A Review on Plant Extracts and Bioactive Molecules in the Treatment of Urinary Tract Infections (UTIs)

Ragunathan Muthuswamy*[1], A. Aarthi[1], S. Abitha[1]

[1]Tamilnadu Dr. MGR. Medical University, Department of Pharmacognosy- PG studies, Swamy Vivekanandha College of Pharmacy, Tiruchengodu, Namakkal, Tamilnadu, India.

Abstract

Urinary tract infections (UTIs) are among the most common bacterial infections. Urinary Tract infections (UTIs) are more common in women than in men. These infections can affect the upper urinary tract, leading to conditions such as pyelonephritis and kidney Infections, or the lower urinary tract, resulting in less severe conditions like cystitis and Urethritis. The primarily caused by uropathogenic Escherichia coli (UPEC), Klebsiella pneumoniae, Proteus mirabilis, and Staphylococcus saprophyticus. The increasing prevalence of antibiotic-resistant strains has spurred interest in alternative treatment options, particularly those derived from medicinal plants which possess strong antimicrobial, anti-inflammatory, anti-adhesive, and diuretic effects, making them promising candidates for UTI management.

This review provides a comprehensive assessment of the therapeutic potential of key medicinal plants and their active constituents in the treatment of UTIs, with a focus on their mechanisms of action, pharmacological properties, and available clinical data. Highlighted species include Vaccinium macrocarpon, known for its proanthocyanidins that prevent bacterial adhesion; Arctostaphylos uva-ursi, which contains Hydroquinone, natural urinary antiseptic; and Camellia sinensis, which contains Epigallocatechin Gallate (EGCG) Ociumum sanctum, which contains Flavonoids; Citrus Paradisi, which contains Procyanidins B1; Armoracia Rusticana (Horseradish), which contains Sinigrin; Eugenia caryophyllata, which contains Eugenol; Zingiber officinale, which contains 6-gingerol;Moringa oleifera, which contains Quercetin; Agathosma betulina, which contains Barosmin, Solanum, Xanthocarpum, which contains spirosol, Echinacea Purpurea, which contains chicaric acid; Chamomilla Matricaria, which contains Apigenin;

Hybanthus Enneasperamus, which contains Kaempferol and Allium sativum , which contains Allicin both of which promote diuresis and exhibit broad-spectrum antimicrobial activity.

Keywords: Plant Bio-molecules, Urinary tract infection, Medicinal Plants, Traditional use, Anti-microbial.

Corresponding Author:

Ragunathan Muthuswamy

Department of Pharmacognosy- PG studies,

Swamy Vivekanandha College of Pharmacy,

Tiruchengodu, Namakkal,

Tamilnadu, India. Mobile: +917306517149; email:ragunathranilmonica@gmail.com

1. INTRODUCTION

A urinary tract infection (UTI) denotes an infection in any segment of the urinary system and is One of the most prevalent bacterial infections, with around 40% of women [1] The cause of UTIs is Bacteria usually enter through the urethra (ascending infection), although bloodstream entry is also a possibility. The majority of uncomplicated cystitis and pyelonephritis cause arise from Ascending infections, mainly instigated by normal bowel flora—most frequently Escherichia coli (≥75% of caues). In young women, Staphylococcus saprophytic is Sometimes responsible (5–10%), whereas Proteus mirabilis and Klebsiella pneumoniae are Uncommon causes. [2] Symptoms of Lower UTIs often result in Painful urination, frequent urination, suprapubic pain, or visible blood in the urine. Upper UTIs occur with fever (>100°F), flank pain, chills, vomiting, nausea, and tenderness close to the Kidneys, occasionally accompanied by cystitis symptoms. Fever is infrequent in lower UTIs unless they are Complicated. Postmenopausal women might experience increased urine loss following UTIs Due to decreased estrogen. Typical UTI indications encompass fever, itching, burning, blisters, Suprapubic Pain, and cloudy urine. [3, 4]

Pathophysiology of UTIs is UTIs begin when gut uropathogens contaminate the periurethral area, colonize the Urethra and bladder, and interact with host cells. Bacteria adhere to bladder epithelium via Pili or adhesins, invade the tissue, release toxins and proteases, and use siderophores to obtain iron. They may cross epithelial barriers, leading to bacteremia. E. Coli, K. Pneumoniae, and S. Saprophytic typically cause uncomplicated UTIs by binding to Umbrella cells. Uroplakins protect these cells from urine damage. Complicated UTIs occur When bacteria attach to catheters, stones, or obstructions, with P. Mirabilis, P. Aeruginosa, and Enterococcus spp. As common culprits. E. Coli can cause both types. Sexual activity Increases risk, while frequent urination lowers it. Acidic pH, organic acids, urea, and host Defenses like vaginal flora, antibodies, mechanical barriers, mucopolysaccharide layers, Tamm-Horsfall protein, and high urine flow help prevent infection [5,6,7].

Diagnosing a UTI requires both a urine Culture showing significant bacterial growth and correlation with urinalysis findings. Clinical symptoms may not always align with lab results. If a patient experiences Frequency, urgency, or dysuria but shows no bacteriuria, acute urethral syndrome, Urethritis, or vaginitis should be considered. Bacteriuria itself can be either symptomatic or Asymptomatic. The standard collection method is a clean-catch midstream urine sample Which should be refrigerated if not processed immediately.[8] The current study compiled all the newer bimolecules and herbs used to treating UTI disorder.

2. PATHOPHYSIOLOGY OF UTIs

The hematogenous and ascending routes are the primary pathways through which Pathogens can enter and spread within the urinary system. In contrast, there is limited Evidence to suggest that infections commonly spread to the urinary system via the Lymphatic channels. Ascending Infections Urinary tract infections (UTIs) in women often follow an upward progression. These Infections typically originate from fecal flora uropathogens that colonize the vaginal Introitus, displacing the normal microbial flora. A critical early stage in recurrent UTIs is the Colonization of the vaginal introitus by Escherichia coli (E. Coli). From there, the urethra Serves as the main pathway for the uropathogens to reach the bladder.[9]

Hematogenous spread refers to the distribution of infection through the bloodstream. While urinary tract infections are more common in females due to the ascending route Hematogenous kidney infections occur less frequently. These infections are typically Caused by Staphylococcus aureus, a Gram-positive bacterium often responsible for Bacteraemia and endocarditis. It is the leading cause of renal parenchymal infections via the bloodstream, such as kidney abscesses. In contrast, hematogenous kidney infections Caused by Gram-negative bacteria are extremely rare [10,11] Lymphatogenous Spread In men, infections can enter the bladder and prostate via lymphatic veins from the colon and rectum. In women, lymphatic spread occurs through the periuterine lymphatic vessels, Facilitating infection of the urinary tract.[12]

Table 1: Herbs and Plant molecules used to management and treatment of UTI

Plant Name	Scientific Name	Family	Active Compounds	Medicinal Uses	Reference
Green Tea	Camellia Sinensis	Theaceae	Catechins [Ec,Ec, Gegc,Egcg],Polyphenols,Alkaloids,Vitamins,Mineral	Antimicrobial, Antioxidant,Supports Overall Health.	13
Cranberry	Vaccinium Macrocarpon	Ericaceae	Proanthocyanidins A[Pacs], Tannic Acid,Organic Acid,Catechins,Iron,Zinc, Resveratrol.	AntiBacterial, Prevents UTIs,Dental Caries;Inhibits E.Coli Adhesion.	14
Tulsi	Ocimum Sanctum	Lamiaceae	Eugenol,Rosmarinic Acid,Apigenin,Orientin, Vicenin, Proanthocyanidins b1.	Antioxidant,Anti Inflammatory,Immune Support	15
Grape Fruit	Citrus Paradisi	Rutaceae	Flavonoids, Tannins,Limonoids, AscorbicAcid, Phenolic Compounds,Terpenoids.	Antimicrobial [Broad-Spectrum],Treat Infection[E.G.Pneumonia ,Gastroentroenteritis]	16

Horsera Dish	Armoracia Rusticana	Brassicaceae	Glucosinolates [Sinigrin, Gluconasturtin] Allyl Thiocyanates,Flavonoids.	Treats UTIs, Respiratory Infection,Disrupts Bacterials Membranes.	17
Clove	Eugenia Caryophyllata	Myrtaceae	Eugenol, Caryophyllene,Vanillin, Gallic Acid.	Antimicrobial [Gram-Positive/Gram-Negative], Anti-Inflummatory,Antioxidant.	18
Garlic	Allium Sativum	Amarylli daceae	Allicin, Glutathione,Glycosides, Saponins, Flavonoids	Antibacterial, Immune Support,Reduces UTIs symptoms	19
Ginger	Zingiber Officinale	Zingiberaceae	6-Gingerols, Shogaols,Zingiberene, Sesquiterpenes.	Antimicrobial [E.Coil, S.Aureus],Treats UTIs,Digestive Issues.	20
Moringa	Moringa Oleifera	Moringaceae	Thiocarbamate Glycoside, Kaempferol,Tocopherol,Phenolic Compounds,Phenethyl Isothiocyanates	Antibacterical [E.Coil, S.Aurues],Antiexdant,Anti-Inflammatory	21
Uva-Ursi	Arctostaphylos Uva-Ursi	Ericaceae	Arbutin, Hydroquinone,Flavonoids,Tannins,Galic Acid	UTIsTreatment, Diuretic,Urinary Antiseptic	22
Buchu	Agathosma Betuina	Rutaceae	Diosmin, Limonene,Diosphenol,Terpinene 4-Ol	Diuretic, Antiseptic For UTIs,Chronic Genitourinary Condition	23
Kantakari	Solanum Xanthocarpum	Solanaceae	Solasodine, Flavonoids,Saponins,Alkaloid, Solasodine kantakari	Antimicrobial [E. Coil Klebsiella] Weak Against Fungi	24
Echinacea	Echinacea Purpurea	Asteraceae	Echinacoside,Phenolic Compound,Polysaccharides,Polyacetylenes,Betaine	Immune Stimulation Reduces UTIs Symptoms, Anti-Inflammatory.	25

Chamomilla Flower	Matricaria Chamomilla	Asteraceae	Terpenoides, Flavonoids,Essential Oil	Anti-Inflammatory, Anti-Cancer,Anti-Bacterical,Used For UTIs	26
Hybanthus	Hybanthus Enneaspermus	Violaceae	Alkaloids, Carbohydrates,Protein,Flavonoids,Phenol,Tannin	Treated For Urinary Tract Infection,Digestive Issue,Respiratory Problems.	27

3. HERBS USER FOR THE MANAGEMENT AND TREATMENT OF UTI

3.1: GREEN TEA (Camellia sinensis)

Fig1: GREEN TEA (Camellia sinensis)

Green tea is derived from the tea plant Camellia sinensis, which belongs to the family Theaceae.Green tea is generally safe, non-toxic, and free from side effects when Consumed [28,29,30] Green tea is made from the non-fermented leaves of the Camellia sinensis plant, while Black teas are produced from its fermented leaves [31,32].The primary active components in green tea responsible for its various Effects are polyphenols, specifically catechins. The main catechins found in green tea Include (−)-epicatechin (EC), (−)-epicatechin-3-gallate (ECG), (−)-

epigallocatechin (EGC), And (−)-epigallocatechin-3-gallate (EGCG), which together account for roughly 30–40% of The water-soluble content in brewed green tea [33,34]Among these, ECG, EGC, and EGCG have demonstrated antimicrobial activity against a Broad range of microorganisms.Camellia sinensis is known to contain a wide array of Phytoconstituents, including catechins, alkaloids, proteins, enzymes, vitamins, Carbohydrates, polyphenols, lipids, and minerals.[35,36,37,38,39,40]

