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A Review on Phytochemical Constituents and Anti-Urolithic Activity of Medicinal Plants

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Abstract

Urolithiasis remains a significant global health burden, characterized by the recurrent formation of crystalline calculi within the urinary tract. Despite advancements in lithotripsy and surgical interventions, these methods often fail to prevent recurrence and are associated with substantial costs. This review synthesizes current knowledge on medicinal plants as sustainable alternatives for the management of kidney stones. It explores the diverse phytochemical profiles of ethnomedicinal species, emphasizing the roles of alkaloids, flavonoids, tannins, and saponins. These bioactive compounds exert anti-urolithiatic effects through multi-targeted mechanisms, including the inhibition of calcium oxalate (CaOx) nucleation, crystal growth, and aggregation, alongside potent diuretic and antioxidant activities. By examining both in vitro dissolution assays and in vivo rodent models, this paper highlights the synergistic potential of herbal formulations in mitigating oxidative stress and renal tissue damage. The findings underscore the necessity for standardized clinical trials to transition traditional botanical knowledge into evidence-based phytotherapies.

Keywords; Urolithiasis, Medicinal Plants, Anti-Urolithiatic Activity, Phytochemicals, Calcium Oxalate Inhibition, Herbal Therapy.

INTRODUCTION

Medicinal plants are an important herbal remedy of indigenous medical systems in India as well as in other countries. These beneficial sources are usually regarded as part of a culture's 'traditional' knowledge (Mishra et al., 2025). Ethnobotanical plants comprise of complex mixtures of phyto-constituents that may be obtained from any raw or processed part of a plant. Over 13,000 plants have been examined for various diseases and disorders worldwide over the last few years. Urinary stone disease (urolithiasis) is a chronic, recurrent metabolic disease characterized by the presence of stones in the urinary system, primarily in the kidney, bladder, and urinary tract. The primary cause of urolithiasis is a metabolic disorder that results in the formation of insoluble salts, leading to the formation of stones. The number of stones and their accession can be most of the time, different. Occasionally, urolithiasis and nephrolithiasis are regarded as the same terms, but nephrolithiasis can be called only the stones in the kidney, not in the other parts of the urinary system. Kidney stones are common ailments that affect people worldwide. Urolithiasis or nephrolithiasis as kidney stones are the third most prevailing disorder of the urinary tract and nearly 80% of these calculi are made up of calcium oxalate (CaOx). Crystal formation, particularly of calcium phosphate (CaP) and CaOx, within the urinary tract is widespread.

Humans excrete millions of urinary crystals daily indicating at least transient development of supersaturation. However, few develop kidney stones, probably because either the crystals do not form in the kidneys or the crystals that form do not stay there. The physiochemical mechanisms of stone formation via precipitation, growth, aggregation, and concretion of various lithogenic salts in urine are still in dispute. Crystals can be retained at many sites in the kidneys and undergo the size-enhancing process of growth and aggregation. In order for stones to be formed, not only do crystals need to be retained within the kidney, but they must be located at sites from which crystals can cause ulceration at the papillary surface to form a stone nidus (Roy et al., 2025). The most important reason for the failure in the development of the anti-urolithiatic drug is due to the involvement of multiple mechanisms in the pathogenesis of urolithiasis. Multiple constituents are possessed by plants that works in a synergistic manner in different stages of urolithiasis with no or less side effects and are available to a large population (More et al., 2025). Hence, compounds with properties such as antioxidant, anti- inflammatory and antispasmodic are an obvious choice for the development of antiurolithiatic drugs. Unlike allopathic medicines which majorly target only one aspect of urolithiatic pathophysiology, most of the plant-based therapies have been shown to be effective at different stages of stone pathophysiology.

Traditional medicinal plants

The advertised composite herbal formulations, Cystone (Himalaya Drug Company, India), Calcuri (Charak Pharmaceuticals, Bombay, India) and Chandraprabhabati (Baidyanath, India) have been broadly utilized clinically to break down urinary calculi in the kidney and urinary bladder. Pharmacological and clinical examinations completed on a composite natural plan, Trinapanchamool comprising of five herbal medications to be specific Desmostachyabipinnata, Saccharum officinarum, Saccharum nunja, Saccharum spontaneum and Imperatacylindrica was seen as compelling both as prophylactic in forestalling the arrangement and as remedial in dissolving the pre-shaped stones in rodents (albino rats) (Prasad et al., 2025). The anti-urolithiatic movement of this definition has been credited to its diuretic action. List of some chosen plants which have been utilized for the treatment of urolithiasis is given in Table 1.

Table 1: Plants have potential to work as anti-urolithiatic agent with specific parts and uses.

