

ORIGINAL ARTICLE

Cymbopogon flexuosus an Assessment of its botany, Conventional utilization, Phytochemistry and Pharmacology

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ABSTRACT

The pharmacological effects of lemongrass (*Cymbopogon Flexus*) essential oil make it commonly grown. Lemongrass essential oil contains a lot of bioactive compounds, including citral, isoneral, isogeranial, geraniol, geranyl acetate, citronellal, citronellol, germacrene-D, and elemol. Lemon grass essential oil contains additional beneficial chemicals. LEO has antifungal, antibacterial, antiviral, anticancer, and antioxidant properties due to these components. Pharmaceutical, cosmetic, and food preservation companies use LEO properties for profit. LEO's use in cancer treatment opens up new pharmacological avenues. Certain LEO components have shown promise anticancer properties in vitro, however their effects on the human body have not yet been shown. Thus, more research is needed on LEO components' anticancer effects. This paper discusses the role of LEO in cancer prevention, healthcare, and food production. *Cymbopogon* is a major essential oil producer in the Poaceae family. The most commonly utilised commercial species are lemon grass, wild lemon grass, citronella, and palmarosa. The plant produces essential oils like lemongrass, palmarosa, citronella, ginger grass, and rusa. Lemon grass essential oil is mostly cyclic and acyclic monoterpenoids. Citral the main component that gives lemongrass its lemony smell has high commercial worth. Citral produces vitamin A and ionone. *Cymbopogon* species were anthelmintic, anti-inflammatory, analgesic, pesticide, antibacterial, and mosquito repellent and Alzheimer's. The chemical components and biological activity of lemongrass essential oil were extensively discussed in this study.

Keywords: *Cymbopogon flexuosus*, Bioactivities, Antioxidant activity, Citral, Monoterpene, Alzheimer's

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INTRODUCTION

The clump-forming perennial grass *Cymbopogon flexuosus* is native to Southeast Asia but is extensively cultivated in tropical and subtropical regions for its aromatic leaf [1]. Common names for this grass include East Indian lemongrass, cochinchina, and lemongrass. When fully grown, these plants can reach a height of 3–5 feet, a width of 3 feet, and flat to slightly arched leaves [2]. The slender, strap-like leaves are produced by sturdy, spherical stalks and feature sharp, highly serrated edges [3]. Seasonal, drooping compound panicles of yellow-brown spikelets appear they are not ornamentally noteworthy and usually only appear in frost-free regions [4]. Kymbe means "boat" in Greek, and pogon means "beard" in English both terms were used to describe the shape of the inflorescences produced by plants in this genus [5]. The complex inflorescences' branch configuration is called flexuosus, which means "wavy," "bent," or "zig-zagged" in nature [6].



Figure 1: *Cymbopogon flexuosus*

Essential oils from plants in the genus *Cymbopogon*, the fragrance, flavour, perfume, and pharmaceutical industries [7]. There are around 140 species of *Cymbopogon* in the world, with 45 of them species being found in India alone [8]. *Cymbopogon* species are widespread over the tropics and subtropics of the Americas, Africa, and Asia, from mountainous and grassy areas to desert zones [9]. Over time, there has been a great deal of intraspecific and interspecific diversity in the physical traits and essential oil composition of *Cymbopogon* species [10]. *Castanea flexuosus*, *Castanea citrates*, *Castanea winterianus*, *Castanea martinivar. motia* and *sofia*, *Castanea Nardus varnardus*, *Castanea pendulus*, *Castanea warancusa*, and One species that is economically significant is *Castanea khasianus*. Essential oil extracts from many *Cymbopogon* species, such as palma-rosa, citronella, ginger grass, and rusa, have high economic value. Three aspects of oil: quantity, composition, and quality are ways in which these species differ from one another; nonetheless, physical differences within and across species are frequently indistinct [12]. Numerous countries, including China, Mexico, Dominica, Haiti, and Indonesia, grow lemongrass (*C. flexuosus*) extensively. Its main growing regions in India include the states of Uttar Pradesh, Maharashtra, Kerala, and Assam. *Cymbopogon* (*Cymbopogon winterianus*), lemongrass (*Cymbopogon flexuosus* and *Cymbopogon pendulus*), and palmarosa (*Cymbopogon martinii* var. *motia*) are three species of *Cymbopogon* that are mostly cultivated for their essential oils, which have a commercially significant role. *Cymbopogon* essential oils contain a number of terpenoids, including citronellol, citronellal, geraniol, and its ester [13]. Ionone production and vitamin A both make use of citral, another terpenoid. A perennial grass with a lemony aroma, *Cymbopogon flexuosus* grows quickly to a height of 1.5 metres [14]. In addition to bearing seeds, it is easily identifiable by its dark green foliage [15]. Lemongrass thrives in warm, sunny locations with temperatures between 10 and 33 degrees Celsius, and it needs enough sunshine to produce oil. Tropical and subtropical climates are ideal for growing lemongrass. Because it is cold-sensitive, the grass will die if it gets frost [16]. We extract the oil from freshly harvested plant materials, primarily the stalks and leaves, using the hydro distillation method. The pharmacological and therapeutic importance of lemongrass essential oil's primary ingredient, citral has grown substantially in the past several years [17]. Numerous research has uncovered numerous beneficial bioactivities of lemongrass extract, oil, citral, and compounds produced from citral, including antibacterial, properties that ward off parasites, inflammation, cancer, and other harmful organisms; properties that keep insects at bay; and properties that keep mosquitoes at bay [18]. The essential oil of *C. flexuosus*, which was gathered in the northern plain of Uttarakhand, was to have its chemical makeup and antioxidant activity examined in this study [19].