The analysis of its volatile components is typicallyPerformed using gas chromatography (GC) and gas chromatography-mass spectrometry (GC-MS), a hyphenated analytical technique. As the name suggests, GC-MS combines two Methods: gas chromatography, which separates the individual components of a mixture, and mass spectrometry, which identifies and characterizes each component. This Combination allows for both qualitative and quantitative analysis of complex chemical Mixtures. Identifying both volatile and non-volatile compounds in green tea is essential for Gaining deeper insight into its physiological, pharmacological, and flavor-contributing Properties [41]

3.2:CRANBERRY (Vaccinium Macrocarpon)

Fig 2: CRANBERRY (Vaccinium Macrocarpon)

The cranberry, a member of the Ericaceae family, is scientifically known as *Vaccinium Macrocarpon, Vaccinium Oxycoccus*, and V. Erythrocarpum*. Its name originates from the Contraction of “crane berry,” inspired by its bilberry flower, which resembles the head and Neck of a sand crane when withered—a bird that frequently feeds on the berries. The plant Features delicate bell-shaped flowers in white or pale rose hues. It is characterized by their Soft, pulpy pericarp and tangy, sour flavor [42]

Cranberry juice (CJ) has been shown to inhibit the adherence of uropathogenic Escherichia Coli (UPEC) strains to uroepithelial cells, helping to prevent the development of urinary Tract infections [43,44]

Cranberry juice concentration and dietary supplementation have been linked to various Health benefits, including the prevention of urinary tract infections (UTIs) and dental caries In children Despite this, major cranberry producers primarily cultivate the fruit for acidic Juice production. The most common use of cranberry juice is UTIs prevention, as these Infections are thought to result from p-fimbriated uropathogenic Escherichia coli (UPEC) Bacteria that invade the bladder and cause infection [45,46]

Cranberries are rich in various bioactive compounds, including proanthocyanidins A (PACs), tannic acid, organic acids, catechins, iron, zinc, and other trace elements. Research indicates that proanthocyanidins A are the primary antibacterial component, Offering protection against dental caries, periodontal disease, and urinary tract infections [47,48,49].

Studies have Shown that the polyphenols in cranberries and blueberries are particularly effective in Combating decay-causing oral bacteria. Over the past decade, in vitro and clinical studies Have demonstrated that certain raspberry extracts—particularly proanthocyanidins—can Hinder microbial infections by preventing the adhesion of *E. Coli* to urothelial cells. Similarly, high-molecular-weight cranberry extracts have been found to block the Attachment of P-fimbriated *E. Coli* and *Helicobacter pylori* to gastric mucosa Potentially reducing the risk of gastric ulcers. These findings align with evidence supporting Cranberry extracts’ role in preventing urinary tract and *H. Pylori* infections. While some Studies suggest cranberry compounds may also inhibit certain skin pathogens, they appear Ineffective against the oral pathogen [50,51]

3.3: TULSI (Ocimum Tenuiflorum)

Fig 3: TULSI (Ocimum Tenuiflorum)

Plants of the genus Ocimum, belonging to the Lamiaceae family, are highly valued for their therapeutic properties. Ocimum sanctum (Holy Basil) has two main Varieties—Krishna Tulsi(black) and Rama Tulsi (green)—both containing similar Chemical compounds.The word ”Tulsi” originates from Sanskrit, meaning ”the Matchless one.” Renowned for its medicinal benefits, Tulsi has been widely used not only In Ayurveda and Siddha but also in Greek, Roman, and Unani traditional Medicine systems [52,53,54] The fresh Leaves and stems of Ocimum sanctum (Tulsi) yield several phenolic compounds with Antioxidant properties, urinary antibacterial agent including cirsilineol, circimaritin, Isothymusin, apigenin, and rosmarinic acid, along with a significant amount of eugenol. The leaves contain approximately 0.7% volatile oil, composed primarily of about 71% Eugenol and 20% methyl eugenol. This essential oil also includes carvacrol and the Sesquiterpene hydrocarbon caryophyllene. Additionally, two flavonoids—orientin and Vicenin—have been isolated from the aqueous extract of the leaves [55,56]

3.4: Grape Fruit (Citrus paradisi)

Fig 4: Grape Fruit (Citrus paradisi)

Citrus paradisi, commonly known as grapefruit, is a species of the Citrus genus within The Rutaceae family. Grapefruit is a popular citrus fruit, characterized by its large size, Yellow outer peel, and thick, sour pulp when ripe. The tree is notably larger than most citrus Varieties, typically reaching heights of 16 to 20 feet, though some can grow as tall as 43 to 50 feet. Its leaves are dark green, glossy,and elongated,providing ample shade. While the Fruit usually has a yellow rind, certain varieties may display a pinkish hue. The pulp ranges From tart to intensely sour and can vary in colour from yellowish-white to light or deep pink [57,58] Flavonoid tannin,limonoiids,ascorbIcacid, phenolic compound and organic acid these phytoconstituent present in grapes Fruit Due to anecdotal reports of their effectiveness in treating bacterial infections,Grapefruit seeds were considered as a potential remedy. One of the authors had previously used seeds to treat infections such as pneumonia and gastroenteritis in rabbits with very positive results. Since the rabbits experienced no adverse effects, this encouraged us to try the seeds in human cases. It's possible that if dry grapefruit seeds had been used in Case 1, the infection might have resolved without resorting to tarivid. The partial success in Case 1 motivated us to use the dry seeds in Case 2. Given the patient's financial Constraints and urgent condition, we did not feel ethically compromised in offering this alternative treatment. Recent studies have confirmed

that grapefruit seed extract (GSE) Possesses antimicrobial properties effective against a broad spectrum of gram-negative and gram-positive bacteria, even at safe dilutions. Scanning transmission electron Microscopy (STEM) has shown that GSE damages bacterial membranes and releases Cytoplasmic contents within 15 minutes of contact, even at lower concentrations .While GSE seems slightly more effective against gram-positive bacteria, it has demonstrated Significant inhibitory effects on a wide range of bacterial strains .The favorable clinical Responses observed suggest Hythat taking 5 to 6 grapefruit seeds every 8 hours for two weeks May have antibacterial effects comparable to established medications. Further research is Needed to explore the potential of this simple, locally available treatment—especially in Tropical regions where infections and undernutrition areprevalent [59,60,61]

3.5 HORSERADISH (Armoracia Rusticana)

Fig 5: HORSERADISH (Armoracia Rusticana)

Horseradish (*Armoracia rusticana* P. Gaertner, B. Meyer & Scherbius; Brassicaceae), a Hardy perennial herb, has been cultivated for over 3,000 years for its pungent, whitethickened roots, which are commonly grated and used as a condiment. The plant forms a Rosette of large, broad leaves with entire margins and produces tall flowering stalks bearing Small white flowers in terminal panicles. As a member of the Brassicaceae family, Horseradish is closely related to cabbage, mustard, and other cruciferous vegetables [62]

Horseradish is rich in bioactive compounds with antioxidant properties, including polyphenols Like glucosinolates (e.g., gluconasturtin, sinigrin, glucobrassicin) and flavonoids. These Compounds, along with organic acids, vanillin, vitamins, minerals (e.g., potassium, calcium, Magnesium), and enzymes, vary in concentration depending on species, growth conditions, and Processing. [63,64] Glucosinolates break down into isothiocyanates and thiocyanates, which contribute to horseradish's health benefits. While essential minerals support human health, excessive transition metals (e.g., zinc, copper) may Pose risks. Due to its bioactive profile, horseradish has long been used in food preservation and Traditional medicine. Analyzing its polyphenol, mineral, and antioxidant content helps assess its Nutritional quality and potential in preventing chronic diseases [65,66] Horseradish (Armoracia rusticana) roots, from the Brassicaceae family, are Traditionally used to treat upper respiratory tract infections (URI) and uncomplicated urinary tract Infections (UTI), especially in women with recurrent cystitis. This is due to their high content of glucosinolates, mainly sinigrin and gluconasturtiin, which are enzymatically converted by Myrosinase into isothiocyanates (ITCs)—potent antibacterial agents.ITCs disrupt bacterial Membranes, increase permeability, and interfere with quorum sensing and biofilm Formation.After ingestion, ITCs are absorbed, metabolized, and excreted via urine and exhaled air, targeting infections locally in the lungs and urinary tract.The strong antibacterial and Therapeutic properties of horseradish are primarily due to its ITC content, making it a viable Herbal option for managing specific infections[67]

3.6: CLOVE (Syzygium aromaticum)

Fig 6: CLOVE (Syzygium aromaticum)

Eugenia caryophyllata (clove), the largest genus in the Myrtaceae family, is a tropical and Subtropical flowering plant native to Asia, Africa, Madagascar, and the Pacific regions. The Prized clove spice contains eugenol, a phenylpropene compound responsible for its Distinct aroma and potent antimicrobial effects against Gram-positive, Gram-negative, Acid-fast bacteria, and fungi. Additionally, clove's flavonoids exhibit anti-inflammatory and Antioxidant properties, supporting cellular defense mechanisms [68,69,70] Chemical constiuent are Eugenol,caryophyllene,vanillin,crategollic acid, Gallic acid,stigmasterol.[71]

The essential oil derived from this plant helps protect against yeast infections and UTIs. Known for its fast-acting anti-inflammatory properties, it also supports immune system function. This essential oil combats yeast infections and UTIs while providing quick antiinflammatory relief and immune support.[72]

3.7: GARLIC (Alliumsativum)

Fig 7: GARLIC (Allium sativum)

Garlic comes from the bulb (an underground stem) of the *Allium sativum* plant, a Member of the Amaryllidaceae family.[73] his study Confirmed the presence of phytoconstituents in garlic, which are known for their Antibacterial properties and have been widely documented. These compounds span Multiple chemical classes, such as glycosides, alkaloids, saponins, tannins, and Flavonoids. [74] Garlic has long been recognized for its antibacterial Properties, which help reduce inflammation and support immune function. It is a rich Source of the potent antioxidant glutathione

and contains high levels of allicin, a sulfur Compound that aids detoxification. Garlic extract may also be effective in treating Recurrent UTIs, with studies suggesting it can reduce urinary urgency, frequency, and pubic Pain. [75,76]

3.8: GINGER (Zingiber officinale)

Fig 8: GINGER (Zingiber officinale)

Ginger (Zingiber officinale) is a rhizome traditionally used in medicine to treat colds, fever, Stomach disorders, diarrhea, jaundice, and as a skin cleanser. [77]Its Components include zingiberene, zingiberol, α-Zingiber, shogaols, gingerols, and Dihydroparadols[78]Ginger (Zingiber officinale), particularly jahe Emprit (small ginger), is widely used in Indonesia due to its high gingerol and shogaol content. Studies, including those in Herbal Medicine: Biomolecular and Clinical Aspects, highlight Ginger's antimicrobial properties, attributed to compounds like sesquiterpenes, shogaol, and Gingerol. Extracts (100–0.01 mg/mL) inhibit bacteria such as S. Aureus, E. Coli, and Salmonella typhi, with varying MICs. Ginger also shows bactericidal effects against enteric E. ColiUrinary tract infections (UTIs) are often caused by UPEC (E. Coli strains with Plasmid-encoded virulence and antibiotic resistance). Emerging antibiotic resistance underscores Ginger's potential, as an in vivo study found it reduced UPEC colonies in menopausal women with asymptomatic UTIs [79,80,81,82,83,84,85]

