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A Comprehensive Review on Herbal Medicinal Plants for Urinary Tract Infections

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Abstract
In a ratio of 1:8, urinary tract infections affect both men and women most frequently. People are affected all throughout their lives. Pathogenic bacteria including Escherichia coli, Staphylococcus saprophyticus, Klebsiella pneumoniae, Proteus mirabilis, and fungus like Candida albicans are responsible for UTIs. UTIs can be treated with antibiotics, but that is not the best course of action. Antibiotic usage destroys healthy bacteria, which are vital for a healthy immune system. Antibiotic effectiveness is decreased and resistant bacterial strains are increased by frequent usage of antibiotics. Therefore, it is recommended to take antibiotics sparingly. Natural antimicrobial medicines serve as an accessible and secure alternative treatment for UTIs without raising the danger of antibiotic resistance. Therefore, the current study describes the efficient natural treatments for UTIs.

1. Introduction

When microbial pathogens are present in the urinary system and there are symptoms present, it is said to be an infection of the urinary tract. Acute cystitis and polynephritis are the names for the infection, which affects both the lower and upper urinary tracts. Predominantly UTIs and subsequently respiratory tract infections are the most frequent bacterial infections observed in primary care. Infections affecting the kidneys, ureters, bladder, and urethra are examples of urinary tract infections. Lower urinary tract, bladder, and urethra all become infected. After blood filters, urine is the by-product. In the kidneys, the process of filtering blood takes place. The urethra is used to expel urine from the body after it has been generated in the kidney and transported to the bladder by the ureters (1).

Urinary tract infections are more likely to affect women than males. It is widespread among women of all ages, and both frequency and prevalence rise with age (2). Female sexual activity and childbearing directly increase the risk of infection. In their lifetime, the majority of women will experience an episode of a UTI, and postmenopausal women are at higher risk of experiencing one (3).

Urinary Tract Infections

Although the terms "urinary tract infection" (UTI) and "cystitis" are sometimes used interchangeably, a urinary tract infection (UTI) officially relates to an infection that affects any part of the urinary system, involving the kidneys, ureters, bladder, and urethra. Every year, millions of individuals are affected by the major health issue of urinary tract infections. The

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second most frequent form of infection in the human body is urinary tract infection. About 80% of adult urinary tract infections are brought on by Escherichia coli (4). In addition to Staphylococcus saprophyticus, Chlamydia tracomatis, and Mycoplasma hominis, other bacteria that cause urinary tract infections include these three. Urinary burning is typically the only symptom of urethritis, which occurs when an infection remains in the urethra and does not spread to the bladder. Literally, the term "cystitis" refers to an illness caused by bacteria that causes inflammation of the bladder. It is frequently referred to as cytourethritis when both the urethra and bladder are affected. The kidneys can occasionally get infected with serious, even life-threatening illnesses if bladder infections are left untreated. The medical term for this ailment is pyelonephritis (5).

Uretitis is the medical term for ureteral infections. After entering the bladder through the urethra, bacteria cause cystitis or just a bladder infection. The infection often stays in the bladder, but it can advance and spread to the kidneys, where it can cause a more serious illness. The first bladder infection often manifests rapidly and urgently. Painful, swiftly progressing, and obscenely intense symptoms are possible. Urinary tract infections typically start with indicators such as frequent urination, burning during urination, voiding very little pee, and perhaps blood in the urine (6).

Urinary tract infection-causing bacteria

Staphylococcus saprophyticus and Escherichia coli are two of the pathogens most frequently responsible for UTIs. The most frequent cause of simple and complex UTIs is another organism, most frequently Proteus mirabilis, Klebsiella pneumoniae, or Enterococcus faecalis (7).

2. Pathophysiology

The hematogenous and ascending pathways are the two main ways that germs may enter and propagate throughout the urinary system. Very little information exists to suggest that an illness would frequently move via lymphatic channels to the urinary system. The hematogenous and ascending pathways are the two main ways that germs may enter and propagate throughout the urinary system. Very little information exists to suggest that an illness would frequently move via lymphatic channels to the urinary system.

There are four ways for pathogens to enter the urinary system.

