



# Phytopharmacological Approaches for Urinary Tract Infections: Bioactive Compounds & Mechanisms

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## ABSTRACT

Urinary tract disorders (UTDs), including urinary tract infections, kidney stones, dysuria, and bladder inflammation, are common health problems affecting millions of people worldwide. Traditional medicinal systems have long utilized plant-based remedies to manage these conditions. Ethno pharmacology explores the relationship between indigenous knowledge, medicinal plants, and their pharmacological effects in treating diseases. Numerous medicinal plants such as *Azadirachta indica*, *Tribulus terrestris*, *Boerhavia diffusa*, *Phyllanthus niruri*, and *Crataeva nurvala* have been traditionally used for their diuretic, antimicrobial, anti-inflammatory, and lithotriptic properties. These plants contain bioactive compounds including flavonoids, alkaloids, tannins, saponins, and phenolic compounds that contribute to their therapeutic effects on the urinary system. Scientific investigations have increasingly validated many of these traditional claims through phytochemical and pharmacological studies. However, in order to fully incorporate ethno pharmacological knowledge into contemporary healthcare, additional clinical research, standardization, and safety evaluations are required. This review highlights the traditional uses, phytochemical constituents, and pharmacological activities of medicinal plants employed in the treatment of urinary tract disorders, emphasizing their potential as sources for novel therapeutic agents.

## Introduction

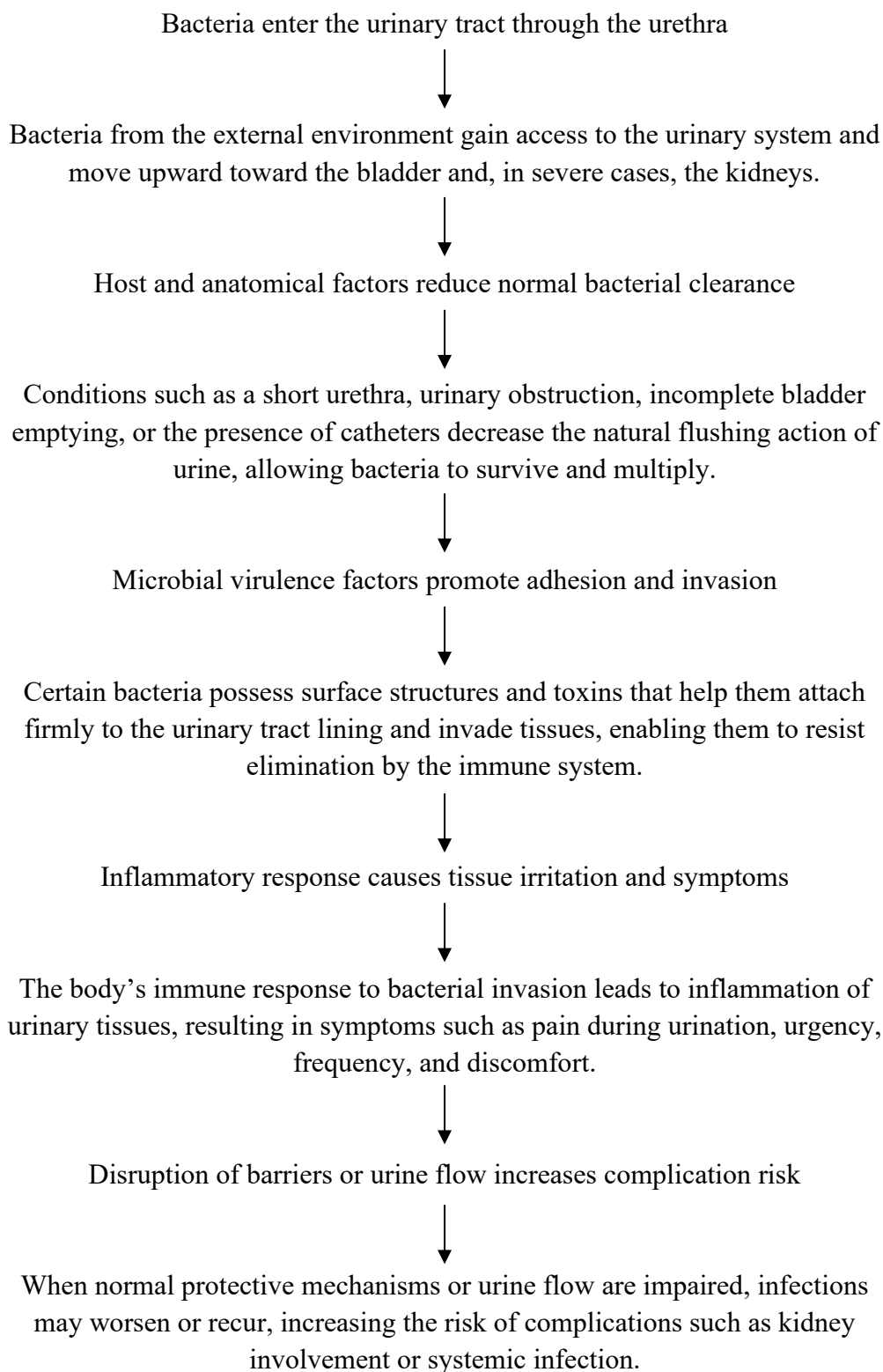
A urinary tract infection (UTI) is one of the most common bacterial infections affecting humans and occurs when pathogenic microorganisms invade any part of the urinary tract, including the kidneys, ureters, urinary bladder, or urethra. UTIs may involve the Lower Urinary tract (Cystitis and Urethritis) or the Upper Urinary tract (Pyelonephritis), the latter being more severe and associated with significant morbidity if left untreated. UTIs affect individuals of all age groups but are particularly prevalent in women, due to anatomical and hormonal factors such as a shorter urethra and proximity to the anal region. It is estimated that more than 50–60% of women experience at least one UTI during their lifetime, with a high rate of recurrence. UTIs are also



commonly observed in elderly patients, pregnant women, diabetic individuals, and patients with urinary catheters or structural abnormalities of the urinary tract.