3.9: MORINGA (Moringa oleifera)

Fig 9: MORINGA (Moringa oleifera)

Moringa oleifera (Shigru) This plant belongs to the Moringaceae family and is commonly known as Sohanjna. ItPossesses antipyretic, anti-inflammatory, and antibacterial properties. Its active Constituents include thiocarbamate glycoside, acetylated carbamate, amino acids, Tocopherol, moringine, spirochin, and kaempferol [86] Shigru Decoctionoffers a compelling solution for symptomatic relief in urinary tract infections (UTIs) due to its antibacterial and anti-inflammatory properties. Studies reveal that the stem bark of Moringa oleiferaexhibits significant activity against various Pathogens, including Escherichia coli,Staphylococcus aureus ,Bacillus cereus, Pseudomonas aeruginosa, and Proteus mirabilis, with particularly strong effects Against E. Coli.[87-90].Additionally, research highlights Shigru's Antiurolithiatic potential, demonstrating its efficacy in managing UTI-related Symptoms .The bark's antioxidant propertieshelp counteract oxidative stress induced by UTIs, attributed to its rich phenolic content. Further studies confirm that Moringa oleifera stem bark inhibits bacterial adherence to the bladder wall, Promoting their expulsion through urine. [91-93]

3.10: UVA-URSI (Arctostaphylos uva-ursi)

Fig 10: UVA-URSI (Arctostaphylos uva-ursi)

Arctostaphylos uva-ursi (Ericaceae), commonly called bearberry, kinnikinnick, or Arbutus, is an evergreen shrub native to North America, Europe, and Asia. Its name comes from Greek (arcto= bear, staphylos = grapes), as bears eat its red berries. The plant has Long woody stems (1.5–1.8 m), forms dense ground cover, and has bell-shaped white or Pinkspring flowers. Only its dried leaves are used medicinally, as specified by the British Pharmacopoeia [94-97] The main active compounds in bearberry include Glycosides (arbutin, methylarbutin, ericolin), allantoin, flavonoids (quercetin, myricitrin), Tannins, hydroquinone, ellagic acid, gallic acid, malic acid, and ursolic acid. It also Provides vitamin A, iron, manganese, selenium, and silicon. Recent studies show that a 50% alcoholic extract of uva ursi can inhibit tyrosinase activity. Uva ursi is widely used In Europe and North American herbal medicine to treat urinary tract infections (UTIs). Approved in Germany for bladder infections, it combats E. Coliand acts as a potent yet Gentle diuretic and urinary antiseptic. When paired with marshmallow, it aids in expelling Kidney and bladder stones while strengthening urinary passages and addressing blood in the urine. For optimal diuretic effects, it should be steeped in cool water—heat reduces its Efficacy. Uva ursi also helps with irritable or atonic bladders, bacterial vaginosis, andUlcerative cystitis, though it may turn

urine brownish-green and works best in alkaline Conditions. Similarly, blueberry (Vaccinium angustifolium) has traditional uses in UTIs Prevention. Like cranberry, its bioactive compounds prevent E. Coli from adhering to Bladder walls. [98-101]

3.11: BUCHU(Agathosma)

Fig 11:BUCHU(Agathosma)

Agathosma betulina (Rutaceae), commonly called Buchu, is a South African shrub Growing up to 2m tall. It hyou as leathery, pale green leaves with oil glands, a peppermint-like Scent, and white/pink star-shaped flowers. Flavonoids (diosmin), mucilage, resins, and Essential oils (limonene, diosphenol, terpinen-4-ol). Sulphur compounds give it a Blackcurrant flavor. [102-104] Buchu Leaf, a South African herb, is used in herbal medicine to treat urinary tract infections (UTIs) and chronic genitourinary conditions. Its essential oil, rich in diosphenol, acts as a natural Diuretic and antiseptic, killing bacteria as it passes through the urinary tract. Known for its black currant-like scent and taste, buchu remains a popular remedy for UTIs. [105]

3.12: KANTAKARI (Solanum virginianum)

Fig 12: KANTAKARI (Solanum virginianum)

Solanum virginianum, commonly known as Kantakari, is a highly prickly, perennial herb That grows in spreading patches. It is belongs to the Solanaceae family.Its flowers and fruits Year-round and is also referred to as Surattense nightshade, yellow-fruit nightshade, Yellow-berried nightshade, Thai green eggplant, or Thai striped eggplant (based on its Unripe fruit). Additionally, it is called Indian nightshade or yellow-berried nightshade. ThePlant has two recognized synonyms: Solanum surattense Brum. F. And Solanum Xanthocarpum[106]The plant contains alkaloids (mainly solasodine), Sterols, saponins, flavonoids (and their glycosides), carbohydrates, fatty acids, and amino Acids. Key compounds in the fruit include solasonine, solasodine, betasolamargine, Solanocarpine, and solanocarpidine, along with trace amounts of isochlorogenic, Neochronogenic, chronogenic, and caffeic acids. Apigenin is found in petals, while Stamens produce sitosterol and quercetin diglucoside. Fruits have the highest alkaloid Content, varying with solvent extraction. Flavonoids, saponins, and permissible heavy Metals (Cu, Fe, Pb, Cd, Zn) were also detected the plant exhibits broad-spectrumAntimicrobial activity, showing strong efficacy against Escherichia colibut weaker effects Against Klebsiella pneumoniae Extracts (alcohol, acetone, and petroleum ether) from the Stem, leaves, and fruits demonstrated potent antibacterial

action againstKlebsiella Pneumoniaeand Salmonella typhi. Additionally, methanolic fruit extracts of S. Xanthocarpum (5, 10, and 15 mg/mL) significantly inhibited bacterial and fungal growth, though less effectively than standard antibiotics ampicillin and amphotericin B [107-109]

3.13: ECHINACEA PURPUREA

Fig13: ECHINACEA PURPUREA

Echinacea purpurea (Asteraceae), commonly called purple coneflower, it is a North American native herb with purple daisy-like flowers. It has a faint aroma, sweet taste, and cause a tingling sensation. Used in herbal medicine and gardening for its vibrant blooms [110,111] Echinacea primarily contains Mucopolysaccharides, echinacoside, echinaceine, isobutylamines, linoleic and palmitic acids, essential oils, glycosides, insulin, polyacetylenes, sesquiterpenes, betaine, and Phenolic compounds. It also provides small amounts of minerals such as iron, iodine, Copper, potassium, and sulfur, along with vitamins A, E, and C [112,113,114] Echinacea boosts the immune System and reduces inflammation, offering quick relief from the burning sensation Commonly associated with UTIs. Medline Plus notes that echinacea stimulates the Immune system to combat infections and helps flush out bacteria by increasing urine flow. For optimal effectiveness, it should be taken as soon as symptoms appear. [115,116]

3.14: CHAMOMILE (Matricaria Chamomilla)

Fig 14: CHAMOMILE (Matricaria Chamomilla)

Matricaria chamomilla, usually referred to as chamomile, is a well-known medicinal Plant from the Asteraceae familyM. Chamomilla essential oil (EO) contains over 120 Constituents, primarily terpenoids like bisabolol, its oxides, bisabolone oxide A, Chamazulene, and β-farnesene. Its composition varies with geography, environment, Cultivar, genetics, drying/extraction methods, salicylic acid levels, and bio-fertilizers. In Contrast, extracts are rich in phenolic compounds (phenolic acids, flavonoids, coumarins) and amino acids, with composition affected by ethephon, cadmium, and copper Exposure [117,118] Urinary tract infections (UTIs) are among the most common human Infections, affecting the kidneys, ureters, bladder, or urethra. Histological studies reveal Kidney damage, renal tubule necrosis, and inflammatory cell infiltration within the first Week of infection Pseudomonas aeruginosa, a key UTIs pathogen, produces elastase and Protease, which contribute to its virulence Lung tissue also shows severe inflammation, Alveolar destruction, and vascular congestion after P. Aeruginosa infection , often leading to chronic pulmonary damage By the fourth week, bladder sections exhibit mild Inflammation and inflammatory cell infiltration . However, treatment withMatricaria Chamomilla(chamomile) ethanolic flower extract shows promising results Kidney Recovery is After two weeks, reduced necrosis and mild inflammation by four weeks, nearnormal kidney histology Mechanism of Chamomile’s antioxidant and antimicrobial Properties. Conclusion of M. Chamomillaextract

Demonstrates significant protective effects against UTIs, supported by biochemical and Histological improvements. [119]

3.15: HYBANTHUS (Hybanthus enneaspermus)

Fig 15: HYBANTHUS (Hybanthus enneaspermus)

Hybanthus enneaspermus Muell., a member of the Violaceae family, is a herb or Undershrub found in tropical and subtropical regions worldwide. In Hindi, this plant is Commonly known as Rantanpurus.Phytochemicals include carbohydrates, proteins Amino acid, Steroids,Triterpenoids,Flavonids,Tannins,Phenolic compound.The leaves of Hybanthus enneaspermus were evaluated for their antimicrobial activity using the agar disc diffusion method against Bacillus subtilis, Escherichia coli, Staphylococcus aureus, Candida albicans, Pseudomonas aeruginosa, and Klebsiella pneumoniae. Among the tested extracts, the ethanolic extract demonstrated the most significant and broad-spectrum antimicrobial activity compared to the chloroform and petroleum ether extracts, as well as the standard controls. These findings suggest that the plant possesses notable antimicrobial properties and contains phytochemical compounds with potential medicina applications [120].

4.BIOMOLECULE:

4.1: EPIGALLOCATECHIN GALLATE

Epigallocatechin Gallate (EGCG)a polyphenolic catechin, exhibits potent antioxidant properties attributed to its multiple hydroxyl groups, which enable it to neutralize free radicals and disrupt bacterial membranes. Its amphipathic structure facilitates interactions with bacterial cell walls, altering membrane permeability and compromising bacterial viability [121] Antimicrobial Effects Against Uropathogens.In vitro studies confirm EGCG's efficacy against common UTI pathogens, including E. coli, Proteus mirabilis, Klebsiella pneumoniae, and Enterococcus faecalis. **Its antimicrobial action involves:** Membrane disruption – damaging bacterial cell integrity Enzyme inhibition– targeting DNA gyrase and topoisomerase IV ;Biofilm suppression– reducing formation, a key factor in recurrent and catheter-associated UTIs.[122,123]

4.2: RESVERATROL

Resveratrol (3,5,4'-trihydroxystilbene) is a naturally occurring stilbenoid polyphenol found in grapes, blueberries, and peanuts. In grapes—particularly in red wine and the skin of red varieties—it functions as a phytoalexin, protecting the plant against pathogenic infections [124] Anti -bacterial Activity Against UropathogensAction Against UPECResveratrol inhibits the growth of uropathogenic E. coli (UPEC) through multiple mechanisms, including disruption of bacterial cell membranes, depletion of intracellular ATP, and interference with DNA replication. Additionally, it suppresses the expression of Type 1 fimbriae, which are critical for bacterial adhesion to uroepithelial cells.

Biofilm Disruption: Biofilms play a key role in recurrent UTIs and antibiotic resistance. Resveratrol counteracts E. coli biofilm formation by downregulating quorum-sensing genes, such as luxS, thereby impeding bacterial communication and colonization. [125].

