



Antiuro lithiatic Potential of Medicinal Plants: An Overview of Polyherbal Remedies and Scientific Investigations

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ABSTRACT

Urolithiasis, the formation of stones in the urinary tract, remains a prevalent and recurring urological disorder worldwide. Conventional therapies, including surgical intervention and chemotherapeutic agents, often pose challenges such as recurrence, high cost, and adverse effects. In recent years, growing attention has been directed towards exploring medicinal plants as safer, effective, and affordable alternatives for managing and preventing urolithiasis. Numerous ethnobotanical surveys and pharmacological studies have identified a wide array of plant species with antiuro lithiatic activity. These medicinal plants exert their therapeutic effects through various mechanisms, including inhibition of crystal nucleation, growth, and aggregation, diuretic action, antioxidant activity, and modulation of urinary constituents. Several plant families, particularly Lamiaceae, Zingiberaceae, Fabaceae, Phyllanthaceae, and Apocynaceae, have demonstrated significant antiuro lithiatic potential across multiple studies. Their members are frequently reported to possess key phytoconstituents such as flavonoids, saponins, alkaloids, and tannins, which contribute to their litholytic, diuretic, and renal protective effects. This review compiles a comprehensive account of single and polyherbal formulations that have been scientifically investigated through in vitro, in vivo, and clinical studies. A significant number of studies demonstrate that polyherbal formulations exhibit synergistic actions and superior efficacy in dissolving or preventing the formation of urinary calculi. The review also highlights experimental models used for evaluating antiuro lithiatic potential and discusses the pharmacognostic basis of traditional remedies. While preclinical findings are promising, clinical validation and standardization of herbal therapies are crucial for their successful integration into mainstream urolithiasis management. This article underscores the therapeutic promise of plant-based remedies and encourages further interdisciplinary research into their pharmacological efficacy and safety profiles.

Keywords: Urolithiasis, Antiuro lithiatic activity, Medicinal plants, Polyherbal formulations, Phytoconstituents

INTRODUCTION

Urolithiasis, commonly referred to as kidney stone disease, is a widespread and recurrent urological condition characterized by the formation of calculi or stones within the urinary tract (figure 1). [1]

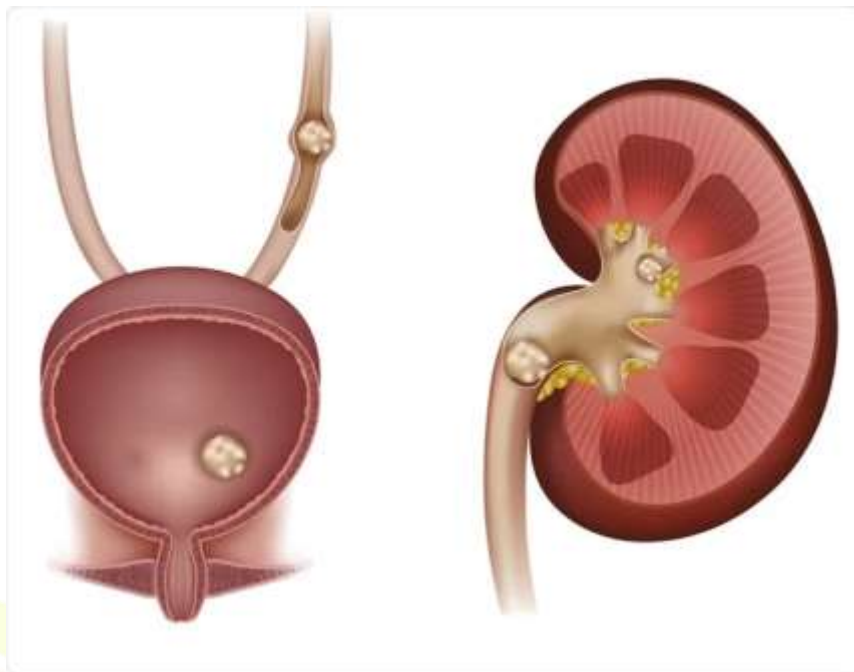


Figure 1: Urolithiasis [Kidney Stone]

