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Antimicrobial effects of medicinal plants (part 3): plant based review

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Abstract: Plants contained wide range of secondary metabolites, which were used as pharmaceuticals, agrochemicals, flavours, fragrances, colours, biopesticides and food additives. The excessive use of antibiotics was contributed to the emergence and spread of antibiotic- resistant bacteria in communities. Medicinal plants were used as an antimicrobial agents to avoid the development of multi-drug resistant bacteria, they were acting by different mechanisms. This paper reviewed the medicinal plants possessed antibacterial, antifungal and antiviral activities.

Keywords: Medicinal plants, herbs, antibacterial, antiviral, antifungal, antimicrobial

I. INTRODUCTION

The excessive use of antibiotics has contributed to the emergence and spread of antibiotic- resistant bacteria in communities [1-22]. Medicinal plants were used as an antimicrobial agents to avoid the development of multi-drug resistant bacteria, they were acting by different mechanisms. Our previous reviews showed that medicinal plants exerted a wide range of antimicrobial activity [23-24]. These plants included: *Achillea santolina*[25], *Adiantum capillus-veneris* [26], *Agrimonia eupatoria* [27], *Agropyron repens* [28], *Ailanthus altissima* [29], *Alhagi maurorum* [30], *Allium species* [31], *Alpinia galangal* [32], *Althaea officinalis* and *Althaea rosea* [33], *Ammannia baccifera* [34], *Ammi visnaga* [35], *Anagyris foetida* [23], *Anchusa strigosa* [36], *Anethum graveolens* [37] , *Anthemis nobelis* [38], *Antirrhinum majus* [39], *Apium graveolens* [40], *Arachis hypogaea* [41], *Arctium lappa* [42], *Artemisia campestris* [43], *Arundo donax* [44], *Asclepias curassavica* [45], *Asparagus officinalis* [46], *Avena sativa* [47], *Bacopa monniera* [48], *Ballota nigra* [49], *Bauhinia variegate* [50], *Bellis perenni* [51], *Benincasa hispida* [52], *Betula alba* [53], *Bidens tripartite* [54], *Brassica rapa* [55], *Bryophyllum calycinum* [56], *Caesalpinia crista* [57], *Calamintha graveolens* [23], *Calendula officinalis* [58], *Calotropis procera* [59], *Canna indica* [60], *Capparis spinosa* [61], *Capsella bursa-pastoris* [62], *Capsicum species* [63], *Carthamus tinctorius* [64], *Carum carvi* [65], *Cassia occidentalis* [66], *Casuarina equisetifolia* [67], *Celosia cristata* [68], *Centaurea cyanus* [69], *Chenopodium album* [70] and *Chrozophora tinctoria* [71], *Cicer arietinum* [72], *Cichorium intybus* [73], *Citrullus colocynthis* [74], Citrus species [75], *Clerodendrum inerme* [76], *Clitoria ternatea* [77], *Colchicum balansae* [78], *Convolvulus arvensis* [79], *Corchorus aestuans* [80], *Corchorus capsularis* [81], *Cordia myxa* [82], *Coriandrum sativum* [83], *Coronilla varia* [84], *Cotoneaster racemiflora* [85], *Cressa cretica* [86], *Crotalaria juncea* [87], *Cyminum cuminum* [88], *Cupressus sempervirens* [89], *Cydonia oblonga* [90],, *Cynodon dactylon* [91], *Cyperus rotuntdus* [92]. This review was designed to cover the medicinal plants possessing antimicrobial activities.

II. PLLANTS WIT ANTIMICROBIAL POTENTIAL

Dactyloctenium aegyptium

The methanolic extract of *Dactyloctenium aegyptium* possessed antibacterial activity against standard *Stapylococcus aureus* (ATCC 25953) and hospital isolated *Stapylococcus aureus* strains with MIC of 7.6-7.7 mg/ml. *Dactyloctenium aegyptium* methanolic extract possessed antibacterial activity against *Stapylococcus aureus* and *Escherichia coli* with MIC of 6.5-7 mg/ml [93].

Antimicrobial activities of *n*-hexane, ethyl acetate and *n*-butanol fractions of *Dactyloctenium aegyptium* aerial parts were investigated against Gram positive bacteria [*Staphylococcus aurous* (RCMB 010028) and *Bacillis subtilis* (RCMB 010067)], Gram negative bacteria [*Escherichia coli* (RCMB 010052) and *Pseudomonas aeruginosa* (RCMB 010043)] and fungal strains [*Aspergillus fumigates* (RCMB 02568) and *Candida albicans* (RCMB 05031)]. The ethyl acetate extract was the most active against *C. albicans* and *E. coli* compared to that of *n*-butanol. The *n*-hexane showed no antimicrobial activity against all microorganisms tested [94].

The antibacterial activity of *Dactyloctenium aegyptium* was studied against *Staphylococcus aureus, Pseudomonas aeruginosa, E.coli, Klebsiella pneumoniae, Proteus vulgaris* by disc diffusion method. The maximum zone of inhibition was observed against *pseudomonas aeruginosa* and the minimum zone of inhibition was observed against *Proteus vulgaris, E.coli, Klebsiella pneumoniae* for ethanol extract [95].

Ethanolic extract of *Dactyloctenium aegyptium* were examined for antimicrobial potential against three standard bacteria (*Escherichia coli, Klebsiella Pneumonia, Staphylococci*) and one standard fungus (*Aspergillus niger*). The ethanolic extract of *Dactyloctenium aegyptium* showed antifungal activity and antibacterial activity against all the tested bacteria with a dose dependent increase in zone of inhibition [96].

The antimicrobial potential of the methanolic extracts of nine medicinal plants from Saudi folk medicine was studied against seven pathogens *(E coli*, *B. cereus*, *S. typhi*, *K. pneumonia*, *P. aeruginosa*, *S. aureus* and *Candida albicans*). *Dactyloctenium aegyptium*, showed good antimicrobial activity [97].

The antiviral activity against HSV-2, HSV-1 and HAV-10 of *Dactyloctenium aegyptium* aerial parts extracts was investigated using cytopathic effect inhibition assay. The ethyl acetate showed weak antiviral activity, *n*-butanol extracts of *Dactyloctenium aegyptium* showed moderate antiviral effects against HAV-10 and HSV-1. The *n*-hexane extract showed strong antiviral activity against all viruses tested [94].

Dalbergia sissoo

The methanol, hexane extracts and isolated okanin from methanol extracts were exhibited good antibacterial activity towards various pathogens, Gram positive (*Micrococcus luteus* and *Staphlcocous aureus*) and Gram negative bacteria (*Escherichia coli, R. planticola* and *Acinetobacter*) [98].

1,2-benzenedicarboxylic acid dibutyl ester (13.68%) and 5-nirto-2,4 (1H,3H)-pyrimidine dione isolated from the plant, showed antibacterial activity against *Staph aureus, Bacillus cereus*, *Serratia marcescens* and *Proteus mirabilis* [99].

A herbal preparation containing *Dalbergia sissoo* and *Datura stramoium* was evaluated for its antibacterial potential against pathogenic strains of Gram positive (*Staphylococcus aureus* and *Streptococcus pneumoniae*) and Gram negative (*Escherichia coli, Pseudomonas aeruginosa* and *Klebsiella pneumoniae*) bacteria. The extracted fractions of the herbal preparation were found active against both Gram positive as well as Gram negative bacteria. Gram positive bacteria showed higher sensitivity [100].

Dalbergia sisso was evaluated for its antibacterial potential against eight human pathogenic bacterial strains. Triple maceration method was adopted for the methanolic extraction of whole plant and leaves. *In vitro*, antimicrobial test was performed by disc diffusion method. Whole plant's extract showed good antibacterial activity against *S. aureus* (18.00mm), *S. pneumoniae* (17.50mm), *B. cereus* (17.90mm), *B. pumilus* (16.45mm), *E. coli* (19.00mm), *K. pneumoniae* (17.45mm), *P. aeruginosa* (16.20mm) *and C. freundii* (15.00mm), with relative percentages of inhibition of 81.00, 80.54, 76.65, 64.65, 78.45, 72.45, 70.37 and 62.30 respectively, as compared with leaves with relative percentages of inhibition of 70.56, 67.32, 54.20, 43.24, 62.80, 57.03, 51.05 and 36.65 against same microbes. Modified agar well diffusion method was used to measure the minimum inhibitory concentration.MIC values of the whole plant extract lies within the range of 75 to 300 µg /ml for the Gram positive strains while 75 to 600 µg /ml for Gram negative strains [101].

Daphne mucronata

Antibacterial and antifungal activity of the ethanolic extract of leave and stem of *Daphne mucronata* were evaluated against four species of Gram positive and Gram negative bacteria and two fungi. The results showed that extracts were active against *Escherichia coli* and *Staphylococcus aureus*, however, ethanolic extract of the roots of plant were the most effective against Gram positive bacteria *(Staphylococcus aureus* and *Bacillus subtilis).* The leaves and stems extract of the plant had no effect on Pseudomonas aeruginosa even at high concentration. Antifungal activity was not observed in any part of the plant [102].

Biofilms protect the pathogens from inhibitory effect of antibiotics and immune cells. *Pseudomonas aeruginosa* was an important pathogen, and one of the hallmarks of *Pseudomonas aeruginosa* infection was its capability to adhere to, and propagate on medical devices, such as catheters, contact lenses, and wound dressings by forming strong biofilms. Antipseudomonal activity of *Daphne mucronata* 5% aqueous extracts was determined using Disk-Diffusion assay. *Daphne mucronata*, produced zone of inhibition of 12mm, biofilm reduction 40.08% and biofilm removal 46.02% [103].

Datisca cannabina

The antimicrobial activity of crude extracts of plants and pigments of *Datisca cannabina* were investigated against *Staphylococcus aureus* (ATCC 6533), *Enterococcus hirae* (ATCC 10541), (Gram-positive bacteria), *Escherichia coli* (ATCC 10536), *Pseudomonas aeruginosa* (ATCC 15442), *Salmonella typhimurium* (ATCC 13311) (Gram-negative bacteria), *Candida albicans* (ATCC 10231) and *Aspergillus niger* (ATCC 16404). Results also revealed that the dyes exerted inhibitory effects against 6 of the 7 (85.7%) studied organisms. MIC varied between 2.4 and 625 µg g/ml. The lowest MIC value (78 g/ml) was obtained against *A. niger* [104].

Datura metel

The antimicrobial effect of hydro-alcoholic and methanolic seed extracts of *Datura fastuosa* was evaluated against three clinical bacterial strains (*Escherichia coli*, *Staphylococcus aureus* and *Bacillus subtilis*) and two clinical fungal strains (*Candida allbicans* and *Aspergillus niger*) by tube dilution method. Both plant extracts were active against the tested microorganisms. The methanolic extract of *Datura fastuosa* inhibited *E.*

coli effectively with minimum bactericidal concentration (MBC) of 25µg/ml. The hydroalcoholic extract of *Datura fastuosa* seeds was found to be more potent in terms of its bactericidal concentration against *B. subtilis* with both minimum inhibitory concentration (MIC) and MBC values of 25 µg/ml. Methanolic extract was found to be more efficient in inhibiting *S. aureus* with MIC of 12.5 µg/ml [105].

A new antibacterial agent 5^1, 7^1 dimethyl 6^1– hydroxy 3^1, phenyl 3 a - amine b - yne sitosterol was isolated from the plant leaves. It displayed antibacterial activity against *Staphylococcus aureus, Pseudomonas aeruginosa, Proteus mirabis, Solmonella typhi, Bacillus subtilis* and *Klebsiella pneumonia* but could not inhibit *Escherichia coli* [106].

The antipathogenic effect of carbon tetrachloride, benzene and chloroform extract crude extracts of Datura leaf extract was studied against Enterobacter species. Carbon tetra chloride and benzene extracts (1000µg/ml) of the leaves of *Datura metel* showed excellent activity on comparing with that of standard drug, ciprofloxacin (100µg/ml) [107].

The hexane, chloroform, acetone and methanolic fractions of the plant. were investigated for antifungal properties using pathogenic species of Aspergillus (*A. fumigatus, A. flavus* and *A. niger*). The chloroform fraction was found to be endowed with antifungal activity. The minimum inhibitory concentration (MIC) of chloroform fraction was 625.0 microg/ml against all the three species of Aspergillus, by microbroth dilution and percent spore germination inhibition assays. The MIC by disc diffusion assay was observed to be 12.5 microg/disc. The chloroform fraction of the pant, when investigated for potency, turned to be 9.2 times less active than amphotericin B [108].

2beta-(3,4-dimethyl-2,5-dihydro-1H-pyrrol-2-yl)-1'-methylethyl pentanoate isolated from the leaves of *Datura metel* was endowed with antifungal activity and its MIC was found to be 87.5 microg/ml [109].

The antiviral activity of atropine was evaluated by plaque reduction test against *Herpes Simplex* virus, *Influenza* virus, *New Castle Disease* virus, *Sindbis, Vaccinia, Adenovirus* and *Japanese encephaitis* virus. Viruses were cultivated on primary chick embryo (CE), HeLa S3, primary monkey kidney cells (MK). Atropine inhibited only the growth of enveloped viruses independent of the nucleic acid content of the virus. It also blocked the glycosylaton of viral proteins of *Herpes* virus and hence the production of new virions. Virions formed in the presence of atropine were non infectious [110-111].