Anti-Inflammatory Effects in the Urinary Tract: Resveratrol exerts potent anti-inflammatory effects by inhibiting the NF-κB and MAPK signaling pathways. In infected bladder cells, it significantly reduces pro-inflammatory cytokines, including IL-6, TNF-α, and IL-1β, mitigating tissue damage. Supporting these findings, studies in a murine UTI model demonstrated that resveratrol markedly attenuates bladder inflammation and neutrophil infiltration [126,127]

4.3: FLAVONOIDS

Tulsi is abundant in flavonoids such as orientin, vicenin, luteolin, apigenin, and quercetin, which are known to exert notable pharmacological effects. Among these, orientin and Vicenin exhibit potent antioxidant and DNA-protective properties [128] Luteolin and apigenin are recognized for their anti-inflammatory and antimicrobial [129] Quercetin exhibits antibacterial effects by inhibiting biofilm formation and triggering Oxidative stress in microbial cells Properties.[130] Membrane Disruption – By increasing bacterial membrane permeability, flavonoids Induce leakage of cellular components, compromising bacterial integrity. Inhibition of Nucleic Acid Synthesis– Certain flavonoids interfere with bacterial DNA/RNA synthesis, disrupting replication and growth. Biofilm Suppression– By inhibiting biofilm formation, flavonoids help prevent Chronic UTIs associated with resistant bacterial colonies.[131].

4.4: PROCYANIDINS

Type A procyanidins are oligomeric flavonoids distinguished by unique interflavan linkages (C4→C8 and C2→O→C7), setting them apart from Type B procyanidins (Foo et al., 2000). These compounds are primarily found in cranberries and demonstrate superior anti-adhesion activity compared to other polyphenols. Grapeseeds and skins, especially in red wine varieties, are rich in Type A procyanidins. These compounds are distinguished from Type B procyanidins by an additional ether linkage, which contributes to their enhanced biological activity. **Anti-Adhesive Effects:** Type A procyanidins inhibit the adhesion of uropathogenic E. coli (UPEC) to the bladder epithelium by suppressing the expression of bacterial fimbriae (such as P-fimbriae) and interfering with host cell receptor binding. **Anti-Biofilm Activity:** Procyanidins impede the formation of bacterial biofilms, a critical factor contributing to recurrent urinary tract infections. **Immunomodulatory Effects:** These compounds may support the host immune defense by regulating the production and activity of inflammatory cytokines.[132]

4.5: SINIGRIN

Sinigrin ($C_{10}H_{16}KNO_9S_2$) is a sulfur-containing glucosinolate that, when hydrolyzed by the Enzyme myrosinase, produces allyl isothiocyanate (AITC), a compound known for its Potent antimicrobial properties. Research indicates that AITC exerts its antibacterial Effects by disrupting bacterial cell membranes and inhibiting biofilm formation—an Important virulence mechanism in

urinary tract infections. [133].Research indicates that AITC exerts its antibacterial effects by disrupting bacterial cell Membranes and inhibiting biofilm formation—an important virulence mechanism in Urinary tract infections.[134].Horseradish extracts containing sinigrin have been shown to:Exhibit broad-spectrum antimicrobial activity against Escherichia coli, Klebsiella Pneumoniae, and Proteus mirabilis Demonstrate synergistic effects with antibiotics, boosting their effectiveness Inhibit biofilm formation, thereby decreasing bacterial adhesion within the urinary Tract. [135].

4.6: EUGENOL

Eugenol (4-allyl-2-methoxyphenol), the primary constituent of clove essential oil (comprising up to 90% of its composition), has demonstrated potent broad-spectrum Antibacterial activity against major UTI-causing pathogens:**Escherichia coli:** Eugenol compromises the bacterial cell membrane by increasing its Permeability and inhibits biofilm formation ; **Klebsiella pneumoniae:** Studies suggest eugenol hinders bacterial growth by disrupting Quorum sensing and efflux pump mechanisms; **Proteus mirabilis:** It effectively reduces swarming motility and urease activity, both crucial for the bacterium's virulence.**Mechanisms of Action :** Eugenol's antimicrobial properties operate through several key mechanisms;Membrane Disruption: It enhances membrane permeability, causing leakage of Intracellular components. [136].

Biofilm Suppression: Eugenol inhibits bacterial adhesion and biofilm development Helping prevent persistent infections. **Antiinflammatory Activity: I**t regulates inflammatory cytokine expression, thereby Easing UTI-related symptoms such as pain and swelling.[137].

4.7: ALLICIN

Allicin (diallyl thiosulfinate) is a bioactive sulfur compound produced when garlic is Crushed, triggering the enzyme alliinase to convert alliin into allicin. It is characterized by **High reactivity:** Quickly degrades into secondary sulfur compounds like diallyl sulfides and Ajoene.Volatility**:** Requires stabilization for effective therapeutic applications **Mechanisms of Action Against Uropathogens; Antibacterial Effects : Membrane Disruption :** Allicin interacts with bacterial thiol (-SH) groups, compromising cell Wall integrity.**;Enzyme Inhibition:** Inhibits key bacterial enzymes, including urease in Proteus mirabilis, Reducing pathogenicity. [138]

Anti-Biofilm Activity Inhibits bacterial adhesion to urothelial surfaces. Disrupts established biofilms formed by E. Coli and K. Pneumoniae. Immunomodulatory Effects Stimulates macrophage phagocytic activity Downregulates pro-inflammatory cytokines such as IL-6 and TNF-α, alleviating UTI-related Inflammation.[139].

4.8:6-GINGEROL

6-Gingerol: The most prevalent and pharmacologically active compound.**8-Gingerol and 10-Gingerol:** Exhibit greater lipophilicity, enhancing their ability to penetrate Bacterial membranes.Despite its potent bioactivity, gingerol's clinical utility is limited by rapid metabolic Degradation, leading to growing interest in nanoformulation strategies for improved stability and targeted delivery.**Mechanisms of Action Against Uropathogens ; Direct Antimicrobial Effects :** Disrupts bacterial membranes through hydrophobic interactions.Inhibits critical bacterial enzymes such as E. Coli DNA gyrase and impairs ATP production.Enhances the efficacy of β-lactam antibiotics, especially against ESBL-producing Klebsiella strains.**Anti-Biofilm Activity:**Reduces swarming motility of Proteus mirabilis by 60% at sub-inhibitory concentrations[140]**.**

Suppresses the expression of E. Coli curli genes (csgA, csgB), which are vital for biofilm Development**. Anti-Inflammatory and Immunomodulatory Effects:** Inhibits NF-κB and COX-2 signaling pathways in bladder epithelial cells (Kim 2005) [141] Attenuates pro-inflammatory cytokine production, notably IL-8 and TNF-α, during UTI Episodes .**Chemical Class:** Flavonol (3,3′,4′,5,7-pentahydroxy flavone) Key Functional Groups: The catechol moiety on the B-ring and the keto group on the C-ring Confer potent redox and antioxidant capa· [142].

4.9: QUERCETIN

Quercetin Content in Moringa: Dried moringa leaves contain approximately 17.3 mg/100 g of quercetin—higher than many traditional medicinal plants. Quercetins therapeutic efficacy is enhanced through synergistic interactions with other moringa phytochemicals such as kaempferol and chlorogenic acid, which also support improved bioavailability. **Mechanisms of Action in UTIs ;Antibacterial Effects Membrane Disruption:** Quercetin binds to membrane proteins in uropathogenic E. Coli (UPEC), increasing membrane permeability.Inhibition of Virulence Factors: At sub-inhibitory concentrations, quercetin suppresses P. Mirabilis urease

activity and downregulates E. Coli adhesins (e.g., FimH), impairing bacterial colonization.**Anti-Biofilm Activity :** Inhibits biofilm formation in Klebsiella pneumoniae by 70% through downregulation of the Quorum-sensing gene luxS.Breaks down mature biofilms by disrupting the extracellular polymeric substance (EPS) Matrix.Immunomodulation : Reduces expression of inflammatory cytokines such as IL-6 and TNF-α in bladder epithelial Cells during infection.Promotes enhanced neutrophil migration to infection sites, facilitating bacterial Clearance.[143]

4.10: HYDROQUINONE

The leaves of Uva ursi contain various bioactive compounds, notably arbutin, which serves as the primary antimicrobial agent. Additional constituents include tannins, flavonoids, and hydroquinone derivatives. Arbutin, a glycosylated hydroquinone (hydroquinone-β-D-glucopyranoside), can make up as much as 17% of the leaf extract. [144] After oral ingestion, arbutin is hydrolyzed in the gut and liver into hydroquinone, which is then excreted in the urine. Hydroquinone demonstrates antibacterial effects, especially against common uropathogens like Escherichia coli, Klebsiella pneumoniae, and Staphylococcus saprophyticus**.** [145]

4.11: BAROSMIN

Mechanism of Action of Diosphenol (Barosmin):buchu Diosphenol, also known as barosmin, demonstrates multiple therapeutic actions relevant to UTI treatment:**Antimicrobial Activity –** It disrupts bacterial cell membranes and inhibits biofilm formation, thereby reducing the adhesion of pathogens to the urothelial lining.**Diuretic Effect** – Buchu extracts enhance urine output, aiding in the mechanical flushing of bacteria from the urinary tract.Anti-inflammatory Action – Diosphenol modulates the release of inflammatory Cytokines, helping to relieve pain and swelling associated with UTIs. [146]

4.12: SPIROSOL-5-EN-3-OL

Solasodine kantakari [(22R,25R)-Spirosol-5-en-3β-ol]. Steroidal glycoalkaloid. Structure:It has a cholestane-type steroid nucleus.Contains a 3β-hydroxy group.Features a spiro-aminoketal ring system (spirosolane structure).The nitrogen atom is part of the E-ring, making it an alkaloid.Bacterial Membrane Disruption: Solasodine disrupts bacterial cell wall synthesis.**Biofilm Inhibition:** It hinders bacterial adhesion to urothelial surfaces, preventing

biofilm Formation.**Urinary Alkalinization:** Alters urine pH to enhance antimicrobial effectiveness.**Antimicrobial Activity:**Solasodine exhibits broad-spectrum antibacterial activity against common UTI pathogens. It disrupts bacterial membranes and prevents biofilm formation—an important factor in recurrent infections. **Antiinflammatory and Diuretic Effects:**UTIs are often accompanied by urinary tract inflammation. Solasodine helps reduce levels of pro-inflammatory cytokines such as TNF-α and IL-6. Additionally, its diuretic effect Supports the elimination of pathogens through increased urine flow. **Immuno modulatory Role:** Solasodine enhances immune defense by stimulating macrophage activity, thereby Promoting the effective clearance of bacterial infections. [147]

4.13: CHICORIC ACID

Chicoric acid (2R,3R-dicaffeoyl-tartaric acid) is a type of hydroxycinnamic acid commonly Found in Echinacea purpurea, chicory, and lettuce. It is a prominent phenolic compound in both the aerial parts and roots of E. Purpurea, playing a key role in the plant's therapeutic properties.[148] **Antimicrobial Activity:**Chicoric acid exhibits antimicrobial effects against uropathogenic bacteria such as Escherichia coli and Staphylococcus saprophyticus Its mode of action includes disrupting bacterial cell membranes and preventing biofilm formation, a key factor in the recurrence Of urinary tract infections (UTIs)[149]

