IJEAST

INTERNATIONAL JOURNAL
OF ENGINEERING APPLIED SCIENCE
AND TECHNOLOGY

VOLUME : 6 ISSUE : 4 Print / Issue Publication Date: 17-Oct-2021

ISSN : 2455-2143

DOI : 10.33564/IJEAST.2021.v06i04.011

Indexed In

Google SCHOLAR OPEN ACCESS doi Crossref

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International Journal of Engineering Applied Sciences and Technology, 2021
Vol. 6, Issue 4, ISSN No. 2455-2143, Pages 78-84
Published Online August 2021 in IJEAST (http://www.ijeast.com)

ANTIBACTERIAL ACTIVITIES OF SOME MEDICINAL PLANTS AND GREEN LEAFY VEGETABLES: A REVIEW

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Abstract - Plants are considered not only as dietary supplement to living organisms but also traditionally used for treating many health problems and the medicinal value of many plants still remains unexplored investigations of plants are carried out to find novel drugs or templates for the development of new therapeutic agents. Plants produce a wide variety of phytochemical constituents, which are secondary metabolites and are used either directly or indirectly in the pharmaceutical industry. Majority of the population, especially those living in rural areas depends largely on medicinal plants for treatment of diseases. The resistance of pathogenic bacterial strains to antibiotics is the major burning issue around the world. Pharmacological industries have produced various new antibiotics ever since, but microorganisms have slowly developed resistance to these drugs because bacteria have the genetic capability to transmit and acquire resistance to these drug. Plants and plant products are a better alternative compared to antibiotics and other synthetic drugs which display negative side effects such as sensitization reactions, and disruption of the metabolic processes in the body via interaction with the body system. Hence antimicrobial agents from plants are a more reliable and effective source to fight these microorganisms without the development of resistance.

Key words: Phytochemicals, Antibacterial activity, Medicinal plants, Green Leafy Vegetables

I. INTRODUCTION

Medicinal plants are the most valuable source of curative drugs used as traditional medicines and folk medicines. Medicinal plants are plants containing potential active ingredients used to cure disease or relieve pain. The term "phyto medicine" determines the parts of plants (leaves, roots, flowers, seeds, bark and stems etc.) used for preparing medicines (Bereksi *et al.,* 2018). A wide range of medicinal plants parts are used to extract raw drugs and they possess varied medicinal properties. While some of these raw drugs are collected in smaller quantities by the local communities and folk healers for local used, many other raw drugs are collected in larger quantities and traded in the market as the raw materials for many herbal industries (De zoysa *et al.,* 2019).
Now a days herbal medicines are used as better remedies due to their lesser side effects, better adoptability with an economical affordability (Firas *et al.,* 2019).

Sri Lanka is blessed with a wide variety of leafy vegetables also. The consumption of leafy vegetables as means of obtaining nutrients especially micronutrients has been developed among Sri Lankans. Furthermore, many leafy vegetables have been used in traditional medicine for therapeutic and curative purposes (Lopez *et al.,* 2018). As well as, many nutritional studies have given an important consideration for dark green leafy vegetables in dietary as rich sources of vitamins, especially vitamins A and C, minerals, including calcium, phosphorus and iron and secondary plant compounds, particularly antioxidants. The dietary intake of leafy vegetables is negatively associated with many chronic disorders conditions such as diabetes mellitus, cancer, cardiovascular diseases, cataract and age related functional declines (Bereksi *et al.,* 2018).

Nasrullah *et al.,* (2019) provide evidence that a substantial proportion of the Sri Lankan people acquires meals that not include servings or very few servings of leafy vegetables, though Sri Lanka produces a significant quantity. Some part of the human population still suffers from one or more micronutrient deficiencies as a result of diets that are deficient in nutrient rich foods.

II. MEDICINAL PLANTS AS ANTIMICROBIAL AGENTS

Microorganisms are becoming resistant towards commercially available antibiotics. Bacteria that are resistant towards antiseptics, antibiotics and disinfectants cause major health problems. Bacterial resistance may be due to mobile genetic elements such as transposons, naked DNA or bacteriophages, plasmids (Pradhan *et al.*, 2019).

