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STUDY OF MEDICINAL HERBS AND ITS ANTIBACTERIAL ACTIVITY: A REVIEW

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ABSTRACT

The beneficial medicinal effects of plant materials typically result from the secondary products present in the plant although, it is usually not attributed to a single compound but a combination of the metabolites. The medicinal actions of plants are unique to a particular plant species or group, consistent with the concept that the combination of secondary products in a particular plant is taxonomically distinct.The screening of plants usually involves several approach; ethno botanical approach is one of the common methods that are employed in choosing the plant for pharmacological study. In the present review paper, antimicrobial properties of various medicinal plants were reviewed. The present review deals with the antibacterial activity of various medicinal plants.

Keywords: Antimicrobial, Herbal Drugs, WHO, Cup-plate Method, Anti-bacterial Activity.

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INTRODUCTION

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

Infectious diseases, particularly skin and mucosal infections, are common. An important group of these skin pathogens are the fungi and bacteria[4]. Infectious dermatological conditions are of common occurrence including dermal inflammation, folliculitis, skin abuses, acne, dermatitis, rosacea *etc*. Multidrug resistant bacteria have become important cause for higher skin care products[5]. Multiple drug resistance has developed due to the indiscriminate use of commercial antimicrobial drugs commonly used in the treatment of infectious disease[6]. Immuno compromised individuals are frequently found suffering from skin infections that are difficult to cure. A novel compound with difference in mode of activity of antibiotics against microbes is an attractive alternative against multidrug resistant bacteria[5]. The drugs already in use to treat infectious disease are of concern also because drug safety remains an enormous global issue. Most of the synthetic drugs cause side effects. To alleviate this problem, antimicrobial compounds from potential plants should be explored. These drugs from plants are less toxic; side effects are scanty and also cost effective. They are effective in the treatment of infectious diseases while simultaneously mitigating many of the side effects that are often associated with synthetic antimicrobials[1]. Topical drug administration is a localized drug delivery system anywhere in the body through ophthalmic, rectal, vaginal, and skin as topical routes. Skin is one of the most accessible organ of human body for topical administration and main route of topical drug delivery system. Number of medicated products is applied to the skin or mucous membrane that either enhances or restores a fundamental function of a skin or pharmacologically alters an action in the underlined tissues. Such products are referred as topical or dermatological products. At the skin surface, drug molecules come in contact with cellular debris, microorganisms, and other materials, which effect permeation. The applied medicinal substance has three pathways to the viable tissue- 1) through hair follicles, 2) *via* sweat ducts and 3) across continuous *stratum corneum* between the appendages (hair follicles, sebaceous glands, eccrine, apocrine glands and nails). This route of drug delivery has gained popularity because it avoids first-pass effect, gastrointestinal irritation and metabolic degradation associated with oral administration. The topical route of administration has been utilized either to produce local effect for treating skin disorder or to produce systemic drug effects[7].

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

ANTIBACTERIAL ACTIVITY OF MEDICINAL PLANTS

Antimicrobials of plant origin have enormous therapeutic potential. They are effective in the treatment of infectious diseases while simultaneously mitigating many of the side effects that are often associated with synthetic antimicrobials. The beneficial medicinal effects of plant materials typically result from the combinations of secondary products present in the plant. In plants, these compounds are mostly secondary metabolites such as alkaloids, steroids, tannins and phenol compounds, flavonoids, steroids, resins fatty acids gums which are capable of producing definite physiological action on body. Compounds extracted from different parts of the plants can be used to cure diarrhea, dysentery, cough, cold, cholera, fever, bronchitis, etc.

Dagmar Janovyska *et al.* tested the antimicrobial activity of crude ethanolic extracts of ten medicinal plants used in traditional medicine against five species of microorganisms: *Bacillus cereus*, *Escherichia coli*, *Staphylococcus aureus*, *Pseudomonas aeruginosa* and *Candida albicans*. Of the 10 plants tested, 5 showed antimicrobial activity against one or more species of microorganisms. The most active antimicrobial plants were *Chelidonium majus*, *Sanguisorba officinalis* and *Tussilago farfara*[8].

