Advances in Bioresearch
Adv. Biores., Vol 16 (3) May 2025: 184-192

Print ISSN 0976-4585; Online ISSN 2277-1573
Journal's URL:http://www.soeagra.com/abr.html
CODEN: ABRDC3
DOI: 10.15515/abr.0976-4585.16.3.184192

Advances in Bioresearch

REVIEW ARTICLE

Lemongrass (*Cymbopogon flexuosus*) Essential Oil Components with Antimicrobial Action

[1]Anubhav Dubey*, [1]Paras Srivastava, [1]Vikram Kumar Sahu, [1]Sribatsa Lanchhana Dash, [2]Amit Mishra, [1]Arvind Kumar

[1]Maharana Pratap College of Pharmacy Kothi, Mandhana, Kanpur - 209217, Uttar Pradesh, India.
[2]Maharana Pratap College of Pharmaceutical Sciences, Kothi, Mandhana, Kanpur - 209217, Uttar Pradesh, India.

Corresponding author
Dr. Anubhav Dubey*

Email-anubhavdwivedi803@gmail.com

ABSTRACT

Cymbopogon flexuosus, more often known as lemongrass, is an aromatic plant that is widely utilized and recognized for its numerous applications in the domains of culinary arts, medicine, and cosmetics. The antimicrobial properties of this substance, in particular its antibacterial and antifungal activity, are the primary concentrate of this review. The essential oil that is produced from lemongrass, which is predominantly constituted of chemicals such as citral, geraniol, and limonene, has shown great activity against a wide variety of pathogenic microorganisms. These pathogens include Gram-positive and Gram-negative bacteria, as well as a number of different fungal strains. Among the mechanisms of action include the breakdown of microbial cell membranes, the suppression of enzyme activity, and the prevention of the formation of biofilm. In view of the growing prevalence of antimicrobial resistance, research has shed light on the potential of lemongrass to serve as a natural preservative in food systems and as a viable option for alternative medicinal agents. Because of its low toxicity and broad-spectrum activity, lemongrass has emerged as a potentially useful natural antibacterial agent. Furthermore, it is imperative that further research be conducted to investigate its applications and mechanisms of action.

Keywords*: Antimicrobial activity, anticancer, antioxidants, cancer signalling, citral, Cymbopogon, essential oil, lemon grass.*

Received 21.03.2025 Revised 16.05.2025 Accepted 25.05.2025

How to cite this article:
Anubhav D, Paras S, Vikram K S, Sribatsa L D, Amit M, Arvind K. Lemongrass (*Cymbopogon flexuosus*) Essential Oil Components with Antimicrobial Action. Adv. Biores., Vol 16 (3) May 2025: 184-192.

INTRODUCTION

Medicinal substances have been sourced from nature for thousands of years. Medicinal plants make up the majority of plant species worldwide [1]. Lemongrass, or *Cymbopogon citratus* (DS.) stapf, is a species of Cymbopogon. It tastes strongly like lemon and is gritty and grassy. Cultivated for its medicinal properties, it is native to tropical and subtropical regions and is exported worldwide. Lemongrass has medicinal uses in the treatment of various conditions, including coughs, gastrointestinal issues, malaria, ophthalmia, pneumonia, and vascular illnesses [2]. The secondary metabolites are the primary phytochemical components of most therapeutic plants. Specifically, alcohols, substances such as glycosides, tannins, saponins, flavonoids, anthraquinones, volatile oils, terpenes, essential oils, and resins [3]. Citral, geraniol, and geranyl acetate are the main components of lemongrass oil. Oils from Cymbopogon spp. also include trace levels of these other compounds. Citral is an isomer blend of the geranial and neral forms of the compound [4]. Citral facilitates the synthesis of both ionones and vitamin A [5]. A wide variety of chemical substances exhibit antimicrobial action. The antifungal, antiyeast, insecticidal, antiparasitic, antiviral, and antiprotozoal properties of lemongrass oil have been documented in previous studies [6-7]. Additionally, it finds use in the cosmetics, food, flavour, and pharmaceutical sectors, as well as in agriculture. To prevent plant diseases, some chemicals are utilised. Inhibitors of sterol biosynthesis, aromatic hydrocarbons, and benzoimidazoles are these compounds. The researchers discovered that gram-positive bacteria were more vulnerable than gram-negative bacteria, as shown in their study [8]. Researchers discovered that lemongrass oil had antibacterial effects against the following bacteria: *Staphylococcus aureus, Acinetobacter baumannii, Aeromonas veronii, Enterococcus faecalis,*

Escherichia coli, Klebsiella pneumoniae, Serratia marcescens, Proteus vulgaris, Salmonella enterica serotype typhimurium, Enterobacter aerogenes, Corynebacterium equii, S. aureus and *P. vulgaris* [9,11].

