Annals of Phytomedicine 12(2): 346-359, 2023

DOI: http://dx.doi.org/10.54085/ap.2023.12.2.44

Annals of Phytomedicine: An International Journal
http://www.ukaazpublications.com/publications/index.php

Print ISSN : 2278-9839 Online ISSN : 2393-9885

Review Article : Open Access

An updated review on the phytopharmacological significance of genus *Cymbopogon*

Gayyur Fatima, Mohammad Irfan Khan◆, Mohammad Ahmad, Badruddeen, Juber Akhtar, Manvi and Andleeb Khan*

Faculty of Pharmacy, Integral University, Lucknow-226026, Uttar Pradesh, India

** Department of Biosciences, Faculty of Science, Integral University, Lucknow-226026, Uttar Pradesh, India*

Article Info

Article history
Received 1 September 2023
Revised 20 October 2023
Accepted 21 October 2023
Published Online 30 December 2023

Keywords
Cymbopogon
Phytomedicine
Phytochemical
Essential oil
Pharmacological

Abstract

The *Cymbopogon* genus consists of a collection of herbaceous plants belonging to the Gramineae family, commonly referred to as the grass family. These plants are particularly well known for their valuable essential oils. These adaptable plants are found on every continent and are widely utilized in a range of industrial and medical applications. Ethnopharmacological research has confirmed their multifaceted properties, encompassing anti-inflammatory, cosmetic, and pesticidal functions. Furthermore, there is a burgeoning enthusiasm for exploring their potential as chemopreventive and antitumor agents. These plants have been classified according to their distinctive chemotypes, which serve as valuable biomarkers. Notably, *Cymbopogon citratus* is distinguished for its myriad pharmacological uses, yet emerging studies indicate that other species may also harbor medicinal potential. Substances like citronellal, when incorporated into intricate cyclodextrin structures, display the ability to inhibit pain pathways. Geraniol and citral, known for their delightful rose and lemon fragrances, are extensively employed in an array of products, including soaps, detergents, mouthwash, and cosmetics, each with its distinct and well-delineated mode of operation. This comprehensive review explores a multitude of pharmacological benefits provided by *Cymbopogon* species. These encompass antibacterial, anti-inflammatory, anticancer, and antiprotozoal properties, with an in-depth examination of the underlying mechanisms and phytochemical constituents. The extensive range of applications underscores the significant worth of *Cymbopogon*. Its potent phytochemicals, found in leaves, roots, aerial parts, rhizomes, and essential oils, form the foundation of its therapeutic potential. A comprehensive exploration is imperative to ensure the efficacy and safety of *Cymbopogon*-derived remedies, serving as a valuable resource for a wide spectrum of ailments.

1. Introduction

Phytonutrients, naturally occurring compounds found in plants, have revealed their potential for specific and robust disease prevention. Both types of phytonutrients, essential and non-essential, actively contribute to various physiological processes. When their physical and metabolic functions, associated goals, and biomarkers are detailed, they are referred to as "bioactive food mechanisms." The future demand for nutraceuticals will depend on consumer awareness and the connection between nutrition and disease. Health professionals, nutritionists, and manufacturers of nutritional supplements should conscientiously collaborate to establish appropriate parameters for delivering therapeutic strategies that can optimize human health and well-being with an emphasis on potency, purity, and safety of nutraceuticals. While functional diets and health supplements undoubtedly play pivotal roles in human health, it is crucial to exercise caution and restraint in areas like biological engineering, regulatory toxicology, and disease management (Shah *et al.,* 2011). Since they are rich in certain nutrients, minerals, and vitamins as well as fibres and active phytonutrients like terpenoids, flavonoids, lignans, sulphides, sterols, polyphenolics, coumarins, beta carotene, saponins, plants had already long been recognized as potential agents for treatment (Abdel-Moenim *et al.,* 1969; Verporate *et al.,*2002; Boukhatem *et al.,* 2014). Polyphenols and phenolic blends, which are primarily present in plant foods, are crucial (Deletre *et al.,* 2015; Bouurgaud *et al.,* 2001). The seeds and skin of fruits contain these phytochemicals, flavonoids, and polyphenols, but leaves also represent a major source of phenolics in significant amounts. Given their efficacy in scavenging prooxidants, oxidative stress, and trace metal, phenolic compounds have the potential to be both antioxidants and reducing agents. This eventuality is increased using phenolic compounds so indeed, the medicinal uses of phenolic and polyphenolic compounds are primarily explained by the principle of antioxidants properties (Velnar *et al.,* 2009).

The genus *Cymbopogon* goes by many names, including Malabar grass, Citronella grass, Cochin grass, Lemongrass, Barbed wire grass, and fever grass. These species are indigenous to Africa, Australia, and tropical islands, and they are extensively dispersed in more than 40 nations worldwide. There are plenitudes of different species names, and applications for *Cymbopogon*, and nearly every one of them is aromatic. There are 144 species of *Cymbopogon*, some of which are: *C. flexuosus* (Cochin grass), *C. nardus* (*Citronella grass*), *C. citratus* (DC.) Stapf (Lemongrass), *and C. giganteus* (Tasuri grass). For instance, *C. citratus* can be found in several locations, including Togo, Bangladesh, the French West Indies, Brazil, Tanzania, Guadeloupe, Argentina, Thailand, Mexico, Nigeria, India, Singapore, and Kenya. Along with other places, Iran and Pakistan are the habitats of *C. jwarancusa* (Khustar *et al.,* 2016; Aibinu *et al.,* 2007). The tropical and subtropical districts of Africa, Asia, and the U.S.A. are

Corresponding author: Dr. Mohammad Irfan Khan
Associate Professor, Faculty of Pharmacy, Integral University, Lucknow-226026, Uttar Pradesh, India
E-mail: irfan9896@gmail.com
Tel.: +91-7897124030

sanctuaries to *Cymbopogon*. This genus having 144 species, possess essential oils, that are currently applied in the production of cosmetics, drugs, and fragrances (Dagupen *et al.,* 2011). *C. flexuosus* (Cochin grass) and *C. citratus* (lemongrass), among others, are species that are grown for commerce in the Congo Kinshasa, Madagascar, and Congo Landmass (Arrey *et al.,* 2014). However, the USSR only exports about 70,000 kg of these plants annually, with Guatemala being the main exporter, trading about 250,000 kg. Some *Cymbopogon* species are more valuable commercially because they can thrive in climatic conditions that range from moderate to remarkably harsh (Ansari and Razdan, 1995; Soenarko, 1977; Toungos, 2019). Indeed, due to their rich content of essential oils, *Cymbopogon* species are believed to exhibit a diverse array of properties that make them valuable in various industries. These include perfumery, pharmaceuticals, insecticides, insect repellents, and cosmetics. Multiple research studies have confirmed not only the dietary significance of *Cymbopogon* species but also their beneficial and pharmacological importance (Karami *et al.,* 2021; Jirovetz *et al.,* 2007). Numerous countries around the world take advantage of this species as an herbal medication for UTI (urinary tract infections), kidney, liver detoxication, bone-related symptoms, heart problems, hypercholesteremia, gastrointestinal problems, weight loss, and indigestion (Khalid *et al.,* 2022; Padalia *et al.,* 2001).

2. Ethnopharmacology of *Cymbopogon* species

Typical uses of the *Cymbopogon* species in various countries include a widely known tea, herbal supplement, insecticide, virus regulation, anti-inflammatory effect with analgesic characteristics (Samreen and Ahmad, 2022). The common names of a few species, their significance, and uses have been depicted in Table 1. The species, *C. citratus* is regarded to be the most widely used throughout the globe. In Nigeria, it is employed to treat stomach aches, treat malaria, as a pest repellent, and as an antioxidant. The prevailing species in India (East and West) are: *C. citratus* and *C. flexuosus*, which have got been used regionally in cosmatics, insecticides, and the diagnosis of gastrointestinal issues and respiratory infections (Negrelle and Gomes, 2007).

