

International Journal of Pharmacognosy and Pharmaceutical Research

ISSN Print: 2664-7168
ISSN Online: 2664-7176
Impact Factor: RJIF 8
IJPPR 2024; 6(2): 01-07
www.pharmacognosyjournals.com
Received: 06-05-2024
Accepted: 07-06-2024

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Exploring the importance of selected Indian medicinal plants for antimicrobial effect

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DOI: <https://doi.org/10.33545/26647168.2024.v6.i2a.71>

Abstract

The fundamental barrier in antimicrobial medicines is antibiotic resistance. The article highlights the extensive research surrounding the antimicrobial properties of medicinal plants. It focuses on scientific evidence supporting the efficiency of herbs against a spectrum of microorganisms, including bacteria, fungi and viruses. This review presented herbal antimicrobial agents which include papaya, clove, garlic, thyme, cinnamon, fennel, guava, apple, black paper, peppermint which are all summarized. It also offers insights into the promising role of herbs in combating microbial infections.

Keywords: Medicinal plants, herbs, herbal extract, antimicrobial effect

Introduction

Infectious diseases are still an important health concern which accounts for 41% of the worldwide disease burden expressed in the form of Disability-Adjusted Life Years. The world is currently facing a severe threat to global public health in the form of pandemics and epidemics of antibiotic resistance, which are primarily caused by the widespread acquisition of bacterial resistance to antibiotics. The issue of antibiotic resistance has caused a change in focus toward physiologically active ingredients that are extracted from plant species and utilized in herbal therapy ^[1].

Antimicrobial agents, also referred to as antimicrobial medicines, are substances that have the ability to either destroy or inhibit the growth of germs. The main pathogens that antimicrobial medications combat, such as bacteria and viruses, are the basis for their classification ^[2]. Antimicrobial drugs play a pivotal role in mitigating the worldwide burden of infectious illnesses ^[3]. It is estimated that only 10% of the total stock of plant metabolites have been isolated for medicinal purposes which again shows the vastness of therapeutic agents in the plant kingdom ^[1].

A. **Papaya:** The papaya (*Carica papaya*) produces a milky sap that is a complex collection of compounds and is commonly referred to as latex. The most prominent of them is the well-known proteolytic enzyme papain. Additionally, carpaine, an alkaloid, is found. Additionally found and possibly contributing to its antibacterial qualities are terpenoids. According to Osato *et al.* ^[4], the latex is bacteriostatic against *Salmonella typhi*, *B. subtilis*, *Enterobacter cloacae*, *E. coli*, *Staphylococcus aureus*, and *Proteus vulgaris* ^[5].

Chemical constituents: Alkaloids, glycosides, tannins, saponins, flavonoids, and glycosides are the primary chemical components of papaya ^[6].

Medicinal Uses

1. **Diabetes:** Many African societies have long used papaya to treat diabetes mellitus. According to a number of studies, some papaya tree pieces may be able to assist reduce blood sugar levels in both people and animals ^[7].
2. **Stomach diseases:** Role of papaya shows various pharmacological activities like Anthelmintic, topical use, bleeding haemorrhoids, stomachic, it also relieves dyspepsia, cures diarrhea, useful in pain of burns and whooping cough ^[8].
3. **Dengue:** Papaya extract is used for increasing platelet count ^[9].

