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The efficacy of herbs against *Klebsiella pneumoniae* with special reference to polyherbal formulation: An update

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ABSTRACT

The world is progressively turning to herbal formulations which are known to be effective against a great range of diseases. More prominently, they are not known to cause any notable decisive effects and are readily available at affordable prices. However, it is stated that herbal remedies are effective and without side-effects, provided they are selected properly and taken under proper medical supervision. The active constituents, most often a secondary metabolite, varies in quality and quantity for a given plant species growing in different locations with diverse climatic conditions. Polyherbal formulations are the combinations of selected herbal drugs and are manufactured under different pharmaceutical processes to result in various dosage forms such as churnas, bhasmas, liquid, lehas, pill, tablet etc. This present review included the efficacy of various polyherbal formulations such as Vallarai chooranam, Chandanadi churna, Bilba churna, Amla churna, Sudarshan churna, Pushyanug churna, Thaaaleesaadhi chooranam, Diacure and Joloo etc against *Klebsiella pneumoniae*.

KEYWORDS: efficacy, polyherbal, churna, *Klebsiella*.

INTRODUCTION

Klebsiella pneumoniae is widely distributed in nature, found abundantly in soil and water. It is an anaerobic, nonmotile, rod-shaped, gram-negative bacterium with a prominent polysaccharide capsule. This capsule encases the entire cell surface, accounts for the large appearance of the organism on gram stain and provides resistance against many host defense mechanisms. It can cause infections of respiratory tract, nasal mucosa, pharynx and generally results in primary pneumonia. It is the second pathogen, next to *E. coli* which causes urinary tract infection. It normally affects persons with low immune system such as hospital patients, diabetes patients and people with chronic lung disease. Many a times, alcoholics also suffer from *K. pneumoniae* infections. Thus, the infections are either hospital-acquired or community-acquired. These bacteria have become important pathogens in nosocomial infections^[1] which have been well documented in United States^[2] and in India^[3]. Infections with Gram negative bacteria are of

looming concern as they are more difficult to treat. *K. pneumoniae* are major nosocomial pathogens producing extended spectrum betalactamase (ESBL). ESBL producers are usually susceptible only to carbapenems and these drugs have been the treatment of choice for severe infections by ESBL producer *K. pneumoniae*. More recently, the emergence of carbapenemase producing *K. pneumoniae* (KPC) has severely challenged antimicrobial therapy, since it confers a high level of resistance to all β -lactams and distinct levels of resistance to carbapenems^[4]. As *K. pneumoniae* is one of the most common nosocomial pathogens, its ability to produce extended spectrum β -lactamases (ESBLs) has caused great concern worldwide^[5]. The ESBL producers can also develop co-resistance to other classes of antimicrobial agents, such as fluoroquinolones, cotrimoxazole and aminoglycosides. However, a recent study showed its inhibition by Fosfomycin, an antibiotic used in the treatment of UTI related infections^[6]. Epidemiology of the species is discussed by Montgomerie in the year of 1979 and the comparison to its genomics study relating to antibiotics resistance is extensively studied and has revealed its resistance capacity^[7]. So, there is an urgent need of introducing new, effective antibiotics with lower side effect, such as natural antibiotic derived from plants. Polyherbal formulations with various active principles and properties have been used from ancient days to treat a whole range of human diseases. Generally, they are collection of therapeutic recipes that are formulated and prepared on the basis of the healing properties of individual ingredients with respect to the condition of sickness. Such herbal constituents with diverse pharmacological actions principally work together in a dynamic way to produce maximum therapeutic efficacy with minimum side effects. Nevertheless, these traditional medicinal preparations gradually lost their popularity and foothold among people due to the fast therapeutic action of allopathic system of medicine. In recent years however, renewed interest has grown on traditional herbal remedies because of the reportage of adverse side effects using synthetic drugs in allopathic medicine. At the same time, WHO also recommends further research on traditional method of treatment^[8].