Nair *et al*. screened nine plants for potential antibacterial activity. The plants screened were *Sapindus emarginatus*, *Hibiscus rosa sinensis*, *Mirabilis jalapa*, *Rhoeo discolor*, *Nyctanthes arbor-tristis*, *Colocasia esculenta*, *Gracilaria corticata*, *Dictyota* sp. and *Pulicaria wightiana*. Antibacterial activity was tested against 6 bacterial strains, *Pseudomonas testosteroni*, *Staphylococcus epidermidis*, *Klebsiella pneumoniae*, *Bacillus subtilis*, *Proteus morganii* and *Micrococcus flavus*. Two methods, Agar disc diffusionand Agar disc diffusion, were used to study the antibacterial activity of all these plants. *Pseudomonas testosteroni* and *Klebsiella pneumonia* were the most resistant bacterial strains. *Sapindus emarginatus* showed strong activity against the tested bacterial strains[9].

Ramasamy and Charles Manoharan found the antibacterial activity of valuable compounds from various solvent extracts of *Anosomeles indica*, *Blumea lacera* and *Melia azadirachta* against *Escherichia coli*, *Pseudomonas aeruginosa*, *Serratia maraceseuns* and *Staphylococcus aureus* by tube diffusion method. Acetone and methanol extracts of all plants showed strong antibacterial effect, whereas petroleum ether and aqueous did not exhibit any effect. *Pseudomonas aeruginosa* and *Serratia marcesenes* were relatively moresensitive[10].

Voravuthi kunchai *et al*. investigated the aqueous and ethanolic extract of ten traditional Thai medicinal plants for their ability to inhibit 35 hospital isolates of MRSA. Nine medicinal plants displayed activity against all isolates tested. Ethanolic extracts of *Garcinia mangostana*, *Pucinia granatum* and *Quercus infectoria* were more effective, with MICs for MRSA isolates of 0.05 -0.4, 0.2- 0.4 and 0.2 -0.4 mg/ml and for *Staphylococcus aureus* of 0.1, 0.2 and 0.1mg/ml. MBCs for MRSA isolateswere 0.1-0.4, 1.6-3.2 and 0.4-1.6 mg/ml for *Staphylococcus aureus* were 0.4, 3.2 and 1.6 mg/ml[11].

Astal *et al*. tested the aqueous extracts of sage and thyme had action against microorganisms. Phenolic extract of sage and thyme showed antibacterial activity against *Staphylococcus aureus* and *Enterococcus* sp. *Escherichia coli* was more affected by the ethanolic extract of parsley. While, that extract does not elicit pronounce effect on the tested Gram positive organisms. The results of commercial oils of sage, thyme and parsley displayed no antimicrobial activity against *Escherichiacoli*, *Proteus mirabilis* and *Salmonella typhi*. The dataobtained revealed that, among the 10 tested microorganisms, *Staphylococcus aureus* was the most susceptible microbe to most extract of the three plants[12].

Kabir *et al*. stated that both water and ethanol extracts of *Terminalia avicennioides*, *Phyllanthus discoideus*, *Ocimum gratissimum* and *Acalypha wilkesiana* were effective on MRSA. The MIC and MBCof the ethanol extract of these plants range from 18.2 to 24.0mcg/ml were recorded for ethanol and water extracts of *Bridella ferriginea* and *Ageratum conyzoides*. Higher MBC values were obtained for the two plants. All the four active plants contained at least trace amounts of Anthraquinones[13].

Poonko thai *et al*. pointed out that petroleum ether, benzene ethyl acetate and acetone extract of *Galinisoga ciliate* leaves displays higher activity against Gram positive bacteria (*Staphylococcus aureus* and *Bacillus subtilis*) rather than Gram the negative bacteria(*Pseudomonas aeruginosa* and *Escherichia coli*). The toxicity against microorganisms may be done to the high amount of phenolic compounds present[14].

Deshpande *et al*. isolated that petroleum ether, acetone and methanol extracts of *Abrus precatorius, Boswellia serrata, Careya arborea, Emblica officinalis, Syzygium cumini*, Woodf*ordia fruticosa* and *Sphaeranthus indicus* shows appreciable antibacterial activity against Gram positive bacteria (*Staphylococcus aureus* and *Bacillus cereus*) and Gram negative bacteria(*Escherichia coli*, *Proteus vulgaris* and *Pseudomonas aeruginosa*). Extracts of some other plants were activeonly against Gram positive bacteria[15].