Anti-inflammatory and Immunomodulatory Effects: Chicoric acid helps regulate the inflammatory response commonly associated with UTIs by Modulating cytokine levels (e.g., IL-6, TNF-α) and enhancing macrophage function, there by Reducing inflammation and aiding in the elimination of infection. Antioxidant Properties:By neutralizing reactive oxygen species (ROS), chicoric acid mitigates oxidative stress and Protects urothelial cells from damage associated with UTIs. [150]

4.14: APIGENIN

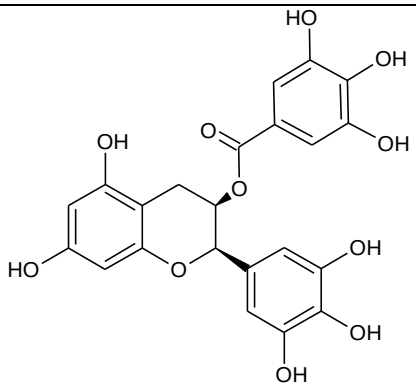
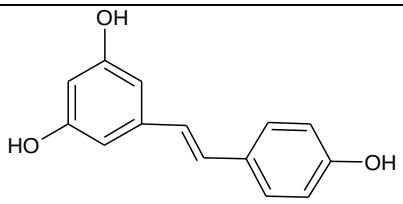
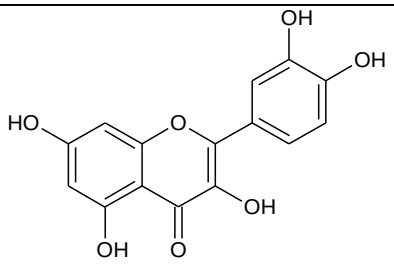
Anti-Inflammatory and Immunomodulatory EffectsApigenin is a naturally Occurring bioactive flavonoid classified under the flavone subclass of Polyphenolic compounds. Its systematic IUPAC name is 5,7-dihydroxy-2-(4-hydroxyphenyl)-4H-chromen-4-one, and it has a molecular formula Of $C_{15}H_{10}O_5$ with a molecular weight of 270.24 g/mol.Structural Characteristics Apigenin consists of: A flavone backbone comprising two benzene rings (A and B)

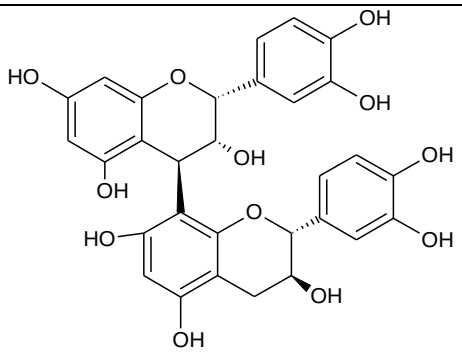
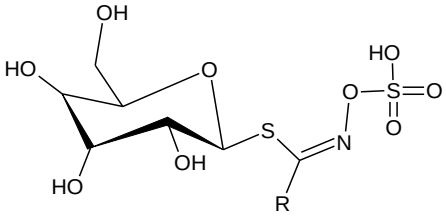
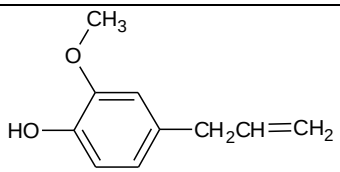
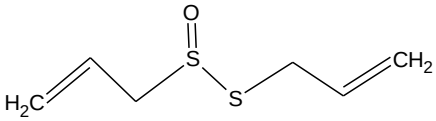
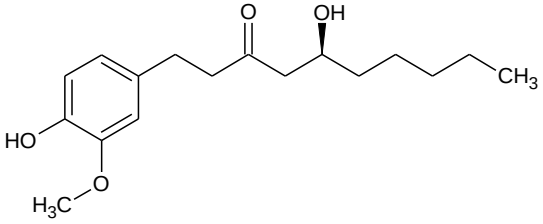
linked by a heterocyclic pyrone ring cycle .Three hydroxyl groups (–OH) at positions 4′ (on ring B), 5, and 7 (on ring A), which are crucial for its biological activity, including antioxidant and antimicrobial effects. Physicochemical Properties; Solubility: Poorly soluble in water but readily dissolves in organic solvents such as ethanol, DMSO, and methanol. Appearance: Yellow crystalline solid in pure form. Biosynthesis in Plant Apigenin is synthesized through the phenylpropanoid pathway where phenylalanine is first converted into cinnamic acid derivatives Subsequent enzymatic reactions, including chalcone synthase (CHS) and chalcone isomerase (CHI), lead to the formation of the flavone structure. Apigenin helps alleviate UTI-induced inflammation and supports immune function by: Inhibiting NF-κB and COX-2 signaling pathways, leading to reduced production of Pro-inflammatory cytokines. Modulating immune activity, thereby accelerating infection resolution.Antimicrobial Properties of Apigenin Against Uropathogens Apigenin demonstrates potent antibacterial activity against common UTI-causing pathogens Through multiple mechanisms: Inhibition of bacterial adhesion: It interferes with fimbrial proteins, reducing E. coli Adherence to urothelial cells.;Disruption of biofilm formation: Apigenin prevents the development of biofilms, Which are crucial for recurrent infections.; Synergistic action with antibiotics: It enhances the effectiveness of antibiotics like Ciprofloxacin and norfloxacin, particularly against resistant bacterial strains.[151]

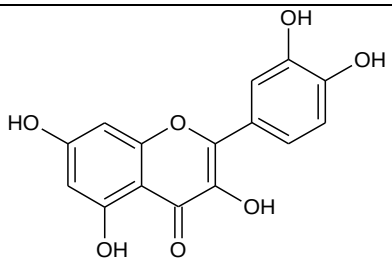
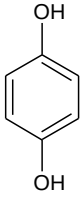
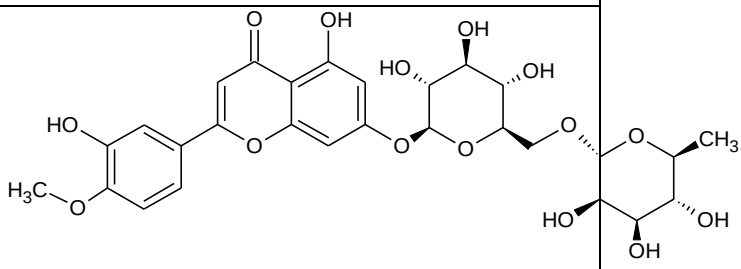
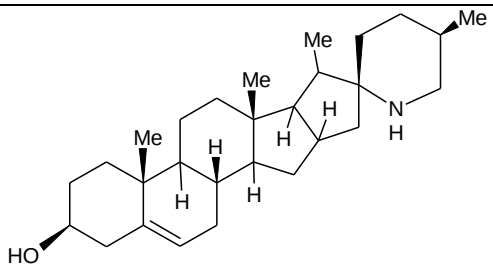
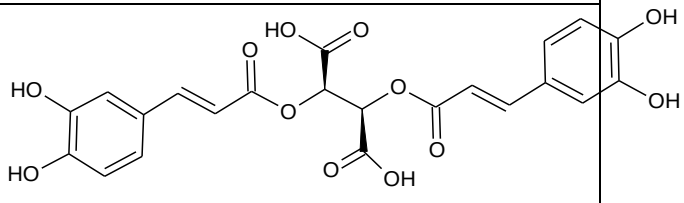
4.15: KAEMPFEROL

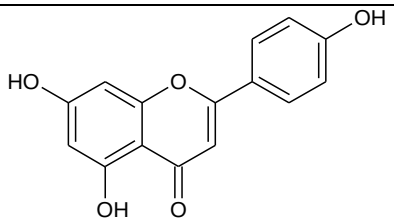
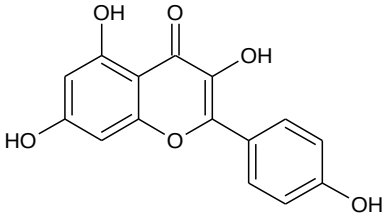
Kaempferol (3,5,7-trihydroxy-2-(4-hydroxyphenyl)-4H-chromen-4-one), a member of the Flavonol class, exhibits potent broad-spectrum antimicrobial and anti-inflammatory Properties, making it a promising candidate for UTI treatment.Antimicrobial Mechanisms Against Uropathogens :Kaempferol addresses UTIs through several targeted actions;Direct Antibacterial Activity :Prevents bacterial adhesion: By interfering with Type 1 fimbriae and FimH adhesins, Kaempferol inhibits the attachment of uropathogenic E. Coli (UPEC) to bladder epithelial Cells.Inhibits biofilm formation: It disrupts biofilms in Proteus mirabilis and Klebsiella Pneumoniae, which are major contributors to recurrent infections.Enhances antibiotic potency: Kaempferol acts synergistically with ciprofloxacin and Nitrofurantoin, improving their effectiveness against resistant bacterial strains [152]

Table 2: Biomolecules used to management and treatment of UTI

BIOLOGICAL NAME	PHYTOCONSTIUE T	PLANT PART	CHEMICAL FORMULA	STRUCTURE
Camellia sinensis	epigallocatechin-3-gallate (EGCG)	Leaves and buds	C22H18011	
Vaccinium Macrocarpon	Resceratrol	Fruit and dry berries and juice	C14H12O3	
Ocimum Tenuiflorum	flavonoids	Leaves and stem	C15H10O2	

Citrus paradisi	proanthocyanidins	Seed and skin	C30H26O12	
Armoracia Rusticana	sinigrin	Root	C10H16KNO9S2	
Syzygium aromaticum	eugenol	Flower bud, leaves and stem	C10H12O2	
Allium sativum	Allicin	Garlic clove	C6H10OS2	
Zingiber officinale	6 Gingerol	Rhizome	C17H26O4	

Moringa oleifera	Quercetin	Leaves	C15H10O7	
Arctostaphylos uva-ursi	hydroquinone	Leaves	C6H5(OH)2	
Agathosma	Barosmin	Leaves	C28H32O15	
Solanum virginianum	Spirosol 5 en 3 ol	Fruit	C27H43NO2	
Echinacea purpurea	Chicaric acid	Root, stem, leaves and flowers	C22H18O12	

Matricaria Chamomilla	Apigenin	Ligulate (ray) florets	C15H10O5	
Hybanthus enneaspermus	Kaempferol	Leaves	C15H10O6	

5. DISCUSSION

We are using several allopathic medicines for Urinary tract infection it produces major side effects. Now days plant extract also have major therapeutic action in Urinary tract infection to treat that it also proved in scientific research. we have referred several research articles as well as some popular journals to manage Urinary tract infection by using some plant herbs and their bioactive molecules. In this generation herbal plants are have main therapeutic effects as well as fewer side effects. Women are facing lot of problems the major problem are Urinary tract infection by treating with herbs 95% problems have been cured. We have discussed some plant herbs like Greentea, garlic, ginger, cranberry, tulsi, grape fruits, horse raddish, clove, moringa, uva-ursi, buchu, kantakari, echinacea purpurea, chamomilla flower, hybanthus etc… By using this plant herbs treat and manage the Urinary tract infection with lesser side effects and more therapeutic effect. The bioconstituent also play a major role in the UTI problem. Some bioconstituents have been discussed above the article are Epigallocatechin gallate, Resveratrol, Flavanoids, Type A procyanidins, sinigrin, eugenol, allicin, 6- gingerol, quercetin, arbutin, diosphenol etc. We concluded by using this plant herbs and bio active constituents are Anti- microbial, Anti-inflammatory, Diuretics some other actions also produced like Anti- adhesive, Anti- biofilm activity, Immunomodulatory effect. By using plant herbs and bio active constituents we have conclude our discussion it produce potential action and fewer sideeffects.

