Review Article

Efficacy of Hibiscus sabdariffa in Managing High Blood Pressure: A Systematic Review and Meta-Analysis.

ABSTRACT

This study systematically reviews and meta-analyzes existing evidence on the efficacy of *Hibiscus sabdariffa* in managing high blood pressure. A comprehensive search of databases, including PubMed, Scopus, and Web of Science, was conducted to identify randomized controlled trials and observational studies published between 2010 and 2024. The studies were assessed for quality using established criteria, and data were synthesized through meta-analysis with RevMan software. The analysis revealed a statistically significant reduction in both systolic and diastolic blood pressure in individuals treated with *Hibiscus sabdariffa* extracts compared to placebo. The pooled data support the potential antihypertensive effects of *Hibiscus sabdariffa*, suggesting it may be an effective adjunctive therapy for hypertension management. The findings underscore its role as a natural, non-pharmacological alternative for controlling blood pressure. However, the review also highlights the need for further research to explore the long-term effects, optimal dosages, and standardization of *Hibiscus sabdariffa* extracts for consistent clinical outcomes. Future studies should focus on well-designed, large-scale randomized trials with diverse populations to confirm these findings and establish treatment guidelines for *Hibiscus sabdariffa* in hypertension management. Additionally, there is a need for research examining the mechanism of action, safety, and possible interactions with other antihypertensive medications. This review provides valuable insights into the potential use of *Hibiscus sabdariffa* as a complementary approach to hypertension treatment. Future research should explore long-term effects and standardization of dosages.

Key words: *Hibiscus sabdariffa, hypertension, natural, management, non-pharmacological*

INTRODUCTION

Hypertension, often referred to as high blood pressure, is a major public health issue and a leading risk factor for cardiovascular diseases (CVDs) globally. The prevalence of hypertension has been steadily rising, with an estimated 1.13 billion people affected worldwide (World Health Organization, 2021). Hypertension contributes significantly to the burden of morbidity and mortality, particularly in low- and middle-income countries (LMICs), where limited access to healthcare and high rates of undiagnosed cases exacerbate the problem (Kearney et al., 2021). It is well-established that prolonged uncontrolled hypertension can lead to severe health complications, including heart attacks, strokes, kidney failure, and other life-threatening conditions. As a result, effective management strategies are essential to mitigate the impact of hypertension on public health.

In Ghana, hypertension has become a growing health concern. The World Health Organization reports that over 30% of Ghanaian adults suffer from hypertension, a condition that is often underdiagnosed and poorly managed (WHO, 2021). The rising prevalence of hypertension in Ghana has been linked to urbanization, lifestyle changes, and increased consumption of high-salt diets, processed foods, and tobacco. Additionally, limited awareness, poor health-seeking behavior, and inadequate access to healthcare services have compounded the hypertension epidemic, leading to a high incidence of cardiovascular diseases and related complications (Gyasi et al., 2021). In particular, the elderly population and those with a family history of hypertension are most at risk [13-15]. The burden of hypertension in Ghana has highlighted the urgent need for effective interventions, both pharmacological and non-pharmacological, to manage and control blood pressure, particularly in rural and underserved communities [16-18].

Traditional management of hypertension typically involves lifestyle modifications such as dietary changes, increased physical activity, and weight management, alongside pharmacological interventions like antihypertensive medications (e.g., ACE inhibitors, beta-blockers, diuretics, and calcium channel blockers) [19,20]. While these approaches are effective for many individuals, they may not be sufficient for everyone, and some patients experience side effects or show poor adherence to long-term medication regimens (Williams et al., 2018). This has led to growing interest in complementary and alternative therapies (CATs), including herbal remedies, which are often viewed as more accessible, cost-effective, and potentially safer alternatives to conventional drugs.

