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REVIEW ARTICLE

Review on a few South Indian medicinal plants as antimicrobial agents

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Abstract: The Plant kingdom is a storehouse of potential drugs. Plant derived medicines have made large contributions to human health and well-being. They play dual role in the development of new drugs. At first they act as a natural blueprint for the development of new drugs and secondly they can be used for the treatment of infectious diseases. Many evidences gathered from earlier studies which confirmed that the presence of variety of phytochemicals in plants contribute medicinal properties. In this present review, an attempt has been made to give an overview of few south Indian medicinal plants and their phytochemicals which are useful in the treatment of several infectious diseases.

Key Words: South Indian, Medicinal Plants, Antibacterial, Antimicrobial activity

Introduction

Infectious diseases are the world`s leading cause of premature deaths, killing almost 50,000 people every day. Morbidity and Mortality due to diarrhea is continuous to be a major problem in many developing countries, especially amongst children. Infections due to a variety of bacterial agents such as pathogenic *E. coli, Vibrio cholera, Shigella spp., Salmonella spp., Pseudomonas spp., Klebsiella spp. and Staphylococcus aureus* are the most common (Parmar Namitha and Rawat Mukesh, 2012). These antibiotics have been proved to be excellent antimicrobial agents. Antimicrobial chemotherapy has been a leading cause for the dramatic rise of average life expectancy. However, disease causing microbes that have become resistant to antibiotic drug therapy are an increasing public health problem. It is estimate that about 70 percent of bacteria that cause infections in hospitals are resistant to at least one of the drugs most commonly used for treatment (Praveen Dahiya and Sharmishtha Purkayastha, 2011). In addition, in developing countries, synthetic drugs are not only expensive and inadequate for the treatment of diseases but also often with adulterations and side effects (Naresh Maharjan *et al.,* 2012). Not only this, antibiotics are sometimes associated with adverse effects on host which include hypersensitivity, depletion of beneficial gut and mucosal microorganisms, immunosuppression and allergic reactions. This has created immense clinical problem in the treatment of infectious diseases (Parmar Namitha and Rawat Mukesh, 2012). Looking at this scenario there is a continuous and urgent need to discover new antimicrobial compounds with diverse chemical structures and novel mechanisms of action for new and re-emerging infectious diseases (Praveen Dahiya and Sharmishtha Purkayastha, 2011). One approach is to screen local medicinal plants for possible antimicrobial properties (Parmar Namitha and Rawat Mukesh, 2012). Nature has very rich botanical wealth and a large number of diverse types of plants grow in different parts of the country.

Traditional medicine has been improved in developing countries as an alternative solution to health problems and costs of pharmaceutical products (Riazunnisa K. *et al.,* 2013). Plant based antimicrobials represent a vast untapped source for medicines and further exploration of plant microbial need to occur (Krishna Rao. M. *et al.,* 2013). In the health care delivery system numerous plant species are used to treat diseases of infectious origin (Ninad Moon *et al.,* 2013). Contrary to the synthetic antibiotic, antimicrobials of plant origin are not associated with many side effects and have an enormous therapeutic potential to heal many infectious diseases (Selvam K.A. and Kolanjinathan K., 2014). The use of medicinal plants as a basis for relief from sickness can be traced back over five millennia to written documents of the early civilization in India, China and the Near east, but it is doubtless an art as old as mankind (Rajendar Singh D.S.R. *et al.,* 2014). WHO, report depicts that more than 80% of world`s population rely on plant based products to meet health care needs. Furthermore, about 42% of 25 top selling drugs marketed worldwide are either directly obtained from natural sources or entities derived from plant products (Preethi Tiwari, 2014). According to National Health experts, 2000 different plants are used for medicinal preparations for both internal and external use in India alone. Up to now only 10% of higher plants were chemically investigated and about 80% of world`s population is dependent on herbal drugs (Nagaprashanthi Ch. *et al.,* 2012). The people of India have a very long-standing tradition in the use of natural medicines and the local

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practices are still quite common in the treatment of diseases. Plants contain numerous biologically active compounds, many of which shown to have antimicrobial activities. Several screening studies have been carried out in the different parts of the world.

