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Lemongrass (*Cymbopogon citratus*): Beneficial Effects on Human Health - A Review

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Abstract: ***Lemongrass (Cymbopogon citratus), a widely known medicinal and aromatic herb, is acclaimed for its diverse therapeutic properties, including antibacterial, antifungal, antioxidant, anti-inflammatory, and sedative effects. Rich in bioactive compounds such as citral, flavonoids, and tannins, lemongrass is a cornerstone in traditional medicine systems and continues to attract scientific interest. This review explores the phytochemical profile, mechanisms underlying its biological activities, and potential applications in healthcare. Challenges in standardization, safety, and clinical validation are highlighted, alongside future opportunities for its development as a therapeutic agent.***

Keywords: Anti-inflammatory, antimicrobial, Lemongrass, Health benefits, Therapeutic plants

1. Introduction

Lemongrass (*Cymbopogon citratus*), a perennial herb belonging to the Poaceae family, is a widely cultivated aromatic plant known for its strong lemon-like aroma and diverse therapeutic properties. Originating from tropical and subtropical regions, lemongrass is extensively grown in countries like India, Thailand, Sri Lanka, and Brazil, where it is used in traditional medicine, culinary practices, and industrial applications. The herb is commonly referred to as "fever grass" in some cultures due to its historical use as a natural remedy for fever and related ailments.

For centuries, lemongrass has been valued in traditional medicinal systems such as Ayurveda, Traditional Chinese Medicine (TCM), and African ethno medicine. It has been employed as a versatile remedy for numerous health conditions, including digestive issues, inflammation, fever, respiratory problems, and infections. The aromatic nature of lemongrass has made it a popular ingredient in teas, soups, and other culinary preparations that not only enhance flavour but also deliver therapeutic benefits. Additionally, the essential oil extracted from lemongrass has been widely used in aromatherapy, cosmetics, and as a natural insect repellent, further highlighting its multifaceted applications.

The therapeutic potential of lemongrass is attributed to its rich phytochemical profile, which includes citral (a mixture of the isomers geranial and neral), myrcene, flavonoids, tannins, alkaloids, and other bioactive compounds. Among these, citral is the primary bioactive compound responsible for its antimicrobial, anti-inflammatory, antioxidant, and anxiolytic effects. Flavonoids and tannins contribute to its antioxidant and Antidiabetic properties, while myrcene and geraniol add to its antifungal and calming effects. These phytochemicals work synergistically, offering a broad spectrum of pharmacological activities that are of interest to both traditional healers and modern researchers.

In modern pharmacological research, lemongrass has demonstrated significant potential as a natural therapeutic agent. Several studies have confirmed its antibacterial and antifungal activity against a variety of pathogens, including drug-resistant strains such as *Staphylococcus aureus* and *Candida albicans*. Its antioxidant properties help combat oxidative stress by neutralizing free radicals, thereby preventing cellular damage associated with chronic diseases like cancer, diabetes, and cardiovascular disorders. Additionally, the anti-inflammatory properties of lemongrass make it an effective natural remedy for managing conditions such as arthritis, asthma, and skin inflammations.

The anxiolytic and sedative effects of lemongrass have also gained attention, with studies showing its ability to modulate the GABAergic system in the brain, promoting relaxation and reducing anxiety. This has made lemongrass a popular choice for aromatherapy and herbal infusions aimed at stress relief. Furthermore, its potential role in regulating blood glucose levels and enhancing insulin sensitivity has positioned it as a promising candidate for managing diabetes and preventing its complications. Preliminary studies on its anticancer activity suggest that citral induces apoptosis (programmed cell death) in cancer cells and inhibits tumour growth, making it a potential natural agent in cancer therapy.

Despite its widespread use and growing recognition, there are still gaps in the scientific validation of many of the traditional claims regarding lemongrass. Variations in its bioactive compound concentrations, influenced by factors such as cultivation conditions, harvesting methods, and extraction techniques, pose a challenge to standardizing its therapeutic applications. Moreover, while preclinical studies have yielded promising results, large-scale clinical trials are essential to confirm its safety, efficacy, and dosage parameters in humans.

