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Chemical constituents and biological activities of *Cymbopogon flexuosus* (Lemon Grass)

Dr. Anju BhatnagarDOI: <https://doi.org/10.22271/reschem.2023.v4.i2b.99>**Abstract**

Cymbopogon is one of the most important essential oil yielding genera of the family Poaceae. The most common economic species viz., Lemon grass (*Cymbopogon flexuosus*), wild lemon grass (*Cymbopogon citrates*), Citronella (*Cymbopogon winterianus*), palmarosa (*Cymbopogon pendulus*). It produces different types of essential oil, such as lemongrass oil, palmarosa oil, citronella oil, ginger grass or rusa oil. Lemon grass essential oil is mainly comprises cyclic and acyclic monoterpenoids. Citral is the major constituent which gives a characteristic lemon like aroma to lemongrass, having significant commercial value. Citral is used in vitamin A and ionone synthesis. *Cymbopogon* species possessed anthelmintic, anti-inflammatory, analgesic, pesticide, antimicrobial and mosquito repellent activities. In this paper we have thoroughly discussed the chemical constituents and biological activities of lemongrass essential oil.

Keywords: *Cymbopogon flexuosus*, *cymbopogon martini*, *cymbopogon winterianus*, citral essential oils, monoterpenoids

Introduction

About 8000 flowering plant species grow in western Himalaya be rich in genetic diversity of medicinal and aromatic plants (Rao, 1994) [24]. Among these, most of the plants possess very refined and pleasant smell which can be utilized in flavor and perfumery. Majority of these plants are used for various ailments as traditional medicines. Various perfumeries, flavor and fragrance industries produce their required products from these plant species for commercial purposes.

Cymbopogon is one of the most important essential oil yielding genera of the family Poaceae, comprising about 140 species worldwide, out of which 45 species have been reported to occur in India. The members of the genus *Cymbopogon* occur abundantly in tropics and sub tropics regions of Asia, Africa and America with a regular distribution ranging from mountains and grassland to arid zones (Soenarko, 1997; Bor, 1960) [3, 25]. *Cymbopogon* species display wide variation in morphological attributes and essential oil composition at inter and intra specific level over the years. The most common economic species viz., *C. winterianus*, *C. flexuosus*, *C. martinii* var. *motia* and *sofia*, *C. nardus* var. *nardus*, *C. citratus*, *C. pendulus*, *C. warancusa*, *C. khasianus* produces different types of essential oil, such as palmarosa oil, lemon grass oil, citronella oil, ginger grass or rusa oil of commercial interest (Gupta & Jain, 1978; Mathela *et al.*, 1986) [6, 14].



Fig 1: Aerial plant Part of *Cymbopogon flexuosus*

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Three *Cymbopogon* grasses, namely, Java citronella (*C. winterinus*), lemongrass (*C. flexuosus* and *C. pendulus*) and palmarosa (*C. martinii* var. *motia*) are the more common species that are widely cultivated for their essential oils of commercial importance (Gupta & Daniel, 1982) [7]. The essential oils from *Cymbopogon* species contain a wide variety of terpenoids, some of which like geraniol and its ester, citronellol and citronellal are important perfume materials. Other constituent like citral is used in vitamin A and ionone synthesis. Several *Cymbopogon* species possessed significant anthelmintic, anti-inflammatory, analgesic, anti-ageing, pesticidal, antimicrobial, mosquito repellent and larvicidal activities and thus, are used in native medicine for curing a number of diseases (Rao, 1997) [16]. Studies on the oil composition of various *Cymbopogon* species have been carried out time to time, who reports geraniol, geranyl acetate, citral, piperitone, limonene, elemicin, monoterpene alcohols and sesquiterpenes as the major constituents in their essential oils (Kulkarni *et al.*, 1992; Khanuja *et al.*, 2005) [11, 10].

