not viewed as alternatives invented outside the health system, but as familiar and culturally embedded health practices. The World Health Organization has recognized that traditional medicine remains part of health-seeking behavior in many regions, although clinical integration requires appropriate evidence, regulation, and safety monitoring [6].

A balanced appraisal is therefore needed. Some herbal products have plausible pharmacological activity and emerging clinical evidence; others are supported mainly by traditional use, preclinical signals, or poorly described studies [6]. Botanical origin does not guarantee efficacy, safety, or quality. Conversely, absence from major hypertension guidelines [2–4] does not prove biological inactivity. The central question is whether a defined product, dose, and preparation produce reproducible benefits [8] that outweigh risks when used alongside guideline-based care [2, 5].

This distinction matters clinically because patients often disclose herbal medicine use only when asked directly. If clinicians do not ask, a parallel therapeutic ecosystem can develop in which patients combine herbs with prescribed medicines, substitute unproven products for necessary pharmacotherapy, or use products of uncertain identity and dose. A constructive review should therefore avoid both uncritical promotion and blanket dismissal. The safer path is product-specific appraisal, transparent discussion, and careful monitoring [6].

To bridge the gap between traditional use and modern cardiovascular management, the primary objective of this narrative review is to critically evaluate the clinical efficacy, mechanistic plausibility, and safety profiles of selected antihypertensive herbal medicines and multi-herb formulations. Specifically, this review aims to define the translational requirements for publication-quality research and establish a pragmatic framework for the responsible integration of these products into guideline-based care. The argument is deliberately product-centered: a household decoction, a standardized extract, and a multi-herb capsule should not be treated as interchangeable merely because they share a plant name or a traditional indication [7,8].

2. METHODS

This manuscript was prepared as a structured narrative review, not as a registered systematic review. The review followed principles of transparent narrative synthesis and SANRA: a defined scope, explicit source selection, critical interpretation, and clear limitations [9]. The guiding question was: which herbal products proposed for blood pressure management have clinically interpretable evidence, plausible mechanisms, safety concerns, and translational readiness for adjunctive use with guideline-based care?

Relevant sources were identified through searches of PubMed/MEDLINE, Scopus, Web of Science, ScienceDirect, Google Scholar, official World Health Organization documents, European hypertension guidelines, Indonesian regulatory documents, and reference lists of relevant reviews and primary studies.

The search combined three core blocks: blood pressure terms, herbal medicine terms, and product-specific terms. Blood pressure terms included "hypertension", "high blood pressure", and "blood pressure". Herbal medicine terms included "herbal medicine", "phytotherapy", "traditional medicine", "medicinal plant", "jamu", "extract", and "decoction". Product-specific terms included "Hibiscus sabdariffa", "*Allium sativum*", "aged garlic extract", "*Olea europaea*", "*Camellia sinensis*", "*Apium graveolens*", "licorice", and "*Glycyrrhiza glabra*". Safety and mechanism terms included "nitric oxide", "RAAS", "ACE inhibition", "diuretic", "natriuretic", "oxidative stress", "herb-drug interaction", "adverse event", "pharmacovigilance", and "product quality".

Eligible evidence included peer-reviewed articles and official documents relevant to herbal medicines used to reduce blood pressure or manage hypertension. Randomized controlled trials, systematic reviews, meta-analyses, guideline documents, pharmacovigilance sources, and studies with clinically interpretable blood pressure outcomes received the greatest weight. Ethnobotanical, preclinical, and *in silico* sources were retained when they clarified candidate selection, mechanisms, regional relevance, or safety signals. They were not treated as proof of clinical efficacy [7-9].

Records were screened for relevance to adults with elevated blood pressure or hypertension, a clearly described herbal product or plant candidate, blood pressure outcomes or mechanistic relevance, and safety or interaction information. Studies were excluded from clinical interpretation when the intervention was not identifiable; blood pressure outcomes were absent, or the report provided only unsupported promotional claims.

Findings were synthesized qualitatively. Studies differed substantially in botanical species, plant part, extraction method, dose, marker compound standardization, comparator, follow-up duration, outcome measurement, background antihypertensive therapy, and adverse event reporting. These differences made statistical pooling inappropriate. This review did not use a PRISMA flow diagram, prospective protocol registration, or formal risk of bias scoring. Therefore, the conclusions should be read as a structured narrative appraisal, not as a definitive quantitative estimate of treatment effect [9].

The narrative approach was chosen to prioritize clinical interpretation and translational readiness. In this field, the same common name may refer to different species or plant parts. The same species may also be prepared as a decoction, powder, capsule, extract, or standardized formulation. A pooled estimate can be misleading when exposure definitions differ widely. **Table 1** summarizes the approach used to strengthen transparency.

Table 1. Structured narrative review approach used to strengthen transparency.

Element	Operational approach	Rationale for journal readiness
Scope	Herbal medicines and selected multi-herb formulations relevant to blood pressure management in adults.	Keeps the review focused while allowing single-herb, multi-herb, mechanistic, clinical, safety, and regulatory evidence to be compared.
Evidence prioritization	Guidelines, randomized trials, systematic reviews, pharmacovigilance reviews, and official regulatory documents were prioritized over uncontrolled or anecdotal reports.	Improves credibility by emphasizing evidence with stronger clinical interpretability.
Contextual evidence	Ethnobotanical and Indonesian regulatory sources were retained where they support cultural relevance, candidate selection, product quality, or implementation context.	Preserves regional relevance without overstating efficacy.
Synthesis method	Qualitative synthesis was used because botanical preparations, doses, comparators, follow-up durations, and outcome measures were heterogeneous.	Avoids inappropriate pooling and clarifies why a narrative approach was selected.
Interpretive stance	Herbal products were evaluated as potential adjuncts to guideline-based care, not substitutes for validated hypertension treatment.	Aligns the clinical message with contemporary hypertension guidance and patient safety.

3. PATHOPHYSIOLOGICAL RATIONALE AND PROPOSED MECHANISMS

Blood pressure is regulated through interacting vascular, renal, neural, endocrine, and inflammatory pathways. Sustained hypertension may reflect increased systemic vascular resistance, expanded intravascular volume, arterial stiffness, endothelial dysfunction, inappropriate activation of the renin-angiotensin-aldosterone system, sympathetic overactivity, impaired sodium handling, oxidative stress, and vascular inflammation [10,11]. Herbal interventions are hypothesized to influence one or more of these pathways rather than acting through a single mechanism.