According to Tambekatr and Kharate *et al. Ocimum sanctum* showed inhibitory effect on *Escherichia coli*, *Staphylococcus aureus*, *Proteus mirabilis*, *Salmonella typhi*, *Enterococcus faecalis*, *Pseudomonas aeruginosa* and *Yersinia enterocolitica*. The leaves extract of various plants such as Tulsi, Pudina and Beetle showed antimicrobial activity of *Escherichia coli*, *Staphylococcus aureus*, *Enterococcus faecalis*, *Salmonella typhi*, *Vibrio cholerae*, *Proteus mirablis*, *Pseudomonas aeruginosa*, *Yersinia enterocolitica* while piper betel showed resistance to *Streptococcus pneumoniae*[16].

Panthi and Chaudhary *et al.* tested eighteen plant species used in folklore medicine for their antibacterial activity by the disk diffusion method. The bacteria employed were Gram positive (*Staphylococcus aureus*) and Gram negative (*Escherichia coli, Pseudomonas aeruginosa* and *Shigella boydii*). Extracts of eight plantsshowed encouraging result against three strains of bacteria, while other showed activity against one or two strains[17].

Balakrishnan *et al*. performed antibacterial activity of *Mimosa pudica*, *Aegle marmelos* and *Sida cordifolia* against *Bacillus subtilis*, *Staphylococcus aureus*, *Klebsiella pneumoniae*, *Pseudomonas aeruginosa*, *Escherichia coli* and *Salmonella* typhi. The maximum inhibitory zone of inhibition *Sida cordifolia* was against *Bacillus subtilis* (35 mm) and *Salmonella typhi* (26 mm). *Minosa pudica* and *Aegle marmelos* were found to be active against all themicroorganisms tested and the maximum activity was noted against *Pseudomonas aeruginosa* and *Salmonella typhi*[18].

Attar Singh Chauhan *et al*. screened Sea buckthorn (*Hippophae rhamnoides*) seeds aqueous extract for antioxidant and antibacterial activities. The antioxidant activities (Reducing power, DPPH and liposome model system) showed a good antioxidant activity. The extract was also found to possess antibacterial activity with a MIC values with respect to *Listeria monocytogenes* and *Yersinia enterocolitica* found to be 750 ppm and 1000 ppm respectively. The antioxidant and antimicrobial effects of the extract implicate its potential for natural preservation.[19]

Bupesh *et al*. evaluated the antibacterial activity in the leaf extracts of *Mentha piperita* against pathogenic bacteria like *Bacillus subtilis, Pseudomonas aureus, Pseudomonas aeruginosa, Serratia marcescens* and *Streptococcus aureus*. The aqueous as well as organic extracts of the leaves were found to possess strong antibacterial activity against a range of pathogenic bacteria as revealed by *in vitro* agar well diffusion method. The ethyl acetate leaf extract of *Mentha piperita* showed pronounced inhibition than chloroform, petroleum ether and water, leaf extracts being more on *Bacillus subtilis, Pseudomonas aeruginosa* than *Streptococcus aureus, Pseudomonas aureus* and *Serratia marcescens*[20].

Mohammad Ahanjan *et al*. tested ethanol, methanol, chloroform, petroleum ether and aqueous extracts of leaves of *Parrotia persica* for antibacterial activity. The zone of inhibition varied from 13 mm to 22 mm. The highest inhibition was obtained with methanol and ethanol. Chloroform and petroleum ether extracts did not show any activity. The MIC value of the methanol extract for the test bacteria ranged between 3.12 mg/ml and 6.25 mg/ml and that of ethanol extract ranged between 6.25 mg/ml and 12.5 mg/ml. The results scientifically validate the use of this plant in the traditional medicine[21].

Priscila Ikeda Ushimaru *et al*. evaluated the *invitro* antimicrobial activity of methanolic extracts of some medicinal plants against *Escherichia coli*, *Salmonella typhimurium*, *Staphylococcus aureus* and *Enterococcus* sp. The methanolic extract of *Caryophyllus aromaticus* presented the highest anti-*Staphylococcus aureus* activity and was effective against all bacterial strains tested[22].

