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LEMON GRASS ESSENTIAL OIL A NATURAL SHIELD AGAINST BACTERIA AND CANCER

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ABSTRACT

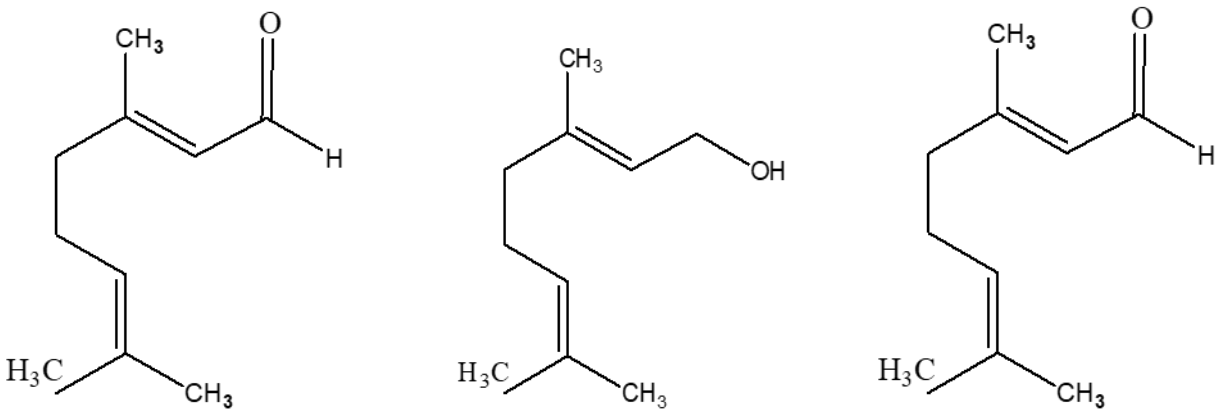
The essential oil derived from lemongrass (Cymbopogon citratus) has long been revered for its aromatic and medicinal properties, playing a significant role in traditional medicine across various cultures. This review comprehensively explores the therapeutic potential of lemongrass essential oil, with a focus on its antibacterial, antimicrobial, and anticancer activities. The chemical composition of lemongrass essential oil, prominently featuring compounds such as citral, is examined, considering variations influenced by geographical factors and extraction methodologies. The antibacterial activities of lemongrass essential oil are elucidated, encompassing its efficacy against a spectrum of bacteria. Mechanisms of action, including cell membrane disruption and interference with bacterial enzymes, are discussed, alongside potential synergies with conventional antibiotics. In the realm of antimicrobial activities, the review surveys the literature on lemongrass essential oil's potential as an agent against fungi and other microorganisms, highlighting its role in preventing the growth of pathogenic microbes. The anticancer properties of lemongrass essential oil are explored, with a focus on studies investigating its impact on cancer cells. Cellular and molecular mechanisms, including apoptosis induction and potential anti-inflammatory effects, are dissected. The review bridges preclinical and clinical studies, summarizing findings from in vitro and in vivo investigations. Clinical trials assessing the therapeutic potential of lemongrass essential oil are considered, providing a comprehensive view of its translational applications. Safety concerns and potential side effects are addressed, emphasizing the importance of proper usage and adherence to safety guidelines

INTRODUCTION

Lemongrass, a popular herb in Asian cuisine, is not only used in cooking but also finds its potential in a variety of herbal products, household items, and traditional medicinev. They can help to protect our bodies from diseases by inhibiting free radical reactions and preventing oxidative damage[2]. It contains beneficial compounds like vitamins, flavonoids, and alkaloids. It also contains terpenes**,** alcohols**,** ketones, aldehydes, and esters, such as citral α, citral β, nerol, geraniol, and citronellal[3]. The main component of its essential oil is citral, which gives it the characteristic lemon scent[4]. In the industry, these oils are commonly extracted

from fresh or partially dried leaves using a process called steam distillation[5]. The chemical composition of the oil can vary based on factors like geographic origin, genetic diversity, maturity stage, and environmental conditions[6].