Several proposed mechanisms recur across the literature. Organosulfur compounds in *A. sativum* (Garlic), especially in Aged Garlic preparations standardized by sulfur-containing markers, may support endothelial function, nitric oxide bioavailability, oxidative-stress

reduction, and angiotensin-converting enzyme-related pathways [12-14]. Polyphenol- and anthocyanin-rich *H. sabdariffa* (Roselle) preparations may influence endothelial function, oxidative stress, and diuretic or natriuretic pathways [15-17]. *O. europaea* (olive leaf extract) has been investigated in stage 1 hypertension and is commonly discussed in relation to oleuropein-rich vascular and metabolic effects [18]. *C. sinensis* (Tea) derived catechins and flavonoids may exert small vascular effects through endothelial and antioxidant pathways [19,20]. *A. graveolens* (celery) preparations are often linked to phthalides, flavonoids, calcium-channel modulation, and diuretic activity, but the human evidence remains less mature and more formulation dependent [21,22].

Mechanistic plausibility is important but insufficient. *In silico* docking, cell studies, and animal experiments can identify candidate pathways, but they do not establish clinical efficacy or safety in humans. A compound that binds a target in a docking model may never reach an active concentration in human plasma or vascular tissue. A decoction that lowers blood pressure in a short animal experiment may not reproduce the same effect in adults using antihypertensive drugs. Translational confidence therefore requires standardized botanical identity, reproducible phytochemical profiles, pharmacokinetic understanding, and adequately powered clinical trials with validated blood pressure outcomes [7,8,10,11].

The most defensible mechanistic interpretation is plural rather than singular. Herbal products may produce small additive effects across endothelial function, oxidative stress, vascular tone, renal sodium handling, and neurohormonal signaling. This multi-target profile is attractive for complex conditions such as hypertension, but it also requires unusually rigorous product characterization and interaction assessment [7,8].

Figure 1 here provides a mechanism map. It links major drivers of hypertension with plausible herbal targets, including RAAS activity, nitric oxide signaling, oxidative stress, inflammation, vascular tone, and renal sodium handling. The figure is a hypothesis framework rather than a claim of proven clinical efficacy.

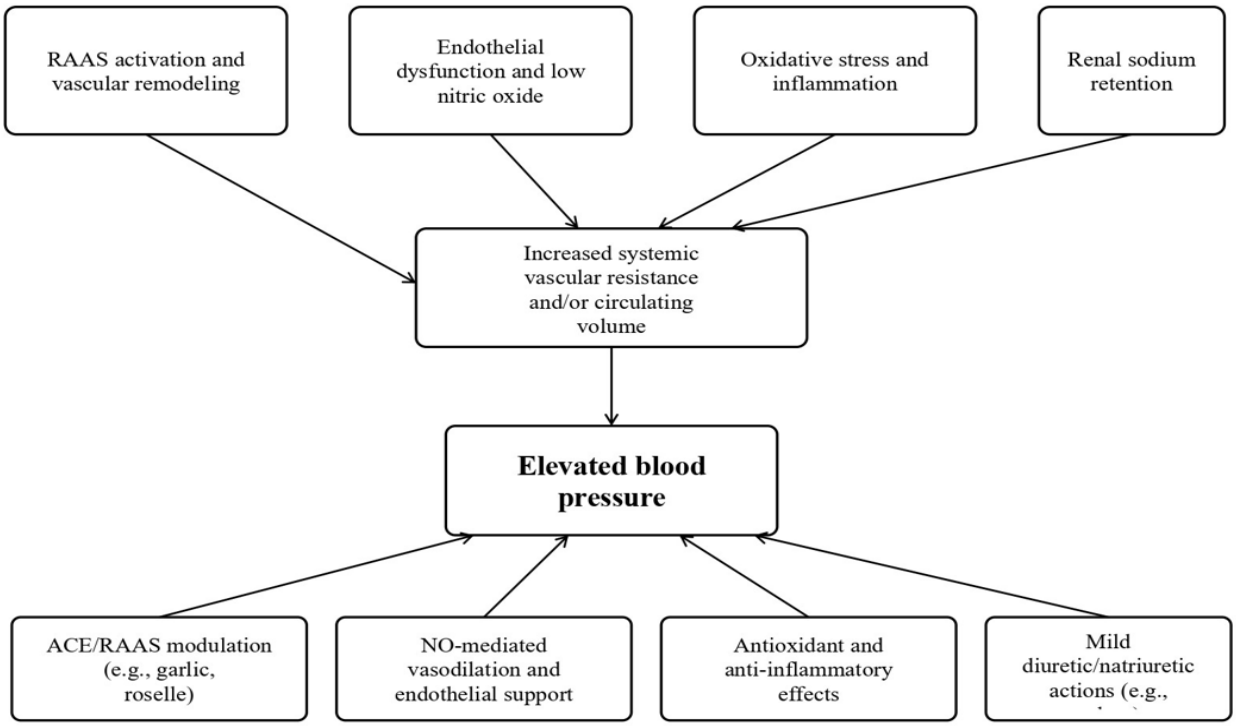

Figure 1. Mechanistic map showing major pathophysiologic drivers of hypertension and proposed pathways through which selected herbal medicines may lower blood pressure. The figure organizes biological hypotheses around specific targets: ACE/RAAS modulation and NO-mediated endothelial support (e.g., *Allium sativum, Hibiscus sabdariffa*) [12–17]; antioxidant and anti-inflammatory effects (e.g., *Olea europaea, Camellia sinensis*) [18–20]; and mild diuretic or natriuretic actions (e.g., *Apium graveolens*) [21, 22]. It should be viewed as a theoretical framework rather than proof of clinical efficacy. ACE, angiotensin-converting enzyme; NO, nitric oxide; RAAS, renin-angiotensin-aldosterone system.