The majority of UTIs are caused by Gram-negative bacteria, with *Escherichia coli* accounting for approximately 70–90% of community-acquired infections. Other causative organisms include *Klebsiella pneumoniae*, *Proteus mirabilis*, *Enterococcus faecalis*, and *Staphylococcus saprophyticus*. These pathogens typically originate from the Gastrointestinal tract and ascend through the urethra into the urinary system.[1, 2]

## 2. Pathophysiology:



The following is the table regarding Herbal drugs with Therapeutic Potential:

| S. No. | Scientific Name                                | Family       | Chemical Constituents                                                                                                                                   | Part of plant     | Findings                                                                                                                                                                                                                                   | Ref. |
|--------|------------------------------------------------|--------------|---------------------------------------------------------------------------------------------------------------------------------------------------------|-------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------|
| 1      | <i>Vaccinium macrocarpon</i><br>(Cranberry)    | Ericaceae    | Proanthocyanidins<br><b>Flavonoids:</b><br>Quercetin,<br>Myricetin<br><b>Organic acids:</b><br>Citric acid,<br>Malic acid,<br>Benzoic acid<br>Vitamin C | Fruit             | <b>UTI</b><br>Inhibits harmful bacteria, especially <i>E. coli</i> which helps prevent infections.                                                                                                                                         | [4]  |
|        |                                                |              |                                                                                                                                                         |                   | <b>Lower Urinary Tract Symptoms(LUTS):</b> They calm inflammation in the bladder and prostate, which can reduce symptoms like frequent urination, urgency, and trouble emptying the bladder.                                               | [5]  |
| 2      | <i>Acrstostaphylos uva-ursi</i><br>(Bearberry) | Ericaceae    | Arbutin<br><br><b>Tannins:</b><br>Gallo tannins<br><br><b>Flavonoids:</b><br>Quercetin<br><br>Ursolic acid                                              | Leaves            | <b>Acute uncomplicated cystitis:</b><br>Arbutin turns into hydroquinone in the urine and works as a natural antibacterial agent, helping fight against <i>E. coli</i> and <i>Enterococcus faecalis</i> .                                   | [6]  |
|        |                                                |              |                                                                                                                                                         |                   | <b>UTI:</b><br><b>Phenolic compounds and flavonoids disrupt bacterial cell walls and membranes, increasing membrane permeability so intracellular contents leak out and the bacteria lose homeostasis, which leads to bacterial death.</b> | [7]  |
| 3      | <i>Zea mays</i><br>(Corn silk)                 | Poaceae      | Mucilage<br><br><b>Flavonoids:</b><br>Maydis,<br>Quercetin<br><br>Potassium salts                                                                       | Hair of corn silk | <b>Urolithiasis:</b><br>Corn silk is rich in natural antioxidants that reduce oxidative stress and help prevent calcium oxalate crystals from sticking to kidney cells.                                                                    | [8]  |
|        |                                                |              |                                                                                                                                                         | Whole corn silk   | <b>Benign Prostatic Hyperplasia:</b><br>Corn silk extract may help reduce prostate enlargement by lowering DHT levels, a hormone that promotes prostate cell growth.                                                                       | [9]  |
| 4      | <i>Equisetum arvense</i><br>(Horsetail)        | Equisetaceae | Silicic acid & silica<br><b>Flavonoids:</b><br>quercetin,                                                                                               | Root              | <b>Urinary incontinence:</b> controls urinary incontinence by calming bladder signals and reducing involuntary bladder contractions.                                                                                                       | [10] |

|   |                                             |                |                                                                                                                                                                                      |                                  |                                                                                                                                                                                                                 |      |
|---|---------------------------------------------|----------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|----------------------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------|
|   |                                             |                | kaempferol<br><b>Alkaloid:</b><br>Equisetine<br><b>Saponins:</b><br>triterpenoids<br>Apigenin,<br>Luteolin                                                                           | Whole plant<br>&<br>aerial parts | <b>Nephrolithiasis:</b><br>Helps in increasing urine flow and reduce crystal build-up, which may prevent kidney stones from forming.                                                                            | [11] |
| 5 | <i>Solidago virga urea</i><br>(Goldenrod)   | Asteraceae     | <b>Saponins:</b><br>Solidago saponins<br><b>Flavonoids:</b><br>Rutin, Quercetin,<br>Kaempferol<br><b>Tannins:</b><br>Catechin<br><b>Phenolic glycosides:</b><br>Leuco anthocyanidins | Stems & leaves                   | <b>Overactive bladder syndrome:</b><br>Relax the bladder by reducing unwanted muscle contractions                                                                                                               | [12] |
|   |                                             |                |                                                                                                                                                                                      | Whole plant                      | <b>Urolithiasis:</b><br>Methanolic extract of <i>Solidago virga urea</i> helps prevent kidney stones by increasing citrate and magnesium in urine, which keeps calcium dissolved and reduces crystal formation. | [13] |
| 6 | <i>Althaea officinalis</i><br>(Marshmallow) | Malvaceae      | Mucilage<br>Polysaccharides<br><b>Flavonoids:</b><br>Rutin,<br>Quercetin,<br>kaempferol<br><b>Pectins:</b><br>galactose                                                              | Root & Whole plant               | <b>Haematuria:</b><br><i>Althaea officinalis</i> contains mucilage, a gel-like substance that coats and soothes the urinary tract, helping calm irritation and reduce bleeding caused by inflammation.          | [14] |
|   |                                             |                |                                                                                                                                                                                      | Root                             | <b>Kidney inflammation:</b><br>By soothing irritated tissues and reducing bacterial irritation, marshmallow root helps support kidney and bladder health and may reduce blood in the urine caused by infection. | [15] |
| 7 | <i>Allium sativum</i><br>(Garlic)           | Amaryllidaceae | Allicin<br><b>Sulfur compounds:</b><br>Ajoene,<br>Diallyl sulphide<br><b>Flavonoids:</b><br>Quercetin<br>Selenium                                                                    | Clove                            | <b>Bladder Cancer:</b><br>Supports tumour suppressing genes and which can slow cancer growth.                                                                                                                   | [16] |
|   |                                             |                |                                                                                                                                                                                      |                                  | Garlic's allicin helps fight UTIs by killing bacteria, preventing biofilm formation, reducing inflammation.                                                                                                     | [17] |
| 8 | <i>Curcuma longa</i><br>(Turmeric)          | Zingiberaceae  | Curcumin<br>Turmerone<br>Atlantone<br>Essential oils                                                                                                                                 | Rhizome                          | <b>Kidney Damage:</b><br>Protects the kidneys by boosting natural antioxidants and reducing cell damage.                                                                                                        | [18] |