Major groups of antimicrobial compounds from plants

Due to the rapid development of organic chemistry and pharmacology, that man determined which active principles are responsible for a given therapeutic effect (Stary F. 1996). In plants, these compounds are mostly secondary metabolites such as alkaloids, steroids, tannins, and phenol compounds, which are synthesized and deposited in specific parts or in all parts of a plant. These compounds are more complex and specific and are found in many taxa, but heterogeneity of secondary compounds is found in wild species. 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 (Ionela Daciana Ciocan, Ion I. Bara, 2007). In many cases, these substances serve as plant defense mechanisms against predation by microorganisms, insects, and herbivores. Useful antimicrobials and Phytochemicals can be divided mainly into several categories, described below (Marjorie Murphy Cowan, 1999).

Phenols and Polyphenols

Simple phenols and phenolic acids: Some of the simplest bioactive phytochemicals consist of a single substituted phenolic ring. Cinnamic and caffeic acids are common representatives of a wide group of phenyl propane derived compounds which are in the highest oxidation state. The herbs tarragon and thyme both contain caffeic acid, which is effective against viruses (Wild R., 1994), bacteria (Brantner A. *et al.,* 1996 and Thomson W.A.R., 1978) and fungi (Duke J.A., 1985). Catechol and pyrogallol both are hydroxylated phenols, shown to be toxic to microorganisms. Catechol has two -OH groups, and pyrogallol has three. The site and number of hydroxyl groups on the phenol group are thought to be related to their relative toxicity to microorganisms, with evidence that increased hydroxlation results in increased toxicity (Geissman T.A., 1963). In addition, some authors have found that more highly oxidized phenols are more inhibitory (Scalbert A., 1991 and Urs *et al.,* 1975). These mechanisms thought to be responsible for phenolic toxicity to microorganism (Mason T.L., and Wasserman B.P., 1987).

Quinones: Quinones are aromatic rings with two ketone substitutions. They are ubiquitous in nature and are characteristically highly reactive. These compounds, being colored, are responsible for the browning reaction in cut or injured fruits and vegetables and are an intermediate in the melanin synthesis pathway in human skin (Schmidt H., 1988). Their presence in henna gives that material its dyeing properties (Fessenden R.J., and J.S. Fessenden, 1982). The switch between diphenol and diketone occurs easily through oxidation and reduction reactions. The individual redox potential of the particular quinone-hydroquinone pair is very important in many biological systems, example is the role of ubiquinone in mammalian electron transport system. Vitamin K is a complex naphthoquinine. Its antihemorrhagic activity may be related to its ease of oxidation in body tissues (Harris R.S., 1963). Hydroxylated amino acids may be made into quinones in the presence of suitable enzymes, such as a polyphenoloxidase (Vamos-Vigyazo L., 1981).

Anthroquinone from *Cassia italica*, a Pakistani tree, which was bacteriostatic for *Bacillus anthracis, Cornebacterium pseudodiphthericum,* and *Pseudomonas aeruginosa* and bactericidal for *Pseudomonas pseudomalliae*. Hypericin, an anthraquinone from St. Jhon's wort (*Hypericum perforatum*), has received much attention in the popular press lately as an antidepressant (Kazmi M.H. *et al.,* 1994). It also had general antimicrobial properties (Duke J.A., 1985).

Flavones, flavonoids, and flavonols: Flavones are phenolic structures containing one carbonyl group. The addition of a 3-hydroxyl group yields a flavonol (Fessenden R.J., and J.S. Fessenden, 1982). Flavonoids are also hydroxylated phenolic substance but occur as a C6-C3 unit linked to an aromatic ring. Since they are known to be synthesized by plants in response to microbial infection (Dixon R. A. *et al.,* 1983), it should not be surprising that they have been found in vitro to be effective antimicrobial substances against a wide array of microorganisms.

Catechins, the most reduced form of the C3 unit in flavonoid compounds. It was noticed some time ago that oolong green teas exerted antimicrobial activity (Toda M. *et al.,* 1989) because they contain a mixture of catechin compounds. These compounds inhibited in vitro *Vibrio cholerae (*Borris R.P.*,* 1996*), Streptococcus mutans (*Batista O. *et al.,* 1994, Sakanaka S. *et al*., 1989, Sakanaka S. *et al*., 1992, Tsuchiya H. *et al.,* 1994*), Shigella (*Vijaya K. *et al.,* 1995*)*, and other bacteria and microorganisms.