4. EVIDENCE SYNTHESIS

The evidence base can be understood as a ladder. At the lower rungs are traditional use, ethnobotanical surveys, *in silico* studies, and animal experiments, which are useful for hypothesis generation and candidate selection. Higher rungs include controlled human studies, randomized trials, and systematic reviews with standardized interventions and validated blood pressure outcomes. Movement up this ladder is not merely academic; it determines whether a product can be discussed as a cultural practice, a research candidate, or a clinically usable adjunct [7–9].

Across this evidence ladder, consistency of product identity is the recurring bottleneck. When a study reports an herb only by common name, omits plant part or extraction method, or does not describe quality testing, the finding becomes difficult to reproduce. Therefore, the following synthesis places the greatest weight on interventions with clearer preparation, human clinical evaluation, and blood pressure outcomes that can be interpreted in practice [7,8].

5. ETHNOBOTANICAL PRECLINICAL EVIDENCE

Ethnobotanical data demonstrate that herbal antihypertensive practices remain relevant in community settings. In Mowila, Indonesia, community members reported using several plants, commonly as leaf decoctions, to manage hypertension, including *Annona muricata*, *Syzygium polyanthum*, *Sauropus androgynus*, *Moringa oleifera*, *Jatropha curcas*, *Persea americana*, *Averrhoa bilimbi*, *Orthosiphon aristatus*, and *Andrographis paniculata* [23]. Such evidence is valuable for mapping real-world use and identifying culturally accepted candidates, but it cannot establish efficacy because it lacks controlled exposure, comparator groups, standardized doses, and outcome verification.

Ethnobotanical findings should therefore be treated as a starting map rather than a clinical destination. They indicate which plants patients may already be using, which products deserve safety surveillance, and which candidates may be acceptable in local research. They also remind investigators that intervention design should be culturally realistic. A trial of a capsule may answer a different question from a community practice based on freshly prepared leaf decoctions [6,9,23].

Preclinical and *in silico* studies provide hypothesis-generating support. In hypertensive female rats, several herbal leaf decoctions reduced blood pressure, with *A. graveolens* (celery) and starfruit producing statistically significant reductions [24]. Molecular docking studies on Illicium verum identified compounds with predicted affinity for neprilysin, suggesting a possible antihypertensive research direction, though requiring biochemical, pharmacokinetic, and clinical validation [25]. These signals are biologically interesting, but translation to humans requires dose conversion, toxicity assessment, standardized product characterization, and controlled trials [7,8].

6. SINGLE-HERB CLINICAL EVIDENCE

Clinical evidence for single-herb interventions is strongest when preparations are standardized, and outcomes are measured using validated office, home, or ambulatory protocols. *A. graveolens* (celery) illustrates the problem of uneven evidence. Local quasi-experimental evidence suggests that *A. graveolens* (celery) leaf decoction may lower blood pressure in menopausal women with hypertension, and preclinical work supports potential vascular or renal mechanisms; however, short follow-up, local sampling, limited blinding, and inconsistent reporting of formulations limit certainty and generalizability [21,22]. The clinically relevant question is therefore not whether *A. graveolens* (celery) as a general category lowers blood pressure, but which preparation, at which dose, in which patient group, and with what monitoring requirements.

H. sabdariffa (Roselle) has more mature evidence base than many single-herb interventions. A systematic review and meta-analysis of randomized trials reported reductions in systolic and diastolic blood pressure with sour *Camellia sinensis (Tea)* or *H. sabdariffa* (Roselle) preparations, although heterogeneity in preparations, doses, and comparators limits direct product-to-product generalization [15*]. H. sabdariffa* (Roselle) has more mature clinical evidence base than many other single-herb interventions. In a randomized, double-blind, placebo-controlled trial involving 65 prehypertensive and mildly hypertensive adults, daily consumption of *H. sabdariffa* (Roselle) tea for 6 weeks resulted in a mean reduction of 7.2 mmHg in systolic blood pressure compared with 1.3 mmHg in the placebo group. Among participants with baseline systolic blood pressure ≥129 mmHg, the reduction reached approximately 13.2

mmHg. These findings indicate a clinically meaningful antihypertensive effect, although the magnitude of benefit may vary according to baseline blood pressure and the specific formulation used. Therefore, the available evidence should be interpreted as product-specific rather than as proof that all *H. sabdariffa* preparations produce equivalent effects [16].

A. sativum (Garlic) evidence also illustrates the importance of formulation, dose, and measurement strategy. Meta-analytic evidence suggests that *A. sativum* (Garlic) can lower blood pressure in hypertensive individuals, with larger effects generally observed in those with elevated baseline values [12,13]. Aged *A. sativum* (Garlic) extract has been evaluated in a dose-response trial and is often standardized by sulfur-containing compounds, which improves interpretability compared with raw *A. sativum* (Garlic) or poorly characterized supplements [14]. However, *A. sativum* (Garlic) should still be considered an adjunctive product rather than a substitute for guideline-based treatment, particularly in patients using antiplatelet or anticoagulant therapy [26,29].

O. europaea (olive leaf extract) provides another example of product-specific evidence. In a randomized, double-blind study involving 232 patients with stage 1 hypertension, treatment with olive leaf extract (500 mg twice daily) for 8 weeks reduced systolic blood pressure by 11.5 mmHg and diastolic blood pressure by 4.8 mmHg from baseline. The antihypertensive effect was comparable to that achieved with captopril, suggesting that standardized olive leaf extract may offer clinically relevant blood pressure reduction when used as an adjunctive intervention. However, interpretation remains product specific, and further independent replication and long-term studies are needed before broader clinical recommendations can be made [18].

C. sinensis (Tea) derived products also have synthesis-level evidence supporting modest reductions in blood pressure. A meta-analysis of 13 randomized controlled trials involving approximately 1,367 participants reported that green tea interventions administered for 3 weeks to 3 months reduced systolic blood pressure by 1.98 mmHg and diastolic blood pressure by 1.92 mmHg. Similarly, a meta-analysis of 11 randomized controlled trials involving approximately 378 participants found that black tea consumption reduced systolic blood pressure by 1.8 mmHg and diastolic blood pressure by 1.3 mmHg. Although these reductions are smaller than those reported for some standardized herbal extracts, they suggest that tea-derived products may contribute to cardiovascular risk reduction as supportive dietary interventions and adjuncts to guideline-based hypertension management rather than as primary antihypertensive therapies [19,20].