Sumathi and Pushpa *et al*. evaluated tested ten bacterial isolates for their sensitivity against standard antibiotics, aqueous and alcoholic extracts of five plant samples and the mixture. Only the growth of *Escherichia coli* was inhibited by the aqueous extracts of *Acalypha indica*. Mollungolatoides was found to be effective in inhibiting the growth of *Escherichia coli* at a concentration of 12.5 mg/ml and 6.25 mg/ml. The MIC of alcoholic extracts of *Nelumbo nucifera* was found to be 0.390 mg/ml for *Klebsiella pneumoniae*. All the plants extracts showed promising antibacterial properties[23].

Rupanjali Shan *et al*. tested the antibacterial activity of different solvent extracts of the air dried bark of *Parkia javanica*, against five antibiotic resistant bacteria *viz*, *Bacillus subtilis*, *Staphylococcus aureus*, *Pseudomonas aeruginosa*, *Micrococcus luteus* and *Escherichia coli* by cup-plate diffusion method. MIC values of each active extract were determined. The results showed dose dependent positive activity against all the bacteria except *Escherichia coli*[24].

Vimala *et al*. carried out the antimicrobial activity of *Ipomea ken trochulous* leaf extracts against several pathogenic microorganisms and microbial isolates by disc diffusion method. The crude, cold methanol, distillate and residual extracts of *Ipomea ken trochulos* were tried on various microorganisms. The crude extract showed zones of inhibition ranging from 0.0 to 21mm, with maximum activity against isolated *Rhizopus* sp. and least activity against *Serratia marcense*, *Yersinia* sp. and *Salmonella typhimurium*. The zone of inhibition to cold methanol, residual extract and distillate ranged between 6-18 mm and 9-19 mm suggesting that the distillate was more effective than the crude, cold and residual extracts of *Ipomea ken trochulous* leaf extract against various pathogens and microbial isolates[25].

Kumar *et al*. evaluated the antimicrobial activities of some Indian medicinal plants against these etiologic agents of *Acne vulgaris*. Ethanolic extracts of *Hemidesmus indicus* (Roots), *Eclipta alba* (Fruits), *Coscinium fenestratum* (Stems), *Curcubito pepo* (Seeds), *Tephrosia purpurea* (Roots), *Mentha piperita* (Leaves), *Pongamia pinnata* (Seeds), *Symplocos racemosa* (Barks), *Euphorbia hirta* (Roots), *Tinospora cordyfolia* (Roots), *Thespesia populnea* (Roots) and *Jasminum officinale* (Flowers) for antimicrobial activities by disc diffusion and broth dilution methods. The results from the disc diffusion method showed that 07 medicinal plants could inhibit the growth of *Propionibacterium acnes*. Among those *Hemidesmus indicus*, *Coscinium fenestratum*, *Tephrosia purpurea*, *Euphorbia hirta*, *Symplocos racemosa*, *Curcubita pepo* and *Eclipta alba* had strong inhibitory effects. Based on a broth dilution method, the *Coscinium fenestratum* extract had the greatest antimicrobial effect. The MIC values were the same (0.049 mg/ml) for both bacterial species and the MBC values were 0.049 and 0.165 mg/ml against *Propionibacterium acnes* and *Staphylococcus epidermidis*[26].

Bin Shah *et al*. investigated the *in vitro* antibacterial activities of a total of 46 extracts from dietary spices and medicinal herbs agar-well diffusion method against five food borne bacteria (*Bacillus cereus*, *Listeria monocytogenes*, *Staphylococcus aureus*, *Escherichia coli* and *Salmonella anatum*). Many herb and spiceextracts contained high levels of phenolics and exhibited antibacterial activity against food borne pathogens. Gram-positive bacteria were generally more sensitive to the tested extracts than Gram negative ones. *Staphylococcus aureus* was the most sensitive, while *Escherichia coli* were the most resistant[27].

