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A REVIEW ON NATURAL PRODUCTS AND THEIR ANTIMICROBIAL PROPERTIES

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ABSTRACT

Natural products have been a rich source of antimicrobial agents since ancient times, playing a crucial role in the development of modern drugs. This review comprehensively explores the antimicrobial properties of natural products derived from various sources, including plants, animals, minerals, and microbes. The diverse array of active principles and secondary metabolites present in these natural sources, such as alkaloids, tannins, terpenoids, essential oils, flavonoids, and proteins, contribute to their effectiveness against a wide range of microorganisms.

Specific examples highlight the antimicrobial potential of various natural products. Neem leaves, essential oils from Thyme, Cinnamon, and Eucalyptus, and triterpenoids from Glycyrrhiza glabra exemplify the broad spectrum of activities exhibited by these compounds. Furthermore, the medicinal value of animal-derived products, such as the Kadaknath breed of poultry and mineral sources like cow urine concentrate and cow dung, underscores the diverse origins of these antimicrobial agents.

The review emphasizes the need for a coordinated approach among researchers, scientists, industrialists, Ayurveda experts, administrators, and funding agencies to fully harness the immense potential of natural products in drug development. As an alternate source for combating infections, natural products offer a promising avenue, and their exploration requires a multidisciplinary effort. This review provides insights into the current understanding of natural products' antimicrobial properties and their significance in the context of contemporary healthcare challenges.

Keywords: Natural products, Antimicrobials, Antibacterial, Infections.

1. INTRODUCTION

Natural products have been a cornerstone of medicine and therapeutics since time immemorial, offering a vast and diverse reservoir of bioactive compounds with potent antimicrobial properties. In the face of emerging antibiotic resistance and the challenges posed by infectious diseases, the exploration of natural products has gained renewed attention in contemporary drug discovery and development programs.

This review aims to provide a comprehensive overview of the antimicrobial properties exhibited by natural products originating from various biological sources, including plants, animals, minerals, and microbes. The allure of these natural sources lies in the intricate biochemical compounds they harbor, ranging from alkaloids, tannins, and terpenoids to essential oils, flavonoids, and proteins. The multifaceted nature of these compounds has rendered them effective against a broad spectrum of microorganisms, making them invaluable candidates for the development of novel antimicrobial agents.

As we delve into the rich tapestry of natural products, specific case studies will illuminate their antimicrobial prowess. From the anti-dermatophytic activity of Neem leaves to the antibacterial effects of essential oils from Thyme, Cinnamon, and Eucalyptus, and the antiviral capabilities of triterpenoids from Glycyrrhiza glabra, these examples underscore the versatility of natural products in combating infectious agents.

Notably, the review will extend its exploration to animal-derived products, such as the famed medicinal properties of the Kadaknath breed of poultry, and mineral sources like cow urine concentrate and cow dung, which have demonstrated antibacterial activity against various pathogens.In addition to highlighting the potency of natural products, this review emphasizes the necessity of a collaborative and coordinated approach among researchers, scientists, industrialists, Ayurveda experts, administrators, and funding agencies. The collective efforts of these stakeholders are pivotal in realizing the full potential of natural products as a robust and sustainable reservoir for antimicrobial drug development. As we embark on this journey through the realm of natural products and their antimicrobial properties, the overarching goal is to contribute insights that inspire further exploration and innovation in the quest for effective and environmentally friendly antimicrobial solutions.

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Naturally occurring antimicrobials?

In the ongoing battle against infectious diseases and the growing challenge of resistance to antibacterial agents, the exploration of naturally occurring antimicrobials has become increasingly vital.

Nature, with its diverse array of organisms, has endowed us with a broad spectrum of compounds possessing intrinsic antimicrobial properties. These natural antimicrobials, found in plants, animals, microbes, and even minerals, have played a fundamental role throughout history in combating pathogens.

This review aims to delve into the diverse landscape of naturally occurring antimicrobials, shedding light on their origins, mechanisms of action, and potential applications. From ancient remedies to modern drug discovery, these compounds have been harnessed for their ability to inhibit or eliminate microorganisms, providing a sustainable and often overlooked alternative to synthetic antibacterial agents.

The versatile nature of naturally occurring antimicrobials spans various chemical classes, including alkaloids, tannins, terpenoids, essential oils, flavonoids, peptides, proteins, and enzymes. Each class introduces a unique set of bioactive molecules, showcasing the adaptability and resilience inherent in the defense mechanisms of the natural world.

Throughout this exploration, we will uncover the antimicrobial potential of specific examples. From the renowned antibacterial properties of essential oils extracted from plants like thyme and eucalyptus to the antiviral activity of triterpenoids found in licorice (Glycyrrhiza glabra), these case studies will illuminate the breadth and specificity of naturally occurring antimicrobials.

Additionally, this review will address the ecological and sustainable aspects of natural antimicrobials, underscoring their potential to mitigate the environmental impact associated with synthetic antibacterial drugs. The holistic understanding of these compounds, coupled with technological advancements, holds promise for the development of new therapeutic solutions to address current and emerging infectious challenges.