Antibiotics were investigated in the 19th century, and administered to patients routinely. They have successfully solved public health disorders caused by bacterial infections, but certain antibiotics also cause detrimental side effects. These side effects include adverse allergic reactions, immune response, hypersensitivity, depression of the bone marrow, nausea, thrombocytopenic purpura and other previously uncommon diseases (Bereksi *et al.,* 2018). Antibiotics react with the body system and disrupt important metabolic processes (Lopez *et al.,* 2018). Apart from that, the indiscriminate use of antibiotics in the treatment of infectious disease and the design of antibiotics with limited chemical scaffolds and few advances since the 1980s, led to the development of multiple drug resistant bacteria (Talbot *et al.*, 2016). A potential solution for this problem is by using alternative antimicrobial agents investigated from nature. The extraction of bioactive components including antimicrobial peptides and phenolic compounds from natural sources like medicinal plants to treat bacterial infections seem attractive (Lehrer *et al.,* 2018).

The knowledge of using plants to naturally alleviate human health has been around for decades. Approximately 70,000 plants have the potential to treat various ailments (Hussain *et al.*, 2017). With few exceptions, naturally occurring plant materials have lesser side effects on the human body when consumed at the right dosage and are more affordable compared to synthetic alternatives (Bereksi *et al.*, 2018). In fact, 80% of the world population depend on plant based medicines (Nasrullah *et al.,* 2019).

Although synthetic drugs and antibiotics brought about a revolution in disease management, medicinal plants serve as a raw material for some important modern medicine and were used to cure lethal diseases even before synthetic drugs were discovered. Medicinal plants serve as a cure for diseases for millions of people inhabiting remote places in the world, who are unable to gain access to synthetic drugs and depend on traditional healers (Muthukrishnan *et al.*, 2017).

Plant extracts are selected as antimicrobial agent after thorough biological evaluation of the safety and efficacy of the extracts followed by the process of identifying bioactive compounds, formulating dosage, efficacy and determining the pharmacokinetic profile of the new drug (Talbot *et al.*, 2016).

III. BIO- ACTIVE COMPONENTS IN PLANTS

There are about 100,000 bioactive compounds produced in plants also identified as the aromatic secondary metabolites. Secondary metabolites are mostly derived from isoprenoid, phenylpropanoid, alkaloid or fatty acid/polyketide pathways and differ from plant primary metabolites as they are not involved in intermediary metabolism of the plant. The numerous secondary metabolites present in plants are a result of plant evolution towards improved defense against microbes and predators giving plants their antimicrobial trait (Dixon, 2017). Most secondary metabolites are constitutive in healthy plants while others may exist as inactive precursors activated by tissue damage or pathogenic infections (Osbourn, 2016).

Medicinal properties of plants are due to the combinations of secondary metabolites such as alkaloids, steroids, tannins, and phenolic compounds that are synthesized and deposited in specific or in all parts of the plant. These medicinal properties are specific in a plant family, genus and species proving the fact that combinations of secondary metabolites are distinct between plant taxa (Parekh *et al.*, 2018).

Medicinal plant extracts and phytochemical constituents present in the plant tissues with well-known antimicrobial properties play an important role in promoting human health and are non-toxic to the human body (Pekamwar *et al*., 2018). Plant extracts work in synergy with synthetic antibiotics against drug resistant bacteria (Ncube *et al.,* 2018). The antimicrobial activity is due to the recognition of potential target sites in microorganisms by plant secondary metabolites which resembles endogenous metabolites, ligands, hormones, signal transduction molecules or neurotransmitters (Parekh *et al*., 2018).

IV. PLANT DERIVED ANTIBIOTICS

Antibiotics function via bacteriostatic or bactericidal actions by accessing the intracellular target sites of bacteria. Gram-positive bacteria do not consist of an outer membrane and are relatively susceptible to antimicrobial agents. Gram-negative bacteria possess of an outer membrane which is a permeability barrier and is the main determining factor of antimicrobial resistance in bacteria (De zoysa *et al.,* 2019).

Plant derived antibiotics that overcome the outer membrane barrier are effective as antimicrobial agents. Plants have multiple methods of defense against pathogens where some defense mechanism are pre-formed while others are triggered after recognition of pathogen attack (Jones & Dangle, 2016). Two groups of plant antibiotics that are involved in plant defense mechanism are phytoalexins and phytoanticipins.