|    |                                            |               |                                                                                                             |                |                                                                                                                                                                                                   |      |
|----|--------------------------------------------|---------------|-------------------------------------------------------------------------------------------------------------|----------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------|
|    |                                            |               |                                                                                                             | Root           | <b>Cystitis glandularis:</b><br>It activates protein kinase D1, which keeps $\beta$ -catenin from moving into the nucleus and triggering cell proliferation.                                      | [19] |
| 9  | <i>Zingiber officinale</i><br>(Ginger)     | Zingiberaceae | <b>Phenolic compounds:</b><br>Gingerols<br>Shogaols<br><br><b>Terpenes:</b><br>Zingiberene,<br>Bisabolene   | Rhizome        | <b>Kidney Health (Nephro protection):</b> Ginger helps protect the kidneys by reducing oxidative stress, restoring antioxidants, which lowers creatinine levels and protein loss.                 | [20] |
|    |                                            |               |                                                                                                             |                | <b>Inflammation and Pain:</b><br>Reduce pain and inflammation by <b>inhibiting pro-inflammatory cytokines (e.g., TNF-<math>\alpha</math>, IL-1<math>\beta</math>, IL-6)</b>                       | [21] |
| 10 | <i>Taraxacum officinale</i><br>(Dandelion) | Asteraceae    | Sesquiterpenes<br>Lactones<br><b>Flavonoids:</b><br>Quercetin,<br>Apigenin<br><b>Triterpenes:</b><br>Inulin | Leaves & Roots | <b>Urolithiasis:</b><br>Helps in preventing kidney stones by inhibiting the formation and growing of calcium oxalate crystals and sticking together.                                              | [22] |
|    |                                            |               |                                                                                                             | Leaves         | <b>Urinary Tract Infection (UTI):</b><br>Plant extracts directly inhibit the growth of bacteria.                                                                                                  | [23] |
| 11 | <i>Agathosma betulina</i><br>(Buchu)       | Rutaceae      | Diosphenol<br><b>Flavonoids:</b><br>Rutin,<br>Diosmin<br><br><b>Volatile oil:</b><br>Limonene,<br>Pulegone  | Leaves         | <b>Prostatitis:</b><br>Buchu leaf extracts help fight infections by killing bacteria and reducing inflammation                                                                                    | [24] |
|    |                                            |               |                                                                                                             |                | <b>Urethritis:</b><br>The plant extract helps relieve urethritis by fighting harmful bacteria, calming inflammation, increasing urine flow to flush them out, and protecting the urethral lining. | [25] |
| 12 | <i>Urtica dioica</i><br>(Stinging nettle)  | Urticaceae    | <b>Flavonoids:</b><br>Kaempferol,<br>Quercetin<br>Lignans<br>Phenolic acids                                 | Aerial parts   | <b>Urolithiasis:</b><br>Stinging nettle contains powerful antioxidants that protect the kidneys by reducing oxidative stress and helping prevent kidney stone formation.                          | [26] |

|    |                                          |                |                                                                                                                           |                 |                                                                                                                                                                                                                         |      |
|----|------------------------------------------|----------------|---------------------------------------------------------------------------------------------------------------------------|-----------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------|
|    |                                          |                |                                                                                                                           | Roots           | <b>Benign prostatic hyperplasia:</b><br>Stinging nettle root extracts may help slow prostate enlargement by reducing DHT levels, the hormone linked to prostate growth.                                                 | [27] |
| 13 | <i>Glycyrrhiza glabra</i><br>(Liquorice) | Fabaceae       | <b>Triterpenoids:</b><br>Glycyrrhizin,<br>Glycyrrhetic acid<br><br><b>Flavonoids:</b><br>Liquiritin,<br>Isoliquiritigenin | Roots & Rhizome | <b>Nephropathy:</b><br>Protects the kidneys by inhibiting apoptotic signals such as <b>caspase-3</b> , suppresses <b>p38-MAPK</b> activation which leads to reducing cell damage and supporting kidney cell survival.   | [28] |
|    |                                          |                |                                                                                                                           | Roots           | <b>Acute kidney injury (AKI):</b><br>Boosting antioxidants, and preventing kidney cell damage.                                                                                                                          | [29] |
| 14 | <i>Azadirachta indica</i><br>(Neem)      | Meliaceae      | Azadirachtin<br>Nimbidin<br>Gedunin<br><br><b>Flavonoids:</b><br>Quercetin                                                | Leaves          | <b>Urinary Tract Infection:</b><br>Neem leaf extract can be used to make silver nanoparticles that kill bacteria more effectively, helps fighting UTI-causing germs like <i>E. coli</i> .                               | [30] |
|    |                                          |                |                                                                                                                           |                 | <b>Nephroprotection:</b><br>Neem helps protect the kidneys by reducing oxidative stress and inflammation, boosting natural antioxidants like SOD, CAT and reduces cell death and thereby preventing kidney cell damage. | [31] |
| 15 | <i>Tinospora cordifolia</i><br>(Guduchi) | Menispermaceae | Tinosporaside<br>Berberine<br><br><b>Alkaloids:</b><br>Magnoflorine,<br>Palmatine<br><br>Diterpenoid                      | Stem            | <b>Nephropathy:</b><br><i>Protects diabetic kidneys by activating PPAR-<math>\gamma</math>, which reduces inflammation and tissue damage, improving kidney function, and lowering protein loss in urine.</i>            | [32] |
|    |                                          |                |                                                                                                                           |                 | <b>Urolithiasis:</b><br>Prevents kidney stones by reducing the formation and build-up of calcium oxalate crystals, supporting urinary tract health.                                                                     | [33] |
| 16 | <i>Phyllanthus niruri</i><br>(Chanca     | Phyllanthaceae | <b>Lignans:</b><br>Phyllanthin,<br>Hypophyllanthin,                                                                       | Aerial parts    | <b>Urolithiasis (kidney stones):</b><br>Magnesium and potassium help prevent kidney stones by                                                                                                                           | [34] |

