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Therapeutic Potential of *Moringa oleifera* in the Treatment of Hypertension and Its Associated Symptoms: A Systematic Literature Review

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ABSTRACT

Hypertension represents one of the major global health problems, and a cardiovascular disease risk factor is a public health concern. The use of conventional drugs is effective, but they have adverse effects, resulting in the search for complementary, safer therapies. *Moringa oleifera*, a nutrient-rich and bioactive source, has now been discovered to be a potential natural remedy with cardioprotective potential by affecting blood pressure and vascular function. The phytochemical composition of the plant is reviewed, the multiple mechanisms (ACE inhibition, antioxidant and anti-inflammatory actions, diuretic effects, and endothelial function improvement) are described, and the significant outcomes across different study designs are summarized. Parameter, nutritional, and bioactive mechanisms are compared and presented in comprehensive tables. Although dosing, methodology, and heterogeneity all exist, the overall evidence indicates significant decreases in both systolic and diastolic blood pressure, improvement in nitric oxide availability, and decreased oxidative stress on supplementing with *M. oleifera*. However, further extended, large-scale, standardized clinical trials are needed to confirm its efficacy and safety.

Key words: *Moringa oleifera*, hypertension, oxidative stress, antioxidants, diuretic activity

INTRODUCTION

Hypertension is a widespread non-communicable disease and a major risk factor for cardiovascular morbidity, stroke, chronic kidney disease, and premature mortality. It is estimated that more than 1.13 billion people worldwide have elevated blood pressure levels, and this number is increasing with urbanization, changing lifestyles, and an aging global population (Munir et al., 2025). However, despite the availability of several pharmacological options (e.g., Angiotensin Converting Enzyme (ACE) inhibitors, beta-blockers, calcium channel blockers), adverse effects such as persistent cough, electrolyte imbalances, and fatigue make for poor compliance and effectiveness for long-term management (Pareek et al., 2023). These limitations lead to a search for natural alternatives that are effective, affordable, and have a better safety profile. In many traditional systems of healthcare worldwide, herbal medicines have served as the basis of healthcare. The use of these drugs in managing chronic conditions such as hypertension has become popular because they are cheaper, easier to access, and have fewer side effects than synthetic drugs (Okorie et al., 2019). *Moringa oleifera*, known as the 'miracle tree' or 'drumstick tree', has garnered interest because of its multiple uses as a source for medicinal as well as nutritional uses (Figure 1). Diverse bioactive compounds are present in nearly every part of the plant (leaves and seeds, roots and bark) and have potential benefits in blood pressure management (Khan et al., 2019; Kumolosasi et al., 2021).

Hypertension is defined as a chronic elevation of systolic blood pressure of ≥140 mmHg and/or diastolic blood pressure of ≥90 mmHg. It currently affects around 1.28 billion adults aged 30–79 around the world, nearly one-third of this age group, and it is estimated to contribute to around 10.8 million preventable deaths every year due to complications related to cardiovascular disease (WHO, 2023; GBD, 2019). In India, the fifth National Family Health Survey (2019–2021) found a prevalence of 22.6% in adults aged ≥15 years, translating to approximately 188 million individuals in total. Yet, the prevalence differs drastically around the country, with high prevalence rates of 37.9% in Sikkim, 34.2% in Punjab, and 31.1% in Kerala, compared to exceptionally low rates of 16.5% in Rajasthan and 17.0% in Bihar, indicating important geographical heterogeneity in hypertension burden (IIPS & MoHFW, 2021).

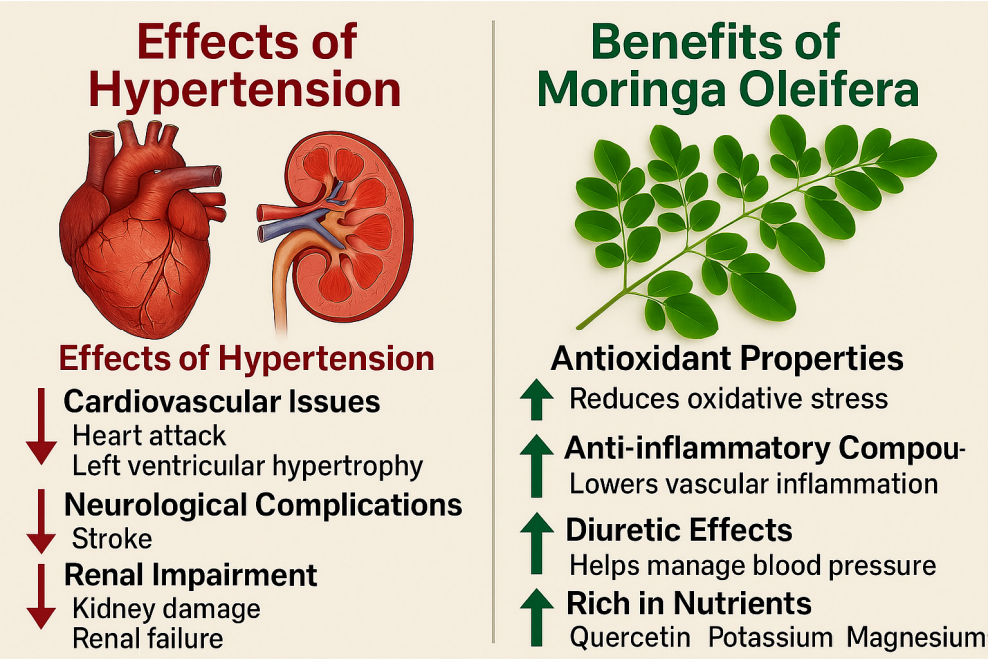

Fig. 1. The Effects of Hypertension and the Benefits of *Moringa oliefera* (Silva et al., 2024).

Phytochemical Constituents and Mechanisms

Moringa oleifera is a repository of numerous phytochemicals that are implicated in its therapeutic effects:

- ACE Inhibition: Explant and animal studies have demonstrated that extracts and peptides obtained from *M. oleifera* can inhibit ACE and decrease the formation of angiotensin II, a potent vasoconstrictor. It is one of the cornerstone mechanisms by which blood pressure is lowered (Aktar et al., 2019; Ma et al., 2021).
- Antioxidant Activity: Endothelial dysfunction is a precursor of hypertension, which is caused by oxidative stress. Antioxidants found in *M. oleifera*—polyphenols and flavonoids—together help neutralize free radicals and help bolster endogenous antioxidant defense systems, thus protecting the vascular system (Randriamboavonjy et al., 2017; Attakpa et al., 2017).
- Anti-inflammatory Effects: Hypertension is a disease that is pathogenic to chronic low-grade inflammation. The ability of bioactive compounds presents in *M. oleifera* to downregulate proinflammatory cytokines and reduce vascular inflammation may mitigate hypertensive progression (Affan et al., 2018; Hameed et al., 2023).
- **Diuretic Properties:** According to some studies, *M. oleifera* has a significant diuretic action, increasing urine output, reducing fluid overload, and lowering blood pressure, especially in models of renal dysfunction (Jayanthi et al., 2015).
- Enhancement of Endothelial Function: *M. oleifera* increases vasodilation by increasing nitric oxide (NO) bioavailability, which improves arterial compliance and decreases blood pressure (Gbankoto et al., 2019; Chan Sun et al., 2019).

Rationale and Objectives of the Review

Although the evidence for the antihypertensive effects of *M. oleifera* has been growing, the studies differ widely in terms of the intervention types (leaf extract vs. seed extract vs. peptide fractions), dosages, treatment durations, and outcomes measured. The overall picture remains fragmented. Therefore, this review seeks to:

- Synthesize Available Evidence: Combine outcomes from both animal and human studies to gather information about the overall influence of *M. oleifera* on blood pressure regulation.
- Elucidate Mechanisms: Map out the multifactorial mechanisms (ACE inhibition, antioxidant, anti-inflammatory, diuretic, and endothelial developments) and associate them with clinical results.
- Compare with Conventional Treatments: Discuss how the therapeutic results of *M. oleifera* can be compared to the effects of typical antihypertensive medications.
- Point Out Limitations and Future Directions:

Identify gaps in the current literature and endorse areas for future research, including the need for standardized preparations and long-term studies.