Although these reductions are smaller than those reported for some standardized herbal extracts, they suggest that tea-derived products may contribute to cardiovascular risk reduction as supportive dietary interventions and adjuncts to guideline-based hypertension management rather than as primary antihypertensive therapies [19,20]. Furthermore, evidence from randomized clinical trials shows that daily consumption of *C. sinensis* (Tea) or extract made from the petals of *H. sabdariffa* (Roselle) significantly lowers systolic and diastolic blood pressure in adults with mild to moderate essential hypertension and in patients with type 2 diabetes, making it clinically significant as an adjunctive therapy.

The clinical significance of the blood pressure-lowering effect of *H. sabdariffa* (Roselle) is best understood as an effect specific to certain products and formulations, rather than to the *H. sabdariffa* (Roselle) plant in general. This suggests that the benefits of *H. sabdariffa* (Roselle) are more relevant as adjunct therapy in the management of hypertension, particularly when used in conjunction with guideline-based therapy rather than as a substitute for primary antihypertensive medications. Thus, the reported reduction in blood pressure is not only statistically significant but also clinically meaningful when observed with standardized preparations used appropriately [16].

The antihypertensive benefits of *H. sabdariffa* (Roselle) are primarily associated with clinically evaluated products and formulations, not with the plant itself. Variations in processing methods, dosages, and bioactive compound content can lead to differences in efficacy among products. Therefore, the use of *H. sabdariffa* (Roselle) is best considered an adjunctive therapy to support blood pressure control within a guideline-based care framework. Thus, the significance of the reported blood pressure reduction lies not only in its statistical value but also in its clinical relevance when obtained from standardized preparations and used appropriately in the appropriate population [16].

7. MULTI-HERB FORMULATIONS AND TRADITIONAL MEDICINE PRODUCTS

Multi-herb formulations raise a different interpretive challenge. Their potential advantage is multi-target activity, but their disadvantage is attribution: it can be difficult to identify which component, constituent, or interaction drives the clinical effect. Traditional Chinese medicine and other multi-component systems are increasingly discussed in cardiovascular pharmacology, but clinical interpretation must remain tied to a defined formulation, dose, manufacturing process, and population [9,30].

For multi-herb products, evidence should follow the product rather than the category. A trial of a single standardized capsule or granule cannot be automatically generalized to unrelated combinations that share a single ingredient or a similar traditional indication. Publication-quality evidence therefore requires full ingredient disclosure, authentication, batch testing, adverse-event monitoring, and clear specification of whether the product is intended as monotherapy for low-risk disease, an adjunct to existing therapy, or a temporary option within a supervised care pathway [8,9,30].

8. QUALITATIVE EVIDENCE TO PRACTICE INTERPRETATION

The overall evidence supports a cautiously optimistic but product-specific interpretation. *H. sabdariffa* (Roselle), Aged *A. sativum* (Garlic) extract, *O. europaea* (olive leaf extract), and *Camellia sinensis (Tea)* derived interventions have more interpretable human evidence than many other herbal products, although the expected effect size is generally modest and preparation-dependent [12,20]. *Apium graveolens* (celery), Indonesian ethnobotanical candidates, and *in silico* candidates such as *Illicium verum* remain better framed as preliminary or investigational unless tested as standardized products in controlled human studies [21,25]. **Figure 2** illustrates this evidence-readiness gradient. Furthermore, to summarize these findings and clarify current clinical expectations, **Table 2** provides an evidence-to-practice matrix for the most frequently investigated herbal antihypertensive interventions.

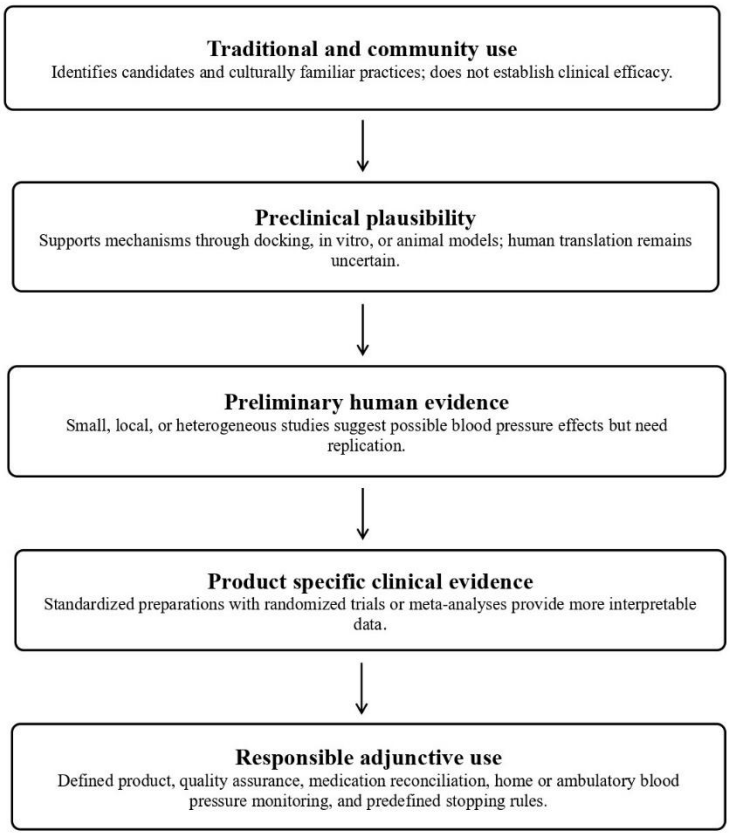

Figure 2. Evidence readiness gradient for herbal antihypertensive products. The figure shows that confidence increases as evidence moves from traditional use and mechanistic plausibility toward standardized, product-specific clinical testing and monitored adjunctive use.

Table 2.Evidence-to-practice matrix for selected herbal antihypertensive interventions.

