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Research Article

Search For Antimicrobial Active Agents From Medicinal Plants

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ABSTRACT

The rise of drug-resistant microbes has made it imperative to develop novel, effective antifungal and antimicrobial medications. The natural therapy of disorders caused by bacteria has mostly focused on medicinal plants. This research investigated the effects of four different in vitro bacterial strains on antibacterial medicinal plant extracts. The curative properties of plants and spices have made them staples in traditional herbal medicine practices dating back to prehistoric times. Infectious diseases caused by bacteria and other pathogens may be effectively treated with these excellent resources of natural antibacterial chemicals. An important component in the treatment of many illnesses, plant extracts, essential oils, and other secondary chemicals shown antioxidant, antiviral, antifungal, and antibacterial properties with few or no harmful side effects. Some bacterial strains may impact food quality and shelf life, although chemicals extracted from medicinal spice plants demonstrate antimicrobial action against these strains. Some of the medical uses of these plants include reducing inflammation, acting as a tonic, expectorant, diuretic, astringent, digestive, carminative, antibiotic, and stimulant, among others.

INTRODUCTION

Medicines derived from plants have a history that predates recorded history. Despite incomplete knowledge of their chemical components, medicinal plants are often recommended due to popular observations on their usage and effectiveness, which greatly aid in the revelation of their therapeutic characteristics. Medicinal plant use has greatly bolstered primary health care systems across the world, particularly in South American nations [1]. Of the estimated 250–500,000 plant species on Earth, only 1–10% are actually consumed by humans and other animals for sustenance [2]. With more than 20% of the world's species, Brazil has the greatest biodiversity. More than 55,000 plant species, or 22% of the world's total, have been identified in this nation, making it the botanically diverse. A widespread acceptance of therapeutic plant usage follows such biodiversity [3]. Almost all Brazilians rely on natural medicine, while the vast majority of that population (80%) uses only 37% of the pharmaceuticals sold in stores [4]. Due to the lack of stringent quality control measures for the safety and effectiveness of medicinal plants in comparison to other medication kinds, phytotherapics were able to join the market with the promise of quicker and cheaper manufacture [5].

Infectious infections are a leading cause of death and disability worldwide, but they disproportionately affect those living in poor nations. The ongoing rise of bacteria and other microbes that are immune to traditional antibiotics has, in turn, prompted pharmaceutical firms to seek for other treatments. Since there are regular reports of isolating bacteria that were previously sensitive to commonly used drugs but have now developed resistance to multiple medications, it appears that some bacterial species have the genetic capacity to develop and transmit resistance against the antibacterials that are currently available [6][7]. As a result, pharmaceutical firms often try to improve the efficacy of current antimicrobial medications by altering their chemical structure, or by restoring the activity that has been lost because of bacterial resistance mechanisms [8]. Overuse of antibiotics has devastating effects on ecosystems, human health, and the environment. Additionally, drug-resistant infections may become more common as a result [1]. The prevalence of antibiotic-resistant microorganisms is on the rise, posing serious challenges to healthcare systems and communities throughout the globe [2].