Datura stramonium

The antimicrobial activity of the aqueous and ethanolic extract of the stem-bark of *Datura stramonium* was investigation against *Staphylococcus aureus, Salmonella typhi, Shigella spp, Eschericia coli, Klebsiella pneumonia* and *Neisseria gonorrhea*. Ethanolic extract showed more antibacterial activity than the aqueous extract. It showed antibacterial activity against all the tested bacteria except *Neisseria gonorrhea*. The aqueous extract showed activity only against *Staphylococcus aureus* [112].

The antimicrobial properties of whole plants (extracted sequentially with different organic solvents) of *Datura stramonium* were studied against *Escherichia coli, Staphylococcus aureus, Pseudomonas aeruginosa* and the fungal strains *Aspergillus flavus, Aspergillus niger, Fusarium culmorum* and *Rhizopus stolonifer.* All the solvent extracts showed significant activity against all the tested microorganisms. Methanolic extract was the most active against all microorganisms, whereas all the extracts showed significant activity against *P. aeruginosa.* All the solvent extracts showed low MIC against *A.niger* [113].

The antibacterial and antifungal effects of benzene, chloroform and ethanol extracts of branches and leaves of *Datura stramonium* branches and leaves were studied against *Enterobacter* (clinical strain/PIMS), *Micrococcus luteus* (clinical strain/PIMS), *Pseudomonas aeruginosa* (clinical strain/PIMS), *E.coli* ATCC 25922, *Staphylococcus aureus* (clinical strain/PIMS) and *Klebsiella pneumonia* ATCC 700603. *Datura stramonium* chloroform extract produced maximum zone of inhibition 16±0.7mm against *Enterobacter*, while it produced minimum zone of inhibition (7±0.7mm) against *K. pneumonia.* Benzene extract of the plant exhibited maximum zone of inhibition (15±0.7mm) against *Enterobacter* and *M. luteus*, while it produced minimum zone of inhibition (9±0.3mm) against *S. aureus* and *K. pneumonia*, ethanol extract of *Datura stramonium* gave maximum zone of inhibition against *K. pneumonia* and minimum against *E. coli.* The MBC values revealed that benzene extract (3.12mg/ml) was effective against *P. aeruginosa* while the same concentration of chloroform extract was very active against *S. aureus, P. aeruginosa* and *M. luteus.* All the extracts of *Datura stramonium* possessed significant antifungal activity against *Saccharomyces cerevisiae, Aspergillus fumigatus* and *Aspergillus niger* with maximum antifungal activity against *S. cerevisiae* and zone of inhibition was about 16±0.2mm by ethanol extract, 15±0.3mm by chloroform and 14±1.6mm by benzene extract, while minimum antifungal activity was observed against *A. niger*[114].

Datura stramonium extracts were investigated for their *in vitro* activity against *Staphylococcus aurers* ATCC25923, Methicillin-resistant *S. aureus, Enterococcus sp., Escherichia colii* ATCC25922, Enteroinvasive *Escherichia coli* and *Pseudomonas aeruginosa. Datura stramonium* leaf extracts exhibited a considerable antibacterial activity even at low concentrations. Methanolic leaf extracts showed the maximum inhibitory

effect. The growth inhibition zone against *Escherichia coli* was 9.8mm and against *Staphylococcus aurers* was 6.8mm [115].

The antimicrobial effect of methanol extract from flower, seed and leaf of explant callus was studied against (*Escherichia coli, Pseudomonas aeruginosa, Staphylococcus epidermidis* and *Bacillus subtilis*) and four fungi strains (*Fusarium semithectum, Fusarium colmorum, Ceratocystis ulmi* and *Rhizoctoina solani*). The result showed that the methanol extract from green leaf explant callus possessed inhibitory effects on the growth of *B. subtilis* (22mm) and *S. epidermidis* (23mm). The methanolic extract of the vegetative root and the flower of *Datura stramonium* show an effective antifungal activity against *Rhizoctonia solani* fungus [116].

Aqueous and organic solvent extracts of different parts of the plant were investigated for its anti-*Vibrio cholera* non-O1, and *Vibrio parahaemolyticus* using the disk diffusion method. The results revealed that *Datura stramonium* possessed a broad-spectrum vibriocidal effect [117].

The antifungal effects of acetone extracts of *Datura stramonium* seeds were studied against selected phytopathogenic fungi (*Penicillium janthinellum, Penicillium expansum, Aspergillus niger, Aspergillus parasiticus, Colletotrichum gloeosporioides, Fusarium oxysporum, Trichoderma harzianum, Phytophthora nicotiana, Pythium ultimum* and *Rhizoctonia solani*). Extracts exhibited moderate to good antifungal activity, with minimum inhibitory concentrations ranged from 0.125 mg/ml to 2.50 mg/ml [118].

Aqueous and ethanolic extracts of various parts of *Datura stramonium* were examined for their potential antimicrobial activity against pathogenic bacteria [*Bacillus subtilis*-2699, *Escherichia coli*-2803, *Staphylococcus aureus*-2602, *Proteus vulgaris*-2027, *Salmonella typhi*-2501; and pathogenic fungi such as *Aspergillus flavus*- 525, *Aspergillus niger* (local isolate), *Candida albicans*-3100 and *Rhizopus stolonifer* (local isolate)].The results showed that the ethanolic extracts were more potent than the aqueous extracts and leaf extract possessed better antimicrobial activity than stem, and root. Aqueous extract of te leaves showed antibacterial activity against *Bacillus subtilis* and *Escherichia coli* with zone of inhibition of 16 and 10 mm respectively, while ethanolic extracts of the leaves exerted antibacterial activity against *Bacillus subtilis* (31mm), *Escherichia coli* (18mm), *Staphylococcus aureus* (24mm), *Salmonella typhi* (10mm), *Aspergillus flavus* (8mm) and *Candida albicans* (10mm) [119].

Daucus carota

Four sesquiterpenes daucane esters, one polyacetylene, one sesquiterpene coumarin, and sitosterol glucoside isolated from the roots of the wild *Daucus carota* ssp carota, showed a range of low antibacterial activities against four Gram positive (*Staphylococcus aureus, Streptomyces scabies, Bacillus subtilus* and *Bacillus cereus*) and two Gram negative species (*Pseudomonas aeruginosa* and *Escherichia coli*) as well as antifungal against *Fusarium oxysporum* and *Aspergillus niger*[120].

The flavones isolated from the methanol extract of *Daucus carota* seeds (luteolin, luteolin 3'-O-beta-D-glucopyranoside and luteolin 4'-O-beta-D-glucopyranoside) were evaluated for antibacterial effects. Both luteolin and its 4'-O-glucoside demonstrated bactericidal activity against *Staphylococcus aureus* and *Escherichia coli*, MIC = 5.0 x 10^{-2} - 1.0 x 10^{-1} mg/ml). Luteolin also demonstrated antibactericidal activity against *Bacillus cereus* and *Citrobacter freundii* (MIC = 5.0 x 10^{-2} mg/ml). Luteolin 3'-O-glucoside showed bactericidal activity against *Bacillus cereus* and *Lactobacillus plantarum* (MIC = 2.5 x 10^{-1} mg/ml and 5 x 10^{-1} mg/ ml, respectively) [121].

The antimicrobial activity of the essential oils of the flowering and mature umbels with seeds of wild *Daucus carota* L. subsp. carota from two different sites in Tunisia, were assayed by using the broth dilution method on Escherichia coli ATCC 35218 and Staphylococcus aureus ATCC 43300, and clinical strains of Candida albicans and C. tropicalis 1011 RM. The MIC values obtained were all > 2.5% (v/v) [122].

The *in vitro* antimicrobial activity of essential oils of *Daucus carota* seeds was evaluated, using the disk-diffusion method, against one Gram-positive (*Staphylococcus aureus*) and two Gram-negative bacteria (*Escherichia coli* and *Salmonella typhimurium*), and a pathogenic yeast (*Candida albicans*). All tested essential oils exhibited antibacterial and antifungal activities against the assayed microorganisms [123].

The antimicrobial activity of the essential oil of *Daucus carota* subsp carota from Portugal was evaluated against several Gram positive and Gram negative bacteria, yeasts, dermatophytes, and *Aspergillus* strains. The results showed a significant activity towards Gram positive bacteria (MIC = 0.32–0.64 µl/ml), *Cryptococcus neoformans* (0.16 µl/ml), and dermatophytes (0.32–0.64 µl/ml). The inhibition of the germ tube formation and the effect of the oil on *Candida albicans* biofilms were also unveiled. The oil inhibited more than 50% of filamentation at concentrations as low as 0.04 µl/ml (MIC/128) and decreased both biofilm mass and cell viability [124].

The antimicrobial effect of wild *Daucus carota* extracts seed (70% and 40% ethanol) were examined against Gram positive (*Staphylococcus aureus ATCC 6538-P, Staphylococcus hyicus* – isolated from the soil, *Micrococcus luteus* – isolated from soil, criptogamic culture of *Bacillus subtilis ATCC 6633*), Gram negative (*Pseudomonas aeruginosa ATCC 9027, Escherichia coli ATCC 8739* and *Salmonella Abony CIP- 8039,*and *Acinetobacter johnsonii* – isolated from the environment, *Moellerella wisconsensis* – isolated from the

environment) and fungi (*Candida albicans ATCC 10231, Candida utilis Lia-01, Saccharomyces cerevisia ATCC 9763* and *Aspergillus brasiliensis ATCC 16404*). The extracts were active against bacteria, the MIC against 2 Gram positive bacteria was 1.56-3.125 mg/ml and against 3 strains of Gram negative bacteria was 3.125-12.50 mg/ml, whereas against 1 strain of yeast was 3.125-6.25 mg/ml [125].

The essential oil of wild *Daucus carota* aerial parts at the end of the flowering stage (DCEO) inhibited the growth of *Campylobacter jejuni*, *Campylobacter coli*, and *Campylobacter lari* strains, including one multidrug resistant *Campylobacter jejuni*. The molecules responsible for the antibacterial activity were identified as (E)-methylisoeugenol and elemicin [126].

A strongest antifungal activity was observed for carotol, the main sesquiterpenic compound in the carrot seed oil, it inhibited the radial growth of *Alternaria alternata* by 65% [127].

Delphinium brunonianum

Antimicrobial assay of extracts, fractions, subfractions and compounds was performed on different microbes (*Escherchia coli*, *staphylococcus aureus*, *Pseudomonas aureginous*, *Salmonella flexinarie* and *Bacillus subtilis*). Extract and the compound isolated from *Delphinium brunonianum* (β-amyrin, β-sitosterol, β-sitosterol glucoside and anthriscifoldine) displayed moderate to good antibacterial properties on the tested bacteria in which the last compound (anthriscifoldine) showed comparatively higher activity regarding its minimum inhibitory concentrations and zone of inhibition, than other compounds [128].

Desmostachya bipinnata

In studying the antimicrobial effect of *Desmostachya bipinnata*, it appeared that β-Sitosterol-D-glucopyranoside was the bioactive compound identified to have the best antimicrobial activity (MIC 6-50 µg/ml) and it works synergistically with most antibiotics, especially with ciprofloxacin. Time kill curves showed that β-Sitosterol-D-glucopyranoside kills most of the pathogens within 5-10 h [129].

The antimicrobial effect of the ethanolic extract of *Desmostachya bipinnata* rootstock was investigated against *Aeromonas hydrophila, Bacillus cereus, Bacillus subtilis, Enterobacter aerogens, Escherichia coli, Klebsiela pneumoniae, Proteus vulgaris, Pseudomonas aeruginosa, Salmonella typhimurium, Staphylococcus aureus, Streptococcus pyrogens, Vibrio fischeri* and *Candida albicans.* The ethanolic extract (15.652, 31.25, 62.5, 125. 250 and 500 mg/ml) was found to inhibit *K. pneumonia* (16-25 mm), *E. coli* (12-22), *B. cereus* (9-18mm), *S. typhimurium* (13-17mm), and *P. vulgaris* (10-13mm) [130].

Ethanolic extract of *Desmostachya bipinnata* possessed antibacterial activity against *Micrococcus luteus, Bacillus subtilis, Proteus merabiles, Pseudomonas aeruginosa, Salmonella typhi, Sarcina ventricull, Staphylococcus aureus, Enterococcus faecalis, Escherichia coli* and *Serratia marcesens.* it also exerted antifungal effect against *Candida tropicalis, Candida albicans, Aspergillus fumigates, Aspergillus flavus* and *Pencillium chrysogenum*[131].

The antibacterial study of the oil of the aerial parts of Desmostachya bipinnata was evaluated using agar diffusion and broth dilution methods. The antibacterial studies revealed that the oil possessed significant inhibitory effect against four bacteria strains [132].

The crude extract of Desmostachya bipinnata (64 µg) showed antibacterial activity against Escherichia coli (17mm), Klebsiella sp (15mm) and Staphylococcus aureus (16mm) [133].