Figure 1. (*Cymbopogon flexuosus*)

Cultivation of *Cymbopogon flexuosus*

Essential oils are the main reason for cultivating Cymbopogon spp. are perennial sedges of the family Poaceae that grow rapidly and are classified as C4. Some of the 180 species that make up the genus Cymbopogon include *Cymbopogon refractus, Cymbopogon martinii, Cymbopogon flexuosus, Cymbopogon winterianus*, and *Cymbopogon citratus*. Because of their many uses in fields as diverse as cosmetics, food, and pharmaceuticals, these fragrant grasses are quite valuable to businesses. The plant looks to have no stem at all, as its thin, lanceolate leaves seem to sprout straight from the dirt, and it spreads by means of seed and slips [12]. India has a stranglehold on the lemongrass market, despite the fact that the plant is grown all over the world [13]. In light of the increasing demand for essential oil and the size of the essential oil market worldwide, several studies have proposed environmentally friendly ways to increase lemongrass yields in both field and laboratory settings by utilising elicitors, nanoparticles, and metabolite regulators [14]. Since 90% of the world's lemongrass exports originate from the port of Cochin in India, the plant is also known as Cochin grass [15]. Vitamins A, C, E, folate, niacin, and riboflavin are abundant in lemongrass, as are protein, antioxidants, and mineral nutrients like nitrogen (0.74%), phosphorus (0.07%), potassium (2.12%), sulphur (0.19%), magnesium (0.15%), calcium (0.36%), zinc (35.51 ppm), manganese (155.82%), iron (126.73%), and copper (56.64 ppm) [16].

Figure 2. *Cymbopogon flexuosus (*Nees ex Steud.) W. Watson

Lemongrass growing is a very lucrative industry. The immense potential of lemongrass in the food, cosmetics, and pharmaceutical sectors is a major motivator for its cultivation. Worldwide, lemongrass is grown on more than 16,000 acres, and each year, the plants produce about 1,000 metric tonnes of essential oil (LEO) [17]. This source accounts for 25% of global production and arable land, with India being the leading producer. An annual yield of about $300 USD per hectare is possible from lemongrass cultivation [18]. After reaching 247 million USD in 2019, the global market for lemongrass oil is projected to reach 421 million USD by 2027, according to recent data from Polisher Market data. This represents a growth rate of 7% CAGR. The demand for lemongrass has been on the rise since 2001, with an export growth of more than 1,250 per percent from 2001 to 2020, according to the Indian city of Kolkata's

directorate general of commercial intelligence and statistics. Not to mention how big the essential oil industry is an estimate that several market research firms provide. Facts and Factors predicts that this industry would grow from its current size of $3 billion to $7 billion by 2027, doubling its anticipated size. This study aims to give a complete and up-to-date evaluation of LEO's ability to fight bacteria and cancer, and to look into creating commercial uses that are both practical and easy to reproduce [18]. Figure 2. shows physical characteristics of the *Cymbopogon flexuosus (*Steud.) Wats plant, particularly the trichome and stomata characteristics. It is shown in Table 1.

Table 1. Taxonomic Details of the Lemon grass

Kingdom	**Plantae**
Division	Magnoliophyta
Class	Liliopsida
Order	Poales
Family	Poaceae
Genus	Cymbopogon
Species	C.citrus

Plant profile:

Scientific classification of *Cymbopogon flexuosus*

Botanical description:

The aromatic perennial tall grass *Cymbopogon flexuosus* is characterised by its rhizomes and densely tufted fibrous roots. Its narrow, ringed-segment subterranean stems bear narrow, slightly leathery leaves that are displayed in dense clusters [19]. The plant is an indigenous plant that originates in India and is grown in a number of nations that are tropical or subtropical20. Here you may see how lemongrass is arranged in the plant kingdom Table 1. Countries such as India, China, and Australia are home to several varieties of lemongrass. Among these species are *Cymbopogon bombycinus, ambiguus, obtectus, refractus, citrate*, *nardus*, and *Schoenanthus*, among others.

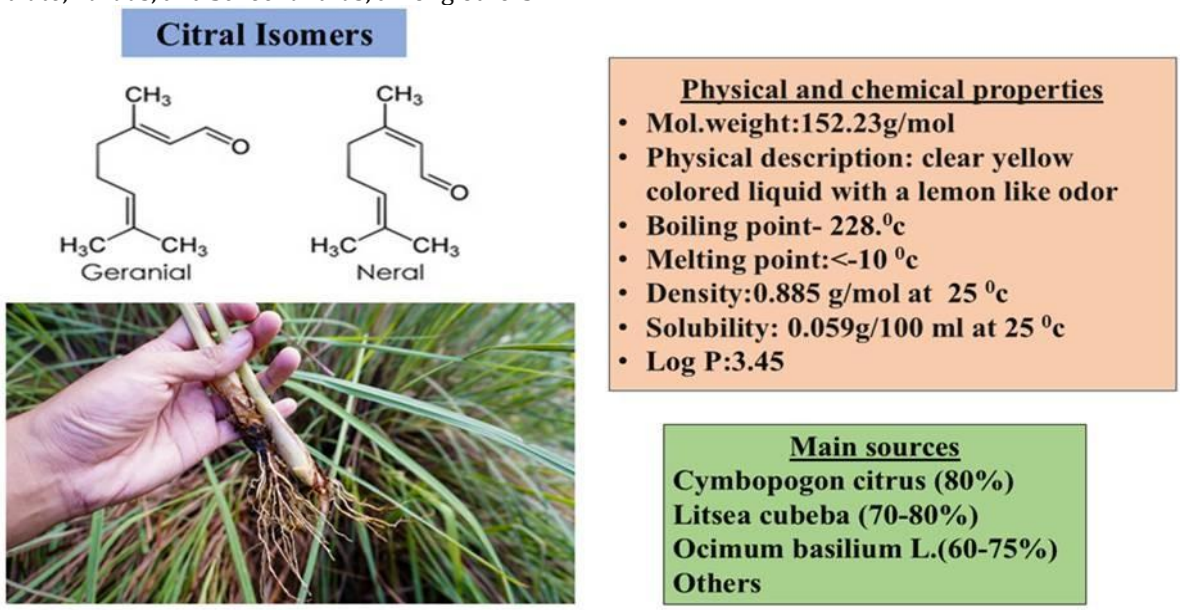

Figure 3.(Citral (3,7-dimethyl-2,6-octadienal), a mixture of two E/Z-isomeric acyclic monoterpene aldehydes)

