Trop J Nat Prod Res, October 2020; 4(10):653-660 **ISSN 2616-0684 (Print)**
ISSN 2616-0692 (Electronic)

Tropical Journal of Natural Product Research

Available online at https://www.tjnpr.org

Review Article

Pharmacology of Herbal Remedies for Urinary Tract Infection in Western Countries

Sadeq A. G. Kaabi*, Baidaa M. Ali**

Biology Department- College of Science- Mustansiriyah University- Baghdad- Iraq

ARTICLE INFO

Article history:
Received 21 July 2020
Revised 05 September 2020
Accepted 10 October 2020
Published online 02 November 2020

ABSTRACT

Medicinal plants native to North America and Europe and known in traditional herbal medicine in North America and Europe for their efficacy in the treatment of Urinary tract infections (UTIs) were reviewed for their pharmacological activities detected for extracts of each plant, Mechanism for each pharmacological activity, active components responsible for each pharmacological activity and animal and human clinical trial studies for extracts or commercial products based on each medicinal plant. These plants were Cranberry (*Vaccinium macrocarpon*), Common nettle (*Urtica dioica*), *Uva ursi* (*Arctostaphylos uva-ursi*), Junipers (*Juniperus spp.*), Buchu (*Agathosma betulina* and *A. crenulata*), Goldenrod (*Solidago canadensis*, *S. virgaurea* and *S. gigantea*), Rosemary (*Rosmarinus officinalis*), Dandelion (*Taraxacum officinale*), Goldenseal (*Hydrastis canadensis*), Marshmallow root (*Althaea officinalis*), Hosretail (*Equisetum arvense)*, Oregon grape (*Mahonia aquifolium)*, Couch grass (*Agropyrum repens*) and Corn silk (*Stigma maydis*).

Keywords: UTIs, Western herbal medicine, Alternative therapy, Herbal anti-adhesives, Herbal Anti-microbial.

Introduction

Urinary tract infections are one of the most frequent bacterial infections that affect mature females in high percentage (50-60%).[1] UTIs could be divided into uncomplicated and complicated. The uncomplicated UTIs affect persons who had no neurological or anatomical abnormalities in the urinary tract and it is divided into cystitis and Pyelonephritis.[2] The predisposing factors for cystitis are gender, genetic susceptibility, infection of the vagina, previous UTI infection, Sexual activeness, diabetes and overweight.[3] The complicated UTIs originate from factors that weaken the immunity of the individual such as kidney transplantation, renal failure, retention of urine owing to neurological disorders, usage of urinary indwelling catheter and immunosuppressive drugs.[4] Urinary indwelling catheters are responsible for 70-80% of complicated UTIs in the United states,[5] and accounts for one million cases yearly.[6] The causative agents of UTIs are Gram-negative bacteria, Gram-positive bacteria and yeast. *Escherichia coli* is the most frequent bacterial pathogens of UTIs with a percentage of 80%, while *Enterobacteriaceae* accounts for 90% of bacterial pathogens of UTIs. In the case of uncomplicated UTIs, the most frequent bacterial pathogens are enteropathogenic *E. coli* (EPEC), *Klebsiella pneumoniae*, *Staphylococcus saprophyticus*, *Enterococcus faecalis*, *Streptococcus pyogenes*, *Proteus mirabilis*, *Pseudomonas aeruginosa*, *Staphylococcus aureus* and *Candida* spp.[7] In complicated UTIs, the most frequent pathogens are Uropathogenic E. coli (UPEC), *Enterococcus spp.*, *K. pneumoniae*, *Candida spp.*, *S. aureus*, *P. mirabilis*, *P. aeruginosa* and *S. pyogenes.*[8] The increasing incidence of bacterial drug-resistance, beside other problems related to antibiotic therapy such as undesired effects of nephrotoxicity, hepatotoxicity, ototoxicity, carcinogenicity, mutagenicity, immunosuppressive action, allergic reactions and elimination of normal bacterial flora from the intestinal tract and body mucosal surfaces[9] made antibiotic therapy much less effective in the treatment of UTIs and necessitated the global research and industry interest to develop a new therapeutic alternative to antibiotic therapy in the treatment of bacterial infections.

Herbal medicine is the first line of alternative therapy towards microbial infections, including UTIs, and the therapeutic potential of medicinal plants in UTIs has been confirmed in thousands of ***In vitro*** and ***In Vivo*** studies worldwide during the last few years.[10,11] A comprehensive glance on the advances in herbal products industry and the available products right now are very important to provoke both scientific research in this field and public acceptance for such alternative therapeutic products at the level of health workers and patients.

Phytoremedies for UTIs in Western countries

A total of fourteen medicinal plants known in western countries for their therapeutic potential for UTIs cases were reviewed for their evidence-based pharmacologic activities, active purified and characterized compounds and latest studies on the efficacy of extracts of these plants on experimental animal models and clinical trials on human patients and volunteers.[12] Table 1 lists the scientific name, English name, parts used, pharmacological activities, regions where the medicinal plant is used and references.

Biological activities of medicinal plants related to the treatment of UTIs

In order to achieve complete recovery from UTI with the use of herbal remedies, various biological activities should be presented in each formulation directed towards this goal. Such activities may work synergistically to control infection and recover the healthy state of affected tissues. Table 2 lists these biological activities with examples of medicinal herbs active in the treatment of UTIs:

Junipers [Cupressaceae]

The genus Juniperus is huge and includes as many as 67 species that are native to the northern hemisphere. Many species of this genus such as *J. communis*,[13] *J. thurifera*,[14] *J. procera*,[15] *J. phoenicea*[16] and *J. excels.*[17] were screened for its antibacterial activity. Extracts of various

*Corresponding author. E mail: sadeqkaabi@uomustansiriyah.edu.iq; baidaabiology@uomustansiriyah.edu.iq
Tel: 009647709023245

Citation: Kaabi SAG and Ali BM. Pharmacology of Herbal Remedies for Urinary Tract Infection in Western Countries. Trop J Nat Prod Res. 2020; 4(9):653-660. doi.org/10.26538/tjnpr/v4i10.1

Official Journal of Natural Product Research Group, Faculty of Pharmacy, University of Benin, Benin City, Nigeria.

species of this genus showed anti-bacterial and antifungal activity in addition to other important biological activities such as anti-inflammatory,[18] anti-oxidantive[19] and analgesic activity.[20] The anti-microbial (anti-bacterial and anti-fungal) activity of essential oil of berries of *J. communis* showed strong to moderate activity,[21,22] whereas such activity of the essential oil of the leaves showed weak or no activity.[23, 24]

Uva ursi [*Arctostaphylos uva-ursi*]

This herb is native to North America and Europe. Leaves of this herb were used traditionally as anti-septic for UTIs and known to be over-the-counter (OTC) herbal remedy in United states and European countries like the United kingdom and Germany.[25] The leaf extract of this plant composed of a set of compounds but the antibacterial activity is confined to Arbutin - an hydroquinone glycosides.[26]

After ingestion of *Uva ursi* leaves, Arbutin will be hydrolyzed to hydroquinone. The hydroquinone is metabolized to glucoronate and sulfate ester that are excreted in the urine and exerts the anti-septic and astringent effects in the urinary tract.[27]