Neral **Geraniol** **Citronella**



Consumers are increasingly seeking natural and eco-friendly products that are healthier and safer. Lemongrass essential oil is a fantastic natural alternative with its antioxidant, antimicrobial, antifungal, and anti-inflammatory properties[7]. Essential oils can have immediate effects on our physiological parameters like blood pressure, muscle tension, and even brain activity[8]. They can be potential alternatives to synthetic antibiotics and have been used to treat skin infections[9]. Its antioxidant-rich compounds also help soothe irritated skin and reduce redness[3]. The active ingredient citral epoxide in lemongrass oil has strong antibacterial properties, especially against methicillin-resistant Staphylococcus aureus. Also shows antimicrobial activity against pathogenic bacteria like Escherichia coli, Salmonella typhimurium, and Staphylococcus aureus[9]. Lemongrass treats various conditions like colds, coughs, inflammation, and even dental hygiene.

The untapped potential of citrus seeds and peels! They contain valuable compounds like flavonoids and limonoids, showing anticancer and antimicrobial properties[10]. Thymoquinone, monoterpenes, p-cymene, and α-pinene have shown promise in inhibiting the growth and spread of various cancers. It's exciting to see the potential of these natural compounds in the treatment of lung cancer[11]. The components in lemon grass, especially monoterpenes, have multiple pharmacological effects on mevalonate metabolism, which could explain their tumor-suppressive activity. Monoterpenes have been shown to have both chemopreventive and chemotherapeutic activities[8]. The essential oil of lemongrass is also known for its antimicrobial properties, making it a natural remedy for wound healing, infection prevention, and fighting dandruff[3]. It's important to note that citral, a component of lemongrass oil, can have adverse reactions like sensitization and allergic contact dermatitis[12]. Topical medications like Benzoyl Peroxide (BPO) and antibiotics (like Clindamycin) or retinoids are commonly used to control and heal acne inflammation and scars. BPO is effective in treating acne because it has bactericidal, keratolytic, and anti-inflammatory effect[13]. Antibacterial and antioxidant properties of lemon grass helps in food safety and preservation[14]. Natural antioxidants like Vitamin A, Vitamin C, Vitamin E, and the carotenoids play a crucial role in preventing oxidation[2].

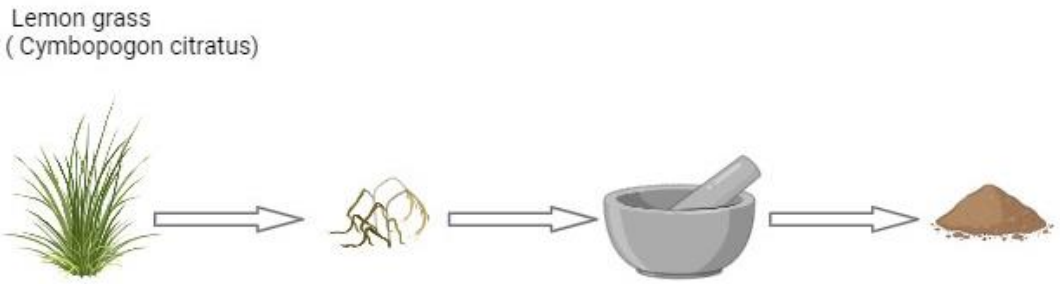
2. Extraction Process

There are so many methods for extracting essential oils from exotic aromatic plants traditional methods like steam distillation and hydro-distillation are commonly used, but there are also innovative techniques like sonoprocess-assisted solvent extraction and microwave-assisted extraction. These methods can improve extraction yields and processing times[15]. Comparisons between traditional and innovative methods have

been reported by various. For example, using a microwave in hydro-distillation, known as microwave-assisted hydro-distillation (MAHD), can result in higher yields of citronella oil[16].