Cymbopogon flexuosus is tall, fast growing, lemon scented, perennial grass reaching a height of 1.5 m. It has distinct, dark green foliage and also produces seed. Lemon grass prefers tropical and subtropical climate, it grows well at a temp range of 10 °C to 33 °C and needs enough sunshine for the development of oil in the plant. The grass is sensitive to cold weather and cannot withstand frost. Essential part of plant is stalks and leaves. The essential oil is extracted from fresh plant material by means of steam distillation (Lawrence, 1988) [12].

Essential oils are generally complex mixtures of compounds, and potential synergistic and antagonistic effects should be taken into account when evaluating their biological activities (Padalia, *et al.* 2011, Ganjewala, 2009) [15, 5]. Most of the bioactivities of lemongrass oil has been attributed to its one or more major chemical constituents namely citral and geraniol. Some of the important bioactivities of citral are antimicrobial, anti-viral anti-inflammatory, allelopathic, anti-parasitic and cognitive activities. Other oil constituents, such as limonene and borneol has immune-stimulatory, analgesic and anesthetic properties whereas geraniol, geranyl acetate and bisabolol possess different types of bioactivities. The commercial aspects of the essential oils of these aromatic grasses and their cultivars prompted us to carry out detailed comparative terpenoid composition of cultivated species of genus *Cymbopogon* from northern plain of India.

Chemical constituents of essential oils

The essential oils are concentrated, hydrophobic liquid containing volatile aroma compounds of plants, which are called aromatic herbs or aromatic plants. They are also known as volatile or ethereal oils, or simply as the oil of the plants from which they are derived, such as camphor oil, peppermint oil, lemon grass oil, etc. Essential oils have played an important role in human life, so much so that they have become indispensable in the production of perfumes, cosmetics, medicines, food preparation and as a starting

material for the synthesis of various other compounds. *Cymbopogon flexuosus* is one of the most important essential oil grasses of the family Poaceae containing cyclic and acyclic monoterpenoids. Citral is the major constituent which gives a characteristic lemon like aroma to lemongrass, having significant commercial value. An essential oil contains more than 200 chemical components, but some are many times more complex. Essential oils consist of chemical compounds which have hydrogen, carbon and oxygen as their building blocks. They can essential classified into two groups.

Volatile fraction

Essential oil constituting of 90-95% of the oil in weight, containing monoterpene and sesquiterpene hydrocarbons, as well as their oxygenated derivatives along with aliphatic aldehydes, alcohols, and esters.

Non-volatile residue

This comprises 1-10% of the oil, containing hydrocarbons, fatty acids, sterols, carotenoids, waxes and flavonoids. However the properties of these components can change. For example, the components from the oils extracted from plants can change according to how, when and where these plants are grown and harvested.