Ethnobotany and Ethnopharmacology

Due to the growing interest in traditional and folk medicines, various scientific principles have emerged such as ethnobotany, ethnomedicine and ethnopharmacology. The term ethnobotany was coined by Hershberger in the year 1895 and since then several definitions have been assigned to ethnobotany. It is now globally defined as the study of the "direct relationship between humans and plants" (Jouda *et al.*, 2018).

The term of Ethnobotany is on how plants are used, managed and perceived in human societies and includes plants are used for food medicine, cosmetics, textiles, clothing, currency, rituals, tools, constructing buildings and social day to day life (Jouda *et al.*, 2018).

According to Jones & Dangle (2016), ethnopharmacology is defined as the "interdisciplinary scientific exploration of biologically active agents traditionally employed or observed by man" and its objectives are "to rescue and document a vast cultural knowledge before it is lost to the world, and to investigate and evaluate the agents employed without any prejudice or bias in order to find the rationale for their use."

Phytochemical screening and Antibacterial activity evaluation

Ghosh *et al.*, (2018) investigated the antibacterial activity of root extract of *Boerhaavia diffusa*. The chloroform and methanol extracts of plants were screened against six bacterial viz *staphylococcus aureus, Escherichia Coli, proteus mirablis, salmonella typhimurium, Pseudomonas aeruginosa* and *Klebsiella aerogenes*. Benzene-ethyl acetate (4:1) of chloroform extract showed activity against *E.Coli, S.typhimurium* and *P.aeruginosa*. The nbutanol extract of methanol was active against *P. mirablis* and *S. typhimurium*. A phenolic compound isolated from the above fraction exhibited activity against *P. mirablis* only.

Umamaheswari *et al*., (2017) studied the qualitative analysis of phytochemicals and antimicrobial activity of various solvent extracts of *Boerhavia diffusa* leaves. The antimicrobial activity of different solvent extracts of *B. diffusa* leaves were tested against the Gram-positive bacteria namely, *Staphylococcus aureus, Bacillus subtilis, Streptococcus faecalis* and *Micrococcus luteus*, and the Gram-negative bacteria namely, *Escherichia coli*, *Pseudomonas aeruginosa, Salmonella typhii, Klebsiella pneumoniae, Proteus vulgaris, Serratia marcescens, Shigella flexneri* and *Vibrio cholera*. The ethanol, methanol, chloroform, ethyl acetate and aqueous extracts of *Boerhavia diffusa* exhibited inhibitory activity against both Gram-positive and Gram-negative bacteria. The ethanol extract of *B. diffusa* leaves showed more activity against Gram-positive and Gram-negative bacteria when compared to other solvent extracts except *V. cholerae*.

Saraf (2017) reported the in vitro antibacterial activity of rhizome extract of *C. speciosus.* The plants have shown efficient results against the bacterial strains like *Escherchia coli*, *Staphyllococcus aureus*, *Klebsiella pneumoniae* and *Pseudomonas aeruginosa.* Rhizome extract of *C. speciosus* was found to be effective against *Staphylococcus epidermidis* and *Salmonella typhimurium*, and hence used as a potential bactericidal agent (Ariharan *et al.,* 2016).

Malabadi *et al.*, (2019) have studied the hexane, methanol and aqueous extracts of stem and rhizomes of *C. speciosus* for *in vitro* antibacterial activities against pathogens isolated from infected burn patients, *Shigella*, *Staphylococcus aureus*, *Escherichia coli, Klebsiella pneumoniae, Pseudomonas*, *Bacillus subtilis* and *Salmonella*. The disc-diffusion method showed significant zone of lysis against all the pathogens studied.

Daisy *et al.*, (2018) investigated the phytochemical content and antibacterial activity of rhizome extracts of *Costus speciosus.* The ethanol rhizome extract of *Costus speciosus* exhibited maximum inhibitory action against both Gram- positive and Gram- negative bacterial strains. Phytochemical screening indicated that, rhizomes were rich in a variety of primary and secondary metabolites.

Choudhury *et al.*, (2018) reported the antimicrobial activity and qualitative phytochemical evaluation of *Costus speciosus*. Methanol leaf extract of *Costus speciosus* revealed the highest antibacterial activity against Gram negative bacterial strain, *Salmonella typhi*. Qualitative evaluation of *Costus speciosus* showed that maximum amount of phytochemical compounds were in leaves by methanol extract than the petroleum ether extract.