|    |                                                     |               |                                                                                                                                                           |                                 |                                                                                                                                                                                                                                                                                 |      |
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|    | piedra)                                             |               | Niranthin<br><b>Flavonoids:</b><br>Quercetin,<br>Rutin<br><b>Alkaloids:</b><br>Phyllanthin,<br>Nirurine<br><b>Tannins:</b><br>Geraniin                    |                                 | reducing crystal formation.                                                                                                                                                                                                                                                     |      |
|    |                                                     |               |                                                                                                                                                           | Leaf                            | <b>Kidney failure:</b><br>The leaf extract helps protect the kidneys by reducing oxidative stress, boosting natural antioxidants.                                                                                                                                               | [35] |
| 17 | <b><i>Bergenia ligulata</i></b><br>(Pashanabheda)   | Saxifragaceae | Bergenin<br><b>Flavonoids:</b><br>Quercetin,<br>Catechin<br>Gallic acid<br><br>Arbutin<br><b>Tannins:</b><br>Tannic acid,<br>Catechin                     | Rhizome                         | <b>Urolithiasis:</b><br>The rhizome helps prevent kidney stones by reducing oxidative stress, lowering lipid and protein oxidation markers (MDA, protein carbonyls)                                                                                                             | [36] |
|    |                                                     |               |                                                                                                                                                           | Roots & Rhizome                 | <b>Dysuria (painful urination):</b><br>Bergenia ligulata compounds such as $\beta$ -Sitosterol and Bergenin reduce urinary tract inflammation by lowering proinflammatory cytokines and suppressing inflammatory pathways, which can help relieve dysuria and painful urination | [37] |
| 18 | <b><i>Aerva lanata</i></b><br>(Mountain Knot)       | Amaranthaceae | <b>Alkaloids:</b><br>Ervine, Ervoside,<br>Ervine<br><b>Flavonoids:</b><br>kaempferol,<br>quercetin,<br>Isorhamnetin<br><br><b>Tannins:</b><br>Tannic acid | Roots,<br>Leaves<br>&<br>Flower | <b>Urolithiasis:</b><br><i>Aerva lanata</i> extracts help prevent kidney stones by reducing crystal formation, increasing urine flow, and boosting antioxidants to protect urinary tract health.                                                                                | [38] |
|    |                                                     |               |                                                                                                                                                           | Whole Plant                     | <b>Acute Renal Failure:</b><br>The ethanol extract improved kidney health by lowering urea and creatinine levels and reducing kidney damage in drug-induced kidney injury.                                                                                                      | [39] |
| 19 | <b><i>Macrotyloma uniflorum</i></b><br>(Horse gram) | Fabaceae      | <b>Alkaloid:</b><br>melatonin<br><br><b>Tannins:</b><br>Proanthocyanidins                                                                                 | Seed                            | <b>Nephrotoxicity:</b><br>The seed extract helps protect the kidneys by reducing waste build up, improving filtration, and normalizing urine output, showing healthier kidney function.                                                                                         | [40] |

|         |                                                       |                 |                                                             |             |                                                                                                                                                                                                                                  |      |
|---------|-------------------------------------------------------|-----------------|-------------------------------------------------------------|-------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------|
|         |                                                       |                 | Polysaccharides<br>Triterpenoids                            |             | <b>Urolithiasis:</b><br><b>Macrotyloma uniflorum seed extract increases urine output, helping flush out stone-forming substances and lowering the risk of calcium oxalate crystal build up that leads to kidney stones.</b>      | [41] |
| 20      | <b><i>Crataeva nurvala</i></b><br>(Varuna)            | Fabaceae        | Triterpenoids<br>Betulinic acid<br>Lupeol<br>Glucosinolates | Stem & Bark | <b>Urinary Tract Infection:</b><br><i>Crataeva nurvala</i> stem bark extract shows antibacterial activity against common UTI-causing bacteria like <i>E. coli</i> and <i>Bacillus cereus</i> , helping fight urinary infections. | [42] |
|         |                                                       |                 |                                                             | Bark        | <b>Urolithiasis:</b><br>The decoction inhibits crystal aggregation and growth in the bladder, preventing stone formation.                                                                                                        | [43] |
| -<br>21 | <b><i>Salvia miltiorrhiza</i></b><br>(Danshen)        | Lamiaceae       | Salvinolic acid<br><br>Tanshinones                          | Roots       | <b>Benign prostatic Hyperplasia:</b><br><i>Boosting of natural oxidants</i>                                                                                                                                                      | [44] |
|         |                                                       |                 |                                                             |             | <b>Chronic Kidney Disease (CKD):</b><br>The extracts help protect the kidneys by blocking harmful cell changes that lead to scarring, helping maintain normal kidney structure and function.                                     | [45] |
| 22      | <b><i>Astragalus membranaceus</i></b><br>(Astragalus) | Fabaceae        | Astragal sides<br><br>Astragalus<br><br>Polysaccharides     | Roots       | <b>Over Active Bladder (OAB):</b><br><i>Astragalus membranaceus</i> helps calm an overactive bladder by healing the bladder lining, reducing frequent urination and urgency.                                                     | [46] |
|         |                                                       |                 |                                                             |             | <b>Chronic Kidney Disease (CKD):</b><br>Clinical studies show that Astragalus helps balance the immune system and reduce inflammation.                                                                                           | [47] |
| 23      | <b><i>Cordyceps sinensis</i></b><br>(Cordyceps)       | Cordycipitaceae | Cordycepin<br><br>Cyclic peptides                           | Fruit       | <b>Acute Kidney Injury (AKI):</b><br><i>Cordyceps sinensis</i> may help kidneys recover after acute injury by boosting the body's cell-clean-up process, reducing inflammation and oxidative damage.                             | [48] |

