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Review Article

NATURAL PRODUCTS AS PROMISING ANTIMICROBIAL AGENTS: A REVIEW

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ABSTRACT

In developing as well as developed countries infectious diseases are one of the major problems. They are caused by pathogenic microorganisms such as bacteria, fungi, viruses or parasites. Traditional medicinal plants are widely used to treat the microbial infections due to their rich source of antimicrobial activity & less cost. The different plant parts such as seed, fruit, root, bark, stem, leaf and even the whole plant were extracted using different solvents like ethanol, methanol, chloroform, petroleum ether, water etc. These plant extracts were tested by different diffusion methods against gram positive, gram negative bacteria and fungi to determine their antimicrobial activity. Identification of traditional remedies for skin is an important activity for the search of novel antimicrobial treatments against skin. There is a need for new topical agents for use in treating superficial skin infections. Medicinal plants possess antimicrobial properties which could be efficiently used as antimicrobial agents for topical use. This review provides a data of medicinal plants with antimicrobial activity thereby offering further scope for investigation of medicinal plant extracts to develop as effective antimicrobial medicines.

Keywords: Medicinal plants, Antimicrobial activity, Plant extracts, Bacteria, Fungi, Skin, Infections.

INTRODUCTION

Medicinal plants are finding their way into pharmaceuticals, cosmetics along with nutraceuticals. In pharmaceutical field medicinal plants are mostly used for the wide range of constituents present in plants which have been used to treat chronic as well as infectious diseases. Long before mankind discovered the existence of microbes, the idea that certain plants had healing potential, indeed, that they contained what we would currently characterize as antimicrobial principles, was well accepted. Man has used plants to treat common infectious diseases and some of these traditional medicines are still included as part of the habitual treatment of various diseases.[1] Medicinal plants are rich sources of antimicrobial agents.[2] According to World Health Organization (WHO) medicinal plants would be the best source to obtain a variety of drugs and 80% of world population is dependent on traditional medicine and a major part of traditional therapies involves the use of plant extracts or their active constituents. Yet a scientific study to determine their antimicrobial active compounds is a comparatively new field.[1,3]

Infectious diseases, particularly skin and mucosal infections, are common. An important group of these skin pathogens are the fungi and bacteria.[4] Infectious dermatological conditions are of common occurrence including dermal inflammation, folliculitis, skin abuses, acne, dermatitis, rosacea etc. Multidrug resistant bacteria have become important cause for

higher skin care products.[5] Multiple drug resistance has developed due to the indiscriminate use of commercial antimicrobial drugs commonly used in the treatment of infectious disease.[6] Immunocompromised individuals are frequently found suffering from skin infections that are difficult to cure. A novel compound with difference in mode of activity of antibiotics against microbes is an attractive alternative against multidrug resistant bacteria.[5] The drugs already in use to treat infectious disease are of concern also because drug safety remains an enormous global issue. Most of the synthetic drugs cause side effects. To alleviate this problem, antimicrobial compounds from potential plants should be explored. These drugs from plants are less toxic; side effects are scanty and also cost effective. They are effective in the treatment of infectious diseases while simultaneously mitigating many of the side effects that are often associated with synthetic antimicrobials.[1] Topical drug administration is a localized drug delivery system anywhere in the body through ophthalmic, rectal, vaginal, and skin as topical routes. Skin is one of the most accessible organ of human body for topical administration and main route of topical drug delivery system. Number of medicated products is applied to the skin or mucous membrane that either enhances or restores a fundamental function of a skin or pharmacologically alters an action in the underlined tissues. Such products are referred as topical or dermatological products. At the skin surface, drug molecules come in contact with cellular debris, microorganisms, and other materials, which effect permeation. The applied medicinal substance has three pathways to the viable tissue- 1) through hair follicles, 2) via sweat ducts and 3) across continuous stratum corneum between the appendages (hair follicles, sebaceous glands, eccrine, apocrine glands and nails). This route of drug delivery has gained popularity because it avoids first-pass effect, gastrointestinal irritation and metabolic degradation associated with oral administration. The topical route of administration has been utilized either to produce local effect for treating skin disorder or to produce systemic drug effects.[7]

Plant based antimicrobials represent a vast untapped source of medicines and further exploration of plant antimicrobials is the need of the hour. Antimicrobials of plant origin have enormous therapeutic potential. Plant-derived antimicrobials have a long history of providing the much needed novel therapeutics.[1] Although hundreds of plants species have been tested for antimicrobial properties, the majority of these have not been adequately evaluated. Considering the vast potentiality of plant as sources for antimicrobial drugs the present study is based on the review of such plants.[2]

PLANTS WITH ANTI-MICROBIAL ACTIVITY

Eclipta alba[8]

Eclipta alba is commonly known as Bhringaraja or Maka belonging to the family Asteraceae/ Compositae.