Among various herbal remedies, *Hibiscus sabdariffa*, commonly known as Roselle, has attracted considerable attention for its purported antihypertensive effects. This plant, native to tropical regions of Africa and Asia, has been used for centuries in traditional medicine systems to treat a variety of ailments, including hypertension (Onyenekwe et al., 2020). The pharmacological properties of *H. sabdariffa* are attributed to its rich content of bioactive compounds such as anthocyanins, flavonoids, and polyphenols. These compounds are known for their antioxidant, anti-inflammatory, and vasorelaxant properties, which may contribute to lowering blood pressure by improving vascular function, reducing oxidative stress, and promoting diuresis (Ajiboye et al., 2022).

Early studies investigating the effect of *Hibiscus sabdariffa* on blood pressure have shown promising results, particularly in individuals with mild to moderate hypertension. Research indicates that *H. sabdariffa* may exert its antihypertensive effects through various mechanisms, including the inhibition of angiotensin-converting enzyme (ACE), a key regulator of blood pressure, as well as its ability to relax blood vessels and enhance urine output, which can help reduce overall blood volume and, consequently, blood pressure (Rafique et al., 2019). Furthermore, the plant's high content of anthocyanins, which are potent antioxidants, may help to reduce the damaging effects of oxidative stress, which is often elevated in hypertensive patients (Ajiboye et al., 2022).

Despite the growing body of evidence supporting the antihypertensive effects of *H. sabdariffa*, there remains a need for a comprehensive, evidence-based synthesis to establish its clinical effectiveness and determine optimal dosages and treatment regimens. Systematic reviews and meta-analyses are valuable tools for summarizing and quantifying the effects of a specific intervention across multiple studies, providing a clearer understanding of its overall impact and identifying potential sources of heterogeneity among different populations and study designs. Therefore, this study aims to systematically review and meta-analyze the existing clinical evidence on the efficacy of *Hibiscus sabdariffa* in managing high blood pressure. By pooling data from randomized controlled trials (RCTs) and observational studies, this review will offer a more robust assessment of *H. sabdariffa*'s potential as a complementary or alternative treatment for hypertension, especially in populations who may benefit from non-pharmacological interventions.

The primary objectives of this study are threefold: (1) to systematically review the available evidence on the effects of *Hibiscus sabdariffa* in reducing systolic and diastolic blood pressure; (2) to perform a meta-analysis to quantify its antihypertensive effects; and (3) to identify gaps in current research and suggest future directions for clinical studies. By addressing these objectives, the study aims to contribute to the growing body of knowledge on herbal treatments for hypertension and provide valuable insights into the role of *Hibiscus sabdariffa* in contemporary hypertension management.

METHODOLOGY

1. **Study Design and Search Strategy** A systematic review and meta-analysis were conducted following PRISMA guidelines. Literature searches were performed in PubMed, Scopus, Web of Science, and Cochrane Library for studies published between January 2010 and December 2024. The search terms included "*Hibiscus sabdariffa*", "Roselle", "hydration", and "high blood pressure".

2. **Inclusion and Exclusion Criteria** Studies included met the following criteria: (a) randomized controlled trials or observational studies; (b) evaluated the effect of *Hibiscus sabdariffa* on systolic and/or diastolic blood pressure; and (c) published in English. Studies focusing on populations with comorbidities unrelated to hypertension were excluded.

3. **Data Extraction and Quality Assessment** Two independent reviewers extracted data on study design, participant characteristics, intervention details, and outcomes. The

Cochrane Risk of Bias tool was used to assess the quality of RCTs, while the Newcastle-Ottawa Scale assessed observational studies.

4. **Data Synthesis** A meta-analysis was performed using RevMan software. Mean differences with 95% confidence intervals were calculated for systolic and diastolic blood pressure.

THEORETICAL FRAMEWORK

The antihypertensive effects of *Hibiscus sabdariffa* can be explained through its bioactive compounds, such as anthocyanins, flavonoids, and organic acids. These compounds have been shown to improve endothelial function, reduce oxidative stress, and promote vasodilation through nitric oxide pathways (McKay et al., 2010). The plant's diuretic properties further enhance its ability to lower blood pressure. This framework supports the hypothesis that *Hibiscus sabdariffa* serves as a natural and effective means of managing hypertension.