|    |                                                           |               |                                                                                                            |       |                                                                                                                                                                                                                             |      |
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|    |                                                           |               |                                                                                                            |       | <b>Chronic Kidney Failure (CKF):</b><br>Reducing oxidative stress, shielding kidney cells from damage and slowing disease progression.                                                                                      | [49] |
| 24 | <i>Punica granatum</i><br>(Pomegranate)                   | Lythraceae    | Punicalagin<br><br>Ellagic acid                                                                            | Fruit | <b>Urolithiasis:</b><br>Fruit extracts prevents the components needed for stone formation such as calcium oxalate, magnesium and phosphorous.                                                                               | [50] |
|    |                                                           |               |                                                                                                            | Peel  | <b>Urinary Tract Infection (UTI):</b><br>Pomegranate peel extract can weaken <i>E. coli</i> and <i>S. aureus</i> by stopping them from producing $\beta$ -lactamase, the enzyme that helps them resist certain antibiotics. | [51] |
| 25 | <i>Eurycoma longifolia</i><br>(Long jack)                 | Simaroubaceae | Quassinoids<br><br>$\beta$ -carboline                                                                      | Stem  | <b>Hyperuricemia:</b><br>70% ethanol extract from the stem of <i>Eurycoma longifolia</i> helps reduce high blood uric acid levels by promoting its excretion through the kidneys.                                           | [52] |
|    |                                                           |               |                                                                                                            |       | <b>Urinary Tract Infection:</b><br><i>Eurycoma longifolia</i> contains natural compounds that kill bacteria by damaging their cells, blocking growth.                                                                       | [53] |
| 26 | <i>Foenum graecum</i><br><i>Trigonella</i><br>(Fenugreek) | Fabaceae      | Trigonelline<br><br>Diosgenin                                                                              | Seeds | <b>Diabetic Nephropathy:</b> helps improve kidney health in diabetes by restoring normal cell signalling and metabolism, supporting healthier kidney function.                                                              | [54] |
|    |                                                           |               |                                                                                                            |       | <b>Renal Damage:</b> Fenugreek seed extract helps protect the kidneys in diabetes by boosting antioxidants like SOD and CAT, which neutralize harmful free radicals.                                                        | [55] |
| 27 | <i>Pygenum africanum</i><br>(African plum)                | Rosaceae      | <b>Phytosterols:</b><br>$\beta$ -Sitosterol<br><b>Pentacyclic triterpenes:</b><br>Ursolic, Oleanolic acids | Bark  | <b>Benign Prostatic Hyperplasia (BPH):</b><br>Pygenum extracts may ease BPH symptoms by reducing inflammation in the prostate and bladder, helping improve urinary flow and comfort.                                        | [56] |

|    |                                                    |           |                                                                                                                                                                                                           |                |                                                                                                                                                                                                       |      |
|----|----------------------------------------------------|-----------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|----------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------|
|    |                                                    |           | <b>Ferulic acid esters:</b><br>n-docosanol ,<br>Tetracosanol                                                                                                                                              |                | <b>Lower Urinary Tract Symptoms:</b><br><i>Pygeum africanum</i> may help ease urinary symptoms by slowing prostate enlargement and limiting cell growth linked to BPH.                                | [57] |
| 28 | <b><i>Secale cereal</i></b><br>(Rye grass)         | Poaceae   | <b>Phytosterols &amp; fatty acids:</b><br>Alpha-linoleic acid<br><br>Vitamins,<br>Minerals<br>Amino acids                                                                                                 | Pollen         | <b>Benign Prostatic Hyperplasia:</b><br>In vivo studies show that the water-soluble fraction T60 can slow the growth of prostate cells, including cells from BPH.                                     | [58] |
|    |                                                    |           |                                                                                                                                                                                                           |                | <b>Chronic prostatitis:</b><br>Grass pollen may help ease chronic prostatitis by reducing prostate inflammation and pelvic pain, sometimes working better than aspirin.                               | [59] |
| 29 | <b><i>Rosmarinic officinalis</i></b><br>(Rosemary) | Lamiaceae | <b>Volatile oils:</b><br>1,8-cineole, camphor, Borneol<br><b>Phenolic Diterpenes:</b><br>Carnosic acid, Carnosol<br><b>Phenolic acids:</b><br>Rosmarinic acid<br><b>Flavonoids:</b><br>Luteolin, Apigenin | Leaves         | <b>Urinary Tract Infection:</b><br>Rosemary essential oil shows antibacterial activity against common UTI-causing bacteria, mainly due to active compounds like 1,8-cineole and $\alpha$ -Pinene.     | [60] |
|    |                                                    |           |                                                                                                                                                                                                           | Leaves & Stems | <b>Urolithiasis:</b> The plant extract improved kidney function by lowering waste levels in the blood and restoring mineral balance, which helps prevent kidney stone formation.                      | [61] |
| 30 | <b><i>Cornelian cherry</i></b><br>(Cornus mas)     | Cornaceae | <b>Anthocyanins:</b><br>Cyanidin derivatives<br><br><b>Iridoid glycosides:</b><br>Loganin<br><br><b>Organic acids:</b><br>Malic, citric acid<br>Vitamin C                                                 | Fruit          | <b>Urinary Tract Infection:</b><br>Anthocyanins in cornelian cherry reduce the ability of <i>E. coli</i> to attach to the urinary tract lining, helping prevent bacterial colonization and infection. | [62] |
|    |                                                    |           |                                                                                                                                                                                                           |                | <b>Acute Kidney Injury (AKI):</b><br>The extract protects the kidneys by reducing the elevated nitric oxide and oxidative stress, helps in preserve normal kidney structure and function.             | [63] |

