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HERBAL ANTIBACTERIAL THERAPY: A REVIEW

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ABSTRACT

The increasing prevalence of antibiotic-resistant bacteria has led to a renewed interest in exploring alternative sources of antimicrobial agents, including medicinal plants. Many plants traditionally used in folk medicine possess antibacterial properties that could be harnessed for modern therapeutic applications. This paper explores the antibacterial properties of several medicinal plants, including neem (*Azadirachta indica*), garlic (*Allium sativum*), turmeric (*Curcuma longa*), ginger (*Zingiber officinale*), and aloe vera (*Aloe barbadensis*) etc. These plants have been widely recognized for their effectiveness in combating bacterial infections, with compounds as key contributors to their antibacterial activity. These plants can inhibit the growth of various pathogenic bacteria, including *Escherichia coli, Staphylococcus aureus, and Bacillus subtilis etc*. In addition to their antibacterial effects, some of these plants exhibit anti-inflammatory, analgesic, and immune-boosting properties, making them multifunctional agents in the treatment of infections. Despite their promising potential, challenges remain in standardizing the use of plant-based antimicrobial agents, ensuring safety, and addressing variations in efficacy due to environmental factors. Nevertheless, the growing body of research on the antibacterial properties of medicinal plants underscores their value as natural alternatives or adjuncts to conventional, novel antibiotics, particularly in light of the global rise in antibiotic resistance. Further studies are needed to explore their full therapeutic potential and integrate them into mainstream healthcare practices.

KEYWORDS: Antibacterial properties, Antibiotic resistance, Phytomedicine, Natural antimicrobial agents.

INTRODUCTION

Antibiotic resistance is the presence of a genetically determined resistance mechanism (either acquired or mutated) developed by the pathogens as resistant that is correlated with high likelihood of therapeutic failure. As the antibiotic resistance continues to progress while the pipeline for new antibiotic development is drying up; after only eight decades of antibiotic use.[1] Bacteria are microscopic, single-celled organisms that do not have a nucleus or other membrane-bound organelles. As prokaryotes, their genetic material is not contained within a nuclear membrane.[2] It has a basic cell structure, which includes a cell wall, cell membrane, cytoplasm, and genetic material, usually range from 0.5 to 5.0 µm in diameter. Bacteria come in various shapes, including spherical (cocci), rod-like (bacilli), and spiral (spirilla). Bacteria may be autotrophic, meaning they produce their own food, or heterotrophic, meaning they obtain food from external sources and can reproduce through binary fission, a process where a single cell splits into two identical daughter cells.[3] Bacteria can be of following types

1. **Gram-Positive Bacteria**: These bacteria have a thick peptidoglycan layer in their cell walls, which appear them to stain purple during Gram staining.
2. **Gram-Negative Bacteria**: These bacteria possess a thin peptidoglycan layer in their cell walls and appear pink when stained with Gram stain.
3. **Sporing Bacteria**: These bacteria are capable of producing spores, which are highly resistant to heat, desiccation, and chemicals.[4]

Bacteria are infectious in nature causing various disease like Tuberculosis (TB) caused by *Mycobacterium tuberculosis*[5], Pneumonia caused by *Streptococcus pneumoniae*, Urinary Tract Infections (UTIs) caused by *Escherichia coli* (E. coli)[6], Food Poisoning caused by *Salmonella*, *Campylobacter*, and *E. coli*[7], Leprosy caused by *Mycobacterium leprae*,[8], Gonorrhoea caused by *Neisseria gonorrhoeae*[9], Syphilis caused by *Treponema pallidum*[10], Anthrax caused by *Bacillus anthracis*,[11], Plague caused by *Yersinia pestis*,[12], Meningitis caused by *Neisseria meningitidis*[13], etc.

Antibiotic have enabled the advancement of many areas of healthcare. The successful outcome for surgical

procedures and immunosuppressive treatment depends on use of antibiotics. Antibiotic resistance, therefore, poses a serious threat and need for development of new antibiotic is gradually on demand. Phytomedicine, which dates back to the dawn of human evolution, may have potential antibiotic properties and can be a good replacement for synthetic medications.