Ayurvedic medicines are the combinations of selected herbal drugs and are manufactured under different pharmaceutical processes to result in various dosage forms such as churnas, bhasmas, liquid, lehas, pill, tablet etc. Churna is defined as a fine powder of drug or drugs in ayurvedic system of medicine. Churna formulations are similar to powder formulations in allopathic system of medicine. In recent days churna is formulated into tablets in order to fix the dose easily. These forms of medicament are prescribed generally because of their particle size. Smaller the particle size greater is the absorption rate from g.i.t and hence the greater is bioavailability. These churnas are made of fresh herbs that have medicinal properties, as well as the ability to neutralize

the toxic effects caused by imbalances within the body. Ayurvedic churnas combine all six of the ayurvedic tastes: sweet, sour, salty, pungent, bitter, and astringent. They are created through the combination of a number of different fresh herbs, and can be added to almost any foodstuff. The present review encompasses all the important aspects of polyherbal formulations against *Klebsiella pneumoniae*.

Efficacy of polyherbal formulations against *Klebsiella pneumoniae*:

Vallarai chooranam is a polyherb, consist of ten different herbs which is used for the treatment of diabetics, urinary tract infection, leucorrhea, venereal disease and also to improve memory power. A study was conducted to study the unexplored area of the *Vallarai* chooranam towards their antibacterial activity against both Gram positive and Gram negative organisms by Disc diffusion method. Aqueous and solvent extracts of the chooranam were tested against selected human pathogens including *K.pneumoniae*. Both the extracts were found to be more effective against all the test pathogens. The results of antibacterial activity revealed that both the extracts exhibited good inhibitory activity against *K.pneumoniae*. The presence of phytochemicals in the formulation was also assayed. Both the extracts of this formulation possess a broad spectrum of activity and open the possibility of finding new clinically effective antimicrobial compounds^[9].

Ayurvedic herbal preparations commonly used in ayurvedic system of medicine in treatment of various infectious diseases such as Pashanbhed churna, Arjuna churna, Bilba churna, Amla churna, Gokharu churna, Panchasakar churna, Trikatu churna, Avipattikar churna, Chandanadi churna, Pushyanug churna were investigated for antibacterial potential by disc diffusion method against *Klebsiella pneumoniae*. The study showed that Chandanadi churna, Bilba churna, Amla churna and Pushyanug churna were effective against the test organism. Hence, it is suggested that these herbal preparations not only supplement of the diet but also an alternative in the treatment and control of enteric bacterial infection^[10].

A study was conducted by et al to evaluate *in vitro* antimicrobial activity of urine from pregnant subjects following cranberry juice cocktail (CJC) or placebo ingestion against common pathogens causing asymptomatic bacteria. This study was conducted as an adjunct to a larger randomized, controlled trial. 4-hour uninfected urine samples were collected from 28 pregnant women who were randomized to cranberry or placebo in three groups: A. CJC 240 ml two times daily (C, C; n=10), B: CJC in the AM, then placebo in the PM (C, P; n=10), C: placebo two times daily (P, P; n=8). The pH of all specimens was adjusted to 7 and filtered. Aliquots were independently inoculated with overnight culture of 10²⁻³ cell/ml each of single strains of *E. coli* with both type I and type II fimbriae, *K. pneumoniae*, and *C. albicans*, and incubated. CFU/ml of

each specimen was enumerated by subculture with quantitative plate counts in duplicate. There were no differences between groups for any of the pathogens studies based on treatment allocation. We demonstrated no differences in direct antimicrobial activity against *E. coli*, *K. pneumonia* or *C. albicans* in the urine of pregnant based on differing daily cranberry doses. This may be due to beta-error. We found no difference in antimicrobial activity against *E. coli*, *K. pneumoniae* or *C. albicans* based on therapy. The lack of difference based on treatment may reflect a beta-error resulting from small sample size, a relatively low concentration of cranberry in the juice products provided, or timing related to ingestion^[11].

Thaaleesaadhi chooranam is a polyherbal formulation prepared from 23 different herbs being used for treatment of various kapha (in tamil) diseases and found to have antibacterial, antitumour, antioxidant, anti-inflammatory, anti-cancer, anti-viral and analgesic properties. The antibacterial activity of thaaleesaadhi chooranam was evaluated by et al. The aqueous and ethanolic extracts of thaaleesaadhi chooranam were tested for antibacterial activity against *K. pneumoniae*. The results of antibacterial activity revealed that the extracts showed good inhibitory activity against the test pathogen. Aqueous and methanol extracts of the formulation were found to be more effective against test pathogen used^[12].