1. Ascending Infections: It usually spreads through the upward path. Female urinary tract infections occur when uropathogens from the fecal flora invade the vaginal introitus and replace the natural flora (diphtheroids, lactobacilli, coagulase-negative staphylococci, and streptococcal species). One of the keys first steps in the development of both acute and recurring UTIs appears to be E. coli colonization of the vaginal introitus. The urethra is the main pathway used by the majority of uropathogens to reach the bladder.
2. Hematogenous spread: Females are more likely than males to have a urinary tract infection. Hematogenous kidney spread is distributed by blood. Staphylococcus aureus is the predominant cause of it in bacteraemia. Humans can get blood-borne infections of the renal parenchyma; however, it happens less frequently than through the ascending route. Staphylococcus aureus, a Gram-positive bacterium that causes bacteraemia and endocarditis, commonly causes kidney abscesses in patients. Hematogenous kidney infections caused by Gram negative bacteria are extremely uncommon (8).
3. Lymphatogenous spread: The infection reaches prostate and bladder in the male through the colon and rectal lymphatic veins. Women's urinary tract via periuterine lymphatics.
4. Direct extension from other organs: Uropathogens proliferate once inside the bladder before passing through the ureters and into the renal parenchyma, where they produce genito-urinary tract fistulas and pelvic inflammatory disorders (9).

Antibiotics used in the treatment of urinary tract infections

According to main recommendations, UTIs are often treated empirically with antibiotics. Antimicrobial therapy seeks to get rid of the infection-causing germs. The selected antibiotic is based on the severity of the infection (complex or not), prevalent local bacteria, and resistance trends (10).

Commonly used antibiotics to treat UTIs are Trimethoprim, Sulfamethoxazole, Nitrofurantoin,

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Ciprofloxacin, Levofloxacin, Cephalexin, Ceftriaxone, Azithromycin, Doxycycline and others.

Herbal medicines as possibilities

To prevent and cure infectious illnesses, plant medicines are employed on a global basis. Due to their extensive biological and pharmacological activity, larger safety margin, and lower cost, botanical medicines are much sought after for basic healthcare in both developed and developing nations (11). Drug resistance to multiple drugs has recently emerged as a result of the careless use of antimicrobial medications to treat infectious infections. The need for antimicrobial drugs that are resistant to present antibiotics is now greater than ever because of the resistance issue (12). Furthermore, although being powerful medications that save lives, traditional antibiotics can actually have the opposite effect when misused (13). The study recommendations on the "safety and effectiveness of natural drugs" were released by the World Health Organization in 1993. In an unambiguous declaration, they stated that the historical usage of a drug was a valid indication of its safety, barring any scientific evidence to the contrary (14). A significant source for the development of novel antimicrobials is the traditional medical practices used around the globe that make use of herbal treatments. Numerous secondary metabolites present in plants, including tannins, alkaloids, terpenoids, and flavonoids, have been demonstrated to possess antibacterial properties in vitro and may be used as a substitute to conventional antibiotics that are efficient, affordable, and safe in the management of infections caused by microbes (15).

Herbal Remedies

The use of herbal diuretics and antibacterial agents is one of nature's greatest methods for maintaining the well-being of the urinary system. Several essential plants that are used to cure infections of the urinary system.

1. **Cranberry** ***(Vaccinium macrocarpon or Vacinnium oxycoccus)***

The typical home cure for UTIs is cranberry juice; cranberry concentrate stops E. coli germs from sticking to the surface of the urinary system. As a result, it lowers the likelihood of recurring UTIs. Proanthocyanidin-A, a flavonoid found in it, has an antimicrobial action. It helps control the PH of urine, eases urination pain, stimulates macrophages to speed up wound healing and lessen inflammation (16), and strengthens the immune system. The threat of asymptomatic bacteriuria is reduced. Cranberry products are advised by the Canadian Society of Obstetricians and Gynecologists to prevent recurrent UTIs (17).

2. **Tea Tree Oil** ***(Melaleuca alternifolia)***

As a result of its antibacterial qualities, it can be utilized to combat the germs that trigger bladder infections. Since this cannot be used orally, ten drops of tea tree oil are added to bathwater and used to clean the urethra opening. It is combined with sandalwood oil before being applied to the abdomen and the region around the bladder. This is an extremely efficient method for eliminating UTIs that cause discomfort. For best effects, apply every day for three to four days (18).

3. **Uva ursi** ***(Arctostaphylos uva-ursi)***

It is a plant that has historically been used to treat certain forms of urinary tract infections. It has a number of compounds and antiseptic qualities that aid in the treatment of UTIs. Tannins are present in large levels. Uva ursi should not be consumed by those who have renal or liver illness, pregnant women, nursing mothers, or youngsters. When consumed in excessive doses for extended periods of time, this plant can cause dark or green urine, nauseousness, buzzing in the ears, indigestion, cancer, or even death (19).