Rosemary [*Rosmarinus officinalis*, *Lamiacea*]

Rosemary is native to temperate countries of Mediterranean like Portugal. Various pharmacological activities were found in the extracts of this plant, including anti-bacterial activity, anti-oxidant activity, anti-inflammatory activity, analgesic activity and anti-diabetic activity.[28-31]

Extracts of rosemary is characterized by high level of anti-oxidative activity and an immuno-boosting properties making it very effective in fighting bacterial infection like urinary tract infection.[32] The extracts of rosemary showed antibacterial activity against most common bacterial pathogens of UTIs like *E. coli*, *K. pneumoniae*, *P. mirabilis*, *P. vulgaris*, *P. aeruginosa* and *S. aureus.*[33]

Goldenrod [Solidago canadensis, Asteraceae]

It is a perennial herb that is native to North America, known to be grown as ornamental in gardens.[34] This herb is active in the treatment of UTIs and urolithiasis beside many other diseases such as skin diseases, arthritis and rheumatism.[35-37] Water and solvent extracts of *S. canadensis* of aerial parts and rhizomes revealed high level of anti-oxidative activity.[38] Ethanol extracts of *S. canadensis* showed potent anti-bacterial activity against Gram-positive bacteria.[36]

Common nettle [Urtica dioica, Urticaceae]

This plant is native to Europe and temperate regions of Asia and western North Africa. This plant is characterized by the presence of stinging hollow hair on surfaces of the leaves and stems that are able to inject histamine into the human skin and results in contact urticaria.[38] Various pharmacological properties were reported for the extracts of this plant including antibacterial activity,[39-43] anti-inflammatory, immuo-modulatory, diuretic activity that are very helpful in the treatment of UTIs.[44] The extracts of common nettle showed antibacterial activity towards most common bacterial pathogens of UTIs like *E. coli* , *P. aeruginosa*, *K. pneumoniae* and *S. aureus.*[39-42] The flavonoid patuline purified from the extracts of this plant has active anti-bacterial activity against Gram-positive bacteria such as *S. aureus* (MIC: 0.02 g/mL) and *S. faecalis* (MIC: 0.002 g/mL) and anti-fungal activity against *C. albicans* (MIC: 0.001 g/mL).[43]

Dandelion [Taraxacum spp., Asteraceae]

It is a perennial herb native to Eurasia and North America.[45] Extracts of the flowers, roots and leaves of this herb showed various pharmacological activities like antibacterial, anti-inflammatory, immuno-modulatory, anti-oxidative and analgesic activities, and are effective in the treatment of UTIs.[46] Solvent extracts of the leaves of *T. officinale* showed anti-bacterial activity against *E. coli*, *K. pneumonia* and *S. aureus*.[47, 48] Diuretic activity of the leaves of this plant is comparable to that of furosemide[49] and stronger than other herbs like Juniper and Equisetum.[50, 51]

Corn silk [Zea mays, Gramineae]

Native to North America, and spread worldwide.[52] Corn silk (CS) is a golden thread that expands from the female flower of the corn.[53] Native American Indians were the first to used CS for treatment UTIs, heart diseases and malaria. It is known in traditional medicines worldwide to be an effective herbal remedy for urinary problems like cystitis, pyelonephritis, prostatitis, renal stones and bedwetting.[54-57] Corn silk has antibacterial activity against Gram-positive and Gram-negative bacterial pathogens.[58] Other pharmacological activities of CS includes kaliuretic and diuretic,[56] anti-inflammatory[59] and anti-oxidative antioxidant[60,61] activities.

Flovonoid glycosides of CS extracts are the most effective anti-bacterial compounds. Two compounds of flavonoid glycosides were purified and characterized and found to be active towards many of the pathogenic Gram-negative bacteria like *P. mirabilis*, *P. vulgaris*, *P. aeruginosa*, *Salmonella typhi*, *S. paratyphi*, *Shigella flexneri*, *Sh. Sonnei* and *Enterobacter aerogenes* and Gram-positive pathogens like *Bacillus subtilis*, *B. cereus* and *S. aureus.*[58]

Couch grass [Agropyrum repens]

It is a perennial herb native to many regions in the northern hemisphere.[62] The rhizome extracts is used traditionally in Europe as a remedy for UTIs.[63] Various pharmacological activities has been reported for the extracts of this plant as anti-adhesive,[64] anti-inflammatory,[65] as glucocorticoid,[66] anti-hyperlipidemic[67] and hypoglycemic.[68]

Animal model studies confirmed the diuretic activity of this plant[69] and the positive effects of the extracts of this plant on urinary tract infections such as cystitis, prostatitis, urethritis, prostatic adenoma and irritable bladder.[70]

The mechanism of diuretic activity of couch depends on the sugar "Mannitol" that is present in high concentration in couch extract. Mannitol is absorbed completely in the intestine and excreted in high concentration from the kidney tubules. This high concentration of excreted Mannitol in the kidney provoke the kidney to excrete large amounts of water to balance the osmotic pressure. Mannitol is called osmotic diuretic owing to this mechanism. Both the anti-adhesive and diuretic activity of couch work together to flush out bacteria from the urinary tract.[71] A commercial product of the rhizome extract of couch (Acorus® drops) for the treatment of UTIs were studies and showed that 69-91% of patients were relieved upon taking this remedy and the percentage of total recovery from UTIs was 32-53%, which indicated that this product is a promising alternative herbal therapy for UTIs.[72]

Marshmallow root [Althaea officinalis L., Malvaceae]

It is a perennial herb native to Europe, USA and Asia. It is used in traditional medicine of many countries as herbal a remedy for gastrointestinal, urinary tract and skin infections.[73] The plant has many pharmacological activities like immunostimulant and anti-inflammatory,[74,75] anti-complement,[74] antimicrobial[76] and antibiofilm,[77] and antioxidant.[78] activities. Extracts of the aerial parts of *A. officinalis* exerted anti-bacterial activity against *Streptococcus agalactiae*, *S. aureus*, *K. pneumoniae* and *E. coli*, but more potent activity was shown against *K. pneumoniae* and *E. coli.*[79]

*Horsetail (*Equisetum arvense)

It is a perennial fern native to the Northern hemisphere especially the artic and temperate regions.[80] It is used traditionally in cases of urination difficulty accompanied by severe pain during urination and presence of blood in urine (dysuria).[81] Horsetail has various pharmacological activities such as anti-bacterial,[80,83] diuretic,[82] and anti-inflammatory[82] activities. Water and ethanol extracts of horsetail have anti-bacterial activity towards bacterial pathogens of UTIs.[83]

A study on rat model for the treatment of experimental UTI by oral administration of ethanol extract of horsetail revealed that group treated with horsetail showed decrease in bladder contraction, drop in adrenaline and noradrenaline levels and drop in level of adenosine triphosphate. These changes were implicated for the effectiveness of horsetail extract in the treatment of UTI.[84]

ISSN 2616-0684 (Print)
ISSN 2616-0692 (Electronic)