Eclipta alba (L.) Hassk is small branched annual herbaceous plant with a long history of traditional medicines uses in many countries especially in tropical and subtropical regions. The herb has been known for its curative properties and has been utilized as antimytotoxic, analgesic, antibacterial, antihepatotoxic, antihemorrhagic, antihyperglycemic, antioxidant, immunomodulatory properties and it is considered as a good rejuvenator too. The antibacterial potential of aerial parts extracts of *Eclipta alba* in solvents like acetone, ethanol, methanol, aqueous and hexane against selected gram positive and gram negative bacterial species. The antibacterial studies were done by agar well diffusion methods. Hexane extract of *Eclipta alba* showed high antibacterial activity against *K.pneumoniae*. Whereas acetone, ethanol, methanol and aqueous extracts showed intermediate activity against *K. pneumoniae*. The inhibitory activities of all the extracts reported were compared with standard antibiotics (Ciprofloxacin 25 µg/ml). A potent antibacterial and hepatoprotective drug could probably be formulated from the plant extract of *Eclipta alba* to combat the effects of bacterial and hepatotoxic infections^[13].

Antimicrobial activity was also studied against *Bacillus subtilis*, *Escherichia coli* (enteropathogen), *Klebsiella pneumonia* and *Staphylococcus aureus* and *Staphylococcus* by using cup-plate method. Erythromycin was used as standard antibacterial agent. The methanol extract was diluted into different concentration (1,2, 4, 6, 8, 10 mg/100 µl)

with DMSO. The results of the study revealed that, the Pasuru exhibited significant antibacterial activity. The presence of these bioactive constituents have been linked to the antimicrobial activity of the plant material. Antibacterial activity of different concentration of methanol extract of Pasuru was measured in terms of Zone of Inhibition. It revealed that significant antibacterial activity was showed against *Klebsiella pneumoniae* in comparison with standard erythromycin. This activity is due to the constituents like *Acalypha indica*, *Ficus bengalensis*, *Morus alba* and *Tridax procumbence*, are having wound healing and antiseptic properties^[14].

Evaluation of the antibacterial activity of ethanolic (EHI), dichloromethanic (EDI) and hexanic (EHE) extracts from *Aristolochia cymbifera* stems and the combination of these extracts with an antimicrobial drug to develop a new antibacterial therapy. The EDI, EHE and EHI extracts were obtained by maceration using three different solvents. The minimal inhibitory concentrations (MIC) of these extracts were determined using the microdilution test to determine the antibacterial potential of these extracts and their combination with streptomycin against *Klebsiella pneumoniae*. The extract dose leading to the cytotoxicity of 50% of the cells (CC50) was evaluated using mammalian cells MA104 and the 3-(4,5-dimethylthiazol-2-yl)-2,5-diphenyltetrazolium bromide (MTT) colorimetric assay. The extracts had a MIC under 500 mg/L and a CC50 lower than 50 mg/L. The antibiotic/extract proportion influenced the antibacterial activity of the mixtures, and the proportion that optimized the antibacterial activity of streptomycin was a mixture that contained 75 percent of extract. This composition included less than 6.5 mg/L of extract and 2.5 mg/L of streptomycin and has potential as a new antibacterial therapy^[15].

Different parts (leaf, bulb and root) of *Acanthephippium bicolor* are collected in two seasons (summer and winter) and phytochemicals present in them are analyzed by et al. Leaf was found to possess most of the phytochemicals. Hence leaf was selected as study material. Antimicrobial activity of the various solvent extracts such as methanol, ethanol, chloroform, acetone, ethyl acetate, benzene and hexane were screened against *Klebsiella pneumoniae* for both summer and winter samples. Among the tested extracts the inhibition is found to be more in methanol extract. This proves that the bioactive compounds reside in methanolic extract. When the summer and winter samples are compared for their antimicrobial efficacy, there was no significant difference. This proves that there is no impact of season on antimicrobial activity of this plant. This research proves that *Acanthephippium bicolor* Lindley leaves can be used as herbal and scientific medicine throughout the year as there is no seasonal impact^[16].