Advantages of naturally occurring antimicrobials?

1. **Biocompatibility**: Naturally occurring antimicrobials are often derived from sources that are compatible with biological systems. This biocompatibility reduces the likelihood of adverse effects on human health compared to some synthetic antimicrobials.
2. **Reduced Antibiotic Resistance:** Overuse of synthetic antibiotics has led to the development of antibiotic-resistant strains of bacteria. Naturally occurring antimicrobials, being part of complex biological systems, may have mechanisms that make it more challenging for bacteria to develop resistance**.**
3. **Sustainability:** Many naturally occurring antimicrobials are derived from renewable resources, such as plants, which can be sustainably harvested or cultivated. This contrasts with some synthetic antimicrobials, which may rely on non-renewable resources**.**
4. **Environmental Impact:** The production and disposal of synthetic antimicrobials can have significant environmental impacts. Naturally occurring antimicrobials, when sourced and used responsibly, may have a lower environmental footprint.
5. **Diverse Sources:** Naturally occurring antimicrobials can be found in a variety of sources, including plants, animals, microbes, and minerals. This diversity provides a wide range of compounds with different modes of action, allowing for a more comprehensive approach to combating microbial threats**.**
6. **Rich in Bioactive Compounds:** Natural sources often contain a complex mixture of bioactive compounds that may have synergistic effects, enhancing their overall antimicrobial properties. This complexity can contribute to a broader spectrum of activity against different pathogens**.**
7. **Cultural and Traditional Knowledge:** Many naturally occurring antimicrobials have been used for centuries in traditional medicine. Leveraging this accumulated knowledge can provide valuable insights into effective and safe antimicrobial applications.
8. **Potential for Combination Therapies:** Natural antimicrobials may be combined with other natural or synthetic compounds to create effective combination therapies. This approach can enhance efficacy while potentially reducing the risk of resistance.
9. **Consumer Preference:** There is a growing awareness and preference among consumers for products with natural ingredients. Using naturally occurring antimicrobials in consumer products aligns with this trend and may contribute to market competitiveness**.**
10. **Cost-Effectiveness:** In some cases, the production of naturally occurring antimicrobials may be more cost-effective, especially when sourced from readily available and sustainable materials**.**

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Classification of natural antimicrobials: Natural antimicrobial agents can be classified based on their activity against different types of microorganisms. (antibacterial, antifungal, antiviral, antiprotozoal and insecticidal agents.)

1. **Anti-bacterial Agents:**

- **Cassia alata Leaves:** In vitro antibacterial activity against Staphylococcus aureus, E. coli, Bacillus subtilis, Salmonella typhi.
- **Samecarpus anacardium (Dry Nuts) Extracts:** Bactericidal activity against Gram-negative strains (E. coli, S. typhi, Proteus vulgaris) and Gram-positive strains (Staphylococcus aureus, Corynebacterium diptheriae).

Thyme, Cinnamon, Eucalyptus Essential Oils: Exhibited antibacterial activity.

2. **Anti-fungal Agents:**

- **Neem Leaves:** Anti-dermatophytic activity.
- **Various Plant Extracts (Eucalyptus, Tulsi, Neem, Castor, Jatropha):** Demonstrated antifungal activities, with Eucalyptus showing 88%, Tulsi 85.5%, Neem 84.66%, Castor 75%, and Jatropha 10%.
- **Aegel mermelos (Bael) Essential Oils:** Exhibited antifungal and sporicidal activity.
- **Cassia alata Leaves:** Showed antifungal activity against Aspergillus niger and Candida albicans.
- **Withania somnifera (Ashwagandha) Roots:** Effective against Aspergillus fumigatus.

3. **Anti-viral Agents:**

- **Glycyrrhizin (from Glycyrrhiza glabra):** Tested effective against RNA viruses like measles, polio, and HIV at higher concentrations, inhibits DNA viruses at lower concentrations.
- **Mangrove Plant Extracts:** Showed antiviral activity against HIV by inhibiting viral adsorption to host cells.
- **Hemidesmus indica Leaves and Cassia fistule Stem Extracts:** Inhibit viral replication and cytopathic effect of Ranikhet Disease (RD) virus and vaccinia virus due to interferon-like factors.

4. **Anti-protozoal Agents:**

- **Quinine (from Cinchona Tree Bark):** Antimalarial drug.
- **Artemisia japonica Extracts:** Inhibited schizont stage of chloroquine-sensitive strains of Plasmodium falciparum.
- **Swertica charata Extracts**: Inhibited catalytic activity of topoisomerase-I enzyme of Leishmania donovoni, showed anti-leishmanial activity.
- **Parthenium hysteroporous (Congress Grass) Extracts:** Exhibited trypanocidal activity against Trypanosoma evansi.