Phytochemical constituents: Qualitative and quantitative phytochemical screening has found important chemical compounds that contribute to the healing effects of *Cymbopogon flexuosus* [21]. Acidic fats, tannins, aldehydes, phenols, terpenes, flavonoids, saponins, steroids, polyphenols, alkaloids, and esters are among the bioactive components that have been identified by researchers. According to studies, the most significant components found in *Cymbopogon flexuosus* are its essential oil and flavonoids [22]. The pharmacological and therapeutic properties of the plant are due to these compounds. The leaves are the principal source of essential oils from lemongrass plants. Essential oils can make up to 5% of the plant's dry weight, which is found in these leaves [23]. Citral, the oil's active component, is responsible for its unique lemon aroma [24].

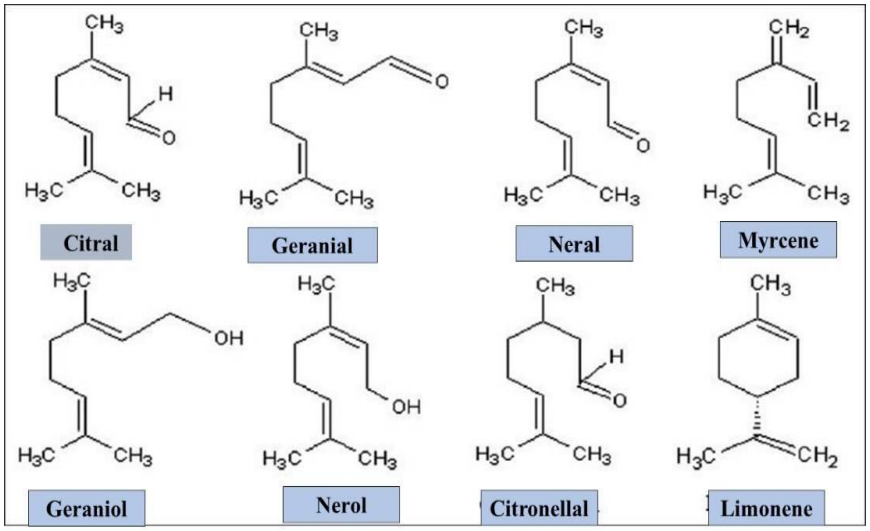

Figure 4. The molecular formula of the active ingredients in lemongrass essential oil

Therapeutics

Research on the bioactivities of essential oils and lemongrass extract has increased at an exponential rate in the last several decades [25]. According to feeding studies, lemongrass oil and extract have a wide variety of antimicrobial, anticancer, antidiarrheal, ant filarial, antitussive, antiseptic, larvicidal, insecticidal, miticidal, ovicidal, acaricidal, analgesic, cosmetic, anti-inflammatory, antioxidant, antinociceptive, antihypertensive, anti-obesity, anxiolytic, and possibly antimutagenic, cardioprotective, antirheumatic, and haematological uses properties [26]. The bioactivities in question are the end result of various main and minor LEO components acting alone or in combination with one another [27]. Because of its low cost, biocompatibility, and inherent naturalness, LEO therapy is quickly becoming a viable substitute for synthetic medications. This review aims to gather the latest studies on LEO's properties and how they might be used in fields such as farming, food storage, animal health, human safety for cleaning surfaces and prosthetics, and potential cancer-fighting effects when LEO components are used alongside standard chemotherapy treatments [28].

Antimicrobial Potential

Both the oil and extract of lemongrass are powerful antimicrobials. On numerous occasions, LEO has been employed as an agent against bacteria, fungi, and viruses. In a similar vein, certain strains of bacteria were found to be hindered in their growth by lemongrass extract, including These include *Staphylococcus aureus*, *Candida albicans*, *Escherichia coli*, *Klebsiella pneumoniae*, and *Bacillus cereus* [29]. Essential oil components' antibacterial potential differs among functional groups. For instance, phenols and aldehydes exhibit the highest activity, while esters and hydrocarbons exhibit the lowest. One of the most popular theories regarding the antibacterial effects of lemongrass oil is that it contains citral, an aldehyde. The antibacterial activity of the complete essential oil, however, was found to be greater than that of a mixture of the main oil components. Researchers found that about 425 of the 1,114 different strains of microbes (e.g., molds, yeasts, bacteria, etc.) from 29 different genera and 105 different species were LEO-sensitive. A tiny quantity of LEO is believed to stop the growth of bacteria, fungi, and viruses, while a larger amount is believed to kill them, leading to the death of microbes. In addition, LEO has been investigated for its antibacterial properties against 42 different microbes, including 20 different bacteria, 15 different fungi, and 7 different yeasts [33].To find out how effective a chemical is against microbes, researchers in the field of microbiology look at two key markers: the half maximum inhibitory concentration (IC50) and the minimum inhibitory concentration (MIC). Although the medication may have cytostatic effects, bacteria can quickly bounce back once exposed to concentrations below its half-life (IC50), the point at which its antimicrobial efficacy is 50% reduced. Furthermore, concentrations are typically evaluated using a scalar dilution, ranging from 1 to 10 and so on, rather than an exact method. But knowing the minimum inhibitory concentration It is more instructive to determine the minimum inhibitory concentration (MIC) an extract from a plant or medicine at which no measurable microbial growth occurs. When tested against *Staphylococcus aureus* in liquid and LEO forms, citral showed a minimum inhibitory concentration (MIC) of 0.0313% (v/v) and 0.0781% (v/v), respectively. When tested against Acinetobacter baumannii bacteria, citral had a MIC of 0.14 v/v and LEO a MIC of 0.65 v/v. You can increase the effectiveness of the oil in two ways: either by adding the key elements or by adding the oil's components, which include limonene, linalool, and myrcene [35].