Khalid Mahmood *et al*. evaluated the antibacterial activity of *Ocimum sanctum* essential oil against five human pathogenic bacterial species *Escherichia coli*, *Klebsiella* sp., *Proteus mirabilis*, *Pseudomonas aeruginosa* and *Staphylococcus aureus* by disc-diffusion method. Six mm discs were impregnated with 5 and 10 µl of undiluted essential oil and seeded over the plates aseptically having test microorganisms. The zones of inhibition were measured after 24 hours at 378°C. The essential oil exhibited significant antibacterial activity against all the test pathogens, with maximum zone of inhibition against *Staphylococcus aureus* (20.0 mm and 41.5 mm) and minimum against *Escherichia coli* (10.2 mm and 17.8 mm) for 5 and 10 µl of essential oil, respectively. Similarly, the inhibition zones recorded in *Proteusmirabilis* were 15.1 mm and 26.0 mm, in *Pseudomonas aeruginosa*10.2 mm and 20.0 mm, in *Klebsiella*sp. 11.1and 19.4 mm for two given concentrations of essential oil[28].

Cock *et al.*reported the antimicrobial activity of *Ocimum sanctum* leaves against bacteria and yeast.The diameter of inhibition zone recorded in *Escherichia coli* was 18 mm for 22 µl of oil. Thesedifferences may be attributed due to presence of antibacterial component in high concentration in local variety enhancing the medicinal importance of indigenous essential oil.[29]

Hadi Mehrgan *et al*. collected the aerial parts of the plant from Alv and mountain side. The air-dried plant materials were ground to fine powder and then extracted by Soxhelet apparatus using methanol. The extract was tested at a concentration of 100 mg/ml against a panel of Gram-positive and Gram-negative bacteria using the disk diffusion technique. This methanolic extract demonstrated antibacterial activity against Gram positive bacteria including *Staphylococcus aureus*, Methicillin resistant *Staphylococcus aureus* (MRSA), *Streptococcus pyogenes*, *Enterococcus faecalis*, Vancomycin - resistant *Enterococcus faecalis* and *Micrococcus luteus* and produced inhibition zones with 8-16 mm diameters. It showed no activity against Gram negative bacteria, such as *Escherichia coli*, *Pseudomonas aeruginosa* and *Salmonella* spp. Minimum concentrations (MC) of theextract forming a clear zone were determined against susceptible bacteria[30].

Roopa shree *et al*. studied the antibacterial activity with respect to their traditional use as anti-psoriatic agents. The herbs were subjected to successive extraction using different solvents and the extracts were subjected to antibacterial evaluation against both Gram positive and Gram negative organisms by Cup plate technique. Among the various extracts, aqueous extracts were found to be more effective against all the bacteria. *Staphylococcus aureus* was more susceptible to the aqueous extracts among the tested organisms[31].

Koshy Philip *et al*. screened 32 extracts from eight selected medicinal plants, namely *Pereskia bleo*, *Pereskia grandifolia*, *Curcuma aeruginosa*, *Curcuma zedoria*, *Curcuma mangga*, *Curcuma inodora*, *Zingiber officinale* and *Zingiber officinale* for their antimicrobial activity against both Gram-positive bacteria and Gram-negative bacteria using agar disc diffusion assay. The efficacy of the extracts was compared to the commercially prepared antibiotic diffusion discs. No inhibition was observed with the water fractions. None of the plants tested showed inhibition against *Escherichia coli*. *Curcuma mangga* showed some remarked inhibition against the bacteria[32].

Bishnu Joshi *et al*. assessed the antibacterial properties of selected medicinal plants *viz*. *Ocimum sanctum* (Tulsi), *Origanum majorana* (Ram Tulsi),*Cinnamomum zeylanicum* (Dalchini) and *Zanthoxylum armatum*

(Timur), for potential antibacterial activityagainst 10 medically important bacterial strains, *Bacillus subtilis, Bacillus cereus, Bacillus thuringiensis, Staphylococcus aureus, Pseudomonas* sp, *Proteus* sp, *Salmonella typhi, Escherichia coli, Shigella dysentriae, Klebsiella pneumoniae.* The antibacterial activity of ethanol extracts was determined by agar well diffusion method. The plant extracts were more active against Gram positive bacteria than against Gram negative bacteria. The most susceptible bacteria were *Bacillus subtilis*, followed by *Staphylococcus aureus*, while the most resistant bacteria were *Escherichia coli*, followed by *Shigella dysenteriae*, *Klebsiella pneumonia* and *Salmonella typhi*. *Origanum majorana* showed the best antibacterial activity. The largest zone of inhibition was obtained with *Xanthoxylum armatum* against *Bacillus subtilis* (23 mm) [33].