These stones are typically composed of crystalline aggregates of minerals such as calcium oxalate, calcium phosphate, uric acid, and struvite. Globally, urolithiasis affects approximately 10–15% of the population, with a higher prevalence in males than females and an increasing incidence in industrialized countries due to dietary and lifestyle changes. The disease not only imposes a significant healthcare burden but also affects the quality of life of patients due to pain, hematuria, urinary obstruction, and the potential for long-term renal impairment.[2]

The pathogenesis of urolithiasis is complex and multifactorial, involving genetic predisposition, environmental influences, dietary habits, metabolic disorders, and urinary tract infections. Despite advances in understanding the disease, its prevention and management remain a challenge due to high recurrence rates and the limitations of existing therapeutic strategies. Conventional treatments such as extracorporeal shock wave lithotripsy (ESWL), ureteroscopy, and pharmacotherapy, though effective in symptom management and stone removal, often do not address the underlying biochemical imbalances and are associated with complications and high costs.[3]

Given these limitations, there has been a growing interest in alternative and complementary therapeutic approaches, especially the use of medicinal plants with antiurolithiatic properties. Traditional systems of medicine, such as Ayurveda, Traditional Chinese Medicine, and Unani, have long utilized plant-based remedies for the prevention and treatment of urinary stones. These herbal interventions are believed to exert multiple beneficial effects including diuresis, stone dissolution, inhibition of crystal aggregation, and correction of metabolic abnormalities.

Recent scientific investigations have begun to validate the efficacy of these traditional remedies, leading to the exploration of single herbs and polyherbal formulations for their potential roles in urolithiasis management. A better understanding of the phytoconstituents involved and their mechanisms of action may provide a basis for the development of safe, cost-effective, and holistic therapeutic agents. This review aims to provide an overview

of the pathophysiology of urolithiasis, the limitations of current therapies, and the emerging role of medicinal plants and their bioactive compounds in managing this condition.[4]

PATHOPHYSIOLOGY OF UROLITHIASIS

Urolithiasis develops when there is a disruption in the homeostasis of urine components, resulting in supersaturation, nucleation, crystal growth, aggregation, and retention of insoluble salts within the urinary tract. These processes are influenced by a complex interplay of physicochemical, metabolic, and anatomical factors.[5]

The most common types of urinary stones include:

- **Calcium stones:** Primarily composed of calcium oxalate and calcium phosphate; account for approximately 80% of all kidney stones.
- **Uric acid stones:** Formed due to acidic urine and hyperuricemia; more prevalent in individuals with gout or metabolic syndrome.
- **Struvite stones:** Associated with infections by urease-producing bacteria such as *Proteus mirabilis*; often found in women with recurrent urinary tract infections.
- **Cystine stones:** Result from a rare inherited disorder causing excessive excretion of cystine.[6]

Supersaturation and Crystallization: The initial event in stone formation is the supersaturation of urine with lithogenic ions such as calcium, oxalate, and phosphate. Supersaturation promotes the nucleation of crystals, which may occur spontaneously or be facilitated by existing crystal nuclei.

Crystal Growth and Aggregation: Once nucleated, crystals grow by accreting additional ions from the supersaturated urine. Aggregation of crystals into larger structures is a critical step in stone formation. Normally, inhibitors like citrate, magnesium, and glycosaminoglycans regulate this process by chelating calcium and preventing crystal aggregation.

Retention and Stone Formation: For stones to form, crystals must adhere to the renal epithelium and evade clearance by urinary flow. Randall's plaques—calcium phosphate deposits at the papillary tips of the kidney—serve as anchoring sites for further crystal growth and stone development.[7]

Risk Factors: Numerous factors predispose individuals to stone formation, including:

- Dehydration and low fluid intake
- High dietary intake of oxalate, protein, and sodium
- Genetic predisposition (e.g., cystinuria, primary hyperoxaluria)
- Hyperparathyroidism and other endocrine disorders
- Obesity and insulin resistance
- Recurrent urinary tract infections[8]

LIMITATIONS OF CONVENTIONAL THERAPIES

Despite significant advances in diagnostic and therapeutic technologies, the management of urolithiasis continues to face several limitations. Conventional approaches include pharmacological interventions, surgical procedures, and lifestyle modifications. However, these methods often fall short in terms of long-term efficacy, cost, and patient compliance.[9]

1. Pharmacotherapy: Drugs such as thiazide diuretics, allopurinol, and potassium citrate are prescribed to prevent recurrence by reducing urinary concentrations of calcium, uric acid, or enhancing citrate excretion. While effective in some patients, these drugs are associated with side effects like hypotension, gastrointestinal disturbances, and metabolic imbalances. Moreover, pharmacotherapy rarely dissolves existing stones and is primarily preventive.