4. **Blueberry** ***(Vaccinium angustifolium)***

They are effective in treating urinary tract infections due to their bacteriostatic properties. For speedy results, sip blueberry juices every morning and evening. Both proanthocyanidins and vitamin C are abundant in blueberry juice. By providing more fluid, this aids in the removal of microorganisms. It strengthens the immune system and stops germs that cause UTIs from growing (20).

5. **Buchu** ***(Agathosma betulina)***

Traditional herbal medicine has long used buchu leaf preparations as diuretics and cleaners of the urinary tract (21). However, the German Commission E literature on buchu comes to the conclusion that there is not enough data to warrant its use in modern

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medicine to treat inflammation and UTIs. Its volatile oil causes urine to be stimulated and is essentially eliminated by the kidneys. It is beneficial to use if you have a bladder infection, acidic urine, and a continual urge to urinate without receiving any sort of relief from doing so (22).

6. Horseradish *(Cochlearia armoracia)*

It has been demonstrated that the volatile oil in horseradish kills bacteria that can result in UTIs. Horseradish extract may aid those with urinary tract infections, according to preliminary research (23).

7. Grapefruit *(Citrus paradisi)*

The seed and pulp of the grape fruit are used to create grape fruit seed extract (GSE). Natural antibacterial, antifungal, and antiviral activities have been discovered in it. Grape fruit extract from seeds contains antibacterial substances that mimic pharmaceutical antibacterial medicines. It has a wide range of activity that influences the development of both gram-positive and gram-negative organisms. The growth of dangerous organisms including Staphylococcus aureus, Pseudomonas aeruginosa, and Klebsiella species in urine is inhibited by its powerful constituents. Within 15 minutes following contact with a solution that has been diluted, the extract has been demonstrated to kill pathogenic bacteria. Every two hours during the day, two capsules of the grape fruit seed extract, berberine, and zinc are advised until the infection is completely gone (24).

8. Garlic *(Allium sativum)*

Garlic is well-known as having antibacterial effects due to its capacity to reduce inflammation and strengthen the immune system. It contains a lot of the sulphur component allicin, which helps with detoxification, and is a great source of the super antioxidant glutathione (25). Garlic extract can be used to treat recurrent UTIs. Additionally, according to reports, using it lessens urination urges and frequency as well as pain in the pubic area (26).

9. Echinacea *(Echinacea purpurea)*

It is regarded as a strong medicinal plant with a range of positive health effects. Echinacea has been utilized as a herbal antibiotic by Native Americans for more than 400 years. To fight against illness, echinacea boosts the immune system. As a recognized therapy for urinary tract infections, Echinacea is now subject to regulation by the German authorities. It comprises a number of plant chemicals and can be consumed as a tincture, tea, or extract from plants in pills. To boost immunity and hasten the recovery from a variety of illnesses, infusions, extracts, tinctures, and poultices are employed (27).

10. Cinnamon *(Cinnamomum zeylanicum)*

The anti-inflammatory, antioxidant, antibacterial, anti-diabetic, and anti-tumor effects of cinnamon make it a well-known spice. It will lessen the inflammation causing pain when urinating and inhibit the germs from multiplying. Staphylococcus aureus and E. coli, two of the main causes of UTIs, have been demonstrated to be resistant to it. 1-4 grams of cinnamon bark powder or 1 teaspoon of cinnamon oil taken daily will limit the growth of germs. It has been demonstrated that cinnamon and clove oils together have a synergistic impact in slowing the development of E. coli (28). Both cinnamon oil and clove oil have anti-inflammatory characteristics that help with pain relief, while clove oil also has antiseptic properties that prevent the formation of pathogens (29).

11. Clove *(Syzygium aromaticum)*

The finest essential oil for treating infections caused by bacteria is clove oil, which is widely utilized. It has analgesic, immune-stimulating, antiviral, antifungal, and antibacterial effects. It works perfectly when used with antibiotic medication for preventing infections caused by yeast and UTI treatment. Quicker recovery is encouraged, and the infection-related inflammation is lessened (30).

12. Oregano *(origanum vulgare)*

The plant extract has potent anti-inflammatory properties and increases cytokine activity to combat infection. Carvacrol, a volatile oil and potent antibacterial agent that combats Salmonella and E. coli, is present in oregano oil. E. coli and P. aeruginosa bacterial strains can't develop because oregano essential oil has antibiotic properties. E. coli, a major cause of UTIs, is targeted by its antibacterial property, which has been discovered to be treatment resistant. Streptococcal infections are also fought off by it. One study described oregano oil as "alternative antimicrobial treatments improving recovery process in

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infections caused by bacteria and as a successful tool for avoiding the occurrence of antimicrobial-resistant strain development (31)."