Abubakar *et al.,* (2017) evaluated the flower and bark extracts of *S. grandiflora* for their antimicrobial activity and the results were compared with standard drugs. Ethanol extracts exhibited highest antibacterial activity being comparatively more prominent on the gram negative bacteria than the gram positive bacteria.

Babalola *et al.,* (2019) investigated the preliminary antibacterial activity of *Manihot esculenta* against both gram-positive and gram-negative organisms by using sauce that was made from the sap of cassava and was reputed to extend the life of cooked meats. Their results revealed that the growth of bacteria was prevented in cooked beef and have determined that the sauce was bacteriostatic at lower concentrations and bactericidal at higher concentrations and that *Bacillus substilis* was more sensitive to cassava sauce than *Escherichia coli.*

Saad *et al.,* (2017) reported the phytochemical constituent and potential antibacterial activity of *Manihot esculenta* against five clinical pathogens (*Escherichia coli, Klebsiella peumoniae, Pseudomonas aeruginosa, Staphylococcus aureus* and *Bacillus subtilis*). The ethanol extracts of plant leaves were prepared by using Soxhlet extraction and the *in-vitro* testing were conducted using disc diffusion method. As the concentrations of extracts increases, the bacterial inhibition zones were also increased; thus, the more effective the antibacterial properties. The most susceptible bacteria were *S.aureus*, followed by *K. peumoniae* and the most resistant bacteria were *P. aeruginosa* and *Bacillus subtilis.*

Popoola *et al.,* (2017) reported antimicrobial inhibitory properties of cassava seed oil in the inhibition of skin pathogenic microorganisms such as *Staphylococcus aureus, Propionibacterium acnes, Escherichia coli, Pityrosporum ovale* and *Candida albicans*. Zakaria *et al.,* (2016) reported low toxicity in the in-vitro antibacterial activity and brine shrimp toxicity of *Manihot esculenta* extracts in which chloroform extract exhibited quite good antibacterial activity against *L. moncytogenes, Vibrio cholerae, Shigella flexneri, Salmonella typhi* while ethanolic extract was effective against *P. aeroginosa, C. diphtheria* and *V. cholera*.

The investigation was carried out by Johnson and Irudayaraj (2018) to examine the phytochemical constituents and antibacterial activity of *Passiflora edulis,* revealed the presence of carbohydrates, glycosides, flavonoids, alkaloids and phenolic compounds as their primary and secondary metabolites. The antimicrobial activities of the leaf extracts were screened against *Escherichia coli, Bacillus subtilis, Staphylococcus aureus, Pseudomonas aeruginosa, Salmonella typhi, Klebsiella pneumoniae* and among the extracts which were examined, Methanol leaf extract exhibited the highest antimicrobial activity against all the tested bacteria.

Rizwana *et al.,* (2019) evaluated the antibacterial activity of petroleum ether, chloroform and ethanol, leaf and stem extracts of *Passiflora edulis.* Crude chloroform extract of leaf showed moderate antibacterial activity against twelve microorganisms at concentration of 500 μg/ml. There were no activity observed in the petroleum ether extract. The crude chloroform and petroleum ether extracts of stem showed notable antibacterial activity at concentration of 500 μg/ml against twelve microorganisms.

Ramaiya *et al.,* (2017) tested the organic extracts of *Passsiflora edulis* for antibacterial activity against clinically important Gram positive and Gram negative bacteria pathogens namely: *Staphylococcus aureus, Bacillus sp, Streptococcus sp, Escherichia coli, Salmonella sp* and *Shigella sp*. Ethyl acetate leaf extract inhibited the growth of *S. aureus, Bacillus sp,, Salmonella sp* and *Shigella sp,* excellently. The ethanol stem extract also showed antibacterial activity against *S. aureus, E. coli* and *Shigella sp* while the ethyl acetate leaf extract indicated broader spectrum of antibacterial activity as compared to the ethanol stem extract, both at higher concentrations.