The *Cymbopogon* plant contains key biologically active chemicals having anti-inflammatory, antibacterial, antidyspeptic, properties, as well as an antihermetic, antispasmodic, analgesic, tranquilizer, antipyretic, and diuretic properties (Leite *et al.,*2010). In South Africa (Tanzania), lemongrass (*Cymbo pogon citratus*) tea is used to reduce fever and used to help alleviate painful menstruation (Tavares *et al.,*2015). Additionally, the lemon grass tea is said to calm blood flow by reviving the fallopian tubes. In Singapore, *C. citratus* is used to treat an infection around the nails (paronychia), flu and cold indications, insect stings, itchy throats, flatulence, and digestive problems, as well as anticarcinogenic effects. Surprisingly, *C. citratus* is also used as a bug repellent against mosquito bites, house flies, and fleas in several countries. The aerial segments of *C. jwarancusa* (oil grass) have been proposed as a panacea for RTI (respiratory tract infections). Root extracts are more effective for stomach ulcers, typhoid, and fever (EL-Kalami *et al.,* 2010; Wang *et al.,*2022). *C. densiflorus* (Steud.) Stapf. pulverized leaves are used to treat rheumatoid arthritis in Gabon, and its flowerhead is used in smoking to treat bronchial irritation and asthma in Malawi (South Eastern Country) and Congo. The root and aerial section of *C. distans* (Nees) are used as carminatives and prevent heart diseases (Kumar *et al.,* 2022). Most of the *Cymbopogon* essential oil is employed in aromatherapy to relieve body revival. It can be found in a variety of products such as fragrances, local shower gels, and candles. In several Asian and African nations, lemongrass has been shown to offer snake and reptile-repelling properties (Takaisi *et al.,* 2000; Tchoumbougnang *et al.,* 2015).

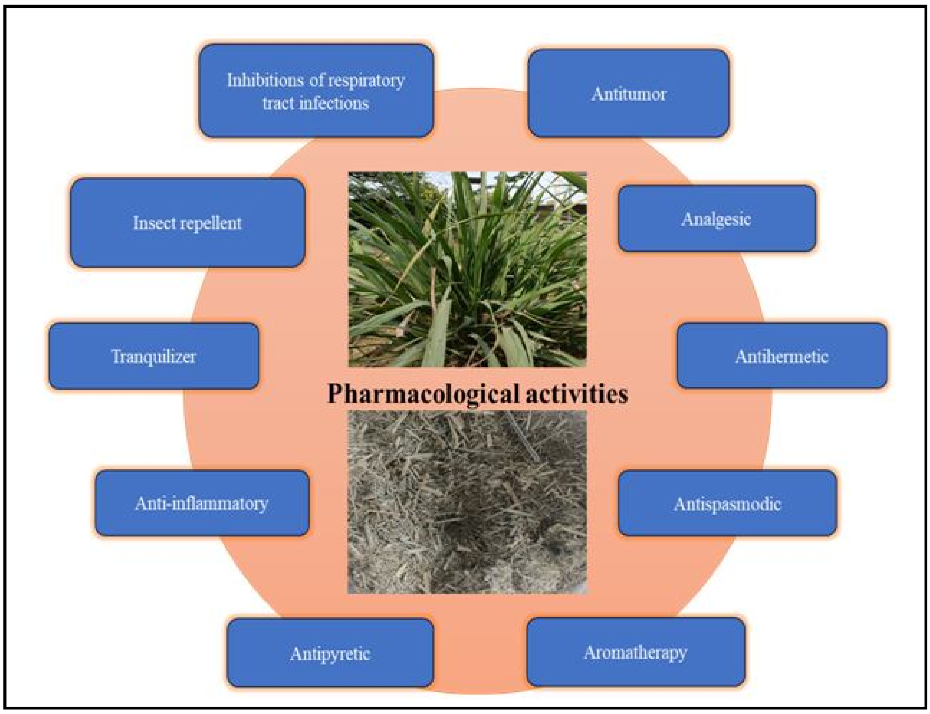


Figure 1: Ethnopharmacological profiles of *Cymbopogon* species.

Table 1: Common names and medicinal uses of *Cymbopogon* species

Species	Common name	Region	Medicinal uses	Parts	References
***Cymbopogon nardus* (L.) Rendle**	Citronella oil	India	Fragrance and insect repellent	Leaves	Sharma *et al.*, 2019; Boukhatem *et al.*, 2014
***Cymbopogon excavatus* Hoscht.**	Bread-leavened Turpentine grass	S. Africa	Insecticides	Sheaths	Ekpenyong *et al.*, 2015; Arrey *et al.*, 2014
***Cymbopogon Validus* (Stapf.)**	African bluegrass	Africa, both Eastern and Southern	Skin cleansers, antia-geing cream, Fumigant and rodent control	Essential oils	Elmahallawy and Agil, 2015; Boukhatem *et al.*, 2014
***Cymbopogon parkeri* (Stapf.)**	Lemongrass	Pakistan	Antiseptic and stomachic	Aerial	Kpoviessi *et al.*, 2015
***Cymbopogon olivieri* (Boss.)**	Pputar	Pakistan	Condiment, and antimalarial	Aerial	Bayala *et al.*, 2018
***Cymbopogon marginatus* (Steud.)**	Lemon-scented grass	South Africa India	Moth repellent, anti-pyretic, and digestives	Aerial Root	Bassoe *et al.*, 2011; Verporate *et al.*, 2002
***Cymbopogon winterianus*(Jowitt.)**	Java grass	Brazil	Antiepilepsy and antianxiety	Fleshy leaves	Lorenzetti *et al.*,1991; Bayala *et al.*, 2018
***Cymbopogon citratus* (Stapf.)**	Lemongrass Limoneria Cana Santa grass tea Limoneria Capim-santo fever grass	India Nigeria Argentina Cuba Costa Rica Colombia Brazil Trinidad and Tobago	Fever, digestives Antidiabetic, anti-inflammatory, Nervine disorders Cold and flu Digestives Grasses are used for cough Carminative For cough mixture Purgatives, pest controlanxiolytic and antihypertensive	Aerial Leaves Leaves Leaves Leaves Rhizome Leaves Grass Rhizome	Prasad *et al.*, 2014 Cunha *et al.*, 2020 Cassia *et al.*, 2013 Soenarko, 1977 Toungos, 2019 Toungos, 2019 Toungos, 2019 Prasad *et al.*, 2014
***Cymbopogon giganteus(*Hochst.)**	Tsauri grass	Camerron	Used for cough and arterial hypertension	Leaves and Flowers	Ketoh *et al.*, 2006
***Cymbopogon ambiguous* (Hack.)**	Lemongrass	Australia	Used for headaches, chest infections, and for muscle cramps	Leaf and stem	Desai and Parikh, 2012
***Cymbopogon procerus* (R.Br.) Domin**	Scent grass	Australia	Used in cosmetics	Leaves and stem	Tibenda *et al.*, 2022
***Cymbopogon flexuosus* (Nees ex Steud.)**	Lemongrass	India	Cosmetics, antiseptic	Leaves	Santin 2009; Abdel-Moenim *et al.*, 1969
***Cymbopogon pendulus* (Nees ex Steud.)**	Jammu lemongrass	India	Antiseptic and used in perfumery industries	Leaves	Saeed *et al.*, 1978; Wei and Wee W, 2013
Cymbopogon scheonanthus	Ethkher	Saudia Arabia	Antipyretic, and antidiarrheal	Leaves	Khanuja *et al.*, 2005
***Cymbopogon obtectus* (S.T. Blake)**	Silkey heads	Central Australia	Used for cough headaches, fever, and sore throat	Mixture	Blasi *et al.*, 1990
***Cymbopogon proximus* (Stapf.)**	Halfabar	Egypt	For ejection of renal calculi and ureteric calculi	Leaves	Andila *et al.*, 2018
***Cymbopogan refractus* (R. Brown)**	Barbed wire grass	Australia	Animal feeds	Leaves	Bagheri *et al.*, 2007
***Cymbopogon densiflorus* (Steud.) Stapf**	Lemongrass	Congo	Antiasthmatics, and antiepileptics	Leaves and rhizome	Bharti *et al.*, 2013
***Cymbopogon jwarancusa* (Jones) Schult.**	Limon	Egypt	Condiment	Whole plant	Nath *et al.*, 2002; Desai and Parikh, 2012