Botanical Names	Common names	Part use	Folk use
Abutilon indicum	Atibalaa	Leaf and Root	Cure urinary problems: used as diuretic.
Achyranthes asper L.	Apamarga	Leaf and Seeds	Luteolytic property to cure urolithiasis
Adiantum capillus-veneris L.	Samalpatti	Leaf	Luteolytic properties and helps in menstruation problems. Leaves powder with Luke-warm water twice a day is beneficial in calculus.
Aerva lanata	Weed, Kapoor Madhuri	Roots	Decrease urinary calcium oxalate uric acid, phosphorus excretion, diuretic
Adiantum venustum D. Don	Hansraj	Leaf	Leaves powder with Luke water twice a day as a diuretic.
Artemisia arborescens L.	Green ginger, vilayati	Whole plant	Luteolytic property and diuretic

LITERATURE REVIEW

(Nandhini & Thiripurasundari, 2023) investigate the effect of aqueous extract of Kalanchoe pinnata leaves on in-vitro urolithiasis. Since most of phytochemical compounds are extracted in water, the objective of the present study was to evaluate the diversity of phyto-constituents present in the extract and to determine the in-vitro anti-urolithiatic potential of aqueous extract of leaves of K. Pinnata for the use of these plants in traditional systems of medicine. Phytochemical screening of aqueous extract of Kalanchoe pinnata was analysed for understanding the phytochemicals present in the extract. The test result indicates that the presence of Phenols, Tannins, Carbohydrates, Flavonoids, Alkaloid, Protein, Triterpenoids, Steroids and Phytosteroids in the aqueous extract of pinnata. In this study, calcium oxalate was also prepared as per the standard protocol and the synthesized calcium oxalate was used for the analysis of anti-urolithiatic potential of the aqueous extract of K. pinnata. Anti-urolithiatic potential of the aqueous extract of K. pinnata was analysed. The result indicates more potency in dissolution of calcium oxalate crystals. Hence the present study demonstrates a significant anti-urolithiatic potential of

the aqueous extract of K. pinnata. Hence, the aqueous extract of K. pinnata may be used for the isolation of anti-urolithiatic compound for commercialization.

(Khan & Khan, 2022) Background: Epidemiological studies indicate a surge in stone disease across the globe and climate change is making it worse. Current treatments for stones are expensive and not easily available to all people in all countries. These treatment options include herbal medicines, acupuncture, alkaline liquids, and others. Herbs being easily available at a relatively lower costs are most commonly used alternative medicines for stone disease. This interest has led to several in vivo and in vitro experimental scientific studies to understand the efficacy of herbs in reducing stone formation, however, the clinical data is limited. We recently performed systematic review of publications dealing with antiurolithic activities of various herbal treatments in rat models of calcium oxalate (CaOx) urolithiasis. A total of 55 eligible clinical studies were retrieved from PubMed indexed with the (Mesh Term) “Urolithiasis” AND “Complementary Therapies/Alternative Medicine, “Urolithiasis” AND “Plant Extracts” and “Urolithiasis” AND “Traditional Medicine”. Further screening resulted in the inclusion of 15 studies. Reduction in stone size, their number, and easy passage were considered favorable outcomes. According to our review of literature, scientific evidence of efficacy of herbal treatments is so far insufficient, but promising, underlining the importance of well-planned and well-defined clinical trials.

(Arya et al., 2024) Urolithiasis, commonly known as kidney stone disease, is a prevalent and painful condition resulting from the formation of calculi in the urinary system. This review aims to elucidate the antiurolithiatic properties of medicinal plants, focusing on urolithiasis and stone formation mechanisms. The ethnopharmacological approaches to managing kidney stones highlight the historical and cultural significance of using medicinal plants. Focusing on the ethnobotanical practices in Uttarakhand, it provides a comprehensive list of plants traditionally employed for kidney stone treatment. Specific emphasis is given to the medicinal plants of prime importance, detailing their phytochemical properties and therapeutic efficacy. Furthermore, it reviews global studies on kidney stone treatment, emphasizing pharmacological research and clinical evidence supporting the use of these plants. The interrelation between urolithiasis and non-communicable diseases, such as heart disease, is explored to underline the broader health implications.

(Desai et al., 2017) Eleusine indica L. Gaertn also known as wire grass belonging to family poaceae. The plant is used for deworming, eliminate or reduce cough and lung troubles, dysentery, heart problems and high blood pressure, spleen and liver complaints, bladder and kidney stone and in case of sprains, dislocation of bones and lumbago. The plant contains cyanogenetic glucoside, albuminoids, starch, fatty oils, phenolic compounds and flavonoids. The present investigation was carried out to isolate, purify and characterize active constituents from the whole plant of Eleusine indica L. Gaertn. Powdered material of whole plant of Eleusine indica L. Gaertn was taken for the preparation of extracts using soxhlet apparatus. The various phytochemical tests were performed for alkaloids, glycosides, phenolic, flavonoids etc. TLC and HPTLC were done for isolation of compounds. The isolated compounds were further characterized by FTIR, Ultraviolet spectroscopy and GC-MS. The diuretic activity was evaluated by using in-vivo model and anti-urolithiatic activity was evaluated by using in-vitro model. In case of diuretic activity ethanol extract increase the total urine volume and total content of sodium, potassium and chloride ions in urine. In the case of antiurolithiatic activity ethanolic extract significantly dissolved the calcium oxalate stones. Thus ethanolic extract of whole plant of Eleusine indica L. Gaertn have significant diuretic and anti-urolithiatic activity.