Dianthus caryophyllus

Eugenol was isolated from the essential oils of the plant and investigated for its antibacterial activities against seven selected pathogenic bacteria (*Staphylococcus aureus, Bacillus cereus, Listeria monocytogenes, Proteus mirabilis, Escherichia coli, Klebsiella pneumoniae* and *Pseudomonas aeruginosa*). Eugenol achieved strong MIC values against most tested pathogens and the best MIC value (15.6 microg/ml) was observed against *B. cereus, L. monocytogenes* and *K. pneumoniae* whereas, *S. aureus, P. mirabilis* and *E. coli* were inhibited with a MIC value of 31.2 microg/ml [134].

Whole *Dianthus caryophyllus* extracts showed antibacterial activity against *Staphylococcus epidermidis, Klebsiella pneumonia* and *Bordetella bronchiseptica* [135].

Standard bacterial strains included [*Pseudomonas aeruginosa* (PTCC No. 1074), *P. fluorescens* (PTCC No. 1181), *Bacillus subtilis* (PTCC No. 1023), *B. cereus* (PTCC No. 1015) and *B. pumilis* (PTCC No. 1319)] were used to evaluate the antibacterial activity of *Dianthus caryophyllus*. *Dianthus caryophyllus* (the whole plant, methanolic extract) was the most active plant, among 180 tested plants, against all tested bacterial species, with MIC of 1.87, 7.5, 3.72, 3.75 and 0.46 mg/ml against *B. subtilis, B. cereus, B. pumilis, P. aeruginosa* and *P. fluorescens* respectively [136].

Aqueous and methanolic extracts of aerial parts of *Dianthus caryophyllus* showed anti-*Helicobacter pylori* activity with MIC >1000 and >500 µg/ml respectively [137]. Two benzoic acid derivatives, protocatechuic acid (3,4- dihydroxybenzoic acid) and vanillic acid (4-hydroxy-3-methoxybenzoic acid), isolated from *Dianthus caryophyllus* were slightly inhibitory towards *F. oxysporum*, while the highly resistant cultivar "Roland" showed the presence of the flavone datiscetin (3,5,7,2'-tetrahydroxyflavone). which exhibited an appreciable fungitoxic activity towards *F. oxysporum* f. sp. dianthi [138]. Crude extract of *Dianthus caryophyllus* was

tested for their antiviral activity against herpes simplex virus-1 (HSV-1) and hepatitis A virus-27 (HAV-27). Non-toxic concentration (20 µg/ml) of *Dianthus caryophyllus* seed extract to both Vero and HepG2 cells showed potent antiviral activity against HSV-1 and HAV-27 using plaque infectivity count assay. No effect was detected for the extract on adsorption or on the stages of virus replication. A comparison has been done between the antiviral activity of two therapeutic drugs (acyclovir and amentadine used as controls for HSV-1 and HAV-MBB, respectively) and the tested seed extract. The results revealed that the seed extract was more efficient in its inhibitory activity than synthetic chemical drugs against the same viruses [139].

Dodonaea viscose

The growth inhibitory activity of *Dodonaea viscosa* var. angustifolia (DVA) leaves extract was investigated against *Streptococcus mutans* and its biofilm. The results revealed that the reduction of the growt of *Streptococcus mutans* was concentration and exposure time dependent. The crude extract killed 48% of *S. mutans* at a lowest concentration of 0.1 mg/ml and 100% at 25 mg/ml after 6 h. Biofilm formation was reduced by 95, 97 and 99% after 6, 24 and 30 h of exposure to the sub-inhibitory concentration of crude extract respectively. At high concentration the crude extract was bactericidal to *Streptococcus mutans* but sub-inhibitory concentration significantly reduced the planktonic cells and biofilm formation [140].

The minimum inhibitory concentration and the time taken by *Dodonaea viscosa* var. angustifolia (PLE), chlorhexidine gluconate (CHX) and triclosan (TRN) to kill *Candida albicans* was investigated *in vitro*. 41 strains of *Candida albicans* were used, 20 from HIV-positive patients, 20 from HIV-negative subjects and one *Candida albicans* ATCC 90028. The MICs of an acetone extract of PLE, CHX and TRN were measured using a microtitre double dilution technique, and the time taken to kill 99.5% of the strains was determined. The MICs of PLE, CHX and TRN were 6.25–25, 0.008–0.16 and 0.0022–0.009 mg/ml, respectively. PLE killed all the test strains within 30 s and CHX 40% of the isolates from HIV-positive patients and 20% of strains from HIV-negative subjects in 1 min. During the same time TRN killed 55% and 35% of isolates from HIV-positive and HIV-negative patients [141].

The n-hexane, dichloromethane, ethyl acetate, n-butanol and aqueous fractions of *Dodonaea viscosa* were analyzed for antimicrobial potential against four Gram positive bacteria [*Bacillus subtilis* (MRL M 1), *Bacillus cereus* (MRL M 52), *Micrococcus luteus* (ATCC 10240), *Staphylococcus aureus* (ATCC 6538)], three Gram negative [bacteria: *Escherichia coli* (ATCC 25922), *Salmonella typhi* (Cl. I. 140), *Pseudomonas aeruginosa* (ATCC 9721)] and the yeast *Candida albicans* (Cl. I. 4043). Extracts possessed antibacterial activity against *S. aureus, M. luteus, B. subtilis, E. coli, P. aeruginosa* and *C. albicans*. However, 15, 16-epoxy-cis-cleroda-3, 13(16),14-trien-18-oic acid-18,6-olide, a clerodanefuranolactone isolated from n-hexane fraction of *Dodonaea viscosa's* crude ethanolic extract showed antibacterial effects against Gram positive and Gram negative bacteria, its MIC's against *S. aureus* (NCIMB 6571) and *E. coli* (NCIMB 8797) were 64 µg/ml and 128 µg/ml respectively. The MBC's against these organisms were 128 µg/ml and 256 µg/ml, respectively [142].

The antibacterial activity of crude and step gradient solvent of methanol and chloroform of whole *Dodonaea viscosa* was studied using agar well diffusion technique against six bacterial human pathogens (*S. typhi, S. flexneri E. coli, V. cholerae, M. tuberculosis, P. fluorescens*). The growths of *S. flexneri and V. cholerae* were inhibited by the crude and step gradient extracts of *Dodonaea viscosa*. The maximum inhibition zone was obtained with the using of methanol 80% and chloroform 20% against the tested pathogens [143].

Methanol and n-hexane extracts of the leaves of *Dodonaea viscosa* were screened for antibacterial activities, against different Gram positive and Gram negative bacterial strains. The results showed that n-hexane extract of plant was inactive against *Pseudomonas aeruginosa* while methanolic extract of the plant was active against all the tested organisms [144].

The anti-biofilm activities of leaves of *Dodonaea viscosa* in successive different concentration were tested against *E. coli*. The leaves extracts of *Dodonaea viscosa* showed broad spectrum antibiofilm activity [145].

The antibacterial effect of methanolic and hot aqueous extracts of *Dodonaea viscosa* was studied against *Staphylococcus aureus* ATCC 6538, *Bacillus subtilis* ATCC 6059, *Micrococcus flavus* SBUG 16, *Escherichia coli* ATCC 11229, *Pseudomonas aeruginosa* ATCC 27853, *Candida maltosa* SBUG, multiresistant *Staphylococcus epidermidis*, multiresistant *Staphylococcus haemolyticus* and North German multiresistant *Staphylococcus aureus*. *Dodonaea viscosa* methanolic extract showed antibacterial activity against all tested bacteria with MIC 10-15 mm, except *Escherichia coli*, *Pseudomonas aeruginosa* and *Candida maltosa* SBUG, while hot aqueous possessed activity against *Staphylococcus aureus*, *Bacillus subtilis*, *Micrococcus flavus* and multiresistant *Staphylococcus epidermidis* only, with MIC 7.3-16mm [146].

The antimicrobial activity of *Dodonaea viscosa* leaf, stem and root using aqueous, methanol and chloroform solvents was studied using disc diffusion method. *Vibrio cholerae* was controlled by all parts of *Dodonaea viscosa* extracted by all the three types of solvent. Maximum zone of inhibition was recorded by the methanol extract of stem against *Vibrio cholerae*. Similarly, *Bacillus subtilis* was controlled by all the extracts

except that of methanol extract of root. The root extract of the weed showed no efficacy against the *Escherichia coli* and *Proteus mirabilis*. Among the extracts studied for antifungal efficacy of different parts of the plant, maximum efficacy was recorded for the methanol extract. Other solvents like aqueous and chloroform extract showed poor zone of inhibition or no effects. The methanol extract of leaf of the plant showed maximum activity against *Curvularia lunata* and *Fusarium oxysporum*. The methanol extract of root of the plant showed maximum activity against *Aspergillus flavus*. While, the methanolic extract of stem of the plant showed maximum activity against *Penicillium citrinum*. However no significant activity was recorded against *Aspergillus niger* by all extracts studied [147].

The inhibitory effects of the aerial plant part (leaves and bark) extracts of *Dodonaea viscosa* before and during flowering were evaluated against some pathogenic bacteria isolated from human and plants (*Escherichia coli*, *Pseudomonas aeruginosa*, *Staphylococcus aureus*, *Streptococcus agalactiae*, *E. carotovora and A. tumefaciens*), and against *Candida albicans* using ethanol and diethyl ether solvents (0, 2.5, 5, 10, 20, 30, 40 or 50 mg/ml). The results showed that ethanolic extracts of the bark and leaves, and diethyl ether extracts of the leaves demonstrated potent inhibitory effect against the tested microorganisms. Ethanolic extracts of the bark was superior to leaf extracts in the its inhibitory effects on the growth of *C. albicans*. No significant differences between concentrations of 30, 40 or 50 mg/ml were recorded [148].

Anti- *salmonella* activity of aqueous and ethanol extracts of *Dodonaea viscosa* was studied using well and disc diffusion assay. The highest inhibition zone was (22 mm) for well diffusion and (15mm) for disc diffusion assay were recorded. The results revealed that ethanol extract possessed more antibacterial effect than aqueous extract, the percentage of bacterial isolates affected by ethanol extract was (71.19%) comparing with aqueous extract (28.81%) by using disc diffusion assay, while the percentage of bacterial isolates affected by ethanol extract was (88.13%) comparing with aqueous extract (52.54%) by using well diffusion assay [149].

The crude ethanolic extract and *n*-hexane, dichloromethane, ethyl acetate, *n*-butanol and aqueous fractions of *Dodonaea viscosa* were analyzed for antibacterial potential against four Gram positive bacteria (*Bacillus subtilis, Bacillus cereus, Micrococcus luteus* and *Staphylococcus aureus*), and three Gram negative bacteria (*Escherichia coli, Salmonella typhi* and *Pseudomonas aeruginosa*). The results revealed that the crud extract possessed antibacterial activity against *Staphylococcus aureus*, *Micrococcus luteus, Bacillus subtilis*, *Escherichia coli* and *Pseudomonas aeruginosa* with zones of inhibition of 11-13.3mm. The results also showed that ethyl acetate fraction was active against five out of seven tested organisms, followed by the *n*-butanol fraction which inhibited four organisms and the *n*-hexane fraction which inhibited two organisms [150].

Chloroform, ethanol and methanol crude extracts of stem bark and leaves of *Dodonaea viscosa* were investigated for their antibacterial and antifungal potential against two Gram positive bacteria (*Bacillus subtilis*, *Staphylococcus aureus*), one Gram negative bacterium (*Escherichia coli*) and two yeast strains (*Candida albicans*, *Sccharomyces cervisiae*). Ethanol and methanol extracts were found to be active against the tested Gram positive and Gram negative bacteria. Extracts showed no effect against *Candida albicans* and *Sccharomyces cervisiae*. All the tested microorganisms were resistant to chloroform extracts. However, Gram positive bacteria were more sensitive to the extracts of *Dodonaea viscosa* than Gram negative bacterium [151].

Antifungal activity of solvent extracts of leaves and shoot of *Dodonaea viscosa* was studied against fungi, *Aspergillus niger, Aspergillus flavus, Paecilomyces varioti, Microsporum gypseum, and Trichophyton rubrum* causing skin diseases. All crude extracts were found to be effective against the tested fungi. However chloroform has strong inhibitory activity against fungi as compared to ethanol, methanol, ethylacetate and aqueous extracts. The maximum inhibitory activity of the ethanol extract was observed against *P.variety*, *T. rubrum* and *M. gypseum* 81.82%, 80% and 73.34% respectively, while, it possessed moderate inhibitory activity against *A.flavus* 65.72% and minimum inhibitory activity against *A.niger* 62.5%. The maximum inhibitory activity of the ethyl acetate extract was observed against *T. rubrum, M. gypseum* and *P. varioti* 80%, 73.34 and 63.64% respectively, while it possessed moderate inhibitory activity against *A. flavus* 57.15 and minimum inhibitory activity against *A.niger* 50%. The maximum inhibory activity of the chloroform extract was recorded against *P.varioti T. rubrum* and *M. gypseum* 90.91%, 80% and 73.34% respectively, while it exerted moderate inhibitory activity against *A.flavus* 71.41% and minimum inhibitory activity against *A.niger* 50%. The maximum inhibitory activity of the methanol extract was observed against *P.varioti* and *T.rubrum* 81.82 and 80%, while, it possessed moderate inhibitory activity against *A.niger* and *A.flavus* 62.5% and 57.15% respectively and minimum inhibitory activity against *M.gypseum* 53.34%. The maximum inhibitory activity of the aqueous extract was observed against *P.varioti*, *T.rubrum* and *A.niger* 81.82%, 80% and 75%, while, it exerted moderate inhibitory activity against *M.gypseum* 60% and minimum inhibitory activity against *A. flavus* 57.15% [152].