Flavonoid compounds exhibit inhibitory effects against multiple viruses. Numerous studies have documented the effectiveness of flavonoid such as swertifrancheside (Pengsuparp T. *et al.,* 1995), glycyrrhizin (Watanbe H. *et al.,* 1996) and chrysin (Critchfield J.W. *et al.,* 1996) against HIV. The small structural differences in the compounds are critical to their activity. The average Western daily diet contains approximately 1g of mixed

flavonoids (Kuhnau J. 1976), pharmacologically active concentrations are not likely to be harmful to human hosts. An isoflavone found in a West African legume, alpinumisoflavone, prevents schistosomal infection when applied topically (Perrett S. *et al.,* 1995). Phloretin, found in certain serovars of apples, may have activity against a variety of microorganisms (Hunter M.D., and Hull L.A., 1993).

Tannins: Tannin is a general descriptive name for a group of polymeric phenolic substances capable of tanning leather or precipitating gelatin from solution, a property known as astringency. Their molecular weights range from 500 to 3,000 (Haslam E., 1996) and they are found in almost every plant part: bark, wood, leaves, fruits, and roots (Scalbert A., 1991). They are divided into two groups, hydrolyzable and condensed taninns. Hydrolyzable tannins are based on gallic acid, usually as multiple esters with D-glucose, while the more numerous condensed tannins are derived from flavonoid monomers. Tannins may be formed by condensations of flavan derivatives which have been transported to woody tissues of plants. Alternatively, tannins may be formed by polymerization of quinone units (Geissman T.A., 1963). This group of compounds has received a great deal of attention in recent years, since it was suggested that the consumption of tannin - containing beverages, especially green teas and red wines, can cure or prevent a variety of ills (Serafini M. *et al.,* 1994). Many human physiological activities, such as stimulation of phagocytic cells, host-mediated tumor activity, and a wide range of anti-infective actions, have been assigned to tannins (Haslam E. 1996).

Coumarins: Coumarins are phenolic substances made of fused benzene and pyron rings (O'Kennedy R., and Thornes R.D., 1997). They are responsbile for the characteristic odor of hay. Their fame has come mainly from their antithrombotic (Thastrup O. *et al.,* 1985), anti-inflammatory (Piller N.B., 1975) and vasodilatory (Namba T. *et al.,* 1988) activities. Warfarin is a particularly well-known coumarin which is used both as an oral anticoagulant and interestingly, as a rodenticide (Keating G.J., and O'Kennedy R., 1997). It may also have antiviral effects (Berkada B., 1978).

As a group, coumarins have been found to stimulate macrophages (Casley-Smith J.R., and J.R. Casley-Smith, 1997), which could have an indirect negative effect on infecitons. More specifically, coumarin has been used to prevent recurrences of cold sores caused by HSV-1 in humans (Berkada B., 1978). Hydroxycinnamic acids, related to coumarins, seem to be inhibitory to gram-positive bacteria (Fernandez M.A. *et al.,* 1996). Also, phytoalexins, which are hydroxylated derivatives of coumarins are produced in carrots in response to fungal infection and can be presumed to have antifungal activity (Hoult J.R.S., and Paya M., 1996).

Terpenoids and Essential Oils:
The fragrance of plants is carried in the so called essential oil fraction. These oils are secondary metabolites that are highly enriched in compounds based on an isoprene structure. They are called terpenes, their general chemical structure is C10H16, and they occur as diterpenes, triterpenes and tetraterpenes as well as hemiterpenes and sesquiterpenes. When the compounds contain additional elements, usually oxygen, they are termed terpenoids. Terpenoids are synthesized from acetate units, and as such they share their origins with fatty acids. They differ from fatty acids in that they contain extensive branching and are cyclized. Examples of common terpenoids are camphor, farnesol and artemisin (Marjorie Murphy Cowan, 1999).