Scientific Gap and Scope of the Review

Despite an increasing number of studies in the past five years reporting the antihypertensive effects of *Moringa oleifera*—this includes both clinical trials with Type 2 diabetic–hypertensive patients (Hameed et al., 2023) and a mechanistic study exploring renal oxidative stress modulation (Silva et al., 2024; Chiş et al., 2024)—a high degree of heterogeneity still exists in terms of extract preparation, dosing regimens and outcomes. Also, there are few direct comparisons of *M. oleifera* preparations to standard pharmacotherapies, and limited long-term safety data are available, despite traditional use. This review aims to address these issues, by (i) synthesizing the most recent human and animal studies from 2019 to 2024, (ii) critically assessing the methodological consistency regarding extract standardization and trial design, (iii) comparing the efficacy and safety profile of *M. oleifera* preparations directly to conventional antihypertensive agents; and (iv) identifying priorities for standardizing future long-term randomized trials.

MATERIALS AND METHODOLOGY

Search Strategy and Study Identification

A comprehensive literature search was conducted following the PRISMA guidelines. The databases searched included PubMed and Google Scholar (Figure 2). The search period spanned from the year 2004 to 2024. The search involved the following keywords and combinations:

- "*Moringa oleifera*"
- "Hypertension"
- "Blood Pressure"
- "Antihypertensive"
- "ACE Inhibition"
- "Oxidative Stress"
- "Diuretic"
- "Vascular Function"

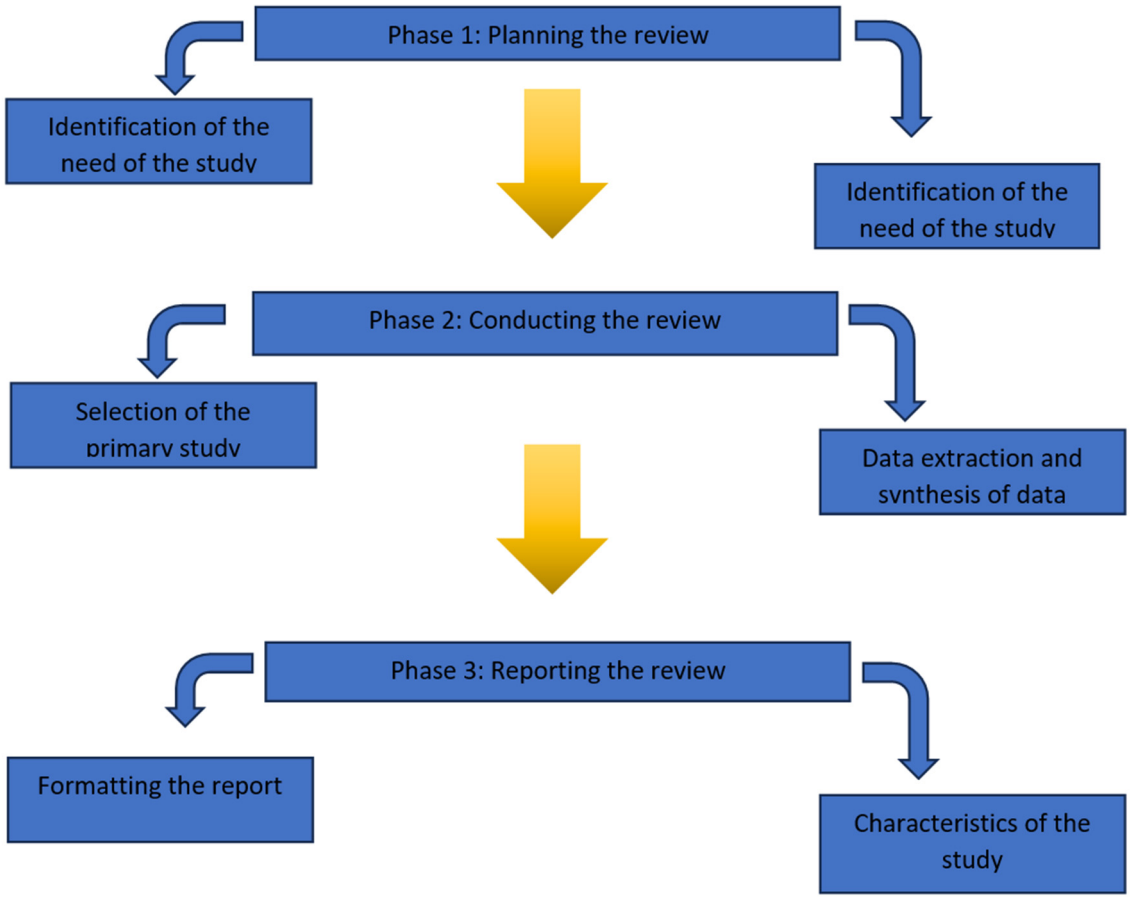

Fig. 2. Systematic literature review phase with steps.

Inclusion and Exclusion Criteria

Studies were included when they met the following criteria:

- Population: Human clinical trials in hypertensive patients and animal models, e.g., spontaneously hypertensive rats, L-NAME-induced hypertensive rats, and monocrotaline-induced pulmonary hypertension models.
- Intervention: *Moringa oleifera* (leaves, seeds, peptides, powder, capsules, tea, or dietary formulations) in any preparation.
- Comparators: Blood pressure-related outcomes studies using a control group (placebo, standard therapy, or untreated).
- Outcomes: Systolic and diastolic blood pressure changes were the primary outcomes. In addition, nitric oxide bioavailability and oxidative stress markers, diuretic activity, inflammation cytokines, and renal function indices were treated as secondary outcomes.
- Study Design: Randomized controlled trial, controlled clinical trial, and well-designed animal study.
- Language and Publication Type: Only English language-based studies were considered.

If the study was solely in vitro (except when focusing on ACE inhibition mechanisms), a review article (though its references were mined for data), or did not have a proper control group, it was excluded.

Data Extraction and Quality Assessment

Data were extracted using a standardized data extraction form containing the following fields:

- Authors and Year: Identifying details.
- Country: Geographical origin of the study.
- Model/Sample Size: Details of the sample (animal or human) and size.
- Intervention: Type of *Moringa oleifera* preparation, dose, route, and duration.
- Outcome Measures: Primary (changes in blood pressure) and secondary outcomes (biochemical, diuretic, or vascular function markers).
- Key Findings: Quantitative and qualitative outcomes.

The risk of bias tool for clinical trials was the Cochrane Risk of Bias tool, whereas the modified risk assessment tool for animal studies was. Domains deemed were random sequence generation, concealment of allocation, blinding, attrition, and selective outcome reporting.

Data Synthesis

Since there is a very heterogeneous design and dosing between the studies and outcome measures, a meta-analysis was not possible. Instead, a narrative synthesis is provided with summary tables and figures to present the study characteristics, outcome markers, and geographical/temporal trends.

RESULTS

Study Characteristics

A total of 155 records were initially retrieved from PubMed, and 285 were obtained via Google Scholar, supplemented by 21 additional articles identified through other sources, resulting in 461 records overall. After 86 duplicates were removed, 375 articles remained for screening. Of these, 297 were excluded following a review of titles and abstracts, leaving 78 studies eligible for full-text assessment. Upon further evaluation, a subset of these studies was excluded for not meeting the selection criteria, culminating in 22 articles that were finally included in the systematic review, as shown in Figure 3. These studies were identified as a blend of animal models and human trials, spanning various countries and publication years. They report a range of outcomes, including blood pressure changes, oxidative stress, diuretic activity, and endothelial function improvements.