Part Used

Leaves and Roots.

Extracted With

Petroleum ether, Benzene, Chloroform, Acetone, Methanol, Water.

Chemical Constituents

The herb contains wedelolactone and demethylwedelolactone. Other prominent chemical constituents present are ecliptal, ecliptine, ecliptalbine, α-terthienylmethanol, β-amyrin and sigmasterol.

Antimicrobial Activity Tested

Antibacterial and Antifungal.

Test Organisms

Bacillus subtilis, Escherichia coli, Pseudomonas fluorescens, Staphylococcus aureus.

Method of Assay

The antibacterial activity of leaves and roots of *Eclipta alba* was evaluated by agar well diffusion method. Antibiotics discs such as penicillin, ampicillin, gentamycin and streptomycin were used as a control for all bacterial strains.

Results Reported

Out of all the extracts benzene and chloroform extract of roots and leaves were reported to be most active against all bacterial strains at concentration of 8 -2 mg /100µl

Tribulus terrestris[9,10]

Tribulus terrestris is commonly known as Gokharu belonging to the family *Zygophyllaceae.*

Parts Used

Roots, Stem, Leaf, Fruit.

Extracted With

10% Acetic acid in Ethanol for extraction of alkaloids.

Phytochemical Screening

Its various parts contain a variety of chemical constituents which are medicinally important, such as flavonoids, flavonol glycosides, steroidal saponins, and alkaloids.

Antimicrobial Activity Tested

Antibacterial and Antifungal.

Test Organisms

Staphylococcus aureus, *Escherichia coli, Proteus mirabilis, Aspergillus flavus and Aspergillus niger.*

Method of Assay

The antibacterial activity of *Tribulus terrestris* was evaluated by disc diffusion assay. Standards used were streptomycin for bacteria and itraconazole for fungi.

Results Reported

All the four extracts demonstrated significant antibacterial activity and found active against all the tested bacteria while the extracts showed no activity against the tested fungi. The range of Minimal inhibitory concentration (MIC) and Minimal bactericidal concentration (MBC) of extracts recorded was 0.019‑0.625 mg/ml and 0.019‑1.25 mg/ml, respectively.

Ficus glomerata[11]

Ficus glomerata is commonly known as Cluster fig belonging to family Moraceae.

Part Used

Fruit

Extracted With

Soxhlet extraction using petroleum ether, chloroform, methanol and water as solvents in increasing polarity successively.

Phytochemical Screening

The fruit was found to contain flavonoids, coumarins, alkaloids, steroids, triterpenes and salicylic acid etc.

Antimicrobial Activity Tested

Antibacterial.

Test Organisms

Escherichia coli (MTCC 46), Staphylococcus aureus (MTCC 96), Salmonella typhimurium (MTCC 98), Enterobacter aerogenes (MTCC 111) and Klebsiella pneumonia (MTCC 432).

Method of Assay

The antibacterial activity of *Ficus glomerata* was evaluated by Well Diffusion Method. The effects were compared to the standard Streptomycin sulphate (50 mg/ml).

Results Reported

The Aqueous extract showed higher amount of yield about 14.50% followed by the methanol extract 11.30% and chloroform extract 7.10% yield. The antibacterial activity against pathogenic organisms was exhibited by all three extracts. Comparatively methanolic extract showed the higher activity followed by aqueous and chloroform extracts. The methanol extract showed antimicrobial activity with zone of inhibition ranging from 12-20 mm, whereas aqueous extracts of *Ficus glomerata* was found to have antimicrobial activity with zone of inhibition ranging from 9-17 mm.

Jatropha tanjorensis[12,13]

Jatropha tanjorensis belongs to the family Euphorbiaceae & it shows intermediacy in phenotypic characters between *J. gossypifolia and J.curcas*. It is commonly called Catholic vegetable, Iyana-ipaja, Lapalapa.