Terpenenes or terpenoids are active against bacteria (Ahmed A.A. *et al.,* 1993, Amaral J.A. *et al.,* 1998, Barre J.T. *et al.,* 1997, Habtemariam S. *et al.,* 1993, Himejima M. *et al.,* 1992, Kubo I. *et al.,* 1992, Mendoza L. *et al.,* 1997, Scortichini M. *et al.,* 1991, Tassou C.C. *et al.,* 1995, Taylor R.S.L. *et al.,* 1996), fungi (Ayafor J.F. *et al.,* 1994, Harrigan G.G. *et al.,* 1993, Kubo I. *et al.,* 1993, Rana B.K. *et al.,* 1997, Rao K.V. *et al.,* 1993, Suresh B. *et al.,* 1997, Taylor R.S.L. *et al.,* 1996), viruses (Fujioka T. *et al.,* 1994, Hasegawa H. *et al.,* 1994, Pengsuparp T. *et al.,* 1994, Sun H.D. *et al.,* 1996, Xu H.X. *et al.,* 1996) and protozoa (Ghoshal S. *et al.,* 1996, Vishwakarma R.A., 1990). In 1977, it was reported that 60% of essential oil derivatives examined to date were inhibitory to fungi while 30% inhibited bacteria (Chaurasia S.C. and Vyas K.K., 1977). The triterpenoid betulinic acid is just one of several terpenoids which have been shown to inhibit HIV (Marjorie Murphy Cowan, 1999). Food scientists have found the terpenoids present in essential oils of plants to be useful in the control of *Listeria monocytogenes (*Aureli P. *et al.,* 1992). Chile peppers are a food item found nearly ubiquitously in many Mesoamerican cultures (Coe S.D., 1994). Their use may reflect more than a desire to flavor foods. Many essential nutrients, such as vitamin C, provitamins A and E, and several B vitmains, are found in chiles (Bosland P.W., 1994). A terpenoid constituent, capsaicin, has a wide range of biological activities in humans, affecting the nervous, cardiovascular, and digestive systems (Virus R.M., and Gebhart G.F.., 1979) as well as finding use as an analgesic (Cordell, G.A., and, O. E. Araujo., 1993). The ethanol-soluble fraction of purple prairie clover yields a terpenoid called petalostemumol, which showed excellent activity against *Bacillus subtilis* and *Staphylococcus aureus* (Hufford C.D. *et al.,* 1993). It is also found that the

terpenoids can also prevented the formulation of ulcers and diminished the severity of existent ulcers (De Pasquale R. *et al.,* 1995).

Alkaloids

Heterocyclic nitrogen compounds are called alkaloids. The first medically useful example of an alkaloid was morphine, isolated in 1805 from the opium poppy *Papaver somniferum (*Fessenden R. J., and J.S. Fessenden, 1982). Codeine and heroin are both derivatives of morphine. Diterpenoid alkaloids, commonly isolated from the plants of the Ranunculaceae family (Jones S.B. *et al.,* 1986, Atta-ur-Rahman and Choudhary M.I., 1995), are commonly found to have antimicrobial properties (Omulokoli E. *et al.,* 1997). Solamargine, a glycoalkaloid from the berries of *Solanum khasianum*, and other alkaloids may be useful against HIV infection (Mcmahon J.B. *et al.,* 1995, Sethi M.L., 1979) as well as intestinal infections associated with AIDS (McDevitt J.T. *et al.,* 1996). Berberine is an important representative of the alkaloid group. It is potentially effective against trypanosomes (Freiburghaus F. *et al.,* 1996) and plasmodia (Omulokoli E. *et al.,* 1997).

Lectins and Polypeptides

A group of proteins, widely distributed in nature that have the ability to agglutinate erythrocytes and many other types of cells. They found in seeds, roots, leaves and bark of plants. They also found in invertebrates and several vertebrates. The term "Phytoagglutinins" is used to refer to plant lectins. Lectin exhibit a variety of unusual biological properties like reaction with human blood groups, induce mitosis in lymphocytes, some plant lectin mimic the direct effects of insulin. Soybean agglutinin and Concanavalin A shown to agglutinate cell lines transformed by viral or chemical carcinogens. Soybean agglutinin also used in bone marrow transplants in patients with severe combined immunodeficiency (Msc. Zeid Abdul-Majied Nima).

Peptides which are inhibitory to microorganisms were first reported in 1942. Recent interest has been focused mostly in studying anti-HIV peptides and lectins, but the inhibition of bacteria and fungi by these macromolecules, such as that from the herbaceous *Amaranthus*, has long been known. Thionins are peptides commonly found in barley and wheat and consist of 47 amino acid residues. They are toxic to yeasts, gram-negative bacteria and gram-positive bacteria (Fernandes de Caleya R. *et al.,* 1972). Fabatin, a newly identified 47-residue peptide from fava beans, appears to be structurally related to g-thionins from grains and inhibits *E. coli, P. aeruginosa* and *Enterococcus hirae* but not *Candida* or *Saccharomyces (*Ionela Daciana Ciocan, Ion I. Bara, 2007).