Antimicrobial activity

1. The papaya seed exhibits antibacterial properties against the trophozoites of *Trichomonas vaginalis*. According to the paper, papaya seed should be used cautiously to treat urinogenital disorders like trichomoniasis in order to prevent toxicity.
 2. Using the agar cup plate method, it was demonstrated that the papaya pulp and seed were bacteriostatic against a number of enteropathogens, including *Salmonella typhi*, *Escherichia coli*, *Bacillus subtilis*, *Enterobacter cloacae*, *Proteus vulgaris*, *Pseudomonas aeruginosa*, and *Klebsiella pneumoniae*.
 3. Purified fruit extracts, both ripe and unripe, exhibit strong antibacterial action against *Shigella flexneri*, *S. aureus*, *Bacillus cereus*, *E. coli*, and *P. aeruginosa* [8].
 4. The highest activity (14 mm zone of inhibition) was shown against *Pseudomonas aeruginosa*, and the aqueous leaf extract showed pronounced inhibition demonstrating higher activities against the test bacteria than the organic solvents, according to I.I. Anibijuwon and A.O. Udeze. The root extracts also showed higher activities against all the gram-positive bacteria than the gram-negative bacteria tested [10].
- B. **Clove:** The *Myrtaceae* family plant clove (*Eugenia caryophyllata*) is used as an antiseptic in medicine to treat infectious disorders such as periodontal disease because of its antibacterial properties against mouth germs. Owing to its potent antibacterial properties against some foodborne diseases, clove is also frequently used in the food sector as a natural addition or antiseptic to extend shelf life. The discovery was made of Eugenol, the primary active ingredient in clove oil and extract [11].

Chemical constituents

Clove contains Eugenol, eugenyl acetate, humulene, 2-heptanone, and caryophyllene [12].

Uses of clove

1. **Oral health:** Mouth rinses were found to be beneficial in preventing gingivitis and plaque, suggesting that they may also help reduce oral bacteria and inflammation [13].
2. **Diabetes:** Lowers blood sugar levels in both prediabetic and healthy individuals [14].
3. **Cancer:** Aids in promoting cancer cell death and inhibiting the formation of malignancies [15].

Antimicrobial Activity

1. Clove has been shown to have antibacterial properties against a variety of bacterial and fungal species. The antibacterial properties of several Indian spice plants, including clove, ginger, garlic, mustard, cinnamon, and mint, were investigated by Sofia *et al.* The aqueous extract of clove at 3% was the only sample that shown full bactericidal action against all food-borne pathogens tested, including *Escherichia coli* (*E. coli*), *Staphylococcus aureus*, and *Bacillus cereus*. Clove extract also shown strong inhibitory activity at 1% concentration. The antibacterial properties of black pepper, geranium, nutmeg, oregano, thyme, and clove were examined against 25 strains of both Gram positive and Gram negative bacteria in another study that was

published by Dorman and Deans. Oregano, clove, and thyme were the oils with the broadest range of activity [16].

2. Clove has the ability to damage bacteria' cell walls and membranes, penetrate cytoplasmic membranes, or infiltrate cells, and therefore prevent the normal creation of proteins and DNA. Clove's main ingredient, eugenol, has the power to break down and lyse cells while also inhibiting *Bacillus cereus*'s capacity to produce amylase and proteases [2].
 3. Oil and eugenol concentrations below the MIC values totally or nearly entirely prevented the production of germ tubes by *Candida albicans* [17].
 4. The best inhibition against *E. coli* is found in clove oil [18].
- C. **Garlic:** Herbal medicine derived from garlic (*Allium sativum*) is a member of the *Amaryllidaceae* family. One of the traditional remedies with antioxidant and antibacterial properties is garlic [2].

Chemical constituents: Allicin, ajoene, different aliphatic sulfides, polysaccharides, and phenolic compounds are examples of organosulfur compounds found in garlic. In addition, it has minerals, B-complex vitamins, amino acids, flavonoids, and vitamins A and C [19].

Uses of garlic

1. **Cardiovascular activity:** Consuming garlic reduces blood pressure, prevents atherosclerosis, lowers serum triglycerides and cholesterol, inhibits platelet aggregation, and boosts fibrinolytic action [20].
2. **Bone Health:** Garlic helps prevent arthritis and osteoporosis [21].