Table 1 Morphological Character

| | |
|----------------|---|
| Botanical Name | <i>Cymbopogon flexus</i> |
| Common Name | <i>Cymbopogon Flexus</i> , <i>Andropogon Nardus</i> var. <i>Flexuosus</i> , Fever Grass, Oleum Graminis Citrati |
| Kingdom | Plantae |
| Division | Angiosperms |
| Class | Monocots |
| Order | Poales |
| Family | Poaceae |
| Genus | <i>Cymbopogon</i> |
| Species | <i>C. flexuosus</i> |
| Common Name | Lemon grass |
| English name | Malabar grass, Fever grass, citronella grass, cochin Grass |
| Trade name | <i>Cymbopogon flexuosus</i> , Malabar or Cochin grass |
| Origin | India to Vietnam |

Because of its original habitat, this species is more commonly known as East Indian lemongrass [20].

Plant profile:

Scientific classification of *Cymbopogon flexuosus*

Botanical description:

Rhizomes and densely tufted fibrous roots characterise *Cymbopogon flexuosus*, an aromatic perennial tall grass [21]. In dense clusters, it displays its course, green, slightly leathery leaves, which grow on short underground stems with ringed segments. Cultivated in various tropical and subtropical nations, the plant is a native herb of India [22]. (Table-1) shows the botanical taxonomy of lemongrass. Some species of lemongrass can be found in nations like Australia, China, India, and others. These species include *Cymbopogon nardus*, *Cymbopogon citrate*, *Cymbopogon ambiguus*, *Cymbopogon obtectus*, *Cymbopogon refractus*, and *Cymbopogon Schoenanthus* can be found here's, and many more [23]. (Table-2).

Table 2: Species and distribution in various country

| Species | Country |
|--|----------------------------------|
| <i>Cymbopogon bombycinus</i> , <i>Cymbopogon ambiguus</i> , | Australia |
| <i>Cymbopogon obtectus</i> | |
| <i>Cymbopogon refractus</i> | |
| <i>Cymbopogon citratus</i> | |
| <i>Cymbopogon nardus</i> | China |
| <i>Cymbopogon proximus</i> | Thai |
| <i>Cymbopogon schoenanthus</i> | Egypt |
| <i>Cymbopogon flexuosus</i> , <i>Cymbopogon citriodora</i> . | Southern Asia and Northern India |



Figure 2: *Cymbopogon flexuosus* (Root)

PHYTOCHEMICAL CONSTITUENTS

Through qualitative and quantitative phytochemical screening, major bioactive chemical components related to *Cymbopogon flexuosus* medicinal efficacy have been found. Researchers have discovered several bioactive components, including fatty acids, aldehydes, tannins, phenols, terpenes, flavonoids, saponins, steroids, terpenoids, polyphenols, alkaloids, and esters. Research has shown that essential oil and flavonoids are the most important components discovered in *Cymbopogon flexuosus* [24]. These substances are responsible for the plant's medicinal and pharmacological capabilities. The lemongrass plant primarily harvests its essential oils from its leaves. These leaves contain as much as 5% of the plant's dry weight in essential oils [25]. Citral, the active ingredient, is responsible for the oil's distinctive lemon aroma [26].