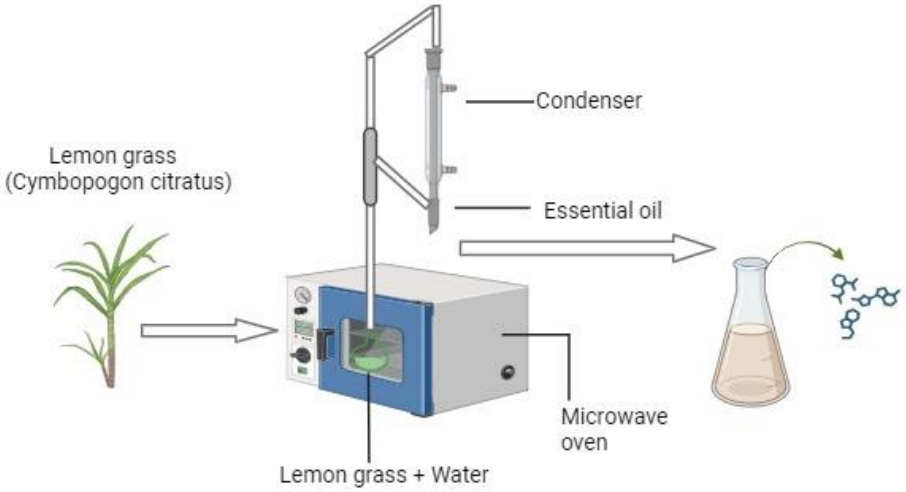
2.1 Sample collection

The first step is to collect the Lemongrass leaves. Make sure to cut the leaves 10cm from the root in the morning when these are fresh. And then found that the essential oil yield was higher for partially dried leaves compared to fresh leaves[17]. To improve the collection efficiency, they soaked the plant material in distilled water for 30 minutes before performing the extraction. It's important to see all the steps they took to optimize the extraction process[18]. The collected leaves dried at room temperature for a week and stored in a sealed plastic bag away from light. Then, used a kitchen grinder to grind the dried leaves at room temperature before the extraction [15].



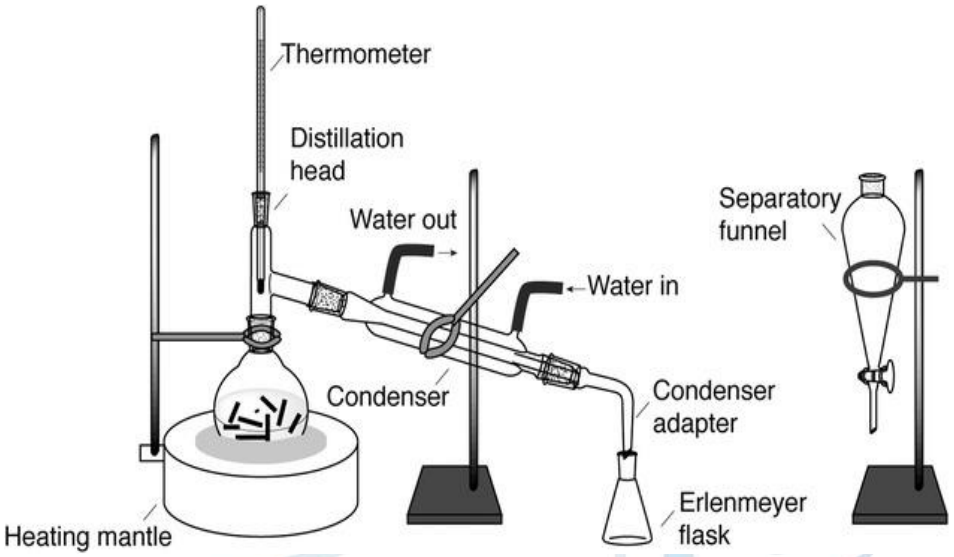
2.2 Microwave extraction

The modified domestic microwave oven, specifically the Samsung MW71E model, is connected to the Clevenger apparatus used for microwave-assisted hydrodistillation (MAHD)[16]. The MAHD was conducted with different water-to-raw material ratios and microwave power settings for various durations. The microwave oven had a power consumption of 1150 Watts and an output power of 800 Watts. Then, found that a 2-hour extraction was sufficient to extract the essential oil from Lemongrass (Cymbopogon citratus) using MAHD. They used a condenser to collect the extracted essential oils[19]. Microwave extraction yielded a higher amount compared to conventional Soxhlet extraction.