13. Juniper berry *(Juniperus communis)*

It has bitter substances in it that make urine flow more freely. Additionally, it promotes the formation of digestive juices that lessen discomfort and aid in absorption. The fruit is frequently employed as a stimulant, diuretic, and antibacterial. Although it is quite helpful for chronic cystitis, it is advisable to avoid using it in cases of acute inflammation since it might irritate the bladder. It has aromatic chemicals that promote increased urine flow. These types of plants are typically consumed as tea (32).

14. Goldenseal (*Hydratis canadensis*)

Several various infections are said to respond well to goldenseal treatment. Goldenseal, Oregon grape, and other plants contain the bioactive substance that may function analogous to proanthocyanidins in preventing bacterial adhesion to bladder walls (33).

15. Plantain (*Plantago lanceolata*)

Plantain has anti-inflammatory properties, therefore individuals with UTIs may find it helpful. Clinical experiments, nevertheless, haven't been carried out to support either this hypothesis or the conventional wisdom that plantains are diuretics (34).

16. Oregon grape (*Berberis aquifolium*)

The berberine found in Oregon grapes may be used to treat UTIs. Nevertheless, the effectiveness of any of these herbs in treating UTIs in people has not yet been investigated (35).

17. Barberry *(Berberries vulgaris)*

Barberry contains berberine, which has exceptional anti-infection capabilities. According to studies, it eliminates bacteria including E. coli and streptococci responsible for urinary tract infections (36). Root of the dandelion (Taraxacum officinalis) includes bitter substances that boost the effectiveness of the body's detoxification and elimination processes. These substances boost the synthesis of bile and other digestive enzymes, as well as regular liver function. It has a laxative action and increases urine flow (37).

18. Chamomile flower (*Matricaria recutita*)

It has fragrant chemicals that boost the flow of digestive juices, alleviate pain and muscular spasms, decrease inflammation, and act as antiseptics. These substances have a soothing and calming impact and are effective in the treatment of UTIs (38).

19. Moringa (*Moringa oleifer*)

Moringaceae is its family. Sohanjna is the name in use. In addition to being antipyretic, it also has antimicrobial properties. There are amino acids, tocopherol, moringine, spirochin, kaempferol, acetylated carbamate, and thiocarbamate glycoside in it (39).

20. Ginger (*Zingiber officinale*)

It is a member of the Zingiberaceae family. Adrak, Sondh is the name in popular usage. It has digestive, anti-inflammatory, and antibacterial properties. It includes shogaols, gingerols, zingiberene, zingiberol, and dihydroparadols (40).

21. Spade flower (*Hybanthus enneaspermus*)

It's a member of the Violaceae family. Spade blossom is the popular name for it. It has antimicrobial, antidiabetic, and antioxidant properties. It has medicinal properties due to the presence of flavonoids, polyphenols, terpenes, alkaloids, phenols, saponins, anthraquinones, glycosides, and tannins (41).

22. Hareer *(Terminalia chebula)*

It is a member of the Combretaceae family. Hareer, or har, is the usual name. It is antimicrobial and hypolipidemic. It includes chebulin, betulinic acid, tannic acid, gallic acid, beta-sitosterol, and fatty acids (42).

23. Tulsi *(Ocimum sanctum)*

It pertains to the Lamiaceae family. Tulsi is a widespread name. It is analgesic, antibacterial, antipyretic, and anti-inflammatory. Flavonoids, polyphenol, flavonols, flavones, carnosic acid, beta-sitosterol, luteolin, myrtenal, apigenin, rosmarinic acid, eugenol, vicenin, and orintin are among its constituents (43).

24. Celery seeds (*Apium graveolens*)

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It's a member of the Apiaceae family. Celery seed is the popular name for it. It has diuretic, anti-inflammatory, and antioxidant properties. Succinic acid, beta-sitosterol, falcarindiol, oplopandiol, lunularin, lunularic acid, trans-cinnamic acid, isofraxidin, trans-ferulic acid, and eugenic acid are all present in it (44).

25. Burdock (*Arctium lappa*)

It's a member of the Asteraceae family. Burdock is the name of the plant. It serves as a diuretic and antibacterial. It has caffeoylquinic acid, cynarin, chlorogenic acid, caffeic acid, quercetin, quercitrin, luteolin, and rhamnoside among other lignins, flavonoids, arctigenin, and arctiin (45).