3. Phytochemistry of *Cymbopogon* species

Lemongrass, which is the vernacular name for the genus *Cymbopogon*, belongs to the Poaceae/Gramineae family (Bidinotto *et al.,* 2011). Lemongrass is a perennial grass that can grow up to one meter in height, featuring numerous rigid and green branches that arise from short rhizomatous roots. In the Philippines and Indonesia, a fragrant grass known as *Cymbopogon citratus* (*C. citratus*) is commonly cultivated. Additionally, *C. citratus* is grown in various regions of Asia and America, especially in their humid climates. While India and Sri Lanka some tropical and subtropical countries where this plant is cultivated, and primarily considered an indigenous herb (Kumar *et al.,* 2023; Wang *et al.,* 2022; Tovar *et al.,* 2011). The species of lemongrass, including *C. nardus*, *Cymbopogon ambigus*, *C. bombycinus*, *Cymbopogon refractus*, and *Cymbopogon citratus*, are widespread worldwide. The extensive information collected from *Cymbopogon* ethnopharmacological programs prompted a study of its chemical components (Cardoso and Soares, 2010). *Cymbopogon* species have been found to contain a variety of compounds, such as hydrocarbons, alcohols, ketones, esters, volatile and non-volatile terpenes, phenolic compounds, acids, carotenoids, and other substances. Most of the essential oils consists of monoterpenes, monoterpenoids, triterpenes, triterpenoids, and rare fatty alcohols like 4-nonanol and 1-octanol. *C. citratus* rhizome was discovered to contain approximately 0.52% alkaloids in every 300 grams of the mentioned plant part (Zahra *et al.,* 2020; Zhang *et al.,* 2022).

4. Volatile components of *Cymbopogon*

Cymbopogon, commonly known as lemongrass, finds extensive use in the food industry, pharmaceuticals, and traditional medicine due to its highly valuable essential oils. The chemical composition of lemongrass varies depending on its geographical origin, particularly concerning the terpenes, ketones, alcohols, and esters present. The plant's leaves, which are a valuable source of essential oils, can contain up to five percent of their dry weight, with the principal component being citral, providing lemongrass with its unique lemon-like aroma (Zhang *et al.,* 2022). The term "lemon" in its name specifically refers to this characteristic because of the presence of citral, a cyclic monoterpene (Thakker *et al.,* 2016). Citral is the primary component of lemongrass essential oil and varies in content from 79.5% to 91.4%. Many consumer products containing lemongrass oil feature additional fragrances such as geraniol (1.7%), myrcene (18.0%), geranial (39.0%), neral (29.4%), linalool (1.3%), and more (Wei and Wee, 2013). Lemongrass also contains myrcene, a phytochemical component known for its antibacterial and analgesic properties. Citral, composed of two aldehydes and a stereoisomeric monoterpene, is used for producing vitamin A. This distinctive compound gives lemongrass its lemon-like aroma (Alitonoua *et al.,* 2006). The trans isomer of geranial is more prevalent in citral (40-62%) than the cis isomer (25-38%). Lemongrass has a long history of use in cosmetics, traditional medicine, and culinary applications.

Due to its enticing fragrance, lemongrass serves as a flavoring ingredient in various non-food products like soaps, perfumes, air fresheners, and insect repellents. The use of essential oils, perfumery, and volatile plant by-products is highly advantageous to both the fragrance industry and traditional medicine. Many essential oil components and the oils themselves possess pharmacological qualities, serving as antioxidants, anti-inflammatory agents, antiageing compounds, and potential anti-cancer substances (Mathew *et al.,* 1996).

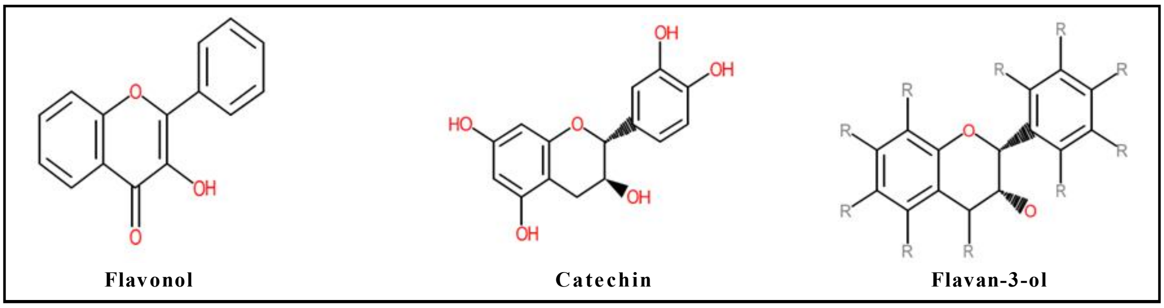
4.1 Phenol

Phenolic compounds constitute a diverse class of secondary metabolites, including flavonoids, lignans, stilbenes, curcuminoids, coumarins, and various other polyphenolic compounds. Among these, flavonoids are the most common phenolic ingredients, encompassing over 10,000 different compounds (Zhang *et al.,* 2022; Ruphin *et al.,* 2016). The *Cymbopogon* species contain a variety of compounds, with the highest concentrations observed in quinic acid (161.52 ± 17.62 g/g), caffeic acid (445.21 ± 32.77 g/g), chlorogenic acid (377.65 ± 4.26 g/g), p-coumaric acid (393.32 ± 39.56 g/g), and quercetin-3-glucoside (151.35 ± 11.34 g/g). Additionally, Australian lemongrass is reported to contain pyrogallol, catechin, diosmin, tricin, procyanidin B2, protocatechuic acid, ferulic acid, and p-hydroxybenzoic acid (Quintans-Junior *et al.,* 2008). In the research by Shah and his team, several phenolic acids, including p-coumaric, chlorogenic, and ferulic acids, were extracted from the roots of *C. nardus*. Furthermore, lutein, apigenin, and their 6,8-glucosides were also identified in *C. nardus* based on the same study. In a specific study, it was found that the total content of soluble phenols in methanolic root extracts of *C. nardus* varied between 4.2 to 30.9 mg GAE/g DW (milligrams of gallic acid equivalents per gram of dry weight) (Shah *et al.*, 2011).

4.2 Flavonoids

These substances possess potent antioxidant properties, such as elemicin and luteolin. It has been reported that the extracts from the leaves and rhizomes of *C. citratus* were used to isolate compounds like Cymaroside (luteolin 7-O-glucoside), luteolin, 2"-O-rhamnosyl isoorientin, and isoscoparin (Pereira *et al.,* 2021).

Additional flavonoid compounds found in the aerial parts of *C. citratus* include chlorogenic acid, elemicin, catechol, caffeic acid, hydroquinone, as well as quercetin, kaempferol, and apigenin (Dubey *et al.,* 1999). According to the literature, the most significant components of *C. citratus* are the flavonoids and essential oils, which contribute to the plant's well-known pharmacological and therapeutic properties (Table 4).