Table 1: Medicinal plants active in the treatment of Urinary tract infection

#	Scientific name (English name)	Parts used	Pharmacological activities	Countries where it is used	References
1	*Juniperus communis* (Junipers)	Berries, Areal parts	Anti-fungal, Anti-bacterial, Anti-inflammatory, Anti-oxidative	Europe and America	13-24
2	*Arctostaphylos uva-ursi* (Uva ursi)	Leaves	Anti-septic, Anti-inflammatory, Anti-oxidative	Europe and America	26, 27
3	*Rosmarinus officinalis* (Rosemary)	Leaves, flowers	Anti-fungal, Anti-bacterial, Anti-inflammatory, Anti-oxidative	Europe	28-33
4	*Solidago canadensis* (Goldenrod)	Rhizome, Areal parts	Anti-bacterial, Anti-inflammatory, Diuretic, Anti-Urolithiatic, Anti-spasmodic	North America	35-36
5	*Urtica dioica* (Common nettle)	Whole plant, Areal parts	Anti-bacterial, Anti-inflammatory, Immunomodulatory, diuretic	Europe and America	39-43
6	*Taraxacum spp*. (Dandelion)	roots, leaves, flowers	Anti-bacterial, Anti-oxidative , Anti-inflammatory, Immunomodulatory	Europe and North America	46-51
7	*Zea mays* (corn silk, Stigma maydis)	Corn silk	Anti-bacterial, Anti-oxidative , Kaliuresis and Diuresis Effect	America	54-61
8	*Agropyrum repens* (Couch grass)	Rhizome, Whole plant	Anti-adhesive, Anti-inflammatory, diuretic	Europe and North America	63-72
9	*Althaea officinalis* (Marshmallow root)	root	Anti-bacterial, Anti-biofilm, Anti-inflammatory, Immunostimulant,	USA and Europe	73-79
10	*Equisetum arvense* (Hosretail)	root	Anti-bacterial, Anti-oxidative , Anti-inflammatory, diuretic	Europe and North America	81-84
11	*Hydrastis canadensis* (Goldenseal)	Root, leaves	Anti-bacterial , efflux pump inhibition	North America	86-95
12	*Agathosma betulina* and *A. crenulata* (Buchu)	leaves	Anti-bacterial, Anti-urolithiatic	Europe and North America	97-100
13	*Mahonia aquifolium* (Oregon grape)	Stem bark	Anti-bacterial, Anti-adhesive, Anti-oxidative , Anti-inflammatory	USA	101-110
14	*Vaccinium macrocarpon* (Cranberry)	Fruit	Anti-adhesive	North America	112-118

Goldenseal *[*Hydrastis canadensis, *Ranunculaceae]*

It is native to North America.[85] Various studies reported the anti-bacterial activity of goldenseal *In Vitro* and *In Vivo*.[86-90] The antibacterial activity of goldenseal is based on the alkaloid compound, berberine[90, 91] that exerts anti-bacterial activity towards Gram-positive pathogens like ***S. aureus.***[92] Many important compounds are present in the root extract of horsetail including berberine, canadine and hydrastine.[93] Another inhibitory compounds for both Gram-positive and Gram-negative bacteria were found in the root/leaf extract of goldenseal that exerts anti-bacterial activity against *Campylobacter jejuni* and *S. aureus*.[94]

The efflux pump inhibitory activity of goldenseal is detected only in aerial extracts of goldenseal.[93] Studies of autography and thin layer chromatography revealed that five bands were correspondent to the efflux pump inhibitory activity. The LC-MS (Liquid chromatography–mass spectrometry) study revealed a list of potential compounds of these bands.[94] Efflux pumps works to pump out the antibiotic from cytoplasm of bacteria and render the bacteria resistant to the antibiotic through increasing Minimum inhibitory concentration (MIC) with continuous pumping out antibiotic before killing the bacteria. Inhibition of Efflux pumps restores the sensitive status of bacterial pathogen.[95]

The efflux pumps inhibition was detected in the leaf extract of goldenseal and was potent in inhibiting different efflux pumps in ***C. jejuni*** and ***S.aureus***. Upon inhibition of efflux pumps by the leaf extract, the MIC of ***S. aureus*** dropped 2 folds, whereas the MIC of ***C. jejuni*** dropped 16 folds. It was found that the leaf extract of goldenseal works to suppress expression of genes coding for efflux pumps.[94]

Buchu [*Agathosma betulina* and *A. crenulata, Rutaceae*]

Buchu is native to South Africa and spread from there to Europe and United states to become an important herbal remedy.[96] The primary use of buchu was for the treatment of urinary tract diseases such as renal stones, infections of the urinary tract and incontinence related to prostate.[97] The therapeutic potential of the leaf extract of buchu for urinary tract diseases is based on two compounds present in the essential oil, diosphenol and monoterpene. The essential oil is absorbed totally in the intestine and excreted in the kidney and passes through the urinary tract and exert anti-bacterial action on bacterial pathognes.[97]

ISSN 2616-0684 (Print)
ISSN 2616-0692 (Electronic)

Table 2: Biological activities of medicinal plants known in western herbal medicine in the treatment of UTIs

Category	Prevent/Treat	Examples
Anti-bacterial activity	Treat	Uva ursi (*Arctostaphylos uva-ursi*), Rosemary (*Rosmarinus officinalis*), Uva ursi (*Arctostaphylos uva-ursi*) Junipers (*Juniperus spp.*)
Diuretic activity	Both	Uva ursi (*Arctostaphylos uva-ursi*), Goldenrod (*Solidago canadensis*), Junipers (*Juniperus spp.*), Common nettle (*Urtica dioica*), Uva ursi (*Arctostaphylos uva-ursi*), Dandelion (*Taraxacum officinale*)
Anti-adhesive activity	Both	Cranberry (*Vaccinium macrocarpon*), Couch grass (*Agropyrum repens*), Oregon grape (*Mahonia aquifolium*), D- mannose.
Anti-biofilm activity	Both	Marshmallow root (*Althaea officinalis*)
Efflux pump inhibitory activity	Both	Goldenseal (*Hydrastis canadensis*)
Spasmolytic activity	Treat	Hosretail (*Equisetum arvense*) , Buchu (*Agathosma betulina* and *A. crenulata*)
Immune stimulant	Both	Marshmallow root (*Althaea officinalis*),
Demulcent	Treat	Corn silk, Couch grass, Marshmallow root
Anti-inflammatory	Treat	Junipers (*Juniperus spp.*), Uva ursi (*Arctostaphylos uva-ursi*), Goldenrod (*Solidago canadensis*

Various studies have reported the anti-bacterial activity of the essential oil of buchu against a variety of bacterial pathogens such as *E. coli*, *K. pnueumoniae*, *P. aeruginosa*, *S. aureus* and *B. subtilis.*[96-99] The leaf extract of *A. crenulata* has spasmolytic action on the urinary tract due to their ability to decrease the level of adenosine monophosphate.[99] The antispasmodic drugs work to relax the contraction of smooth muscles of the urinary bladder, thus, expanding the capacity of the bladder and decrease or even eradicate urinary incontinence.[100] Both the spasmolytic action and antibacterial activity of *A. crenulata* contribute to the healing properties of buchu for urinary tract diseases.[100]

Oregon grape [***Mahonia aquifolium***, *Berberidaceae*]

M. aquifolium is native to United states of America, and known worldwide to be an ornamental plant.[101] Various pharmacological activities were reported for this plant as anti-bacterial,[101-103] anti-fungal,[104] anti-inflammatory,[105-107] antitumoral and immunomodulatory[108] activities. The anti-bacterial activity of *M. aquifolium* is based on two alkaloids, berberine chloride and oxyacanthine sulphate extracted from the stem bark. These alkaloids exerted anti-bacterial and anti-fungal activity towards a variety of bacterial and fungal microorganisms including the most important bacterial pathognes of UTIs.[101, 109]

Berberine is responsible for the yellow golden appearance of *M. aquifolium*. Berberine has the ability to prevent the adherence of *E. coli* to uro-epithelial cells via suppression of the expression of genes responsible for the synthesis and assembly of fimbriae[110] (Figure 1).