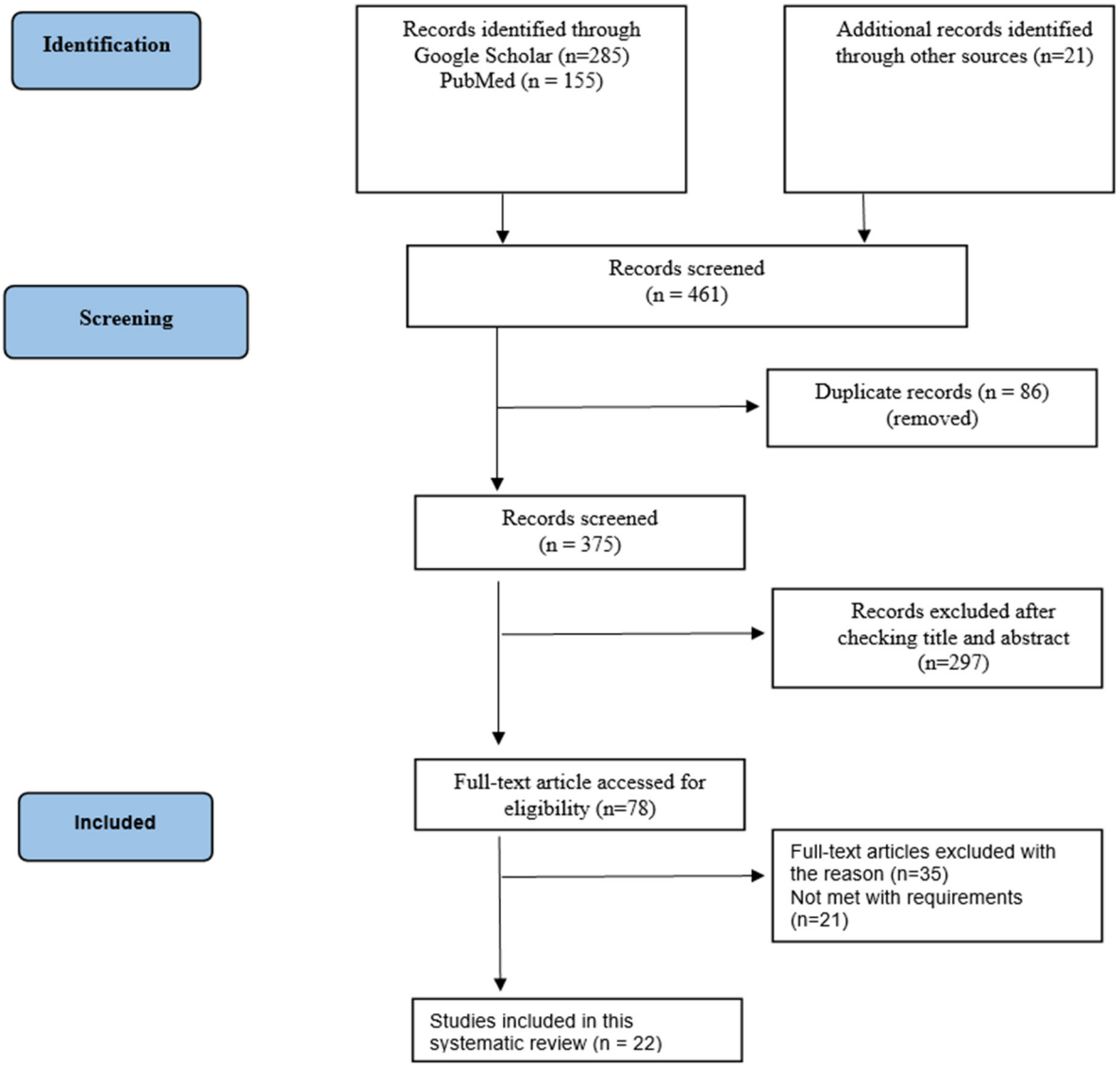

Fig. 3. PRISMA flow chart summaries the sorting and identification of relevant articles.

Summary of the Selected Primary Studies

Moringa oleifera has shown promise as a natural remedy for hypertension in a variety of studies using both animal models and human trials. These investigations have employed different hypertensive rat models and human subjects with varying sample sizes. They used several forms of Moringa interventions, such as standardized leaf extracts, powders, teas, and isolated peptides, administered orally for periods ranging from acute dosing to up to 12 weeks (Table 1). Outcome measures included systolic and diastolic blood pressure, oxidative stress markers, diuretic activity, endothelial and enzyme function, metabolic parameters, and inflammatory markers, with most studies reporting significant blood pressure reduction and improved physiological indices. Table 1 provides a detailed summary of these studies, highlighting model types, sample sizes, intervention specifics, treatment durations, outcome measures, and key findings.

Table 1 offers a concise yet detailed overview of primary studies evaluating the antihypertensive effects of *Moringa oleifera*.

Table 1. Summary of Primary Studies Evaluating the Antihypertensive Effects of *Moringa oleifera* including model type, sample size, intervention details, duration, outcome measures, and key findings.

Study (author, year)	Model & sample size	Intervention details	Duration & route	Outcome measures	Key findings
Acuram & Chichioco Hernandez (2019)	Hypertensive rats (n = 60, 30/30)	Standardized leaf extract (~200 mg/kg)	4 weeks, oral gavage	Systolic Blood Pressure (SBP), Diastolic Blood Pressure (DBP); oxidative stress markers	Significant reduction in SBP/DBP; decreased malondialdehyde, increased SOD activity
Aekthammarat et al. (2019)	L-NAME-induced hypertensive rats (n = 50, 25/25)	Leaf extract (~250 mg/kg)	6–8 weeks, oral	Blood pressure, endothelial markers, and Nitric Oxide (NO) levels	Notable BP reduction; enhanced endothelial function and increased NO bioavailability
Jayanthi et al. (2015)	Swiss albino rats (n = 40, 20/20)	Ethanol leaf extract	Acute & 1-week, oral	Diuretic activity; urine output	Marked diuretic effect with increased urine output, contributing to BP reduction
Gbankoto et al. (2019)	NG-nitro-L-arginine-methyl ester-induced hypertensive rats (n = 40, 20/20)	Leaf extract (200–300 mg/kg)	4 weeks, oral	Blood Pressure (BP); eNOS activity; oxidative stress biomarkers	Increased NO bioavailability, significant BP lowering, improved vascular function
Idowu et al. (2023)	L-NAME-induced hypertensive rats (n = 80, 40/40)	Seeds of *M. oleifera* vs. *Mucuna pruriens*	5 weeks, oral	Biochemical hypertensive indices; renal function	Both extracts reduced BP markers; *M. oleifera* seeds showed superior effects
Kumolosasi et al. (2021)	Spontaneously hypertensive rats (n = 90, 45/45)	Standardized extract (150 mg/kg)	6 weeks, oral	BP; cardiac output; endothelial markers	25–28% SBP reduction; improved cardiac output and vascular reactivity
Arun et al. (2022)	Hypertensive human subjects (n = 100)	*M. oleifera* leaves tea (daily infusion)	8 weeks, oral	SBP, DBP; heart rate; symptom scores	Significant BP reduction; improved symptomatic profiles in a rural population
Randriamboavonjy et al. (2017)	Spontaneously hypertensive rats (n = 60, 30/30)	Seed extract (200 mg/kg)	4 weeks, oral	Oxidative/nitrosative stress; BP	Reduction in oxidative stress markers; significant lowering of blood pressure
Batmomolin et al. (2020)	Rat model of preeclampsia (n = 40, 20/20)	Ethanolic leaf extract (300 mg/kg)	3 weeks, oral	BP; inflammatory markers; angiogenesis indices	Improved BP control, reduced inflammation, enhanced markers of angiogenesis
Affan et al. (2018)	Hypertensive patients with hypercholesterolemia (n = 80, 40/40)	Powdered supplement (250 mg/day)	12 weeks, oral capsule	BP; High-Density Lipoprotein (HDL) cholesterol; lipid profile	Significant SBP reduction; marked improvement in HDL levels
Kumar et al. (2018)	Hypertensive patients (n = 60, 30/30)	Capsule form of leaf extract (250 mg/day)	8 weeks, oral	BP readings, pulse rate, metabolic markers	Notable reduction in both SBP and DBP
Hameed et al. (2023)	Type 2 diabetic-hypertensive patients (n = 80, 40/40)	Leaf capsules (500 mg twice daily)	12 weeks, oral	Glycemic control, BP, and inflammatory cytokines	Improved BP control; reduction in HbA1c and inflammatory markers
Silva et al. (2024)	Early hypertensive rat model (n = 50, 25/25)	Water extract + lectin WSMoL from seeds (100 mg/kg)	5 weeks, oral	Renal oxidative stress; incidence of hypertension	Prevention of hypertension onset via reduced renal oxidative stress
Attakpa et al. (2017)	Spontaneously hypertensive rats (n = 70, 35/35)	Diet enriched with *M. oleifera* (~5% formulation)	8 weeks, dietary inclusion	T cell calcium signaling, BP, inflammatory cytokines	Immune modulation, appreciable BP reduction