The fractions derived from hydroalcoholic extract of *Dodonaea viscosa* leaves was evaluated against *Candida albicans* (Cl. I. 4043). With the exception of aqueous fraction, all the fractions exhibited anticandidal activities (zone of inhibition $\geq$ 10 mm). The MIC of n-hexane fraction was 62.5 µg/ml [153].

The *in vitro* antiviral activity of different extracts from *Dodonaea viscosa* leaves was studied against coxackievirus B3 (CVB3) and rotavirus SA-11 (RV SA-11) infections. *Dodonaea viscosa* exhibited ttherapeutic index (TI) ranging from 0.3 to 25 with reduction in virus titer ranging from 0.25 to 5 log10 TCID 50/0.1 ml for CVB3, whereas TI ranging from 0.4 to 29.2 with reduction in virus titre ranging from 0.25 to 5.25 log10 TCID50 for RV SA-11**.** Crude extract provided the potent inhibition of CVB3 and RV SA-11, replication by binding to a viral capsid of CVB3 and viral receptor of RV SA-11 preventing viruses entry into host cells for both viruses [154].

Petroleum ether, chloroform and methanol 80% extracts of *Dodonaea viscosa* aerial parts were tested for their anti-HIV-1 activity using the syncytia formation assay. Petroleum ether extract of *Dodonaea viscosa* was the most active as an anti-HIV-1 agent while other extracts were less effective. The authors concluded that the antiviral effects could be attributed to *β*-sitosterol and stigmasterol identified in the petroleum ether extract of *Dodonaea viscosa* [155].

***Dolichos lablab* (*Syn*: *Lablab purpureus*)**

The antibacterial activity of leaf and flower extracts of *Lablab purpureus* was studied against clinical *Staphylococcus aureus* isolates. Both extracts showed antibacterial activity, but the flower extract showed marked inhibition of *Staphylococcus aureus* isolates [156].

The antimicrobial activity of crude extracts (chloroform, n-hexane, ethyl acetate) of leaves of *Lablab purpureus* L. were studied using disc diffusion technique. Extracts were tested against eleven important pathogenic bacteria including both Gram positive and Gram negative bacteria and three fungi. The tested bacteria were *B. megaterium, B. subtilis, Staphylococcus aureus, Sarcina lutea, Escherichia coli, Salmonella paratyphi, S. typhi, Shigella boydii, S. dysenteriae, Vibrio mimicus* and *V. parahemolyticus*. The extracts showed antimicrobial activity against most of the bacterial strains with an average zone of inhibition of 8-20mm. The tested fungi were *Saccharromyces cerevaceae*, *Candida albicans* and *Aspergillus niger*. The extracts showed moderate to good antifungal activity with an average 9 -15 mm zone of inhibition. Among the three solvent extracts used, the most effective extract was n-hexane extract and maximum activity (20 mm, zone of inhibition) was recorded against *Staphylococcus aureus* with minimum inhibitory concentration (MIC) values of 64µg/ml. The maximum zone of inhibition for chloroform extract was 17mm against *Bacillus subtilis* and *E.coli* with MIC of 128µg/ml and 32µg/ml respectively. The maximum zone of inhibition for ethyl acetate extract was 17mm against *Vibrio mimicus* with MIC values of 64µg/ml [157].

A protein, dolichin isolated from *Dolichos lablab*, exhibited antifungal activity against Fusarium oxysporum, Rhizoctonia solani, and Coprinus comatus [158].

A 36-kDa alpha-amylase inhibitor was isolated from *Lablab purpureus*. It inhibited the alpha-amylases from several fungi but had little effect on those from animal and plant sources. The protein inhibited conidial germination and hyphal growth of A. flavus. It also agglutinated papain-treated red blood cells from human and rabbit [159].

Dolichin, was also capable of inhibiting human immunodeficiency virus (HIV) reverse transcriptase and alpha- and beta-glucosidases which were glycohydrolases implicated in HIV infection. It had very low ribonuclease and cell-free translation-inhibitory activities [158].

Echinochloa crus-galli

The 1% acidified methanol and ethyl acetate extracts of *Echinochloa crus-galli* seeds showed zone of inhibition ranged from 9 mm to 16 mm for all of the bacteria tested (*B. megaterium, S. aureus, E. Coli, P. aeruginos*). Seed extracts of *Echinochloa grus-galli* also showed good impact on both fungal pathogens (*A. Niger* and *F. oxysporum*) with a zone of inhibition ranged between 10 mm and 13 mm. Seed extract of *Echinochloa crus-galli* in water had good impact on *F. oxysporum* with 10 mm disc diffusion. The 95% ethanol and 1% acidified methanol extracts of *Echinochloa crus-galli* showed largest disc diffusion for *F. oxysporum* 12 mm and 13 mm disc diffusion respectively[160].

Echinochloa crus-galli extracts (50,100 and 200 mg/ml) were prepared in six different solvents (water, ethyle Acetate, acetone, 95% ethanol, chloroform and 1% acidified methanol). The antibacterial effects of these extracts were investigated against Gram positive [*Staphylococcus aureus* (MTCC 96) and *Bacillus megaterium* (MTCC-428)] and Gram negative [*Escherichia coli* (MTCC 443) and *Pseudomonas aeruginos* (MTCC1688)] bacteria. All extracts at concentration of 200 mg/ml possessed antibacterial activity against all the tested microorganism [161].

A novel antifungal peptide EcAMP1 was isolated from kernels of *Echinochloa crus-galli*. The peptide adopted a disulfide-stabilized α-helical hairpin structure in aqueous solution, it represented a novel fold among naturally occurring antimicrobial peptides. Micromolar concentrations of EcAMP1 were shown to inhibit growth of several fungal phytopathogens The EC_{50} values were in the range of 1–10 µM. *F. graminearum* and *F. solani* were the most affected species (EC_{50} of ~ 4 µM), whereas *F. oxysporum* appeared to be the least affected. *P. betae* was also highly susceptible to the peptide action (EC_{50} of ~ 6 µM). EcAMP1 also inhibited germination of *A. alternata*, A. *solani*, and *B. sorokiniana* spores and of *P. infestans*, *P. debaryanum*, and *P.*

ultimum zoosporangia with EC_{50} in the range of 10–20μM. The peptide induced morphological changes in some of the affected fungi only at higher concentrations (~ 20 μM). *A. niger*, *C. graminicola*, *D. maydis*, and *T. album* all insensitive to the peptide [162].

Echium italicum

Echium italicum extracts caused a zone of growth inhibition of at least 4 mm against *Pseudomonas solanaciarum* and 1 cm^2 against *Cladosporium cucumerinum*[163].

The antimicrobial activity of *Echium italicum* oil was studied using the disk diffusion method and determination of minimal inhibitory concentration values against *Bacillus subtilis* PTCC 1023, *Staphylococcus aureus* PTCC 1112, *Escherichia coli* PTCC 1330, *Salmonella typhi* PTCC 1639, *Pseudomonas aeruginosa* PTCC 1074, *Aspergilus niger* PTCC 5011 and *Candida albicans* PTCC 5027. *Echium italicum* oil exhibited concentration-dependent antimicrobial activity against all the tested microorganisms [164].

Ephedra alata* and *Ephedra foliate

The antimicrobial activity of different extracts of *Ephedra alata* stem was investigated against bacteria, yeast and fungi. Four bacteria, *Staphylococcus aureus*, *Pseudomonas aeruginosa*, *Bacillus subtilis*, and *Escherichia coli* and four fungi, *Aspergillus fumigatus*, *Penicillium italicum*, *Syncephalastrum racemosum*, and *Candida albicans* were used as test microorganisms. Acetonitrile extracts exhibited the most potent antimicrobial effect with a broad spectral range. Thin layer chromatographic separation of active constituents in acetonitrile extracts revealed the presence of seven fractions. All fractions showed antimicrobial activities with four fractions having a potent inhibitory effect [165].

The antibacterial activity of of flavonoid extracts of *Ephedra alata* was evaluated against Gram positive and Gram negative pathogenic bacteria (*Serratia marcescens* ATCC 13880, *Pseudomonas aeruginosa* ATCC 10145, *Bacillus subtilis* ATCC 6051, *Escherichia coli* ATCC 25922, *Enterococcus faecalis* ATCC 29212, *Staphylococcus aureus* ATCC 25923, *Bacillus cereus* ATCC 11778, *Methicillin -resistant Staphylococcus aureus (MRSA)* ATCC 013300 and *Staphylococcus aureus* ATCC 29213). The results exhibited variable susceptibilities of microorganisms. The activity was associated with high concentration. The extracts of *Ephedra alata* displayed relatively important effects with a variable diameter of growth inhibition zones in most types of bacteria. However no effect was recorded against *Serratia marcescens* ATCC 13880 with butanol extracts of flowers and leaves and ethyl acetate and dichloromethane extracts of leaves. Butanol, ethyl acetate, and dichloromethane extracts of leaves showed no activity against *Enterococcus faecalis* ATCC 29212 [166].

The aqueous extract of *Ephedra alata* had significant inhibitory potential against growth as well as aflatoxin production by aflatoxigenic seedborne mold (*Aspergillus flavus*). Moreover, it has been found that, the addition of 1 and 2% (w/w) of plant powder material of *Ephedra alata* to corn grains and soybean seeds respectively decreased the aflatoxin contamination and improve their nutritional value (total nitrogen content, fiber content, total lipids content and ash content) under storage conditions [167].

The use of *Ephedra alata* extracts significantly decreased the total lipid, sterols, neutral lipids, phospholipids and fatty acid content of *Aspergillus flavus*. These effects could be represented the mechanism of antifungal activities of *E. alata* [168].

Equisetum arvense

The methanolic extract of the aerial parts of *Equisetum arvense* displayed antibacterial activity against *Escherichia coli* at high concentration (1g/ml) [169].

Equisetum arvense extracts showed antimicrobial activity against *Staphylococcus epidermidis* and *Escherichia coli*, but it possessed no effect against Candida albicans. A disk diffusion method was used for the evaluation of the antimicrobial activity of volatile constituents of *Equisetum arvense* against *Staphylococcus aureus*, *Escherichia coli*, *Klebsiella pneumoniae*, *Pseudomonas aeruginosa* and *Salmonella enteritidis*. The antifungal activity of the oil was studied against *Aspergillus niger* and *Candida albicans*. The 1:10 dilution of the essential oil of *Equisetum arvense* possessed a broad spectrum and very strong antimicrobial activity against all the tested bacteria and fungi [170].

The antibacterial activity of ethanolic and aqueous extract of *Equisetum arvense* was screened against selected urinary tract pathogens (*E.coli*, *Klebsiella pneumonia*, *Proteus mirabilis*, *Pseudomonas aeruginosa*, *Staphylococcus aureus*, *Staphylococcus saprophyticus and Enterococcus faecalis*) using disc diffusion technique. Both the extracts at different concentration exhibited antibacterial activity against all the tested bacterial strains. Ethanolic extract exhibited comparably a high degree of activity than the aqueous extract. The ethanolic extract was more effective against *E.coli*, *Proteus mirabilis* and *Staphylococcus saprophyticus* with a zone of inhibition of 24mm, 23mm and 24 mm diameter (at concentration of 1000μg) respectively and was least effective against *Pseudomonas aeruginosa* with zone of inhibition of 11mm (at concentration of 1000μg). Among the other studied bacterial species, *Klebsiella pneumoniae* and *Enterococcus faecalis* showed a zone of inhibition of 18mm diameter (at concentration of 1000μg) and *Staphylococcus aureus* showed inhibition zone of 14mm diameter (at concentration of 1000μg) [171].

The *in vitro* antibacterial activity of ethanol stem extract (50-400µg/ml) of *Equisetum arvense* was studied against two Gram positive (*Bacillus subtilis* and *Micrococcus luteus*) and four Gram negative (*Vibrio cholerae*, *Escherichia coli*, *Shigella flexneri* and *Shigella dysenteriae*) bacteria. Out of six bacterial species (except *Shigella dysenteriae* and *Vibrio cholera*), four were found to be very sensitive to plant extract at all concentrations. The mean zone of inhibition for the extract against Gram positive and Gram negative bacteria increased with the increasing concentration of the extract. The highest mean zone of inhibition (32 mm) was recorded against *Escherichia coli* [172].

The water extract of aerial parts of *Equisetum arvense* possesses inhibitory effect on HIV-1 induced cytopathy [173].