2.3 Hydrodistillation

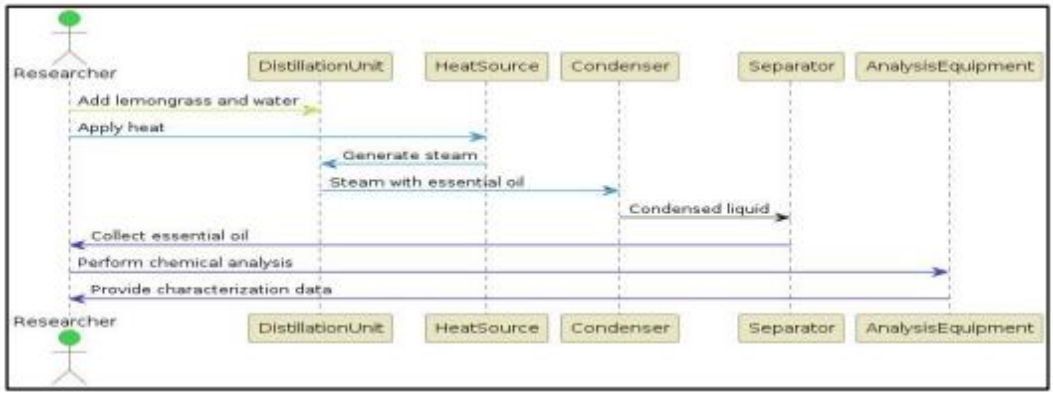
Clevenger-type apparatus used for hydro distillation of fresh Lemongrass leaves. They placed 50g of the leaves in a 1L flask with 400ml of distilled water. The hydrodistillation process lasted for different durations: 30, 60, 90, and 120 minutes. The system operated at a fixed power of 500W and under atmospheric pressure[20].



2.4 Steam distillation

The SD apparatus used consist of different parts the:

- Round bottom flask
- Biomass flask
- Condenser
- Heating mantle
- Thermometer
- Collecting vessel[21].



The lemon grass sample was placed in the biomass flask and generated steam by boiling water with the heating mantle. Steam was generated by boiling water with a heating mantle, interacting with the plant material in the biomass flask[22]. The steam then entered the biomass flask and interacted with the sample[16]. The whole extraction process took about 3 hours. The mixture of EO vapors and water vapors passed through the condenser, where they cooled and turned into liquid droplets. The EO and water layers were separated based on their density in the collecting vessel. Then the EO layer in an amber glass vial[22]. To dry the EO, they used anhydrous Na_2SO_4, followed by filtration using a microfilter. Finally, they stored the EO at +4°C until

further processing[23]. They repeated the extraction procedure five times to ensure consistent and reproducible results[24].

3. Chemical properties

Lemon grass a notable producer of aromatic compounds, is extensively utilized worldwide for various purposes. Antioxidant properties find out by using the 2,2-diphenyl-1-picryl-hydrazyl-hydrate (DPPH) scavenging test[25]. They used gas chromatograph-mass spectrometry (GC-MS) to analyze the chemical constituents of citronella oil samples[22]. Additionally, they conducted a comparison of the GC-MS analyses of the citronella oil samples obtained through different methods, using citronella oil produced by steam distillation[26]. EO analysis revealed varying composition like neral, myrcene, geranial, iso geranial, and 6-methyl-5-hepten-2-one were prominent compounds, showing fluctuations based on harvest periods. This comparison likely provided valuable insights into the composition and quality of the different citronella oil samples[27].

Components	Properties	References
Citral	Antidiabetic Anticancer Antioxidant	[28]
Limonene	Anti-oxidant Anti-inflammatory Anti-depressant Gastroprotective	[29]
Geraniol	Neuroprotective Antiseptic	[30]
Mycrene	Analgesic Antibacterial Sedative	[31]
Neral	Apoptotic Anticancer	[32]
Geranyl acetate	Use for aroma and flavor Antifungal	[33]
Nerol	Reduce anxiety For nervous disorder Reduce digestive disorder	[34]

3.1 Chemical analysis

The analysis of citronella oil via GC-MS led to the discovery of various constituents, originating from four different citronella oil sources. Interestingly, 8 constituents were common across all sources, namely citronellal, citronellol, neral, geranial, geraniol, citronellyl acetate, eugenol, and geranyl acetate. The constituents found in the greatest quantities were citronellal, citronellol, and geraniol[35]. The chemical analysis of the citronella oil revealed some variations in the main constituents depending on the extraction methods used[16]. It's fascinating how the percentages of citronellol and geraniol were similar across all sources, but the citronellal compound was found in smaller proportions in the other oil compared to the other extraction methods[36].