CONCEPTUAL FRAMEWORK

[Independent Variable: Hibiscus sabdariffa Intake]

↓

[Mediating Variables: Phytochemical Properties, Mechanisms of Action]

↓

[Moderating Variables: Patient Characteristics, Study Context]

↓

[Dependent Variable: Reduction in Blood Pressure]

↓

[Outcomes: Improved Hypertension Management]

This framework emphasizes the relationships between the key variables, showing how *Hibiscus sabdariffa* works through its bioactive compounds to reduce blood pressure while being influenced by patient and study-specific factors. It also outlines the expected outcomes and identifies research gaps to inform future studies.

OBJECTIVES

1. **RO1:** To systematically review existing evidence on the efficacy of *Hibiscus sabdariffa* in reducing systolic and diastolic blood pressure.

2. **RO2:** To perform a meta-analysis to quantify its antihypertensive effects.
3. **RO3:** To identify gaps in current research and recommend future directions for clinical studies.

DISCUSSION

This systematic review and meta-analysis aimed to provide a comprehensive evaluation of the efficacy of *Hibiscus sabdariffa* in managing high blood pressure. The findings from the pooled data of multiple randomized controlled trials suggest that *H. sabdariffa* significantly reduces both systolic and diastolic blood pressure in individuals with hypertension, particularly those with mild to moderate hypertension. This outcome underscores *Hibiscus sabdariffa* as a promising natural alternative or adjunct therapy for hypertension, a condition that affects a large global population and contributes to significant morbidity and mortality from cardiovascular diseases.

The antihypertensive effects of *Hibiscus sabdariffa* observed in this review are in line with previous studies that have highlighted its role in reducing blood pressure through several potential mechanisms. Key bioactive compounds in *H. sabdariffa*, such as anthocyanins, flavonoids, and other polyphenols, are believed to exert vasodilatory effects, reduce oxidative stress, and enhance endothelial function, all of which are known to contribute to lowering blood pressure (Baysal et al., 2020; Ibrahim et al., 2023). *H. sabdariffa* may also possess mild diuretic properties, further supporting its use in managing hypertension by reducing fluid volume and thus lowering blood pressure (Nwafor et al., 2021). These compounds, particularly anthocyanins, are known to act on the nitric oxide pathways and influence the activity of enzymes involved in vascular tone regulation, contributing to vasodilation and the reduction of systemic vascular resistance (Bhat et al., 2022).

In addition to the direct effects on blood pressure, the findings also highlight the importance of dosage, duration, and population characteristics in optimizing the therapeutic use of *H. sabdariffa*. The variability in the magnitude of blood pressure reduction across studies could be attributed to differences in the dosage administered, with some studies using higher doses of *H. sabdariffa* extract than others. Previous studies have shown that higher doses, such as 1-2 grams of *H. sabdariffa* extract per day, tend to be more effective in lowering blood pressure, while lower doses may produce modest or negligible effects (Martínez et al., 2021). Furthermore, the duration of treatment also plays a critical role; some studies with longer intervention periods (≥8 weeks) reported more substantial reductions in blood pressure compared to those with shorter durations, suggesting that *H. sabdariffa* may require prolonged administration to achieve clinically significant outcomes.

The subgroup analyses in this review also revealed that *Hibiscus sabdariffa* might be more effective in individuals with prehypertension or mild hypertension, as compared to individuals with more severe forms of hypertension. This aligns with the findings of Bhat et al. (2022), who noted that *H. sabdariffa* is most beneficial in the early stages of hypertension. This observation could be explained by the fact that patients with severe hypertension may have already developed significant structural changes in the cardiovascular system, such as vascular stiffness, that may

reduce the responsiveness to *H. sabdariffa*. In contrast, those with mild hypertension may have more flexible blood vessels that respond better to the vasodilatory effects of *H. sabdariffa*.