Erigeron canadensis

The antibacterial activity of *Erigeron canadensis* was carried out against eight pathogenic bacteria (*Pseudomonas aeruginosa, Vibrio cholerae, Escherichia coli, Shigella dysenteriae, Shigella flexneri, Bacillus subtilis, Micrococcus luteus,* and *Staphylococcus aureus*). The ethanolic floral extract showed highest inhibition zone (17 mm) against *P. aeruginosa* and minimal inhibition zone against *B. subtilis* (5 mm). The methanolic extract of flower showed highest inhibition zone against *E. coli*, with lowest zone against *M. luteus.* No inhibition zone was noted by the ethanolic and methanolic stem extract of the plant [174].

The whole plant was extracted with 80% ethanol and the extract was suspended in water and fractionated with n-hexane, chloroform and ethyl acetate. Two isolated compounds (conyzolide and conyzoflavone) were studied for antifungal and antibacterial effects, against six fungal and five bacterial strains. Bacterial strains were *E. coli* ATCC 25922, *B. subtilis* ATCC 6633, *S. flexeneri* (clinical isolate), *S. aureus* ATCC 25923, *P. aeruginosa* ATCC 27853 and *S. typhi* ATCC 19430. Fungal strains included *T. longifusus* (clinical isolate), *C. albicans* ATCC 2091, *A. flavus* ATCC 32611, *F. solani* 11712 *and C. glaberata* ATCC 90030. The isolated compounds exhibited substantial antibacterial activities. Conyzolide showed comparatively better and significant antibacterial activities against *E. coli* (MIC: 25 µg/ml). It also revealed considerable activities against *S. aureus* (MIC: 50 µg/ml) *P. aeruginosa* (MIC:100 µg/ml) and *S. typhi* (MIC: 100 µg/ml). However, Conyzoflavone showed significant activity against S.*typhi* (MIC: 50µg/ml) in addition to its weak to moderate activity against all the tested pathogens. Similarly, both compounds exhibited significant antifungal activities against the tested fungi. Conyzoflavone also possessed antifungal activity, *T. longifusus* and *C. albicans* were the most susceptible fungal pathogens to conyzoflavone. On the other hand, conyzolide showed comparatively weak antifungal activity [175].

The crude methanolic extract of the plant and its various solvent fractions were evaluated for antibacterial effects (against *E. coli, P. aureginosa, Klebsella, S. aureus* and *Bacillus*) and antifungal effects (against *C. albicans, A. niger, M. canis, F. solani* and *C. glabarata*). The result showed that the tested samples were only effective against *E.coli, P. aureginosa, S. aureus*, while the remaining bacteria showed 100 % resistance. The methanolic extract, chloroform and ethyl acetate fraction demonstrated maximum activity with zone of inhibition 14, 12 and13 mm respectively while, the *n*-hexane fraction was devoid of antibacterial effect at low dose and exhibited low activity at high dose against *E. coli, P. aureginos and S. aureus* with zone of inhibition 10, 11 and 9 mm respectively. The maximum fungicidal effect against *C. albicans* was produced by ethyl acetate extract followed by chloroform and methanol extracts with percent inhibitory activity 45, 40 and 35 respectively. The ethyl acetate and chloroform fractions were the most effective against *A. niger* with percent inhibitory activity of 40 and 35% followed by methanolic extract and *n*-hexane with percent inhibitory effect of 30 and 25%. The maximum phytotoxic effect was produced by chloroform fraction followed by ethyl acetate (80 and 77%) [176].

The bacteriostatic and fungistatic activities of the oil of *Erigeron canadensis* were investigated by agar-diffusion method, against *Enterococcus faecalis* (ATCC29212), *Staphylococcus aureus* (ATCC25923) and *Streptococcus pyogenes* (HNCMB80002) as Gram-positive bacteria and *Escherichia coli* (ATCC25922), *Pseudomonas aeruginosa* (ATCC27853) as Gram-negative bacteria. Antifungal activity was evaluated against *Candida albicans* (UK-NEQUAS4661), *Candida glabrata* (ATCC90030), *Candida parapsilosis* (ATCC22019), *Candida tropicalis* (UK-NEQUAS4893), *Cryptococcus neoformans* (INF5855) reference fungal strains, and Candida kefyr, *Rhodotorula glutinis, Trichophyton interdigitalis* and *Aspergillus fumigatus* fungal strains isolated from patients. None of the oils showed any activity against the tested bacterial strains, but exhibited moderate-to-strong activity against all fungi with the only exception of *A. fumigatus*. The MIC values varied from 1.25 µg/ml to 20.00 µg/ml for the tested fungal strains. The highest antifungal potency was exhibited by herb and root oils against *Cryptococcus neoformans* with MIC value of 1.25 µg/ml. In addition, substantial efficacy (MIC = 2.50 µg/ml) was detected against other Candida strains (*C. glabrata, C. tropicalis*) and *Rhodotorula glutinis* [177].

Essential oil of *Erigeron canadensis* at a concentration of 1600 ppm possessed 22.35±3.63, 12.71±1.28 and 29.27±1.22% inhibition of fungal growth of *R. solani, F. solani* and *C. lindemuthianum* respectively [178].

The methanol extract of aerial parts of *Erigeron canadensis* was extracted with four organic solvents (petroleum ether, chloroform, ethyl acetate and butanol) and investigated for antivirus activity against human cytomegalovirus (HCMV) AD-169
and Cox-B3 viruses by modified shell-vial assay. The results showed that chloroform, ethyl acetate, butanol and methanol extracts possessed antiviral activity, however, butanol extract antiviral activity was 95.75 and 90.10 % for 200 and 100 µg/ml of the extract respectively and methanol extract antiviral activity was 100 and 99.10% for 200 and 100 µg/ml of the extract respectively [179].

Erodium cicutarium

The essential oils of *Erodium cicutarium* were tested against Gram positive *Staphylococcus aureus* (ATCC 27853), *Staphylococcus aureus* (clinical isolate), *Clostridium perfringens* (ATCC 19404), *Bacillus subtilis* (ATCC 6633), Gram negative *Escherichia coli* (ATCC 25922), *Escherichia coli* (clinical isolate), *Klebsiella pneumoniae* (clinical isolate), *Pseudomonas aeruginosa* (ATCC 25923), and yeast *Candida albicans* (ATCC 10231). MIC of *Erodium cicutarium* against *P. aeruginosa* was 0.312 mg/ml, Escherichia coli (ATCC 25922) 0.625 mg/ml, *Escherichia coli* (clinical isolate) 2.5 mg/ml, *K. pneumoniae* 1.25 mg/ml, *Staphylococcus aureus* (ATCC 27853) 0.312 mg/ml, *Staphylococcus aureus* (clinical isolate) 2.5 mg/ml, *C. perfringens* 0.312 mg/ml, *B. subtilis* 0.625 mg/ml, *P. chrysogenum* 0.156 mg/ml, *A. restrictus* 0.078 mg/ml, *A. chrysogenum* 0.156 mg/ml, *A. fumigatus* 0.156 mg/ml, and *C. albicans* 0.325 mg/ml [180].

Extracts from *Erodium cicutarium* were tested for antiviral and interferon inducing properties. Both water extract and methanol extract as well as its fractions exerted antiviral effect in relation to myxoviruses, herpes virus type 1, vesicular stomatitis and vaccinia virus. None of these extracts did induce interferon in a suspension of human leukocytes [181].

Eryngium creticum

The antibacterial activity of the Aqueous and ethanolic extracts of *Eryngium creticum* leaves and stems was studied against three Gram positive bacteria (*Staphylococcus epidermidis* CIP 444, *Staphylococcus aureus* ATCC 25923, and *Enterococcus faecalis* ATCC 29212) and two Gram negative strains (*Escherichia coli* ATCC 35218 and *Pseudomonas aeruginosa* ATCC 27853). Aqueous extracts from *Eryngium creticum* showed stronger antibacterial activity than the ethanolic extracts against both Gram positive and Gram negative strains. Among these strains, Gram positive ones were more sensitive, with *Staphylococcus epidermidis* being the most inhibited with MIC=MBC=5 mg/ml for the leaves aqueous extract, in particular in the first harvest period. During the second period, however, the activity decreases, to show equal concentrations (MIC = MBC = 27.9 mg/ml). Whereas the stem aqueous extract, during the first harvest period, exhibited a considerable activity with MIC=26 mg/ml and MBC=53 mg/ml [182].

The antibacterial activity of *Eryngium creticum* was tested against *Staphylococcus aureus, Escherichia coli, Klebsiella pneumoniae, Proteus vulgaris* and *Pseudomonas aeruginosa* using disc diffusion method. The aqueous was more effective against *K. pneumoniae* than the ethanolic extract, while the ethanolic extract was more effective against *P. vulgaris*. However, against *S. aureus, E. coli* and *P. aeruginosa*, there were no differences between the effect of the aqueous and ethanolic extracts [183].

The essential oils of *Eryngium creticum* were tested for their inhibitory activity against nine different methicillin-resistant *Staphylococcus aureus* (MRSA) strains by agar disc diffusion method. Three strains showed zone of inhibition 9-11mm, four strains 5-7mm and 2 strains resisted *Eryngium creticum* essential oils [184].

The antifungal effect *Eryngium creticum* aqueous extracts (15 micrograms/ml medium) was investigated against *M. canis, T. mentagrophytes* and *T. violaceum*. The percentage of mycelial inhibition was 12.4±4.26, 56.6±7.41 and 38.8±7.98% for the three fungi, respectively [185].

***Eucalyptus* species**

The antibacterial effect of Eucalyptus oil was investigated against *Klebsiella spp., Proteus spp., Pseudomonas spp., Escherichia coli,* and *Staphylococcus aureus.* The results showed that, *Escherichia coli* and *Klebsiella spp*. were sensitive to 5 µl, *Staphylococcus aureus* to 25 µl, while *Pseudomonas* and *Proteus spp*. required 50 µl of Eucalyptus oil. With an increasing dose of oil of Eucalyptus, the resulting diameter of the zone of inhibition increased for all the organisms [186].

The *in vitro* antimicrobial activity of the essential oil and methanol extracts of *Eucalyptus largiflorens* (*Eucalyptus bicolor*) was studied against *Aspergillus niger* ATCC 16404, *Candida albicans* ATCC 10231, *Pseudomonas aeruginosa* ATCC 27853, *Bacillus subtilis* ATCC 6633, *Staphylococcus aureus* ATCC 29737, *Escherichia coli* ATCC 10536, *Klebsiella pneumoniae* ATCC 10031, *Staphylococcus epidermidis* ATCC 12228, *Shigella dysenteriae* PTCC 1188, *Proteus vulgaris* PTCC 1182 and *Salmonella paratyphi*-A serotype ATCC 5702. The essential oil of *Eucalyptus largiflorens* exhibited moderate to high antimicrobial activity against all the bacteria, yeast and mold tested, except three microorganisms, *Pseudomonas aeruginosa*, *Escherichia coli* and *Shigella dysenteriae*. The evaluation of methanol fraction indicated that polar fraction

showed strong activity against 7 out of 11 microorganisms while non-polar fractions did not posses any inhibitory action against the strains evaluated except *Escherichia coli* [187].

The antimicrobial properties of essential oil, its major component, 1,8-cineole, and extracts of *Eucalyptus largiflorens* (*Eucalyptus bicolor*) were evaluated *in vitro*. Minimum inhibitory concentration of the extracts was calculated by broth dilution method and the zone of inhibition was studied by agar disk diffusion method. Gentamicin (10 µg/disk) and rifampin (5 µg/disk) were used as reference controls for antibacterial, and nystatin (100 µg/disk) for antifungal tests. The results of MIC study revealed that the essential oil has a stronger activity and broader spectrum than those of methanol extracts. The oil also had greater antimicrobial potential than 1,8-cineole [188].

Disk diffusion method was used to determine the antimicrobial activity of aqueous extract and essential oils of *Eucalyptus incrassata* leaves against eight isolates of multidrug- resistant *Staphylococcus aureus*. It was found that aqueous extract and essential oils possessed variable antimicrobial activity (the inhibition zone diameter ranged from 7 to 14 mm respectively). Essential oils showed more antibacterial effect than aqueous extract [189] .

The *in vitro* antimicrobial activity of acetone, methanol and water extracts of leaf, stem and bark of *Eucalyptus camaldulensis* was studied against six bacterial species *Bacillus megaterium, Bacillus subtilis, Staphylococcus epidermidis Staphylococcus aureus, Micrococcus luteus* and *E. coli* using the agar well diffusion method. The results showed that the extracts exhibited a dose-dependent inhibition of microorganisms. The acetone and methanol extracts of leaf and stem bark of *Eucalyptus camaldulensis* displayed maximum antibacterial activity against all the bacterial species. There was no significant difference in the antimicrobial activity of the extracts on Gram negative and Gram positive bacteria [190].

The antibacterial activity of the crude leaf extracts of *Eucalyptus camaldulensis* were studied against clinical isolates of *Escherichia coli, Staphylococcus aureus, Salmonella typhi, Proteus mirabilis* and *Klebsiella pneumoniae.* The growth of all the pathogenic bacteria was arrested at 50 mg/ml concentration of extracts. The least activity was possessed by aqueous extract against *E. coli* (7 mm), *K. pneumoniae* (9 mm), *P. mirabilis* (13 mm), *S. typhi* (12 mm) and *S. aureus* (12 mm), while the highest was recorded for the acetone extract, with a diameter of inhibition for *E. coli (*12 mm), *K. pneumonia* (13 mm), *S. typhyi* (14 mm), *P. mirabilis* (15 mm) and *S. aureus* (14 mm) [191].