Saponins

Saponins are glucosides with foaming characteristics. They consist of a polycyclic aglycones attached to one or more sugar side chains. The aglycone part, which is also called sapogenin, is either steroid or a triterpene. The foaming ability of saponin is caused by the combination of a hydrophobic sapogenin and a hydrophilic sugar part. Saponins have a bitter taste. Some saponins are toxic and are known as sapotoxin.

Saponins are phytochemicals which can be found in most vegetables, beans and herbs. Saponins have many health benefits. Most scientific studies investigate the effect of saponins from specific plant sources and the results cannot be applied to other saponins. They are useful in reducing cholesterol and cancer risk. They can act as an immunity booster.

Steroids

Plant steroids are type of natural organic compounds found in plants. Many types of plant steroids exist and play important roles in the biological process of plants, such as growth and development, cell division and resistance to damage from environmental stresses like cold weather. Some plant steroids are also useful for their effects when consumed by human beings because their presence decreases the amount of cholesterol in the blood stream. Plant steroids should not be confused with anabolic steroids used to increase muscle mass, which are a synthetic substance that imitates the effects of human androgenizing hormones such as testosterone.

All steroids have a characteristic chemical structure based around carbon atoms linked by single or double bonds and arranged into four interconnected rings. Additional groups of atoms called functional groups are bonded to the carbon atoms in the rings at various points, which vary from one steroid to another. Different steroids have different properties that vary according to their number of double bonds in the carbon rings and the composition of the attached functional groups.

The most biologically prominent plant steroid is brassinolide, which is important to the development of plant cells and promoting the plant's growth. Brassinolide is synthesized from campesterol, another plant steroid that is part of a group of similar steroid compounds called phytosterols. Beta-sitosterol and brassicasterol are other examples for phytosterols.

Phytosterols with a chemical structure similar to that of cholesterol, a steroid found in animals. Phytosterols have demonstrated ability to reduce

cholesterol levels in the human blood stream. There is also research suggesting that phytosterols consumption can decrease the risk of some cancers, such as lung, breast and stomach cancer.

Glycosides

Formally, a glycoside is any molecule in which a sugar group is bonded through its anomeric carbon to another group via an glycosidic bond. The sugar group is then known as the glycone and the non-sugar group as the aglycone. The glycone can consists of a single sugar group or several sugar groups.

Glycosides play numerous important roles in living organisms. Many plants store important chemicals in the form of inactive glycosides; if these chemicals are needed, the glycosides are brought in contact with water and an enzyme, and the sugar part is broken off, making the chemical available for use. Many such plant glycosides are used as medications. In animals including humans poisons are often bound to sugar molecules in order to remove them from the body.

Glycosides classified according to the chemical nature of aglycone

Alcoholic glycosides: Salicin, is one of the example which is found in the genus Salix. Salicin is converted in the body into salicyclic acid, which is closely related to aspirin and has analgesic, antipyretic and anti-inflammatory effects.

Anthraquinone glycosides: These contain an aglycone group that is a derivative of anthraquinone. They are present in Senna, rhubarb and aloes, they have a laxative effect.

Coumarin glycosides: Apterin, is one of the example, which is reported to dilate the coronary arteries as well as block calcium channels.

Cyanogenic glycosides: These can release the poisonous hydrogen cyanide if acted upon by some enzyme. An example of these is amygdalin from almonds. They also found in the fruits of the rose family.

Flavonoid glycosides: Hesperidin, Naringin, Rutin, Quercitrin are some of the examples. Among the important effects of flavonoids are their antioxidant effects. They are also known to decrease capillary fragility.

Phenolic glycosides: An example is arbutin found in the *Arctostaphylos uva-ursi*. It has a urinary antiseptic effect.

Saponin glycosides: These compounds give a permanent froth when shaken with water. They also cause hemolysis of red blood cells. These are found in liquorice. Their medicinal value is due to their expectorant effect.

Steroidal glycosides or cardiac glycosides These glycosides are found in the plant genera *Digitalis, Scilla* and *Strophanthus*. They are used in the treatment of heart diseases.