Intervention or evidence source	Clinical signal	Major limitations	Current interpretation
H. sabdariffa (Roselle)	A randomized placebo-controlled trial (n=65) showed that consumption of Hibiscus sabdariffa tea for 6 weeks reduced systolic blood pressure by 7.2 mmHg and diastolic blood pressure by 3.1 mmHg compared with placebo. Meta-analytic evidence further supports reductions in both systolic and diastolic blood pressure across randomized trials [15–17].	Preparation, anthocyanin content, dose, comparator, and treatment duration vary across studies.	One of the more credible single-herb options, but use should remain adjunctive, product-specific, and monitored.
A. sativum and Aged *A. sativum* extract	Meta-analyses support the blood pressure-lowering effects of garlic in hypertensive individuals. In a randomized dose-response trial (n=79), standardized Aged Garlic Extract administered for 12 weeks reduced systolic blood pressure by 11.8 mmHg compared with the control group [14].	Effects depend on preparation, standardization of sulfur compounds, dose, baseline blood pressure, and background therapy.	Potential adjunct: assess gastrointestinal tolerance, bleeding risk, surgery status, and antiplatelet or anticoagulant therapy.
O. europaea leaf extract	A randomized double-blind trial involving 232 patients with stage 1 hypertension showed that olive leaf extract (500 mg twice daily) administered for 8 weeks reduced systolic blood pressure by 11.5 mmHg and diastolic blood pressure by 4.8 mmHg. The effect was comparable to captopril therapy [18].	Evidence is product- and context-specific; independent replication and longer follow-up are needed.	Promising standardized extract, but not generalizable to all olive products.
C. sinensis-derived products	Meta-analyses of randomized controlled trials support modest reductions in blood pressure with tea-derived products. Green tea interventions (13 RCTs; approximately 1,367 participants; 3 weeks to 3 months) reduced systolic and diastolic blood pressure by 1.98 mmHg and 1.92 mmHg, respectively. Black tea interventions (11 RCTs; approximately 378 participants) reduced systolic and diastolic blood pressure by 1.8 mmHg and 1.3 mmHg, respectively [19,20].	Effect size is usually modest; caffeine content, dose, and background diet vary.	Supportive dietary adjunct rather than primary therapy.
A. graveolens	Local human evidence and preclinical studies support plausibility [21,22].	Formulation varies by seed, leaf, stalk, extract, decoction, and dose; controlled human evidence remains limited.	Preliminary adjunctive candidate; should be studied as a defined standardized preparation.
Indonesian ethnobotanical plants[#]	Community use supports cultural relevance and candidate selection [23].	Survey evidence cannot establish efficacy, dose, safety, or interaction profile.	Useful for research prioritization and pharmacovigilance, not for direct efficacy claims.
Illicium verum/ star anise	Docking studies suggest possible neprilysin-related activity [25].	*In silico* evidence only; clinical relevance, bioavailability, toxicity, and dose remain uncertain.	Investigational; should not be promoted as proven antihypertensive therapy.
Standardized multi-herb formulations	Systems-level and formula-based approaches may offer multi-target activity [11,30].	Attribution, reproducibility, batch consistency, and interaction assessment are difficult.	Evidence must be formulation-specific; category-level claims are not sufficient.

[#]Indonesian ethnobotanical plants include *Annona muricata*, *Syzygium polyanthum*, *Sauropus androgynus*, *Moringa oleifera*, *Jatropha curcas*, *Persea americana*, *Averrhoa bilimbi*, *Orthosiphon aristatus*, and *Andrographis paniculata*

9. CLINICAL INTERPRETATION AND INTEGRATION WITH GUIDELINE-BASED CARE

The overall clinical conclusion is conservative: selected herbal medicines may modestly reduce blood pressure, but the strength of the evidence varies substantially by product, formulation, and study design. While the blood pressure reductions associated with these herbal adjuncts are generally modest (e.g., 3 to 8 mmHg), epidemiological evidence confirms that even a 5 mmHg reduction in systolic blood pressure significantly reduces the long-term risk of major cardiovascu-

lar events and stroke. Therefore, these modest reductions are clinically meaningful when sustained alongside guideline-based care. Consequently, specific herbal products may be considered as possible adjuncts for selected patients, a role supported by recent synthesis-level evidence [12, 15, 19]. However, they must never replace validated lifestyle interventions, home or ambulatory blood pressure monitoring, and comprehensive risk stratification [3, 4], nor should they substitute for established pharmacotherapy [2,5]

From a clinical perspective, even modest reductions in blood pressure may translate into meaningful cardiovascular benefits at the population level. Evidence from large-scale meta-analyses has demonstrated that reductions in systolic blood pressure of approximately 5–10 mmHg are associated with lower risks of stroke, coronary heart disease, heart failure, and cardiovascular mortality. Therefore, the blood pressure reductions reported for standardized preparations of Hibiscus sabdariffa, Aged *A. sativum* extract, and *O. europaea* leaf extract are not only statistically significant but may also be clinically relevant when integrated with guideline-based hypertension management. Nevertheless, the magnitude of benefit varies according to baseline blood pressure, patient characteristics, product formulation, treatment duration, and concurrent antihypertensive therapy.

This distinction is especially important for patients with stage 2 hypertension, hypertension-mediated organ damage, diabetes, chronic kidney disease, established cardiovascular disease, pregnancy, secondary hypertension, resistant hypertension, or very high office or home blood pressure. In these circumstances, delaying guideline-based treatment may expose patients to avoidable risk [2-5]. For low-risk patients with grade 1 hypertension or elevated blood pressure, herbal products may be discussed within shared decision-making only when quality assurance, safety, interactions, and monitoring can be addressed [2-4,26-29].

A practical pathway begins with direct questioning about herbal medicine use. Clinicians should record the product name, manufacturer if available, plant part, preparation, dose, and frequency. They should assess potential interactions, obtain baseline office and home or ambulatory blood pressure readings, and continue guideline-based care. Benefit and safety should be reassessed after a defined period. Products should be discontinued if blood pressure worsens, hypotension occurs, adverse effects emerge, or the product cannot be adequately identified [2-4, 27].