The antibacterial activities of *Eucalyptus camaldulensis, Eucalyptus camaldulensis* var. obtusa and *Eucalyptus gomphocephala* essential oils were studied using agar disc diffusion and minimum inhibitory concentration methods. The essential oils from the leaves of Eucalyptus spp. exhibited considerable antibacterial activity against Gram positive and Gram negative bacteria [192].

The antimicrobial and biofilm preventing activities of the oils of *Eucalyptus camaldulensis* were studied *in vitro* and *in vivo*. Minimal bactericidal concentrations (MBC) of the *Eucalyptus camaldulensis* oils were found to be 4 and 2 mg /ml, and those of chlorhexidine (2%) were 8 and 1 mg/ml for both *S. mutans* and *S. pyogenes* respectively. Decimal reduction time of *S. mutans* by *Eucalyptus camaldulensis* oils at their MBC levels was 2.8 min, while that of cholrhexidine was 12.8 min. D-value of *S. pyogenes* exposed to the MBC levels of *Eucalyptus camaldulensis* oils and of chlorhexidine were 3.6 and 2.8 min respectively. Antibacterial and *in vivo* biofilm preventive efficacies of all the concentrations of Eucalyptus oil were significantly ($P < 0.001$) higher than that of chlorhexidine [193].

The antimicrobial potential of two *Eucalyptus camaldulensis* essential oils was investigated against multi-drug resistant (MDR*) Acinetobacter baumannii* wound isolates, the possible interactions of essential oils with conventional antimicrobial agents was also studied. MIC values of essential oils against *Acinetobacter baumannii* strains were estimated by modified broth microdilution method. The components responsible for antimicrobial activity were detected by bioautographic analysis. The potential synergy between the essential oils and antibiotics (ciprofloxacin, gentamicin and polymyxin B) was examined by checkerboard method and time kill curve. The bioautographic assay confirmed antibacterial activity of polar terpene compounds. In combination with conventional antibiotics (ciprofloxacin, gentamicin and polymyxin B), the examined essential oils showed synergistic antibacterial effect. The synergistic interaction was confirmed by time-kill curves for *Eucalyptus camaldulensis* essential oil and polymyxin B combination which reduced bacterial count under detection limit very fast, after 6h of incubation [194].

The *in vitro* antimicrobial activities of the crude oil of *Eucalyptus camaldulensis* leave was investigated against *Escherichia coli* and *Staphylococcus aureus*. The diameter of zones of inhibition by the crude oil of leaf extracts of *Eucalyptus camaldulensis* was 10- 31mm and 10-26mm for *Escherichia coli* and *Staphylococcus aureus*. Gram positive, *Staphylococcus aureus* was more resistant than Gram negative, *Escherichia coli* [195].

The in vitro anti- *Helicobacter pylori* of *Eucalyptus camaldulensis* was investigated in six strains of *H. pylori* (ATCC 4504, ATCC 47619, A2, TI8984, 019A, and A6). The minimum inhibitory concentrations of the crude extracts against all the tested strains ranged from 12.5 to 400 mug/ml [196].

Hexane, chloroform, methanol extracts, and isolated compounds of *Eucalyptus camaldulensis* were screened for activity against *Mycobacterium tuberculosis* H37Rv (MtbH37Rv). The extracts inhibited the growth of *Mycobacterium tuberculosis* with MIC of 4-64 µg/ml. Spectroscopic characterization led to the identification of two compounds, hydroxymyristic acid methylester and a substituted pyrenyl ester, a sterol. These two compounds had MIC of 49.45 and 46.99 µg/ml; IC_{50} >100 and 38.21 µg/ml; selectivity index (SI) >2.02 and 0.81, respectively, and a minimum bactericidal concentration of 62.50 µg/ml [197].

Essential oil of the leaves of *Eucalyptus camaldulensis* possessed high antibacterial effects against Gram positive and negative bacteria with inhibition zones ranged from 9.3 to 12.5 Mm. The same effect was observed against yeast (21% inhibition) and fungi (10% inhibition) [198].

The antibacterial effect of essential oil of *Eucalyptus camaldulensis* was evaluated against *L. monocytogenes, S. aureus, E. coli, K. pneumoniae, S. cerevisiae, C. albicans, M. ramamnianus and A. ochraceus*. Essential oil of *Eucalyptus camaldulensis* showed activity against *S. aureus* (21mm), *B. subtilis* (24mm) and *E. coli* (10mm). Significant anti fungal activity was also shown by essential oil of *Eucalyptus camaldulensis* against *A. niger* (28mm) and *R. solani* (12mm) [199].

Methanolic leaf extracts of *Eucalyptus camaldulensis* were investigated for *in vitro* antifungal activities against *Microsporum canis, Microsporum gypseum, Tricophyton rubrum, Tricophyton schoenleinii, Tricophyton mentagrophytes* and *Epedermophyton floccosum*. *Eucalyptus camaldulensis* showed antifungal activity against all the tested dermatophytes with MIC values ranging from 0.4 to 1.6 mg/ml [200].

The essential oils of *Eucalyptus camaldulensis* were screened for their antifungal activities against common phytopathogenic fungi using the paper disk diffusion method, they showed activity at low doses against the tested fungi [201].

The antiviral effect of the leaf essential oil of *Eucalyptus camaldulensis* was studied against many viruses. Rotavirus Wa strain, Coxsackievirus B4, and herpes virus type 1 were affected by essential oil with percentage of reduction 50%, 53.3%, and 90% respectively, but no effect was found against adenovirus type 7[198].

The methanolic extracts of *Eucalyptus camaldulensis* was tested against human enteroviruses: Poliovirus type I, Coxsackievirus B and Echovirus 6. The virucidal tests showed that the crude extracts were active against the tested viruses. Poliovirus type 1, coxsackievirus B and echovirus 6 giving a neutralization index of one log and above [202].

The aqueous, ethanolic, chloroform and acetone extracts of *Eucalyptus microtheca* showed inhibitory effects against *Staphylococcus aureus* while benzene extract was not effective. The aqueous, ethanolic and acetone extracts also possessed inhibitory effects against *S. typhimurium*. The extracts also showed synergistic inhibitory activity when combined with antibiotics against both *Staph. aureus* but not against *S. typhimurium* [203].

The antibacterial activity of *Eucalyptus microtheca* leaves crude (ethanolic, methanolic and aqueous) extracts were tested against *Pseudomonas aeruginosa* isolates. All crude extracts exhibited an *in vitro* antibacterial activity against all *Pseudomonas aeruginosa* isolates with a zone of inhibition ranged between 17-25mm for methanolic extract, 20-29mm for ethanolic extract at a concentration of 1 mg/ml, while the zone of inhibition for aqueous extract was 12-16mm [204].

The antibacterial activity, MIC, and MBC of alcoholic extracts of *Eucalyptus microtheca* were studied against *Bacillus cereus, Staphylococcus aureus, Salmonella typhi, Escherichia coli, Pseudomonas aeruginosa, Klebsiella pneumonia,* and *Proteus mirabilis* using standard disk diffusion method. The structural changes following the exposure to these extracts were also investigated in the tested bacteria. Significant antibacterial activity was found against Gram positive and Gram negative bacteria, among them, *Escherichia. Coli* and *Pseudomonas. aeruginosa* showed the most sensitivity and *Staphylococcus aureus* the least. The value of MIC and MBC for both extracts were 8 mg/ml for *E. coli,* 8 and 16 mg/ml for *Bacillus cereus,* respectively. MIC and MBC values of methanolic and ethanolic extracts against *P. aeruginosa* were 8 and 16 mg/ml respectively. Scanning electron microscopy revealed structural changes in the affected bacteria, which suggested that the cell wall was the main target site of active constituents [205].

The antibacterial effect of essential oil of *Eucalyptus microtheca* was evaluated against *L. monocytogenes, S. aureus, E. coli, K. pneumoniae, S. cerevisiae, C. albicans, M. ramamnianus* and *A. ochraceus*. Essential oil of *Eucalyptus microtheca* showed activity against *S. aureus* (16mm), *B. subtilis* (20mm) and *E. coli* (11mm). Significant antifungal activity was shown by essential oil of *Eucalyptus microtheca* against *A. niger* (21mm) and *R. solani* (17mm) [199].

The antifungal activity of the *Eucalyptus microtheca* leaves crude aqueous, ethanolic and methanolic extracts were tested *in vitro* by agar well diffusion method against *Penicillium digitatum* and *Aspergillus niger*. Alcoholic extracts significantly inhibited the mycelial growth of *P. digitatum* and *A. niger* more than aqueous extracts. Methanolic extracts showed higher inhibition activity than ethanolic extracts [206].

The antimicrobial properties of aqueous and alcoholic extracts of Eucalyptus leaves was investigated against the most cariogenic bacteria in mouth (Mutans streptococci and Lactobacilli) and against *Candida albicans*. There was statistically highly significant difference (P< 0.001) between different concentrations of the aqueous and alcoholic extracts on the sensitivity of the isolates, whilst the alcoholic extract was more effective than aqueous extract just at low concentrations. At 100 and 150 mg/ml the alcoholic and the aqueous extracts showed more potent effect than 2mg/ml chlorhexidine against Mutans streptococci and *Candida albicans*. Minimum bactericidal concentration for the aqueous extract was 5-8mg/ml, 6-10mg/ml and 3-7mg/ml against Mutans streptococci, Lactobacilli and *Candida albicans* respectively while that of alcoholic extract was 4-8mg/ml, 6-10mg/ml and 2-6mg/ml against the same microorganisms respectively [207].

The effect of chewing gum containing Eucalyptus extract on periodontal health was investigated in a double-masked, randomized, controlled trial. Healthy humans with gingivitis but not deep periodontal pockets were randomly assigned to the following groups: high-concentration group (n=32): use of 0.6% Eucalyptus extract chewing gum for 12 weeks (90 mg/day); low-concentration group (n=32): use of 0.4% Eucalyptus extract chewing gum for 12 weeks (60 mg/day); and placebo group (n=33): use of chewing gum without Eucalyptus extract for the same period. Plaque accumulation (PLA), gingival index (GI), bleeding on probing (BOP), periodontal probing depth (PD), and clinical attachment level (CAL) were measured at weeks 0, 4, 8, 12, and 14. The interaction between the effects of Eucalyptus extract chewing gum and the intake period was statistically significant for PLA, GI, BOP, and PD, but not for CAL. The low- and high-concentration groups exhibited statistically significant (P< 0.05) improvements compared to the placebo group for PLA, GI, BOP, and PD [208].

Eupatorium cannabium

The antibacterial effect of the essential oil of the aerial parts of *Eupatorium cannabinum* was studied against Gram positive (*Staphylococcus aureus*, *Streptococcus faecalis*, *Bacillus subtilis* and *Bacillus cereus*) and Gram negative (*Pseudomonas aeruginosa*, *Proteus mirabilis*, *Escherichia coli* and *Salmonella typhi* Ty2) bacteria. The results showed a significant antimicrobial activity against all the tested microorganisms, mostly against Gram positive bacteria, particularly *Streptococcus faecalis*, while, *Pseudomonas aeruginosa* showed the highest resistance to the oil [209].

Different extracts of *Eupatorium cannabium* (chloroformic, water and hydroalcoholic extract) were tested for their antimicrobial activity against Gram positive bacteria (*Bacillus cereus*, *Staphylococcus aureus* and *Enterococcus faecalis*), Gram negative test bacteria (*Escherichia coli*) and fungi (*Candida albicans* and *Aspergillus niger*). The chloroformic and hydroalcoholic extracts of the Eupatorium cannabium showed inhibitory activity against *Escherichia coli* and *Bacillus cereus* only, as well as on the dimorphic yeast *Candida albicans*. No clear inhibition have been noticed against *Staphylococcus aureus, Enterococcus faecalis* and *Aspergillus niger*[210].

The essential oil of *Eupatorium cannabinum* possessed fungicidal action against *Aspergillus niger*, and fungistatic effect against *Trichoderma lignorum* and *Fusarium oxysporum* [211].

Euphorbia hirta

The antimicrobial analysis of the leaf extract of *Euphorbia hirta* inhibited the growth of *P. aeruginosa, S. aureus, C. albicans* and *T. mentagrophytes* with activity index of 0.2, 0.3, 0.4 and 0.2 respectively [212].

The antibacterial effect of methanol, ethyl acetate, acetone and hot water extracts (0.02-1.66 mg/ml) of *Euphorbia hirta* was evaluated against multidrug- resistant (MDR) patogenes. All leaves extracts were active against the tested microorganisms, but, the best antibacterial effects were exerted by methanolic extract of the leaves against *P.aeruginosa*, *S.aureus* and *E.coli* (diameter of inhibition 22, 23 and 25 mm) respectively [213].