Steviol glycosides: These glycosides have steviol as the aglycone part. These sweet glycosides found in the *Stevia rebaudiana bertani* have 40 to 300 times the sweetness of sucrose. The two primary glycosides, stevioside and rebaudioside A, are used as natural sweeteners in many countries.

Thioglycosides: These compounds contain sulfur. Examples include Sinigrin, found in black mustard, and Sinalbin, found in white mustard.

Previous work on medicinal plants as antimicrobials

There are several reports on the antimicrobial activity of different herbal extracts in different regions of the world referenced according to Jinu John *et al.,* The essential oil obtained from the leaf of *Lantana camera* showed good antimicrobial activity against *E. coli,* while the leaf extracts from hexane and chloroform showed good antimicrobial activity against *Bacillus subtilis, Pseudomonas spp.* and *E. coli.* Qualitative analysis showed that it contains alkaloids, terpenoids, coumarins and saponins. Uma Maheswari J. *et al.,* reported that the leaves of *Alternanthera sessilis* contains flavonoids, alkaloids, tannins, lignins and glycosides which possess various biochemical activities such as antibacterial, antifungal, antioxidant and anti-hyperglycemic activity. The chloroform extract of this plant possess better inhibitory activity against gram +ve and gram-ve bacteria. Prathiksha B.R. *et al.,* stated that the partially purified protein of *Aristolichia* root extract was beneficial and can be used as antibacterial agent against *E. coli* and which showed significant inhibitory effect compared to antibiotic Gentamycin. Sampath Kumar P. *et al.,* reported that the *Lippia nodiflora* has rich secondary metabolite composition which makes it is a protective agent against hepatotoxins. According to Parvataneni Radhika the Hexane and methanolic extracts of the roots of *Andrographis paniculata* were found to inhibit both gram+ ve and gram-ve bacteria. The effects produced by these extracts were comparable with the standard antibacterial agent, benzyl penicillin. Goswami S. *et al.,* concluded that the Artemisinin, derived from *Artemisia annua* is an established antimalarial drug. Recently, it is found that it has strong anti-*Helicobacter pylori* activity. Therefore, it is expected to contribute to current novel therapy for peptic ulcer diseases. Ingle R.B. *et al.,* reported that the Dimethyl sulphoxide extracts of *Annona reticulata, Withania somnifera, Chlorophytum borivilianum* and *curcuma longa* have been tested for their antibacterial

activity, out of 30 strains of MRSA (antibiotic resistance strain of *Staphylococcus aureus*), most strains are inhibited by these plant extracts. Mishra S.H. *et al.,* concluded that the bacteria like *Staphylococcus aureus, Enterococcus faecalis, Clostridium perferingens, E. coli, Enterobacter aerogens, Pseudomonas aeruginosa, Pseudomonas fluorescence, P. vulgaris, P. mirabilis* and *K. pneumoniae* as inhabitant of burn wound, the use of cholic acid in combination therapy as well as suggest the use of herbs like *Aloe vera* to cure minor burns. It is one of the alternative remedy to fight against predominant burn infectious pathogens. Richa Shri *et al.,* stated that the methanol and water extracts of *Aethusa cynapium* have demonstrated significant anxiolytic activity as compared to the standard drug diazepam.

Table: Mechanism of action of some important phytochemicals.

Phytochemicals	Activity	Mechanism
Quinones	Antimicrobial	Binds to adhesins, complex with cell wall, inactivates enzymes
Flavonoids	Antimicrobial	Complex with cell wall, binds to adhesions
	Antidiarrhoeal	Inhibits release of autocoids and prostaglandins, Inhibits contractions caused by spasmogens, Stimulates normalization of the deranged water transport across the mucosal cells, Inhibits GI release of acetylcholine
Polyphenols and Tannins	Antimicrobial	Binds to adhesins, enzyme inhibition, substrate deprivation, complex with cellwall, membrane disrupion, metal ion complexation.
	Antidiarrhoeal	Makes intsestinal mucosa more resistant and reduces secretion, stimulates normalization of deranged water transport across the mucosal cells and reduction of the intestinal transit, blocks the binding of B subunit of heat-labile enterotoxin to GM1, resulting in the suppression of heat-labile enterotoxin-induced diarrhea, astringent action.
	Anthelmintic	Increases supply of digestible proteins by animals by forming protein complexes in rumen, interferes with energy generation by uncoupling oxidative phosphorylation, causes a decrease in G.I. metabolism.
Coumarins	Antiviral	Interaction with eucaryotic DNA.
Terpenoids and essential oils	Antimicrobial	Membrane disruption
	Antidiarrhoeal	Inhibits release of autocoids and prostaglandins.
Alkaloids	Antimicrobial	Intercalates into cell wall and DNA of parasites
	Antidiarrhoeal	Inhibits release of autocoids and prostaglandins
	Antihelmintic	Possess anti-oxidating effects, thus reduces nitrate generation which is useful for protein synthesis, suppresses transfer of sucrose from stomach to small intestine, diminishing the support of glucose to the helminthes, acts on CNS causing paralysis.
Lectins and Polypeptides	Antiviral	Blocks viral fusion or adsorption, forms disulfide bridges.
Glycosides	Antidiarrhoeal	Inhibits release of autocoids and prostaglandins.
Saponins	Antidiarrhoeal	Inhibits histamine release in vitro
	Anticancer	Possesses membrane permeabilizing properties
	Anthelmintic	Leads to vacuolization and disintegration of teguments
Steroids	Antidiarrhoeal	Enhance intestinal absorption of sodium ions and water.