Antimicrobial drug resistance is a common trait among pathogenic bacteria; as a result, the treatment of infectious illnesses has largely failed due to the prevalence of multidrug-resistant bacteria [2][3]. Thus, it is essential to seek out and develop new methods of controlling esistant bacteria. The sensible localization of bioactive phytochemicals with antibacterial action is one potential strategy [1][4]. Plants having a wide range of secondary chemicals are now the focus of study because of their potential as a source of antibacterial drugs [5][6]. The structural diversity of the bioactive chemicals found in these plants makes them promising candidates for the development of natural medicinal medicines [7]. Some examples of medicinal plants that show promise are henna, oleander, parsley, mint, Aloe vera, christ's thorn, olive, chamomile, cinnamon, licorice, and ginger [8]. Vitamins, decanal, nonanal, linalool, and a plethora of other beneficial compounds are abundant in coriander (Coriandrum sativum).A wide variety of bacteria, both Gram-positive and Gram-negative, are susceptible to its effects [1][9]. Traditional medicine often recommends parsley (Petroselinum crispum) for its purported beneficial effects on gastrointestinal, menstrual, and urinary problems, cough, and myalgia [10]. Oleander, scientifically known as Nerium oleander, is a massive evergreen plant that produces milky juice. Oleander leaves are known to prevent the growth of several bacteria, both Gram positive and Gram negative [11].
The development of bacterial resistance to currently available medical treatments was a suitable indicator of the particular antimicrobial capability. Osteomyelitis, food poisoning, toxic shock syndrome, and other illnesses are all caused by gram-positive bacteria, such as Staphylococcus species. As an example, septicemia, pneumonia, lower urinary tract infections, and gram-negative bacteria like Escherichia sp. . The ability to synthesize therapeutic substances is an inherent gift of God from plants. The therapeutic properties of some plants have made them popular medicinal herbs since ancient times . In order to cure illnesses caused by bacteria and other diseases, these medicinal plants are essential resources for their natural antibacterial properties. According to the World Health Organization (WHO), medicinal plants are the most reliable way to get a wide range of medications . The economically useful medications were manufactured from the natural compounds of plants that were based on both traditional and contemporary medicine. The care of many illnesses relies on the antibacterial, antiviral, antifungal, and antioxidant actions of plant extracts, essential oils, and other secondary chemicals, all of which have little to no harmful consequences. Phytochemicals consist of secondary substances such alkaloids, flavonoids, terpenoids, steroids, carotenoids, and other phenolic compounds. Various sections of the plants contain them. Respiratory illness, UTIs, skin infections, and gastrointestinal disorders are just a few of the many significant ailments that these phytochemicals are utilized to treat in the drug development process. Their medicinal value is high. A group of herbs that are used to treat respiratory disorders include Artemisia vulgaris, [9]

A number of initiatives have been launched in recent years to identify novel antibacterial chemicals derived from diverse natural resources [10]. Given the current climate in which bacteria are able to acquire resistance to medical treatments, it is more important than ever to identify the antimicrobial activity of different medicinal plants. The spread of antibiotic-resistant microorganisms necessitates a cautious approach to preventing and treating infections caused by various bacterial, viral, and fungal diseases. Accordingly, determining what went into making medications with stronger antibacterial capabilities is the first and foremost concern. Isolated antibacterial substances from plants are used for food preservation. Spices and essential oils have been employed for food preservation by ancient civilizations in China, India, and Egypt. Asian countries are the primary producers of several spices, including ginger, garlic, mint, turmeric, pepper, nutmeg, cinnamon, cloves, and more [14][15]. America is known for its cultivation of ginger, pepper, sesame seeds, and nutmeg plants. Massive crops of celery, watercress, bay, dill, basil, coriander, and thymus are cultivated in Europe Cosmetics, fragrances, rituals, flavoring, coloring, and traditional food preparation methods in the food industry have all made use of spices due to their preservative properties. It is possible to extract a wide variety of compounds from spices, some of which have antimicrobial properties and can inhibit the growth of certain bacteria that can compromise food safety and spoilage. In addition to helping with digestion and promoting saliva production, they are also useful in treating colds by reducing nausea and vomiting (15).
A number of viral disorders have found relief via the use of phytochemicals and other plant-derived components. Utilization of plants demonstrates little or no toxicity. We used them with antibiotics to decrease bacterial drug resistance as they are sometimes enough on their own. An overview of the antibacterial properties of spices and medicinal plants used for human illness treatment across the world is presented in this review article. By combining plant extracts with antibiotic and non-antibiotic medications, we may evaluate the antibacterial and synergistic effects of medicinal plants on microbes.

METHODOLOGY

The antibacterial properties of many medicinal herbs and spices are included in this review. Information is gathered on plants that exhibit stronger antibacterial properties against certain diseases. Not to mention that you can grow a few of them with relative ease. More than a hundred papers, including reviews and research, published between 2015 and 2021 were consulted for this purpose. This review article so contains accurate and current information.