Cranberry [*Vaccinium macrocarpon*, *Ericaceae*]

It is an evergreen groundcover shrubs that extend up to 4 meters. It is native to North America. Flowers of this plant is pink coloured with reddish black berries. Cranberry is widespread throughout the cold regions of the northern hemisphere.[111] Native American Indians were the first population to used the fruit of this plant as a remedy for UTIs.[112] Cranberry fruit is composed of 88% of water, while the other percentage is composed of Flovonoids, Catechins, Triterpenoids and Anthocynidins with high concentration of Vitamic C (200 mg/kg).[112]

The anti-bacterial activity of Cranberry fruit is attributed to the proanthocyanidins (PAC) and anthocyanidins.[112, 113]

Many studies have reported the correlation of the administration of Cranberry fruit and prevention of UTIs.[113-117] Cranberry is an anti-adhesive agent that prevents adhesion of bacteria to mucosal surfaces of urinary tract and stop the cascade of colonization and invasion that follow adhesion of bacteria to mucosal surfaces. This anti-adhesive activity of extract of Cranberry fruit is attributed to proanthocyanidins and fructose. The fructose is known to bind to type 1 fimbriae on bladder mucosa blocking it from attachment to mannose-sensitive uroplakin receptors on the epithelial cells. The proanthocyanidins is known to bind to P fimbriae blocking it from attachment to Mannose-insensitive GAL glycolipid receptors on renal epithelial cells (Pink cells) [118] (Figure 2).

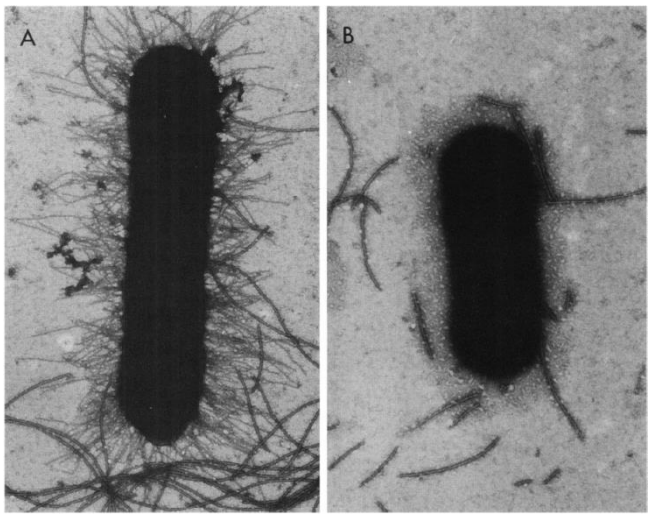

Figure 1: (A) Heavy piliation and flagellation of the strain *E. coli* C16 after cultivation on brain-heart infusion broth at 37^{o}C for 18 hours. (B) Depletion of piliation and splitting of flagella owing to cultivation of *E. coli* C16 at 37^{o}C for 18 hours in the presence of 200 µg/mL of berberine chloride. (x 33200). [110]

ISSN 2616-0684 (Print)
ISSN 2616-0692 (Electronic)

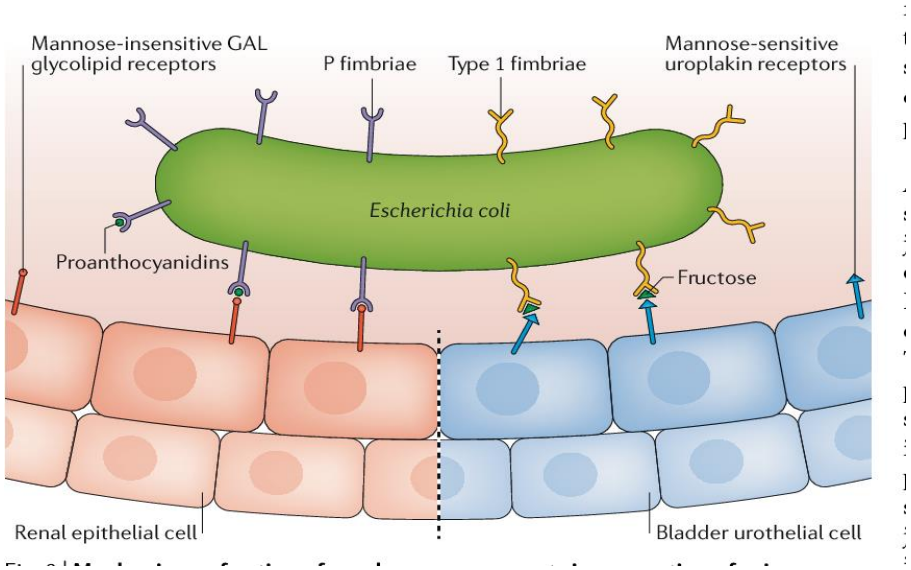

Figure 2: Mechanism of anti-adhesive activity of Cranberry fruit extract. The fructose specifically binds to type 1 fimbriae on bladder mucosa blocking it from attachment to mannose-sensitive uroplakin receptors on epithelial cells. The proanthocyanidins specifically binds to P fimbriae blocking it from attachment to Mannose-insensitive GAL glycolipid receptors on renal epithelial cells (Pink cells)[118].

Conclusions and Recommendations

Various pharmacologic activities were reported for each of the 14 medicinal plants reviewed in this article. All the reported activities could act synergistically to control and prevent bacterial infection and treat the harmful immunological reaction and physiological disorders. The anti-bacterial, anti-biofilm and anti-adherence activities make the plants a promising alternative anti-bacterial agents for the treatment of non-drug responsive infections that pose the most serious health challenge facing humans.[10,11] Preparation of commercial herbal formulae based on the above mentioned 14 medicinal plants and other selected plants is one of the most potent and successful phytoremedies produced for the treatment of human diseases. Further studies on animal model for UTIs and clinical studies on human UTIs cases are required to confirm the therapeutic efficacy of such medicinal plants.

Conflict of interest

The authors declare no conflict of interest.

Authors' Declaration

The authors hereby declare that the work presented in this article is original and that any liability for claims relating to the content of this article will be borne by them.