Rajendran Darling Anpin Raja *et al.,* 2011 reported that the methanolic extracts of *Chassalia curviflora, Cyclea peltata* and *Euphorbia hirta are* potentially good source of antibacterial agents and they showed activity on *Streptococcus pyogenes, Proteus vulgaris.* According to Indu M.N. *et al.,* 2006 that the garlic (*Allium sativum*) extract showed excellent antibacterial activity against *E. coli, Salmonella, Aeromonas hydrophila* whereas the nutmeg (*Myristica fragrans*) showed good activity on *Listeria monocytogenes* and *Aeromonas hydrophila.* According to Priscila Ikeda Ushimaru *et al.,* 2007 that the methanolic extract of *Caryophyllus aromaticus* presented the highest activity on *Staphylococcus aureus* and also showed activity on *Escherichia coli, Salmonella typhimurium* and *Enterococcus* sp. Hema. T.A *et al.,* 2013 stated that the propanolic leaf extracts of *Adhatoda vasika, Bacopa monnieri, Carica papaya, Cissampelos pareira and Cynodon dactylon* acts as a good source of antibiotics against *Bacillus subtilis, Enterobacter aerogenes, Escherichia coli, Klebsiella pneumoniae, Proteus vulgaris, Pseudomonas aeruginosa, Salmonella typhi, Shigella sp., Staphylococcus aureus* and *Streptococcus sp.* The phytochemical analysis revealed the presence of alkaloids in all plants selected and other secondary metabolites like tannins, glycosides and saponins were also observed in all the extracts, but in *Cynodon dactylon* carbohydrates, resins and diterpenes are observed. According to Jamuna Bai. A *et al.,* 2011 that the methanolic extract of the leaves of *Mecylon malabaricum* showed significant antimicrobial activity against *Staphylococcus aureus*, the methanolic extract of the leaves and flowers of *Cochlospermum religiosum* showed activity against *staphylococus aureus, Salmonella typhi, Enterobacter aerogenes,* the methanolic extract of leaves of *Andrographis serpyllifolia* showed activity on *Staphylococcus aureus* and *Salmonella typhi.* The phytochemical screeining of methanolic extract of *M. malabaricum* leaves, the leaves and flowers of *C. religiosum* revealed the presence of