Extraction of essential oil

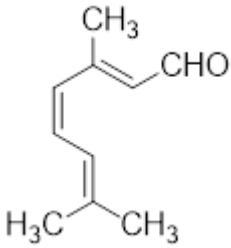
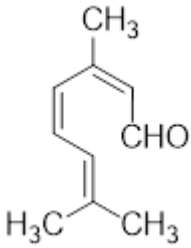
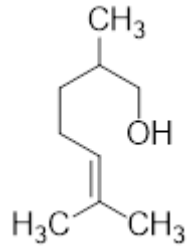
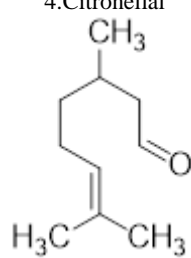
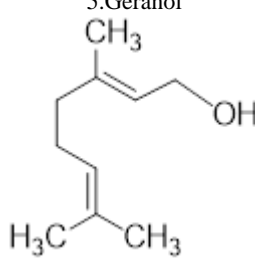
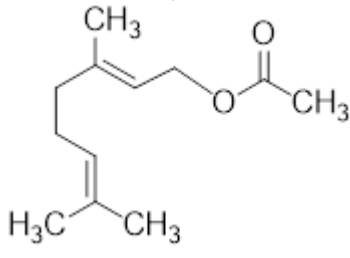
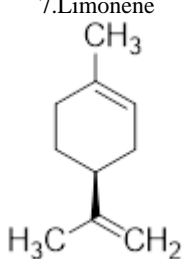
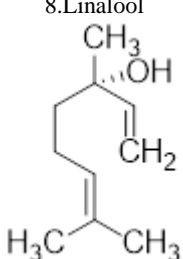
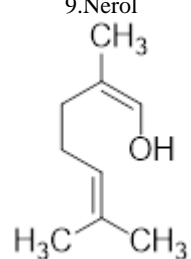
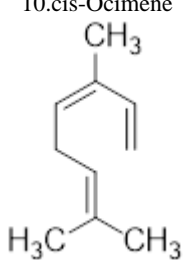
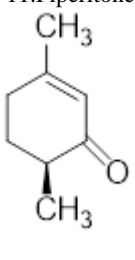
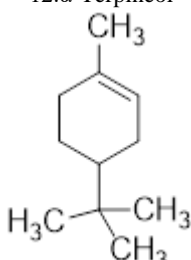
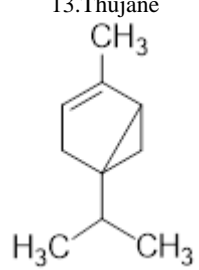
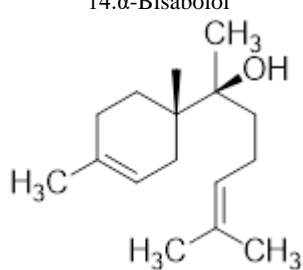
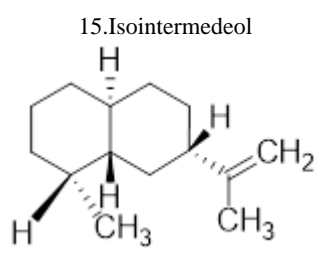
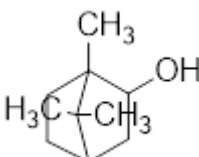
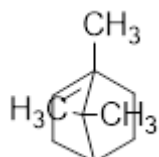
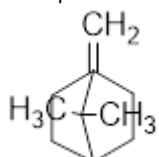
Lemongrass oil is mainly extracted by hydro-distillation method (Kulkarni *et al.*, 2003) [26]. The fresh plant leaves were collected in the during 1st week of harvesting month from experimental sites and dried at ambient temperature for two days in the laboratory. The dried leaves were cut into small pieces. The dried plant leaves used for extraction of essential oils. The oil was extracted from 100 gm plant samples in 3 replicates by hydro-distillation using Clevenger-type apparatus. The essential oil was separated from an aqueous phase using a separating funnel. The essential oil was dried over anhydrous Na₂SO₄ and was stored in sealed vials under refrigeration prior to analysis. Oil content in terms of oil percentage was calculated as the mean of 3 samples. The oil yield was calculated on the basis of fresh weight of the material (v/w).

Essential oil composition

The essential oil is obtained by hydrodistillation of plant, it is low density, slightly coloured, aromatic liquids, volatile in nature and characterized by a strong odour. The majority of components in essential oil are terpenes, with monoterpenes and sesquiterpenes. The Gas liquid chromatography has been the used for essential oil analysis. Due to the complexity of essential oil compositions, HPLC –GC is preferred for analysis.

The lemongrass yields 1 to 2% EO on a dry weight basis. The essential oil of lemon grass have been exhaustively investigated for chemical compositions (Sharma *et al.* 1999; Nath *et al.*, 1994, Khanuja *et al.*, 2005 and Ganjewala *et al.* 2008) [10, 27].