|    |                                             |            |                                                                                                                                                                                                     |        |                                                                                                                                                                                                                              |      |
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| 31 | <i>Matricaria chamomilla</i><br>(Chamomile) | Asteraceae | <b>Volatile oils:</b><br>$\alpha$ -bisabolol,<br>chamazulene<br><br><b>Flavonoids:</b><br>Apigenin,<br>Luteolin<br><br><b>Coumarins:</b><br>Herniarin<br><br>Mucilage                               | Flower | <b>Lower Urinary Tract Inflammation:</b><br>$\alpha$ -Bisabolol, a key component of chamomile oil has antibacterial effects that may help slow or stop the growth of bacteria causing lower urinary tract infections.        | [64] |
|    |                                             |            |                                                                                                                                                                                                     |        | <b>Acute Cystitis:</b><br>Reduces inflammation by blocking inflammatory pathways and lowering enzymes that cause swelling and irritation.                                                                                    | [64] |
| 32 | <i>Thymus vulgaris</i><br>(Thyme)           | Lamiaceae  | <b>Volatile oils:</b><br>Thymol, carvacrol<br><b>Flavonoids:</b><br>Apigenin,<br>Luteolin<br><br><b>Tannins:</b><br>Proanthocyanidins<br><b>Phenolic acids:</b><br>Rosmarinic acid,<br>Caffeic acid | Leaves | <b>Urinary Tract Infection:</b><br>It reduces fimH gene activity in uropathogenic <i>E. coli</i> , limiting FimH protein production and decreasing bacterial attachment, colonization, and persistence in the urinary tract. | [65] |
|    |                                             |            |                                                                                                                                                                                                     | Leaves | <b>Pyelonephritis:</b><br>Lowers inflammatory cytokines like TNF- $\alpha$ and IL-6 and inhibits the NF- $\kappa$ B pathway, decreasing tissue damage in pyelonephritis.                                                     | [66] |
| 33 | <i>Hibiscus sabdariffa</i><br>(Hibiscus)    | Malvaceae  | <b>Anthocyanins:</b><br>Delphinidin,<br>Cyanidin<br><br><b>Organic acids:</b><br>Citric, malic,<br>tartaric<br><b>Flavonoids:</b><br>Anthocyanins,<br>quercetin<br><br>Polysaccharides              | Flower | <b>Renal Dysfunction:</b><br>Hibiscus sabdariffa slows enzymes like PLA <sub>2</sub> , COX-2, 5-LOX, and CYP450 that produce inflammatory and vasoconstriction there by regulates kidney blood flow and reduce damage.       | [67] |
|    |                                             |            |                                                                                                                                                                                                     |        | <b>Urinary Tract Infection:</b><br>Hibiscus extract strongly reduced <i>Candida albicans</i> biofilm formation, preventing the fungus from adhering to and colonizing the urinary tract.                                     | [68] |
| 34 | <i>Lavandula angustifolia</i>               | Lamiaceae  | <b>Volatile oils:</b><br>Linalool, linalyl acetate                                                                                                                                                  | Flower | <b>Chronic Prostatitis:</b><br>Lavender essential oil lowers inflammation-causing molecules.                                                                                                                                 | [69] |

|    |                                              |            |                                                                                                                                                           |                |                                                                                                                                                                                                                           |      |
|----|----------------------------------------------|------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------|----------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------|
|    | (Lavender)                                   |            | <b>Terpenes:</b><br>linalool, linalyl acetate<br><b>Tannins:</b><br>Proanthocyanidins<br>Coumarins                                                        |                | <b>Renal ischemia:</b><br>Lavender oil helps protect the kidneys by boosting natural antioxidant enzymes (SOD, CAT&GPx) and reducing oxidative damage, especially after blood flow is restored.                           | [70] |
| 35 | <i>Panax ginseng</i><br>(Ginseng)            | Araliaceae | <b>Saponins:</b><br>Ginsenosides (Rb1, Rg1, Re)<br><br>Polysaccharides<br><br><b>Peptides:</b><br>ginseng oligopeptides, ginsentides<br><br>Polyacetylene | Roots          | <b>Benign Prostatic Hyperplasia:</b><br>Slows prostate enlargement by reducing the 5 $\alpha$ -reductase activity by lowering androgen receptor levels, and decreasing blood dihydrotestosterone DHT.                     | [71] |
|    |                                              |            |                                                                                                                                                           |                | <b>Nephrotoxicity:</b><br>Rats exposed to copper often show signs of kidney stress, like higher creatinine and urea levels. Giving them Panax ginseng helped lower these markers, indicating healthier kidney function.   | [72] |
| 36 | <i>Cinnamomum verum</i><br>(Cinnamon)        | Lauraceae  | <b>Volatile oils:</b><br>Cinnamaldehyde, Eugenol<br><br><b>Tannins:</b><br>Cinnamtannin B1<br>Coumarins<br>Mucilage                                       | Bark           | <b>Urinary Tract Infection:</b><br>Trans-Cinnamaldehyde helps prevent urinary tract infections by blocking E. coli from attaching to and invading the bladder lining, weakening the bacteria and reducing infection risk. | [73] |
|    |                                              |            |                                                                                                                                                           | Bark           | <b>Urolithiasis:</b><br>The extract helps prevent kidney stones by reducing calcium oxalate crystal formation                                                                                                             | [74] |
| 37 | <i>Filipendula ulmaria</i><br>(Meadowsweet ) | Rosaceae   | <b>Salicylates:</b><br>Salicin<br><br><b>Flavonoids:</b><br>rutin, kaempferol<br><br>Tannins<br><br>Volatile oils                                         | Herbs & Flower | <b>Cystitis:</b><br>Helps in reducing inflammation by blocking COX-1 and COX-2 enzymes. This lowers prostaglandin levels, which helps ease pain, swelling, and irritation in the urinary tract.                           | [75] |
|    |                                              |            |                                                                                                                                                           | Leaves         | <b>Urolithiasis:</b><br>The extract reduced calcium, oxalate, and phosphate levels in the urine, which prevents the formation of stones.                                                                                  | [76] |