Part Used

Leaf.

Extracted With

The leaves were extracted with hexane, chloroform and methanol using Soxhlet apparatus.

Chemical Constituents

The herb contains friedelin, β-amyrin, stigmasterol and R (+) 4-hydroxy-2-pyrrolidinone.

Antimicrobial Activity Tested

Antibacterial and Antifungal.

Test Organisms

Different concentrations of the solvent extracts of leaves were tested against human pathogenic microorganisms such as gram-positive bacteria of *Bacillus cereus, Bacillus subtilis, Staphylococcus aureus, Staphylococcus epidermis*, gram-negative bacteria of *Aeromonas hydrophila, Escherichia coli, Klebsiella pneumoniae, Pseudomonas aeruginosa, Proteus mirabilis, Proteus vulgaris, Salmonella paratyphi, Salmonella paratyphi A, Vibrio alcaligenes, Vibrio cholera* and fungi of *Aspergillus fumigatus, Candida albicans, Microsporum gypseum* and *Trichophyton rubrum*.

Method of Assay

The antibacterial activity of *Jatropha tanjorensis* was evaluated by disc diffusion and agar well diffusion method. The solvent without extracts served as negative control. Standard antibiotic Ciprofloxacin was used as positive control.

Results Reported

Gram-positive bacteria produced maximum inhibition of 24, 23, and 22 mm to methanol at 50, 25, and 12.5 mg/ml to Bacillus cereus. Similar concentrations in methanol extract moderately inhibited Staphylococcus epidermis such as 20, 19 and 18 mm. Gram-negative bacteria at 50, 25 and 12.5 mg/ml recorded maximum inhibition such as 26, 25 and 24 mm in methanol extract to Klebsiella pneumoniae. Similar concentrations produced 24, 22 and 19 mm to methanol extract against Proteus mirabilis. Among fungi, at 50, 25 and 12.5 mg/ml, maximum inhibition respectively recorded such as 15, 13 and 12 mm to methanol against A. fumigates and 16, 12 and 11 mm to methanol against T. rubrum. The potential of *Jatropha tanjorensis extract* against the strains of *S. aureus* and *P. aeruginosa* may be explored to develop a topical antimicrobial therapy.

Enicostemma hyssopifolium[14]

Enicostemma hyssopifolium commonly known as Chhota chirayata is a common weed of grassland and more frequent in open fields.

Part Used

Whole plant.

Extracted With

Petroleum ether, chloroform, n-Butanol, ethanol and water.

Phytochemical Screening

The leaves, root and stem contains alkaloids, glycoside, saponins, terpenoids, phenols, tannins, flavonoids, triterpenoids, steroids

Antimicrobial Activity Tested

Antibacterial and Antifungal.

Test Organisms

Pseudomonas aeruginosa, *Escherichia coli,* Cogulase positive *staphylococci,* Cogulase negative *staphylococci, Enterococcus* species, *Candida albicans* and *Candida parapsilosis.*

Method of Assay

The antimicrobial activity of *Enicostemma hyssopifolium* was evaluated using agar gel diffusion susceptibility test. The standards used for comparison of activity were Penicillin, Tetracycline, Erythromycin, Streptomycin, Fluconazole and Amphotericin B.

Results Reported

Among all solvents used ethanol extract gave the highest zone of inhibition. With *Escherichia coli,* zone of inhibition was 20.0mm, with Cogulase (+) *Staphylococci* it was 27.3 mm., with Cogulase (-) *Staphylococci* 26.6 mm., with Pseudomonas aeruginosa 25.0 mm., with Enterococcus sp. 23.6 mm., with Candida albicans and Candida parapsilosis it was 22.0 mm and 20.5 mm respectively.

Curcuma zedoaria[15,16,17]

Curcuma zedoaria, an important member of the genus Curcuma, belongs to the family Zingiberaceae.

Part Used

Tubers.

Extracted With

Petroleum ether, hexane, chloroform, acetone and ethanol.

Chemical Constituents

Curcuma zedoaria is a rich source of essential oils, starch, curcumin, arabin, gums, etc. Sesquiterpenes from the rhizome of Curcuma zedoaria include furanodiene, furanodienone, zedorone, curzerenone, curzeone, germacrone, 13- hydroxygermacrone, dihydrocurdione, curcumenone and zedoaronediol.