Chemical structures of *Cymbopogon flexuosus* essential oil constituents

1. Citral-a 	2. Citral-b 	3. Citronellol 
4. Citronellal 	5. Geranol 	6. Geranyl Acetate 
7. Limonene 	8. Linalool 	9. Nerol 
10. cis-Ocimene 	11. Piperitone 	12. α-Terpineol 
13. Thujane 	14. α-Bisabolol 	15. Isointermedeol 
16. Borneol 	17. α-Pinene 	18. β-Pinene 

The chemical constituents of essential oils of *Cymbopogon* species, viz. *Cymbopogon martinii* var *motia*, *Cymbopogon flexuosus* Nees., *Cymbopogon winterianus* Jowitt., growing in Garhwal region of Uttarakhand, India. The essential oils were obtained by hydro-distillation and subjected to detailed Gas Chromatography-Mass Spectroscopy (GC-MS) analysis in order to determine the variation in their volatile

constituents. Twenty seven compounds are α -pinene, β -myrcene, Limonene, Cis-b-Ocimene, p-Cymene, Terpinolene, 6-Methyl hept-5-en-2-one, Citronellal, Linalool, Linalyl acetate, β -Elemene, β -Caryophyllene, Citronellyl acetate, Neral, α -Terpineol, Borneol, Gerinal, γ -Cadinene, Geranyl acetate, Citronellol, Nerol, Geraniol, Caryophyllene oxide, Germacrene-D-4-ol, Elemol, Epi- α -

cadinol, δ -Cadinol representing 92.24 to 95.86% of the oil compositions as identified. While comparing the common constituents of three different species of cymbopogon taxa, the remarkable variation in compositions of essential oil was observed and it was in concentration (%) of nearl (0.40;34.9;1.6), gerinal (nil;47.5;0.96) geraniol (82.5;4.5;20.15), citronellol (T;0.2;12.39), citronellal (0.1;0.5;36.19), and linalool (0.8;1.6;0.96) for *C.martini*, *C.flexuosus*, *C. winterianus* respectively.

Biological activities

Essential oils of lemongrass has a pleasant aroma, non-toxic in nature and become increasing popular in pharmaceuticals and medicines. Essential oil are complex mixtures of bioactive compounds, (Padalia, *et al.* 2011, Ganjewala, 2009) [15, 5]. Most of the bioactivities of lemongrass oil has been attributed to its one or more major chemical constituents namely citral and geraniol. Some of the important bioactivities of citral are antimicrobial, anti-viral anti-inflammatory, allelopathic, anti-parasitic and cognitive activities.

Anti-microbial activity

Lemongrass oil and its constituents have shown strong anti-bacterial potential. Bacterial efficiency of lemongrass oil was found to be proportional to the Citral content of the oil. Myrcene enhanced the activity of citral when combined with them tests on the influence of different emulsifiers on the bactericidal action of the oil showed that of the emulsifiers, triethanolamine or potassium oleate and rosin soap were the best. Lemongrass essential oil and citral displayed potent antifungal activity against *C.albicans*, *C. glabrata*, *C. krusei*, *C. parapsilosis* and *C. tropicalis* (Silva *et al.*, 2008) [21]. Other oil components citral, geraniol and myrcene exhibited significant antibacterial activities against four strains of clinically isolated *bovine mastitis* pathogens, including *S.aureus*, *Streptococcus agalactiae*, *Bacillus cereus* and *Escherichia coli* (Aiemsard *et al.*, 2011) [1].

The essential oil of *Cymbopogon citratus* shows rapid bacterial activity against both Gramnegative and Gram positive bacteria in laboratory studies. Gram positive bacteria were the more active bacteria.

Cymbopogon

Citratus oil has shown detectable activity against *Bacillus subtilis*, *Staphylococcus aureus* and *Escherichia coli*. But when the oil was oxidized activity reduced and was completely lost when the oil was as extensively oxidized. Inclusion of antioxidants in the oil samples reduced the ratio of oxidation and enhanced the antibacterial activity.

The *Cymbopogon flexuosus* essential oil has shown the possibility to inhibit the growth of two human pathogen, *Vibrio cholera* and *salmonella paratyphi*.