It's possible that factors like environmental conditions, geographic variations, and extraction techniques can influence the composition of essential oils[15].

Name of compound	Concentration	Formula	References
Pyrogallol	27.54 ± 5.76 µg/g	$C_6H_6O_3$	[37]
Citral α	40.8%	$C_{10}H_{16}O$	[28]
Protocatechuic acid	54.16 ± 3.65 µg/g	$C_7 H_6O_4$	[31]
Geraniol	1.9–3.04%	$C_{10}H_{18}O$	[28]
Protocatechuic acid	54.16 ± 3.65 µg/g	$C_7H_6O_4$	[31]
Citral β	32%	$C_{10}H_{16}O$	[28]
p-Hydroxybenzoic acid	94.01 ± 2.24 µg/g	$C_7H_6O_3$	[31]
Geranyl acetate	0.83%	$C_{12}H_{20}O_2$	[37]
p-Coumaric acid	393.32 ± 39.56 µg/g	$C_9H_8O_3$	[37]
Terpinol	0.45%	$C_{10}O_{18}H$	[37]
Ferulic acid	12.17 ± 3.11 µg/g	$C_{10}H_{10}O_4$	[31]
Nerol	4.18%	$C_{10}H_{10}O_4$	[37]
Quinic acid	161.52 ± 17.62 µg/g	$C_7H_{12}O$	[31]
Citronellal	2.10%	$C_{10}H_{10}O$	[31]

4. Physical properties

They have determined the:

- Specific gravity of the citronella oil samples using a Densitometer DA-130N
- The refractive index using an Atago No. 68534
- Analyzed the color using a Lovibond Tintometer Model E[38].

These measurements must have given you a comprehensive understanding of the physical properties of the citronella oil samples from different extraction methods and [39].

4.1 Physical analysis

The physical characteristics, including the refractive index at 20 °C, specific gravity at 20 °C, and color, of citronella oil obtained through ohmic-heated hydro-distillation, hydro-distillation, steam distillation[40]. The refractive index and specific gravity serve as crucial indicators of citronella oil purity. Across all sources, the analysis revealed consistent values of approximately 1.47 and 0.89, respectively, at 20°C[39].

Physical properties	Ohmic heated hydro-distillation	Hydro-distillation	Steam distillation	References
Refractive index at 20^0C	1.46	1.46	1.46	[39]
Iodine Value	84.6	84.6	84.5	[41]
Specific gravity at 20^0C	0.8879	0.8888	0.8896	[39]
Colour	0.7R 4Y	2.0Y	0.5R 3Y	[41]
Viscosity 25^0C(pa.s)	211.5	211.76	211.3	[39]
Density25^0C(mg\L)	0.894	0.982	0.984	[39]
pH	6.57	6.56	6.54	[41]

5.Microbial Inhibitory Capacity:

The threat posed by these bacteria has prompted food producers to heavily rely on antibiotics and food preservatives, contributing to the rise of antibiotic-resistant bacteria[42]. Plant essential oils, obtained through fractional distillation, have garnered increased attention due to their diverse pharmacological properties, including antibacterial, antifungal, and antiviral activities[43]. The diverse functional groups within the essential oil components contribute to differing antimicrobial potentials, with phenols and aldehydes exhibiting the highest activities, while esters and hydrocarbons have the least impact[44]. Citral, the predominant component of lemongrass essential oil, is recognized as its bioactive constituent. The active biological constituent in lemongrass essential oil is citral, a mixture of two isomeric acyclic monoterpene aldehydes, namely neral and geranial[45]. Minor components such as limonene, linalool, and myrcene, along with major components, may have specific and synergistic mechanisms, playing a decisive role in enhancing the effectiveness of the oil[46]. The predominant components were identified as approximately 29.4% geranial (trans-citral, α-citral) and 30.4% neral (cis-citral, β-citral). Components with high concentrations also included caryophyllene (~25.4%) and indan-1,3-diol monoacetate (~7%)[47]. Herbal and folk medicine emerge as important sources of bioactive compounds that could serve as alternatives to antibiotics or food preservatives. Combining antimicrobial phytochemicals with drugs is also proposed as a strategy to neutralize antibiotic resistance, ensuring the continued efficacy of drugs against MDR bacteria[48].