The study was carried out to evaluate the antibacterial activity of herbal syrup formulation containing *Cocos nucifera* Linn against *K. pneumonia*. The antibacterial effect of aqueous soluble extract of root of *Cocos nucifera* Linn. at different concentrations were studied by disc-diffusion method in the concentrations of 25µl/disc, 50µl/disc and 100µl/disc. Ciprofloxacin hydrochloride taken at 5µl/disc was selected as the standard drug. Increased antibacterial activity was observed with increase in concentration. The study concluded that the additives present in the formulation were not affecting the antibacterial activity. The report of *in-vitro* antibacterial activity revealed that there was no significant difference in activity between the water soluble extract and the formulation containing water soluble drug. The study concluded that the additives present in the formulation were not affecting the antibacterial activity^[17].

The aim of this work is based on assessing the prevalence of the bacteria *Klebsiella pneumonia* in the patients of pneumonia and to check the activity of medicinal plants and their effect in synergism with allopathic drugs against the organism. Fruit parts and aerial parts of five medicinal plants of *Dasmodium gangeticum*, *Nelumbo nucifera*, *Canabis*, *Sesame white* and *Sesame black* have been used in the form of three different extract i.e. methanolic, ethanolic and aqueous and their antibacterial activity was carried out. The antibacterial activity of 12 commercial drugs was assayed by Kirby-Bauer disc diffusion method. Approximately 80% of the recovered isolates showed the sensitive activity against Ceftazidime, ofloxacin, gentamycin, ciprofloxacin, and resistant activity against Carbencillin, Ceftizoxime, Amikacin, Cefotaxime, Amoxicillin, Cephalexin, Chloramphenicol and Tetracycline. The diameter of inhibition zones observed in 4 drugs namely Ceftazidime (16mm), ofloxacin (20mm), gentamycin (22mm), ciprofloxacin (20mm). Our study showed that aqueous extract of all the selected plants gave maximum zone of inhibition against *Klebsiella pneumonia*^[18].

Leaf decoctions of *Carissa spinarum*, *Urtica dioica*, *Warburgia ugandensis*, *Senna didymobotrya*, *Physalis peruviana*, *Bidens pilosa*, *Leonotis nepetifolia* and *Toddalia asiatica*, are used for the treatment of diabetes, malaria and pneumonia among other diseases in Kisii region, southwest Kenya. However, the pH levels of aqueous extracts of these herbs have not been adequately described yet these would have implications on the body's biological system. A study was carried out on these herbs in the year 2011 to 2012 by Moses et al. They have determined the pH levels of the aqueous extracts of these herbs. In the study, leaf samples of the eight selected plants were obtained from Kisii region, washed, air-dried and milled. A portion of the powdered leaves was dissolved in distilled water to obtain aqueous extract. The pH levels of the aqueous extracts of the samples were measured using a pH meter. Results showed that the pH

levels of these selected herbs are acidic with pH ranged from 5.27 to 5.99. The exception was *Urtica dioica* which had basic pH of 7.5. They have concluded that the acidity and basicity of the eight herbs evaluated is within the permitted pH range of 4.0 to 7.5^[19].

The crude extract of the leaves of *Mitracarpus scarber* "Zucc" was formulated as syrup. The antimicrobial activity of the formulation was evaluated using agar plates and concentrations of the extract varying between 25mg/ml and 300mg/ml to determine the minimum inhibitory concentration at 37°C against *Klebsiella pneumoniae*. The growth of *Klebsiella pneumoniae* was inhibited by the formulation at a minimum inhibitory concentration of 75mg/ml. Formulating this extract, as syrup did not obstruct the diffusion of the active principle(s) in the formulation hence the zones of inhibition at 75mg/ml recorded for both the simple solution and the syrup were the same^[20].