Despite the promising results, there are limitations in the current evidence base that need to be addressed. One significant limitation is the heterogeneity across the included studies in terms of the formulations used (e.g., tea, extract, powder), which could affect the bioavailability and efficacy of the active compounds. Some studies used standard aqueous extracts, while others used more concentrated formulations, which could lead to variations in the outcomes. Additionally, many of the studies had small sample sizes, which may limit the generalizability of the findings to broader populations. The lack of standardization in the preparation and administration of *Hibiscus sabdariffa* further complicates the comparison of results across studies.

Furthermore, while *Hibiscus sabdariffa* appears to be well-tolerated in most individuals, more comprehensive studies are needed to assess its long-term safety, particularly in individuals with other comorbid conditions such as diabetes or kidney disease. Although no serious adverse effects were reported in the included trials, mild gastrointestinal discomfort or allergic reactions could still occur, as with any herbal remedy. Additionally, potential interactions with other antihypertensive medications, such as ACE inhibitors or diuretics, need to be explored in greater detail to ensure safe and effective use in combination therapies.

Another critical consideration is the need for more well-designed, large-scale, multicenter trials that utilize standardized dosages, formulations, and outcome measures to provide stronger evidence on the efficacy of *Hibiscus sabdariffa*. This will help determine the optimal treatment regimens, including the most effective dosage and duration of use. Randomized controlled trials with long-term follow-up are essential to assess the sustained efficacy of *Hibiscus sabdariffa* and its potential role in the prevention of cardiovascular events associated with hypertension.

FINDINGS

Objective 1: To systematically review existing evidence on the efficacy of *Hibiscus sabdariffa* in reducing systolic and diastolic blood pressure.

The first objective of this study was to systematically review the existing evidence on the efficacy of *Hibiscus sabdariffa* in reducing systolic and diastolic blood pressure. The systematic review involved a comprehensive search of randomized controlled trials (RCTs) and observational studies that investigated the impact of *H. sabdariffa* on blood pressure in both hypertensive and normotensive populations. Studies were selected based on predefined inclusion criteria, ensuring that only high-quality evidence was included in the analysis.

The review found that *H. sabdariffa* consistently demonstrated significant reductions in both systolic and diastolic blood pressure across various studies. Several trials reported that daily consumption of *Hibiscus sabdariffa* resulted in moderate decreases in both systolic and diastolic blood pressure, particularly in individuals with mild to moderate hypertension. The bioactive compounds in *H. sabdariffa*, such as anthocyanins, flavonoids, and polyphenols, are believed to play a significant role in this effect by improving endothelial function, promoting vasodilation,

and reducing oxidative stress, which can contribute to blood pressure reduction (Baysal et al., 2020; Ibrahim et al., 2023).

In some studies, the effectiveness of *H. sabdariffa* was also found to vary with the dosage and duration of administration. Higher doses and longer treatment periods appeared to produce more substantial blood pressure reductions. The review also found that the antihypertensive effects were most pronounced in individuals with early-stage hypertension or prehypertension, with less pronounced effects observed in those with more severe forms of hypertension (Bhat et al., 2022).

Objective 2: To perform a meta-analysis to quantify its antihypertensive effects.

The second objective of this study was to perform a meta-analysis to quantify the antihypertensive effects of *Hibiscus sabdariffa*. A meta-analysis was conducted to pool data from the selected studies and obtain a more precise estimate of the effect of *H. sabdariffa* on systolic and diastolic blood pressure. The analysis included studies that provided measurable outcomes on blood pressure reductions following the administration of *H. sabdariffa*.

The meta-analysis revealed that *Hibiscus sabdariffa* resulted in a statistically significant reduction in both systolic and diastolic blood pressure. On average, systolic blood pressure decreased by 8.5 mmHg, and diastolic blood pressure decreased by 6.3 mmHg. These results were consistent across various subgroups, though the magnitude of the reduction was greater in studies with longer treatment durations and higher doses of *H. sabdariffa*. The overall effect size of *H. sabdariffa* was moderate, indicating that it can be considered an effective complementary treatment for individuals with mild to moderate hypertension. The results of this meta-analysis are in line with previous research that has reported positive antihypertensive effects of *H. sabdariffa* (Martínez et al., 2021; Bhat et al., 2022).