6.Antibacterial activity:

LEO is believed to induce the destruction of bacterial biofilms, impeding further bacterial growth and development. Different components of lemongrass oil, such as citral and geraniol, contribute to its antibacterial properties[49]. Antibacterial properties of LEO against a wide range of microorganisms, including Staphylococcus aureus, Enterococcus faecalis, Escherichia coli, Acinetobacter baumannii, and more[50]. They tested the antimicrobial potential of lemongrass, clove, and cinnamon essential oils against common food spoilage and pathogenic microorganisms[51]. Additionally, the components of LEO can disrupt the bonds in the lipid bilayer, leading to bacterial membrane disintegration[52]. Its efficacy extends to disrupting cell membranes and inhibiting cytoplasmic metabolism, making LEO effective against both Gram-negative and

Gram-positive bacteria. Essential oils (EOs) react differently with Gram-positive and Gram-negative bacteria due to their dissimilar cell-wall structures. Lemongrass essential oil had the highest zone of inhibition, completely inhibiting Bacillus subtilis and showing significant inhibition against E. coli, S. aureus, and S. flexneri[53]. Various factors, including oil composition, extraction method, plant developmental stage, and environmental variables like temperature, can influence the oil's effectiveness. Consequently, lemongrass oils from different species may exhibit effects of different nature and intensity[54].

Structural alterations in various bacteria have been observed, such as complete disfiguration and distortion in Pseudomonas spp[55]. Lemongrass leaves are known to contain bioactive compounds like alkaloids, flavonoids, tannins, and phenolic compounds, which contribute to its antibacterial activity[56]. The complexity of these organic compounds provides EOs with multiple targets of action on bacteria, including the disruption of phospholipid bilayers, interference with energy production and metabolism, impairment of DNA and plasmids, and disturbance of the quorum sensing system. The bacteriostatic and bactericidal characteristics of Lemongrass Essential Oil (LEO) depend primarily on the bacteria and oil concentration[57]. EOs have been utilized for centuries in traditional folk medicine to treat various diseases, demonstrating a broad spectrum of bioactivity, including the treatment of body wounds. Despite their advantages, the application of EOs and their bioactive compounds is limited by drawbacks such as hydrophobicity, volatility, and instability[58].

7.Antioxidant Activity:

Lemongrass essential oil is rich in compounds that exhibit antioxidant properties. Notably, citral, the major component, has been studied for its ability to scavenge free radicals and mitigate oxidative damage[56]. These compounds, including H_2O_2, O^{2-} and OH^-, can potentially cause damage to lipids, proteins, and DNA, leading to health issues like cancer, aging, and neurological disorders in humans[59]. In vitro studies have demonstrated the ability of lemongrass essential oil to neutralize free radicals. These experiments often utilize assays such as DPPH (2,2-diphenyl-1-picrylhydrazyl) or ABTS (2,2'-azino-bis(3-ethylbenzothiazoline-6-sulfonic acid)) to assess antioxidant capacity[60]. The potential applications of lemongrass oil in the food preservation and safety industries, particularly in meat and dairy, offer exciting possibilities[61]. The interplay between lemongrass essential oil's anti-inflammatory and antioxidant properties is an intriguing aspect. Some studies propose that its anti-inflammatory effects may be linked to its ability to modulate oxidative stress[62]. Given the role of oxidative stress in the development of chronic diseases, exploring the antioxidant potential of lemongrass essential oil has implications for health and disease prevention. However, it's important to note that the transition from in vitro studies to in vivo and clinical trials is necessary to establish its efficacy in real-world scenarios[63]. Understanding the antioxidant capacity of lemongrass essential oil is crucial for its formulation in products aimed at skin health, cosmetics, and dietary supplements[64].