Crude extracts of *Punica granatum* pericarp was prepared and converted into a gel and tested against *Klebsiella pneumonia*. The MIC was also recorded as the lowest concentration of drug which showed clear fluid without turbidity. Minimum inhibitory concentration of *Punica granatum* peel ranged from 0.05-3.2 mg/ml⁻¹. The formulation containing the extract showed significant zone of inhibition as compared to the marketed preparation^[21].

An attempt was made to evaluate the antibacterial activity of hexane, petroleum ether, benzene, methanol and aqueous extracts of root and seed of *Mucuna pruriens* by Murugan et al. The extracts were tested against *Klebsiella pneumoniae* using disc diffusion method. The extracts of *Mucuna pruriens* root and seed possess various degrees of significant inhibitory effect against the tested organism. Benzene, Petroleum ether and methanol extracts of root and seed showed activity against *Klebsiella pneumoniae*. Aqueous extract of the seed fails to inhibit the growth of *K. pneumoniae*^[22].

The antibacterial efficacy of polyherbal formulation was studied by Muthubalaji et al against *K. pneumonia*. The different solvents used for the preparation of extracts were hexane, acetone, ethanol and water. Among these solvents, acetone and ethanol extracts showed fine antibacterial activity against *K. pneumonia*. Acetone and ethanol extracts showed (14mm & 12mm) zone of inhibition against *K. pneumonia* whereas no zone was observed in aqueous and hexane extract. This antibacterial efficacy of the herbal formulation may be due to the presence of various secondary metabolites such as flavonoids, terpenoids and tannins. The results of the study exhibited that the tested Polyherbal extracts possess antibacterial activity against tested pathogen^[23].

A study was done to screen the antibacterial activity of the seed extracts of *Pongamia pinnata* Linn against *Klebsiella pneumonia*. Good quality seeds were collected and the extracts were prepared by using methanol and ethanol as solvents. The seed extract was tested by using Agar well Diffusion method at the concentration of 100µg/ml and the same was compared with the antibiotic Cefazidime at equal concentration. Methanol extracts of *Pongamia pinnata* showed higher antibacterial activity than ethanol extracts of *Pongamia pinnata*^[24].

The decoction of the aerial parts of *Rhynchosia recinosa* is used in combination with the stem barks of *Ozoroa insignis*, *Maytenus senegalensis*, *Entada abyssinica* and *Lannea schimperi* as a traditional remedy for managing peptic ulcers. The individual extracts and their combinations were tested for antibacterial activity against *Klebsiella pneumoniae* using the microdilution method. Both the individual plant extracts and the mixed extracts of five plants exhibited weak to moderate antibacterial activity against the test organism^[25].

Diacure a polyherbal formulation containing eleven medicinal plants. Methanol extract of diacure was tested against *Klebsiella pneumonia* by using disc diffusion method. The methanol extract of diacure was found to be effective against the test organism. The extract was evaluated at different concentrations among them the 100µl/disc showed greatest antimicrobial activity^[26].

Methanol and acetone extract of five Indian spices were used to determine their antibacterial properties against *Klebsiella pneumonia* by Bhawana et al. The five common Indian spices used for their study were clove, ajwain, turmeric, dalchini and black pepper. The results revealed that the methanol extracts of the spices have higher antimicrobial activities as compare to acetone extracts of the spices in same concentration. In the antimicrobial study of spices, antimicrobial activity against *Klebsiella pneumoniae* maximum activity was shown in methanol extract of dalchini and minimum activity was shown in both acetone and methanol black pepper extract^[27].

The present work aimed to find out the antibacterial activity of *Nymphaea nouchali* flower on human and plant pathogenic bacteria. Antibacterial potency of methanol, acetone, ethyl acetate and petroleum spirit extracts of *Nymphaea nouchali* flower has been tested against *Klebsiella pneumonia* (ATTC 10031) by disc diffusion assay. Methanol extract possessed better antibacterial activity as compared to the other extracts^[28].