ANTIMICROBIAL ACTIVITY

Lemongrass (*Cymbopogon flexuosus*) exhibits notable antimicrobial activity due to its rich composition of essential oils, primarily citral, which has been shown to inhibit the growth of various bacteria, fungi, and viruses. Studies indicate that lemongrass oil can be effective against pathogens such as *Staphylococcus aureus, Escherichia coli,* and *Candida species* [36]. The antimicrobial effects are attributed to mechanisms such as disruption of microbial cell membranes, interference with metabolic processes, and modulation of enzyme activities. Additionally, lemongrass has been used in traditional medicine for its potential health benefits, including its role as a natural preservative in food products [37].

Antifungal Activity:

Lemongrass (*Cymbopogon flexuosus*) has garnered attention for its antifungal properties, primarily attributed to its essential oil, which contains compounds like citral, geraniol, and limonene. Research has shown that lemongrass oil can effectively inhibit the growth of various fungal pathogens, including Candida species, Aspergillus, and Trichophyton [38].

Mechanisms of Action

1. **Cell Membrane Disruption: The** essential oils can penetrate fungal cell membranes, leading to increased permeability and ultimately cell death [39].
2. **Inhibition of Biofilm Formation:** Lemongrass has shown potential in preventing biofilm formation, which is crucial for the pathogenicity of many fungi [40].
3. **Metabolic Interference**: Active compounds may disrupt metabolic pathways essential for fungal growth and reproduction [41].

Efficacy Against Specific Fungi –

Candida albicans: Studies have demonstrated significant inhibitory effects on growth and biofilm formation-Aspergillus species. Lemongrass oil exhibits antifungal activity, particularly against A. flavus and A. niger, which are known for their role in food spoilage and mycotoxin production [42].

Trichophyton: Some research indicates effectiveness against dermatophytes responsible for skin infections [43].

Antibacterial Activity: Lemongrass is recognized for its antibacterial properties, primarily due to its essential oils, which contain fragrant and active ingredients including limonene, geraniol, and citral. These substances have undergone the focus of various studies investigating lemongrass's effectiveness against a range of bacterial pathogens [44].

Mechanisms of Action

1. **Cell Membrane Disruption:** The essential oils can penetrate bacterial membranes, leading to increased permeability and cell lysis [45].
2. **Inhibition of Enzymatic Activity**: Compounds in lemongrass may inhibit key enzymes involved in bacterial metabolism and growth [46].
3. **Biofilm Disruption**: Lemongrass has shown potential in preventing or disrupting biofilm formation, which is crucial for bacterial survival and resistance [47].

Efficacy against Specific Bacteria

Gram-positive Bacteria: Lemongrass has demonstrated strong activity against pathogens like Staphylococcus aureus and Streptococcus species, which are significant in both clinical and food safety contexts [48].

Gram-negative Bacteria: It has also been effective against Escherichia coli, Salmonella typhimurium, and Pseudomonas aeruginosa, highlighting its broad-spectrum potential [49].

Food borne Pathogens: The antibacterial properties of lemongrass are particularly relevant in food preservation, helping to inhibit pathogens that cause spoilage and food borne illness [50].

Applications

1. **Food Preservation:** Due to its antibacterial activity, lemongrass oil fragrant and active ingredients including limonene, geraniol, and citral. These substances have undergone [51].
2. **Pharmaceuticals:** Its antibacterial properties make it a candidate for developing alternative treatments, especially in the face of increasing antibiotic resistance [52].
3. **Cosmetics and Personal Care**: Lemongrass oil is also utilized in products for its antimicrobial effects, contributing to skin care formulations [53].

Antioxidant activity: There has been interest in phenolic acid and flavonoids as possible natural antioxidants and free radical scavengers because of their pharmacological activity. The plant exhibited the anti-oxidant profile, which included acids, phenolics, [54].

Anti-Diarrhoeal Activity: Actually, to cure diarrhoea, the entire lemongrass plant is boiled and then swallowed. Citral, the principal chemical component of C. citrates stalk decoction, is used extensively in traditional medicine, hence its efficacy as investigated a potential anti-diarrheal [55].