5. **Insecticidal Agents:**

- **Neem Oil:** Placed over breeding places, inhibited breeding of Anopheles stephani and Aedes aegypti mosquitoes**.**
- **Camphor Oil and Neem Cream:** Applied on exposed body parts, significantly protected against Aedes, Culex, and Anopheles mosquito bites.
- **Derris elliptica Roots:** Yields 'rotenone' effective against head lice, scabies, and other ectoparasites.
- **Pyrethrum (from Pyrethrum Flowers):** One of the oldest known insecticides.
- **Anti-microbial properties of some animal products:**

1. **Milk:**

- **Immunoglobulins:** Present in milk, they contribute to its antimicrobial properties.
- **Lactoperoxidase System:** An enzymatic system that generates antimicrobial compounds.
- **Lactoferrin:** Binds to iron, limiting its availability to microbes.
- **Lysozyme:** Enzyme that can break down bacterial cell walls.

2. **Kadaknath Breed of Poultry:** Black Meat and Blood: Known for its medicinal value and potential antimicrobial properties.
3. **Cow Products:**

- **Cow Urine Concentrate:** Shows antibacterial activity against bacteria like B. subtilis, P. aeruginosa, etc.
- **Cow Dung**: Exhibits antibacterial activity against various bacteria.

Antimicrobial properties of some traditionally used medicinal plants

1. **Neem (Azadirachta indica):**

- **Antibacterial:** Effective against a wide range of bacteria.
- **Antifungal:** Shows activity against various fungi.
- **Antiviral:** Exhibits antiviral activity against certain viruses.

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2. **Turmeric (Curcuma longa):**
- **Antibacterial:** Demonstrates antibacterial activity against several strains.
- **Antifungal:** Shows antifungal activity against certain fungi.
- **Antiviral:** Exhibits antiviral properties.

3. **Aloe Vera (Aloe barbadensis miller):**
- **Antibacterial:** Exhibits antibacterial activity.
- **Antifungal:** Shows antifungal properties.
- **Antiviral:** Potential antiviral effects.

4. **Ginger (Zingiber officinale):**
- **Antibacterial:** Demonstrates antibacterial activity.
- **Antifungal:** Exhibits antifungal effects.
- **Antiviral:** Shows potential antiviral properties

5. **Thyme (Thymus vulgaris):**
- **Antibacterial:** Known for strong antibacterial effects.
- **Antifungal:** Exhibits antifungal activity.
- **Antiviral:** Shows antiviral properties.

6. **Cinnamon (Cinnamomum verum):**
- **Antibacterial:** Known for antibacterial properties.
- **Antifungal:** Exhibits antifungal activity.
- **Antiviral:** Shows potential antiviral effects.

Things to be done for the Improvement and the utilization of natural antimicrobials

It involves various aspects ranging from research and development to sustainable practices.

1. **Research and Development:**
- **Explore New Sources:** Invest in research to identify new plant, animal, and microbial sources with potent antimicrobial properties.
- **Bioactive Compound Isolation:** Work on isolating and characterizing bioactive compounds from natural sources to understand their mechanisms and optimize efficacy.

2. **Sustainable Cultivation Practices:**
- **Organic Farming:** Promote organic and sustainable farming practices to ensure the quality and potency of natural antimicrobials.
- **Biodiversity Conservation:** Protect and conserve plant and animal species that are sources of natural antimicrobials.

3. **Standardization and Quality Control:**
- **Quality Assurance:** Establish quality standards for the production and processing of natural antimicrobials to ensure consistency and safety.
- **Certification Programs:** Develop certification programs for products derived from natural sources, indicating adherence to quality and sustainability standards**.**

4. **Education and Awareness:**
- **Public Awareness:** Educate the public about the benefits of natural antimicrobials and sustainable harvesting practices**.**
- **Training Programs:** Provide training programs for farmers, herbalists, and producers on best practices for cultivating and processing natural antimicrobials.

5. **Collaboration and Networking:**
- **Industry-Academia Collaboration:** Foster collaboration between researchers, industry professionals, and academic institutions to accelerate the development and application of natural antimicrobials.

2. CONCLUSION

The antimicrobial properties exhibited by various natural products highlight their potential as alternatives to synthetic counterparts, offering a holistic and sustainable approach to combat infections. The multifaceted nature of these agents, ranging from alkaloids and essential oils to peptides and proteins, emphasizes the versatility and adaptability inherent in nature's defense mechanisms. The ecological and sustainable aspects of natural antimicrobials are highlighted, emphasizing the need for responsible harvesting and cultivation practices. The potential to mitigate the environmental impact associated with synthetic antimicrobials further positions natural products as valuable assets in

the global fight against infectious diseases. As we navigate the complexities of microbial threats, a coordinated approach is advocated. Collaboration among researchers, scientists, industry professionals, traditional healers, and policymakers is essential to unlock the full potential of natural products. The integration of traditional knowledge with modern scientific methodologies, coupled with robust clinical trials, can bridge the gap between traditional medicine and evidence-based practices.

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