6. CONCLUSION

Plant extracts and biomolecules represent a promising approach for treating and preventing urinary tract infection (UTIs). Particularly in light of increasing antibiotic resistance. Although traditional medicine has historically utilized this natural compound rigorous scientific validation through standardized research and clinical trials is necessary to ensure their safe and effective incorporation into mainstream healthcare

7.REFERENCE

1.Neil Sheerin,2011, urinary tract infection, volume:39, issue :7, page no:384-389.

2.Jasmine B.L ,Lee Guy H.,2007 urinary tract infection.Neild medicine . volume :35 issue: 8 .3. Rajinder Kaur .2021. urinary tract Infection.Medical Journal, Volume 97, Issue 1154.Pages 803–812

4. Hooton TM. 2012. Urinary tract infection. N Engl J Med Overseas Ed, Volume:366 page no:1028–37.

5.M. Vishwanath Swamy, Md Aqib Ali Faraz, 2020.Urinary tract infection. Sowjanya MendemInternational Journal of Current Microbiology and Applied Sciences, ISSN: 2319-7706 Volume: 9, Issue :7

6.Bono MJ, Reygaert WC. 2019.Urinary tract Infection. InStat Pearls.

7.Najar MS, Saldanha CL, Banday KA.2009. Approach to urinary tract infections. Indian J Nephrol. Volume :19, issue:4, page no: 129–139.

8.Catherine D. Bacheller MD Jack M. Bernstein. 1997. Urinary tract infection.Volume: 81 issue :3.

9.Salvatore S, Salvatore S, Cattoni E, Siesto G, Serati M, Sorice P, et al. 2011.Urinary tract Infections in women. European Journal of Obstetrics and Gynecology and Reproductive Biology. Volume: 156, issue:2, page no:131-6. https://doi.org/10.1016/j.Ejogrb.2011.01.028

10.Malankara Saiyed, Dr. Rajesh Maheshwari, Dilsar Gohil3, Krupa Joshi.2023A Comprehensive Review on Herbal Medicinal Plants for Urinary Tract Infections.

11.DIO:http://www.urologychanel.com/uti/causes/shtm

12.Neu HC.1992. The crisis in antibiotic resistance. Science. Volume: 257, issue:5073 Page no:1064-73. DIO:

https://doi.org/10.1126/Science.257.5073.1064

13.Afsaneh Noormandi, Fatemeh Dabaghzadesh. 2015 uses of green tea escherichia coli as a uropathoga. Journal of Traditional and complementary medicine.Volume:5, Issue:1,Page no:15-20.DOI:https://doiorg/10.1016/j.jtcmcm.2014.10.005.

14.Marcelo Hisano, Homero Bruschini,Antonio Carlos Nicodemo,Miguel Srougi.2012.Cranberries and lower urinary tract infection prevention.Clinics(Sao Paulo).Volume:67,Issue:6,Page no:661–667. Doi: 10.6061/clinics/2012(06)18.

15.Prakash.P and Neelu Gupta.2005. Therapeutic uses of Ocimum sanctum linn(Tulsi).Indian J Physio pharmacol.Volume:49,Issue:2,Page no :125-131.

16.Osungunna MO, Onawunmi GO.2015. Uses of graph fruit (Citrus Paradisi) seed extract and Juice against Bacteria.University of Lagos Jounal of Basic Medical Volume:3,Issue:6

17.Elena Jimenez Negro, Jandisk sendker,Timo stark,Bartosz Lipowiez,Andreas Hensel.2022.Function of Horseradish (Armoracia Rusticana)against bacteria. Fitoterapia. Volume: 162. DOI:https://doi.org/10.1016/j.fitote.2022.105282.

18.Vanessa Lee Rosarior, Pei Shan Lim,Wei Kit Wong,Chen Son Yue,Hok Chai Yan, Sheri-Annian.2021.Clove extract A stronge Anti microbial agent against UTIs.Tropical life Suinas Research.Volume:32.Issue:2.Page no:45-63.DOI:10.21315/tlsr2021.32.2.4.

19.Okunye olufemi Lionel, Idowu Philip Adegboyega,Adeleke D.Ezekiel,Babalola Caroline Olufunke.2020. Antimicrobial Activity of Garlic.Wolters Kluwer-Medknown.Page no:134 DOI:10.4103/atp.atp-9-20.

20.Rara Sagita, Elighty M.Kurniawati,Zakiyatul Faizah.2022.Ginger is used in the Treatment for Women Urinary tract infection.Tropical Journal of Natural Product Research.Volume:6, Issue:9,Page no:1367-1371.

21.Rahima Tanbin Tama, Md.Sakhawat Hossain,Md.Ashikur Rahaman,Md.Ashraful Alam,Md.Mafizur Rahman,Anzana Parvin,Rifaia Sultana Chowdhury,Md.Shahidul Islam.2024.Natural Product of Moringa against bacterial urinary tract infection. Science Volume:13

22.Charles E. Deutch.2025. Use of Arctostaphylos uva-ursi Extracts for the Treatment of Urinary Tract. InfectionsEuropean Journal of Medicinal Plants. Volume: 36, [Issue :3], Page: 62-87.DOI: 10.9734/ejmp/2025/v36i31264

23.Bibi Sedigheh Fazly Bazzaz,Sareh Darvishi Fork,Reza Ahmadi,Bahman Khameneh.2021.Deep insights into urinary tract infections and effective natural remedie of Buchu.African Journal of Urology.Volume:27 Issue:6.DOI:https://doi.org/10.1186/s12301-020-00111-z

24.Vanya Gupta, Om Prakash Gupta,Priyanka,Aditi Yadav.2023.Exploring the Medicinal Importance of Kantakari.Journal of Ayurveda and Integrated Medical Sciences.Volume:8,Issue:4,Page no:194-206.DIO:10.21760/jaims.8.4.33

25.Benjamin Kligler, M.D., M.P.H.2003.Uses of Echinacea for treating the urinary tract infection. American Family Physician. Volume:67, Issue:1, Page no:77-80.

26.Rana H. Raheema and Muntadher A. Alsaidi.2016. Protective effect of chamomile recutita flowers extract against Urinary tract infection induced by Pseudomonas aeruginosa .Journal of Health, Medicine and Nursing ISSN2422-8419. Volume:22.DOI:www.iiste.org

27.P.B.Rajsekhar,R.S.Arvind Bharani,K.Jini Angel Maya Ramachandran &Sharadha Priya Vardhaini Rajsekhar.2016.Uses of hybanthus against urinary tract infection .Journal of chemical & Pharmaceutical Research.Volume:8,Issue:1,Page no:351-355

28.Arakwa H, Maeda M, Okubo S, Shimamura T.2004. Role Of hydrogenperoxide in bactericidal Action of Catechin. Biol Pharm Bull, volume:27, page no: 277-281.

29.Tiwari R.P., Bharti S.K, Kaur H.D., Dikshit R.P. and Hoondal G.S.2005. Journal of Medical Research, volume:122. Page no :80-84.

30.J.Ananthi and R. Sagaya Giri.2018.World Journal of Pharmaceutical and Medical Research.Volume:4.issue:9,Page no: 181-185.

31.McKay, D. L., and Blumberg, J. B.2002. The role of tea in humanhealth: an update. J. Am. Coll. Nutr.21, Page no:1–13.

32.Wanda Reygaert and Ilir Jusufi.2013. Original Research Article.Doi: 10.3389/fmicb.2013.00162

33.Wang, Y., and Ho, C. T. 2009.Polyphenolic chemistry of tea andCoffee: a century of Progress. J. Agric.Food. Chem. 57, 8109–811jf804025 doi:10.1021/jf804025c

34.Yam, T. S., Shah, S., and HamiltonMiller, J. M. T. 1997. Microbial Activity of whole and Fractionated Crude extracts of tea (Camellia sinensis), and of tea components. FEMS Microbiol. Lett. Volume:152, Page no: 169–174. Doi:10.1111/j.1574-6968. 1997 tb10424.x

35.Taguri, T., Tanaka, T., and Kouno, I.(2004). Antimicrobial activity of 10 Different plant Polyphenols against Bacteria causing food-borne disease.Biol. Pharm. Bull. Volume:27, page no: 1965–1969. Doi:10.1248/bpb.27.1965

36.Guri, T., Tanaka, T., and Kouno (2006). Antibacterial spectrum of plant polyphenols and Extracts depending upon hydroxyphenyl structure. Biol. Pharm.Bull. Volume:29, page no: 2226–2235. Doi:10.1248/Bpb.29,2226

37.Taylor, P. W., Hamilton-Miller, J. M. T., And Stapleton, P. D. (2005). Antimicrobial Properties of green tea catechins. Food Sci. Technol. Volume :2, Page no:71–81.

38.Friedman, M. (2007). Overview of Antibacterial, antitoxin, antiviral and antifungal Activities of tea Flavonoids and teas. Mol. Nutr. Food Res. Volume:51, Page no:116–134. Doi:10.1002/Mnfr.200600173

39.Song, J. M., and Seong, B. L. (2007) Tea catechins as a potential alternative anti-infectious agent. Expert Rev.Anti. Infect. Ther. Volume:5, Page no:497–506. Doi:10.1586/14787210.5.3.497

40.Gradišar, H., Pristovšek, P., Plaper, A.And Jerala, R. (2007). Green tea catechins inhibit Bacterial DNA gyrase by interaction with its ATP binding doiSite. J. Med. Chem. Volume:50, Page no:264–268. Doi:10.1021/jm0608170

41.S. Valli and M. Divya (2019) International Journal of Pharmacy and Biological SciencesIJPBSTM (2019). Volume :9 , Issue:3, Page no::966-973 Online ISSN: 2230-7605, Print ISSN: 2321-3272.

42. Fanos V, Atzei A, Zaffanello M, et al. (2006). Cranberry and prevention of urinary tract infections In children. J Chemother 2006; 18 Spec no. 3: 21-4 19. Raz R, Chazan B, Dan M (2004). Cranberry Juice and urinary tract infection. Clinical Infection Diseases Volume:38 1413-9.

43.González de Llano, D., Victoria Moreno-Arribas, MAnd Bartolomé, B. 2020. Cranberry Polyphenols And prevention against urinary tract infections: Relevant considerations. Molecules 25(15), 3523.Hellström, J., Törrönen, R. And Mattila, P. 2009.

44.Mantzourani, I., Bontsidis, C.A., Plessas, S., Alexopoulos, A., Theodoridou, E., Tsigalou, C., Voidarou, C., Douganiotis, G., Kazakos, S.L., Stavropoulou, E. And Bezirtzoglou, E. 2019. Comparative susceptibility study against pathogens Using fermented cranberry juice and Antibiotics. Front. Microbiol. Volume:10, Issue:1294.

45.Hmood, Hayder Kamil Jabbar Al Kaabi andBaheeja A. Open Veterinary Journal, (2025), Vol. 15, Issue:2, Page no: 813-819.

46. Strandwitz, P.O Connor, K., Morrissette, M., Ghiglieri, M., Caboni, M., Liu, H., Khoo, C., D'Onofrio, A. and Lewis, K. (2019). Cranberry extracts promote growth of Bacteroidaceae And decrease abundance of Enterobacteriaceae in a human gut sitimulator 31 model. PLoS One 14(11), e0224836.

47.Das, S. 2020. Natural therapeutics for urinary tract Infections—a review. Egypt J. Chem. Volume:63, Issue:8, Page no:2865–2878.