History of use of medicinal plants

According to the World Health Organization (WHO), 80% of the global population relies on traditional medicines, and the best way to get pharmaceuticals is from medicinal plants. Involvement of humans in the use of plants as medicine dates back many centuries in Asia. Herbal remedies offer a wide variety of active ingredients that may alleviate symptoms of both acute and chronic diseases. Records detailing the preparation of medications from medicinal plants date back around 5,000 years, according to ancient documented data. It included twelve drug-preparation formulas for two hundred and fifty distinct plants, some of which included alkaloids like poppy, henbane, and mandrake. Historically, people relied on plant remedies for illness treatment since scientists had a firm grasp on what exactly caused certain ailments [16]. The 365 medications were recorded and created using the dried sections of plants in the Chinese book 'Pen T. Sao,' which was published by Emperor Shen Nung about 2500 BC and is based on roots and grasses. Many of these plants are still utilized today for things like cinnamon bark, ginseng, Jimson weed, camphor, Ephedra, Podophyllum, and Rhei rhizoma [17].

Written in Egypt approximately 1550 BC, the Papyrus Ebers contains a mixture of 700 plant species, including medicinal ones like coriander, onion, garlic, aloe, castor oil, pomegranate, and many more [18]. Ancient Roman and Greek contributions to traditional medicine were substantial and well-coordinated, and their writings on the subject are part of the "known world" medical canon. Half of the top 50 pharmaceuticals sold in European pharmacies are natural goods, such as herbal and/or dietary supplements. The "Rig-Veda" (1700-1100 BCE), the "Yajur-Veda" (1400-1000 BCE), and the "Atharva Veda" (1200 BCE) are ancient texts that describe health-care requirements and ailments in India. These texts date back 5,000 years BCE. Fig. 1 [4] shows that later texts like the "Dhanwantari Nighantu" (1800 CE), the "Charaka Samhita" (990 BCE), and the "Sushruta Samhita" (660 BCE) highlighted and extensively used the use of plants and poly herbal compositions. When we talk about traditional medicine, we're usually referring to practices that either started in India or that entered the nation from another country and became part of Indian culture throughout time. The three main branches of this medical system are Ayurveda, Siddha, and Unani . 'Science of life' is the meaning of the term Ayurveda. The essence of Ayurvedic medicine is that "it deals with the life and gives the knowledge of life, also it measures the quality and expectancy of life".

Fig. 1. Enlisted ancient Indian medicinal manuscripts[4].

The World Health Organization has just labeled COVID-19 a worldwide epidemic. The contagiousness of the sickness was enormous. The SARS-CoV-2 virus occurred as a result [21]. In response to stress caused by environmental stimuli and pathogens, plants use secondary metabolism, which allows them to synthesize a wide variety of essential chemical components . Worldwide, people are encouraged to utilize medicinal herbs as a means of preventing the spread of the COVID-19 virus, as no effective therapeutic or preventative medications have yet been identified . Infections may be effectively treated with medicinal spice plants because of their antiviral, anti-inflammatory, cytoprotective, and immunomodulatory characteristics .

Antimicrobial activity

Spices have been an integral part of human culture from the very beginning. The religious texts, such as the "Bhagavad Gita," provide legendary proof of the multipurpose usage of spices. Because of their excellent preservative property, spices are often employed for preservation purposes. Ayurveda states that medicinal herbs assist maintain the body's moisture equilibrium . In addition to altering the flavor, aroma, and color of food, spices like turmeric, coriander, and chili powder also alter its look. Ginger, nutmeg, and cinnamon are a few spices that help with digestion and a sore throat [18]. There have been a plethora of papers detailing the antibacterial qualities of spices in recent years. Various solvents, including water, ethyl acetate, methanol,

ethanol, etc., were used to assess the antibacterial activity of plant parts and extracts against microorganisms. Maceration, fluid extracts, oils, syrups, juices, decoctions, powders, tea, ointments, and so on are all forms these plants take.

Essential oils extracted from these spices have a long history of usage, dating back to ancient times, and are now used in aromatherapy, the treatment of anxiety and stress, and depression [22]. Coriander and mint both have active ingredients that may alleviate pain. The anti-inflammatory effects of cumin, coriander, and celery are also well-documented [23]. Naturally occurring antioxidants abound in these plants. Table 1 shows the many medicinal spice plants and the main chemicals found in them that have antibacterial properties against different types of bacteria.