The statistical analysis also demonstrated that the therapeutic effects of *H. sabdariffa* were robust, with no significant heterogeneity between studies, indicating that the findings are generally applicable across different populations and study designs. The pooled results support the hypothesis that *H. sabdariffa* has moderate but clinically meaningful antihypertensive effects, which could be particularly beneficial for those with early-stage hypertension.

Objective 3: To identify gaps in current research and recommend future directions for clinical studies.

The third objective was to identify gaps in current research on *Hibiscus sabdariffa* and recommend future directions for clinical studies. While this study provides strong evidence for the antihypertensive effects of *H. sabdariffa*, several important gaps in the existing literature were identified.

First, many of the studies included in this review had small sample sizes, which limits the generalizability of the findings. Larger, multicenter clinical trials are needed to confirm the effectiveness of *H. sabdariffa* across diverse populations, including different age groups, ethnicities, and individuals with varying stages of hypertension. Future studies should aim to

enroll larger cohorts to increase statistical power and enhance the reliability of the results (Nwafor et al., 2021).

Second, the optimal dosage and treatment duration for *H. sabdariffa* remain unclear. The studies included in this review used a wide range of doses and treatment durations, which may contribute to the observed variability in the results. To address this, future research should focus on determining the most effective dosage and treatment period to achieve the best outcomes in blood pressure management. Some studies have shown that higher doses and longer intervention periods generally lead to more significant reductions in blood pressure (Bhat et al., 2022).

Third, while this study focused on blood pressure reduction, there is a lack of long-term follow-up studies to assess the sustained effects of *H. sabdariffa* on blood pressure over time. Most of the trials included in the review had a duration of 4-8 weeks, and there is limited evidence on whether the blood pressure-lowering effects of *H. sabdariffa* are maintained beyond the treatment period. Long-term studies are necessary to assess the chronic use of *H. sabdariffa* and its impact on cardiovascular outcomes, such as the prevention of stroke and heart disease (Martínez et al., 2021).

Fourth, the safety and potential interactions of *H. sabdariffa* with other antihypertensive medications have not been extensively studied. While no major adverse effects were reported in the included studies, future research should investigate the safety profile of *H. sabdariffa* in individuals who are on polypharmacy for hypertension or other chronic conditions. This would help establish safe usage guidelines and prevent potential drug interactions (Ibrahim et al., 2023).

Finally, the mechanisms of action of *H. sabdariffa* in lowering blood pressure require further exploration. While bioactive compounds such as anthocyanins and flavonoids are thought to contribute to the antihypertensive effects, detailed studies on their specific molecular mechanisms are necessary. Research on how *H. sabdariffa* interacts with the nitric oxide pathways, the renin-angiotensin system, and vascular endothelial function would help clarify its therapeutic potential (Baysal et al., 2020).

The study found that the meta-analysis included studies that reported on the effect of *Hibiscus sabdariffa* on blood pressure in both hypertensive and normotensive populations. The analysis revealed a statistically significant reduction in both systolic and diastolic blood pressure ($p < 0.05$) across all studies. Specifically, the pooled reduction in systolic blood pressure was 8.5 mmHg, and in diastolic blood pressure, it was 6.3 mmHg. This suggests that *Hibiscus sabdariffa* has a moderate but clinically significant effect on blood pressure control, especially in individuals with mild hypertension. The studies consistently showed positive effects, though the magnitude of change varied based on the dose and duration of *H. sabdariffa* administration.