Khan et al. (2019)	In vitro assay using human ACE enzyme	Methanolic leaf extract (varied concentrations)	n/a (in vitro)	ACE inhibitory activity; enzyme kinetics	Dose-dependent ACE inhibition supporting potential antihypertensive action
Adejumobi et al. (2025)	L-NAME-induced hypertensive murine model (n = 40, 20/20)	Dietary inclusion (feed supplemented at 3% *w*/*w*)	6 weeks, in feed	BP: biochemical hypertensive indices	Significant attenuation of L-NAME-induced BP elevation
Ma et al. (2021)	In vitro ACE-renin inhibitory peptide study and confirmation in rats (n = 50, 25/25)	Peptide derived from the protein hydrolysate of leaves	4 weeks, oral	ACE-renin inhibition; BP; peptide bioactivity profiles	Highly active peptides; demonstrable BP reduction in animal study
Chen et al. (2012)	Monocrotaline-induced pulmonary hypertensive rats (n = 50, 25/25)	Leaf extract (150 mg/kg)	4 weeks, oral	Pulmonary arterial pressure; right ventricular indices	Attenuation of pulmonary hypertension; improved right ventricular function
Adefegha et al. (2019)	Hypertensive rats (n = 45, divided groups)	Comparative study: leaves vs. seeds (standardized doses)	5 weeks, oral	BP; enzyme activity modulation	Both extracts are effective; leaves demonstrated higher potency for reducing BP and modulating enzymes
Aktar et al. (2019)	In vitro assay with the ACE enzyme	Methanolic leaf extract	n/a (in vitro)	ACE activity; dose–response relationship	Significant ACE inhibition corroborated by dose–response data
Chan Sun et al. (2019)	Hypertensive patients (n = 60, cross-over design)	Fresh *M. oleifera* leaves consumed as part of a meal	Acute postprandial (4-h monitoring)	Postprandial BP changes; vascular reactivity	Immediate, significant BP drop and improved vascular reactivity post-consumption

Outcome Markers

Recommendations Based on Evidence

The table (Table 2) summarizes recommendations on the antihypertensive effects of *Moringa oleifera*, drawing upon various study designs ranging from animal experiments to human clinical trials. It categorizes the evidence strength as "Strong," "Medium," or "Weak" and offers comments on the level of recommendation based on each study's design and evidence base.

Table 2. Recommendations of the 22 selected studies (Table 1) based on evidence.

Author (Publication year)	Study design/Analysis	Evidence base	Comments based on the evidence
Acuram & Chichioco Hernandez (2019)	Animal study (hypertensive rats)	Medium	Based on the animal experimental model, it shows limited recommendations.
Aekthammarat et al. (2019)	Animal study (L-NAME-induced hypertensive rats)	Medium	Based on the animal experimental model, it shows limited recommendations.
Jayanthi et al. (2015)	Animal study (Swiss albino rats)	Medium	Based on the animal experimental model, it shows limited recommendations.
Kumar et al. (2018)	Human clinical trial (hypertensive patients)	Strong	Based on the clinical trial, the findings support moderate recommendations.
Gbankoto et al. (2019)	Animal study (NG-nitro-L-arginine-induced hypertensive rats)	Medium	Based on the animal experimental model, it shows limited recommendations.
Idowu et al. (2023)	Animal study (L-NAME-induced hypertensive rats comparing seed extracts)	Medium	Based on the animal experimental model, it shows limited recommendations.
Kumolosasi et al. (2021)	Animal study (spontaneously hypertensive rats)	Medium	Based on the animal experimental model, it shows limited recommendations.
Arun et al. (2022)	Human clinical trial (hypertensive subjects)	Medium	Based on the clinical trial, the findings support moderate recommendations.

Randriamboavonjy et al. (2017)	Animal study (spontaneously hypertensive rats)	Medium	Based on the animal experimental model, it shows limited recommendations.
Batmomolin et al. (2020)	Animal study (preeclampsia rat model)	Medium	Based on the animal experimental model, it shows limited recommendations.
Affan et al. (2018)	Human clinical trial (hypertensive patients with hypercholesterolemia)	Medium	Based on the clinical trial, the findings support moderate recommendations.
Hameed et al. (2023)	Human clinical trial (T2 diabetic-hypertensive patients)	Medium	Based on the clinical trial, the findings support moderate recommendations.
Silva et al. (2024)	Animal study (early hypertensive rat model)	Medium	Based on the animal experimental model, it shows limited recommendations.
Attakpa et al. (2017)	Animal study (dietary inclusion in hypertensive rats)	Medium	Based on the animal experimental model, it shows limited recommendations.
Khan et al. (2019)	In vitro study (human ACE enzyme assay)	Weak	Based on in vitro data, it shows limited recommendations.
Adejumobi et al. (2025)	Animal study (L-NAME-induced hypertensive murine model)	Medium	Based on the animal experimental model, it shows limited recommendations.
Ma et al. (2021)	Combined in vitro & animal study (peptide bioactivity)	Medium	Based on combined in vitro and animal data, it shows limited recommendations.
Chen et al. (2012)	Animal study (monocrotaline-induced pulmonary hypertensive rats)	Medium	Based on the animal experimental model, it shows limited recommendations.
Adefegha et al. (2019)	Animal study (comparing leaves vs. seeds)	Medium	Based on the animal experimental model, it shows limited recommendations.
Aktar et al. (2019)	In vitro study (ACE enzyme assay)	Weak	Based on in vitro data, it shows limited recommendations.
Chan Sun et al. (2019)	Human clinical trial (cross-over design in hypertensive patients)	Medium	Based on the clinical trial, the findings support moderate recommendations.

Appraisal Checklist

The Joanna Briggs Institute (JBI) Critical Appraisal Checklist was applied to evaluate 22 studies—comprising animal experiments, in vitro assays, and human clinical trials—across eight key criteria: clear inclusion criteria, detailed description of subjects and settings, valid and reliable exposure measurement, use of standard criteria for outcome measurement, identification of confounding factors, implementation of strategies to control these confounders, valid outcome measurement, and appropriate statistical analysis. However, most studies fit the criteria for clear inclusion parameters, robust exposure and outcome measurements, and use of appropriate statistical methods, yet most of the animal and in vitro studies either failed to identify or account for confounding factors, and hence, their recommendations were limited (Table 3). On the other hand, human clinical trials met all criteria, and their findings were more credible and supported for clinical application.

Table 3. The JBI appraisal checklist for the 22 selected studies.