Antimicrobial activity

1. A number of studies have assessed the antibacterial properties of several garlic preparations, including garlic paste and fresh or crude garlic extract (FGE). Numerous laboratories have reported on the antibacterial activity of garlic paste and FGE against commensal and pathogen enteric bacteria, including *Salmonella species*, *Shigella species*, *Vibrio species*, *Campylobacter species*, *Listeria monocytogenes*, *Lactobacillus acidophilus*, *Staphylococcus aureus*, *Streptococcus species*, and *Clostridium difficile* [19]. It has been demonstrated that allicin possesses broad-spectrum antibacterial activity against both Gram-positive and Gram-negative bacteria, including those that are resistant to multiple drugs [22].
 2. Studies have shown that garlic is beneficial against a wide range of bacteria, including gram-positive, gram-negative, and acid-fast types. *Salmonella*, *Escherichia coli*, *Pseudomonas*, *Proteus*, *Staphylococcus aureus*, *Salmonella*, *Micrococcus*, *Bacillus subtilis*, *Clostridium*, *Mycobacterium*, and *Helicobacter* are an assortment of these [23].
 3. It was found that the aged and fresh garlic extracts have exceptional antimicrobial activity against *Salmonella* enteric, *Listeria monocytogenes* and *Staphylococcus aureus* [24].
- D. **Thyme:** The subshrub thyme (*Thymus vulgaris*) is indigenous to the western Mediterranean region and is a

member of the *Lamiaceae* family. Many people use thyme as a spice to give dishes a unique flavor. According to current research, thyme has effective antibacterial properties and is used to prolong the shelf life of some goods [25].

Chemical constituents: Thyme contains monoterpene phenols, including carvacrol, thymol and p-cymene, and other monoterpenes, such as α -pinene, 1, 8-cineole, camphor, linalool and borneol [26].

Uses

1. **Antineoplastic Activity:** Several studies have shown the protective properties of numerous medicinal plant extracts as well as their capacity to cause harm to cancer cells via a variety of molecular pathways, such as autophagy, necroptosis, and intrinsic or extrinsic caspase-dependent apoptosis [27].
2. **Cardio-protective effect:** Thymol and carvacrol are two of the components of thyme that work well against oxidative agents that cause cardiovascular disease [28].
3. **Respiratory diseases:** Thyme is used to relieve sore throats, colds, and chest infections [29].

Antimicrobial activity

1. Thymol inhibits the growth of *S. aureus* [30].
 2. Tohidpour and associates examined the impact of *Eucalyptus globulus* Labill. EO and *T. vulgaris* on clinically isolated MRSA. It was discovered that thyme EO, which primarily included thymol, has superior abilities to prevent the growth of these microbes [31].
 3. Thymol was discovered to have antibacterial activity against specific *E. coli* strains that are verocytotoxic [32].
- E. **Cinnamon:** *Cinnamomum zeylanicum*, a member of the *Lauraceae* family, is commonly used in soups, pickles, and savory foods [25].

Chemical constituents: Cinnamaldehyde, cinnamate, cinnamic acid, and several essential oils, including eugenol, L-borneol, caryophyllene oxide, b-caryophyllene, L-bornyl acetate, E-nerolidol, α -cubebene, α -terpineol, terpinolene, and α -thujene, are examples of resinous chemicals [33].

Uses

1. **Cancer:** Additionally, cinnamon can strengthen the colon's health and lower the chance of colon cancer [34].
2. **Diabetes:** Because of its physiologically active ingredients, which improve glucose absorption, cinnamon has been demonstrated to have insulin mimicking qualities [35].

Antimicrobial activity

1. The effectiveness of cinnamon and other plant aqueous extracts against oral bacteria was documented in a recent study. Overall, compared to other examined plant extracts like *Azadirachta indica* and *Syzygium aromaticum*, the essential oil from cinnamon is more effective [34].
2. A few investigations concentrated on the antimicrobial and antifungal properties of cinnamon extracts and essential oil against specific endodontic infections. The presence of bacteria that have been isolated as

planktonic cells or biofilms is the primary cause of endodontic infection [36].