2. Surgical and Non-invasive Interventions: ESWL, percutaneous nephrolithotomy (PCNL), and ureteroscopy are commonly employed to remove stones. These procedures are effective for large or obstructive stones, but they do not prevent recurrence and may cause complications such as hematuria, infection, renal damage, and ureteral strictures. Furthermore, multiple sessions are often required, increasing patient burden and healthcare costs.

3. High Recurrence Rates: One of the most significant drawbacks of conventional therapy is the high recurrence rate of kidney stones, estimated at 30–50% within five years after initial stone formation. This necessitates ongoing monitoring, lifestyle adjustments, and repeated interventions.

4. Inaccessibility and Cost: In many low- and middle-income countries, advanced surgical interventions and specialized medications are not readily available. This highlights the need for affordable and accessible therapeutic alternatives.

5. Lack of Holistic Approach: Conventional medicine often focuses on symptomatic treatment and mechanical removal of stones without addressing the multifactorial etiology of urolithiasis. There is limited emphasis on correcting underlying metabolic or dietary imbalances.[10]

ROLE OF MEDICINAL PLANTS IN UROLITHIASIS MANAGEMENT

Medicinal plants have been used for centuries across various traditional systems of medicine for the treatment of urinary disorders, including urolithiasis. These natural remedies often consist of whole plants, extracts, or polyherbal formulations and are known for their multifaceted therapeutic properties.[11]

1. Historical and Traditional Use:

In Ayurveda, the term “Ashmari” refers to urinary calculi, and numerous herbs are indicated for its management, such as *Tribulus terrestris*, *Boerhaavia diffusa*, and *Crataeva nurvala*. Traditional Chinese Medicine employs formulations containing *Desmodium styracifolium* and *Pyrrosia lingua*. Unani and Siddha systems also describe various herbs with diuretic, litholytic, and anti-inflammatory actions.

2. Diversity of Plant Species:

A wide range of medicinal plants have been reported to possess antiurolithiatic properties. Some notable examples include:

- *Phyllanthus niruri*: Known for inhibiting crystal formation and promoting stone expulsion.
- *Bergenia ligulata*: Contains bergenin, a potent litholytic agent.
- *Didymocarpus pedicellata*: Frequently used in polyherbal formulations.
- *Hordeum vulgare* and *Zea mays*: Traditionally used as diuretics.

3. Polyherbal Formulations:

Many commercial and traditional polyherbal formulations have gained popularity due to their synergistic effects. Examples include Cystone®, Calcury®, and Neeri®, which combine multiple herbs to exert diuretic, antimicrobial, and crystallization-inhibiting effects.

4. Advantages over Conventional Therapy:

Medicinal plants offer several benefits:

- Fewer side effects
- Availability and affordability
- Holistic action addressing multiple aspects of disease
- Potential for long-term use and prevention

5. Scientific Validation:

Modern pharmacological studies, both in vitro and in vivo, have begun to validate the antiurolithiatic efficacy of various herbs. These studies support traditional claims and pave the way for developing standardized herbal formulations.

The growing interest in phytotherapy is driven by the need for safer, more accessible, and sustainable alternatives to conventional treatments.[12, 13]

MECHANISMS OF ANTIUROLITHIATIC ACTION OF PHYTOCONSTITUENTS

Medicinal plants exhibit antiurolithiatic activity through diverse mechanisms attributed to their complex array of phytochemicals. These mechanisms target different stages of stone formation and help in both treatment and prevention.[14]

1. Inhibition of Crystal Nucleation and Growth:

Many plant extracts contain polyphenols, flavonoids, and saponins that interfere with the initial stages of stone formation by inhibiting crystal nucleation, growth, and aggregation. For instance, flavonoids in *Phyllanthus niruri* have been shown to disrupt calcium oxalate crystal formation.