Warda *et al*. tested four plants (*Marrubium vulgare, Thymus pallidus*, *Eryngiumilicifolium* and *Lavandulastoechas*) against *Streptococcus pneumonia* responsible for pharyngitis, rhinitis, otitis and sinusitis infections. Aqueous and methanol extracts have been prepared and tested on *Streptococcus pneumoniae* collected in four regions. A significant activity has been observed with methanol extracts of three plants; *Marrubiumvulgare, Thymus pallidus*and*Lavandula stoechas*[34].

Doss *et al*. isolated compounds of pharmacological interest (Tannins) from the plant species, *Solanumtrilobatum* and assayed against the bacteria, *Staphylococcus aureus*, *Streptococcus pyrogens*, *Salmonella typhi*, *Pseudomonas aeruginosa*, *Proteus vulgaris* and *Escherichia coli* using agar diffusionmethod. Tannins exhibited antibacterial activities against all the tested microorganisms. *Staphylococcus aureus* was the most resistant to tannins isolated from the plant material followed by *Streptococcus pyrogens*, *Salmonella typhi*, *Escherichia coli*, *Proteus vulgaris* and *Pseudomonas aeruginosa*. Minimum inhibitoryconcentration of the tannins ranged between 1.0 and 2.0 mg/ml while the minimum bactericidal concentration ranged between 1.5 and 2.0 mg/ml[35].

Sukanya *et al*. examined the ethno botanical efficacy of Indian medicinal plants; *Achyranthes aspera, Artemisia parviflora, Azadirachta indica, Calotropis gigantean, Lawsonia inermis, Mimosa pudica, Ixora coccinea, Parthenium hysterophorus* and *Chromolaena odorata* using agar disc diffusion method against clinicalbacteria (*Escherichia coli* and *Staphylococcus aureus*) and phyto-pathogenic bacteria (*Xanthomonas vesicatoria* and *Ralstonia solanacearum*). Leaves were extracted using different solvents such as methanol, ethanol, ethyl acetate and chloroform. Among treatments, maximum *invitro* inhibition was scored in methanol extracts of *Chromolaena odorata* which offered inhibition zone of 10, 9, 12 and 12 mm against *Escherichia coli, Staphylococcus aureus*, *Xanthomonas vesicatoria and Ralstonia solanaccearum*, followed by chloroform extract of the same plant leaf with inhibition zone of 8, 4, 4 and 4A significant inhibition of *Escherichia coli* was found in aqueous and in all tested solvent extracts of *Acalypha indica*. In case of *Staphylococcus aureus*, maximum inhibition of 8 mm was obtained in aqueous extracts of *Acalypha indica* and 6 mm from methanol extract of *Lawsonia inermis*[36].

Swati Chauhan *et al*. assessed the antibacterial activity of standard routine antibiotics along with 23 plant extracts by disc diffusion procedure (Bauer-Kirby method) against *Klebsiella pneumoniae* isolated from nasal samples of pneumonic Barbari goats. The isolate was characterized using biochemical methods and was identified as *Klebsiella pneumoniae*. The organism was found to be resistant against Amoxicillin, Erythromycin, Cephadroxil, Cefaclor, Roxithromycin and Cephalexin. *Terminalia catappa* (Leaves), *Punica granatum* (Bark), *Syzygium cumini* (bark) and *Azadirachta indica* (leaves) showed potential activity with MICs at 62.5 mg/ml, 31.2 mg/ml, 62.5 mg/ml and 125 mg/ml respectively[37].

Sheeba *et al*. detected the antibacterial activity against *Staphylococcus aureus*, *Streptococcus* sp., *Bacillus subtilis*, *Escherichia coli*, *Pseudomonas aeruginosa*, *Salmonella typhi*, *Shigella dysenteriae* and *Vibrio cholerae*. The highest antibacterial activity wasobserved in 500 µg concentration of leaf extracts of all bacteria screened except *Shigella dysenteriae*. The minimum zone of inhibition observed in 25 µg concentration of leaf extract except *Pseudomonas aeruginosa* and *Shigella dysenteriae*. These results indicate that the extracts were bacteriostatic at higher concentrations[38].