References

1. Flores-Mireles AL, Walker JN, Caparon M, Hultgren SJ. Urinary tract infections: epidemiology, mechanisms of infection and treatment options. *Nat Rev Microbiol*. 2015; 13(5):269–284.
2. Hannan TJ, Totsika M, Mansfield KJ, Moore KH, Schembri MA, Hultgren SJ.. Host–pathogen checkpoints and population bottlenecks in persistent and intracellular uropathogenic *Escherichia coli* bladder infection. FEMS Microbiol Rev. 2012; 36:616–648.
3. Foxman B. Urinary tract infection syndromes: occurrence, recurrence, bacteriology, risk factors, and disease burden. Infect Dis Clin North Am. 2014; 28: 1–13.
4. Levison ME and Kaye D. Treatment of complicated urinary tract infections with an emphasis on drug-resistant Gram-negative uropathogens. Curr Infect Dis Rep. 2013; 15:109–115.
5. Lo E, Nicolle LE, Coffin SE, et al. Strategies to prevent catheter-associated urinary tract infections in acute care hospitals: 2014 update. Infect Control Hosp Epidemiol. 2014; 35(5):464-479.
6. Foxman B. The epidemiology of urinary tract infection. Nature Rev Urol. 2010; 7:653–660.
7. Kline KA, Schwartz DJ, Lewis WG, Hultgren SJ, Lewis AL. Immune activation and suppression by group B streptococcus in a murine model of urinary tract infection. Infect Immun. 2011; 79(9):3588-3595.
8. Chen YH, Ko WC, Hsueh PR. Emerging resistance problems and future perspectives in pharmacotherapy for complicated urinary tract infections. Expert Opin Pharmacother. 2013; 14(5):587-596.
9. Lopez A, Hudson JB, Towers GHN. Antiviral and antimicrobial activities of Colombian medicinal plants. J Ethnopharmacol. 2001; 77:189-196.
10. Cowan MM. Plant Products as Antimicrobial Agents. Clin Microbiol Rev, 1999; 12(4): 564-582.
11. Parmar N and Rawa M. Medicinal plants used as Antimicrobial agents: A review. Int Res J Pharm, 2012; 3(1):31-40.
12. Cowan MM. Plant Products as Antimicrobial Agents. Clin Microbiol Rev. 1999; 12(4):564-582.
13. Sela F, Karapandzova M, Stefkov G, Cvetkovikj I, Trajkovska-Dokik E, Kaftandzieva A, Kulevanova S. Chemical composition and antimicrobial activity of leaves essential oil of *Juniperus communis* (Cupressaceae) grown in Republic of Macedonia. Maced Pharm Bull. 2013; 59 (1, 2):23-32.