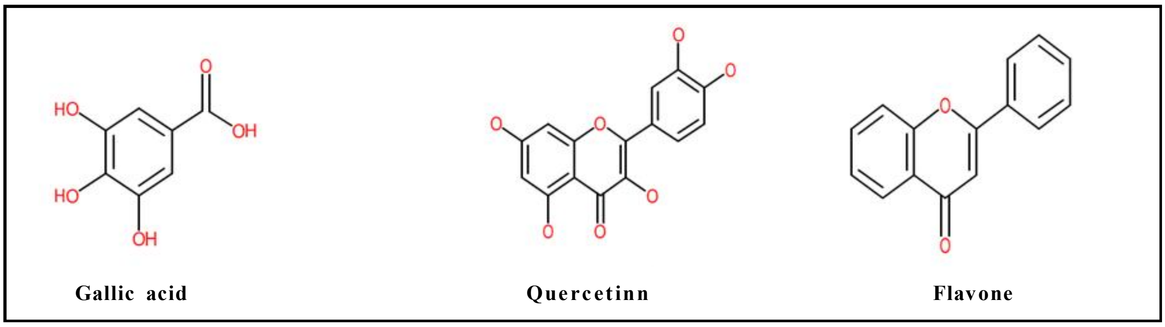


Figure 2: Chemical structures of flavonoids and phenolics in *Cymbopogon* species.

4.3 Tannins

The tannin content in *Cymbopogon* species, particularly *C. citratus*, is widely utilized. As per the findings by Figueirinha *et al.* (2008). The fractionated extracts containe approximately 10 mg of hydrolyzable tannins, specifically proanthocyanidins. In contrast, *C. citratus* from Nigeria was determined to have an approximate tannin content of 0.6 per cent (0.6%). Furthermore, the condensed tannin content in *C. nardus* has been observed in several studies summarized in Table 4.

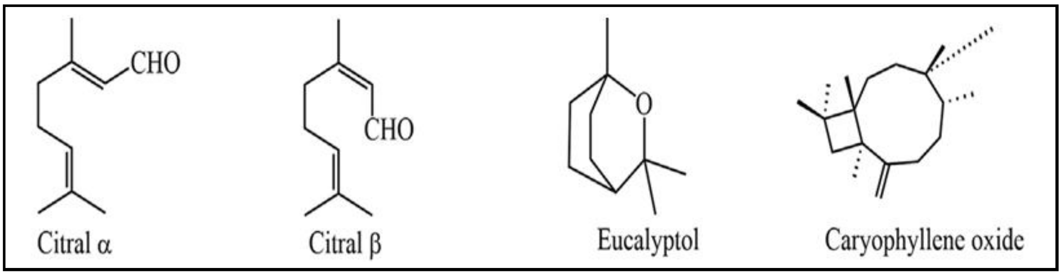
4.4 Essential oils

Cymbopogon essential oils are widely utilized in the fragrance, food, aroma, and cosmetic industries. The lemongrass essential oils found in different spcies such as *Cymbopogon flexuosus (C. flexuosus), C. citratus,* and *Cymbopogon pendulous.* Citronella oil, another well-known variety, is derived from *C. nardus* and *Cymbopogon winterianus.* Palmarosa and ginger grass oil are also obtained from *C. martini*. Other species that yield essential oils include *C. schoenanthus (Camel grass), C. afronardus, Cymbopogon caesius (Inchi/Kachi grass), C. clandestinus, C. exaltatus, C. goeringii, C. coloratus, C. giganteus, C. polyneuros, C. jwarancusa*, and *C. procerus* (Blanco *et al.,* 2009). The essential oils of *Cymbopogon* species are primarily composed of monoterpene fractions. Previous reports have revealed the presence of compounds such as citral (a mixture of geranial and neral), geraniol, citronellol, citronellal, linalool, elemol, 1,8-cineole, limonene, β-caryophyllene, methyl heptenone, geranyl acetate, and geranyl formate in the essential oils of different species, with significant variations reported (Figure 3). Additionally, the composition of essential oil components is greatly influenced by genetic, environmental, and geographical factors. The essential oils in *Cymbopogon* species are biosynthesized in the rapidly growing leaves and stored in specialized oil cells in the parenchymal tissue. A study on *Cymbopogon citratus* has reported the presence of various essential mineral constituents, including sodium (Na), potassium (K), calcium (Ca), iron (Fe), magnesium (Mg), manganese (Mn), zinc (Zn), and phosphorus (P). Other minerals observed in *C. citratus* include cadmium (Cd), chromium (Cr), nickel (Ni), copper (Cu), arsenic (As), and lead (Pb).

Cymbopogon schonenanthus, on the other hand, was reported to contain essential minerals such as calcium (Ca), phosphorus (P), potassium (K), magnesium (Mg), copper (Cu), zinc (Zn), manganese (Mn), and cobalt. These findings are detailed in Table 2 (Francisco *et al.,* 2011; Dubey *et al.,* 1999; Pereira *et al.,* 2021).

Table 2: Bioactive constituents reported in *Cymbopogon* species

Mineral contents	Phytonutrients	Vitamins
Sodium	Flavonoids	Vitamin A
Potassium	Vitamins	Vitamin C
Calcium	Alkaloids	Vitamin E
Iron	Phenols	Folate
Phosphorus	Tannins	Thiamine
Selenium	Essential oils	Niacin
Zinc	Saponins	Pyridoxin
Magnesium	Steroids	Riboflavin



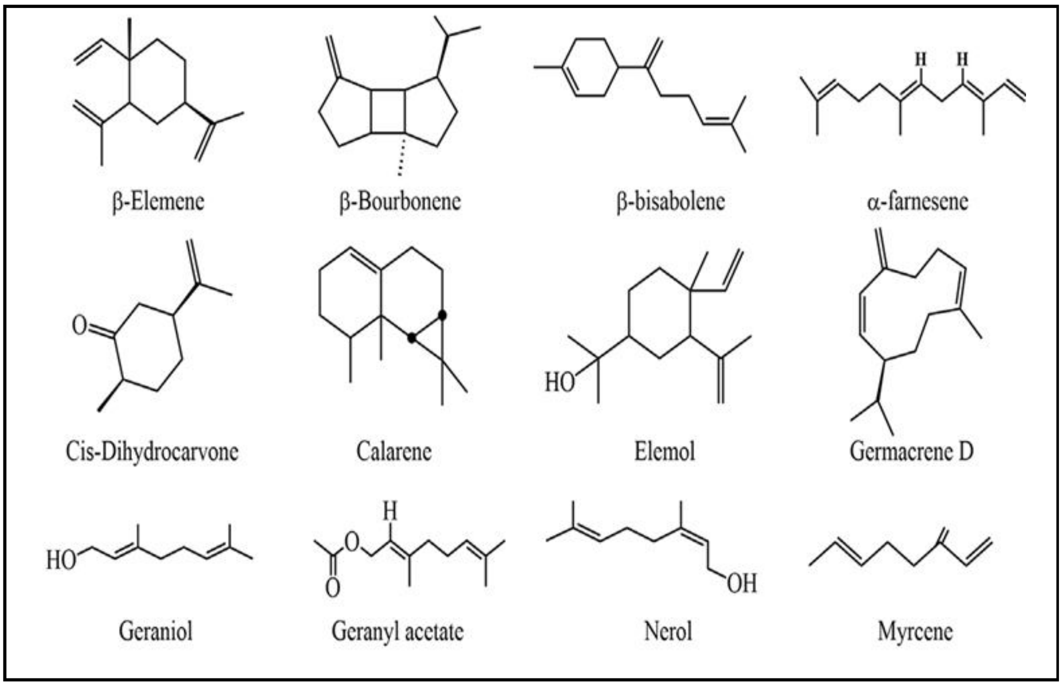


Figure 3: Reported chemical components of *Cymbopogon* essential oils.