ANTIMICROBIAL PROPERTIES OF MEDICINAL PLANTS

This study confirms prior research showing that the antimicrobial properties of the herb "carqueja" (Baccharis trimera Less.) decoction are more effective against gram-positive (Staphylococcus aureus and Streptococcus uberis) than gram-negative (Salmonella gallinarum and Escherichia coli) bacteria (9). Asian plant extracts (Ruta graveolens and Zingiber officinale) also showed inhibitory action against Bacillus cereus strains in antimicrobial tests.

Another research examined the inhibitory efficacy of plant extracts from fourteen different Brazilian species against MRSA strains [11]. The compounds that showed inhibitory effect were components of T. avellanedae wood (purple trumpet tree) and ethanol extract and its fractions (n-hexane, water, chloroform, dichloromethane, ethyl acetate, and n-butanol) from Punica granatum fruit (pomegranate). The ethyl acetate fraction of P. granatum and the hexane and chloroform fractions of T. avellanedae exhibited the highest levels of activity.

When it comes to Achillea millefolium, or common yarrow, the antibacterial activity of the essential oil is greater than that of the methanol extracts separated by chloroform, which were not all soluble. The oils had a mild inhibitory effect on Mycobacterium smegmatis, Acinetobacter lwoffii, and Candida krussei, and a complete halt to the development of Streptococcus pneumoniae, Clostridium perfringes, and Candida albicans. Researchers looked at how well several plant extracts (aqueous and 40% hydroalcoholic) killed germs in dogs' mouths (13). The study discovered that extracts from garlic (Allium sativum), "espinheira santa" (Maytenus ilicifolia), and guava tree leaves (Psidium guajava) were sensitive to standard S. aureus strain as well as isolated Streptococcus oralis and Streptococcus mitis strains.

The antimicrobial effects of chamomile were also discovered to be effective against Staphylococcus aureus. This action is due to the phenolic chemicals found in its ethanol extract (14). Additional information suggests that artichoke aqueous extract (Cynara scolymus) and "macela" (Achyrocline satureioides) ethanol extracts (80% each) suppressed the development of some bacteria (14). A study conducted in Argentina found that terpene compounds found in local plant essential oils had an inhibitory impact on MRSA. These substances included eugenol, geraniol, thymol, and carvacrol (15).

An additional study examined the antimicrobial activity of 28 different plant essential oils against different serotypes of E. coli. The results showed that the Brazilian palmarosa (Cymbopogon martinii) oil inhibited three different E. coli serotypes and two different EPEC serotypes, while the Java citronella grass (Cymbopogon winterianus) oil inhibited one EPEC serotype and two ETEC serotypes (16). Other plants only produced inhibition at greater doses, while the concentration that inhibited microbes ranged from 100 to 500 µg/mL.

Table 1. Findings about the synergistic effects of antibacterial medicines with plant extracts or essential oils against strains of Staphylococcus aureus [5].

Drugs	**“Alecrim-do-campo”**		**“Assa-peixe”**		**Chamomile**		**Surinam cherry**	
Oil	Extracts	Oil	Extracts	Oil	Extracts	Oil	Extracts	
Cephalothin	S	I	S	I	I	I	I	I
Gentamicin	S	I	S	I	I	I	S	I
Tetracycline	S	I	S	I	I	S	I	I
Sulfazotrin	S	I	S	I	S	I	S	I
Ciprofloxacin	S	I	S	I	S	I	S	I
Cefepime	S	I	S	I	I	I	I	I
Chloramphenicol	S	I	S	I	I	I	I	I
Rifampicin	S	I	S	I	S	S	I	I

ANTIMICROBIAL ACTIVITY MECHANISMS OF NATURAL PRODUCTS

To ward against invaders, particularly microbes, the majority of plant species possess a number of chemicals with antimicrobial capabilities. Figure 2 shows the molecular structures of many antibacterial chemicals derived from plants, as reported by Cowan.

Some plant active chemicals have antibacterial function; for instance, thymol and carvacrol are found in thyme,

eugenol and isoeugenol in clove, and terpinenol-4 and carvacrol are found in oregano. Some terpenes have more antibacterial potency than others, and this is especially true of those derived from essences that dissolve in water.