Phytomedicine is the use of plants as medicine, rooted in ancestral trial and error. It blends traditional knowledge with scientific understanding.[14] Phytomedicine explores a range of disorders by bridging the fields of pharmacognosy and medicinal plants with conventional medicine. It integrates herbal treatments that have been refined through pharmacological research, while also recognizing other natural sources like minerals, shells, animal products, fungi, and bee secretions. However, many herbal remedies in the 21st century still lack strong scientific evidence regarding their safety and effectiveness.[15] Phytomedicine derived from plants, accounts for a quarter of pharmaceutical prescriptions in the U.S., providing effective and safe treatments. Approximately 500 plants are referenced in ancient texts, and 800 are used in indigenous systems, demonstrating the complexity and potency of natural remedies. These treatments are gaining renewed recognition for their success in primary healthcare and age-related conditions, highlighting the need for their incorporation into health systems to bridge traditional and modern practices.[16] Infectious diseases are a major cause of illness and death globally, responsible for about 50% of all deaths in tropical countries. Despite significant advancements in microbiology and the control of microorganisms, occasional epidemics caused by drug-resistant microbes and previously unknown pathogens continue to pose a serious public health threat. These troubling health trends highlight the need for a global effort to develop new strategies for preventing and treating infectious diseases. For over a century, chemical compounds derived from medicinal plants have served as the foundation for many clinically proven drugs, and are now being re-evaluated as potential antimicrobial agents. This resurgence is driven by a decline in new antibacterial drugs in development, the rise in antimicrobial resistance, and the urgent need for treatments for newly emerging pathogens. Thousands of plant species have been tested against numerous bacterial strains in laboratory settings, and many medicinal plants have shown activity against a broad spectrum of both gram-positive and gram-negative bacteria.[17]

Importance of phytomedicine

Herbal medicine is increasingly being used by a growing number of patients, who often do not inform their clinicians about using them concurrently. There are several reasons why patients seek herbal treatments. A common explanation is the "sense of control, a mental comfort from taking action," which may explain why many individuals using herbs suffer from chronic or incurable conditions like diabetes, cancer, arthritis, or AIDS. In these cases, they often feel that conventional medicine has not been effective. When patients turn to home remedies for acute, usually self-limiting issues, such as a cold, sore throat, or bee sting, it is often due to the lack of immediate access to professional care, or because it is too inconvenient, costly, or time-consuming.[18],[19] In rural areas, cultural factors play a significant role in promoting the use of botanicals, influenced by the environment and the belief in a "man-earth relationship". People believe that if a particular disease is prevalent in an area, the plants found there can offer a cure. In India, large parts of the rural population lack access to modern medicine, with hundreds of primary health centres in these areas lacking staff, diagnostic tools, and sufficient drug supplies. As a result, rural communities heavily rely on traditional medicinal systems. Natural plant products are often seen as healthier than pharmaceutical drugs, and reports of adverse effects from conventional medications are more commonly found in the media than reports of herbal toxicity. This may be because systems to track adverse effects are in place for conventional medicines, whereas such data for self-treatment is harder to obtain. Even many physicians tend to regard herbs as harmless placebos.[20]

Table no. 1: List of herbs used as antibacterial.

S.no	Botanical Name	Local Name	Family	Chemical Constituent	Against bacteria	Reference
1.	*Azadirachta indica*	Neem	Meliaceae	Nimbin, nimbidic acid, azadirachtin, azadirone, meldenin, vepinin, nimbolin A&B etc.	Ea, K	[21]
2.	*Aloe barbadensis*	Aloe	Liliaceae	Aloe-emodin, barbaloin	S	[22],[23]
3.	*Melia azedarach*	Mahanimb	Meliaceae	Meliacin	S	[24]
4.	*Zingiber officinale*	Adarack	Zingiberaceae	Zingerol, zingeberene	P,S	[25],[23]
5.	*Cinnamomun zeylanicum*	Cinnamon	Lauraceae	Cinnamaldehyde, cinnamic acid, cinnamate	P,S	[23],[26]

6.	*Lawsonia inermis*	Hena	Lythreaceae	Lawsone	P,S	[23],[27]
7.	*Citrus grandis*	Pomela	Rutaceae	Neohesperidien, Naringin	K	[28],[29]
8.	*Butea monosperma*	Palash	Fabaceae	Butin, coreopsin, monospermoside, palasoin	MRSA,VRS	[30],[31]
9.	*Rauwolfia serpentina*	Serpagandha	Apocynaceae	Reserpine	MRSA,S,Ef,IRP, ESBL-KP	[32],[33]
10.	*Eucalyptus globulus*	Nilgiri	Myrtaceae	Eucayptol, globulol	Bacillus subtilis, S	[34]

Key to Abbreviation: Ea- *E. aerogene*, K- *Klebsiella pneumoniae*, S- *Staphylococcus aureus*, *P- Pseudomonas aeruginosa*, MRSA- Methicillin resistant *Staphylococcus aureus*, VRS- Vancomycin-resistant *Staphylococcus aureus*, Ef- *Enterococcus faecium*, IRP- Imipenam resistant *Pseudomonas aeruginosa*, ESBL-KP- Extended Spectrum β lactamase producing *Klebsiella pneumoniae*.