(Rangasamy et al., 2019) The present study comprises preparation of hot crude plant extract from Clitoria ternatea L. blue flowered leaves and successive fractionation of the filtered extract using various solvents. During qualitative phytochemical analysis, all the fractions displayed all the phytocompounds tested such as alkaloids, flavonoids, phenols, tannins, sterols, saponins and terpenoids. All the fractions contained an adequate level of quantitatively determined secondary metabolites such as total phenols, flavonoids, terpenoids and tannins. All the fractions showed varied level of antioxidant activities assayed. Interestingly, among various fractions, n-butanol fraction only exhibited significant inhibition of nucleation, aggregation and growth of CaOx crystals. This may be due to significant free radical scavenging activities of this fraction for total antioxidant capacity, ABTS•+, nitric oxide and DPPH would further strengthen its use to ameliorate urolithiasis induced oxidative stress.

(Panda et al., 2024) Kidney stones are formed by the crystallization ofminerals and salts in the kidneys or urinary tract. Despite significant advances in the knowledge of pathophysiological etiology, therapeutic options remain

limited and often expensive. Herbal therapy for the treatment of kidney stones is gaining popularity as an alternative medication. The selected medicinal plants significantly showed antiurolithiasis activity in EG-induced rats. Histopathological studies demonstrate the better regeneration of glomeruli and very less structural damage in high-dose extracts whereas PHF has shown better results compared to individual high doses. These positive results might be the presence of a supportive phytochemicals group such as saponins, alkaloids, flavonoids and phenols. Hence, it can be concluded that the selected methanolic extracts of Nelumbo nucifera, Anogeissus latifolia, and Leucas aspera have significant antiurolithiasis activity in EG-induced rat model.

(Farooqui, 2024) In this present study, the antiurolithiatic potential in Cuminum cyminum was investigated through invitro assay. The work was performed by using invitro Anti-urolithiatic model for calculating percentage in comparison with standard drug cystone. The anti- urolithiatic properties were evaluated by titrimetric and turbidity assay. The result shows that for C. cyminum folds (55%) and for standard drug cystone (82%) for titrimetric assay. For turbidity assay. C. cyminum has significant properties (47.9±19%). The findings of the nucleation assay indicate that phytoconstituents inhibited the crystallization of CaOx in solution. The size and the number of calcium oxalate crystals decreased with increasing concentration upto 400µg of the phytoconstituents. The study concludes that the seed extracts of Cuminum cyminum have inhibitory effect on calcium oxalate for crystal nucleation. It also showed great efficacy in the dissolution of calcium oxalate crystals. Thus, this extract may be valuable resources for treatment of urolithiasis.

(Amari et al., 2023) The current investigation aimed to evaluate the medicinal use of E. arborea in Algeria's Bejaia region, and to examine the anti-urolithiatic, antibacterial, anti-inflammatory (in vivo), analgesic, and toxicity effects of E. arborea hydromethanolic extracts from leaves (EALE) and flowers (EALE) to give a justification for its use in the traditional medicine. The in vitro anti-urolithiathic activity of E. arborea leaf and flower hydromethanolic extracts nucleation and aggregation of crystals were measured using spectrophotometric methods. Results indicated that 28.04 % of people in the studied region used E. arborea in traditional folk medicine. Finally, results of the toxicity assay showed that EAME is safe and no deaths or changes in mice behavior were observed even when doses as high as 5 g/kg DW were used. From the ethnopharma-cological studies, our consequences endorse the benefit of E. arborea in folk medicine. Results of this investigation suggest that the leaf and flower extracts of E. arborea exhibit notable anti-urolithiatic, anti-inflammatory, analgesic, and antibacterial activities and are safe as a natural source of drugs with the above effects.

CONCLUSION

The management of urolithiasis through herbal interventions represents a robust intersection of traditional ethnobotanical wisdom and modern pharmacological validation. This review confirms that medicinal plants such as *Kalanchoe pinnata*, *Eleusine indica*, and *Aerva lanata* possess complex secondary metabolites that address the multifactorial pathogenesis of stone formation. Unlike conventional uricosuric agents, these botanical extracts function via a holistic mechanism of action. They effectively modulate the urinary biochemical environment by increasing the excretion of inhibitors, reducing the supersaturation of lithogenic salts, and providing nephroprotective effects through antioxidant pathways. The evidence presented suggests that the efficacy of these plants is primarily attributed to their ability to interfere with the crystallization kinetics of calcium oxalate and calcium phosphate. Furthermore, the diuretic properties observed in several species facilitate the mechanical flushing of micro-calculi from the urinary system. However, a significant gap remains between experimental success and clinical application. While *in vitro* and *in vivo* data are promising, the lack of large-scale human clinical trials and standardized dosing protocols limits the integration of these extracts into mainstream urology. Future research should prioritize the isolation of specific bioactive lead compounds and the exploration of their long-term safety profiles to establish plant-based therapies as primary or adjunctive treatments for urolithiasis.

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