2. Chelation of Stone-forming Ions:

Some phytoconstituents act as chelating agents, binding to calcium or oxalate ions and reducing supersaturation. Citric acid from *Citrus* species binds calcium, preventing calcium oxalate precipitation.

3. Diuretic Activity:

Many antiurolithiatic plants possess strong diuretic properties, which help flush out small crystals and reduce urinary stasis. Diuretics also dilute urinary solutes, lowering the risk of supersaturation. *Boerhaavia diffusa*, *Equisetum arvense*, and *Coriandrum sativum* are known for this property.

4. Antioxidant and Anti-inflammatory Effects:

Oxidative stress and inflammation play a role in renal epithelial damage, promoting crystal adherence. Antioxidants like quercetin, kaempferol, and ascorbic acid scavenge free radicals, protecting renal tissues. Anti-inflammatory effects also reduce renal injury, thereby inhibiting crystal retention.

5. Litholytic Activity:

Some phytoconstituents can dissolve existing calculi. Berberin from *Berberis ligulata* and potassium-rich herbal extracts have shown litholytic potential in experimental models.

6. Modulation of Urinary pH:

Alkalinizing or acidifying effects of certain plant extracts help in dissolving uric acid or cystine stones. Herbs like *Punica granatum* and *Tribulus terrestris* influence urinary pH favorably.

7. Antimicrobial Properties:

Urease-inhibiting and antibacterial effects are especially useful in preventing struvite stones. Herbal agents like *Azadirachta indica* and *Ocimum sanctum* help in controlling infections that predispose to stone formation.

8. Correction of Metabolic Abnormalities:

Herbal formulations have also demonstrated efficacy in correcting hyperoxaluria, hypercalciuria, and hypocitraturia, thereby addressing the root causes of urolithiasis.

These mechanisms often work in a synergistic manner, particularly in polyherbal combinations, providing a broad-spectrum and holistic approach to managing urolithiasis. Continued research is needed to isolate, standardize, and optimize these bioactive constituents for clinical application.[15, 16]

OVERVIEW OF SINGLE MEDICINAL PLANTS WITH ANTIUROLITHIATIC ACTIVITY

Numerous medicinal plants have been traditionally used and scientifically explored for their antiurolithiatic properties (figure 2, table 1). These single herbs are often chosen for their known pharmacological profiles, ethnomedicinal relevance, and availability. Each plant typically contributes a unique mode of action such as diuresis, crystallization inhibition, or litholysis, thus making them valuable as monotherapies or components of polyherbal formulations.



Figure 2: Medicinal plants used for their antiurolithiatic properties ^[17]

Table 1: Summary of Medicinal Plants with Antiurolithiatic Potential: Botanical Information, Phytochemical Constituents, and Pharmacological Activities

S.No	Botanical Name (Family)	Chemical Constituents	Part Used	Pharmacological Activities
1	<i>Phyllanthus niruri</i> (Phyllanthaceae)	Phyllanthin, hypophyllanthin, lignans	Whole plant	Antiurolithiatic, antioxidant, diuretic, anti-inflammatory
2	<i>Bergenia ligulata</i> (Saxifragaceae)	Bergenin, gallic acid, catechin	Rhizome	Litholytic, antioxidant, urinary alkalizer
3	<i>Tribulus terrestris</i> (Zygophyllaceae)	Protodioscin, saponins, flavonoids	Fruit	Diuretic, antispasmodic, crystallization inhibitor
4	<i>Boerhaavia diffusa</i> (Nyctaginaceae)	Punarnavine, rotenoids, alkaloids	Root	Diuretic, anti-inflammatory, crystallization inhibitor
5	<i>Crataeva nurvala</i> (Capparaceae)	Lupeol, crataepoxide, saponins	Bark	Litholytic, anti-inflammatory, bladder tonic
6	<i>Didymocarpus pedicellata</i> (Gesneriaceae)	Saponins, tannins, flavonoids	Whole plant	Antiurolithiatic, renal protective, anti-inflammatory
7	<i>Aerva lanata</i> (Amaranthaceae)	Alkaloids, flavonoids, β -sitosterol	Whole plant	Diuretic, crystallization modulator, anti-inflammatory
8	<i>Cynodon dactylon</i> (Poaceae)	Flavonoids, triterpenoids, glycosides	Whole plant	Diuretic, antioxidant, anti-inflammatory
9	<i>Ocimum sanctum</i> (Lamiaceae)	Eugenol, ursolic acid, flavonoids	Leaves	Antioxidant, antimicrobial, antiurolithiatic
10	<i>Coleus aromaticus</i> (Lamiaceae)	Carvacrol, thymol, flavonoids	Leaves	Antiurolithiatic, antimicrobial, anti-inflammatory
11	<i>Biophytum sensitivum</i> (Oxalidaceae)	Flavonoids, tannins, saponins	Whole plant	Diuretic, antioxidant, antiurolithiatic
12	<i>Buchanania lanzan</i>	Alkaloids, flavonoids,	Leaves/Fruit	Antioxidant, anti-