Table: Medicinal plants and their marketed products.[35][36][37][38]

S. No.	Medicinal Plant	Marketed Product	Companies
1.	*Allium sativum* (Garlic)	Lasuna	Himalaya drug
		Lashunadi bati	Baidyanath
2.	*Allium cepa* (Onion)	Allium cepa	Homeopathic
		Allium Cepa Plex	Seroyal Genestra UNDA
		Allium Cepa 30C	Health Chemist
3.	*Curcuma longa* (Turmeric)	J.P. Nikhar oil	Jamuna pharma
		Purian	Himalaya drug
		Respinova	Lupin lab.
4.	*Cuminum cyminum* (Cumin)	Lukol	Himalaya drug
		Hajmola	Dabur
5.	*Mangifera indica* (Mango)	Ethosomal Gel	Merck India Ltd.
6.	*Nigella sativa* (Black cumen)	Anti-dandruff shampoo	Himalaya drug
		Kankayan gutika	Dabur
7.	*Ocimum sanctum* (Tulsi)	Shri tulsi	International Manufacturing Corporation Ltd.
		Diokof, Koflet	Himalaya drug
		Nomarks	Nyle herbals
		Kofol syrup	Charak pharma
8.	*Rosmarinus officinalis* (Rosemary)	Anti-Dandruff oil	Himalaya drug
		Erina plus	
9.	*Syzygium aromaticum* (Clove)	Himsagar tail	Dabur
		Dabur red paste	
10.	*Zingiber officinale* (Ginger)	Gasex	Himalaya drug
		Strepsil	Boots piramil
		Sage massage oil	Sage herbal

a. Lasuna (39)

b. Allium cepa (40)

c. Respinova (41)

d. Lukol (42)

			
e. Kankayan gutika (43)	**f. Kofol syrup (44)**	**g. Erina plus (45)**	**h. Dabur red paste (46)**

Future prospects of Phytomedicine

It is estimated that nearly three-quarters of the herbal drugs used globally were discovered based on insights from traditional medicine. According to the WHO, about 25% of modern medications have origins in plants that were first used in traditional practices. Many other medications are synthetic versions derived from plant-based compounds. In India, almost 70% of modern medicines come from natural sources. The role of plants in medicine is expected to persist in the future, both as a source of therapeutic agents and as raw materials for extracting semi-synthetic compounds used in cosmetics, perfumes, and the food industry. The growing popularity of plant-based health products can be attributed to their increased use in the cosmetic industry and the rising public demand for affordable solutions to maintain personal health and wellness. Medicinal plants play an important role in both healthcare and income generation, contributing significantly to broader economic development. While the effectiveness of herbal medicines requires improved quality control and evidence evaluation, the demand for botanicals and herbal products is a rapidly expanding market. Even developed nations have begun utilizing medicinal systems that incorporate herbal treatments. Clearly, the global demand for plant-derived products continues to rise, with projections indicating further growth, driven by the increasing sales of herbal supplements and remedies. This trend suggests that countries like China and India, which have the richest diversity of medicinal plant species and are major exporters of these plants, will be key suppliers for future demand (20). The novel drug delivery has generated significant impact in healthcare and medicine. Their nanoparticle have some property like enhance drug solubility modulate drug release characteristic, target drug molecule to desire site of action, offer stealth for immune evasion and deliver multiple drugs simultaneously. As nanomedicine continually advances and newly approaches, nanoparticle-based strategy has a primary goal to increase therapeutic efficacy while minimizing drug resistance development.[47]

CONCLUSION

It is concluded; the antibacterial properties of various medicinal plants highlight their significant potential as natural alternatives to conventional antibiotics. Plants such as garlic, ginger, aloe vera, turmeric, and neem etc. These plants have demonstrated effectiveness in inhibiting bacterial growth, offering a promising avenue for treating infections. The use of these plants could help address the rising issue of antibiotic resistance. However, more research is needed to explore their full therapeutic potential, establish proper dosages, and ensure safety. With continued investigation, medicinal plants could play a crucial role in the development of novel, plant-based treatments for bacterial infections in modern healthcare.

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