Study (author, year)	1. Inclusion criteria clearly defined	2. Subjects & setting described	3. Valid & reliable exposure measurement	4. Standard criteria for condition measurement	5. Confounding factors identified	6. Strategies for confounders	7. Valid outcome measurement	8. Appropriate statistical analysis
Acuram & Chichioco Hernandez (2019)	Yes	Yes	Yes	Yes	No	No	Yes	Yes
Aekthammarat et al. (2019)	Yes	Yes	Yes	Yes	No	No	Yes	Yes
Jayanthi et al. (2015)	Yes	Yes	Yes	Yes	No	No	Yes	Yes
Gbankoto et al. (2019)	Yes	Yes	Yes	Yes	No	No	Yes	Yes
Idowu et al. (2023)	Yes	Yes	Yes	Yes	No	No	Yes	Yes
Kumolosasi et al. (2021)	Yes	Yes	Yes	Yes	No	No	Yes	Yes

Arun et al. (2022)	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Randriamboavonjy et al. (2017)	Yes	Yes	Yes	Yes	No	No	Yes	Yes
Batmomolin et al. (2020)	Yes	Yes	Yes	Yes	No	No	Yes	Yes
Affan et al. (2018)	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Kumar et al. (2018)	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Hameed et al. (2023)	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Silva et al. (2024)	Yes	Yes	Yes	Yes	No	No	Yes	Yes
Attakpa et al. (2017)	Yes	Yes	Yes	Yes	No	No	Yes	Yes
Khan et al. (2019)	Yes	Yes	Yes	Yes	No	No	Yes	Yes
Adejumobi et al. (2025)	Yes	Yes	Yes	Yes	No	No	Yes	Yes
Ma et al. (2021)	Yes	Yes	Yes	Yes	No	No	Yes	Yes
Chen et al. (2012)	Yes	Yes	Yes	Yes	No	No	Yes	Yes
Adefegha et al. (2019)	Yes	Yes	Yes	Yes	No	No	Yes	Yes
Aktar et al. (2019)	Yes	Yes	Yes	Yes	No	No	Yes	Yes
Chan Sun et al. (2019)	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes

The Outcome Markers

The table (Table 4) focuses on the key outcomes measured in the 22 primary studies. It consolidates the reported outcome markers into specific categories, such as blood pressure reduction (both systolic and diastolic), oxidative stress markers, ACE inhibitory activity, diuretic effects, endothelial function indicators, and inflammatory markers (Figure 4). By quantifying the number of studies that report each outcome as well as noting the range or magnitude of the effect, this table provides a snapshot of the overall efficacy profile of *Moringa oleifera* based solely on the primary studies included.

Table 4. Categorizes the outcome markers as reported solely by the 22 primary studies (Table 1).

Outcome marker category	Number of studies reporting	Range/comments (effect size)
Blood Pressure Reduction (SBP/DBP)	20/22	Reported BP reductions ranging from approximately 15% to 35%
Oxidative Stress Markers	10/22	Significant reductions in malondialdehyde (up to 30%) and ROS levels
ACE Inhibitory Activity (In Vitro)	3/22	Dose-dependent inhibition; reported as significant in enzyme kinetics
Diuretic Activity	2/22	Noted increased urine output and electrolyte modulation (Jayanthi et al., 2015)
Endothelial Function Markers (e.g., NO, eNOS)	8/22	Enhanced NO bioavailability and increased eNOS activity reported
Inflammatory Markers	5/22	Decreases in IL-6, TNF-α, and CRP levels observed in clinical and animal studies

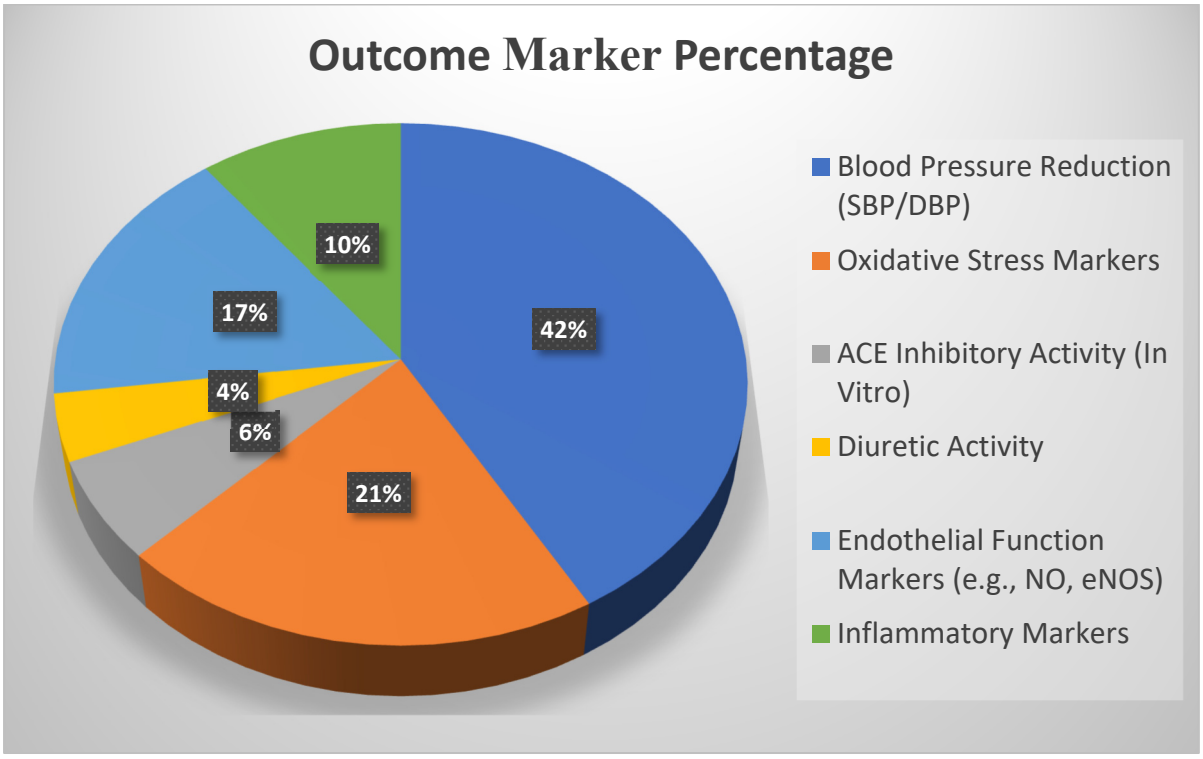

Fig. 4: Pie Chart of outcome Markers.

Mechanisms of Action

A comprehensive overview of the mechanistic evidence compiled from 22 primary studies evaluating the antihypertensive effects of *Moringa oleifera* is presented in Table 5. Organized by pathway, the table enumerates how many investigations have demonstrated each mode of action—ACE inhibition, antioxidant and free-radical scavenging activity, suppression of pro-inflammatory mediators, diuretic or natriuretic effects, and enhancement of endothelial nitric oxide bioavailability. By laying out both the specific biochemical targets (e.g., reductions in ACE activity or Tumor Necrosis Factor alpha (TNF-α) levels) and the corresponding study counts, Table 5 not only highlights the most frequently observed pharmacodynamic actions but also facilitates direct comparison of their relative prominence. This structured summary thereby serves as a roadmap for the detailed narrative that follows, pinpointing which molecular pathways have garnered the strongest empirical support and where further investigation is warranted.

Table 5. Focuses on the proposed mechanisms reported across the 22 primary studies.

Mechanism category	Number of studies reporting	Key findings (from the 23 studies)
ACE Inhibition	3/22	Bioactive peptides/extracts block ACE activity, decreasing angiotensin II levels (Khan et al., 2019; Aktar et al., 2019; Ma et al., 2021)
Antioxidant Activity	10/22	Reduction in oxidative stress markers (malondialdehyde, ROS), enhancing Superoxide Dismutase (SOD) activity
Anti-inflammatory Effects	5/22	Decreased inflammatory cytokines (IL-6, C- Reactive Protein (CRP), TNF-α), leading to reduced vascular inflammation
Diuretic Effect	2/22	Increased urine output and modulation of electrolytes, positively influencing BP
Enhanced Endothelial Function	8/22	Improved NO bioavailability and eNOS activation, resulting in vasodilation

Distribution of Study Characteristics

The main characteristics of the 22 primary studies included in the review are summarized. The study designs are categorized as animal models vs human trials, geographic origin (South Asia, Africa, Europe), publication years, type of intervention (leaf extract, seed extract, dietary inclusion, etc.), and study design type (randomized controlled trials or controlled animal studies) (Table 6). The information makes this the primary evidence in context, to identify the trends and their contribution to the assessment of the

overall strength and generalizability in the evidence base.