Shared decision-making remains essential because herbal use often reflects culture, access, preferences, or previous experience. Dismissing herbal use may reduce disclosure, whereas endorsing unstandardized products without monitoring can pose safety risks [6,26-29]. **Figure 3** translates the recommended middle ground into a practical pathway. It starts with disclosure and product verification, then moves through risk assessment, guideline-based treatment, monitoring, and stopping rules [8,9,28,35].

H. sabdariffa is one of the herbal products with relatively stronger clinical evidence compared to many other herbal candidates. Clinical trials in individuals with prehypertension and mild hypertension have demonstrated that consuming *H. sabdariffa* tea for 6 weeks can reduce systolic blood pressure. These reductions are clinically relevant and support the use of standardized *H. sabdariffa* preparations as adjuncts to guideline-based hypertension management rather than as substitutes for established antihypertensive therapies [16].

However, these benefits were observed with well-defined formulations and under controlled monitoring conditions. Therefore, these findings support the use of *H. sabdariffa* (Roselle) as an adjunct therapy to complement guideline-based hypertension care rather than as a substitute for pharmacological therapies that have been proven effective.

H. sabdariffa is among the herbal interventions supported by relatively robust clinical evidence. In a randomized controlled trial of 65 adults with prehypertension or mild hypertension, consumption of *H. sabdariffa* tea three times daily for 6 weeks resulted in a mean reduction of 7.2 mmHg in systolic blood pressure, with a larger reduction of approximately 13.2 mmHg among participants with higher baseline blood pressure. These findings suggest that standardized Hibiscus sabdariffa preparations may provide clinically relevant adjunctive benefits when integrated with guideline-based hypertension management. Nevertheless, the evidence remains product-specific, and the herb should not be regarded as a substitute for established antihypertensive therapy [16].

Comparable findings have also been reported for standardized aged garlic extract formulations. In a randomized clinical trial involving 79 patients with uncontrolled hypertension, supplementation with aged garlic

extract for 12 weeks produced a mean reduction of 11.8 mmHg in systolic blood pressure. These findings support the potential role of standardized garlic preparations as adjunctive interventions in selected patients, although careful consideration of herb-drug interactions and bleeding risk remains necessary, particularly among individuals receiving antiplatelet or anticoagulant therapy [14].

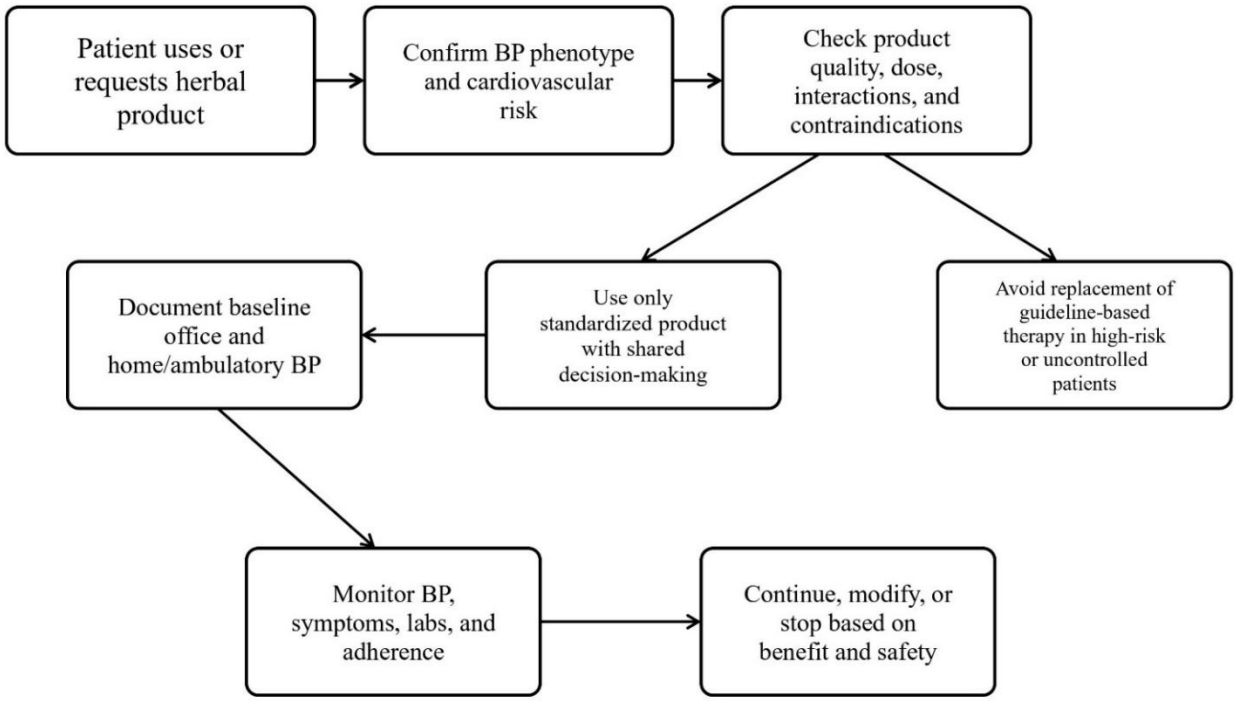

Figure 3. Pragmatic pathway for integrating herbal antihypertensive products as adjuncts to guideline-based care. The pathway emphasizes patient disclosure, product identification, cardiovascular risk assessment, interaction screening, continued evidence-based treatment, home or ambulatory blood pressure monitoring, adverse event surveillance, and predefined stopping or escalation criteria [2-4,6,8,9,26-29,35]. BP, blood pressure.

10. SAFETY, HERB-DRUG INTERACTIONS, AND PRODUCT STANDARIZATION

Safety is a central translational issue because many patients use herbal products alongside prescribed antihypertensive drugs. Potential risks include additive hypotension, dizziness or falls, electrolyte disturbance, renal or hepatic injury, bleeding risk, altered drug exposure, allergic reactions, contamination, adulteration, and substitution of unproven products for necessary medical care. Reviews of herbal drug interactions emphasize that risk assessment should consider both the herbal product and the patient context, including comorbid diseases and concurrent therapies [28,29].