Table 3: Major phytoconstituents of *Cymbopogon* species: Traditional, medicinal, and economic importance

Species	Essential constituents	Medicinal/Therapeutic uses	References
Cymbopogon clandestinus (Nees ex Steud.) Stapf	Limonene, camphene, citronellol, neral citronellal, geraniol, nonan-4-ol, and citral	Perfumery and cosmetics	Deletre *et al.,* 2015; Makhaik *et al.,* 2005
Cymbopogon bombycinus (R.Br.) Domin	flavone C-glycosides and tricin	Used for making tea, drinks, flavouring agent, antioxidant and as skin conditioner	Bouurgaud *et al.,* 2001; Puatanachokchai *et al.,* 2002; Makhaik *et al.,* 2005
Cymbopogon caesius (Hook and Arn.) Stapf.	Carvone, limonene, citronellol, citronellal and perillyl alcohol	It is used as a mosquito repellent and to relieve morning sickness in pregnant women	Gbenou *et al.,* 2013; Figueirinha *et al.,* 2008
Cymbopogon citratus (DC.) Stapf.	Citronellal, geraniol camphene, citral, limonene, citronellol, neral, and nonan-4-ol	Used for medicinal purposes like antifilarial antidiarrheal, hypolipidemic effects, anti-bacterial, antimalarial, antifungal, anti-inflammatory, hypoglycaemic, gastronomic properties	Wany *et al.,* 2013; Tibenda *et al.,* 2022; Ketoh *et al.,* 2006
Cymbopogon commutatus Stapf.	Limonene	Species are used in the perfumery and cosmetics industries.	Avoseh *et al.,* 2015
Cymbopogon distans (Nees ex Steud.)	Methyl eugenol, terpineol, geraniol, piperitone, and limonene	Species are used for anti-inflammatory activity and in treatment of asthma, and chronic bronchitis	Sari *et al.,* 2017
Cymbopogon martini Stapf.	Geraniol, linalool, geranyl acetate, citral, and citronellol	Used as a mosquito repellent, preservative, parasiticidal and antimicrobial agent	Edris, 2007 Avoseh *et al.,* 2015
Cymbopogon validus (Stapf.) Stapf. ex Burtt Davy	Hedycaryol and α-eudesmol, linalool, northujane, verbenone, naphthalene, artemisia ketone, and δ-cadinene,	These species are used for medicinal purposes like antiplasmodic, anti-inflammatory, antirodent, emetic, anti-infective, and in morning sickness	Noor *et al.,* 2012; Cunha *et al.,* 2020
Cymbopogon winterianus Jowitt ex Bor	Geraniol, methyl-iso-eugenol, nerol, citronellol, geranyl acetate, citronellyl acetate, citronellal, caryophyllene, elemol, and linalyl acetate,	Mosquito-repellent, molluscicidal, and anti-fungal agents	Quintans-junior *et al.,* 2008; EL-Kamali *et al.,* 2010

Cymbopogan olivieri (Boiss.) Bor	Piperitone, α-terpinene, α-eudesmol, delta-3-carene, β-caryophyllene, and elemol	Antimicrobial activity	Phillips and Hua, 2005
Cymbopogon nervatus (Hochst.) Chiov.	β-bergamotene, β-selinene, β-elemene, and germacrene-D.	Antimicrobial activity and molluscicidal effect	Moreira and Guliford, 1997
Cymbopogon nardus (L.) Rendle	2,6-Octadienal, limonene, citronellol, caryophyllene, and eugenol	Perfumery industries and antibacterial activity	Ganjewala and Gupta, 2012
Cymbopogon schoenanthus (L.) Spreng.	Piperitone, dihydrocarveol, limonene, elemol δ-terpinene, and α-terpineol	Acetylcholinesterase effect and insecticidal effect	Kanjilal *et al.,* 1995
Cymbopogon procerus (R.Br.)	Pinene and elemicin	Used for tea, gastronomic purposes	Jummes *et al.,* 2020
Cymbopogon proximus (Hochst. ex A. Rich.) Chiov.	Carene, limonene, piperitone, and elemol	Anticonvulsant and anxiolytic	Chagonda *et al.,* 2000
Cymbopogon jwarancusa subsp. olivieri (Boiss.) S. Soenarko	β-pinene and γ-terpinene citronellal, p-cymene, geraniol	Antipyretic, antirheumatic, dyspepsia, rheumatism, antitussive, and antifungal activity	Choudhury and Leclercq, 1995
Cymbopogon giganteus Chiov.	Trans-p-2, 8-menthadien-1-ol, trans-p-1(7), 8-menthadien-2 -ol, cis-p-1(7), 8- menthadien -2-ol, cis-p-2, 8-menthadien -1-o	Antimicrobial, antitrypanosomal, antiplasmodic, anti-inflammatory agent	Chagonda *et al.,* 2000
Cymbopogon flexuosus (Nees ex Steud.)	Myrcene, geranyl acetate, Citral, and citronellol	Anti-inflammatory effect	Sari *et al.,* 2017
Cymbopogon densiflorus (Steud.) Stapf.	Trans-p-mentha-2, cis-p-mentha-2, 8-dien-1-ol, 8-dien-1-ol, 8-dien-2-ol, trans-p-mentha-1(7), and cis-piperitol	Antibacterial effects and antitumor activity	Blanco *et al.,* 2009

Table 4: Phytoconstituents of *Cymbopogon* species and their biological activities

Essential oils	For pharmacological purposes, aromatherapy, aromatherapy, food preservatives, hypo-cholesterolemic, antidiabetic, antimicrobial, diuretic, hypoglycaemic, anti-inflammatory, antioxidant, and anticarcinogenic, used for hematological, and neuropharmacological effects.
Tannins	Antimicrobial, astringent, antioxidant, hypoglycemics, and anti-inflammatory properties.
Saponins	Biological activities of saponins like mild astringents, anti-inflammatory activity, used for hypocholesterolaemia effects.
Flavoniods	Antioxidant, antimicrobial and antipyretic activity.
Alkaloids	Neuropharmacological effects and astringent purposes.
Vitamins	Cardioprotective actions and antioxidant activity.
Minerals	Cell signaling and transport processes, neuropharmacological actions and hemodynamic activity.

5. Biological activities of *Cymbopogon* species

Pharmacological actions often differ depending on the presence of active constituents. Subsequent research efforts have resulted in the identification of several therapeutic effects, each supported by a well-established mechanism of action of constituents (Figure 1 and Table 3).

5.1 Anticancer effect

Numerous studies have explored the antitumor potential of essential oils from *Cymbopogon flexuosus* and *C. densiflorus*. In a murine tumor model immunized with S-180 (murine sarcoma cancer cell lines), *C. flexuosus* oil induced apoptosis in HL-60 cells (human leukemia cell lines) both *in vitro* and *in vivo*. Interestingly, human cancer cell lines derived from the colon, liver, cervix, and leukemia exhibited the most significant response. Additionally, treatment with *C. densiflorus* oil demonstrated antitumor effects on rare and TP53-mutated bladder cancer cells. These findings suggest that the essential oils of *Cymbopogon densiflorus* and *C. flexuosus* may be used in conjunction with various anticancer drugs as adjuvant therapy (Sharma *et al.,* 2009).

5.2 Antitrypanosomal and antimalarial effect

It has been demonstrated that essential oils from similar species of *Cymbopogon*, namely *C. citratus, C. nardus, C. giganteus,* and *C. schoenanthus*, are effective against *Trypanosoma brucei* and *Plasmodium falciparum*. Bioactive compounds such as monoterpenoids (myrcene, citronellal) and citral (3, 7-dimethyl-2, 6-octadienal), have been identified as antimalarial agents, inhibiting

Plasmodium growth by 86.6 per cent when compared to chloroquine. Notably, *Cymbopogon pendulus* (*C. pendulus*) essential oil was found to contain elemicin, a precursor for the antimalarial drug trimethoxyprim. Another study revealed that ethanol extracts of *C. citratus* essential oil enhanced the antioxidant defense against malaria-induced oxidative stress (Tchoumbougnang *et al.,* 2005; Dutta *et al.,* 2016).