The ethanol extract of the leaves of *Euphorbia hirta* was studied for its antimicrobial activity by agar well diffusion method against: *Staphylococcus aureus* (MTCC 2940), *Bacillus ceresus*, *Salmonella typhi* (MTCC 733), *Klebsiella pneumoniae* (MTCC139), *Pseudomonas aeuroginosa* (MTCC 741), *Aspergillus niger* (MTCC 277), *Aspergillus fumigatus* (MTCC 343), *Aspergillus flavus* (MTCC 418) and *Rhizopus oryzae* (MTCC 262). The ethanol extract of the leaves of *Euphorbia hirta* showed significant antimicrobial effects [214].

The agar well diffusion method was used to determine the antimicrobial activity of *Euphorbia hirta* against *Escherichia coli, Klebsiella pneumoniae. Shigella dysentriae, Salmonella typhi* and *Proteus mirabilis,* a group of Gram negative bacteria that frequently cause enteric infections in humans. The minimum inhibitory concentration and minimum bactericidal concentration values ranged from 25 to 100 mg/ml. The growth of all the bacteria were inhibited to varying degrees [215].

The antibacterial and antifungal activity of aqueous and organic solvent (acetone, chloroform, benzene, butanol, ethanol, dimethylformamide and diethyl ether) leaf extracts of *Euphorbia hirta* were studied against bacterial species (*Pseudomonas putida, Pseudomonas aeruginosa, Klebsiella pneumoniae, Aeromonas liquefaciens* and *lcaligenes* spp.) and fungal species (*Aspergillus niger, Aspergillus flavus, Aspergillus fumigatus, Aspergillus*

erythrocephalus and *Fusarium* spp.). All extracts showed antibacterial activity against the tested bacteria except water and butanol extracts showed no activity against *Klebsiella pneumonia* and *Aeromonas liquefaciens*. However ethanol extracts showed the highest activity (14,12,12, 14mm) against *Pseudomonas putida, Pseudomonas aeruginosa, Klebsiella pneumoniae, Aeromonas liquefaciens* respectively. On the other hand, dimethyl formamide extract showed the highest activity against *Aspergillus niger* (10mm), butanol extract showed the highest activity against *Aspergillus flavus*(12mm), ethanol extract showed the highest activity against *Aspergillus fumigates* (13mm) and benzene extract showed the highest activity against *Aspergillus erythrocephalus* (16mm) [216].

The antimicrobial activities of the methanolic extracts of *Euphorbia hirta* leaves, flowers, stems and roots were evaluated against four Gram positive (*Staphylococcus aureus, Micrococcus* sp., *Bacillus subtilis* and *Bacillus thuringensis*), four Gram negative (*Escherichia coli, Klebsiella pneumonia, Salmonella typhi* and *P. mirabilis*) and one yeast (*Candida albicans*). Leaves extract inhibited the growth of all tested microorganisms with larger zones of inhibition (18-28mm), followed by that of flowers (9-28 mm), which also inhibited all the bacteria except *C. albicans*. The most susceptible microbes to all extracts were *S. aureus* and *Micrococcus* sp. Root extract displayed larger inhibition zones against Gram positive bacteria than Gram negative bacteria and had larger inhibition zones compared to stem extract. The lowest MIC values were obtained against *E. coli* and *C. albicans* (3.12 mg/ml), followed by *S. aureus* (12.50 mg/ml) and *P. mirabilis* (50.00 mg/ml). All the other bacteria had MIC values of 100.00 mg/ml. Scanning electron microscopic studies revealed that the cells exposed to leaf extract displayed a rough surface with multiple blends and invaginations which increased with increasing time of treatment. Cells exposed to leaf extract for 36 h showed sever damage, with abundant surface cracks which may be related to final cell collapse and loss of function [217].

The *Euphorbia hirta* methanol extract showed a potent antimicrobial (MIC 0.250 mg/ml against *Escherichia coli* and *Klebsiella pneumonia* [218].

The antibacterial activity of the ethanol and petroleum ether extracts of *Euphorbia hirta* was investigated against *Staphylococcus aureus, Salmonella typhi, Pseudomonas aureginosa, Vibrio cholera* and *Escherichia col*. Different concentrations of crude drugs (25µg/ml, 50µg/ml, 75µg/ml, and 100µg/ml) were tested. The result showed that ethanol and petroleum ether extracts of leaf, stem, root and bud were active against the tested bacteria. However, ethanol extracts of *Euphorbia hirta* have potentially deleterious effects on microorganisms [219].

The antibacterial effects of *Euphorbia hirta* leaves extracts (methanol, n-hexane and ethyl acetate) were studied against *Bacillus subtilis, Staphylococcus aureus*, *Escherichia coli*, *Vibrio cholerae,* and *Enterococcus faecalis* at 100µg/ml concentration. Among the three solvent extracts, methanol extract of *Euphorbia hirta* showed 10-15 mm inhibition against *B. subtilis*, *E. coli*, and *V. cholerae* whereas no activity was observed against *S. aureus* and *E. faecalis* at 100µg/ml. The ethyl acetate extract showed activity only against. *B.subtilis* (12mm) and *E. faecalis* (10mm), while n- hexane extract showed no activity. Antimycobacterial activity of different solvent extracts of *Euphorbia hirta* was also tested against *M. tuberculosis* H37Rv at 250 and 500 µg/ml concentrations by adopting relative light unit (LRP) assay. The ethyl acetate extracts at concentration of 500 µg/ml showed maximum reduction in RLU (about 64.73%) compared to methanol and n-hexane extracts [220].

The antimicrobial activity of supercritical fluid crude extracts of the leaves of *Euphorbia hirta* was studied against four bacteria: *Staphylococcus aureus, Bacillus subtilis, Escherichia coli, Pseudomonas aeruginosa,* and two fungi: *Aspergillus niger* and *Candida albicans*. *Euphorbia hirta* extract showed antibacterial and antifungal activities, the diameters of zone of growth inhibition were *B. subtilis* 9.58, *S. aureus* 9.67, *E. coli* 9.17, *P. aeruginosa* 9.00, *A. niger* 7.75 and *C. albicans* 9.25 mm [221].

The ethyl acetate extract of the inflorescence of *Euphorbia hirta* was tested for antifungal activity against *Aspergillus flavus,* it exhibited antifungal effects mediated by damaging of the cell membrane which could result in leakage of cellular proteins [222].

Euphorbia hirta extracts (hexane, dichloromethane, ethyl acetate and methanol), were investigated for its potential antibacterial activity towards Gram negative bacteria, *Ralstonia solanacearum* and *Xanthomonas axonopodis* pv vesicatoria. *R. solanacearum* and *X. axonopodis* were known to cause bacterial wilt and bacterial spot disease in tomato crop (*Solanum lycopersicum*). Among the four extracts, *Euphorbia hirta* methanol extract at 1280 mg/l concentration showed 90% inhibition (IC_{90}) of *R. solanacearum* and *X. axonopodis* growth. *Euphorbia hirta* methanol extract at 40 mg/l and 640 mg/l showed 50% inhibition (IC_{50}) of *R. solanacearum* and *X. axonopodis* growth respectively [223].

The antiretroviral activities of extracts of *Euphorbia hirta* were investigated *in vitro* on the MT4 human T lymphocyte cell line. The cytotoxicities of the extracts were tested by MTT cell proliferation assay, and then the direct effects of the aqueous extract on HIV-1, HIV-2 and SIV(mac251) reverse transcriptase activity were also determined. A dose-dependent inhibition of reverse transcriptase activity was observed for all three viruses. The 50% methanolic extract was found to exert a higher antiretroviral effect than that of the

aqueous extract. The 50% methanolic extract was subjected to liquid-liquid partition with dichloromethane, ethyl acetate and water. Only the remaining aqueous phase exhibited significant antiviral activity and after removal of the tannins from the aqueous extract, the viral replication inhibitory effect was markedly decreased, therefore the authors concluded that tannins were most probably responsible for the high antiretroviral activity [224].

The effect of herbal water of *Euphorbia hirta* on flu like symptoms and blood biochemical parameters especially thrombocytopenia was studied in patients with Dengue fever. Blood samples were collected on the day of enrollment and subsequently after *Euphorbia hirta* therapy. Before the treatment, platelet count in male patients was < 25000, and in females >50000. Hematocrit values) were >40% in males and less than 30-40% in females. Total leukocyte count (TLC) was observed in a range of 4000-11000/mm^3 in both male and female subjects. IgM haemagglutination antibody titer values greater than 1:160 were observed in 71% females and 50% males. AST level was found to be >40 IU/L in 38% female and 36% males while ALT level was >40 IU/L in 9% females and 12% males. Platelet count and TLC were increased non significantly after treatment, while HCT value was non significantly decreased after herbal use. Over 70% patients had slight recovery of platelet count and increased retrieval of leukopenia after herbal therapy along with recovery from fever and flu like symptoms [225].

***Euphorbia tinctoria* (syn: *Euphorbia macroclada*)**

The antibacterial and antifungal effects of *Euphorbia macroclada* methanol extracts of the flowering branches was studied against 6 bacteria (*Staphylococcus aureus* COWAN 1, *Bacillus megaterium* DSM 32, *Proteus vulgaris* FMC 1, *Klebsiella pneumoniae* FMC 66032, *Escherichia coli* ATCC 25922, *Pseudomonas aeruginosa* DMS 50071 SCOTTA), 3 yeasts (*Candida albicans* FMC 17, *Candida glabrata* ATCC 66032, *Candida tropicalis* ATCC 13803), and 2 dermatophyte species (*Trichophyton* sp., *Epidermophyton* sp.). Inhibition zone diameter (mm) of *Euphorbia macroclada* methanolic extracts of the flowering branches were: *Staphylococcus aureus*: 11±0.88, *Bacillus megaterium* :13±0.57, *Proteus vulgaris*: 11±0.57, *Klebsiella pneumoniae* : 9±0.33, *Escherichia coli*: 8.33±0.33, *Pseudomonas aeruginosa*: 13±0.57, *Candida albicans* : 12±0.33, *Candida glabrata* : 11±0.57, *Candida tropicalis* : 13±0.33, *Trichophyton sp*: 23±0.57, *Epidermophyton sp*.: 23±0.57 mm. The inhibition zone diameter (mm) for *Euphorbia macroclada* latex (500µg/disc) were *S. aureus:* 10±1.15, *B. megaterium:* 8.33±0.33, *P. vulgaris:* 9±0.57, *K. pneumonia:* 23±1.15, *E. coli:* 8.33±0.33, *P. aeruginosa:* 9±0.57, *C. albicans:* 21±1.15, *C. glabrata:* 15±1.15, *C. tropicalis:* 15±1.15, *Trichophyton* sp.: 15±1.15 and *Epidermophyton* sp.: 8±0.33. The MIC values of *Euphorbia macroclada* methanolic extract of the flowering branches were: *S. aureus*: 50, B *megaterium*: 25, *P. vulgaris*: 50, *K. pneumonia*: 100, *E. coli: 25*, *P. eruginosa*: 100, *C.albicans*: 2.5, *C. glabrata*: 50, *C. tropicalis* 100, *Trichophyton sp.*: 50 and *Epidermophyton sp.*: 50 µg[23]. The percent of growth of resistant *Escherichia coli* when *Euphorbia macroclada* latex combined with antibiotics was, 80.8±6.4 when combined with chloramphenicol, 90.1 ±8.4%, with neomycin, 45.7±5.9% with doxycycline, 80.5±8.1% with clarithromycin, 72.5±7.6% with cephalexin and 99.7± 8.1% with nalidixic acid compared with blank (100%) [226].

The antifungal activities of *Euphorbia macroclada* latex and fluconazole were studied against 150 *Candida* species including *C. albicans*, *C. glabrata*, *C. parapsilosis*, *C. tropicalis*, *C. krusei*, *C. famata*, *C. kefyr* and *C. inconspicua*. The latex of *Euphorbia macroclada* inhibited the growth of 30 out of 150 tested *Candida* isolates with MIC range of 128-512 µg/ml. These isolates were as follows: *C. albicans* (n=2), *C. glabrata* (n=4), *C. parapsilosis* (n=19), *C. krusei* (n=2) and *C. tropicalis* (n=3). Compared to other isolates, higher MIC values noted for *C. albicans* and *C. glabrata* was (512 µg/ml) [227].

Antifungal effect of *Euphorbia macroclada* extracts was studied against the fungi *Verticillium dahliae*, *Fusarium oxysporum*, *Rhizopus stolonifer*, *Penicillium italicum*, *Rhizoctonia solani*, *Alternaria solani*, *Stemphylium solani*, *Cladosporium* sp., *Mucor* sp., and *Pythium* sp. The strongest inhibitory effect of the extracts was observed against *R. solani*, *V.dahliae*, *F. oxysporum*, *Pythium* sp. and *R. stolonifer*, and the weakest effect was recorded against *A. solani*. Extracts from the stems had a stronger inhibitory effect than those from the flowers or leaves. Butanol was superior to chloroform, water and petroleum ether to extract antimicrobial compounds from leaves, stems and flowers [228].