Some safety concerns are product-specific. *A. sativum* (Garlic) products may be relevant in patients using antiplatelet or anticoagulant therapy, particularly at supplement doses rather than culinary exposure [26-29]. Licorice-containing products are clinically important because glycyrrhizin can promote sodium retention, potassium loss, and elevated blood pressure; therefore, products containing *G. glabra* require caution in patients with hypertension [31]. Diuretic-like products may be important in patients taking diuretics or those with chronic kidney disease. These examples illustrate why the safest response is structured medication reconciliation rather than assumptions about whether a product is natural [26,31].

Product quality is equally important. Botanical identity, plant part, harvest conditions, extraction solvent, marker compounds, active constituent concentration, microbial quality, heavy metal contamination, pesticide residues, adulteration, and batch-to-batch consistency can all influence efficacy and safety [8,9,28]. These issues are particularly relevant for multi-herb products, in which multiple constituents may interact with one another and with prescribed medicines [9,30].

In Indonesia, the regulatory pathway for herbal products distinguishes traditional use from progressively stronger categories requiring greater evidence and quality assurance. Regulations on good traditional medicine manufacturing practices and registration of natural medicinal products provide a framework for safer development, but clinical adoption still requires transparent evidence, product standardization, and post-marketing surveillance [32–35].

The safety message for clinicians and researchers is therefore not simply to avoid herbal products. It is to avoid vague products, unknown doses, undocumented combinations, and unsupervised substitution. **Table 3** summarizes practical safety and interaction considerations for clinical and research use.

Table 3. Safety and interaction considerations for clinical and research use of herbal antihypertensive products.

Issue	Examples	Recommended response	References
Additive blood pressure lowering	Concurrent use with ACE inhibitors, angiotensin receptor blockers, calcium channel blockers, beta blockers, diuretics, or other antihypertensive medicines may increase the risk of excessive blood pressure lowering, dizziness, or falls.	Monitor home blood pressure, dizziness, falls, syncope, and dose changes. Avoid unsupervised combination in frail or high-risk patients.	[2-4,26-29].
Bleeding risk	A. sativum (Garlic) supplements may affect platelet function or perioperative bleeding risk, especially with antiplatelet or anticoagulant therapy.	Review medication list and perioperative status. Counsel patients to report bruising, bleeding, or planned surgery.	[26-29]
Blood pressure elevation	Licorice-containing products can raise blood pressure through mineralocorticoid-like effects and potassium loss.	Avoid or monitor closely in patients with hypertension, hypokalaemia, kidney disease, heart disease, or diuretic use.	[31]
Renal and electrolyte effects	Diuretic or natriuretic products may interact with diuretics or increase the risk in patients with chronic kidney disease or unstable renal function.	Consider creatinine and electrolytes when clinically indicated. Avoid use in unstable renal function unless medically supervised.	[2-4,26]
Pregnancy and lactation	Safety data are often insufficient for therapeutic-dose herbal products, and adverse-event monitoring is limited in many herbal medicine studies.	Avoid nonessential herbal antihypertensive products unless supported by pregnancy-safety data and specialist advice.	[28,35]
Product quality	Variability in species, plant part, extraction method, active compounds, contamination, adulteration, or mislabelling can affect efficacy and safety.	Use registered, quality-assured products. Document the manufacturer, batch, dose, and marker compounds when possible.	[8,9,28,32,33]
Masked treatment delay	Patients may substitute herbal therapy for needed medical evaluation, risk assessment, lifestyle treatment, or pharmacotherapy.	Emphasize adjunctive use. Escalate guideline-based care for sustained, severe, symptomatic, or high-risk hypertension.	[1-6]
Adverse-event underreporting	Short trials may miss rare, delayed, product quality-related, or interaction-mediated harms.	Build active adverse event monitoring and pharmacovigilance into clinical trials and practice.	[28,35]

More specific herb-drug interactions also need to be considered in clinical practice. *H. sabdariffa, A. sativum*, and *O. europaea* may produce additive blood pressure-lowering effects when used concomitantly with ACE inhibitors such as lisinopril, enalapril, or captopril, which may increase the risk of symptomatic hypotension [15, 17, 18, 26]. Similar concerns may arise when these herbal products, or calcium-modulating herbs like *Apium graveolens*, are combined with calcium channel blockers such as amlodipine or nifedipine [21, 22, 29]. Herbal preparations with mild diuretic or natriuretic properties, including *H. sabdariffa* and *O. aristatus*, may potentiate the diuretic effects of drugs such as hydrochlorothiazide or furosemide and may cause dehydration or electrolyte disturbances in susceptible individuals [23, 28].

Additionally, *A. sativum* may inhibit platelet aggregation**,** thereby increasing the risk of bleeding when used in combination with antiplatelet agents (e.g., aspi-

rin, clopidogrel) or anticoagulants (e.g., warfarin, apixaban, rivaroxaban) [14, 26, 27]. These interactions underscore the importance of medication reconciliation, blood pressure monitoring, and individual risk assessment before initiating additional herbal therapy [26–29].

11. TRANSLATIONAL CHALLENGES FOR PUBLICATION QUALITY RESEARCH

The evidence base will remain difficult to interpret until researchers report herbal interventions with the same precision expected for conventional medicines. A trial of an herbal product should identify the botanical species, voucher specimen or authentication method, plant part, extraction method, dose, excipients, marker compounds, batch numbers, manufacturer, quality-control testing, and stability. Without these details, reproducibility and regulatory interpretation are weak [8,9].

Outcome measurement also requires strengthening. Office blood pressure should be measured using validated devices and standardized procedures, but home or ambulatory blood pressure monitoring should be incorporated whenever feasible. Ambulatory blood pressure outcomes are particularly important because they capture daytime, nighttime, and 24 hour exposure and reduce white-coat or masked hypertension bias [2-4]. Trials should also predefine clinically meaningful endpoints, report means with standard deviations or confidence intervals, and include adverse-event tables with seriousness, causality assessment, and withdrawals [8,9,35].

Future studies should not only ask whether a product lowers blood pressure in the short term. They should also ask which population benefits, which dose and preparation are optimal, and whether effects persist after discontinuation. Safety with common antihypertensive regimens also needs testing. Longer-term studies should assess patient-centered and cardiovascular outcomes. These questions require larger multicenter trials, longer follow-up, trial registration, transparent statistical analysis plans, and data availability [5,8,9].