5.3 Anti-inflammatory effect

Worldwide tissue infections pose a significant public health challenge. The adoption of wealthier lifestyles due to technological advancements has been associated with a lower incidence of these infections. Inflammation is closely linked to diseases such as diabetes, arthritis, heart disease, and cancer, and it increases the risk of human mortality. Animal tissues generally undergo swelling in response to physical stress or exposure to chemical inflammatory inducers like lipopolysaccharide. Prostaglandin E2 and nitric oxide (NO), known pro-inflammatory mediators, are released when lipopolysaccharide-stimulated cells are cultured with macrophages, leading to systemic inflammation. Other inducers include the generation of reactive oxygen species, cytokines like interleukins, tumor necrosis factor, and increased nuclear factor kappa-B activation. Citral, as demonstrated by ethnomedicinal studies on *Cymbopogon*, possesses anti-inflammatory properties. The volatile oil from *Cymbopogon flexuosus,* which contains a high citral content, has been shown to reduce common inflammatory markers in human skin sections and significantly alleviate chemically induced skin inflammation in a mouse model, both when applied topically and ingested orally. Currently, it is widely employed in creams and gels for the treatment of topical inflammation (Boukhatem *et al.,* 2014; Han and Parker, 2017; Francisco *et al.,* 2011; Alitonou *et al.,* 2006).

5.4 Antiprotozoal effect

Citral is the primary constituent of the essential oils of *C. flexuosus* and *Cymbopogon citratus*. According to some research, both citral and myrcene have demonstrated antileishmanial effects on various species, including *L. infantum*, *L. tropica*, and *Leishmania* major. Furthermore, citral has been shown to exhibit antitrypanosoma activity and the capability to impede the morphological and ultrastructural changes of *L. amazonensis* without causing cytotoxic effects. In other investigations, essential oil from *Cymbopogon* species was found to be effective against *E. histolytica* in broth culture (Hacke *et al.,* 2020; Jummes *et al.,* 2020).

5.5 Antiobesity effect and hypertensive activity

Various studies have explored the potential of lemongrass (*C. citratus*) extract as a hypolipidemic and hypoglycemic agent, with the aim of reducing the risks associated with obesity and hypertension. According to available data, feeding rats with 500 mg/kg/day of *C. citratus* aqueous extracts led to a significant reduction in low blood sugar levels. Additionally, there was a notable decrease in low-density lipoprotein (LDL) levels in the arteries, indicating a hypolipidemic effect. Researchers have linked these effects to factors such as hyperinsulinemia (high insulin levels in the blood) or increased peripheral glucose uptake, though the precise mechanisms remain unclear. Lemongrass aqueous extracts contain essential oils and other extractants, including antihypertensive substances like flavonoids and alkaloids, which have been found to enhance the hypoglycemic effects of the extract. Tea made from *Cymbopogon* leaves is commonly consumed to help regulate blood sugar, lipid, and fat levels, which may aid in the prevention of obesity and hypertension. In a study using a water extract of *C. citratus*, it was found to reduce fasting plasma levels of glucose, total cholesterol, triglycerides, low-density lipoproteins (LDL), and very low-density lipoproteins (VLDL), while increasing plasma levels of high-density lipoprotein (HDL) with no impact on plasma triglyceride levels.

Similarly, *C. nardus* reduced obesity by inhibiting the expression of genes related to apoptosis and lipogenesis. The evidence suggests that *Cymbopogon* species may contribute to insulin secretion for blood sugar control and blood pressure reduction (Jummes *et al.*, 2020; Adeneye and Agbaje, 2007).

5.6 Antinociceptive effect

The herb *Cymbopogon* has a historical reputation for its traditional use in alleviating distress and anxiety in both humans and animals. When combined with cyclodextrin, citronellal, a compound found in several *Cymbopogon* species, has shown the ability to suppress pain pathways and exhibit sustained antihyperalgesic effects. Additionally, the essential leaf oil from *C. winterianus* was discovered to possess antinociceptive properties by effectively inhibiting prostaglandin synthesis (Leite *et al.*, 2010; Katiki *et al.*, 2011; Tibenda *et al.*, 2022).

5.7 Antioxidant effect

Plants contain organic compounds known as phytochemicals, which not only serve as vital nutrients for life but also offer potential health benefits. Recent research has focused on the medicinal value of plant-based products, emphasizing the ability of phytochemical components to exert strong pathological and physiological effects on the human body, making them effective as medicine. Lemongrass is widely consumed worldwide due to its nutritional, medicinal, and cosmetic advantages. Previous studies on phytoconstituents have revealed that lemongrass contains active ingredients, deoxy sugars, tannins, phenols, saponins, phenolics, anthraquinones, and various essential oil constituents. Recent research has shed light on the fact that one of the primary causes of ageing and the development of diseases is cellular damage caused by free radicals. The body's primary defence against this is antioxidants, which protect against free radical damage and are considered essential for maintaining optimal health. Lemongrass is a rich source of phytochemicals and antioxidants. Similarly, another study reported that the total phenolic activity in lemongrass cold and hot filtrations ranged from 1.3 to 4.7 milligrams and from 2.6 to 7.3 milligrams of gallic acid equivalents (GAE)/g DW, respectively. The antioxidant capacity in both cold and hot filtrations ranged from 65.4 to 81.3%, and the total flavonoid concentration varied from 6.9 to 11.3 µg/g and from 6.9 to 12.9 µg/g QE on a dry weight basis for cold and hot filtrations, respectively (Leite *et al.,* 2010; Ahmad *et al.,* 2018; Sari *et al.*, 2017; Jummes *et al.,* 2020).

5.8 Anxiolytic effect

To investigate whether lemongrass tea is effective in treating anxiety-related syndromes, researchers have examined its anxiolytic properties. Previous studies had reported adverse effects of lemongrass tea extracts. However, earlier research indicated that lemongrass extracts and infusions, particularly lemongrass tea, may have calming effects when administered to animals. This was supported by the encouraging results of the bright or slightly shady box test. In this test, a biphasic dose-response relationship (U-curve) was observed, aligning with those extensively studied. The calming effects of the extract appeared to involve the GABAergic mechanism, like how effective anxiolytic drugs operate. These findings validate the traditional use of lemongrass extracts in treating central nervous system disorders (CNS). Researchers agree that, contrary to some beliefs in folk medicine, lemongrass tea is safe for use both at home and in other contexts (Hacke *et al.,* 2020; Mahabir and Gulliford, 1997; Ganjewala and Luthra, 2007).

5.9 Hypoglycaemic effect

Type I diabetes, also known as insulin-dependent or juvenile diabetes, and type II diabetes, which is non-insulin-dependent diabetes mellitus (NIDDM), are both chronic metabolic disorders. The catechins in lemongrass tea exhibit their survival mechanism by reducing enzymatic hydrolysis during consumption and subsequent duodenal digestion. Extracts from *Cymbopogon* herbs present a safer alternative to medications for controlling hyperglycemia (high blood glucose) and hypercholesterolemia. Research has shown that a fresh leaf water extract of lemongrass reduces plasma glucose levels, decreases triglycerides, lowers levels of lipoproteins (LDL), and reduces total cholesterol in normal mice. Additionally, it was observed that there was a dose-dependent increase in plasma high-density lipoprotein levels (HDL), with no apparent effects on plasma triglyceride levels (Adeneye *et al.,* 2007; Al-Ghamndi *et al*., 2007).

5.10 Cytotoxicity and mutagenicity effect

Numerous *in vivo* and *in vitro* studies have been conducted to assess the cytostatic and mutagenic effects of lemongrass extract, confirming the safety of lemongrass tea. None of the phenolic compounds isolated from methanolic plant extracts were found to be toxic to human lung cells, even at high concentrations. In another study, adult rats consumed lemongrass tea for 2 months, and neither the rats nor their offspring exhibited any harmful effects. Interestingly, rats consuming lemongrass extract, specifically myrcene, did not develop tolerance to it, as they did with the analgesic drug morphine. It is essential to consider these factors when conducting experiments, as it has been reported that a 5% ethanol extract can restore the integrity of stressed murine macrophages' mitochondria. Moreover, 80% ethanol-based lemongrass extracts did not exhibit mutagenic properties in a *Salmonella* mutation assessment. *S. typhimurium* strains TA98 and TA100 in the plant extract also demonstrated resistance to chemical alteration (Chiamenti *et al.,* 2019; Guandalini *et al.,* 2020; Kpoviessi *et al.,* 2014).