	(Anacardiaceae)	saponins		inflammatory, litholytic
13	<i>Carica papaya</i> (Caricaceae)	Papain, flavonoids, alkaloids	Leaves/Seeds	Diuretic, urinary tract cleanser, anti-inflammatory
14	<i>Cyperus rotundus</i> (Cyperaceae)	Essential oils, flavonoids, terpenoids	Rhizome	Antioxidant, diuretic, nephroprotective
15	<i>Dendrophthoe falcata</i> (Loranthaceae)	Tannins, flavonoids, saponins	Leaves	Diuretic, antiurolithiatic
16	<i>Elettaria cardamomum</i> (Zingiberaceae)	Essential oils (cineole), flavonoids	Seeds	Diuretic, anti-inflammatory, renal protective
17	<i>Eleusine coracana</i> (Poaceae)	Polyphenols, dietary fiber, flavonoids	Seeds	Antioxidant, nephroprotective, reduces oxalate
18	<i>Gymnema sylvestre</i> (Apocynaceae)	Gymnemic acids, flavonoids	Leaves	Diuretic, anti-inflammatory, antiurolithiatic
19	<i>Hyoscyamus niger</i> (Solanaceae)	Tropane alkaloids, flavonoids	Seeds/Leaves	Antispasmodic, analgesic, diuretic
20	<i>Ipomoea batatas</i> (Convolvulaceae)	Anthocyanins, flavonoids, beta-carotene	Tubers	Antioxidant, renal protective
21	<i>Jasminum auriculatum</i> (Oleaceae)	Flavonoids, glycosides	Leaves/Flowers	Diuretic, litholytic, antioxidant
22	<i>Kaempferia galanga</i> (Zingiberaceae)	Ethyl cinnamate, essential oils, flavonoids	Rhizome	Diuretic, anti-inflammatory, analgesic
23	<i>Macrotyloma uniflorum</i> (Fabaceae)	Flavonoids, phenolics, steroids	Seeds	Antiuro lithiatic, nephroprotective, diuretic
24	<i>Mallotus philippensis</i> (Euphorbiaceae)	Rottlerin, chalcones, flavonoids	Fruits/Glands	Diuretic, anti-inflammatory, antioxidant
25	<i>Melia azedarach</i> (Meliaceae)	Limonoids, flavonoids, tannins	Leaves/Fruits	Diuretic, litholytic, antimicrobial
26	<i>Moringa oleifera</i> (Moringaceae)	Flavonoids, glucosinolates, alkaloids	Leaves/Seeds	Nephroprotective, antioxidant, antiurolithiatic
27	<i>Nerium oleander</i> (Apocynaceae)	Oleandrin (cardiac glycoside), flavonoids	Leaves (toxic)	Antioxidant, nephroprotective (caution: toxic in high dose)
28	<i>Nervilia aragoana</i> (Orchidaceae)	Flavonoids, phenolics (limited data)	Whole plant	Antioxidant, traditional renal uses
29	<i>Parmelia perlata</i> (Parmeliaceae)	Usnic acid, lichen acids	Whole lichen	Diuretic, antioxidant, traditional antiurolithiatic agent
30	<i>Pedaliium murex</i> (Pedaliaceae)	Flavonoids, saponins, phytosterols	Fruit	Diuretic, lithotriptic, antiurolithiatic
31	<i>Rotula aquatica</i> (Boraginaceae)	Alkaloids, sterols, flavonoids	Root	Potent antiurolithiatic, diuretic, nephroprotective
32	<i>Strychnos potatorum</i> (Loganiaceae)	Strychnine, flavonoids, diterpenoids	Seeds	Antiuro lithiatic, nephroprotective, antioxidant