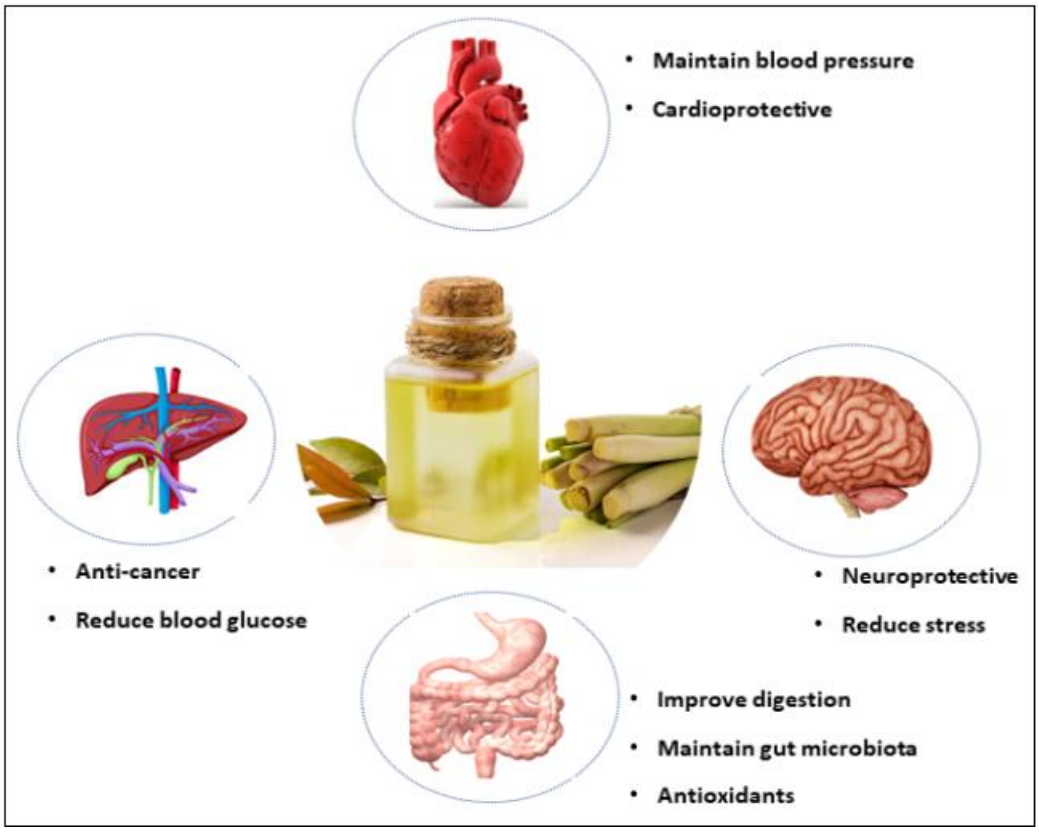
In addition to its medicinal properties, lemongrass holds significant economic and environmental value. Its cultivation is relatively low-maintenance, making it a viable crop for small-scale and large-scale farmers alike. As a renewable natural resource, lemongrass supports sustainable agricultural practices and the development of eco-friendly products, from natural insect repellents to biodegradable packaging infused with its essential oils. lemongrass (*Cymbopogon citratus*) represents a remarkable blend of traditional knowledge and modern scientific potential. Its

diverse range of health benefits, coupled with its safety and accessibility, makes it a promising candidate for developing natural remedies and pharmaceutical formulations. This review aims to provide a comprehensive overview of the beneficial effects of lemongrass, highlighting its phytochemical composition, pharmacological properties, and mechanisms of action. By bridging the gap between traditional uses and contemporary scientific evidence, this study seeks to underscore the relevance of lemongrass in modern medicine and its future prospects as a versatile therapeutic agent.