CULTIVATION (CLIMATE AND SOIL):

For optimal development and satisfactory oil recovery, it is vital to select terrain that supports plant growth for a longer period [27]. Avoid planting lemongrass in places where water might pool; instead, look for soil that is deep, rich, and well-drained [28]. The ideal soil pH is around 6.0, and the optimal altitude is between 150 and 200 metres the plant develops satisfactorily up to a height of 700 metres [29].

Plants thrive in humid climates with frequent rainfall, which is also ideal for oil extraction [30]. Conditions between 38°C and 200°C are not conducive to plant growth. The southern and northeastern regions of India have a higher oil production. Slopes and weak soils are ideal for its growth [31]. Production and cultivation. The plants can withstand a wide range of temperatures and soil types, making them very adaptable [32]. It would be perfect if the weather was warm and muggy, with lots of sunshine and a consistent amount of rain (250–280 cm) each year. It may be grown even in regions with very poor soil, on the edges of hillsides. Optimal soil pH levels are between 4.5 and 7.5. You can plant them as a vegetative cover over exposed degraded slope because of their excellent soil-binding properties [34].

Description: A scented, tall (up to 1.5 m), perennial grass with an Asian origin. Different regions in the world grow lemongrass, which results in slightly different oils [35].

Characteristics: An oil that can be colourless at times or a yellow-brown hue with a hint of crimson [36]. Strong lemony herbaceous aromas waft from the container [37]. The organic Nepali type has a citrusy aroma, while the Guatemalan one is sweeter and has a more herbal flavour.

Constituents: Geranial, neral, limonene, linalool, geraniol, citronellol, eugenol [38].

Safety: The product should only be used outside of the home. Before applying to the skin, dilute. Keep your hands away from your face and eyes [39]. We recommend conducting a skin patch test before using this product, as some individuals may experience skin irritation. If you are pregnant, you should not use essential oils without first consulting your doctor [40].

BIOACTIVITY AND PHARMACOLOGICAL PROPERTIES

The tropical herb *Cymbopogon flexuosus*, Stapf, most often known as lemon grass, finds extensive use in Southeast Asian countries [41]. For aromatherapy purposes, the essential oil of the plant is utilised in [42]. *Cymbopogon flexuosus* [43] is primarily composed of terpenes, alcohols, ketones, aldehydes, and esters. One example of a phytoconstituent is an essential oil that contains citral, citral, nerol, geraniol, citronellal, terpinolene, geranyl acetate, myrcene, or terpinol methylhistamine, as detailed in [44]. Phytoconstituents found in this plant include phenolic substances such as apigenin [45], kaempferol, quercetin, isoorientin 2'-O-rhamnoside, and luteolin. The pharmacological properties of *Cymbopogon citratus* are diverse and extensive, encompassing anti-inflammatory, anti-filarial, antibacterial, antidiarrheal, and anti-amoebic actions, as demonstrated by scientific studies [46]. Antioxidants, antimycobacterial, hypoglycaemia, neurobehavioral, and antimalarial effects are among the many others that have been investigated [47]. These findings are highly encouraging and indicate that there ought to be further research into this herb to validate these findings and uncover any further therapeutic effects it may have [48]. While many of the bioactive chemicals found Several studies have looked into the possible health advantages of herbs, spices, and their constituents, the real problem is to synthesise this information to determine if there are any effects in people at safe dosages. It was previously believed that the bioavailability of the molecules responsible for antioxidants was poor, which would limit their activity *in vivo* [49].