sterols, cardiac glycosides, saponins, flavonoids, tannins and phenols, the leaves of *A.serpyllifolia* possess sterols, saponins, tannins and phenols. Narayanan A.S. *et al.,* 2011 concluded that the methanolic leaf extracts of *Azadirachta indica, Euphorbia hirta* and stem extract of *Tinospora cordifolia* showed activity against *Staphylococcus epidermidis, Streptococcus faecalis, Staphylococcus aureus, Pseudomonas aeruginosa, Klebsiella pneumoniae, Escherichia coli, Proteus mirabilis.* Mohamed Sham Shihabudeen. H *et al.,* 2010 reported that the methanolic extracts of *Eugenia jambolana (*kernel) and *Cassia auriculata (*flowers) showed the highest toxicity against *Staphylococcus aureus, Staphylococcus epidermidis, Escheichia coli, Klebsiella pneumoniae, Pseudomonas aeruginosa.* The phytochemical analysis revealed the presence of coumarins, flavonoids, glycosides, phenols, tannins, saponins and steriods. According to Jeyachandran R. *et al.,* 2009 that the plumbagin and chloroform extracts of *Plumbago zeylanica L.* root showed antibacterial activity against Escherichia *coli, Salmonella typhi* and *Staphylococcus aureus* and also showed moderate activity on *Klebsiella pneumoniae, Serratia marcescens* and *Bacillus subtilis.* Doss A. *et al.,* 2009 reported that the methanolic extracts of *Sesbania aegyptica (*leaf), *Eupatorium glandulsom* (leaf), *Vitex trifolia (*leaf), *Asteracanth longifolia*, (leaf*) Berberis tinctoria (*root), *Passiflora edulis* (leaf*), Spheranthus indicus (*wholeplant*), Solanum trilobatum (*leaf), *Delonex elata (*leaf*), Gynema sylvestre (*leaf*), Spathodea campanulata (*leaf*), Euphorbia tirucalli (*wholeplant) showed potential antibacterial activity against *Escherchia coli, Staphylococcus aureus, Salmonella typhi, Pseudomonas aeruginosa and Bacillus subtilis. Solanum trilobatum* was found to possess significant antibacterial activity against *Staphylococcus aureus.* According to Natchimuthu Karmegam *et al.,* 2012 that the aqueous and ethanol extracts of leaves of *Aegle marmelos, Albizia amara, Cassia auriculata and Cissus quadrangularis* showed more activity in combination of extracts rather than individually against *Staphylococcus aureus, Bacillus cereus, Pseudomonas aeruginosa, Escherichia coli, Salmonella typhi* and *Bacillus subtilis.* Thenmozhi. K *et al.,* 2013 stated that the methanolic root extract of *Emilia sonchifolia* possess significant antimicrobial activity against *Bacillus cereus, Stapylococcus aureus, Salmonella typhi, Streptococcus faecalis.* Kadhar Nivas R. and Boominathan M. reported that the methanolic extracts of aerial parts of *Bougainvillaea spectabilis, Marsilea quadrifolia, Launaea nudicaulis* showed significant activity against *Streptococcus pneumoniae*, phytochemical screening showed that *Marsilea quadrifolia* having saponins,terpenoids, phenols. *Launaea nudicaulis* having alkaloids, saponins, flavonoids. *Bougainvillaea spectabilis* having terpenoids, saponins and flavonoids. According to Kavitha R. *et al.,* 2011 that the methanolic leaf extract of *Couroupita guianensis* showed antibacterial activity against *Salmonella typhi, Escherichia coli, Staphylococcus aureus* and the phytochemical analysis showed that the presence of carbohydrates, tannins, phenols, saponins, gums, mucilage and flavonoids. Hema. T.A. *et al.,* 2012 concluded that the ethanolic leaf extract of *Azima tetracantha* showed significant antibacterial activity against *Proteus sp., Serratia sp., Pseudomonas sp., E. coli, Staphylococcus aureus* and *Klebsiella sp*., phytochemical analysis showed that the presence of alkaloids, saponins, tannins and also the presence of dimeric piperdine alkaloids azimine, azacarpaine, carpaine, triterpenoids, isorhammetin 3-rutiniside and novel fatty acids. presence of neoascorbinogen and glucosinolates has also been reported. Veeramuthu Duraipandiyan *et al.,* 2006 stated that the methanolic extract of stem bark of *Albizia procera*, leaf and flower of *Cassia auriculata*, flower of *Peltophorum pterocarpum*, root of *Punica granatum*, seed of *Syzygium cumini*, leaf of *Syzygium lineare* and leaf of *Toddalia asiatica* showed antibacterial activity against *Bacillus subtilis, Staphylococcus aureus, Staphylococcus epidermidis.*

Conclusions

Traditional medicine is one of the most inexpensive and easily accessible sources of treatment in the healthcare. Hence, several plants have been extensively investigated scientifically for their antimicrobial activity. It results that a large number of plant products have been shown to inhibit the growth of pathogenic microorganisms and also the plant products used as natural drug for the treatment of several infectious diseases by us. Laboratories of the world have found literally thousands of phytochemicals which have inhibitory effects on all types of microorganisms *in vitro.* Even though there is a need for the detailed investigation of the active compounds of certain plants for the exact mechanism of action will contribute greatly to the development of new drugs.

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