These single herbs represent the cornerstone of many traditional and modern therapeutic strategies for urolithiasis. Continued phytochemical analysis and mechanistic studies are vital for understanding and optimizing their clinical potential.[18, 19]

Over the past few decades, a surge in experimental research has aimed to validate the antiurolithiatic claims of medicinal plants. These studies range from in vitro assays assessing crystal inhibition to in vivo animal models evaluating stone prevention and dissolution.

1. In Vitro Models

In vitro studies are primarily employed to assess the capacity of plant extracts to inhibit nucleation, growth, and aggregation of crystals, especially calcium oxalate. For instance, ethanolic extract of *Phyllanthus niruri* significantly inhibits calcium oxalate crystallization in synthetic urine systems. Similarly, aqueous extracts of *Bergenia ligulata* and *Didymocarpus pedicellata* have demonstrated inhibition of crystal growth and adhesion to renal epithelial surfaces.[20]

2. In Vivo Animal Models

Ethylene glycol and ammonium chloride-induced urolithiasis models in rats are most commonly used. These agents cause hyperoxaluria and promote the deposition of calcium oxalate crystals in renal tissues, mimicking human urolithiasis. Several plant extracts have shown efficacy in these models:

- *Tribulus terrestris* extract significantly reduces calcium and oxalate excretion.
- *Boerhaavia diffusa* normalizes urinary pH and lowers serum creatinine and urea levels.
- *Aerva lanata* extract not only prevents stone formation but also protects against tubular damage.

Biochemical parameters (urine volume, calcium, oxalate, phosphate, magnesium) and histological analysis of kidney tissue are routinely used endpoints. Many herbs also demonstrate the ability to enhance antioxidant enzyme levels (e.g., SOD, catalase) and reduce lipid peroxidation in renal tissues, highlighting their nephroprotective potential.

3. Mechanistic Studies

Mechanistic insights from these studies reveal that phytochemicals such as flavonoids, saponins, alkaloids, and terpenes act through:

- Chelation of calcium ions
- Restoration of urinary citrate and magnesium levels
- Downregulation of stone-promoting proteins like osteopontin
- Upregulation of renal transporters involved in oxalate handling

4. Standardization and Quality Control

While these studies confirm efficacy, they also emphasize the need for standardized extract preparation. Variables such as plant part used, solvent type, and extraction duration significantly affect bioactivity. Hence, reproducibility and quality control are ongoing challenges in experimental herbal research.[21]

CLINICAL STUDIES ON HERBAL AND POLYHERBAL FORMULATIONS

Clinical validation is essential for transitioning herbal remedies from traditional use to mainstream therapeutics. Several herbal and polyherbal preparations have been subjected to clinical evaluation, with varying degrees of methodological rigor.

1. Monotherapy Trials

Small-scale clinical trials and observational studies have examined the effects of single herbs:

- *Phyllanthus niruri* was found to reduce the size and number of kidney stones over a 3-month period in patients with asymptomatic nephrolithiasis.
- *Bergenia ligulata* has been reported to improve urinary flow and reduce pain in patients with small calculi.

These trials often rely on ultrasonographic or radiographic evidence of stone reduction, along with improvements in urinary biochemical profiles.

2. Polyherbal Formulations

Several commercially available polyherbal formulations have undergone clinical assessment:

- **Cystone®** (containing *Didymocarpus pedicellata*, *Saxifraga ligulata*, *Rubia cordifolia*, etc.) has demonstrated efficacy in promoting spontaneous passage of stones and preventing recurrence.
- **Neeri®** and **Calcury®**, widely used in South Asia, have shown improvement in urinary parameters, pain reduction, and stone dissolution over 4–6 week treatment periods.