Akinjogunla *et al*. assessed the antibacterial activity of extracts of the root and leaf of *Phyllanthusamarus* against extend spectrum lactamase (ESBL) producing *Escherichia coli* isolated from the stool samples of HIV sero-positive patients with or without diarrhoea using Bauer disc diffusion method. The phenotypic confirmation of ESBL - *Escherichia coli* were done by Double Disc Synergistic Methods (DDST). The phytochemical analysis of both root and leaf revealed the presence of alkaloids, flavonoids, saponins, tannins, cardiac glycoside, terpenes and anthraquinones. The strains isolated from both HIV sero- positive patients were susceptible to various concentrations of the extracts (5 mg ml-1, 10 mg ml^{-1}, 20 mg ml^{-1}, 40 mg ml^{-1} and 80 mg ml^{-1}) [39].

Adegoke *et al*. investigated the phytochemical screening and antimicrobial potentiality of *Phyllanthus amarus* against multidrug resistant pathogens usingstandard microbiological techniques. The extracts were tested by agar well diffusion method for activity against *Staphylococcus aureus*, *Escherichia coli*, *Pseudomonas aeruginosa* and *Klebsiella* sp. isolated from clinical samples. The susceptibility patterns of the test isolates against the crude extract was determined at extract concentrations of 10 mg/ml, 50 mg/ml, 100 mg/ml and 150 mg/ml respectively. The results revealed that the extracts did not inhibit the growth of *Escherichia coli*,*Pseudomonas* sp. and *Klebsiella*sp. at 10mg/ml but thelargest zones of growth inhibition for the ethanolic extract was recorded with *Staphylococcus aureus*, *Escherichia coli* and *Klebsiella*sp. with a mean zone diameter of 20 mm concentrations. The minimum inhibitory concentration (MIC) of the ethanolic plant extracts on *Escherichia coli*, *Staphylococcus aureus*, *Pseudomonas aeruginosa* and *Klebsiella*sp. were at 10 mg/ml, 50 mg/ml, 150 mg/ml and100 mg/ml while the MBC were at 50 mg/ml, 100 mg/ml, 150 mg/ml and 150 mg/ml respectively[40].

Ajayi and Akintola *et al*. screened the leave extracts from medicinal plants *in vitro* in the laboratory for their antibacterial activity against two prominent enteric bacteria, *Escherichia coli* and *Salmonella typhimurium* using the agar disc diffusion method. The tyndalized leave extract of *C. zambesicus* showing antibacterial inhibition zone of 4 and 2 mm against *Salmonella typhimurium* and *Escherichia coli* exhibited highestactivity than the autoclaved samples and other plant sources tested independently or combined, showing that the combinations of the extract samples do not exhibit synergistic effects[41].

Saranraj *et al*. evaluated the antibacterial potentiality of ethanol and ethyl acetate solvent extracts of mature leaves of *Acalypha indica* against nine pathogenic bacterial isolates *viz*., *Staphylococcus aureus, Bacillus subtilis, Bacillus cereus, Escherichia coli, Salmonella typhi, Shigella flexneri, Klebsiella pneumoniae, Vibrio cholera* and *Pseudomonas aeruginosa*. The turbidity of the bacterial inoculums was compared with 0.5 McFarland standards and the antibacterial potential of *Acalypha indica* ethanol extract was tested by using Agar well diffusion method. The ethanol extract of *Acalypha indica* (100 mg/ml) showed maximum zone of inhibition (30 mm) against *Pseudomonas aeruginosa, Escherichia coli* and *Bacillus subtilis*. *Staphylococcus aureus* showed less zone of inhibition (12 mm). The ethyl acetate extract of *Acalypha indica*(100 mg/ml) showed maximum zone of inhibition(23 mm) against *Escherichia coli*[42].