Protecting Cells from Damage: The anti-mutagenic properties of Salmonella typhimurium strains TA98 and TA99 were found to be induced by an ethanolic extract of lemongrass. 100 TA.
Anti-inflammatory activity: For the treatment of inflammation-related disorders, especially those impacting the gastrointestinal system, researchers investigated the anti-inflammatory capabilities of dendritic cells stimulated by lip polysaccharide. Activity against malaria: Researchers looked at the effects of *Cymbopogon citratus* on mice infected with *Plasmodium berghei* investigated [56].
Anti-nociceptive properties: These are the characteristics of citrates essential oil. A strong analgesic impact. In three distinct nociception models—the hot-plate, mice writhing in acetic acid, and the formalin test—results showed that essential oil acts both peripherally and centrally [57].
Traditional importance
People in Africa, Asia, and South America have been drinking the leaves as a decoction or tea for a long time. Analgesic, antipyretic, tranquillizer, antiherpetic, diuretic, anti-inflammatory, antiseptic, anti-dyspeptic, and anti-fever actions are all regulated by the plant's essential bioactive components found in the leaves. Many products use them as a deodorant, such as candles, local soaps, perfume, and bug repellents. It has a history of use as a snake and reptile repellent in certain Asian and African countries [58-60].

CONCLUSION

Lemongrass, a natural plant with antimicrobial activity, has potential for both industrial and therapeutic applications. Its antibacterial and antifungal properties make it an appealing alternative for developing new antibacterial and antifungal solutions. Lemongrass's Essential oils are highly sought-after due to their extensive use in both traditional medicine and culinary technology. To learn more about its workings, optimal dosages, and possible synergistic effects with other natural antibacterial agents, a comprehensive phytochemical and pharmacological study is required. The anti-depressant, analgesic, antipyretic, bactericidal, anti-septic, and carminative qualities of lemongrass essential oil make it useful in the pharmaceutical industry. More and more people are looking to lemongrass for its natural ingredients, which could lead to better treatments and more clinical trials.

ACKNOWLEDGMENTS

The authors are thankful to the College authorities for providing the necessary facilities to conduct the work.

FUNDING

None

CONFLICTS OF INTERESTS IF ANY

None

REFERENCES

1. Castillo-Morales RM, Serrano SO, Villamizar ALR, Mendez-Sanchez SC, Duque JE. (2021). Impact of *Cymbopogon flexuosus (*Poaceae) essential oil and primary components on the eclosion and larval development of Aedes aegypti. Scientific Reports [Internet]. 21;11(1). Available from: https://doi.org/10.1038/s41598-021-03819-2
2. Barbosa LCA, Pereira UA, Martinazzo AP, Maltha CRÁ, Teixeira RR, De Castro Melo E. (2008). Evaluation of the Chemical Composition of Brazilian Commercial *Cymbopogon citratus*(D.C.) Stapf Samples. Molecules [Internet]. ;13(8):1864–74. Available from: https://doi.org/10.3390/molecules13081864
3. Akhila A. (2009). Essential Oil-Bearing Grasses:(The genus Cymbopogon. CRC Press.
4. Ashaq B, Rasool K, Habib S, Bashir I, Nisar N, Mustafa S, et al. (2024). Insights into chemistry, extraction and industrial application of lemon grass essential oil -A review of recent advances. Food Chemistry X [Internet]. 101521. Available from: https://doi.org/10.1016/j.fochx.2024.101521
5. Shah G, Shri R, Panchal V, Sharma N, Singh B, Mann A. (2011). Scientific basis for the therapeutic use of *Cymbopogon citratus*, stapf (Lemon grass). Journal of Advanced Pharmaceutical Technology Amp Research [Internet].2(1):3. Available from: https://doi.org/10.4103/2231-4040.79796
6. Bonjar S. (2004). Evaluation of antibacterial properties of some medicinal plants used in Iran. Journal of Ethnopharmacology [Internet]. 30;94(2–3):301–5. Available from: https://doi.org/10.1016/j.jep.2004.06.007
7. Robinson N. (2006). Integrated traditional Chinese medicine. Complementary Therapies in Clinical Practice [Internet]. 30;12(2):132–40. Available from: https://doi.org/10.1016/j.ctcp.2006.01.006
8. Carter AP, Clemons WM, Brodersen DE, Morgan-Warren RJ, Wimberly BT, Ramakrishnan V. (2000). Functional insights from the structure of the 30S ribosomal subunit and its interactions with antibiotics. Nature. 407(6802):340–8. Available from: https://doi.org/10.1038/35030019