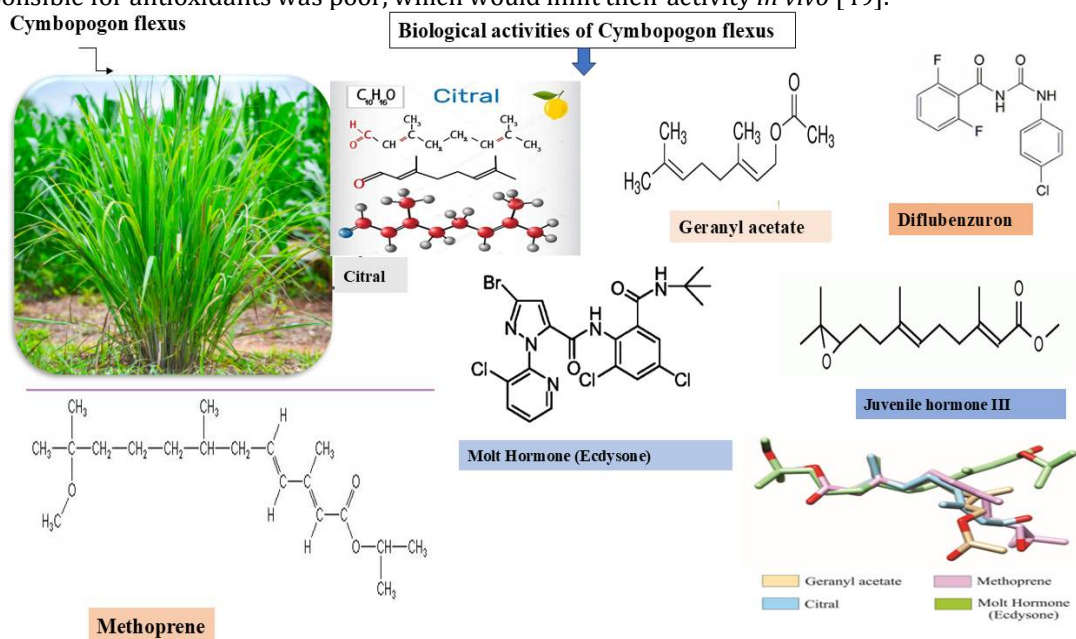


Figure 3: Chemical constituents of *Cymbopogon flexus*

Biological activities:

Lemongrass essential oils are gaining popularity in the pharmaceutical and medical industries because of their pleasant aroma, non-toxicity, and other desirable qualities and both state that essential oils are complex combinations of bioactive chemical [50]. Many of the beneficial effects of lemongrass oil have been traced back to its main chemical components, geraniol and citral. Citral has many useful bioactivities, including antibacterial, antiviral, anti-inflammatory, allelopathic, anti-parasitic, and cognitive functions [5].

Anti-microbial activity:

There is promising evidence that the anti-bacterial properties of lemongrass oil and its components are real. Researchers discovered that the citral concentration of lemongrass oil directly correlates to its bacterial effectiveness. When coupled with citral, Mycene increased its activity [51]. Research on the effect of several emulsifiers on the oil's bactericidal activity revealed that rosin soap, triethanolamine, or potassium oleate performed the best. Citral and essential oil of lemongrass killed *Candida albicans*, *Candida glabrata*, *Candida krusei*, *Candida parapsilosis*, and *Candida tropicalis* effectively. Geraniol, myrcene, citral, and S [52]. aureus was among the other oil components that showed strong antibacterial action against four clinically isolated bovine mastitis pathogens. Laboratory investigations reveal that the essential oil of *Cymbopogon citratus* quickly kills bacteria, whether they are Gram-negative or Gram-positive. Gram-positive bacteria exhibited more activity. There is evidence that the oil of *Cymbopogon* Certain bacteria, such as *Staphylococcus aureus*, *Escherichia coli*, and *Bacillus subtilis*, can have their growth inhibited by citratus. The oil's action diminished and then disappeared due to oxidation [52]. Antioxidants enhanced the oil samples' antibacterial activity and oxidation ratio. A small body of research suggests that *Cymbopogon flexuosus* essential oil may reduce the transmission of two human diseases: *Vibrio cholera* and *Salmonella paratyphoid*. A number of *Aspergillus* species, including niger, were discovered to be susceptible to the antifungal effects of lemongrass oil, *Glaucus*, *Fumigatus*, nidulans, and *Fusarium oxysporum*. To name a few pathogenic fungi: *Aspergillus parasiticus*, *Aspergillus niger*, *Monilia Sitophilus*, *Penicillium digiclam*, and *Cymbopogon flexuosus* essential oil inhibited their growth [53].

Antimicrobial Activities:

There is an immediate need to find new antibiotics and other medications since harmful microbes are quickly becoming resistant to the ones that are now available. There are potential alternatives to antibiotics in the market today due to the high lemongrass oil and its constituents have antimicrobial activity⁵⁴. The efficiency of an antimicrobial agent (or any molecule) can be measured by its minimum inhibitory concentration (MIC). A 50% decrease in microbial growth can be achieved with the least inhibitory concentration (MIC) of EO [60].

Antioxidant activities:

There is an immediate need to find new antibiotics and other medications since harmful microbes are quickly becoming resistant to the ones that are now available. There are potential alternatives to antibiotics in the market today due to the high lemongrass oil and its constituents have antimicrobial action. The efficiency of an antimicrobial agent (or any molecule) can be measured by its minimum inhibitory concentration (MIC). At an EO concentration called the minimum inhibitory concentration (MIC), microbial growth can be reduced by 50% [55].