Antimicrobial Activity Tested

Antibacterial and Antifungal.

Test Organisms

The microbial strains used for testing antimicrobial activities included the Gram positive bacteria *Bacillus subtilis* NCIM 2603, *Staphylococcus aureus* NCIM 2127 and *Micrococcus luteus* NCIM 2103, and Gram negative bacteria *Escherichia coli* NCIM 2574, *Proteus mirabilis* NCIM 2300 and *Klebsiella pneumonia* NCIM 2957. The fungal cultures used were *Candida albicans* NCIM 3102 and *Aspergillus niger* NCIM 596

Method of Assay

The antimicrobial activity of *Curcuma zedoaria* was evaluated using the agar-well diffusion method. The standards used for comparison of activity were Gentamycin and Tetracycline for bacteria and Clotrimazole for fungi.

Results Reported

In *Curcuma zedoaria* all the solvent extracts, except water, showed significant inhibitory activity. Inhibition was observed against all bacterial strains except *Escherichia coli* and *Staphylococcus aureus*. Petroleum ether, hexane, chloroform and acetone extracts showed higher activity than ethanolic extracts and produced inhibition zones ranging from 8 to 15 mm in diameter at a concentration of 75 µg/well. All extracts inhibited *Candida albicans* at a concentration of 75 µg/well. The MIC value of *Curcuma zedoaria* extracts ranged from 0.01 to 0.15 mg/ml

Allangium salvifollium[18]

Alangium salviifolium (L. F.) Wangerin is a deciduous, rambling shrub or a tree belonging to the family Alangiaceae.

Part Used

Flower

Extracted With

Aqueous and ethanolic extracts were prepared and tested on multiple drug resistant Gram-positive and Gram-negative organisms

Phytochemical Screening

Phytochemical analysis of the extract confirmed the presence of various phytochemicals including tannins, saponins, flavonoids, alkaloids, quinines, cardiac glycosides, coumarins, phenols, anthraquinones, steroids, catechin, reducing disaccharide and proteins.

Antimicrobial Activity Tested

Antibacterial

Test Organisms

The microbial strains used for testing antimicrobial activities included the Gram-positive bacteria : *Staphylococcus aureus, Enterococci and Staphylococcus epidermidis* and Gram-negative bacteria : *Citrobacter, Pseudomonas aeruginosa, Proteus vulgaris, Proteus mirabilis, Klebsiella species, Enterobacter, E. coli* and *Seratia marcescens*

Method of Assay

The antimicrobial activity of *Alangium salvifollium* flower was evaluated using the Agar disc diffusion method.

Results Reported

Antimicrobial assays showed that aqueous extract was active against all the tested microbial species in inhibiting 10 out of 11 test microorganisms that were used with 8–17

mm zone of inhibition. Citrobacter species that were most resistant to the antibiotics used as reference was inhibited by the aqueous extract.

Solanum khasianum[19]

Solanum khasianum Clarke synonym of *Solanum aculeatissimum* Jacq., *Solanum* viarum Dunal commonly called as Dutch egg plant belongs to the Family: Solanaceae

Part Used

Berries.

Extracted With

95% ethanol by cold maceration method.

Chemical Constituents

The berries mostly comprise of the steroidal glycoalkaloid known as Solasodine.

Antimicrobial Activity Tested

Antibacterial.

Test Organisms

The antibacterial activity of *Solanum khasianum* was tested against bacterial strains including *Staphylococcus aureus* and *E. coli*

Method of Assay

The antimicrobial activity of *Solanum khasianum* was evaluated using the agar well diffusion method. The standard used for the evaluation of activity was Streptomycin

Results Reported

Antimicrobial activity by agar well diffusion method by using microorganisms *Staphylococcus aureus, Escherichia coli*, states that alcoholic extract of *Solanum khasianum* Clarke shows maximum zone of inhibition i.e., antimicrobial effect against the microorganism when compared to the standard drug.

Symplocos paniculata[20,21]

Symplocos paniculata is a species of Symplocaceae family which is commonly known as lodh, lodhra and sapphire berry.