Publication-quality research on herbal antihypertensives should also account for implementation. Trials should document background antihypertensive therapy, adherence, dietary sodium advice, caffeine and alcohol intake where relevant, and changes in lifestyle intervention during follow-up. When trials are conducted in settings with high rates of traditional medicine use, investigators should monitor the co-use of other herbal products [6,26-29].

Finally, translational research should include patient-centered and implementation outcomes. A product that lowers systolic blood pressure modestly but is expensive, poorly standardized, poorly tolerated, or difficult to monitor may have limited public health value. Conversely, a safe, affordable, standardized product with a modest effect could be useful if it improves engagement with care and does not delay necessary treatment. These questions require collaboration among pharmacologists, clinicians, regulatory scientists, traditional medicine experts, and patient communities [6,32-35].

Recent literature reinforces these translational priorities. The WHO Global Traditional Medicine Strategy 2025-2034 emphasizes evidence generation, safety, regulation, and the appropriate integration of traditional, complementary, and integrative medicine into health systems [36]. The 2025 AHA/ACC high blood pressure guideline further supports the need to preserve validated blood pressure measurement, cardiovascular risk assessment, lifestyle intervention, and pharmacotherapy as the foundation of care [37]. Recent literature on herbal antihypertensives and pharmacovigilance also underscores the need for standardized formulations, supervised integration, and active adverse-event reporting [38,39]. To support these translational goals and improve the reproducibility of future studies, **Table 4** proposes a recommended minimum reporting checklist for herbal antihypertensive clinical trials.

12. LIMITATIONS OF THIS REVIEW

This review has several limitations. First, it is a narrative review and not a prospectively registered systematic review. Study identification and appraisal were therefore not conducted under a full PRISMA workflow, and no formal risk-of-bias scoring was applied [9]. Second, the search strategy was broad but may still have missed unpublished studies, non-indexed local reports, theses, conference abstracts, negative trials, or studies in languages beyond the search terms. Third, the included sources are heterogeneous. They range from ethnobotanical surveys and mechanistic studies to randomized trials and quantitative evidence syntheses. This

makes direct comparison difficult and prevents a reliable pooled effect estimate [7-9].

Fourth, many herbal studies describe products incompletely. Missing details on species authentication, plant part, extraction method, dose, marker compounds, batch testing, and contaminants limit reproducibility and clinical interpretation [7,8]. Fifth, some local studies have short follow-up periods, small sample sizes, limited blinding, incomplete statistics, and weak control for diet, salt intake, adherence, or background antihypertensive therapy. Sixth, safety evidence is limited because many trials are short and underpowered to detect rare, delayed, product quality-related, or interaction-mediated adverse events [35,36].

Finally, the strongest clinical evidence is concentrated in selected standardized products and specific populations. This limits generalizability across regions, informal preparations, multi-herb formulations, and health-system contexts. These limitations do not remove the signal of benefit for selected interventions, but they require cautious interpretation. Stronger claims will require standardized products, adequately powered randomized trials, longer follow-up, transparent reporting, active safety surveillance, and independent replication [7,8,35]..

Table 4. Recommended reporting checklist for future herbal antihypertensive trials.

Domain	Minimum information to report	Why it matters
Botanical identity	Latin binomial, authority, if possible, common name, voucher or authentication method.	Prevents species confusion and supports reproducibility.
Plant material and processing	Plant part, source, harvest conditions, drying, extraction solvent, ratio, preparation method.	Different preparations can have different pharmacology and safety profiles.
Standardization	Marker compounds, active constituents if known, batch numbers, certificate of analysis, contaminant testing.	Enables batch consistency and regulatory evaluation.
Dose and adherence	Dose, frequency, duration, route, adherence measurement, missed doses.	Supports dose-response interpretation and replication.
Comparator and co-interventions	Placebo, active comparator, usual care, background antihypertensive therapy, lifestyle advice.	Clarifies whether observed effects are product-specific.
Blood pressure measurement	Validated device, cuff size, protocol, office, home, or ambulatory schedule, number of readings.	Reduces measurement bias and improves clinical interpretability.
Safety reporting	Adverse events, serious adverse events, withdrawals, hypotension, laboratory tests, interaction monitoring.	Determines whether benefits outweigh harms.
Transparency	Trial registration, protocol, statistical analysis plan, risk-of-bias reporting, data sharing.	Improves credibility and journal readiness.

13. CONCLUSION

Antihypertensive herbal medicines have credible but product-specific potential as adjunctive tools for blood pressure management. Current evidence is more persuasive for standardized and clinically studied products such as *H. sabdariffa* (Roselle) preparations, Aged *A. sativum* (Garlic) extract, *O. europaea* (olive leaf extract), and *C. sinensis* (Tea)-derived interventions than for broadly named or poorly characterized herbal categories. *A. graveolens* (celery) and several ethnobotanical or *in silico* candidates remain promising but preliminary. The clinical role of these products should remain complementary, cautious, and individualized. Future research must move beyond general claims about herbs and toward rigorously characterized products, reproducible doses, validated blood pressure measurements, long-term safety, interaction monitoring, and pharmacovigilance. Until those standards are met, herbal medicines should be discussed transparently with patients and integrated only in ways that preserve guideline-based hypertension care.

The practical conclusion is deliberately modest. Herbal antihypertensive products deserve continued scientific evaluation, but the unit of evidence should be the defined product rather than the general idea of herbal therapy. When the product is identifiable, standardized, monitored, and used alongside guideline-based care, selected interventions may offer adjunctive value. When those conditions are absent, the risk of overstatement, interaction, or treatment delay increases.

Supplementary Materials

Not applicable.

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Funding

This research received no external funding.

Institutional Review Board Statement

ot applicable.

Informed Consent Statement

Not applicable.

Data Availability Statement

No new data were generated or analyzed in this study.

Acknowledgments

None.

Artificial Intelligence (AI) Declaration

During the preparation of this manuscript, the authors used ChatGPT for language editing and grammatical refinement. The authors reviewed, verified, and edited the generated content as necessary and take full responsibility for the final content of the manuscript.

Conflicts of Interest

The authors declare no conflicts of interest.

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