14. Manel M, Nouzha H, Rim M, Imane M, Sana A, Yasmine O, Ammar A. Antibacterial and antioxidant activity of *Juniperus thurifera* L. leaf extracts growing in East of Algeria. Vet World. 2018; 11(3):373-378.
15. Ibrahim EH, Kilany M, Ghramh HA, Ali Khan K, Islam S. Cellular proliferation/cytotoxicity and antimicrobial potentials of green synthesized silver nanoparticles (AgNPs) using ***Juniperus procera***. Saudi J Bio Sci. 2019; 26:1689-1694.
16. Ramdani M, Lograda T, Silini H, Zeraib A, Chalard P, Figueredo G, Bouchaala M, Zerrar S. Antibacterial Activity of Essential oils of *Juniperus phoenicea* from Eastern Algeria. J App Pharm Sci. 2013; 3(11):022-028**.**
17. Omari K, Hamze M, Alwan S, Osman M, Jama C, Chibibi E. In-vitro evaluation of the antibacterial activity of the essential oils of *Micromeria barbata*, *Eucalyptus globulus* and *Juniperus excelsa* againststrains of *Mycobacterium tuberculosis* (including MDR), *Mycobacterium kansasii* and *Mycobacterium gordonae*. J Infect Pub Heal. 2019; 12:615-618.
18. Tunon H, Olavsdotter C, Bohlin L. Evaluation of anti-inflammatory activity of some Swedish medicinal plants. Inhibition of prostaglandin biosynthesis and PAF-induced exocytosis. J Ethnopharm. 1995; 48(2):61-76.
19. Höferl M, Stoilova I, Schmidt E, Wanner J, Jirovetz L, Trifonova D, Krastev L, Krastanov A. Chemical Composition and Antioxidant Properties of Juniper Berry (***Juniperus communis*** L.) Essential Oil. Action of the Essential Oil on the Antioxidant Protection of Saccharomyces cerevisiae Model Organism. Antioxid (Basel). 2014; 3(1):81-98.
20. Banerjee S, Mukherjee A, Chatterjee TK. Evaluation of analgesic activities of methanolic extract of medicinal plant *Juniperus communis* Linn. *International* Int J Pharm Pharm Sci. 2012; 4(5):547-550.
21. Filipowicz N, Madanecki P, Gołebiowski M, Stepnowski P, Ochocka JR. HS-SPME/GC analysis reveals the population variability of terpene contents in *Juniperus communis* needles. Chem Biodiv. 2009; 6(12):2290-2301.
22. Stassi V, Verykokidou E, Loukis A, Harvala A, Philianos S. Essential Oil of *Juniperus oxycedrus* L. subsp. *macrocarpa* (Sm.) Ball. J Essent Oil Res. 1995; 7(6):675-676.
23. Angioni A, Barra A, Russo MT, Coroneo V, Dessi S, Cabras P. Chemical composition of the essential oils of Juniperus from ripe and unripe berries and leaves and their antimicrobial activity. J Agric Food Chem. 2003; 51(10):3073-3078.
24. Asili J, Emami SA, Rahimizadeh M, Fazly-Bazzaz BS. Hassanzadeh MK. Chemical and Antimicrobial Studies of *Juniperus communis* subsp. *hemisphaerica* and *Juniperus oblonga* Essential Oils. J Essent Oil Bearing Plants. 2008; 11(1):96-105.
25. Trill J, Simpson C, Webley F, Radford M, Stanton L, Maishman T, Galanopoulou A, Flower A, Eyles C, Willcox M, Hay A, Griffiths G, Little P, Lewith G, Moore M. Uva-ursi extract and ibuprofen as alternative treatments of adult female urinary tract infection (ATAFUTI): study protocol for a randomised controlled trial. Trials. 2017 Sep 8;18(1):421.
26. Matsuda H, Nakamura S, Shiomoto H, Tanaka T, Kubo M. Yakugaku Zasshi. 1992; 112(4):276-282.
27. Yarnell E. Botanical medicines for the urinary tract. World J Urol. 2002; 20(5):285-293.
28. Bak rel T, Bak rel U, Kele OÜ, Ülgen SG, Yardibi H. *In vivo* assessment of antidiabetic and antioxidant activities of rosemary (*Rosmarinus officinalis*) in alloxan-diabetic rabbits. J Ethnopharmacol. 2008; 116(1):64-73.
29. Bozin B, Mimica-Dukic N, Samojlik I, Jovin E. Antimicrobial and antioxidant properties of rosemary and sage (*Rosmarinus officinalis* L. and *Salvia officinalis* L., *Lamiaceae*) essential oils. J Agric Food Chem. 2007; 55(19):7879-7885.
30. Campo JD, Amiot MJ, Nguyen-The C. Antimicrobial effect of rosemary extracts. J Food Protect. 2000; 63(10):1359-1368.
31. Cheung S and Tai J. Anti-proliferative and antioxidant properties of rosemary ***Rosmarinus officinalis***. Oncol Rep. 2007; 17(6):1525-1531.
32. Habtemariam S. The therapeutic potential of rosemary (***Rosmarinus officinalis***) diterpenes for Alzheimer's disease. Evid-Based Compl Altern Med. 2016; 6:1-14.
33. Zakerin A, Ahmadi E, Fasihi-Ramandi M, Abdollahi S, Molazadeh A, Jafari S, Allahverdi G, Kouhpayeh SA, Meshkibaf MH. The Effects of Ecologic Condition on Antimicrobial Activity of Endemic Herbal Extracts in Fars Province. J Fasa Univ Med Sci. 2015; *5*(1):111-119.
34. Zihare L and Blumberga D. Insight into bioeconomy. Solidago canadensis as a valid resource. Brief Rev Energy Proc. 2017; 128:275–280.
35. Apati P, Szentmihalyi K, Kristo Sz. T, Papp I, Vinkler P, Szoke E, Kery E, Herbal remedies of ***Solidago*** - correlation of phytochemical characteristics and antioxidative properties. J Pharm Biomed Anal. 2003; 32:1045-1053.
36. Kołodziej B, Kowalski R, Kędzia B. Antibacterial and antimutagenic activity of extracts aboveground parts of three Solidago species: ***Solidago virgaurea*** L., ***Solidago canadensis*** L. and ***Solidago gigantean***. J Med Plants Res. 2011; 5(31):6770-6779.
37. Šutovská M, Capek P, Kocmálová M, S.Fraňová S, Pawlaczyk I, Gancarz R, Characterization and biological activity of ***Solidago canadensis*** complex. Int J Biol Macromol. 2013; 52:192-197.
38. Krystofova O, Adam V, Babula P, Zehnalek J, Beklova M, Havel L, Kizek R. Effects of various doses of selenite on stinging nettle (*Urtica dioica* L.*).* Int J Environ Health Res Public Health. 2010; 7:3804-3815.
39. Brantner A and Grein E. Antibacterial activity of plant extracts used externally in traditional medicine. J Ethnopharmacol. 1994; 44:35-40.
40. Keles O, Bakirel T, Alpmar A. The antibacterial activity of some plants used for medicinal purposes against pathogens of veterinary importance. Folia Vet. 2001; 1:22-25.
41. Kukrića ZZ, Topalić-Trivunovića LN, Kukavicab BM, Matoša SB, Pavičića SS, Borojab MM, Savića AV. Characterization of antioxidant and antimicrobial activities of nettle leaves (***Urtica dioica*** L.). Acta Period Technol (APTEFF). 2012; 43:259-272.
42. Turker AU and Usta C. Biological screenings of some Turkish medicinal plant extracts for antimicrobial and toxicity activities. Nat Prod Res. 2008; 22:136-46.
43. Saeed A, El-Eraqy W, Ahmed Y. Flavonoids of *Urtica urens* L. and biological evaluation. Egypt J Pharm Sci. 1995; 36:1-6.
44. Joshi BC, Mukhija M, Kalia AN. Pharmacognostical review of *Urtica dioica* L. Int J Green Pharm. 2014; P:201-209.
45. Yarnell E, Abascal K. Dandelion (*Taraxacum officinale* and *T mongolicum*). Integr Med. 2009; 8(2):35-38.
46. Gonzalez-Castejon M, Visioli F, Rodriguez-Casado A. Diverse biological activities of dandelion. Nut Rev. 2012; 70(9):534-547.
47. Díaz K, Espinoza L, Madrid A, Pizarro L, Chamy R. Isolation and Identification of Compounds from Bioactive Extracts of *Taraxacum officinale* Weberex F. H. Wigg. (Dandelion) as a Potential Source of Antibacterial Agents. Evid-Based Compl Altern Med. 2018; Article ID 2706417, 8 pages.
48. Kenny O, Brunton NP, Walsh D, Hewage CM, McLoughlin P, Smyth TJ. Characterisation of antimicrobial extracts from dandelion root (*Taraxacum officinale*) using LC-SPE-NMR. Phytother Res. 2015; 29(4):526-532.