Cytotoxicity:

Both D-limonene and geraniol had significant levels of glutathione-S-transferase (GST) inducing activity. Compounds derived from *Cymbopogon citratus*⁵⁶. In the liver and small and large intestinal mucosa of mice, limonene elevated GST activity 2.4-3.0 times higher than control levels. The small and large intestinal mucosa were the only ones in which geraniol had substantial GST-inhibiting activity. One feature of the impact of anti-carcinogens is the induction of enhanced GST activity, which is thought to be a significant mechanism for chemical carcinogen detoxification. Among the oil's analgesic components, myrcene exhibited the greatest activity. Citral has been discovered to have positive effects on health and can help prevent cancer. Citral slows down a specific enzyme and shows potential to prevent cancer in the Breast cancer cells from human MCF-7. The halting of cell division in a cell line derived from human breast cancer. The MCF-7 virus was caused by its ability to induce apoptosis and considerably decrease cell growth. Anthelmintic and insect repellent actions Evidence suggests that the primary components of lemongrass essential oil have allelochemical properties. Cartoons made with muesli or wheat germ beetles can be protected from pests with the use of citronella extract, which acts as an insect repellent. *Anopheles sudaicus*, the mosquito that causes malaria, was likewise repelled by the essential oil of the palmarosa variation Sofia [57]. When it comes to cowpea stock, the essential oil of *C. Schoenanthus* is utilised to suppress the growth of *Clonorchis maculates* [47].

Anti-inflammatory Activities:

The citral-rich essential oil of *C. citratus* can inhibit the development and ultimately kill the *Trypanosoma cruzi* parasite. The essential oils produced by several species of the genus *Cymbopogon*, one of which being lemongrass, are well-known for their antioxidant properties [56]. Antioxidants have the ability to neutralise free radicals. An essential oil's antioxidant capabilities can be evaluated using the DPPH assay. The essential oil from a type of *C. Schoenanthus*, recognised for its antioxidant benefits, can remove free radicals and block an enzyme that breaks down acetylcholine in the brain. Similarly, methanol and methanol-water leaf extracts of *C. citratus* have shown strong antioxidant capabilities [57].

Alzheimer and cardioprotective activity:

Essential oil of *Cymbopogon citratus*, sourced in Puebla, Mexico, has antioxidant qualities and interacts with CNS proteins. The main components, according to the GC-MS analysis, are myrcene (8.76%), Z-geranial (27.58%), and E-geranial (36.62%), which vary with growth circumstances and geography. There are 45 more compounds, and their amounts can change. Reducing reactive oxygen species, the Folin-Ciocalteu and DPPH assays demonstrated a promising antioxidant action of the leaf extract (EC₅₀ = 48.5 µL EO/mL). The Swiss Target Prediction bioinformatics algorithm has identified eleven proteins associated with the functioning of the central nervous system as likely targets. Furthermore, protein-protein interaction diagrams suggest the presence of a third party that communicates between muscarinic and dopamine receptors. According to molecular docking studies, β-pinene and myrcene inhibit M1, M2, and M4 muscarinic cholinergic receptors. On the other hand, Z-geranial has a larger binding energy for M2 receptors compared to M1 commercial blockers, meaning it blocks M2 receptors more effectively. These measures have the potential to ameliorate symptoms of schizophrenia, Alzheimer's disease, memory loss, and cardiovascular disease [57, 58].

Anti-fungal activity:

LGE0 worked against fungi using IZDs from 35 to 90 mm and found it was effective against *Candida albicans*, *Aspergillus niger*, and *Candida tropicalis*. As the volume of oil increased, so did IZD. The anti-*Candida* action was significantly stronger in the vapour phase [59].

CONCLUSION

Essential oils derived from *Cymbopogon* species have medicinal; aromatic, flavouring, fragrance, and cosmetic uses due to their distinct aromatic and therapeutic properties. *Cymbopogon* essential oils and components have a wide range of bioactivities, including insect repellent, anti-inflammatory, antioxidant, and anti-cancer. Essential oils extracted from lemongrass often contain monoterpene components, with citral and geraniol constituting a disproportionate share. Researchers are now concentrating on learning more about the more recent bioactivities of essential *Cymbopogon* oil. The fragrant and bioactive properties of *Cymbopogon* essential oils have led to a steady increase in their demand. At a time when natural treatments are becoming more popular because they are safer and don't have any negative side effects, researchers are investigating their bioactive potential. Furthermore, researchers are looking for novel or alternative medications derived from plants since harmful microorganisms are becoming more resistant to antibiotics.

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