48.Ruchała MA, Gościniak A, Paczkowska-Walendowska M, Skotnicka A,CieleckaPiontek J. 2021.Can Plant Materials Be Valuable in the Treatment of Periodontal Diseases? Practical Review. Pharmaceutics. Volume:13, Issue:12, Page no:2185 Doi:10.3390/pharmaceutics13122185. PMID: 34959467; PMCID: PMC8705740.

49. Darvishi M, Shahi S, Goli M, Maghsoudi Z, Ranjbaran SM (2021). Evaluation of optical Parameters of Vaccinium macrocarpon fruit (Iranian cranberry) as a substitute For Cornus Mas

with emphasis on chemical properties in the prevention and Treatment of oral Diseases. Yafteh. Volume:23, Issue:2, Page no:196-208.

50. Hlazunov O, Hruzdeva A, Fesenko V, Korniichuk O, Penskyi K. (2022) The particulars Of Applying Odontoprotectors at different stages of therapeutic Process of Periodontal Diseases (A Scoping Review). International Journal of Statistics In Medical Research.Volume:11, Page no:41-50.

51.Ranjbar R, Barzegar PEF, Yazdanian M, Tahmasebi E, Alam M, Abbasi K. (2022) The Current Natural/chemical materials and innovative technologies in periodontal Diseases therapy nd regeneration: A narrative review. Materials Today Communications. 2022; 104099.

52. Journal of Medicinal Plants Studies Year: 2014, Volume: 2, Issue: 2 First page: (1) Last Page: (08) ISSN: 2320-3862.

53.Kumar V., Andola H.C., Lohani H. And Chauhan N. (2011). Pharmacological Review on Ocimum sanctum N Linnaeus: A Queen of herbs. J of Pharm Res, Volume:4, Page no:366-368.

54.Mondal S., Bijay R. Miranda R. B., and Sushil C. M. (2009). The Science behind Sacredness of Tulsi (Ocimum sanctum LINN.). Ind J of Physiol Volume :53, Page no:291-306.

55.Gupta, S.K, Prakash J and Srivastava S (2016). Validation of traditional claim of Tulsi, Ocimum sanctum Linn. As a medicinal plant. Journal of Phytopharmacology.Volume:5, Issue:5, Page no: 205-20. Indian.J Exp Biol. 2002;Volume:5,Page no:765-773.

56.Uma Devi.P (2001). Radioprotective, anticarcinogenic and antioxidant Properties of the Indian Holy basil, Ocimum sanctum (Tulasi). Indian J Exp Biol. 2001; Volume:39Page no:185-190.

57.Umer Saeed, Imrani Anwar, Hussain Bukhari,Saman Saee Original Article1454 P J M H S .(2018).A Study of Antimicrobial Effects of Citrus Paradisi‘Grape Fruit’.Volume: 12, Page no:4.

58.Mehdavi R, Nikniaz Z, Rafraf M, Jouyban A (2010). Determination And comparison of total Polyphenol and vitamin C contents of Natural fresh and commercial juices. Pak jour of Nutr.2010; Volume :9, Issue:10, Page no: 968-972.

59.Heggers JP, Cottingham J, Gusman J, Reagor L, McCoy L, Carino E, Cox R, Zhao JG, Reagor L(2002) .The effectiveness of processed Grapefruit seed extract as an antibacterial agent. II.

Mechanism Of action and in-vitro toxicity. J Altern Complement Med Volume:8, Page no:333–340.

60.Reagor L, Gusman J, McCoy L, Carino E, Heggers JP (2002). The effectiveness of processed Grapefruit seed extract as an antibacterial agent; I. An in-vitro agar assay. J Altern Complement Med 2002; Volume:8, Page no:325–332.

61.LAdeyemi,O.A.Oyelami,F.W.A.C.P.,E.A.Agbakwuru,F.W.A.C.S.,F.M.L.S.(Nigeria)andG.Badeeji,M.Sc.2005.The Journal of Alternative and Complementary Medicine Volume 11,Page no: 369–371.

62.Shehata, A.; Mulwa, R.M.S.; Babadoost, M.; Uchanski, M.; Norton, M.A.; Skirvin, R.; Walters, S.A(2009). Horseradish: Botany, Horticulture, breeding. Volume:35, Page no:221–261.

63.Negro, E. J., Sendker, J., Stark, T., Lipowicz, B., & Hensel, A. (2022). Phytochemical and Functional Analysis of horseradish (Armoracia rusticana) Fermented and non-fermented Root extracts. Page no: 162, 105282

64.Knez, E., Kadac-Czapska, K., Dmochowska-Ślęzak, K., & Grembecka, M. (2022). Root VegetablesComposition, Health Effects, and Contaminants.International Journal of Environmental Research and Public Health, Volume :19, Issue:23, 15531.

65.Popović, M., Maravić, A., Čikeš Čulić, V., Đulović, A., Burčul, F., & Blažević, I. (2020). Biological effects of glucosinolate degradation products from horseradish: A horse that Wins the race. Biomolecules Volume :10, Issue :2, Page no:343.

66.Agneta, R., Möllers, C., & Rivelli, A. R. (2013). Horseradish (Armoracia rusticana), a Neglected Medical and condiment species with a relevant Glucosinolate profile: a review. Genetic resources and Crop evolution, Volume:60, Page no:1923-1943.

67.Elena Jimenez Negro, Jandirk Sendker , Timo Stark Bartosz Lipowicz ,2022. Introduction of clove. Andreas Hensel page no: 162 .

68. Ullah, M. A., Hassan, A., and Hamza, A. (2023). Role of Clove in Human Medical History. SAR J Anat Physiol, Volume:4, Issue:2, Page no:10-19.

69.Kiong, H. L. &Khalid, K (2010). Screening of some Malay medicated oils for Antimicrobial Activity. Archives of Biological Sciences, Volume:62, Issue :2, Page no:393-395.

70.Batiha, G. E. S., Alkazmi, L. M., Wasef, L. G., Beshbishy, A. M., Nadwa, E. H., and Rashwan, E. K. (2020). Syzygium aromaticum L (Myrtaceae): traditional uses, bioactive Chemical Constituents, pharmacological and toxicological activities. Biomolecules, Volume :10, Issue:2.

71.Isha Kumari, Shifali Thakur, Shailja Choudhary, Madhusudan S, Bhawna Walia, Hemlata Kaurav and Gitika Chaudhary (2021). Phytoconsition of Ginger.Journal of Current Research Vol. 13, Issue, 02, Page no:16368-16375.DOI: https://doi.org/10.24941/ijcr.4080

72.Anusha N.Pulipati et.al. S, Babu P S.Narasu M L, 2017 .An overview on urinary tract Infections and effective Natural remedies.

73.Gayatri Waghmare, Sushma PParde, Mayuri Thote, Vrushabh Sang (2024) IJSDR ,Volume: 9 Issue :6

74.Gibbons S.2003. An overview of plant extracts as a potential therapeutics. Expert Opin Ther Pat 2003.

75.Wang H, Luo K, Tan L-Z. 2012.induced Gene 3Mediates Cell Death Induced by Glutathione Peroxidase.The Journal of Biological Chemistry. Volume:287 Issue:201,16890-16902. Page no:53.

76. Mansour A, Hariri E, Shelh S, Irani R, Mroueh M. (2014) Efficient and Cost-Effective Alternative Treatment for Recurrent Urinary Tract Infections and Interstitial Cystitis in Women: A TwoCase Report. Case Reports in Medicine, 2014, 698758.

77.Bashir, A., Mohammed, S. S. D, David, A.A.D., Abdul- Rahman, A.A. and Ninyio, N.N (2019). Traditional uses of Ginger.IFE Journal of Science and Technology.Volume :3. Issue :1.

78.Mohamad LS. (2019) The effect of alcoholic extracts of zingiberofficinale anti-E. Coli isolates Isolated from Urinary tract infection. Iraqi Journal of Science. Volume:60, Issue:10, Page no:2136-40.

79.Wijaya CH, Fathona D (2011). Kandungan Gingerol dan Shogaol, Intensitas Kepedasan dan Penerimaan Panelis terhadap Oleoresin Jahe Gajah. Institut Pertanian Bogor. 2011. [WebPage]

80. Bode AM, Dong Z. (2011). The Amazing and Mighty Ginger. [PubMed] [CrossRef]

81. Gull I, Saeed M, Shaukat H, et al.(2012). Inhibitory Effect of Allium Sativum and Zingiber Officinale Extracts on Clinically Important DrugResistant Pathogenic Bacteria. Ann Clin Microbiol Antimicrob Volume :11, Issue: 8.[PubMed] [CrossRef]

82. Murray PR, Rosenthal KS, Pfaller (2016). Medical Microbiology E-Book, 8th Edition. Elsevier

83. Bharathi D., Kumari R., Lakshmi G., et al (2015). Identification Of Urovirulent Markers in Uropathogenic Escherichia Coli. Int J Curr Res Rev 2015; Volume:7, Page no: 51–54. [WebPage]

84. Brooks G. Jawetz, Melnick, &Adelberg's Medical Microbiology, Twenty-Fifth Edition (LANGE Basic Science). Atlanta (US): McGraw-Hill Professional Publishing, 2010.

85. Rosmana D, Hardianto G, Debora MS K.2018. Jahe Mengurangi Jumlah Koloni Uropathogenic Escherichia Coli pada Wanita Menopause dengan Infeksi Saluran Kemih Asimtomatis. Maj Obstet Ginekol Volume :24, Issue:1 [CrossRef]

86.Maurya SK and Singh AK.2024. Clinical efficacy of Moringa oleifera Lam. Stems bark in urinary Tract Infections. International scholarly research notices. PMC4897232. Doi: 10.1155/2014/906843

87. Karandikar GK.1960. Effect of some Ayurvedic remedies On the urine output in rats and dogs. Ind Jour Med Sciences volume:14, Page no:585-9.

88. Akila B, Manickavasakam K.2012. Oral acute and subacute toxicity studies of two siddha Formulations Vedikara silasathu parpam (vsp) and nerunjil Kudineer (nk) in experimental Rats. Int J Pharm Sci 2012; Volume:4, Issue 2, Page no:88- 90.

89. Rastogi T, Ghorpade DS, U. A. Deokate, and S. S. Khadabadi,2009. Studies on antimicrobial Activity of Boswellia serrata, Moringa oleifera and Vitex Negundo: a comparison. Research Journal of Pharmacognosy and Phytochemistry; Volume :1, Issue:1, Page no:75–77.

90.Vijayalakshmi FJ, M. C. S. Kumar, G. P. Kodancha, B. Adarsh, A. L. Udupa, and U. P. Rathnakar.2010. Antiurolithiatic activity of aqueous extract of bark Of Moringa oleifera (Lam.) in Rats. Health; Volume:2, Issue:4, Page no: 352–5.

91.Chetia B and S. Gogoi.2011. Antibacterial activity of the Methanolic extract of stem bark of Spondias Pinnata, Moringa oleifera and Alstonia scholaris. Asian Journal of Traditional Medicines 2; volume:6, Issue:4, Page no:163–7.

92.Gul M, E. Kurutas, P. Ciragil.2005. Urinary tract infection Aggravates oxidative stress in Diabetic patients. The Tohoku Journal of Experimental Medicine; volume:206, Issue:1,Page no :1–6.