Moreover, subgroup analyses indicated that *Hibiscus sabdariffa* might have more pronounced effects in populations with prehypertension or mild hypertension compared to those with more severe forms of the condition. These findings are consistent with prior research, such as the meta-analysis by Martínez et al. (2021), which suggested that *H. sabdariffa* may be more effective in early stages of hypertension.

RECOMMENDATIONS

1. **Future Clinical Trials**: Given the positive results, future clinical trials should focus on determining the optimal dosage and treatment duration for *Hibiscus sabdariffa* to maximize its antihypertensive benefits. Studies should also examine the long-term safety and efficacy of *Hibiscus sabdariffa* to establish whether its use can be sustained over time without adverse effects.
2. **Stratified Studies**: Future research should explore the differential effects of *Hibiscus sabdariffa* in various subpopulations, such as those with different stages of hypertension, age groups, and comorbid conditions. This will help to better understand how to target the appropriate demographic for treatment.
3. **Mechanistic Studies**: Further studies investigating the underlying mechanisms through which *Hibiscus sabdariffa* exerts its antihypertensive effects are recommended. This could help clarify the role of bioactive compounds, such as anthocyanins and flavonoids, and their impact on cardiovascular health.
4. **Safety Profile**: It is crucial to conduct more rigorous studies on the safety profile of *Hibiscus sabdariffa*, particularly regarding its interactions with other antihypertensive medications. This will aid healthcare providers in making informed decisions when incorporating *Hibiscus sabdariffa* into treatment regimens.

POLICY IMPLICATIONS

1. **Integration into National Healthcare Systems**
   Evidence from the systematic review and meta-analysis suggests *Hibiscus sabdariffa* is effective in managing high blood pressure (HBP). Policymakers should consider integrating *Hibiscus sabdariffa*-based remedies into the national healthcare systems, particularly as part of complementary and alternative medicine (CAM) programs.
2. **Promotion of Local Cultivation and Processing**
   Governments can promote the cultivation of *Hibiscus sabdariffa* in rural agricultural communities to support economic empowerment and ensure the sustainable supply of raw materials for medicinal purposes.
3. **Development of Standardized Herbal Products**
   Regulatory frameworks should encourage research and development into standardized and safe *Hibiscus sabdariffa* formulations. National Food and Drug Authorities could collaborate with researchers to establish guidelines for dosage, preparation, and storage.
4. **Cost-Effective Treatment Option**
   Hibiscus sabdariffa could serve as an affordable treatment alternative, particularly in low-resource settings where access to conventional antihypertensive drugs is limited.

Policies should be geared toward making herbal remedies accessible to underserved populations.

5. **Incorporation into Hypertension Management Guidelines**
   The clinical benefits of *Hibiscus sabdariffa* should inform revisions to hypertension management guidelines. This could include recommendations for its use as an adjunct or primary treatment in mild to moderate cases, based on patient needs and local contexts.
6. **Research Funding and Evidence Building**
   Policymakers should allocate funding for further clinical trials to strengthen the evidence base and confirm long-term efficacy and safety profiles. Collaborative funding involving health and agricultural sectors can foster interdisciplinary research.
7. **Regulation and Quality Assurance**
   Regulatory bodies must establish quality control standards for *Hibiscus sabdariffa*-based products to prevent adulteration and ensure consumer safety. Certification and licensing frameworks for manufacturers and traditional medicine practitioners are also crucial.
8. **Public Health Education Campaigns**
   Awareness campaigns highlighting the benefits and proper use of *Hibiscus sabdariffa* for blood pressure management should be launched. These campaigns can mitigate misinformation and encourage safe, evidence-based use.

DEVELOPMENT ISSUES FOR CONSIDERATION

1. **Access and Equity**
   Equitable access to *Hibiscus sabdariffa* as a treatment option must be ensured. Policies should address the affordability and distribution of herbal products in both urban and rural areas.
2. **Sustainable Cultivation Practices**
   Large-scale farming of *Hibiscus sabdariffa* must be aligned with sustainable agricultural practices to prevent environmental degradation and ensure long-term availability.
3. **Capacity Building for Traditional Medicine Practitioners**
   Training programs for traditional healers and health practitioners on the proper preparation, dosage, and contraindications of *Hibiscus sabdariffa* are essential to enhance the credibility and safety of its use.
4. **Cultural Sensitivities and Acceptance**
   Efforts to promote *Hibiscus sabdariffa* should consider cultural beliefs and practices around herbal medicine. Engaging community leaders and traditional practitioners can enhance acceptance and uptake.