The natural product components that are believed to target specific places or structures inside the bacterial cell are shown in figure.

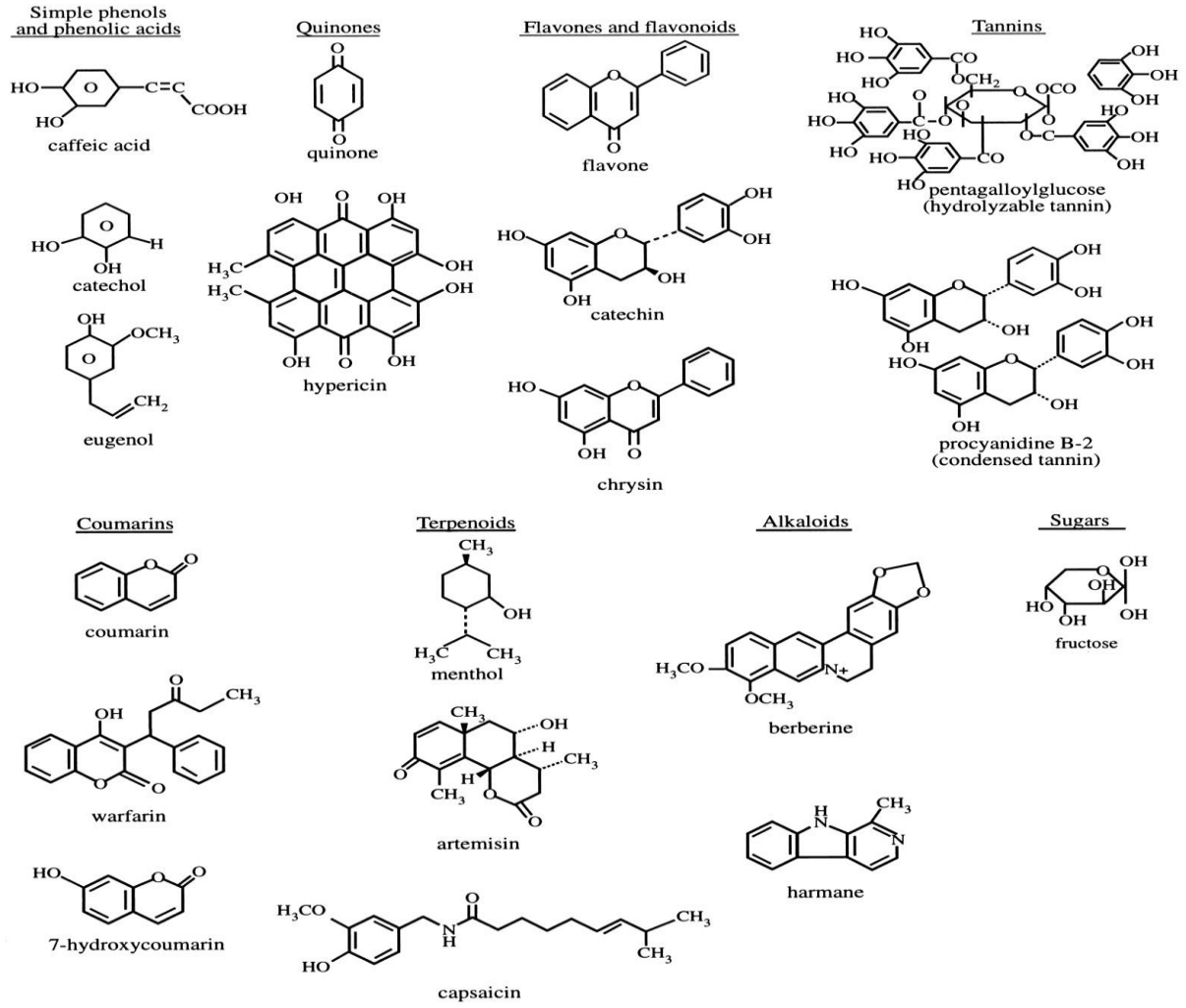

Figure 2. Chemical structures of antimicrobial compounds [5].