93. Pinar, B. K. Ergul, G. Mustafa, K. Metin, A. MMuratAnd G. Alanur.2005. The effects of oxidative Stress in Urinary tract infection during pregnancy. Mediators Of Inflammation; volume:5, Page no:309–11.

94. Lis-Balchin, M., Hart, S., and Simpson, E (2001). Buchu (Agathosma betulina and A. Crenulata, Rutaceae) essential oils: their Pharmacological action on guinea-pig ileum And Antimicrobial activity on Microorganisms. J Pharm Pharmacol 2001; volume:53, Issue:4, Page no:579-582.

95.Spreeth AD (1976). A revision of the Commercially important AgathosmSpecies.Journal Of South African Botany, volume:42: Page no:109-119.

96.Van Wyk B-E, Van Oudtshoorn B, Gericke N (1997). Medicinal plants of South Africa.Briza Publications, Pretoria, Page no: 34-35 .Michael T. Murray, ND., Textbook of Natural Medicine 2ndEdition; Volume 1.

97. Blumenthal M, Goldberg A, Brinckmann J. (2000). Herbal Medicine: Expanded Commission E Monographs. Boston: Integrative Medicine Communications; Page no:389-393.

98.Rakel D. Rakel: Integrative Medicine, 2nd Ed. Philadelphia, PA: Saunders; 2008;24

99.Bevrlidingslaan, Netherlands, ESCOP Secretariat, 1992. European Scientific Co operative for Phytotherapy. Proposal for European Monographs. Volume:3.

100.M. Blumenthal, W.R. Busse, A. Goldberg et al.(eds).1998. The Complete German Commission E Monographs: Therapeutic Guide to Herbal Medicines, (Austin American Botanical Council of Boston: Integrative Medicine Communications), Page no:224-225.

101. C. Newall, L Anderson, J. Phillipson. 1996.Herbal Medicines: A Guide for Health-care Professionals (London: Pharmaceutical Press, Page no:258-259.

102.Brown D (1995) The RHS Encyclopedia of Herbs and Their Uses. Dorling Kindersley, London, Page no:106.

103.Bruneton J (1999). Pharmacognosy, Phytochemistry, Medicinal plants. 2nd edn. Lavoisier Paris, Page no:464 .

104.Chevallier A (2001). Encyclopedia of Medicinal Plants. New edn. Dorling Kindersley, London, Page no:67(sub Barosma)

105.Posthumus MA, Van Beek TA, Collins NF, Graven EH (1996). Chemical composition ofAThe essential oils of Agathosma betulina, A. Crenulata and an A. Betulina x crenulata Hybrid (buchu). J. Essent. Oil Res. Volume:8, Page no: 223-228.

106.Gupta MP, Dutt S.1938. Chemical examination of the seeds of Solanum xanthocarpum. II. Constituents. Journal of the Indian Chemical Society; volume:15, page no:95–100.

107.Udaykumar R, Velmurugan, K, Srinivasan D, Krishna RR.2003. Phytochemical and Antimicrobial Studies of extracts of Solanum xanthocarpum. Anc Sci Life; volume:23, Issue :2, Page no:90-94.

108. Abbas K, Niaz U, Hussain T, Saeed MH, Javaid Z, Idrees A, Rasool S. 2014.Antimicrobial Activity of fruits Of Solanum nigrum and Solanum xanthocarpum. Acta Poloniae Pharmaceutica -Drug Research; volume:71, Issue:4, Page no: 415-21.

109.Amin AH Mehta DR, Samarth SS. In: Proceedings, First International Pharmacological Meeting, Stockholm, Pergamon Press Ltd.

110. Head KA.2008. Natural approachs to prevention and treatment of infections of the lower Urinary tract. Altern Med Rev.; volume:13, issue:3, Page no:227-44.

111.Jonasson A, Larsson B, Fianu S. 1993.Prophylactic effect of UVA-E in women with Recurrent cystitis: a preliminary report. Curr Ther Res.; volume:53, Page no:441-443.

112.Sunset Western Garden Book. 1995.Page no:606–607.

113.Awang DVC, Kindack DG. Echinacea. Can Pharm J (1991). 124:512-6. 99.

114.V. N Samorodov, S. V. Pospelov, G. F. Moiseeva and A. V. Sereda., Phytochemical Composition of plants Echinacea.

115.Linde K, Barrett B, Wölkart K, Bauer R, Melchart D (2006). “Echinacea for Preventing And treating the common cold”. Cochrane Database of Systematic Reviews (Online).

116.Woelkart K, Marth E, Suter A, et al. 2006.Bioavailability and pharmacokinetics of Echinacea Purpurea preparations and their Interaction with the immune system. Int J Clin Pharmacol Ther. ; volume 44, Issue:9, Page no:401-8.

117.Orav, A.; Raal, A.; Arak, E.2010. Content and composition of the essential oil of Chamomilla Recutita (L.) Rauschert from some European countries. Nat. Prod. Res. volume :24, page no:48–55. DIO:https://doi.org/10.1080/14786410802560690.

118.Piri, E.; Sourestani, M.M.; Khaleghi, E.; Mottaghipisheh, J.; Zomborszki, Z.P.; Hohmann, J.; Csupor, D. Chemo-diversity and Antiradical potential of twelve Matricaria chamomilla L. Populations from Iran: Pproof of ecological effects. Molecules 2019, volume :24, Page no:1315. DIO:https://doi.org/10.3390/molecules24071315.

119.Roby MH, Sarhan MA, Selim KA. 2013.Antioxidant and antimicrobial activities of essential oil And extracts of Fennel (Foeniculum vulgare L.) and chamomile (Matricaria chamomilla L)Ind Crop Prod, ; volume:44, Page no:437-45.

120.Lingaraj Kulkarni, Pradeep Bhal,Gaesh Hegde.(2022).World Journal of Pharmaceutical Research.Volume:11, Issue:4,Page no:1361-1372.DOI:10.20959/wjpr20224-23569.

121. Khan, N., & Mukhtar, H. (2007). Tea polyphenols for health promotion. Life Sciences.Volume:81, Issue:7, Page no: 519–533.DOI: https://doi.org/10.1016/j.lfs.2007.06.011

122.Sudano Roccaro, A., Blanco, A. R., Giuliano, F., Rusciano, D., & Enea, V. (2004). Epigallocatechin-gallate enhances the activity of tetracycline in staphylococci by inhibiting its efflux from bacterial cells. Antimicrobial Agents and Chemotherapy.Volume:48, Issue :6, Page no:1968–1973.DOI: https://doi.org/10.1128/AAC.48.6.1968-1973.2004

123. Jeong, C. H., & Kim, J. H. (2021). Antibacterial and antibiofilm activities of green tea catechin against clinical isolates of uropathogenic Escherichia coli. Journal of Microbiology and

Biotechnology.Volume:31, Issue:3, Page no:386–392. DOI:https://doi.org/10.4014/jmb.2010.11007

124.4. Baur JA, Sinclair DA.(2006) Therapeutic potential of resveratrol: the in vivo evidence. Nat Rev Drug Discov. Volume:5,Issue:6,Page no:493–506.

125. Zhang.Z.(2013). Resveratrol inhibits Escherichia coli biofilm formation by represing luxS expression. Volume :8, Issue: 10: e76260.

126.Wu CC (2013). Resveratrol suppresses E. coli-induced inflammation in human uroepithelial cells via NF-κB and MAPK signaling pathways. Volume: 8, Issue:4:e61420.

127. Kim HJ (2020). Resveratrol ameliorates chronic cystitis by modulating the TLR4/NF-κB signaling pathway. Int Immunopharmacol. Volume:80: 106213.

128.Singh, S., Taneja, M., & Majumdar, D. K. (2012). Biological activities of Ocimum sanctum L. Fixed oil—An overview. Indian Journal of Experimental Biology.Volume:45, Issue:5, Page no :403–412.

129.Pattanayak, P., Behera, P., Das, D., & Panda, S. K. (2010). Ocimum sanctum Linn. A reservoir plant for therapeutic applications: An overview. Pharmacognosy Reviews.Volume: 4, Issue;7, Page no: 95.

130.Drewnowski, A., & Gomez-Carneros, C. (2000). Bitter Taste, phytonutrients, and the consumer: a review. The American Journal of Clinical Nutrition.Volume:72, Issue:6, Page no:1424–1435.

131.Cushnie, T. P., & Lamb, A. J. (2005). Antimicrobial activity of flavonoids. International Journal of Antimicrobial Agents, Volume:26, Issue:5, page no:343–356.

132.Howell, A. B. (2005) A-type cranberry proanthocyanidins and uropathogenic bacterial anti-adhesion activity.* Phytochemistry, Volume:66Issue:18, Page no:2281-229.

133.Dufour, V (2015). Applied And Environmental Microbiology, Volume:81, Issue:4 Page no: 1372-1379.

134.Borges, A. (2015). Food Chemistry, Volume :167, Page no:36-44.

135.Algburi, A. (2016). Foodborne Pathogens and Diseas.Volume:13, Issue:6, Page no:341-347.

136.Bakkali, F. (2008). Biological effects of essential Oils.Food and Chemical Toxicology.Volume: 46, Issue:4, Page no: 446-475.

137. Khan, M. S. A. (2018). Eugenol inhibits Bacterial biofilms Frontiers in Microbiology Volume:9, Page no:1364.

138.Miron, T., (2008). Allicin inhibits Proteus mirabilis urease. Antimicrobial Agents and Chemotherapy. Volume:52, Issue:8, Page no: 3067–3072.

139.Bayan, L. (2014). Garlic: A review of potential therapeutic effects. Avicenna Journal of Phytomedicine.Volume:4, Issue:1, Page no:1–14.

140. Packiavathy ., 2014. Ginger: A review of therapeutic effect.

141. Kim , 2005. Anti-Inflammatory and Immunomodulatory Effects of ginger.

142.Karuppiah, P., & Mustaffa, M. (2016). Asian Pacific Journal of Tropical Biomedicine Volume:6, Issue:3, Page no:238-242

143.Gupta, P., (2021). Phytomedicine, Volume :85, Page no:153298.

144.Blumenthal M (1998). The Complete German Commission E Monographs. American Botanical Council.

145.McCutcheon A.R (1992) .Antibacterial screening of Medicinal plants of the British Columbian native peoples. J Ethnopharmacol. Volume:37, Issue:3 Page no:213–223.

146.Khan, A., & Gilani, A. H. (2011). Antimicrobial and anti-inflammatory activities of Agathosma Betulina.Journal of Ethnopharmacology.Volume: 135, Issue :2 Page no:313-319.

147.Patel, N. (2014). Anti-inflammatory and diuretic effects of solasodine in Experimental UTI models. Phytomedicine Volume:21, Issue:5, Page no:678-684

148.Thygesen, L.(2007). Chicoric acid content in Echinacea purpurea Planta Medica Volume:7 Issue:6, Page no:585-591.

149.Almalki, D. A. (2022). Chicoric acid as a potential antibacterial agent for urinary tract Infections. Phytomedicine.Volume :95, 153876.

150.Cech, N. B.(2010). Antibacterial activity of Echinacea purpurea root extracts Against uropathogenic bacteria Planta Medica.Volume: 76, Issue:7 Page no:694-698.

151.Becker, B (2021). Efficacy of chamomile extract in uncomplicated UTIs: A pilot study. Phytotherapy Research, Volume :35, Issue:4,Page no: 1982-1989.

152.Rahman, M.(2018). Phytochemical and pharmacological potential of Hybanthus Enneaspermus. Journal of Ethnopharmacology, Volume :220, Page no:94-110