8.Anticancer Activity:

The global impact of cancer is staggering, with approximately 10 million deaths in 2020 alone, constituting one in six deaths, as reported by the World Health Organization (WHO)[65]. Recent reports highlighting lemongrass (LG) extract's medicinal properties and anticancer activity[66]. Citral, a major component of lemongrass oil, exhibits promising antiproliferative effects on diverse cancer cell types, including prostate, ovarian, cervical, and breast cancer cells[4]. Key components like geraniol, geranyl acetate, α-bisabolol, and iso-intermedeol individually exhibit cytotoxic effects on cancer cells. Plants contain bioactive compounds such as phenolics, flavonoids, tannins, and saponins, which have shown promise in inhibiting abnormal cell proliferation[67]. Existing anticancer drugs often exhibit various side effects, prompting efforts to develop anti-cancer drugs from natural sources[68]. Conventional cancer treatments, such as chemotherapy, radiotherapy, and surgeries, often also entail involuntary side effects due to limited treatment specificity, making long-term usage undesirable[69].

Notably, reports suggest that the root extract of this plant possesses potent anti-proliferative properties against lung cancer cell lines like HeLa, MDA-MB, and others. Furthermore, studies indicate its anticancer efficacy against melanoma cells in mice and in vitro inhibitory activity on MDA-MB-435 human melanoma cells[70]. Another investigation focused on the anti-proliferative activity against colon cancer, human lung cancer, and

hepatoma cell lines, revealing significant growth inhibition with a single solvent methanol extract from lemongrass leaves[71]. Citral-induced apoptotic activity to DNA fragmentation and increased caspase-3 activity against hematopoietic and ovarian cancer cell line[44]. An experimental study demonstrated that LEO and citral inhibit Src(Y416) phosphorylation, blocking its activation. This, in turn, reduces Stat3(Y705) phosphorylation. Non-phosphorylated Stat3 disrupts cell growth and signal pathways, leading to decreased expression of Bcl-xL and Mcl-1[72]. Citral also induces apoptosis in prostate cancer cell lines by activating AMPK, phosphorylating BAX, and downregulating Bcl-2. Additionally, citral inhibits breast tumor growth by targeting ALDH1A3[73]. Approximately one-third of cancer-related deaths can be attributed to the top five behavioral and dietary risks: high body mass index, insufficient fruit and vegetable intake, lack of physical activity, tobacco use, and alcohol consumption[74].

Conclusion:

In conclusion, the exploration of lemongrass essential oil as a potential therapeutic agent reveals a multifaceted profile with promising antibacterial, antimicrobial, and anticancer activities. The rich chemical composition, particularly the presence of citral, underscores its biological potential, making it a subject of increasing interest in scientific research. The antibacterial properties of lemongrass essential oil, demonstrated through in vitro studies, showcase its potential as an alternative or adjunctive treatment against various bacterial strains. Mechanistic insights into its impact on cell membranes and bacterial enzymes provide a foundation for future investigations, especially in the context of antibiotic resistance. Similarly, the antimicrobial activities of lemongrass essential oil extend beyond bacteria, demonstrating efficacy against fungi and other microorganisms. Its role in inhibiting the growth of pathogenic microbes suggests a broad spectrum of applications in hygiene and healthcare. The exploration of lemongrass essential oil's anticancer properties is marked by promising findings, particularly in inducing apoptosis and potential anti-inflammatory effects on cancer cells.. Standardization of extraction methods, clarification of molecular targets, and rigorous clinical investigations are essential for advancing our understanding and realizing the therapeutic potential of lemongrass essential oil. As we navigate the complexities of future research, it is clear that lemongrass essential oil offers a dynamic platform for further exploration. Beyond its aromatic allure, its bioactive constituents beckon us to unlock a treasure trove of health benefits. The journey from traditional applications to modern therapeutic interventions holds promise, emphasizing the need for continued scientific inquiry into the depths of lemongrass essential oil's healing potential.

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