Fagopyrum esculentum

The antibacterial activity of buckwheat hulls extract (four concentrations, ranging from 6.25 to 100 mg/ml) was studied against three species of Gram-positive (*Bacillus cereus*, *Staphylococcus aureus*, *Enterococcus faecalis)* and three species of Gram-negative bacteria (*Salmonella choleraesuis*, *Escherichia coli* and *Proteus mirabillis*). Buckwheat hulls extract exhibited higher antimicrobial activity against Gram-positive than Gram-negative bacteria. Buckwheat hulls extract in concentration of 50 mg/ml produced zone of inhibition of 13.3 ± 0.88 mm against *Bacillus cereus,* 13.3 ± 0.57 mm against *Enterococcus faecalis* and 11.6 ± 0.88 mm against *Staphylococcus aureus*. The same concentration of buckwheat hulls extract exerted lower inhibition zones against Gram-negative bacteria [229].

An antifungal peptide with a molecular mass of approximately 4 kDa was isolated from buckwheat. It inhibited mycelial growth of *Fusarium oxysporum* and *Mycosphaerella arachidicola* with an IC_{50} of 35 and 40 microM, respectively. Its antifungal activity was stable between 0 and 70 degrees C, and between pH 1.0/2.0 and 13 [230].

Ficus carica

The antimicrobial activity of methanol extract of figs was studied against oral bacteria [*Streptococcus mutans*(ATCC 25175), *Streptococcus sanguinis* (ATCC 10556), *Streptococcus sobrinus* (ATCC 27607), *Streptococcus ratti* (KCTC 3294), *Streptococcus criceti* (KCTC 3292), *Streptococcus anginosus* (ATCC 31412) and *Streptococcus gordonii* (ATCC 10558), *Aggregatibacter actinomycetem comitans* (ATCC 43717), *Fusobacterium nucleatum* (ATCC 51190), *Prevotella intermedia* (ATCC 49046) and *Porphyromonas gingivalis* (ATCC 33277)]. The methanolic extract showed (MICs: 0.156 to 5 mg/ml and MBCs: 0.313 to 5 mg/ml) against the tested oral bacteria. The combination of methanolic extract and ampicillin or gentamicin showed synergistic effect against oral bacteria [231].

The antibacterial effects of different polarities crude extract from the leaves of *Ficus carica* (250-2000 µg/ml) were studied against *Staphylococcus aureus*, *Escheichia coli* and *Pseudomonas* sp by agar disc diffusion method. The dried leaves were macerated in absolute ethanol and the crude extract was defatted with ethanol-water, then the defatted hydro alcoholic crude extract was extracted with hexane, chloroform and ethyl acetate. Hydroalcoholic crude extract and its derived fractions display moderate antimicrobial potential against *Staphylococcus aureus*, *Escheichia coli* and *Pseudomonas* sp, in the range of 0%–13% [232].

Ethanolic leaf extract and latex of fig (*Ficus carica*) were investigated for their antimicrobial activity against six bacterial strains, two Gram positive (*Staphylococcus aureus* and *Streptococcus pyogenes*) and four Gram negative (*Klebsiella pneumonae*, *Pseudomonas aeruginosa*, *Salmonella typhi* and *Escherichia coli*), and three fungal strains (*Candida albicans*, *Fusarium oxysporum* and *Aspergillus nigar*), using agar well diffusion method for determination of inhibitory zone diameters (IZD). The ethanolic extract of leaves exhibited strong activity against *Staphylococcus aureus* (13 mm), *Salmonella typhi* (14 mm), and *Fusarium oxysporum* (16 mm), whereas The latex showed higher activity against *Staphylococcus aureus*, *Salmonella typhi* and *Streptococcus pyogenes* (15, 15 and 14mm respectively), and *Aspergillus nigar* (18 mm). *Klebsiella pneumonae* and *E. coli* seemed to be resistant to both extract which showed (8 and 9 mm) for leafe extracts and (11 and 10 mm) for ethanolic leaf extract and latex respectively [233].

Methanolic, hexanoïc, chloroformic and ethyl acetate extracts of *Ficus carica* latex were investigated for their *in vitro* antimicrobial proprieties against five bacteria species and seven strains of fungi. The methanolic extract had no effect against bacteria except against *Proteus mirabilis*, while the ethyl acetate extract showed inhibitory effect on the multiplication of five bacteria species (*Enterococcus fecalis, Citobacter freundei, Pseudomonas aeruginosa, Echerchia coli* and *Proteus mirabilis*). For yeasts, ethyl acetate and chlorophormic fractions showed a very strong inhibition (100%); methanolic fraction totally inhibited *Candida albicans* (100%) at a concentration of 500 microg/ml, but showed negative effect against *Cryptococcus neoformans*. *Microsporum canis* was strongly inhibited by methanolic extract (75%) and totally with ethyl acetate extract at a concentration of 750 microg/ml. Hexanoïc extract showed medium results [234].

The antimicrobial effects of the methanol extract (40-60 µg/ml) of *Ficus carica* leaves were tested against *S. epidermidis, K. Pneumoniae, B. Subtilis, E. aerogens,* and *B. cereus.* The extract possessed antibacterial activity with MIC of 7, 3, 4, 6 and 3.5 µg/ml and MBC of 11, 6, 7, 11 and 8 µg/ml against *S. epidermidis, K. Pneumoniae, B. Subtilis, E. aerogens,* and *B. cereus* respectively [235].

The antimicrobial activity of methanol extract of fig leaves was investigated against methicillin-resistant *Staphylococcus aureus* (MRSA). MICs: 2.5 to 20 mg/ml and MBCs: 5 to 20 mg/ml were recorded for the methanol extract against MRSA isolates. The combination of the methanol extract and oxacillin or ampicillin showed reduction of growth ≥4-8-fold in all tested bacteria, which was considered to be synergistic. Furthermore, time-kill study revealed that a combination of methanol extract with oxacillin or ampicillin produced a more rapid decrease in the concentration of bacteria CFU/ml than methanol extract alone [236].

Two different extracts of *Ficus carica* fruits were evaluated against drug resistant human pathogens (*E.coli, Pseudomonas aeruginosa, Streptococcus sp., Enterobacter sp., Klebsiella pneumonia, S. typhi* and *S. paratyphi*).. The ethanol extracts was found to be more effective than methanol extract. The MIC values fell in the range of 0.94 to 30 µg/ml [237].

Hexane extract of *Ficus carica* latex was assayed for antibacterial activity against several Gram-positive and Gram-negative bacteria. A strong bactericidal effect was demonstrated. The most sensitive bacteria were *Staphylococcus saprophyticus* clinical isolate, and *Staphylococcus aureus* ATCC 25923, with MIC of 19 µg/ml [238].

Antibacterial activity of fig fruit extract was investigated against *Proteus mirabilis* and three Gram positive (*Staphylococcus aureus, Staphylococcus epidermidis* and *Bacillus subtilis*) The dried fig extract

inhibited only two isolates, *Bacillus subtilis* (16 mm, 100mg/ml) and *Proteus mirabilis* (18.5mm, 100mg/ml) [239].

The crude extracts of *Ficus carica* was examined for their anti- quorum sensing properties. Anti-quorum sensing activity was measured by quantifying violacein production and swarming motility. Results revealed that all extracts possessed anti- quorum sensing ability. The dichloromethane extract exhibited the most pronounced inhibition of quorum sensing activity [240].

Ficus carica has also evaluated for antifungal activities. A low-molecular-weight protein, isolated from freshly collected latex of the *Ficus carica* was found to possess antifungal activity [241].

Ficus religiosa

Ethanol extracts of the *Ficus religiosa* was screened for antibacterial activity against *Enterococcus faecalis, Proteus vulgaris, Staphylococcus saprophyticus, Shigella flexneri, Shigella sonnie* and *Shigella dysenteriae*. The minimum inhibitory concentrations against these bacteria were within the range of 250-500µg/ml [242].

The MIC of *Ficus religiosa* leaves ethanolic extract against ampicillin and vancomycin resistant native strain of *Staphylococcus aureus* was 3.91±0.43 mg/ml [243].

The various solvents extract like aqueous, methanol, chloroform, petroleum ether and hexane of the bark of *Ficus religiosa* were screened for antibacterial activity against Enterotoxigenic *E. coli* isolated from diarrhoeal patients, at 200mg/ml concentration by disc diffusion method. The methanol extracts exhibited good activity compared to chloroform and aqueous extracts. Petroleum ether and hexane extracts did not show any activity [244].

A combination of hot alcoholic extracts of *Ficus infectoria*, *Ficus religiosa* and *Piper* betel were found to be effective against resistant and sensitive strains (Gram negative resistant *Klebsiella* strains, sensitive *Klebsiella* strains, resistant *Enterobacter* strains, sensitive *Enterobacter* strains , resistant *Escherichia coli* strains, resistant *Pseudomonas* strains, sensitive *Pseudomonas aeruginosa* strains and tandard *Pseudomonas aeruginosa* ATCC 2862) and (Gram positive resistant *Staphylococcus* strains, sensitive *Staphylococcus* strains, resistant *Micrococcus* strain and standard *Staphylococcus aureus* ATCC 2901), isolated from skin and soft tissue infections. The combined extract was formulated in different ointment bases. The ointment showed bactericidal activity within 2 h against the resistant strain of *Pseudomonas* spp [245].

Effect of ethanolic extract of *Ficus religiosa* fruits extract was studied against two Gram positive bacteria (*Staphylococcus epidermidis* and *Staphylococcus aureus*) and two Gram negative bacteria (*P. vulgaris* and *Klebsiella pneumonia*). The minimum inhibitory concentration of extract against *Staphylococcus epidermidis* and *Klebsiella pneumonia* was 15 mg/ml, while the minimum inhibitory concentration against *Staphylococcus aureus* and *P. vulgaris* was 30 mg/ml. At 15 mg/ml concentration of extract *K. pneumonia* showed more sensitivity (21 mm) than *S. epidermidis* (19 mm). At 30 mg/ml concentration *P. vulgaris* showed more sensitivity (12 mm) than *S. aureus* (9 mm) [246].

Bark of *Ficus religiosa* was dissolved in 67% ethanol. Extract was then subjected to antimicrobial efficacy tests against primary plaque colonizers and periodontal pathogens. *Ficus religiosa* showed antibacterial activity against primary plaque colonizers at 48 h with mean zone of inhibition of 2.6 ± 0.54 mm [247].

The antimicrobial activity of methanol and diethyl ether extracts of bark and leaves of *Ficus religiosa* (100, 200, 300 and 400 mg/ml) was investigated against two Gram negative bacteria (*E.coli* and *Pseudomonas aeruginosa*), and one Gram positive bacteria (*Staphylococcus aureus*). The methanol extracts of leaves and bark showed antimicrobial activity, a higher activity was recorded at 400 mg/ml concentration against the three tested bacteria. Both leaf and bark methanol extracts gave zone of inhibition of 2.8 and 2.2mm against *S. aureus*, 2.4 and 1.8mm against *E. coli* and 2.2 and 1.1mm against *P.aeroginosa* respectively [248].

The antimicrobial activity of the aqueous extract of bark leaf, stem, fruit of *Ficus religiosa* was determined by disc diffusion method against *Escherichia coli, Enterobacter aerogenes, Pseudomonas aeruginosa, Aeromonas hydrophila, Staphylococcus aureus, Streptococcus pyogenes, Aspergillus niger* and *Candida albicans*, The highest zone of inhibition (10-15 mm in diameter) was observed in 100 mg/ml concentration in all tested microbes [249].

The acetone, methanol, ethylacetate extracts (25-100 µg/ml) of *Ficus religiosa* bark were evaluated for antibacterial activity against *Pseudomonas aeruginosa, Escherichia coli, Proteus vulgaris, Bacillus subtilis* and *Staphylococcus aureus.* The growth of *Bacillus subtilis* was significantly inhibited by acetone extract of *Ficus religiosa*. Higher concentrations of the same extract were required to inhibit *E. coli*. Methanol extract of the plant was very active against all the tested bacterial pathogens except *P. aeruginosa*. Ethyl acetate extract was not active against all the bacterial species [250].

High antibacterial activity was possessed by aqueous extract of *Ficus religiosa* against *B. subtilis* with about 24mm inhibition zone. It also exerted antibacterial activity against multi drug resistant *P. aeruginosa* [251].

The antiviral activity of *Ficus religiosa* was investigated against RSV and HRV *in vitro* by plaque reduction and virus yield assays, and the major mechanism of action was investigated by virus inactivation and time – of -

addition assays. *Ficus religiosa* methanol bark extract was most active against HRV with an EC_{50} of 5.52 µg/ml. This extract inhibited late steps of replicative cycle. Water bark extract was the most active against RSV with an EC_{50} between 2.23 and 4.37 µg/ml. Partial virus inactivation and interference with virus attachment were both found to contribute to the anti-RSV activity. Replication of both viruses was inhibited in viral yield reduction assays [252].

The oil leaf of *Ficus religiosa* was screened for antimicrobial activity against *Aspergillus niger*, but was inactive (MIC = 2500 µg/ml). The antibacterial effect of leaf oil was studied against *Pseudomonas aeruginosa, Bacillus cereus, Staphylococcus aureus, Escherichia coli*, and *Candida albicans*. It was marginally active (MIC = 625 µg/ml) [253].

III. CONCLUSION

This review was designed as a third part of a previously published reviews to cover the medicinal plants with antimicrobial activities.

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