49. Clare BA, Conroy RS, Spelman K. The Diuretic Effect in Human Subjects of an Extract of ***Taraxacum officinale*** Folium over a Single Day. The J Alt Comp Med. 2009; 15(8):929-934
50. Bisset NG, Phillipson JD, Czygan FC, Frohne D, Hiller K, Höltzel C, Nagell A, Pachaly P, Pfänder HJ, Wichtl M, Willuhn M, Buff W. Herbal Drugs and Phytopharmaceuticals: A Handbook for Practice on a Scientific Basis. Boca Raton, FL: CRC Press. 1994:486–489.
51. Newall CA, Anderson LA, Phillipson JD. Herbal Medicines: A Guide for Health-Care Professionals. London: The Pharceutical Press; 1996, P: 338-346
52. Hernández JAS. The origin and diversity of maize in the American continent. Greenpeace México, Santa Margarita 227, Col. del Valle, C.P. 03100, Mexico, Mexico City. 2009, P: 83-94.
53. Maksimović Z, Malenčić Đ, Kovačević N. Polyphenol contents and antioxidant activity of *Maydis stigma* extracts. Bioresour Technol. 2005; 96:873–877.
54. Caceres A, Giron LM, Martinez AM. Diuretic activity of plants used for the treatment of urinary ailments in Guatemala. J Ethnopharmacol. 1987; 19:233–245.
55. Doan DD, Nguyen NH, Doan HK, Nguyen TL, Phan TS, van Dau N, Grabe M, Johansson R, Lindgren G, Stjernström NE. Studies on the individual and combined diuretic effects of four Vietnamese traditional herbal remedies (*Zea mays*, *Imperata cylindrica*, *Plantago major* and *Orthosiphon stamineus*). J Ethnopharmacol. 1992; 36(3):225-31.
56. Grases F, March JG, Ramis M, Costa-Bauzá A. The influence of ***Zea mays*** on urinary risk factors for kidney stones in rats. Phytother Res. 1993; 7:146–149.
57. Yeşilada E, Honda G, Sezik E, Tabata M, Fujita T, Tanaka T, Takeda Y, Takaishi Y. Traditional medicine in Turkey. V. Folk medicine in the inner Taurus Mountains. J Ethnopharmacol. 1995; 46:133–152.
58. Nessa F, Ismail Z, Mohamed N. Antimicrobial Activities of Extracts and Flavonoid Glycosides of Corn Silk (*Zea mays* L). Int J Bacteriol Biotechnol Wellness Indus. 2012; 1:115-121.
59. Wang GQ, Xu T, Bu XM, Liu BY. Anti-inflammation effects of corn silk in a rat model of carrageenin-induced pleurisy. Inflamm. 2011; 35:822–827.
60. El-Ghorab A, El-Massry KF, Shibamoto T. Chemical composition of the volatile extract and antioxidant activities of the volatile and nonvolatile extracts of Egyptian corn silk (*Zea mays* L.). J Agric Food Chem. 2007; 55:9124-9127.
61. Mohsen SM and Ammar ASM. Total phenolic contents and antioxidant activity of corn tassel extracts. Food Chem. 2009; 112:595-298.
62. Al-Snafi AE. Chemical constituents and pharmacological importance of *Agropyron repens* – A review. Res J Pharm Toxicol. 2015; 1(2): 37-41.
63. Committee on Herbal Medicinal Products (HMPC). European Medicines Agency. Community herbal monograph on *Agropyron repens* (L.) P. Beauv., rhizoma EMA/HMPC/563408/2010.
64. Shah SMA, Akhtar N, Akram M, Shah PA, Saeed T, Ahmed K, Asif HM. Pharmacological activity of *Althaea officinalis* L. J Med Plants Res. 2011; 5(24):5662-5666.
65. Petrova AP, Krasnov EA, Saprykina EV, Subbotina YA, Ermilova EV. Chemical composition of couch grass and studies of its antioxidant activity in allergic contact dermatitis. Pharm Chem J. 2009; 43:30-32.
66. Mascolo N. Biological screening of Italian medicinal plants for anti-inflammatory activity. Phytother Res. 1987; 1:28-29.
67. Committee on Herbal Medicinal Products (HMPC). European Medicines Agency. Assessment report on Agropyron repens (L.) P. Beauv., rhizome [Online]. Available from: http://www.ema.europa.eu/docs/en_GB/document_library/Herbal_HMPC_assessment_report/2012/01/WC500120706.pdf. [cited 2020 July 17].
68. Eddouks M, Maghrani M, Michel JB. Hypoglycaemic effect of *Triticum repens* P. Beauv. in normal and diabetic rats. J Ethnopharmacol. 2005; 102(2):228-232.
69. Racz-Kotilla E, Mozes E. Contributii la cunosterea actiunii diuretice a droguluin rhizomes graminis, Rev Med. 1971; 17:82–84.
70. Barsom S. Die Behandlung von Miktionsbeschwerden mit dem Phytopharmakon Acorus. Erfahrungsheilkunde. 1981; 30:1011–1016.
71. Bone K, Mills S. Principles and Practice of Phytotherapy-Modern Herbal Medicine. Churchill Livingstone. 2nd edition. 2013, P: 144-151.
72. Hautmann C and Scheithe K. Fluid extract of *Agropyron repens* for the treatment of urinary tract infections or irritable bladder. Results of multicentric post-marketing surveillance. Zeitschrift für Phytotherapie. 2000; 21(5):252-255.
73. Al-Snafi AE. The Pharmaceutical Importance of ***Althaea officinalis*** and ***Althaea rosea*** : A Review. Int J PharmTech Res. 2013; 5(3):1378-1385.
74. Scheffer J, Wagner H, Proksch A. Radix althaeae und Flores chamomillae Extrakte auf Entzündungsreaktionen humaner neutrophiler Granulozyten, Monozyten und Rattenmastzellen. In: *Abstracts of the Third Phytotherapy Congress.* Lübeck-Travemünde: Abstract P9. 1991.
75. Bonaterra GA, Bronischewski K, Hunold P, Schwarzbach H, Heinrich EU, Fink C, Aziz-Kalbhenn H, Müller J, Kinscherf R. Anti-inflammatory and Anti-oxidative Effects of Phytohustil® and Root Extract of *Althaea officinalis* L. on Macrophages *in vitro*. Front Pharmacol. 2020; 11: Article ID 290.
76. Naovi SAH, Khan MSY, Vohora SB. Antibacterial, anti-fungal and anthelmintic investigations on Indian medicinal plants. Fitoter. 1991; 62(3):221-228.
77. Aminnezhad S, Kasra R, Kermanshahi K, Ranjbar R. Effect of ***Althaea officinalis*** Extract on Growth and Biofilm Formation in ***Pseudomonas aeruginosa***. J Pure Appl Microbiol. 2016; 10(3):7 pages.
78. Masaki H, Sakaki S, Atsumi T, Sakurai H. Active-oxygen scavenging activity of plant extracts. Biol Pharm Bull. 1995; 18(1):162-166.
79. Zarei B, Saifi T, Fazeli A, Khodadadi E, Namavar A. Evaluation of Antibacterial effects of marshmallow (*Althaea officinalis*) On four strains of bacteria. Int J Agric Crop Sci. 2013; 5:4 pages.
80. Pallag A, Filip GA, Olteanu D, Clichici S, Baldea I. *Equisetum arvense* L. Extract Induces Antibacterial Activity and Modulates Oxidative Stress, Inflammation, and Apoptosis in Endothelial Vascular Cells Exposed to Hyperosmotic Stress. Oxid Med Cellular Longev. 2018; 2018: Article ID 3060525, 14 pages.
81. Carneiro DM**,** Jardim TV**,** Araújo YCL**,** Arantes AC**,** de Sousa AC**,** Barroso WKS**,** Sousa ALL**,** da Cunha LC**,** Cirilo HNC**,** Bara MTF, Jardim PCBV**.** *Equisetum arvense*: New Evidences Supports Medical use in Daily Clinic. Pharmacogn Rev. 2019; 13(26):50-58.
82. Gründemann C, Lengen K, Sauer B, Garcia-Käufer M, Zehl M, Huber R. *Equisetum arvense* (common horsetail) modulates the function of inflammatory immunocompetent cells. BMC Compl Altern Med. 2014; 14:283.
83. Geetha RV, Lakshmi T, Roy A. *In Vitro* Evaluation of Anti Bacterial Activity of *Equisetum Arvense* Linn On Urinary Tract Pathogenes. Int J Pharm Pharam Sci. 2011; 3(4):323-325.
84. Zhang H, Li N, Li K, Li P. Effect of ethanol root extract of *Equisetum arvense* (L) on urinary bladder activity in rats