Some urologic herbs' chemical compositions beneficial against UTIs.

The proanthocyanidins in cranberries stop E. coli, the most prevalent bacterium responsible for UTIs, from sticking to the cells lining the bladder walls (46). Numerous illnesses, including UTIs, are treated by the tannin found in blueberry leaves (47). The volatile oils and flavonoids in buchu leaves range from 1.0 to 3.5%. Buchu's antibacterial effects on the urinary system are assumed to be caused by its volatile oils (48). A broad range of antibiotic action against disease-causing organisms, including Chlamydia, E. coli, Salmonella typhi, and Entamoeba histolytica, is being demonstrated by berberine, which makes about 5-6% of the total alkaloid found in the goldenseal root and rhizome (49). Horseradish's volatile oil has been demonstrated to be effective in killing bacteria that can result in UTIs. Horsetail is thought to have a diuretic effect due to the inclusion of flavonoids and saponin (50). Terpinen-4-ol, one of the volatile oils in juniper, may increase urine volume without leading to an electrolyte loss like potassium (51). The active ingredients in nettle that help cure UTIs are likely polysaccharides and lectins (52).

The berberine found in Oregon grapes reduces the ability of bacteria to adhere to human cells, hence reducing the risk of infections, notably in the urinary tract (53). Mucilage, iridoid, glycosides—particularly aucubin—and tannins make up the majority of a plantain's chemical makeup. These components may work in concert to offer plantains moderate anti-inflammatory and anti-microbial properties (54). It is thought that the main component of sassafras that is responsible for curing UTIs is its volatile oil. Up to 85% of the terpenoid known as in this volatile oil is Saffron (55). The primary active ingredient in uva ursi is the glycoside arbutin. It is believed that uva ursi's capacity to cure urinary tract infections is due to hydroquinone, a potent antibacterial compound generated from arbutin and methylarbutin (56).

3. Discussion

The microbe that causes UTI can develop in the kidneys, urinary bladder, ureter, and urethra, among other parts of the urinary tract system. UTI is the most common cause of pediatric illness and mortality in the poor around the globe, particularly in the tropical regions of countries like India, Afghanistan, Pakistan, Bangladesh, etc (57). In wealthy nations like America, Japan, and Europe, between 3% and 8% of girls and 1% of boys have been diagnosed with UTI (58). The most typical infection listed by doctors in underdeveloped nations is UTI. Diabetes, renal failure, prolonged corticosteroid therapy, and use of immune-suppressive medications for autoimmune illnesses are a few long-term illnesses that increase the possibility of UTI. Another risk factor is urinary obstruction brought on by prostatic hypertrophy, pregnancy, tumors, and bladder catheterization (59).

Klebsiella species, E. faecalis, and E. coli are the main causes. In subtropical regions, uncommon bacteria including Pseudomonas, Staphylococcus, and Proteus vulgaris cause UTI (60). Using herbal medications is simple, affordable, and safe. Since germs do not have resistance to these herbal medications, that is their main benefit. The usage of these herbal medications can help to solve the issue of resistance that results from the use of traditional treatment. Due to the great variety of phytochemical components found in medicinal plants, which are mainly accountable for their positive effects along with the synergistic effects, there have not yet been any reports of microbial susceptibility to herbal medicine.

The phytochemicals used for treating UTI were the only ones included in this review. Research is currently being done to determine the precise processes by which these herbs and the phytochemicals they contain affect UTI. Clearer explanations of these phytochemicals' mechanisms of action require more study. To confirm which phytoconstituents are in charge of treating UTI, more research is required. It is thus necessary to do

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more genetic research and develop techniques to determine how phytoconstituents work to remove harmful microorganisms.

4. Conclusion

The frequency of urinary tract infections is greater in women than in men, making them one of the most prevalent illnesses in both developing and developed countries. Depending on how severe the infection is, different antibiotics are used to treat UTI. However, the uropathogens linked to UTIs have become increasingly difficult for doctors to treat due to antibiotic treatment resistance. Alternative therapy options include herbal remedies, which have been shown to be the most effective therapeutic approach and are regarded as a divine boon to use in the management of UTI. Nevertheless, more focus was needed on cutting-edge methods like RNA sequencing for directly examining uropathogens for the detection of UTI, suitable proof of medicinal plants utilizing barcoding technology, and their bioactive components that contribute to antibacterial activity. Ultimately, we may expect that thorough research on the issues identified could create a new window for the creation of innovative herbal formulations in complementary therapies for the medical management of UTI.

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