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EVALUATION OF NATURAL COMPOUNDS IN ANTIMICROBIAL DRUG DISCOVERY

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ABSTRACT

In the recent years research efforts are increasing towards use of plants as sources of drugs. Ethnopharmacologists, botanists, microbiologists, and natural-products chemists are working towards identification of phytochemicals and "leads" which can be of use to develop newer molecules for the treatment of infectious or non-infectious diseases. Among the currently available antimicrobial therapeutics for the treatment of infectious diseases very few are from natural sources. Plants are rich in a wide variety of secondary metabolites, such as tannins, terpenoids, alkaloids, and flavonoids, and these have been evaluated to demonstrate their antimicrobial properties. This review summarizes the current status of investigation of various antimicrobial agents from natural sources. The structure and antimicrobial properties of phytochemicals are also included.

KEYWORDS: Antimicrobial agents, Natural compounds, Phytoconstituents, Drug discovery.

I. INTRODUCTION

Natural antimicrobials are compounds derived from natural sources, such as plants, animals, and microorganisms, which exhibit antimicrobial properties.[1,2] These substances have been used for centuries in traditional medicine and are of interest for their potential applications in modern medicine, food preservation, and other industries. Some important examples of natural antimicrobial agents include essential oils (Tea Tree oil, Eucalyptus oil, Lavender oil, Thyme oil, Oregano oil), honey, garlic, ginger, turmeric, cinnamon, Manuka honey, coconut

oil, neem oil, Propolis, citrus extracts.[3-8] Honey has been used for its medicinal properties for centuries and has natural antimicrobial components. It is used topically to treat wounds and burns.[6,9-11] Allacin, an important constituent of garlic possess antibacterial and antifungal properties. It has been used traditionally for its medicinal properties.[12] Similarly, Gingerol, the active compound in ginger, has demonstrated antimicrobial activity against various bacteria and fungi[13,14] Curcumin is the main active ingredient in turmeric and has antimicrobial properties. It is known for its anti-inflammatory and antioxidant effects. Cinnamon has been studied for its antimicrobial properties against various bacteria and fungi.[15-17] Manuka honey is derived from the nectar of the Manuka tree in New Zealand and it is known for its potent antibacterial properties.[18] Coconut oil has been used traditionally for various health purposes. It contains lauric acid, which has antimicrobial properties.[19] Collected by bees from tree buds, propolis has natural antimicrobial properties. It is used by bees to seal and protect their hives. Neem oil, extracted from the neem tree, contains compounds with antibacterial and antifungal properties. It is used in traditional medicine and in skin care products.[20] Citrus fruits like grapefruit and lemon contain important phytoconstituents with antimicrobial properties. These extracts are sometimes used in natural cleaning products.[21,22] In this manuscript, a summary of various reported antimicrobial agents from natural sources along with their structure and phytoconstituents are provided.

II. NATURAL ANTIMICROBIAL COMPOUNDS

It's important to note that while these natural antimicrobials have demonstrated activity against various microorganisms in laboratory settings, their efficacy and safety can vary. Research is ongoing to explore their potential applications and to understand their mechanisms of action. Additionally, natural antimicrobials are often considered as complements to, rather than replacements for, conventional antimicrobial agents. Always consult with healthcare professionals or experts in the specific field for guidance on the use of natural antimicrobials. Many plants produce compounds that exhibit antimicrobial properties as a defense mechanism against pathogens. These natural antimicrobial compounds can be used for various purposes, including medicinal applications, food preservation, and hygiene. Some important plants and their antimicrobial components include various examples and are detailed in Table 1. The well reported plants and their antimicrobial compounds have been studied for their potential therapeutic applications. It's important to note that while these natural sources can have antimicrobial effects, they are not a replacement for conventional medical treatments when needed. Additionally, individual

responses to these natural compounds can vary, and consulting with healthcare professionals is advisable, especially in the case of medical conditions.[23-25]

Table 1: Some important plants, their antimicrobial Components and Properties.