Synergistic effect of individual counterparts of formulations leads to the development of combination therapy. The synergistic effect of two medicinal plants viz. *Murraya koenigii* and *Sesamum indicum* for their *in-vitro* antibacterial activity was carried out by Manjulika et al. *In-vitro* antibacterial activity was assessed for a range of varied concentrations of formulation against *Klebsiella pneumoniae* and the results were compared with standard drug, ampicillin as

well as with individual plants. The formulation was found to have significant efficacy in comparison to the individual plants. The minimum inhibitory concentration of formulation was 0.075mg/ml against *Klebsiella pneumoniae* which is very low as compared to individual plants. This formulation with enhanced potential to reduce bacterial infections could be developed as a novel therapeutic agent. The higher MIC values associated with the *S. indicum* aqueous extract were found to be 5.0 mg/ml for *K. pneumoniae*. The study therefore not only justified the traditional use of these two medicinal plants viz. *M. koenigii* and *S. indicum* as antibacterial agents but also validates their synergistic effect with improved antibacterial potential in the formulation^[29].

Joloo is a herbal preparation locally used in the management of breast tumour in southwestern Nigeria. A study was conducted to evaluate the antibacterial property of the formulation by Oloyede et al against *Klebsiella pneumoniae*. The antimicrobial screening of Joloo was carried out *in-vitro* in three different concentrations (500mg/ml, 1000mg/ml and 1500mg/ml) by using the agar well dilution method. The study revealed that *Klebsiella pneumoniae* was resistant to the preparation^[30].

A study was aimed to design, develop and evaluate the antiseptic activity of herbal wound pad Neemplast containing distillate of Neem leaves (*Azadirachta indica*) and Black pepper (*Piper nigrum*) and the oil of clove (*Syzygium aromaticum*) and Eucalyptus (*Eucalyptus globules*). Various formulation batches were prepared and evaluated for their antimicrobial activity. Neemplast wound pad was successfully designed and developed after extensive manufacturing and evaluation process by specialized techniques for evaluation of antiseptic activity *in vitro*. The study showed that the developed polyherbal antiseptic wound pad was successfully designed, developed and assessed its activity by antimicrobial activity against *Klebsiella pneumoniae*^[31].

Sudarshan Churna is very potent ayurvedic medicine; composed of 42 medicinal plants, which is used traditionally in treatment of malaria, viral fever and bacterial infection. The activity of this formulation was compared with the standard antibiotics like Amikacin and Norfloxacin by Baljinder et al. Ethanol, methanol and acetone extract of Sudarshan Churna were prepared and studied against *Klebsiella pneumoniae*. The results of their study demonstrated good antimicrobial activity and thus can form the basis for the development of a novel antibacterial formulation. From their study it was observed that *Klebsiella pneumoniae* showed sensitivity against ethanol and acetone extract^[32].

The essential oil of *Ocimum gratissimum* was tested for its antibacterial activity against *Klebsiella* sp. by Nakamura et al. The minimal inhibitory concentrations against *Klebsiella* sp., was found to be at concentrations ranging from 3 to 12 µg/ml. The minimum bactericidal concentration of the essential oil was within a twofold dilution of the MIC for this organism. The essential oil was also active against members of the family Enterobacteriaceae. The compound that showed antibacterial activity in the essential oil of *O. gratissimum* was identified as eugenol^[33].

Hydro-distilled volatile oils from the leaves of *Ocimum gratissimum* from Meru district in Eastern Kenya were evaluated for antimicrobial activity by Matasyoh et al. The antimicrobial activities of the essential oils were evaluated against both Gram positive and Gram negative organisms including *K. pneumoniae* along with fungal strains. The minimum inhibitory concentration of oil for gram negative bacteria ranged from 107 to 750 mg/ml and 93.7 to 150 mg/ml for gram positive bacteria. The minimum inhibitory concentration for the fungus *C. albicans* was 50 mg/ml. The minimum inhibitory concentration values for chloramphenicol ranged from 22.5 to 31.3 mg/ml. The oil had pronounced antibacterial and antifungal activities on all the microbes^[34].

The antimicrobial activity of methanolic extract of *Mimosa pudica* was tested against *Klebsiella pneumonia* at different concentrations of 50, 100 and 200 µg/disc by Gandhiraja et al. The antimicrobial activity was attributed due to the presence of bioactive constituents like terpenoids, flavonoids, glycosides, alkaloids, quinines, phenols, tannins, saponins and coumarin^[35].