6. Perfumery and fragrances

According to various reports, lemongrass oil can be used to flavor wines, soups, desserts, spices, and tea leaves, as well as enhance the taste of certain fish. In Southeast Asian countries such as the Philippines, Taiwan, Malaysia, Thailand, and Pakistan, lemongrass is widely utilized as an edible herb due to its aromatic, lemon-like qualities. It can be consumed either fresh or in dried, powdered form. Despite its challenging texture, lemongrass rhizome can be incorporated into foods or used in seasoning rubs. The oil secretors in the pseudostem, containing the essential oils, are released when it is shaken or crushed. The popular *Cymbopogon* species are known for their high yield of aromatic essential oils, making them valuable in the perfume and fragrance industries. Java citronella oil, renowned for its natural fragrance, is used to extract aromatic compounds that are incorporated into various products for their distinctive scents. The primary source of lemongrass oil in Indian perfumery is *C. pendulus*. The *C. winterianus* oil is used in affordable products like sprays, cleaners, and polishes, adding a pleasant aroma. Due to its strong and long-lasting rose-like scent, also found in some oral fresheners, it is used in soaps, like palmarosa oil. Essential oils from *C. caesius*, *C. winterianus* (ginger grass, palmarosa, Java citronella), and other plants are used to fragrance shampoos and scented cosmetics. Commercially, essential oil from the *Cymbopogon* genus serves as a perfume ingredient and a soap fragrance, including palmarosa oil. Numerous proprietary formulas in the cosmetic industry incorporate components like glycerol, lemongrass, and lemon balm oil into lemongrass-based products. Lemongrass essential oil has been found to repel insects, making it a useful ingredient in insect-repellent ointments. Its antioxidant properties are highly beneficial to the cosmetic industry as they can help prevent various skin conditions related to oxidative stress. Similarly, this component can be used in antiageing creams because oxidative stress is linked to chronic progressive diseases that accelerate the ageing process (Santosa *et al.,* 2016; Wright *et al.,* 2008; Bhuyan *et al.,* 2015; Edris, 2007; Avoseh *et al.,* 2015).

7. Toxicological aspects of genus *Cymbopogon*

Variables to consider include soil pollution with heavy metals, potential interactions with medications involving *Cymbopogon*, and improper ingestion, all of which may lead to adverse effects. Citronella oil, derived from species such as *C. winterianus*, *C. nardus*, and *Cymbopogon validus*, is a component of insect repellents and is locally used to prevent mosquito bites, according to specific research. However, adverse effects have raised concerns among the public. These include reports of skin reactions or irritation, lung damage following inhalation, and cases of child poisoning after ingesting insect repellents containing citronella oil. There have been instances of toddlers becoming ill after consuming insect repellents containing citronella oil, reports of skin problems or itching upon direct skin contact, as well as toxic alveolitis resulting from inhalation, along with an increase in amylase and bilirubin levels. There are additional adverse effects associated with the use of lemongrass. Research indicates that while *C. citratus* volatile oil has a low level of toxicity and is suitable and safe for long-term use at levels up to 100 mg/kg, lemongrass is not recommended for use during pregnancy or nursing due to its potential to accelerate uterine contractions and menstruation, even though it is generally considered safe in the United States (Paviani *et al.*, 2006; Fernandes *et al.,* 2012; Han and Parker, 2017; Hacke *et al.,* 2020).

8. Discussion

The essential oil derived from the *Cymbopogon* genus, possesses a wide array of valuable properties. It is hailed for its potent antibacterial, antiviral, and anti-cold vaporizing capabilities. This essential oil is a versatile substance with diuretic, antispasmodic, tonic, and stimulating attributes, making it a popular choice for various purposes. Among its many applications, lemongrass oil is particularly beneficial for individuals experiencing urinary issues and is highly recommended for use in hot weather, as it aids in cooling the body and invigorating the mind and soul. It also offers relief from digestive discomfort, nausea, menstrual problems, and a range of ailments, including migraines, muscle pain, tremors, and rheumatism. This exceptional oil, primarily composed of citral and other components, is attributed with anticancer properties and has been linked to a reduced risk of various malignancies, either through its cancer cell elimination properties or its immune-boosting capabilities.

Numerous species within the *Cymbopogon* genus are recognized for their extensive medicinal and therapeutic qualities, which emanate from the essential oil and the entire plant. Most *Cymbopogon* species are considered safe for consumption, and they have been used for various applications beyond simple tea, beverages, or food flavoring. Medicinally, they are associated with a wide range of properties, such as antidyspeptic, anti-inflammatory, antipyretic, antiseptic, antispasmodic, analgesic, tranquilizing, antihermetic, and diuretic effects. While traditional dosages may not be standardized or scientifically endorsed, many cultures believe that consuming one cup of lemongrass tea daily can boost immunity.

However, lemongrass, citral, and its other constituents are not without their potential drawbacks. High doses of lemongrass may negatively affect taste and smell perception, while smaller amounts are thought to have more favorable effects. Research has shown that lemongrass essential oil concentrations in food products can range from 0.2 to 10 l/ml. Furthermore, excessive, and careless overuse of lemongrass essential oil (LEO) may lead to issues such as tumors, gene damage, and carcinogenic effects. There is a need for additional research to comprehensively understand the effects of lemongrass on various health concerns, as well as to establish safe dosage limits. Overstepping these limits may result in unwanted changes in the sensory qualities of food products, rendering them unappealing to consumers.

Despite its remarkable benefits, the use of essential oils, including lemongrass, for preserving food presents certain challenges. The advantages of food preservation, resistance to multi-resistant microbes, and improved sensory characteristics must be weighed against potential pitfalls. Customer satisfaction is paramount in this context, and ensuring that essential oils do not negatively impact the taste, odor, or safety of the final products is crucial. Moreover, the essential oil derived from lemongrass offers a myriad of health and therapeutic benefits, making it an asset for various applications. Its widespread use is supported by a wealth of research, and its positive attributes range from antibacterial and antiviral properties to anti-cold and diuretic effects. However, caution is required, as excessive use may lead to undesirable consequences. This exemplifies the complexity of incorporating essential oils into food preservation processes, where advantages and disadvantages must be meticulously weighed to ensure customer satisfaction and product safety.

9. Future perspectives

Cymbopogon species are diverse and versatile medicinal applications that primarily rely on essential oils rich in monoterpenes, sesquiterpenes, and fatty alcohols. Further research is imperative to expand on existing knowledge and unveil hidden potentials. Scientists should focus on harnessing natural substances for safer and more effective commercial products, reducing the need for harsh chemicals with adverse effects. Rigorous testing of drug dosage and administration will enhance pharmaceutical efficacy, benefiting health and well-being.

10. Conclusion

Cymbopogon, a versatile herb, serves as a flavouring, fragrance ingredient, and boasts various medicinal uses. It is employed as an anticonvulsant, antispasmodic, analgesic, and more, addressing ailments from anxiety to gastrointestinal issues. Rich in phytoconstituents like terpenoids, flavonoids, phenolic compounds, and essential oils, these constituents contribute to its unique properties. While specific bioactivities and mechanisms remain less explored, Cymbopogon's potential as a source for novel phytopharmaceuticals with therapeutic benefits is evident, warranting further research and development.

Conflict of interest

The authors declare no conflicts of interest relevant to this article.

Acknowledgements

The authors extend their sincere appreciation to the Honourable Chancellor of Integral University, Lucknow-226026, Uttar Pradesh, India, for generously providing research infrastructure. They also express their gratitude to the Dean, Faculty of Pharmacy at Integral University for providing the essential resources. Special thanks are extended to the R&D cell at Integral University for assigning the Manuscript communication number (IU/R&D/2022-MCN0001429).

References

Abdel-Moneim, F.M.; Ahmed, Z.F.; Fayez, M.B.E. and Ghaleb, H. (1969). Constituents of local plants. Planta Med., **17**(3):209-216.

Adeneye, A.A. and Agbaje, E.O. (2007). Hypoglycemic and hypolipidemic effects of fresh leaf aqueous extract of *Cymbopogon citratus* Stapf. in rats. J. Ethnopharmacol., **112**(3):440-444.