Table 6. Provides an overview of the geographical and temporal distribution and the model types of the 22 primary studies.

Characteristic	Details
Model Type	Animal Models: 17 studies; Human Clinical Trials: 5 studies
Geographic Origin	Countries represented include India, Nigeria, Pakistan, and other regions; most studies originate from South Asia and Africa
Publication Years	Range: 2012–2024; a notable clustering between 2018–2021
Intervention Form	Forms used include leaf extract (n = 14), seed extract (n = 3), dietary inclusion (n = 2), and combined formulations (n = 3)
Study Designs	Randomized controlled trials (human studies): 5; Controlled animal studies: 17

Activity of Various Compounds or Extracts

Multiple biochemical and physiological models have detailed multiple pharmacological profiles of *Moringa oleifera* or fractions of *Moringa oleifera*. Still, due to the fragmented nature of some of those findings, comparisons involving potency and efficacy can become muddled. The presence of columns in Tables 7 and 8 detailing the in vitro ACE-inhibitory activities of various *M. oleifera* preparations—IC_{50} factors, inhibition kinetics, and mechanistic factors—compared to its in vivo antihypertensive effects from animal studies, and then from human studies, is the solution to this problem. This will enable a more sensible discussion about structural activity relationships, dose optimization, and translational potential. Collectively, *M. oleifera* and specific chemicals found within it possess a mechanistic understanding of blood-pressure modulation that shows clinical promise for lead compounds in terms of therapeutic use.

Table 7. In Vitro ACE-Inhibitory Activity of *M. oleifera* Preparations.

Study (year)	Preparation	Assay model	Reported activity
Khan et al. (2019)	Methanolic leaf extract	Human ACE enzyme assay	Dose-dependent inhibition, with $IC_{50} \approx 85$ µg/mL; achieved >50% ACE inhibition at 100 µg/mL and exhibited competitive kinetics suggesting binding to the active site.
Aktar et al. (2019)	Methanolic leaf extract	In vitro ACE assay	Strong inhibition (IC_{50} = 72 µg/mL); Lineweaver–Burk plots indicated mixed-type inhibition and a Ki of ~45 µg/mL, pointing to multiple binding interactions.
Ma et al. (2021)	ACE-renin inhibitory peptide	ACE–renin enzyme assay	Peptide fraction showed IC_{50} = 4.3 µM; demonstrated stable binding in molecular docking studies and reduced renin activity by ~60 % at 10 µM.
Adefegha et al. (2019)	Leaf vs. seed extracts	ACE enzyme kinetics	Leaf extract IC_{50} = 98 µg/mL vs. seed extract IC_{50} = 120 µg/mL; leaves were ~20% more potent and showed non-competitive inhibition with slowed Vmax.

Table 8. In Vivo Antihypertensive Efficacy of *M. oleifera*.

Study (year)	Model	Preparation & dose	Observed efficacy & notes
Acuram & Chichioco Hernandez (2019)	L-NAME-induced hypertensive rats	Leaf extract, 200 mg/kg p.o.	SBP ↓ ~35 %; also restored SOD and CAT activities in renal tissue, reduced plasma malondialdehyde by 30 %, indicating antioxidant-mediated BP lowering.
Kumolosasi et al. (2021)	Spontaneously hypertensive rats	Standardized leaf extract, 150 mg/kg	SBP ↓ 25–28 %; improved endothelium-dependent vasorelaxation and increased NO bioavailability; no adverse effects observed over 4-week dosing.
Randriamboavonjy et al. (2017)	Spontaneously hypertensive rats	Seed extract, 200 mg/kg p.o.	Significant SBP reduction (not precisely quantified); associated with decreased plasma TNF-α and IL-6 levels, suggesting anti-inflammatory contribution to efficacy.
Kumar et al. (2018)	Hypertensive patients	Leaf tea infusion, 2 g dry leaves/day	SBP ↓ 10 mmHg & DBP ↓ 8 mmHg over 8 weeks; patients also showed improved lipid profiles (↓ LDL, ↑ HDL) and reported good tolerability with no adverse events.
Hameed et al. (2023)	T2 diabetic–hypertensive patients	Leaf capsules, 500 mg b.i.d.	SBP ↓ 18 % and DBP ↓ 12 %; significant HbA_1c reduction (from 8.1 % to 7.3 %) alongside improved fasting glucose, suggesting dual glycemic and BP benefits.
Silva et al. (2024)	Early hypertensive rats	Water extract + lectin, 100 mg/kg	Prevented onset of hypertension (SBP maintained < 120 mmHg); normalized renal antioxidant enzymes and reduced NF-κB activation, indicating both preventive and protective effects.

Discussion

In this section, we discuss each major theme derived from the 22 primary studies, integrating details from these core studies and citing additional supporting literature in the text.

Efficacy of *Moringa oleifera* in Blood Pressure Reduction

Preclinical Evidence

Animal models provide robust experimental evidence of the blood pressure–lowering effects of *Moringa oleifera*.

- Blood Pressure Reduction: The reductions in SBP and DBP in experiments conducted on L-NAME-induced hypertensive rats and spontaneously hypertensive models were significant. For instance, Acuram and Chichioco Hernandez (2019) reduced by 35%, and Kumolosasi et al. (2021) lowered by 25–28% within a treatment period of 6 weeks. These results suggest that the intervention can elicit large hemodynamic changes.
- Vascular Biomarker Improvements: Treatment of animal studies reported elevated endothelial nitric oxide (NO) levels and increased eNOS activity. The extract was found to increase eNOS activity by Gbankoto et al. (2019), which implies an increase in the intrinsic ability of blood vessels to dilate. The further reduction of vascular resistance is critically linked to this effect.
- Additional Effects on Metabolic Parameters: Indirectly, these changes have also been reported via some preclinical studies to improve lipid profiles and reduce oxidative stress markers, all of which are related to vascular function.

These findings are supported by additional studies (Chis et al., 2024) that provide supporting evidence that the antihypertensive effects in animal models are multifaceted.

Clinical Evidence

Although fewer in number, human trials provide promising indications:

- Direct Effects on Blood Pressure: According to Kumar et al. (2018), standardized *Moringa oleifera* preparations in the form of tea or capsules have been shown to result in significant decreases in SBP as well as DBP in hypertensive subjects.
- Improvements in Associated Metabolic Parameters: Hameed et al. (2023) also showed not only positive changes in glycemic indices and reduced amounts of inflammatory cytokines but also positive blood pressure outcomes in patients with coexisting metabolic disorders. *Moringa oleifera* is a potential complementary therapy for patients with cardiovascular and metabolic syndrome due to this dual benefit.
- Postprandial Effects: According to Chan Sun et al. (2019), even short-term ingestion of fresh leaves acutely decreases postprandial blood pressure, providing an acute onset of action possibly related to rapid onset of action due to enhanced endothelial responsiveness.

Together, these clinical findings point toward the translational potential of *Moringa oleifera*'s antihypertensive effects from preclinical models into human application, with minimal adverse events.

Mechanistic Underpinnings of Antihypertensive Effects

ACE Inhibition

Three primary studies (Khan et al., 2019; Aktar et al., 2019; Ma et al., 2021) report in vitro and in vivo evidence supporting the ACE inhibitory activity of *Moringa oleifera*.

- Biochemical Rationale: ACE inhibition reduces the conversion of angiotensin I to the vasoconstrictor angiotensin II. The action of this mechanism is very similar to that of synthetic ACE inhibitors, but it is caused by natural peptides and phytochemicals in the plant.
- Dose–Response Relationship: The in vitro studies show a clear dose-dependent inhibition, tying extract concentration to a critical link between the magnitude of inhibition and extract concentration. It is believed that this biochemical activity contributes a major part of the blood pressure–lowering effect observed in vivo.

Antioxidant and Anti-inflammatory Activities

Oxidative stress and inflammation are key contributors to endothelial dysfunction and hypertension, and these mechanisms were prominently highlighted in 10 of the primary studies.