9. Clemons WM, Brodersen DE, McCutcheon JP, May JLC, Carter AP, Morgan-Warren RJ, et al. (2001). Crystal structure of the 30 S ribosomal subunit from Thermus thermophilus: purification, crystallization and structure determination. Journal of Molecular Biology [Internet].310(4):827–43. Available from: https://doi.org/10.1006/jmbi.2001.4778
10. Ernst E. (2008). Chiropractic: a critical evaluation. Journal of Pain and Symptom Management].35(5):544–62. Available from: https://doi.org/10.1016/j.jpainsymman.2007.07.004
11. Bayala B, Bassole IHN, Maqdasy S, Baron S, Simpore J, Lobaccaro JMA. (2018). *Cymbopogon citratus*and Cymbopogon giganteus essential oils have cytotoxic effects on tumor cell cultures. Identification of citral as a new putative anti-proliferative molecule. Biochimie [Internet]. 6;153:162–70. Available from: https://doi.org/10.1016/ j.biochi.2018.02.013
12. Kpoviessi S, Bero J, Agbani P, Gbaguidi F, Kpadonou-Kpoviessi B, Sinsin B, et al. (2013). Chemical composition, cytotoxicity and in vitro antitrypanosomal and antiplasmodial activity of the essential oils of four Cymbopogon species from Benin. Journal of Ethnopharmacology [Internet]. 21;151(1):652–9. Available from: https://doi.org/10.1016/j.jep.2013.11.027
13. Zhang Y, Long Y, Yu S, Li D, Yang M, Guan Y, et al. (2020). Natural volatile oils derived from herbal medicines: A promising therapy way for treating depressive disorder. Pharmacological Research [Internet]. 11;164:105376. Available from: https://doi.org/10.1016/j.phrs.2020.105376
14. Kumar VP, Chauhan NS, Padh H, Rajani M. (2006). Search for antibacterial and antifungal agents from selected Indian medicinal plants. Journal of Ethnopharmacology [Internet].28;107(2):182–8. Available from: https://doi.org/10.1016/j.jep.2006.03.013
15. Tadeg H, Mohammed E, Asres K, Gebre-Mariam T. (2005). Antimicrobial activities of some selected traditional Ethiopian medicinal plants used in the treatment of skin disorders. Journal of Ethnopharmacology [Internet]. 21;100(1–2):168–75. Available from: https://doi.org/10.1016/j.jep.2005.02.031
16. Tao Y, Deng Y, Wang P. (2023). Traditional uses, phytochemistry, pharmacology, processing methods and quality control of *Lindera aggregata* (Sims) Kosterm: A critical review. Journal of Ethnopharmacology [Internet].26;318:116954. Available from: https://doi.org/10.1016/j.jep.2023.116954
17. Ríos JL, Recio MC. (2005). Medicinal plants and antimicrobial activity. Journal of Ethnopharmacology [Internet]. 20;100(1–2):80–4. Available from: https://doi.org/10.1016/j.jep.2005.04.025
18. Francisco V, Figueirinha A, Neves BM, García-Rodríguez C, Lopes MC, Cruz MT, et al. (2010). *Cymbopogon citratus*as source of new and safe anti-inflammatory drugs: Bio-guided assay using lipopolysaccharide-stimulated macrophages. Journal of Ethnopharmacology [Internet]. 13;133(2):818–27. Available from: https://doi.org/10.1016/j.jep.2010.11.018
19. Shah G, Shri R, Panchal V, Sharma N, Singh B, Mann A. (2011). Scientific basis for the therapeutic use of *Cymbopogon citratus*, stapf (Lemon grass). Journal of Advanced Pharmaceutical Technology Amp Research [Internet]. 1;2(1):3. Available from: https://doi.org/10.4103/2231-4040.79796
20. International Journal of Advanced Research in Science, Communication and Technology. International Journal of Advanced Research in Science Communication and Technology [Internet]. 2020 Nov 17; Available from: https://doi.org/10.48175/568
21. G. Shah, R. Shri, V. Panchal, N. Sharma, B. Singh, A. Mann, (2011). Scientific basis for the therapeutic use of *Cymbopogon citratus*, staff (Lemongrass), J. Adv. Pharmaceut. Techn. Res. 2 (1):3–8.
22. Quisumbing E. (1978). Medicinal plants of the Philippines.
23. Kouame NM, Kamagate M, Koffi C, Die-Kakou HM, Yao N a. R, Kakou A. (2015). *Cymbopogon citratus*(DC.) Stapf : ethnopharmacology, phytochemistry, pharmacological activities and toxicology. Phytotherapy. 17;14(6):384–92. Available from: https://doi.org/10.1007/s10298-015-1014-3
24. Clement YN, Baksh-Comeau YS, Seaforth CE. (2015). An ethnobotanical survey of medicinal plants in Trinidad. Journal of Ethnobiology and Ethnomedicine.15;11(1). Available from: https://doi.org/10.1186/s13002-015-0052-0
25. Oniha MI, Ahuekwe EF, Akinpelu SO. (2023). Phytochemical Contents of Essential Oils from Cymbopogon Species: A Tropical Medicinal Plant. In: Intech Open eBooks [Internet]. Available from: https://doi.org/10.5772/intechopen.105396
26. Clement YN, Baksh-Comeau YS, Seaforth CE. (2015). An ethnobotanical survey of medicinal plants in Trinidad. Journal of Ethnobiology and Ethnomedicine [Internet]. 15;11(1). Available from: https://doi.org/10.1186/s13002-015-0052-0
aturomunda M, Ssekatawa K, Niwagaba S. (2024). A Preliminary Evaluation of the Antibacterial Activity of Lemon Fruit Juice, Mondia whitei Ethanolic Extract, and Their Combination Against Streptococcus mutans. Infection and Drug Resistance. Vol17:4291–9. Available from: https://doi.org/ 10.2147/idr.s474810
27. De Bona Da Silva C, Guterres SS, Weisheimer V, Schapoval EES. (2008). Antifungal activity of the lemongrass oil and citral against Candida spp. The Brazilian Journal of Infectious Diseases [Internet].1;12(1). Available from: https://doi.org/10.1590/s1413-86702008000100014
28. Oliveira VCS, Moura DMS, Lopes J a. D, De Andrade PP, Da Silva NH, Figueiredo RCBQ. (2008). Effects of essential oils from *Cymbopogon citratus*(DC) Stapf., *Lippia sidoides* Cham., and *Ocimum gratissimum* L. on growth and ultrastructure of *Leishmania chagasi* promastigotes. Parasitology Research [Internet].15;104(5):1053–9. Available from: https://doi.org/10.1007/s00436-008-1288-6