Murugan and Saranraj *et al*. tested the herbal plant *Acalypha indica* for its antibacterial activity against Nosocomial infection causing bacteria. The *Acalypha indica* was shade dried and the antimicrobial principleswere extracted with Methanol, Acetone, Chloroform, Petroleum Ether and Hexane. The antibacterial activity of *Acalypha indica* was determined by Agar Well Diffusion Method. It was found that 50mg/ml of methanolic extract of the plant able to inhibit the growth of nosocomial infection causing bacteria when compared to other solvent extracts. From this it was concluded that the solvent methanol able to leach out antimicrobial principle very effectively from the plant than the other solvents. The phytochemicals present in the *Acalypha indica* was tested and it conferred that the possible antibacterial principle resided in tannins and alkaloids[43].

Siva Sakthi *et al*. evaluated the antibacterial potentiality of ethanol and ethyl acetate solvent extracts of mature leaves of *Datura metel* against nine pathogenic bacterial isolates *viz*., *Staphylococcus aureus, Bacillus subtilis, Bacillus cereus, Escherichia coli, Salmonella typhi, Shigella flexneri, Klebsiella pneumoniae, Vibrio cholera* and *Pseudomonas aeruginosa*. The turbidity of the bacterial inoculums was compared with 0.5 McFarland standards and the antibacterial potential of *Datura metel* ethanol extract was tested by using Agar well diffusion method. The ethanol extract of *Datura metel* (100 mg/ml) showed maximum zone of inhibition (26 mm) against *Pseudomonas aeruginosa*, *Escherichia coli* and *Bacillus subtilis*. *Staphylococcus aureus* showed less zone of inhibition (8 mm). The ethyl acetate extract of *Datura metel* (100 mg/ml) showed maximum zone of inhibition (19 mm against *Escherichia coli*. There was no zone of inhibition against *Pseudomonas aeruginosa*[44].

Saranraj and Sivasakthivelan *et al*. tested the antibacterial activity of *Phyllanthus amarus* was tested against Urinary tract infection causing bacterial isolates *viz*., *Staphylococcus aureus*, *Serratia marcescens*, *Escherichia coli*, *Enterobacter* sp., *Streptococcus faecalis*, *Klebsiella pneumoniae*, *Proteus mirabilis* and *Pseudomonas aeruginosa*. The *Phyllanthus amarus* wasshade dried and the antimicrobial principles were extracted with methanol, acetone, chloroform, petroleum ether and hexane. The antibacterial activity of *Phyllanthus amarus* was determined by Agar Well Diffusion Method. It was found that methanol extract of *Phyllanthus amarus* showed more inhibitory activity against UTI causing bacterial pathogens when compared to other solvent extracts[45].

Saranraj *et al*. evaluated the bioactivity of *Mangifera indica* ethanol extract against human pathogenic bacteria and fungi. The plant material was collected, shade dried and powdered. The powdered material was extracted using the organic solvent ethanol. Antimicrobial activity of *Mangifera indica* ethanol extract was determined by Disc diffusion method. The zone of inhibition of *Mangifera indica* ethanol extract against bacteria was maximum against *Vibrio cholerae* followed by *Klebsiella pneumoniae*, *Staphylococcus aureus*, *Proteus mirabilis*, *Pseudomonas aeruginosa* and *Escherichia coli*. The least zone of inhibition was recorded against *Salmonella typhi*. The Minimum Inhibitory Concentration (MIC) was ranged from 2 mg/ml to 4 mg/ml. The Minimum Bactericidal Concentration (MBC) value ranged between 2mg/ml and 4mg/ml. For fungi, the zone of inhibition was maximum against *Candida albicans*, followed by*Aspergillus fumigatus*, *Aspergillus flavus*, *Aspergillus niger*, *Candida tropical is* and *Candida cruzei*. The least zone of inhibition was recorded against *Penicillium* sp. The MIC was 0.5 mg/ml and the MFC value was 1 mg/ml[46].

CONCLUSION

In conclusion, various studies on antimicrobial activity of herbal plant extracts showed that the various solvent extracts showed promising antimicrobial activity against bacterial and fungal human pathogens. The results of various herbal researchers also indicated that scientific studies carried out on medicinal plants having traditional claims of effectiveness might warrant fruitful results. These plants could serve as useful source of new antimicrobial agents.

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