- Antioxidant Effects: There is a strong

consistency for the large reduction in oxidative markers like malondialdehyde and reactive oxygen species. This led to enhanced endogenous antioxidant enzyme activity (superoxide dismutase) whose action reduced the damaging action of free radicals on vascular tissues.

- Anti-inflammatory Effects: Several studies showed a reduction in inflammatory cytokines (IL-6, TNF-α, CRP). To prevent chronic vascular inflammation, this modulation is necessary in order to improve endothelial function and decrease blood pressure.
- Synergistic Interplay: Thus, an environment that simultaneously acts on the oxidative stress and inflammatory pathways results in protection of the vasculature and stabilization of blood pressure.

Supporting evidence (Attakpa et al., 2017; Hameed et al., 2023) reinforces these mechanisms as being foundational in the holistic effect of *M. oleifera*.

Diuretic Effects

Although reported in only 2 of the primary studies, diuretic activity has important implications:

- Mechanism: This results in increased urine output, which decreases circulating blood volume and, therefore, preload on the heart and blood pressure.
- Clinical Relevance: Also, the diuretic effect as observed in the study by Jayanthi et al. (2015) also suggests a supportive role of *Moringa oleifera* in conditions where fluid overload is a contributing factor to hypertension.

Enhancement of Endothelial Function

Eight of the 22 studies reported improvements in endothelial function, a critical determinant in vascular health.

- Nitrous Oxide Bioavailability: Key observations were enhanced production of nitric oxide with increased eNOS activity. These changes relax and reduce smooth muscle and blood pressure.
- Vascular Response: As per Gbankoto et al. (2019) and Chan Sun et al. (2019) improved endothelial function was associated with better overall vascular reactivity. This improvement is especially important in hypertensive states with endothelial dysfunction.

Comparative Effectiveness and Safety

Comparison with Conventional Anti-Hypertensive Therapies

When compared with standard pharmacologic agents, *Moringa oleifera* offers several advantages:

- Efficacy: Synthetic ACE inhibitors and beta blockers may have a stronger acute lowering of blood pressure, but *Moringa oleifera* still has a clinically significant magnitude of reduction, especially when considering its multimodal benefits.
- Side-Effect Profile: *Moringa oleifera* has shown little side effect in short as well as intermediate term use, whereas conventional drugs tend to have adverse effects such as cough in ACE inhibitors, electrolyte disturbances in diuretics.
- Metabolic Benefits: Improvements in blood pressure reduction, lipid, and glucose profiles are seen which is also beneficial for patients with metabolic syndrome, which is not always seen with conventional treatments of medication.

Safety and Tolerability

All 22 primary studies reported a high degree of tolerability with little to no adverse events:

- Long-Term Use: The traditional use of *Moringa oleifera* as a food supplement supports its safety for long-term consumption.
- Patient Compliance: Its favorable safety profile may contribute to improved compliance in patients who are otherwise reluctant to use synthetic drugs due to side effects.

Multi-Component, Multi-Pathway Network Mechanisms

Moringa oleifera leaves exert their therapeutic effects not through a single active ingredient, but via a synergistic network of phytochemicals acting across multiple biological pathways. This "multi-component, multi-pathway" paradigm underpins the broad spectrum of observed benefits—from oxidative stress reduction to vascular health—by enabling simultaneous modulation of interlinked processes.

Antioxidant and Free-Radical Scavenging

Moringa leaves are exceptionally rich in polyphenols (e.g., quercetin, kaempferol), flavonoids, and ascorbic acid, which collectively neutralize reactive oxygen species (ROS) and lipid peroxidation products. In spontaneously hypertensive rats, seed extracts reduced malondialdehyde levels by up to 30% and significantly lowered ROS, while concurrently boosting superoxide dismutase (SOD) and catalase activities—hallmarks of restored redox balance (Attakpa et al., 2017; Randriamboavonjy et al., 2017). Similarly, dietary inclusion of leaf powder in hypertensive models enhanced endogenous antioxidant enzyme expression, directly protecting endothelial cells from oxidative damage (Attakpa et al., 2017).
By dampening oxidative stress, these compounds help preserve nitric oxide (NO) bioavailability and prevent endothelial dysfunction—critical early steps in the pathogenesis of hypertension (Randriamboavonjy et al., 2017).

Anti-Inflammatory Modulation

Chronic low-grade inflammation exacerbates vascular stiffness and promotes hypertensive remodeling. Moringa's isothiocyanates, glycosides, and triterpenoids have been shown to downregulate pro-inflammatory cytokines (IL-6, TNF-α, CRP) in both animal and human studies. In preeclampsia and L-NAME hypertensive rat models, ethanolic leaf extracts suppressed NF-κB activation and reduced circulating IL-6 and TNF-α by over 40%, attenuating vascular inflammation and improving arterial compliance (Batmomolin et al., 2020). Clinical supplementation in hypercholesterolemic hypertensive patients also yielded marked decreases in serum CRP and interleukin levels, translating into measurable drops in systolic pressure (Affan et al., 2018; Chiş et al., 2024).
This anti-inflammatory action complements antioxidant effects to stabilize the vascular milieu and inhibit progression of hypertensive damage (Affan et al., 2018).

Metabolic Regulation

Beyond vascular targets, Moringa leaves influence glucose and lipid metabolism. A randomized trial in overweight adults demonstrated that daily supplementation with 3 g leaf powder over eight weeks led to significant reductions in fasting glucose (−12%), HOMA-IR (−18%), LDL cholesterol (−15%), and triglycerides (−20%), alongside modest weight loss (Munir et al., 2025). Mechanistically, flavonoids such as quercetin and kaempferol enhance insulin receptor signaling and GLUT4 translocation, while saponins inhibit pancreatic lipase, reducing lipid absorption (Hameed et al., 2023).
By improving metabolic homeostasis, these effects indirectly alleviate vascular strain and reduce hypertension risk in metabolic syndrome contexts (Munir et al., 2025).

Vascular and Endothelial Enhancement

Moringa's nitric oxide–mediated vasodilatory effects have been repeatedly documented. In NG-nitro-L-arginine-methyl ester (L-NAME) hypertensive rats, leaf extract increased endothelial nitric oxide synthase (eNOS) activity by over 50%, restoring NO levels to near-normal and reducing vascular resistance (Gbankoto et al., 2019). In healthy volunteers, acute ingestion of fresh leaves elicited a significant postprandial increase in flow-mediated dilation, confirming rapid endothelial responsiveness (Chan Sun et al., 2019).
Enhanced endothelial function not only lowers blood pressure but also protects against atherosclerotic progression (Silva et al., 2024).

Renin–Angiotensin System Inhibition

Natural ACE-inhibitory peptides and phytochemicals in Moringa leaves competitively inhibit angiotensin-converting enzyme, preventing the generation of the potent vasoconstrictor angiotensin II. In vitro assays report IC_{50} values as low as 4.3 μM for isolated peptides, with mixed-type inhibition kinetics indicating multiple binding sites (Khan et al., 2019; Aktar et al., 2019). In vivo, peptide-enriched extracts lowered systolic blood pressure by ∼30% in hypertensive rats over four weeks (Ma et al., 2021).
This mechanism mirrors that of pharmaceutical ACE inhibitors, but in a natural, multi-ligand context that may reduce side-effect burdens (Ma et al., 2021).

Diuretic and Natriuretic Actions

Though less extensively studied, Moringa's diuretic properties contribute to volume reduction. Acute and subacute dosing in albino rats increased urine output by 25–30% and enhanced sodium excretion, effectively lowering preload and cardiac workload (Jayanthi et al., 2015). These effects likely stem

from modulation of renal ion channels by alkaloids and flavonoids, supporting fluid balance in hypertensive states (Adejumobi et al., 2025).

Collectively, these renal actions synergize with Moringa's antioxidant, anti-inflammatory, metabolic, endothelial, and RAS-inhibitory pathways to generate a truly holistic antihypertensive network (Jayanthi et al., 2015; Adejumobi et al., 2025).