Plant	Active compounds	Antimicrobial properties	Ref.
Tea tree (*Melaleuca alternifolia*)	Terpinen-4-ol, Cineole	Broad-spectrum antibacterial and antifungal properties. Used in various skincare and medicinal products	[26]
Garlic (*Allium sativum*)	Allicin, Ajoene	Antibacterial, antifungal, and antiviral properties. Used traditionally for various health purposes	[27]
Eucalyptus (*Eucalyptus spp*.)	Eucalyptol (Cineole), Terpenes	Known for its antibacterial and antiviral properties. Often used in essential oils and chest rubs	[28]
Ginger (*Zingiber officinale*)	Gingerol, Shogaol	Exhibits antibacterial and antifungal properties. Commonly used in traditional medicine and cooking	[29]
Thyme (*Thymus vulgaris*)	Thymol, Carvacrol	Strong antibacterial and antifungal properties. Used as a culinary herb and in natural remedies	[30]
Oregano (*Origanum vulgare*)	Carvacrol, Thymol	Exhibits strong antibacterial and antifungal effects. Used in cooking and herbal medicine	[31]
Neem (*Azadirachta indica*)	Nimbin, Azadirachtin	Possesses antibacterial, antiviral, and antifungal properties. Used in traditional medicine and skincare	[32]
Turmeric (*Curcuma longa*)	Curcumin	Exhibits antibacterial, antiviral, and antifungal properties. Known for its anti-inflammatory effects	[33, 34, 35]
Cinnamon (*Cinnamomum spp*.)	Cinnamaldehyde, Eugenol	Strong antibacterial and antifungal properties. Used in cooking and as a natural preservative	[36]
Aloe Vera (*Aloe barbadensis miller*)	Aloe-emodin, Aloin	Exhibits antibacterial and antifungal properties. Used for skincare and wound healing	[37]
Citrus Fruits (*Citrus spp*.)	Citrus flavonoids	Display antibacterial and antifungal effects. Used in natural cleaning products and for flavor	[38, 39]
Rosemary (*Rosmarinus officinalis*)	Rosmarinic acid, Camphor	Exhibits antibacterial and antifungal properties. Used in cooking and natural remedies	[40]

Phytoconstituents are bioactive compounds found in plants, and many of them exhibit antimicrobial properties. These natural compounds have been extensively studied for their potential applications in medicine, food preservation, and other industries. Some common phytoconstituents which have been evaluated for antimicrobial activity includes alkaloids,

flavonoids, tannins, terpenoids, saponins, lignans, phenolic acids, quinones, coumarins, curcuminoids, etc.[41] Their examples and antimicrobial properties are elaborated in Table 2. These phytoconstituents can act individually or synergistically to exert antimicrobial effects. The antimicrobial activity of plant-derived compounds often depends on their concentration, the specific microbial target, and the method of application. Research continues to explore the therapeutic potential of these natural compounds for combating infectious diseases and developing alternative antimicrobial agents.

Table 2: Antimicrobial Phytoconstituents and Their properties.

Name of Phytoconstituent	Examples	Antimicrobial Activity
Alkaloids	Berberine, Morphine, Quinine	Broad-spectrum antibacterial and antifungal effects.
Flavonoids	Quercetin, Kaempferol, Catechins	Exhibits antibacterial, antifungal, and antiviral properties. Quercetin, found in various fruits and vegetables, is known for its antimicrobial effects
Tannins	Ellagic acid, Gallotannins	Possesses antibacterial and antifungal properties. Tannins are often found in plant tissues such as bark and leaves
Terpenoids (Essential Oils)	Menthol, Limonene, Pinene	Many essential oils derived from plants exhibit strong antimicrobial effects against bacteria, fungi, and viruses. For example, tea tree oil contains terpinen-4-ol with notable antimicrobial properties
Saponins	Quillaja saponins, Ginsenosides	Exhibits antimicrobial effects against bacteria and fungi.
Lignans	Podophyllotoxin, Arctigenin	Demonstrates antibacterial and antifungal properties. Lignans are present in various plant sources
Phenolic Acids	Caffeic acid, Gallic acid	Exhibits antibacterial and antifungal effects. Phenolic acids are commonly found in fruits, vegetables, and medicinal plants
Quinones	Juglone, Plumbagin	Displays antimicrobial properties against bacteria and fungi. Juglone, for instance, is found in walnuts and has been studied for its antibacterial effects
Coumarins	Esculin, Umbelliferone	Shows antibacterial and antifungal effects. Coumarins are present in various plants and are known for their diverse pharmacological activities
Curcuminoids	Curcumin	Exhibits antibacterial, antifungal, and antiviral properties. Curcumin is the active component of turmeric

III. MECHANISM OF ANTIMICROBIAL ACTION

Some phytochemicals may act by inhibiting microbial growth, inducing cellular membrane perturbations, interference with certain microbial metabolic processes, modulation of signal transduction or gene expression pathways.[42] Understanding of mechanism of action of antimicrobial drugs from natural products will be helpful in order to increase the value of natural products as a source of novel drug candidates for infectious diseases. Few examples are explained here. Alkaloids are a diverse group of naturally occurring organic compounds that often possess pharmacological activities, including antimicrobial properties. The mechanisms of action of alkaloids as antimicrobial agents can vary depending on the specific alkaloid and the type of microorganisms they target. Here are some common mechanisms associated with the antimicrobial activity of alkaloids. Alkaloids (like Berberine) act by disruption of cell membrane integrity.[43,44]

IV. CONCLUSION

The declining efficacy of antimicrobial drugs has become a global public health problem and there is continuous demand for newer agents. The major reasons identified for this includes inappropriate use of antimicrobial drugs, presence of antibiotics in animal and plant feed, lack of sanitary practices, and variation in the genetic makeup of microbes. Natural products are the important sources to search for new antibacterial drugs. They possess a broad spectrum of chemical and functional diversity and to provide possible solution in case of antibiotic resistance.

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