- F. **Fennel:** The *Umbelliferae* family includes fennel (*Foeniculum vulgare*), which is widely grown for its aromatic fruits and culinary use in temperate zones and the tropical belt [25].

Chemical constituents: A-pinene, camphene, limonene, trans-anethole (60-65%, but up to 90%), fenchone (2-20%), estragole (methyl chavicol), fenchyl alcohol, and anisaldehyde are among the monoterpenes. There are also trace amounts of α -pinene, camphene, δ - α -phellandrene, dipentene, methyl chavicol, and ρ -hydroxy phenyl acetone. The primary constituents of the fixed oil consist of petroselinic, oleic, linoleic, and palmitic acids. There is 0.66-0.6% volatile oil in dried fennel seeds [37].

Uses

1. **Heart health:** Significant levels of fiber can be found in fennel. Because it lowers blood levels of low-density lipoprotein (LDL) and total serum cholesterol, fiber lowers the risk of heart disease [38].
2. **Gastrointestinal system:** Reduces bloating, cramping, and gas by assisting in the relaxation of smooth muscles. Painful spasms in the stomach muscles resulting from gastrointestinal disorders such as Crohn's disease, ulcerative colitis, and irritable bowel syndrome can be managed with fennel seed tinctures or teas [39].
3. **Dysmenorrhea:** Fennel has been reported to have analgesic and anti-inflammatory properties, which may help with dysmenorrhea [40].
4. **Gynecological disorders:** Fennel is effective in premenstrual disorders, dysmenorrhea, menopause, amenorrhea, lactation and PCOS [41].

Antimicrobial activity

1. The essential oil that was isolated from the fruits of *F. vulgare* shown antibacterial activity against microorganisms that are found in food, including *Bacillus megaterium*, *Escherichia coli*, and *Staphylococcus aureus* [42].
2. EOs exhibit multitarget action against bacteria that are resistant to many drugs due to their multicomponent composition (MDR) [43].

- G. **Guava:** The fruit plant guava (*Pisidium guajava* L.), which belongs to the *Myrtaceae* family, has been used to treat and prevent diarrhea. Its leaves and roots have also been shown to have strong antibacterial properties against the bacteria that cause food-borne diarrhea, including *Pseudomonas*, *Shigella*, and *Staphylococcus* species. In addition, guava is used to treat diabetes, hypertension, pain fever, respiratory conditions, gastroenteritis, diarrhea, and dysentery. It is also used as an antibacterial and anti-inflammatory [44].

Chemical constituents: Apigenin, avicularin, caffeic acid, catechin, gallic acid, epigallocatechin gallate, hyperin, myricetin and quercetin are all found in guavas [45].

Uses

1. **Immune system:** Vitamin C, which is essential for sustaining immunological function, is abundant in guavas [46].

- Diabetes:** In addition to restoring blood glucose homeostasis, *Psidium guajava* treatment reversed pathologic and metabolic alterations that had occurred in the pancreatic islets [47].
- Stress Relief:** Consuming guava might increase your energy and reduce stress. Guava's magnesium content aids in the regulation of the stress hormone cortisol, which helps to relax the body's muscles and nerves [48].

Antimicrobial activity

- It has been demonstrated that guava extract works well against *E. coli*, a bacteria resistant to most of the antibiotics now available on the market [49].
- The strongest antimicrobial action found in guava leaf extract can inhibit *S. aureus* development. The strongest antimicrobial activity is seen in methanolic extracts of *P. guajava* from the leaves and bark of the plant. These extracts have the ability to hinder bacteria, particularly *Salmonella* and *Bacillus* [50].

H Apple: Apples, or *Malus domestica* Borkh, are a widely farmed fruit crop that belong to the *Rosaceae* family. They are cultivated in over 93 nations worldwide and are an old fruit [51].

Chemical constituents

Quercetin-3-galactoside, glucoside, rhamnoside, procyanidin, cyanidin-3-galactoside, coumaric acid, gallic acid, chlorogenic acid, and phloridzin are all found in apples [52].