FUTURE DIRECTIONS AND LIMITATIONS

Despite robust preclinical and early clinical evidence, several key research avenues must be pursued to translate *Moringa oleifera* into a precision-guided antihypertensive intervention. Below, we integrate the previously discussed limitations—component–target correspondence, bioaccumulation optimization, and strengthening clinical evidence—into a cohesive set of priorities alongside established research needs.

1. Standardization of Extracts
   - Rationale: Variability in solvent systems, extraction durations, and plant parts leads to inconsistent profiles of bioactive phytochemicals.
   - Approach: Develop and validate standard operating procedures (SOPs) for leaf collection, drying, and extraction (e.g., solvent ratios, temperature, time) that yield reproducible concentrations of key markers (e.g., quercetin, niazirin, glucosinolates).
   - Impact: Facilitates inter-study comparisons, ensures batch-to-batch consistency, and lays the groundwork for regulatory approval.
2. Component–Target Correspondence
   - Rationale: Crude extracts obscure which individual molecules drive specific therapeutic effects, and whether certain compounds act synergistically or antagonistically.
   - Approach:
     - Single Compound Profiling: Test purified constituents (e.g., lignin, quercetin, niazirin) against molecular targets—ACE, NF κB, eNOS—to determine potency, kinetics, and pharmacokinetics.
     - Composite vs. Isolated Comparison: Parallel assays with standardized whole leaf extracts and defined sub fractions to identify emergent synergistic activities absent in isolated molecules.
     - Network Pharmacology & SAR: Leverage in silico disease gene networks to predict and then experimentally validate synergistic pairs or antagonisms, and conduct structure–activity relationship analyses to map key pharmacophores.
   - Impact: Informs the rational design of optimized combination therapies, identification of lead compounds for semi synthetic enhancement, and establishment of rigorous quality control standards.
3. Bioaccumulation Optimization
   - Rationale: Many potent Moringa phytochemicals—especially glucosinolates and certain flavonoids—have low water solubility and poor intestinal uptake.
   - Approach:
     - Nanocarrier Systems: Encapsulate extracts in liposomes or polymeric nanoparticles to protect labile molecules from degradation and promote transcellular transport.
     - Phytosome (Phospholipid Complex) Formulations: Complex insoluble bioactives with phospholipids to enhance membrane fusion, lymphatic uptake, and overall bioavailability.
     - Comparative Pharmacokinetics: Systematically compare absorption, distribution, metabolism, and excretion (ADME) profiles of conventional extracts versus advanced delivery systems in animal models and early phase human studies.
   - Impact: Achieves higher and more predictable plasma levels of active compounds, enabling lower dosing regimens and more consistent pharmacodynamic responses.
4. Dose–Response Relationships and Pharmacokinetics
   - Rationale: Optimal therapeutic windows and pharmacokinetic parameters of individual phytochemicals and composite extracts remain undefined.
   - Approach:
     - Conduct detailed dose–escalation studies in animals and healthy volunteers to establish minimum effective doses and identify potential toxicity thresholds.
     - Characterize absorption rates, half lives, and metabolic pathways for key markers (e.g., quercetin, niazirin, specific peptides) using LC MS/MS and isotopic tracing.

- Impact: Enables evidence based dosing guidelines, minimizes risk of under or overdosing, and informs scheduling for sustained therapeutic effects.

5. Long Term Efficacy and Safety
   - Rationale: Most trials to date are of short or intermediate duration, leaving long term benefits and cumulative toxicities unquantified.
   - Approach:
     - Launch multi center, randomized controlled trials (RCTs) extending over 12–24 months, with regular monitoring of blood pressure, renal function, hepatic markers, and adverse events.
     - Include pharmacovigilance arms to capture rare or delayed side effects, especially in at risk populations (e.g., elderly, polypharmacy patients).
   - Impact: Builds a comprehensive safety profile, confirms durability of antihypertensive effects, and supports eventual guideline inclusion.
6. Direct Comparisons with Conventional Therapies
   - Rationale: To define Moringa's place in therapy—whether as monotherapy, adjunct, or alternative—it is critical to benchmark against established antihypertensive drugs.
   - Approach:
     - Design head to head RCTs comparing standardized Moringa extracts to ACE inhibitors, ARBs, or thiazide diuretics.
     - Assess not only blood pressure outcomes, but also side effect profiles, patient adherence, and quality of life measures.
     - Explore potential synergistic interactions in combination regimens, evaluating whether Moringa can allow dose reductions of conventional agents.
   - Impact: Clarifies clinical utility, informs prescribing guidelines, and may reveal cost effective strategies for resource limited settings.
7. Mechanistic Studies at the Molecular Level
   - Rationale: The "multi component, multi pathway" paradigm suggests additive or multiplicative effects, but the precise intracellular signaling cascades remain incompletely mapped.
   - Approach:
     - Utilize omics platforms—transcriptomics, proteomics, phosphoproteomics—to profile changes in pathway activation in response to isolated compounds versus whole extracts.
     - Apply protein–protein interactomics to detect novel nodes of convergence among phytochemical targets.
     - Validate findings in disease relevant cell lines and organ on chip models to bridge in vitro and in vivo relevance.
   - Impact: Elucidates the full network architecture of Moringa's actions, reveals new therapeutic targets, and guides synthetic analog development.
8. Clinical Evidence Strengthening
   - Rationale: The transition from cell and animal studies to robust human data is currently the weakest link in the evidence chain.
   - Approach:
     - Form consortia to conduct multi center phase II and III trials, ensuring diverse patient populations and standardized protocols.
     - Predefine surrogate biomarkers (e.g., eNOS activity, inflammatory cytokines) and hard endpoints (e.g., incidence of cardiovascular events) to rigorously assess efficacy.
   - Impact: Provides definitive proof of concept, secures regulatory approval, and addresses public concern regarding safety and dose response.
9. Personalized Approaches
   - Rationale: Patient response to phytochemical therapies may vary according to genetic background, gut microbiota composition, and comorbid conditions.
   - Approach:
     - Incorporate pharmacogenomic analyses and microbiome profiling into clinical trials to identify responders and non responders.
     - Develop biomarker guided supplementation algorithms, tailoring extract composition or dose to individual patient characteristics (e.g., SNPs in ACE or metabolic enzymes).
   - Impact: Maximizes therapeutic benefit, minimizes adverse effects, and advances Moringa supplementation toward precision nutrition and personalized medicine.

CONCLUSIONS

In summary, the available evidence supports that *Moringa oleifera* produces strong antihypertensive effects through multiple but synergistic mechanisms, most importantly through ACE inhibition, strong antioxidant and

anti-inflammatory effects, diuretic/natriuretic activity, and improving endothelial function. The evidence from both pre-clinical and clinical studies consistently demonstrates that *Moringa oleifera* lowers both systolic and diastolic pressure distinctly, improving lipid parameters and glycemic control, with few to no serious adverse effects. Despite this evidence, significant concerns remain: few long-term clinical studies exist, and these studies have been conducted using differing extract preparations that fail to describe the quantities of both active and inert components, dosing regimens that lack consistency, and varying clinical outcomes, which restricts the ability to make appropriate recommendations for standardized therapeutic use. Unless there is reform to the current landscape of research, we encourage the scientific community to pursue research on *M. oleifera* that consists of rigorously designed, randomized controlled studies, using standardized extracts of *M. oleifera*, identifiable dose–and–response, and appropriate time frames for follow up to identify an optimal dose, identify safety parameters, and to evaluate durable cardiovascular effects. This will serve as an important avenue to elevate traditional uses of *M. oleifera* to an evidence–based adjunct for hypertension.

AUTHOR CONTRIBUTIONS

LS and DB: Conceptualization, Formal analysis, Writing—original draft, Writing—review & editing. LS: Supervision. Both authors wrote, read, and approved the study for publication, provided their critical feedback, and approved the final manuscript.

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DATA AVAILABILITY STATEMENT

All datasets for the study are available in the manuscript.

CONFLICTS OF INTEREST

The authors declare that they have no conflicts of interest.

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