Part Used

Stem bark

Extracted With

95% Ethanol

Chemical Constituents

Three common triterpenoids ursolic acid, corosolic acid and 2α, 3α, 19α, 23-tetrahydroxyurs-12- ene-28-oic acid have been reported from the stem of *S. paniculata*

Antimicrobial Activity Tested

Antibacterial

Test Organisms

Antimicrobial activity of the alcoholic extract was tested against *Staphylococcus aureus, Bacillus subtilis, Pseudomonas aeruginosa, Escherichia coli*

Method of Assay

Antimicrobial activity with different concentrations of the extract (reconstituted with dimethyl sulfoxide) was evaluated by cup plate assay method. Antimicrobial susceptibility testing was done by Agar disc diffusion method using standard Erythromycin (1mg/ml) and standard Ampicillin (1mg/ml). MICs of the samples were determined by tube dilution method.

Results Reported

Symplocos paniculata possess antibacterial activity against *Staphylococcus aureus, Bacillus subtilis, Pseudomonas auroginosa* and *Escherichia coli.* When tested by the disc diffusion method, the extract was found active with MIC value of 250–500 µg/ml when compared to Erythromycin and Ampicillin. On the basis of results, it was conclude that the extract had a potent antibacterial activity.

Lepidium sativum[22]

Lepidium sativum, known as pepper cress or Elrashad, belongs to the family Brassicaceae (cruciferae)

Part Used

Seed.

Extracted With

Petroleum ether, methanol and water.

Phytochemical Screening
Lepidium sativum seeds revealed the presence of flavonoids, alkaloids, sterols and/or triterpenes, tannins and glucosinolates.

Antimicrobial Activity Tested
Antibacterial and Antifungal.

Test Organisms
Extracts were tested against six pathogenic bacteria *Staphylococcus aureus* ATCC/25923, *Escherichia coli* ATCC/27853, *Klebsiella pneumoniae* ATCC/3565, *Proteus vulgaris* ATCC/27853, *Pseudomonas aeruginosa* 27853/ATCC and fungus *Candida albicans* ATCC/7596.

Method of Assay
The Agar well diffusion method was used in this study to assess the antimicrobial activity of *Lepidium sativum.* The antimicrobial activity of plant seeds extracts were compared with that of Gentamycin or Ketoconazole, as reference antibiotics.

Results Reported
The petroleum ether extract of *Lepidium sativum* seeds in different concentrations (2.5-5-10%) were found to be active antimicrobials against all the test microorganisms with a strong antifungal activity against *Candida albicans* at the concentration 2.5 and 10%. High inhibitory effect against *Staphylococcus aureus*, *Escherichia coli*, *Klebsiella pneumonia* and *Proteus vulgaris* at 2.5%. *Proteus vulgaris* was well inhibited by 2.5% petroleum ether and 10% of both methanolic and aqueous extracts.

Ricinus communis[23,24]
Ricinus communis belongs to family Euphorbiaceae.

Part Used
Leaves.

Extracted With
Methanol, Ethanol, Water.

Chemical Constituents
Essential oil predominantly composed of α-thujone and 1,8-cineole, followed by α-pinene, camphor and camphene.

Antimicrobial Activity Tested
Antibacterial and Antifungal.

Test Organisms
Staphylococcus aureus (ATCC 6538), Pseudomonas aeruginosa (ATCC 7221), Klebsiella pneumoniae, Bacillus subtilis, Aspergillus fumigatus, Aspergillus flavus.

Method of Assay
The antimicrobial activity of plant extract was determined by Agar well diffusion method. The antibacterial activity of the extracts was compared to standard Penicillin as positive control.

Results Reported
The *R. communis* methanolic leaf extract showed maximum antibacterial activity as compared to ethanol and aqueous extract against *Staphylococcus aureus*. The ethanolic leaf extract showed maximum zone of inhibition against *S.aureus and Bacilus subtilis*. The methanol and water extracts of *R. communis* showed broad antifungal activity against tested fungal isolates at final concentration of 12 mg/ml.

Rumex dentatus[25]
Rumex dentatus belongs to the family Polygonaceae.

Part Used
Whole plant.

Extracted With
Soxhlet extraction with solvents including Petroleum ether, ethyl acetate, chloroform, butanol and water.

Phytochemical Screening
The plant contains Alkaloids, Terpenoids, Flavonoids, Total phenols, Tannins, Saponins, Anthraquinone and cardiac glycoside.