Adoni et al investigated the effect of aqueous and ethanolic extracts of the stem bark of two Nigerian medicinal plants against *K. pneumonia* using two standard antibiotics (Chloramphenicol and Ampicilin) as reference drugs. The plants used for their study were *Alstonia boonei* and *Morinda lucida*. The result showed that, the aqueous extract of the stem bark of *M. lucida* found to be inactive at the concentration between 500-1000mg/ml against *K. pneumonia*. The ethanol extract of the stem bark however, gave the best result at MIC dose of between 250-1000mg/ml by inhibiting the growth of *K. pneumonia*^[36].

Maneemegalai et al studies the antibacterial activity of ethanol, methanol and aqueous extracts of dry flower and ethanol, methanol and acetone extracts of fresh flower of *Cassia auriculata* by using agar disc diffusion method using *Klebsiella pneumoniae*. The extracts were found to be less active against the test organism. The minimum inhibitory concentration ranged between 12.5 mg/mL and 75mg/mL depending on microorganism and the extract used^[37].

The antibacterial effect of the methanolic and aqueous extract of the leaves of *Annona muricata* was tested against *Klebsiella pneumonia* (NCIM No.2719). The extracts were found to be active against the test organism *K. pneumonia*. Leaf extract of *Annona muricata* is used in the treatment of various bacterial infectious diseases such as pneumonia, diarrhoea, urinary tract infection and even some skin disease^[38].

The light petroleum ether, chloroform and ethanol extracts of *Mesua ferrea* seeds, leaves and stem bark were evaluated against *Klebsiella* species by disk diffusion method at 400 µg disk-1. Chloroform extract of *M. ferrea* stem bark displayed strong activity against the test organism whereas of leaves extracts were found to be mild to moderate active against this^[39].

Antibacterial activity of aqueous and alcoholic extracts of *M. ferrea* seeds were tested at 100 µl by the agar disc diffusion and agar well diffusion methods against *K. pneumoniae* (NCIM2719). Maximum antibacterial activity was found against *K. pneumoniae* (20mm). The ethanol/methanol extracts^[40] were more active than aqueous extracts^[40].

Phomopsis sp. GJJM07 (an endophyte) was isolated from *M. ferrea*. The crude ethyl acetate extract of the fungus was evaluated for antimicrobial activity. The endophytic fungus was grown in different media and was tested against *K. pneumoniae*. Among the different media, M1D medium showed good growth 1.57 g MDW/100 ml and broad spectrum of antimicrobial activity by exhibiting prominent zone of inhibition against the test pathogen *K. pneumoniae* (16 ± 0.19)^[41].

The ether-water extracts of *G. glabra* were prepared and tested against *K. pneumonia*. It was found to have effective antibacterial activity this test organism^[42].

Bark extracts of *Saraca asoca* (Roxb.) de Willde were investigated for *in vitro* antibacterial activity against *Klebsiella pneumoniae* at 4 mg/ml using agar well diffusion method. The ethanol and distilled water extracts showed significant broad spectrum antibacterial activity^[43].

CONCLUSION

Presently there is an increasing interest worldwide in herbal medicines accompanied by increased laboratory investigation about their pharmacological properties of the bioactive constituents and their ability to treat various diseases. In recent years, there has been an increase in *Klebsiella* infections, especially in hospitals, mostly due to multiple antibiotic resistant strains. It can evade host defenses in normal and impaired hosts and spreads to the upper or lower respiratory tract, it may invade the bloodstream, causing invasive diseases. Besides, it is constantly being studied for the frequency with which resistance occurs against the most common antibiotics. This present review has covered the morphology and types of diseases

caused by *Klebsiella pneumoniae*. The activity of different plant parts in different solvents against *Klebsiella pneumoniae* was included. Special emphasis about the efficacy of polyherbal formulations against *Klebsiella pneumoniae* was included which will encourage the young researchers to carry out further study of polyherbal formulations.

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