and analysis of principal plant constituents. Trop J Pharm Res. 2015; 14(8):1451-1458.
85. Pengelly A, Bennett K, Spelman K, Tims M. Appalachian plant monographs: *Hydrastis canadensis* L. goldenseal. Appalachian Center for Ethnobotanical Studies. 2012.
86. Hwang BY, Roberts SK, Chadwick L, Wu CD, Kinghorn DA. Antimicrobial constitutents from goldenseal (the rhizomes of *Hydrastis canadensis*) against selected oral pathogens. Planta Med. 2003; 69:623–627.
87. Khosla PK, Neeraj VI, Gupta SK, Satpathy G. Berberine, a potential drug for trachoma. Rev Int Trach Pathol Ocul Trop Subtrop Sante Publique. 1992; 69:147–165.
88. Knight SE. Goldenseal (*Hydrastis canadensis*) versus penicillin: a comparison of effects on *Staphylococcus aureus*, *Streptococcus pyogenes*, and *Pseudomonas aeruginosa*. Bios. 1999; 70:3–10.
89. Mahady GB, Pendland SL, Stoia A, Chadwick L. *In vitro* suceptibility of *Helicobacter pylori* to isoquinoline alkaloids from *Sanguinaria canadensis* and *Hydrastis canadensis*. Phytother Res. 2003; 17:217–221.
90. Scazzocchino F, Cometa MF, Tomassini L, Palmery M. Antibacterial activity of *Hydrastis canadensis* extract and its major isolated alkaloids. Planta Med. 2001; 67:561–564.
91. Chadwick LR, Wu CD, Kinghorn AD. Isolation of alkaloids from goldenseal (*Hydrastis canadensis* rhizomes) using pH-zone refining countercurrent chromatography. J Liq Chrom Rel Technol. 2001; 24:2245–2453.
92. Villinski JR, Dumas ER, Chai HB, Pezzuto JM, Angerhofer CK, Gafner S. Antibacterial activityand alkaloid content of *Berberis thunbergii*, *Berberis vulgaris* and *Hydrastis canadensis*. PharmBiol. 2003; 41:551–557.
93. Ettefagh KA, Burns JT, Junio HA, Kaatz GW, Cech NB. Goldenseal (*Hydrastis canadensis* L.) extracts synergistically enhance the antibacterial activity of berberine via efflux pump inhibition. Planta Med. 2011; 77(8):835–840.
94. Rangineni J. Effect of Goldenseal (*Hydrastis Canadensis*) on Bacterial Multi Drug Resistant Efflux Pumps. Ph.D. Dissertation. Clemson University. 2011. All Dissertations. 785.
95. Lewis K and Ausubel FM. Prospects for plant-derived antibacterials. Nature Biotechnol. 2006; 24:1504–1507.
96. Moola A. Phytochemical and Pharmacological Investigation of Indigenous *Agathosma* Species. M.Sc. thesis. University of the Witwatersrand, Johannesburg. South Africa. 2005.
97. Geetha RV, Roy A, Lakshmi T. *In vitro* evaluation of anti bacterial activity of leaf extract of *Agathosoma betulina* on urinary tract pathogens. Int J Pharm Sci Rev Res. 2012; 14(2):15:94-97.
98. Sandasi M, Kamatou GPP, Baranska M, Viljoen AM. Application of vibrational spectroscopy in the quality assessment of Buchu oil obtained from two commercially important *Agathosma* species (Rutaceae). South Afr J Bot. 2010; 76:692–700.
99. Lis-Balchin M, Hart S, Simpson E. 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; 53(3):579-582.
100. Gill BC. What is the role of antispasmodic drugs in the treatment of neurogenic bladder. Medscape. [online]. Available from: https://www.medscape.com/answers/453539-45977/what-is-the-role-of-antispasmodic-drugs-in-the-treatment-of-neurogenic-bladder [cited 2020 July 10].
101. Rohrer U, Eva M, Kuz K, Lenkeit K, Schaffner W, Meyer J-RG. Antimicrobial activity of *Mahonia aquifolium* and two of its alkaloids against oral bacteria. Schweiz Monatsschr Zahnmed. 2007; 117:1126–1131.
102. Li AR, Zhu Y, Li XN, Tian XJ. Antimicrobial activity of four species of *Berberidaceae*. Fitoter. 2007; 78(5):379-381.
103. Cernáková M and Kostálová D. Antimicrobial Activity of Berberine- a Constituent of *Mahonia aquifolium*. Folia Microbiol (Praha). 2002; 47(4):375-378.
104. Volleková A, Kost'álová D, Kettmann V, Tóth J. Antifungal activity of *Mahonia aquifolium* extract and its major protoberberine alkaloids. Phytother Res. 2003; 17(7):834-837.
105. Zhang L, Ravipati AS, Koyyalamudi SR, Jeong SC, Reddy N, Smith PT, Bartlett J, Shanmugam K, Münch G, Wu MJ, Antioxidant and anti-inflammatory activities of selected medicinal plants containing phenolic and flavonoid compounds. J Agric Food Chem. 2011; 59(23):12361-12367.
106. Coklar H and Akbulut M. Anthocyanins and phenolic compounds of *Mahonia aquifolium* berries and their contributions to antioxidant activity. J Funct Foods. 2017; 35:166–174.
107. Rackova L, Oblozinsky M, Kostalova D, Kettmann V, Bezakova L. Free radical scavenging activity and lipoxygenase inhibition of *Mahonia aquifolium* extract and isoquinoline alkaloids. J Inflam. 2007; 4:15.
108. Andreicuț AD, Fischer-Fodor E, Pârvu AE, Țigu AB, Cenariu M, Pârvu M, Cătoi FA, Irimie A. Antitumoral and Immunomodulatory Effect of *Mahonia aquifolium* Extracts. Oxi Med Cell Long. 2019; Article ID 6439021, 13 pages.
109. Čerňáková M and Košťálová D. Antimicrobial activity of berberine—a constituent of *Mahonia aquifolium*. Folia Microbiol. 2002; 47:375–378.
110. Sun D, Abraham SN, Beachey EH. Influence of Berberine Sulfate on Synthesis and Expression of Pap Fimbrial Adhesin in Uropathogenic *Escherichia coli*. Antimicrob Agents Chemother. 1988; 32(8):1274-1277.
111. Krishnaeswari V, Manikandan S, Vijayakumar J. Bioactive components of *Vaccinium macrocarpon* and its antioxidant activity: an *In-Vitro* study. IJPSR. 2019; 10(1):438-444.
112. Johnson DE, Russell RG, Lockatell CV, Zulty JC, Warren JW, Mobley HL. Contribution of *Proteus mirabilis* urease to persistence, urolithiasis, and acute pyelonephritis in a mouse model of ascending urinary tract infection. Infect Immun. 1993; 61:2748–2754.
113. Wang CH, Fong CC, Chen NC, Liu S, You PH, Wu TY, Chen WT, Lee CC, Chen SC. Cranberry-containing products for prevention of urinary tract infections in susceptible populations: A systematic review and meta-analysis of randomized controlled trials. Arch Intern Med. 2012; 172:988-996.
114. Howell AB. Bioactive compounds in cranberries and their role in prevention of urinary tract infections. Mol Nutr Food Res. 2007; 51:732–737.
115. Nowack R and Schmitt W. Cranberry juice for prophylaxis of urinary tract infections—Conclusions from clinical experience and research. Phytomed. 2008; 15:653–667.
116. Raz RB, Chazan B, Dan M. Cranberry juice and urinary tract infection. Clin Infect Dis. 2004; 38:1413–1419.
117. Tempera G, Corsello S, Genovese C, Caruso FE, Nicolosi D. Inhibitory activity of cranberry extract on the bacterial adhesiveness in the urine of women: An ex-vivo study. Int J Immunopathol Pharmacol. 2010; 23:611–618.
118. Sihra N, Goodman A, Zakri, R. *et al.* Nonantibiotic prevention and management of recurrent urinary tract infection. Nat Rev Urol. 2018;15, 750–776.