29. Irfan S, Ranjha M, Nadeem M, Safdar M, Jabbar S, Mahmood S, et al. (2022). Antioxidant Activity and Phenolic Content of Sonication- and Maceration-Assisted Ethanol and Acetone Extracts of *Cymbopogon citratus* Leaves. Separations [Internet]. 5;9(9):244. Available from: https://doi.org/10.3390/separations9090244
30. Liu JZ, Zhang CC, Fu YJ, Cui Q. (2021). Comparative analysis of phytochemical profile, antioxidant and anti-inflammatory activity from *Hibiscus manihot* L. flower. Arabian Journal of Chemistry [Internet]. 15(1):103503. Available from: https://doi.org/10.1016/j.arabjc.2021.103503
31. Mishra A, Seth A, Maurya S. (2016). Therapeutic significance and pharmacological activities of Antidiarrhoeal medicinal plants mention in Ayurveda: A review. Journal of Intercultural Ethnopharmacology [Internet]. 1;5(3):290. Available from: https://doi.org/10.5455/jice.20160426094553
32. Chowdhury R, Sinha B, Sankar MJ, Taneja S, Bhandari N, Rollins N, et al. (2015). Breastfeeding and maternal health outcomes: a systematic review and meta-analysis. Acta Paediatrica [Internet].14;104(S467):96–113. Available from: https://doi.org/10.1111/apa.13102
33. Figueirinha A, Cruz MT, Francisco V, Lopes MC, Batista MT. (2010). Anti-Inflammatory activity of *Cymbopogon citratus* Leaf infusion in Lipopolysaccharide-Stimulated dendritic cells: contribution of the polyphenols. Journal of Medicinal Food [Internet]. 13(3):681–90. Available from: https://doi.org/10.1089/jmf.2009.0115
34. Tchoumbougnang F, Zollo PH, Dagne E, Mekonnen Y. (2005). *In Vivo* Antimalarial Activity of Essential Oils from *Cymbopogon citratus* and *Ocimum gratissimumon* Mice Infected with *Plasmodium berghei*. Planta Medica [Internet]. 71(1):20–3. Available from: https://doi.org/10.1055/s-2005-837745
35. Viana GSB, Vale TG, Pinho RSN, Matos FJA. (2000). Antinociceptive effect of the essential oil from *Cymbopogon citratus*in mice. Journal of Ethnopharmacology. 70(3):323–7. Available from: https://doi.org/ 10.1016/s0378-8741(99)00168-3
36. Borges PHO, Pedreiro S, Baptista SJ, Geraldes CFGC, Batista MT, Silva MMC, et al. (2021). Inhibition of α-glucosidase by flavonoids of *Cymbopogon citratus*(DC) Stapf. Journal of Ethnopharmacology..280:114470. Available from: https://doi.org/10.1016/j.jep.2021.114470
37. Aftab T, Hakeem KR. (2021). Medicinal and aromatic plants: Healthcare and Industrial Applications. Springer Nature.
38. Prabuseenivasan S, Jayakumar M, Ignacimuthu S. (2006). In vitro antibacterial activity of some plant essential oils. BMC Complementary and Alternative Medicine.30;6(1). Available from: https://doi.org/10.1186/1472-6882-6-39
39. Farnsworth NR. (1982). Medicinal plants and traditional medicine in Africa. By Abayomi Soowora. John Wiley & Sons, Inc., One Wiley Dr., Somerset, NJ 08873. 256 pp.
40. Marderosian AD. Reviews. (1982). Journal of Pharmaceutical Sciences. 71(4):481. Available from: https://doi.org/10.1002/jps.2600710445
41. J V, Organization WH. (2003). Basic laboratory procedures in Clinical bacteriology. World Health Organization.
42. Bonjar GHS. (2004). Antibacterial screening of plants used in Iranian folkloric medicine. Fitoterapia [Internet]. 1;75(2):231–5. Available from: https://doi.org/10.1016/j.fitote.2003.12.013
43. Figueirinha A, Cruz MT, Francisco V, Lopes MC, Batista MT. (2010). Anti-Inflammatory activity of *Cymbopogon citratus*Leaf infusion in Lipopolysaccharide-Stimulated dendritic cells: contribution of the polyphenols. Journal of Medicinal Food [Internet]. 3;13(3):681–90. Available from: https://doi.org/10.1089/jmf.2009.0115
44. Verma RS, Joshi N, Padalia RC, Singh VR, Goswami P, Verma SK, et al. (2017). Chemical composition and antibacterial, antifungal, allelopathic and acetylcholinesterase inhibitory activities of cassumunar-ginger. Journal of the Science of Food and Agriculture. 98(1):321–7. Available from: https://doi.org/10.1002/ jsfa.8474
45. Tibenda JJ, Yi Q, Wang X, Zhao Q. (2022). Review of phytomedicine, phytochemistry, ethnopharmacology, toxicology, and pharmacological activities of Cymbopogon genus. Frontiers in Pharmacology [Internet]. 29;13. Available from: https://doi.org/10.3389/fphar.2022.997918
46. Zia-Ul-Haq M, Al-Huqail AA, Riaz M, Gohar UF. (2023). Essentials of medicinal and aromatic crops. Springer Nature.
47. Onawunmi GO, Yisak WA, Ogunlana EO. (1984). Antibacterial constituents in the essential oil of *Cymbopogon citratus*(DC.) Stapf. Journal of Ethnopharmacology [Internet]. 1;12(3):279–86. Available from: https://doi.org/10.1016/0378-8741(84)90057-6
48. Ruberto G, Baratta MT, Deans SG, Dorman HJD. (2000). Antioxidant and Antimicrobial Activity of Foeniculum vulgare and *Crithmum maritimum* Essential Oils. Planta Medica [Internet]. 66(8):687–93. Available from: https://doi.org/10.1055/s-2000-9773
49. Nguefack J, Budde BB, Jakobsen M. (2004). Five essential oils from aromatic plants of Cameroon: their antibacterial activity and ability to permeabilize the cytoplasmic membrane of *Listeria innocuous* examined by flow cytometry. Letters in Applied Microbiology [Internet]. 7;39(5):395–400. Available from: https://doi.org/10.1111/j.1472-765x.2004.01587.x
50. Helal GA, Sarhan MM, Shahla ANKA, El-Khair EKA. (2006). Effects of *Cymbopogon citratus* L. essential oil on the growth, lipid content and morphogenesis of *Aspergillus niger* ML2-strain. Journal of Basic Microbiology [Internet]. 30;46(6):456–69. Available from: https://doi.org/10.1002/jobm.200510106
51. Rajurkar N, Hande S. (2011). Estimation of phytochemical content and antioxidant activity of some selected traditional Indian medicinal plants. Indian Journal of Pharmaceutical Sciences [Internet].1;73(2):146. Available from: https://doi.org/10.4103/0250-474x.91574