Antimicrobial Activity Tested
Antibacterial and Antifungal

Test Organisms
Bacterial strains including *Escherichia coli, Pseudomonas aeruginosa , Shigella flexneri , Klebsiella pneumoniae, Salmonella typhimurium and Staphylococcus aureus*; Fungal strains including *Aspergillus versicolor , Aspergillus flavus, Penicillium dimorphosporum, Acremonium spp., Candida albicans, Candida kruesie* and *Candida parapsilosis*.

Method of Assay
Antimicrobial activity of extracts was determined using Agar-disc diffusion method.

Results Reported
Among all the extracts, the butanol extract showed strong antibacterial activity against *Klebsiella pneumonia* and aqueous extract showed no activity any of the bacterial strains. Maximum antifungal activity was observed against Aspergillus *flavus* by aqueous extract.

Begonia malabarica[26]
Begonia malabarica, known as Narayanachanjeeve in Tamil belongs to the family Begoniaceae.

Part Used
Leaf.

Extracted With
Water, Methanol, Chloroform.

Phytochemical Screening
The plant contains flavone, sterol, triterpene, phenol, quinone, saponin, tannin and starch.

Antimicrobial Activity Tested
Antibacterial and Antifungal.

Test Organisms
Gram-negative bacteria, viz. *Aeromona shydrophila*, *Chromobacterium violaceum*, *Escherichia coli*, *Klebsiella pneumoniae*, *Pseudomonas aeruginosa*, *Salmonella typhi*, *Vibrio cholera* and *Vibrio parahaemolyticus*; the Grampositive bacteria, *Bacillus subtilis* and *Staphylococcus aureus*; and the fungi, *Aspergillus flavus*, *Aspergillus fumigatus*, *Aspergillus niger* and *Candida albicans*.

Method of Assay
The antimicrobial activity of extracts was tested using Agar well diffusion method. The effect was compared to standards such as Ceftriaxone (30 µg/disc), Chloramphenicol (30 µg/disc), Erythromycin(15 µg/disc), Novobiocin (30 µg/disc), Trimethoprim (5 µg/disc).

Results Reported
It was observed that all the extracts of the leaves of *B. malabarica* were devoid of antifungal activity against the tested fungi. The activity of the chloroform and aqueous extracts against *C. violaceum* supports the use of plant against skin lesions and pyameia.

Jasminum humile[27]
Jasminum humile is commonly known as Yellow Jasmine; Peeli Chameli belongs to the family Oleaceae.

Part Used
Leaf.

Extracted With
Soxhlet extraction with methanol as solvent.

Phytochemical Screening
The herb contains Flavonoids, Alkaloids, Saponins, Tannins.

Antimicrobial Activity Tested
Antibacterial

Test Organisms
The methanolic extract was studied for antibacterial activity against *Staphylococcus aureus, Bacillus subtilis, Streptococcus faecalis, Escherichia coli, Pseudomona aeruginosa.*

Method of Assay
The screening of Antibacterial activity of plant extracts was carried out using the agar well diffusion method. The effect obtained was compared against standard Ciprofloxacin as positive control for all bacterial strains.

Results Reported
Antibacterial screening of methanolic extract of *J. humile* revealed significant activity against all tested bacterial strains at different concentrations. But the maximum antibacterial

activity (3.7 cm zone of inhibition) of extract was exhibited against *Staphylococcus aureus* at concentration 50 mg/ml when compared with Ciprofloxacin. The results of the study showed methanolic extract of the plant have broad antibacterial activities.

CONCLUSION

Medicinal Plants are important in healthcare as a source of new pharmaceuticals. Multidrug resistance in human pathogenic bacteria as well as undesirable side-effects of certain antibiotics has led to the increasing interest in the search for new antimicrobial drugs of plant origin. This review suggests that some of the medicinal plants possess antimicrobial properties which could be used as antimicrobial agents for topical use and also for incorporation of the plant extracts into topical drug delivery systems. Thus plant extracts and biologically active compounds isolated from plant species may be used in herbal medicine efficiently. Topical antibacterial agents remain attractive alternatives to systemic agents because of their versatility. It may be concluded that medicinal plants with activity against different pathogens can be used as antimicrobial agents in new drugs for therapy of infectious diseases in human.

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