2. Beneficial Effects of Lemongrass

1) **Antibacterial Activity**
   Lemongrass is effective against harmful bacteria such as *Escherichia coli* and *Staphylococcus aureus*. Citral, its primary compound, disrupts bacterial cell membranes and essential enzymatic pathways, making it a potent agent against infections, especially for skin wounds and foodborne illnesses.
2) **Antifungal Activity**
   Citral and geraniol in lemongrass help combat fungal infections by altering the integrity of fungal cell walls. This results in leakage of intracellular contents, inhibiting fungal growth. It is particularly effective against *Candida albicans* and other dermatophytes.
3) **Antioxidant Activity**
   Bioactive compounds like flavonoids and alkaloids in lemongrass neutralize reactive oxygen species (ROS), preventing oxidative stress. This helps reduce the risk of chronic diseases, such as cancer, diabetes, and cardiovascular disorders.
4) **Anti-inflammatory Effects**
   Lemongrass inhibits pro-inflammatory enzymes like cyclooxygenase (COX) and cytokines such as TNF-α and IL-6. These actions make it beneficial in managing inflammation-associated conditions like arthritis, asthma, and inflammatory bowel diseases.
5) **Anxiolytic and Sedative Properties**
   Citral and myrcene in lemongrass exhibit calming effects by modulating the GABAergic system, which regulates brain relaxation pathways. This helps reduce stress, anxiety, and improve sleep quality, making it popular in aromatherapy.
6) **Antidiabetic Activity**
   Compounds in lemongrass enhance insulin sensitivity, regulate glucose metabolism, and inhibit enzymes such as α-amylase. This can lower blood sugar levels and prevent diabetes complications.
7) **Anticancer Properties**
   Citral induces programmed cell death (apoptosis) in cancer cells and inhibits angiogenesis, the formation of new blood vessels necessary for tumour growth. Preliminary studies have shown its effectiveness against cancers like colon, breast, and liver.
8) **Gastro protective Effects**
   The herb reduces gastric acidity and promotes mucosal protection, alleviating issues like ulcers and indigestion. Its bioactive compounds stimulate tissue healing in the digestive tract, relieving discomfort.
9) **Immunomodulatory Activity**
   Lemongrass enhances immune responses by increasing macrophage activity and regulating inflammatory mediators. This makes the immune system more robust in combating infections and inflammation-related diseases.
10) **Cardioprotective Effects**
    By lowering cholesterol and triglyceride levels and preventing platelet aggregation, lemongrass contributes to better cardiovascular health. It can reduce the risk of atherosclerosis, high blood pressure, and heart diseases.

Therapeutic Activity	Description	Mode of Action
Antibacterial	Inhibits growth of *E. coli*, *S. aureus*, and other pathogens.	Damages bacterial membranes, disrupts cellular processes via citral and flavonoids.
Antifungal	Effective against fungi such as *Candida albicans* and dermatophytes.	Inhibits ergo sterol synthesis, leading to fungal cell membrane disruption.
Anti-inflammatory	Reduces inflammatory markers and pain.	Suppresses COX-2 and pro-inflammatory cytokines through citral activity.
Antioxidant	Neutralizes free radicals and reduces oxidative stress.	Boosts activity of endogenous antioxidant enzymes (e.g., SOD, catalase).
Anxiolytic	Relieves stress and promotes relaxation.	Modulates GABAergic pathways and reduces neural excitability.
Anticancer	Induces apoptosis in tumour cells in vitro.	Activates pro-apoptotic pathways, inhibits angiogenesis.
Antidiabetic	Regulates blood glucose levels.	Enhances insulin secretion and improves insulin sensitivity.



Comparison of Plants Exhibiting Similar Activities

Plant	Activity	Active Compounds	Mode of Action	References
Lemongrass (*Cymbopogon citratus*)	Antibacterial	Citral, flavonoids	Damages bacterial membranes by disrupting lipid integrity.	Nagappan, 2012 [1]
Clove (*Syzygium aromaticum*)	Antioxidant	Eugenol	Scavenges free radicals, enhances superoxide dismutase (SOD) levels.	Gill & Holley, 2004 [2]
Neem (*Azadirachta indica*)	Antifungal	Azadirachtin	Disrupts fungal cell wall synthesis and inhibits spore formation.	Pandey et al., 2014 [3]
Ashwagandha (*Withania somnifera*)	Anti-inflammatory	Withaferin A	Inhibits NF-κB signalling and COX-2 pathways to reduce inflammation.	Singh et al., 2018 [4]
Aloe Vera (*Aloe barbadensis miller*)	Gastro protective	Polysaccharides	Forms a protective mucous layer, reducing gastric acid effects.	Joseph & Raj, 2010 [5]

Future Prospects of Lemongrass as a Therapeutic Plant

1) **Clinical Validation:** While preclinical studies demonstrate promising results, large-scale clinical trials are needed to validate lemongrass's therapeutic effects in humans.
2) **Formulation Development:** Development of standardized, safe, and effective formulations, including capsules, gels, and topical treatments.
3) **Integrated Medicine:** Incorporation into complementary and alternative medicine frameworks for chronic diseases.
4) **Bioengineering Applications:** Genetic modifications to enhance active compound production in lemongrass.
5) **Sustainability:** Exploring sustainable cultivation practices to meet increasing demand while preserving natural habitats.

Conflict of Interest

The authors declare no conflicts of interest related to the preparation and publication of this review.

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