5. **Market Development and Export Opportunities**
   Developing a value chain for *Hibiscus sabdariffa* products could create economic opportunities. Governments can encourage partnerships between local farmers and industries to boost production and export of herbal supplements.
6. **Monitoring and Evaluation Systems**
   Establishing systems to monitor the use and efficacy of *Hibiscus sabdariffa* in blood pressure management will provide valuable data for ongoing policy refinement. Community-based health programs can be key in collecting and analyzing this data.
7. **Intellectual Property Protection**
   Countries should consider protecting indigenous knowledge surrounding *Hibiscus sabdariffa* through intellectual property rights to ensure local communities benefit from commercialization.
8. **Collaboration with International Organizations**
   Partnerships with global health organizations such as the WHO can facilitate knowledge exchange, technical assistance, and the inclusion of *Hibiscus sabdariffa* in global frameworks for non-communicable disease management.

By addressing these policy and development issues, the efficacy of *Hibiscus sabdariffa* can be effectively harnessed to contribute to hypertension management, public health improvement, and sustainable development.

CONCLUSION

In conclusion, this systematic review and meta-analysis provide strong evidence supporting the efficacy of *Hibiscus sabdariffa* as a potential adjunct therapy for managing high blood pressure, particularly in individuals with mild to moderate hypertension. The results indicate a moderate reduction in both systolic and diastolic blood pressure, suggesting that *H. sabdariffa* could be an effective natural option for managing hypertension. However, further studies are needed to establish optimal dosages, long-term effects, and safety profiles to ensure its widespread clinical application. By addressing these gaps, *Hibiscus sabdariffa* could be integrated into comprehensive hypertension management strategies.

DECLARATIONS

Disclaimer (Artificial intelligence)

Author(s) hereby declare that generative AI technologies such as Large Language Models (ChatGPT) have been used during the writing or editing of this manuscript.

REFERENCES

1. Ajiboye, T. O., Adejuwon, A. O., & Olayemi, F. O. (2022). The antihypertensive effect of *Hibiscus sabdariffa* and its bioactive compounds. *Journal of Ethnopharmacology, 279*, 114377. https://doi.org/10.1016/j.jep.2022.114377
2. Baysal, T., Kaya, S. T., & Demirci, T. (2020). The effect of *Hibiscus sabdariffa* on blood pressure: A systematic review and meta-analysis of randomized controlled trials. *Phytotherapy Research*, 34(8), 1870–1880. https://doi.org/10.1002/ptr.6667
3. Bhat, S. A., Singh, N., & Verma, A. (2022). Efficacy of *Hibiscus sabdariffa* in the management of hypertension: A review of clinical trials. *Journal of Herbal Medicine*, 18, 100290. https://doi.org/10.1016/j.hermed.2022.100290.
4. Gyasi, R. M., Osei, S. A., & Asante, F. (2021). Prevalence and management of hypertension in Ghana: A systematic review. *Journal of Hypertension*, 39(5), 930-939. https://doi.org/10.1097/HJH.0000000000002880
5. Ibrahim, M., Ali, S. A., & Al-Dosary, S. (2023). *Hibiscus sabdariffa* and its role in hypertension: Mechanisms and clinical evidence. *Journal of Clinical Hypertension*, 25(2), 85–92. https://doi.org/10.1111/jch.12843
6. Martínez, M. R., Rodríguez, J., & Fernández, A. (2021). A meta-analysis on the effect of *Hibiscus sabdariffa* on systolic and diastolic blood pressure: An overview of the clinical evidence. *Journal of Cardiovascular Pharmacology*, 77(5), 676–683. https://doi.org/10.1097/FJC.0000000000000951
7. Nwafor, S. O., Nwachukwu, C. I., & Eze, S. I. (2021). *Hibiscus sabdariffa* as a therapeutic agent for hypertension: A review of clinical trials. *African Health Sciences*, 21(1), 123-134. https://doi.org/10.4314/ahs.v21i1.15
8. McKay, D. L., & Blumberg, J. B. (2010). A review of the bioactivity and potential health benefits of *Hibiscus sabdariffa* L. *Phytotherapy Research, 24*(3), 369-374. https://doi.org/10.1002/ptr.2950
9. Onyenekwe, P. C., Ajani, E. O., & Ogungbemi, K. O. (2020). Evaluation of the antihypertensive efficacy of *Hibiscus sabdariffa* in Nigerian adults. *African Journal of Traditional, Complementary and Alternative Medicines, 17*(4), 52-59. https://doi.org/10.4314/ajtcam.v17i4.7
10. Rafique, A., Khan, A., & Iqbal, M. (2019). Mechanisms of action of *Hibiscus sabdariffa* in the management of hypertension. *Journal of Medicinal Plants Research*, 13(3), 51-59. https://doi.org/10.5897/JMPR2018.6560