Lemon grass oil exhibited good antifungal activity against *Aspergillus* species, *A. niger*, *A. glaucus*, *A. fumigatus*, *A. nidulans* and *Fusarium oxysparu*. The essential oil of *Cymbopogon flexuosus* showed inhibitory effect against pathogenic fungi, *Monilia sitophila*, *Penicillium digiclam*, *Aspergillus parasiticus*, *Aspergillus niger* and *Aspergillus fungis*.

Antioxidant activities

Essential oil of lemon grass and *Cymbopogon flexuosus* has also shown their strong antioxidant properties. Antioxidants are ability to scavenge free radicals. The antioxidant

activities of essential oils are determined using the DPPH assay. Antioxidant activities of lemongrass vary to a relatively small extent during the year and are not dependant on the time. Similarly leaf extract of *C. citratus* prepared with methanol also exhibited powerful antioxidant properties (Khadria *et al.*, 2008) [9]. Essential oil of *C. citratus* rich in citral content displayed significant anti-proliferative effect against *Trypanosoma cruzi* and trypanocidal activity against the parasite (Santora *et al.*, 2007) [28]. Lemongrass is also known for analgesic and anti-inflammatory properties, however only little work has been carried out.

Cytotoxicity

d-limonene and geraniol from *Cymbopogon citratus* showed high glutathione-S-transferase (GST) inducing activity. D-limonene increased GST activity 2.4-3.0 fold higher than controls in the mouse liver and mucosa of the small intestine and large intestine. Geraniol showed high GST-including activity only in mucosa of the small and large intestine. Induction of increased GST activity, which is believed to be a major mechanism for chemical carcinogen detoxification, has been recognized as one of the characteristics of the action of anti-carcinogens. Myrcene was the most active analgesic component of the oil. Citral has been found to be beneficial for health and chemo-prevention of carcinogenesis. Citral has shown chemo-preventive effects in human breast cancer cell line MCF-7 and on cyclooxygenase activity. It has significantly inhibited cell proliferation and induced apoptosis which resulted in arrest of cell cycle in human breast cancer cell line MCF-7.

Insect repellent and anthelmintic activities

Lemongrass essential oil and its major constituents are shown to function as allelochemicals. Citronella extract has insect repellent activity and used to prevent cartoons containing muesli and wheat germ beetles (Wong *et al.* 2005) [23]. Palmarosa variety sofia essential oil also showed repellent action against malaria causing mosquitoes *Anopheles sudaicus* (Das *et al.*, 2003) [4]. The essential of *C. schoenanthus* is used to control *Callosobruchus maculates* development in cow pea stock (Ketoh *et al.*, 2005) [8]. On the other side, essential oil of *C. citratus* exhibit alleopathic activity on seed germination and seedling growth of corn and barnyard grass (Li *et al.*, 2005) [13]. Other species of the genus *cymbopogon* also displayed many more other useful bioactivities such as anti-nociceptive, anxiolytic types and neurobehavioral activity (Bankole *et al.*, 2007) [2].

Conclusions

Essential oil of *Cymnopogon* species are used in flavor, fragrance, perfumery, cosmetic and pharmaceuticals due to their specific aromatic and medicinal properties. Some of bioactivities of *Cymbopogon* essential oils and constituents include anti-inflammatory, anticancer, antioxidant and insect repellency. Lemongrass essential oil of diverse origin and compositions are mainly consisted of monoterpene fractions, with large proportion of citral and geraniol. At present, the focus of research is to investigate the newer bioactivities of *Cymbopogon* essential oil. The demand for *Cymbopogon* essential oils has grown day by day, moving from their aromatic potential to their bioactive potential. Exploring its bioactive potential at a time when the demand for natural medicines is rising due to their safety and lack of

adverse effects. In addition, the growing resistance of pathogenic microbes against current antibiotics has prompted the search for plant-based new or alternative drugs.

Acknowledgements

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