|    |                                                   |                |                                                                                                                                        |                |                                                                                                                                                                                         |      |
|----|---------------------------------------------------|----------------|----------------------------------------------------------------------------------------------------------------------------------------|----------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------|
| 38 | <i>Phyllanthus emblica</i><br>(Indian gooseberry) | Phyllanthaceae | <b>Vitamin C</b><br><br><b>Tannins:</b><br>Emblicanin A & B<br><br><b>Flavonoids:</b><br>quercetin,<br>Myricetin<br><br>Phenolic acids | Fruit          | <b>Urolithiasis:</b><br>The amla extract significantly reduced struvite crystal formation, with about a 60% decrease in the number of crystals compared to the control.                 | [77] |
|    |                                                   |                |                                                                                                                                        |                | <b>Acute kidney Injury (AKI):</b><br>Contrast dyes reduce kidney oxygen and increase harmful reactive oxygen species, damaging kidney cells and raising BUN and creatinine levels.      | [78] |
| 39 | <i>Juniperus communis</i><br>(Juniper berry)      | Cupressaceae   | <b>Volatile oils:</b><br>Alpha-Pinene,<br>sabinene<br><br><b>Flavonoids:</b><br>Quercetin,<br>Apigenin<br><br>Tannins<br>Resins        | Fruit          | <b>Urinary Tract Infection:</b><br>Juniper's antimicrobial oils, such as terpinen-4-ol, damage bacterial membranes, inhibit growth, and help kill UTI-causing bacteria.                 | [79] |
|    |                                                   |                |                                                                                                                                        | Whole plant    | <b>Acute kidney Injury (AKI):</b><br>LPS triggers inflammation via the TLR4–NF-κB pathway, but <i>Juniperus communis</i> extract blocks NF-κB, reducing inflammation and tissue damage. | [80] |
| 40 | <i>Petroselinum crispum</i><br>(Parsley)          | Apiaceae       | <b>Volatile oils:</b><br>Apiol, Myristicin<br><b>Flavonoids:</b><br>Apigenin<br>Coumarins<br>Vitamins A & C                            | Seeds          | <b>Kidney Injury:</b><br>Parsley supports kidney function by reducing sodium absorption and increasing urine output, with diuretic effects enhanced by Myristicin and apiol.            | [81] |
|    |                                                   |                |                                                                                                                                        | Seeds          | <b>Urolithiasis:</b><br>Studies in rats show that parsley reduces urinary calcium levels, helps in preventing calcium-oxalate kidney stone formation.                                   | [81] |
| 41 | <i>Apium graveolens</i><br>(Celery seed)          | Apiaceae       | <b>Volatile oils:</b><br>Limonene,<br>sedanolide<br><br><b>Flavonoids:</b>                                                             | Leaves & Stems | <b>Urolithiasis:</b><br>Celery extract was found to increase the amount of calcium in the urine, which may help prevent calcium from building up and forming kidney stones.             | [82] |

|    |                                          |               |                                                                                                                                                                    |         |                                                                                                                                                                                                         |      |
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|    |                                          |               | Apigenin,<br>Luteolin<br>Coumarins<br><b>Phthalides:</b><br>sedanolide ,<br>sedanolide                                                                             | Fruit   | <b>Urinary Tract Infection:</b><br>Celery fruit extract dose-dependently blocks <b>E. coli</b> from attaching to the bladder lining, reducing bacterial build up and lowering UTI risk.                 | [83] |
| 42 | <i>Cucurbita pepo</i><br>(Pumpkin)       | Cucurbitaceae | <b>Carotenoids:</b><br>Beta-carotene<br><br><b>Polyphenols:</b><br>Protocatechuic,<br>Ferulic<br><br><b>Fatty acids:</b><br>Oleic acid, linoleic acid              | Seeds   | <b>Benign Prostatic Hyperplasia:</b><br>Pumpkin seed extract reduces prostate enlargement by blocking DHT, inhibiting hormone-producing enzymes, and limiting testosterone-driven prostate growth.      | [84] |
|    |                                          |               |                                                                                                                                                                    |         | <b>Overactive Bladder (OAB):</b><br>Pumpkin seed extract contains adenosine, which activates A <sub>1</sub> receptors to calm bladder nerves, reduce muscle contractions, and ease urgency and leakage. | [85] |
| 43 | <i>Sambucus nigra</i><br>(Elderberry)    | Adoxaceae     | <b>Flavonoids:</b><br>Rutin, quercetin<br><b>Phenolic acids:</b><br>Hydroxyl<br>Cinnamic acid<br>Volatile oils<br>Mucilage                                         | Berries | <b>Urinary Tract Infection:</b><br>Elderberry flavonoids and phenolic acids damage microbial membranes, disrupt key enzymes, and work synergistically to boost antimicrobial activity.                  | [86] |
|    |                                          |               |                                                                                                                                                                    |         | <b>Nephrotoxicity:</b><br>Protects Kidney function.                                                                                                                                                     | [87] |
| 44 | <i>Uncaria tomentosa</i><br>(Cat's claw) | Rubiaceae     | Ox indole alkaloids<br><b>Glycosides:</b><br>quinovic acid glycosides<br><b>Flavonoids:</b><br>Procyanidins<br><br><b>Tannins:</b><br>Catechin                     | Bark    | <b>Bladder cancer:</b><br>kills bladder cancer cells by inducing apoptosis via caspase-3 activation and NF-κB regulation.                                                                               | [88] |
|    |                                          |               |                                                                                                                                                                    |         | <b>Cystitis:</b><br>Quinovic acid glycoside fraction (QAPF) reduces P2X7 receptor activity in the bladder, lowering inflammation and pain in cystitis.                                                  | [89] |
| 45 | <i>Ocimum sanctum</i><br>(Holy basil)    | Lamiaceae     | <b>Volatile oils:</b><br>Eugenol, methyl eugenol<br><b>Triterpenes:</b><br>Ursolic acid<br><b>Flavonoids:</b><br>Orientin, Vicenin<br><b>Tannins:</b><br>catechins | Leaves  | <b>Urolithiasis:</b><br>The extract prevents kidney stones by inhibiting early calcium oxalate crystal formation and aggregation.                                                                       | [90] |
|    |                                          |               |                                                                                                                                                                    |         | <b>Urinary Tract Infection:</b><br>Ocimum sanctum leaf extract inhibits the growth of UTI-causing bacteria, including <i>E. coli</i> , helping control urinary tract infections.                        | [91] |