Uses

- Diabetes and obesity:** Apples have a low glycemic index and can prevent weight gain because of their anti-inflammatory and antioxidant properties [53].
- Lung cancer:** The only food that had an inverse relationship with the risk of lung cancer was apples [52].

Antimicrobial activity

- In terms of the total amount of phenolic compounds, apples came in second. These compounds include quercetin, catechin, phloridzin, and chlorogenic acid, all of which are potent antioxidants that can balance out free radical activity and prevent damage to cells [54].
- There was a noticeable antibacterial activity of apple extracts from organic farms against *E. coli* and *Bacillus cereus* [55].

I. Black pepper

Black pepper, or *Piper nigrum* L., is a member of the *Piperaceae* family and is widely distributed throughout the tropical parts of Asia and the east coast of India [56].

Chemical constituents

Vitamins, minerals, phenolic chemicals, flavonoids, terpenoids, and carotenoids are all present in black pepper. Primary essential oils including β -caryophyllene, sabinene, β -bisabolene, limonene, α -pinene, and α -copaene are found in the bioactive chemical alkaloids piperine [57].

Uses

- Anti-Arthritis:** Joint swelling is a symptom of arthritis. Black pepper has a high anti-inflammatory effect, thus

it can be used to treat and lessen arthritic symptoms as well as enhance bone health [58].

- Immune Support:** Black pepper can aid in boosting your immune system, which is crucial for preventing illness. Its active ingredients help your body produce more white blood cells, which are needed to fight off invasive viruses and bacteria [59].
- Anti-cancer:** Increasing bioavailability of other anti-tumor spices, pepper dramatically increases their potency and effectiveness against cancer. Black pepper counteracts cancer development directly.

Antimicrobial activity

- As the concentration of piperine rises, so does its antimicrobial efficacy against both current fungi and bacteria. It also validates the previous studies. Gram positive bacteria are more sensitive to pepper extracts than gram negative bacteria, according to the results of the current investigation. Nonetheless, there have been reports of antibacterial action against *B. megaterium*, *B. sphaericus*, *B. polymyxa*, *E. coli*, and *S. aureus* [60].
- The antibacterial activity of piperine against *S. aureus* has been reported to be enhanced when used in conjunction with medicines like ciprofloxacin [61].

J Peppermint: Steam distillation of *Mentha piperita* Linn's flowering tops yields mentha oil. Family: *Labiatae* [62].

Chemical constituents: The volatile oil extracted from peppermint is 0.1-1% and is mostly made up of menthol (29-48%), menthone (20-31%), menthofuran (6.8%), and menthyl acetate (3-10%). Berries, caffeic acid, flavonoids (12%), polymerized polyphenols (19%), carotenes, tocopherols, betaine, choline, and tannins are other pharmacologically active components [63].

Uses

- Indigestion:** Other digestive issues like upset stomach and indigestion can be effectively relieved with mint [64].
- Allergies:** The compound rosmarinic acid, which has anti-inflammatory and antioxidant properties, is found in mint plants. Asthma symptoms decreased on using rosmarinic acid [65].

Antimicrobial activity

- The components of mint, thymol and carvacrol, are linked to its antimicrobial properties. Effective against both Gram-positive and Gram-negative bacteria, these isomers are antibacterial agents [66].
- Mint exhibits strong antibacterial properties against *Streptococcus pyogenes* and *Staphylococcus aureus* [67].

Conclusion

Herbs are well-known for antimicrobial activity and their promising potential as natural agents against various pathogens. The diverse range of phytochemicals present in these herbs shows their ability to inhibit microbial growth. Medicinal plants use is essential for most of the antimicrobial activity due to drawbacks of modern-day medicine, herbal treatments have already attracted global interest. It suggests that incorporating herbal remedies could be a valuable adjunct to conventional antimicrobial strategies.

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