3. Observational and Retrospective Studies

Longitudinal cohort studies have indicated a reduction in recurrence rates and symptomatic relief with the use of polyherbal remedies in combination with lifestyle interventions. However, the lack of placebo control, randomization, and blinding limits the conclusiveness of these studies.

4. Safety and Tolerability

Most herbal formulations have shown good tolerability with minimal adverse effects reported. Mild gastrointestinal discomfort and allergic reactions are the most common side effects noted. No significant hepatotoxicity or nephrotoxicity has been reported in short-term usage.

5. Limitations of Current Clinical Evidence

Despite promising results, clinical trials on herbal therapies often suffer from:

- Small sample sizes
- Short duration
- Lack of standardization
- Inconsistent outcome measures

Robust randomized controlled trials (RCTs) with standardized extracts and validated endpoints are needed to establish their clinical efficacy.[22]

CHALLENGES AND FUTURE PROSPECTS IN HERBAL UROLITHIASIS THERAPY

Despite increasing interest and promising preclinical and clinical findings, several challenges hinder the mainstream adoption of herbal medicines in urolithiasis management.[23]

1. Lack of Standardization and Quality Control

Variability in phytochemical composition due to differences in cultivation, harvesting, and processing practices makes it difficult to ensure consistency across batches. Standardization of bioactive markers and validated extraction methods is essential.

2. Regulatory Barriers

Herbal products often fall under dietary supplement categories, resulting in less stringent regulatory oversight compared to pharmaceuticals. This raises concerns about quality, efficacy, and safety.

3. Limited Clinical Data

As highlighted earlier, the scarcity of large, multicentric, and well-controlled clinical trials limits the evidence base for regulatory approval and clinical recommendations.

4. Integration into Conventional Medicine

There is a need for more collaborative approaches between traditional practitioners, researchers, and clinicians to develop evidence-based integrative protocols that include herbal medicine.

5. Bioavailability and Pharmacokinetics

Many phytochemicals suffer from poor bioavailability, limiting their therapeutic potential. Advances in formulation technology such as nanoencapsulation, phytosomes, and herbal-drug conjugates may help enhance systemic delivery.

6. Intellectual Property and Biopiracy Issues

Ethnobotanical knowledge is often exploited without fair compensation to indigenous communities. Ensuring ethical sourcing, benefit sharing, and acknowledgment of traditional knowledge systems is crucial.

Future prospects:

- Development of standardized, single or polyherbal antiurolithiatic products with known mechanisms of action
- Application of systems biology and omics technologies to elucidate herbal effects
- Integration of herbal medicine into clinical guidelines with appropriate regulatory support
- Promotion of cross-disciplinary research networks to bridge traditional and modern medicine. [24, 25]

CONCLUSION

Urolithiasis remains a significant health challenge due to its high prevalence, recurrence, and limitations of conventional treatments. Medicinal plants offer a promising avenue for both prevention and management, thanks

to their multifactorial actions including diuretic, litholytic, anti-inflammatory, and antioxidant properties. Traditional knowledge, supported by emerging scientific evidence, points toward the effectiveness of both single herbs and polyherbal formulations.

Experimental and clinical investigations have substantiated the role of herbs such as *Phyllanthus niruri*, *Bergenia ligulata*, *Tribulus terrestris*, and *Boerhaavia diffusa* in modifying lithogenic risk factors and promoting stone expulsion. Polyherbal formulations have shown efficacy in reducing stone burden and preventing recurrence with minimal side effects.

However, to fully realize the therapeutic potential of these remedies, challenges such as lack of standardization, insufficient clinical data, and regulatory ambiguities must be overcome. Future efforts should focus on integrating herbal medicine with modern clinical practice through robust scientific validation, innovative formulation strategies, and ethical research practices.

ACKNOWLEDGEMENTS

The authors wish to acknowledge the contributions of researchers, herbalists, and clinicians whose work has enriched the understanding of antiurolithiatic medicinal plants. We also express gratitude to the institutions and laboratories that supported the research and documentation of traditional knowledge.

CONFLICTS OF INTEREST

The authors declare no conflicts of interest related to the content of this review.

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