Muthumani *et al.,* (2017) investigated the phytochemical screening and antibacterial activity of *Toddalia asiatica.* Antibacterial activity of aerial parts of ethanol, chloroform and ethyl acetate extracts showed significant inhibitory activity against the human pathogens such as *Enterobacter faecalis* causing nosocomial infections, *Proteus vulgaris, Pseudomonas aeruginosa* causing urinary tract infections and *Serratia marcescens* causing wound and urinary tract infections. Gakuubi *et al.,* (2017) have studied the antibacterial prospective of essential oil (EO) extracted from *Toddalia asiatica* against four pathogenic bacteria.

Pradhan *et al.,* (2019) evaluated the in-vitro antibacterial potential of *Adhatoda vasica* Nees. leaves against some selected human pathogens causing infections of UT, GIT and skin. N-hexane, methanol and water were used as solvents for the extraction in a successive manner. The methanolic extract of *Adhatoda vasica* showed the highest antibacterial activity against *Streptococcus mitis.*

Sheeba and Mohan (2017) stated the antibacterial activity of *Adhatoda vasica* against clinical pathogens.

Methanol, ethanol, acetone, chloroform, diethyl ether and water were used as solvents for the preparation of plant extracts in various concentrations. As per the results, diethyl ether extract of *Adhatoda vasica* showed the highest activity on *Klebsiella pneumoniae* followed by *Streptococcus Pyogens*.

Bhattacharya *et al.*, (2018) evaluated the antibacterial activity of aqueous and ethanol leaf extracts of *Coccinia grandis* against *Shigella flexneri*, *Bacillus subtilis*, *Escherichia coli*, *Salmonella choleraesuis*, *Shigella dysenteries*, and *Shigella flexneri*. Aqueous extract of *Coccinia grandis* showed highest significant antibacterial activity in comparison to ethanol extract. A polar moiety of this *Coccinia grandis* extract is more responsible for antibacterial properties.

Kavitha *et al.*, (2017) evaluated the in vitro antibacterial activity of *Coccinia grandis* leaves and stem extracts against gram positive and gram negative bacterial strains. The crude extract exhibited a broad spectrum antibacterial activity against both the gram positive and gram negative bacterial groups.

Kumari *et al*., (2017) evaluated the phytochemical screening and antibacterial Activity of *Erythrina variegata*. Hexane, chloroform, dichloromethane, ethyl acetate, methanol and aqueous were used as solvents for their phytochemicals and antibacterial activity against selected five bacterial culture namely *Staphylococcus aureus*, *Pseudomonas aeruginosa*, *Escherichia coli*, *Klebsiella pneumoniae, Proteus vulgaris*. The chloroform extract showed greater activity than other extracts. The methanolic leaf extract of *Erythrina variegata* showed higher activity against *Pseudomonas aeruginosa* and *Staphylococcus aureus* followed by *Klebsiella pneumoniae*, *Proteus vulgaris* and *Escherichia coli*. The methanolic leaf extract of *Erythrina variegata* exhibited the maximum zone of inhibition against *Staphylococcus aureus*. The ethyl acetate extract of *Erythrina variegata* showed the highest activity against *Escherichia coli* and *Staphylococcus aureus* followed by methanol, chloroform, hexane and aqueous extracts. The results showed that the antimicrobial activity exhibited by *Erythrina variegata* chloroform and aqueous extract noted to be most effective than other solvents.

Muthukrishnan *et al*., (2017) stated phytochemical screening and antibacterial activity of *Erythrina Variegata*. Aqueous, methanol, ethanol, hexane and dimethyl sulfoxide extracts were evaluated for their phytochemicals and antimicrobial activity against selected five bacterial strains. The ethanolic leaf extract of *Erythrina variegata* exhibited higher activity against *Pseudomonas aeruginosa* followed by *Klebsiella pneumoniae*, *Escherichia coli* and *Bacillus cereus*. The methanolic leaf extract of *Erythrina variegata* showed highest zone of inhibition against *Staphylococcus aureus*. The results showed that the antimicrobial activity exhibited by *Erythrina variegata* ethanolic extract noted to be most effective than other solvents.

V. CONCLUSION

It could be concluded that the findings of this review support to the traditional knowledge of local users and provide a preliminary scientific validation for the use of medicinal plants and Green Leafy Vegetables for antibacterial activity which will be a platform for clinical applications.

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