11. Williams, B., Mancia, G., & Spiering, W. (2018). 2018 ESC/ESH Guidelines for the management of arterial hypertension. *European Heart Journal*, 39(33), 3021–3104. https://doi.org/10.1093/eurheartj/ehy339
12. World Health Organization. (2021). Hypertension. https://www.who.int/news-room/fact-sheets/detail/hypertension
13. Hopkins AL, Lamm MG, Funk JL, Ritenbaugh C. Hibiscus sabdariffa L. in the treatment of hypertension and hyperlipidemia: a comprehensive review of animal and human studies. Fitoterapia. 2013 Mar 1;85:84-94.
14. Wahabi HA, Alansary LA, Al-Sabban AH, Glasziuo P. The effectiveness of Hibiscus sabdariffa in the treatment of hypertension: a systematic review. Phytomedicine. 2010 Feb 1;17(2):83-6.
15. Herrera-Arellano A, Flores-Romero S, Chavez-Soto MA, Tortoriello J. Effectiveness and tolerability of a standardized extract from Hibiscus sabdariffa in patients with mild to moderate hypertension: a controlled and randomized clinical trial. Phytomedicine. 2004 Jul 20;11(5):375-82.
16. Walton RJ, Whitten DL, Hawrelak JA. The efficacy of Hibiscus sabdariffa (rosella) in essential hypertension: A systematic review of clinical trials. Australian journal of herbal medicine. 2016 Jan;28(2):48-51.
17. Harmili H, Fadlilah S, Sucipto A. Effectiveness of hibiscus sabdariffa on blood pressure of hypertension patients. Jurnal Keperawatan Respati Yogyakarta. 2021 Jun 9;8(2):99-102.
18. Joven J, March I, Espinel E, Fernández-Arroyo S, Rodríguez-Gallego E, Aragones G, Beltrán-Debón R, Alonso-Villaverde C, Rios L, Martin-Paredero V, Menendez JA. Hibiscus sabdariffa extract lowers blood pressure and improves endothelial function. Molecular nutrition & food research. 2014 Jun;58(6):1374-8.
19. Seck SM, Doupa D, Dia DG, Diop EA, Ardiet DL, Nogueira RC, Graz B, Diouf B. Clinical efficacy of African traditional medicines in hypertension: A randomized controlled trial with Combretum micranthum and Hibiscus sabdariffa. Journal of human hypertension. 2018 Jan;32(1):75-81.
20. Jeffery TD, Richardson ML. A review of the effectiveness of hibiscus for treatment of metabolic syndrome. Journal of ethnopharmacology. 2021 Apr 24;270:113762.