The antibacterial properties of essential oils are due in large part to their hydrophobic components, which invite lipids from bacterial cell membranes to participate, disrupting cell structures and making them more permeable.

Proteins in the cytoplasm may also be affected by chemical components found in essential oils. Enzymes known to be positioned at the cytoplasmic membrane and encased in lipid molecules are the targets of cyclic hydrocarbons. It is also conceivable for lipophilic chemicals to directly interact with hydrophobic portions of the protein, and lipid hydrocarbons may alter the lipid-protein interaction. The fact that some essential oils promote the expansion of pseudo-mycelia suggests that they could interact with enzymes that play a role in the production of bacterial cell wall components.

Below is a list of several substances along with the ways in which they affect microbes.

Carvacrol and thymol

Despite their structural similarities, thymol and carvacrol vary in where the hydroxyl group is located in the phenolic ring. The membrane seems to be affected by both chemicals. porous. They increase ATP permeability in gram-negative bacteria by rupturing their outer membrane and releasing lipopolysaccharides (LPS). This activity is unaffected by magnesium chloride, which points to a chelating mechanism of various cations on the outer membrane .

Eugenol

The ability of B. cereus to produce amylase and protease may be inhibited by varying doses of eugenol. In addition, there were reports of cell wall degradation and cell lysis .

p-Cymene

It is a hydrophobic molecule that, like carvacrol, causes the cytoplasmic membrane to enlarge, but to a larger extent .

Carvone

Tests with doses greater than carvone's minimal inhibitory concentration reveal that it neutralizes gradient pH and cell membrane potential. Carvone may work by disrupting the overall metabolic state of the cell, as its effects on the development of E. coli, Streptococcus thermophilus, and Lactococcus lactis may vary with concentrations .

Cinnamaldehyde

At quantities comparable to those of carvacrol and thymol, cinnamonaldehyde inhibits the development of E. coli and Salmonella Typhimurium. Neither the outer membrane nor the intracellular ATP are weakened, but. Because of its protein-binding carbonyl group, it inhibits E. aerogenes resistance to decarboxylase amino acids. Provide a promising avenue for the development of novel therapeutics; they have the ability to augment the efficacy of already used antimicrobials; and as a result, they have the potential to reduce treatment costs while simultaneously improving treatment quality. On the other hand, antibiotic treatment may have antagonistic effects in certain plants.

Since bacteria resistant to conventional medicines are becoming more common, medicinal plants provide an alternative for infection treatment. One important aspect is the search for new compounds with antimicrobial action and synergism with existing antimicrobial drugs.

Several instances using essential oils and plant extracts shown the antibacterial action of plants. So, this quality has the potential to be a helpful tool in the search for new antibiotics that can withstand the growing number of bacteria that have developed resistance to current treatments.

Consequently, it is exceedingly challenging to relate the numerous reports on the antimicrobial action of these products in this review article regarding a subject of such immense complexity, which necessitates a multidisciplinary approach, given the extensive literature on tests for the antimicrobial action of plant products, which continues to grow in publication volume year after year.

CONCLUSION

Throughout history, several societies have used plants to effectively address many ailments, including infections. Extensive research has been conducted on the pharmacology of medicinal plants due to their potential as a source for developing novel medications and their ability to enhance the effects of traditional antimicrobials. This might potentially lead to reduced costs and improved quality of treatment. Nevertheless, some plants may exhibit antagonistic reactions while undergoing antibiotic treatment.

An essential aspect involves the exploration of novel compounds that possess antimicrobial properties and can work in synergy with existing antimicrobial drugs. This is particularly important due to the growing prevalence of bacteria that are resistant to conventional medications. As a result, medicinal plants offer a viable alternative for the treatment of infections.

The efficacy of plants in inhibiting the growth of microorganisms has been shown via several instances, using essential oils and extracts. Therefore, this trait has the potential to be a valuable asset in the creation of medications essential for addressing the growing prevalence of bacterial strains that are resistant to traditional antibiotics.

Due to the extensive literature on tests for the antimicrobial action of plant products, which is continually growing, it is challenging to incorporate all the reports on this subject in this review article. The complexity of the topic, which necessitates a multidisciplinary approach, further adds to the difficulty.

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