|    |                                              |               |                                                                                                                                                                                                          |         |                                                                                                                                                                                             |       |
|----|----------------------------------------------|---------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|---------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-------|
| 46 | <i>Momordica charantia</i><br>(Bitter melon) | Cucurbitaceae | <b>Saponins:</b><br>triterpenoid<br><b>Flavonoids:</b><br>Rutin, kaempferol<br><b>Alkaloids:</b><br>Momordicin,<br>Charantin<br><b>Polypeptides:</b><br>polypeptide-p,<br>polypeptide-k                  | Fruit   | <b>Urolithiasis:</b><br>Fruit extracts helped reduce excess oxalate, calcium, and phosphate in the urine and kidneys, preventing the formation and growth of calcium oxalate kidney stones. | [92]  |
|    |                                              |               |                                                                                                                                                                                                          | Leaves  | <b>Urinary Tract Infection:</b><br>Momordica charantia leaf extracts contain flavonoids, alkaloids, damage bacterial cell walls, inhibit enzymes, and stop bacterial growth.                | [93]  |
| 47 | <i>Acorus calamus</i><br>(Sweet flag)        | Acoraceae     | <b>Essential oils:</b><br>$\beta$ -Asarone<br><b>Flavonoids:</b><br>Apigenin,<br>Luteolin<br><b>Alkaloids:</b><br>Phenylpropanoids<br><b>Sesquiterpenes:</b><br>cadinane                                 | Rhizome | <b>Urolithiasis:</b><br>Increases urine flow and electrolyte excretion, helping flush out crystals and reduce kidney stone formation.                                                       | [94]  |
|    |                                              |               |                                                                                                                                                                                                          |         | <b>Urinary Tract Infection:</b><br>The rhizome hexane extract shows broad-spectrum antibacterial activity, inhibiting the growth of urinary pathogens.                                      | [95]  |
| 48 | <i>Morus alba</i><br>(White mulberry)        | Moraceae      | <b>Flavonoids:</b><br>quercetin,<br>kaempferol<br><b>Alkaloids:</b><br>Polyhydroxylated alkaloid<br><b>Phenolic acids:</b><br>Chlorogenic acid<br><b>Tannins:</b><br>Proanthocyanidins,<br>Phlobatannins | Leaves  | <b>Chronic Kidney Disease (CKD):</b><br>Chlorogenic acid and flavonoids that reduce kidney oxidative stress, protecting cells and slowing CKD progression.                                  | [96]  |
|    |                                              |               |                                                                                                                                                                                                          |         | <b>Urolithiasis:</b><br>The extract's strong antioxidant activity reduces kidney oxidative stress, protecting cells and lowering the risk of kidney stone formation.                        | [97]  |
| 49 | <i>Withania somnifera</i><br>(Ashwagandha)   | Solanaceae    | Withanolides<br><br><b>Alkaloids:</b><br>Anahygrine,<br>Cuscohygrine<br><br><b>Saponins:</b><br>Sitoindosides<br><br><b>Flavonoids:</b><br>Rutin, Kaempferol                                             | Leaves  | <b>Urolithiasis:</b><br>Withania somnifera antioxidants reduce oxidative stress in kidneys, helps in preventing calcium oxalate stones and kidney damage.                                   | [98]  |
|    |                                              |               |                                                                                                                                                                                                          | Roots   | <b>Nephrotoxicity:</b><br>Doxorubicin causes kidney damage through oxidative stress, while Withania somnifera reduces oxidation and boosts antioxidants, protecting kidney function.        | [99]  |
| 50 | <i>Aloe Barbadosis</i><br>(Aloe Vera)        | Asphodelaceae | <b>Polysaccharides:</b><br>Acemannan<br><br><b>Anthraquinones</b>                                                                                                                                        | Leaves  | <b>Nephrotoxicity:</b><br>Diclofenac induces kidney damage via oxidative stress, while Aloe barbadensis lowers MDA levels and boosts                                                        | [100] |

|  |  |  |                                                             |  |                                                                                                                                                                         |       |
|--|--|--|-------------------------------------------------------------|--|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-------|
|  |  |  | : Barbaloin                                                 |  | antioxidants to protect kidney cells.                                                                                                                                   |       |
|  |  |  | <b>Flavonoids:</b><br>Apigenin,<br>Naringenin,<br>Quercetin |  | <b>Interstitial Cystitis:</b><br>Aloe vera leaf extract helps interstitial cystitis by restoring the bladder's GAG layer, reducing urine irritation, pain, and urgency. | [101] |

**Conflict of Interest:**

The authors declare that there are no conflicts of interest regarding the publication of this manuscript. The authors alone are responsible for the content and writing of the paper.

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**Conclusion:**

Ethnopharmacology plays an important role in understanding and utilizing traditional medicinal knowledge for the management of urinary tract disorders. In traditional medicine, many different plants have been used to treat things like urinary tract infections, kidney stones, dysuria, and bladder inflammation. Plants like *Azadirachta indica*, *Tribulus terrestris*, *Boerhavia diffusa*, *Phyllanthus niruri*, and *Crataeva nurvala* have shown significant therapeutic potential due to their diuretic, antimicrobial, anti-inflammatory, and lithotriptic properties. The presence of bioactive phytochemicals like flavonoids, alkaloids, tannins, saponins, and phenolic compounds is primarily responsible for these effects. The traditional use of these plants has been increasingly supported by scientific research, highlighting their potential as complementary or alternative treatments for urinary tract disorders. However, further pharmacological studies, clinical trials, and standardization of herbal formulations are necessary to ensure their safety, efficacy, and quality. New therapeutic agents and safer, more cost-effective treatments for urinary tract disorders may be discovered by combining traditional ethno pharmacological knowledge with contemporary scientific methods.

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