52. Jallali I, Zaouali Y, Missaoui I, Smeoui A, Abdelly C, Ksouri R. (2013). Variability of antioxidant and antibacterial effects of essential oils and acetonic extracts of two edible halophytes: *Crithmum maritimum* L. and *Inula crithmoïdes* L. Food Chemistry [Internet]. 2013 Sep 13;145:1031–8. Available from: https://doi.org/10.1016/j.foodchem. 2013.09.034
53. Serrano C, Matos O, Teixeira B, Ramos C, Neng N, Nogueira J, et al. (2011). Antioxidant and antimicrobial activity of *Satureja montana* L. extracts. Journal of the Science of Food and Agriculture. 28;91(9):1554–60. Available from: https://doi.org/10.1002/jsfa.4347
54. Kotan R, Cakir A, Dadasoglu F, Aydin T, Cakmakci R, Ozer H, et al. (2009). Antibacterial activities of essential oils and extracts of *Turkish Achillea*, *Satureja* and Thymus species against plant pathogenic bacteria. Journal of the Science of Food and Agriculture [Internet]. 4;90(1):145–60. Available from: https://doi.org/10.1002/ jsfa. 3799
55. Güllüce M, Sökmen M, Daferera D, Ağar G, Özkan H, Kartal N, et al. *In Vitro* Antibacterial, Antifungal, and Antioxidant Activities of the Essential Oil and Methanol Extracts of Herbal Parts and Callus Cultures of *Satureja hortensis* L. Journal of Agricultural and Food Chemistry [Internet]. 2003 May 28;51(14):3958–65. Available from: https://doi.org/10.1021/jf0340308
56. De Bona Da Silva C, Guterres SS, Weisheimer V, Schapoval EES. Antifungal activity of the lemongrass oil and citral against Candida spp. The Brazilian Journal of Infectious Diseases [Internet]. 2008 Feb 1;12(1). Available from: https://doi.org/10.1590/s1413-86702008000100014
57. Irfan S, Ranjha M, Nadeem M, Safdar M, Jabbar S, Mahmood S, et al. Antioxidant Activity and Phenolic Content of Sonication- and Maceration-Assisted Ethanol and Acetone Extracts of *Cymbopogon citratus* Leaves. Separations [Internet]. 2022 Sep 5;9(9):244. Available from: https://doi.org/10.3390/separations9090244
58. Boukhatem MN, Ferhat MA, Kameli A, Saidi F, Kebir HT. (2014). Lemon grass (*Cymbopogon citratus*) essential oil as a potent anti-inflammatory and antifungal drugs. Libyan Journal of Medicine. 9(1). Available from: https://doi.org/10.3402/ljm.v9.25431
59. Amornvit P, Choonharuangdej S, Srithavaj T. (2014). Lemongrass - Incorporated Tissue Conditioner Against *Candida albicans* Culture. Journal Of Clinical and Diagnostic Research [Internet]. 1; Available from: https://doi.org/10.7860/jcdr/2014/8378.4607
60. Weinheimer V, Miron D, Silva CB, Guterres SS, Schapoval EE. (2010). Microparticles containing lemongrass volatile oil: preparation, characterization and thermal stability. Pharmazie. 65(12):885-90. PMID: 21284257