Ahmad, U.; Akhtar, J.; Singh, S.P.; Badruddeen, Ahmad, F.J.; Siddiqui, S. and Wahajuddin, (2018). Silymarin nanoemulsion against human hepatocellular carcinoma: Development and optimization. Artif. Cells. Nanomed. Biotechnol., **46**(2):231-241.

Aibinu, I.; Adenipekun, T.; Adelowotan, T.; Ogunsanya, T. and Odugbemi, T. (2007). Evaluation of the antimicrobial properties of different parts of *Citrus aurantifolia* (lime fruit) as used locally.; Afr. J. Tradit. Complement. Altern. Med., **4**(2):185-190.

Al-Ghamdi, S.S.; Al-Ghamdi, A.A. and Shammah, A.A. (2007). Inhibition of calcium oxalate nephrotoxicity with *Cymbopogon schoenanthus* (Al-Ethkher). Drug. Metab., **1**(4):241-244.

Alitonou, G.A.; Avlessi, F.; Sohounhloue, D.K.; Agnaniet, H.; Bessiere, J.M. and Menut, C. (2006). Investigations on the essential oil of *Cymbopogon giganteus* from Benin for its potential use as an anti-inflammatory agent. Int. J. Aromather., **16**(1):37-41.

Andila, P.S.; Hendra, I.P.A.; Wardani, P.K.; Tirta, I.G.; Sutomo, S. and Fardenan, D. (2018). The phytochemistry of *Cymbopogon winterianus* essential oil from Lombok Island, Indonesia and its antifungal activity against phytopathogenic fungi. Nus. Biosci., **10**(4):232-239.

Ansari, M.A. and Razdan, R.K. (1995). Relative efficacy of various oils in repelling mosquitoes. Indian J. Malariol., **32**(3):104-111.

Arrey, T.P.; Franzoi, K.D.; Lee, S.; Lee, E.; Vivarelli, D.; Freitas-Junior, L.; Liuzzi, M.; Nolé, T.; Ayong, L.S.; Agbor, G.A. and Okalebo, F.A. (2014). *In vitro* antiplasmodial activities and synergistic combinations of differential solvent extracts of the polyherbal product, Nefang. Biomed Res. Int., **2014**:1-10.

Bagheri, R.; Mohamadi, S.; Abkar, A. and Fazlollahi, A. (2007). Essential oil compositions of *Cymbopogon parkeri* STAPF from Iran. Pak. J. Biol. Sci.,**10**(19):3485-3486.

Bassolé, I.H.N.; Lamien-Meda, A.; Bayala, B.O.L.C.; Obame, L.C.; Ilboudo, A.J.; Franz, C.; Novak, J.; Nebié, R.C. and Dicko, M.H. (2011). Chemical composition and antimicrobial activity of *Cymbopogon citratus* and *Cymbopogon giganteus* essential oils alone and in combination. Phytomedicine, **18**(12):1070-1074.

Bayala, B.; Bassole, I.H.; Maqdasy, S.; Baron, S.; Simpore, J. and Lobaccaro, J.M.A. (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., **153**:162-170.

Bharti, S.K.; Kumar, A.; Prakash, O.; Krishnan, S. and Gupta, A.K. (2013). Essential oil of *Cymbopogon Citratus* against diabetes: Validation by *in vivo* experiments and computational studies. Bioanalysis and Biome-dicine, **5**(5):194-203

Bhuyan, P.D.; Tamuli, P. and Boruah, P. (2015). *In vitro* efficacy of certain essential oils and plant extracts against three major pathogens of *Jatropha curcas* L. American Journal of Plant Sciences, **6**(2):362-365.

Bidinotto, L.T.; Costa, C.A.; Salvadori, D.M.; Costa, M.; Rodrigues, M.A. and Barbisan, L.F. (2011). Protective effects of lemongrass (*Cymbopogon citratus* STAPF) essential oil on DNA damage and carcinogenesis in female Balb/C mice. J. Appl. Toxicol., **31**(6):536-544.

Blanco, M.M.; Costa, C.A.R.A.; Freire, A.O.; Santos Jr, J.G. and Costa, M. (2009). Neurobehavioral effect of essential oil of Cymbopogon citratus in mice. Phytomedicine, **16**(2-3):265-270.

Boukhatem, M.N.; Ferhat, M.A.; Kameli, A.; Saidi, F. and Kebir, H.T. (2014). Lemon grass (*Cymbopogon citratus*) essential oil as a potent anti-inflammatory and antifungal drugs. Libyan J. Med., **9**(1):1-10.

Bourgaud, F.; Gravot, A.; Milesi, S. and Gontier, E. (2001). Production of plant secondary metabolites: A historical perspective. Plant Sci., **161**(5):839-851.

Cardoso, J. and Soares, M.J. (2010). *In vitro* effects of citral on *Trypanosoma cruzi* metacyclogenesis. Memorias do Instituto Oswaldo Cruz, **105** (8):1026-1032.

Chagonda, L.S.; Makanda, C. and Chalchat, J.C. (2000). The essential oils of wild and cultivated *Cymbopogon validus* (Stapf) Stapf ex Burtt Davy and *Elionurus muticus* (Spreng.) Kunth from Zimbabwe. Flavour Fragr J., **15**(2):100-104.

Chiamenti, L.; Silva, F.P.D.; Schallemberger, K.; Demoliner, M.; Rigotto, C. and Fleck, J.D. (2019). Cytotoxicity and antiviral activity evaluation of *Cymbopogon* spp hydroethanolic extracts. Braz. J. Pharm. Sci., **55**:1-9.

Choudhury, S.N. and Leclercq, P.A. (1995). Essential oil of *Cymbopogon khasianus* (Munro ex Hack.) Bor from northeastern India. J. Essent. Oil Res., **7**(5):555-556.

Chowdhury, S.R.; Tandon, P.K. and Chowdhury, A.R. (2010). Chemical composition of the essential oil of *Cymbopogon flexuosus* (Steud) Wats. growing in Kumaon region. J. Essent. Oil-Bear. Plants., **13**(5):588-593.

Cunha, B.G.; Duque, C.; Caiaffa, K.S.; Massunari, L.; Catanoze, I.A.; Dos Santos, D.M.; de Oliveira, S.H.P. and Guiotti, A.M. (2020). Cytotoxicity and antimicrobial effects of citronella oil (*Cymbopogon nardus*) and commercial mouthwashes on *S. aureus* and *C. albicans* biofilms in prosthetic materials. Arch. Oral. Biol., **109**:104577.

Dagupen, M.K.T.; Januszewska, R.; Lino, L.L.; Tagarino, D.; Viaene, J.; Arguelles, R. and Bautista, R. (2009). Consumer behavior towards lemongrass (*Cymbopogon citratus*) tea in Benguet province, Northern Philippines. Int. J. Multidisip. Res., **6**(2):1-12.

De Blasi, V.; Debrot, S.; Menoud, P.A.; Gendre, L. and Schowing, J. (1990). Amoebicidal effect of essential oils *in vitro*. J. Toxicol. Clin. Exp., **10**(6):361-373.

de Cássia da Silveira e Sá, R.; Andrade, L.N. and de Sousa, D.P. (2013). A review on anti-inflammatory activity of monoterpenes. Molecules, **18**(1):1227-1254.

Deletre, E.; Chandre, F.; Williams, L.; Duménil, C.; Menut, C. and Martin, T. (2015). Electrophysiological and behavioral characterization of bioactive compounds of the *Thymus vulgaris, Cymbopogon winterianus, Cuminum cyminum* and *Cinnamomum zeylanicum* essential oils against *Anopheles gambiae* and prospects for their use as bednet treatments. Parasit. Vectors., **8**:1-14.

Desai, M.A. and Parikh, J. (2012). Microwave assisted extraction of essential oil from *Cymbopogon flexuosus* (Steud.) Wats.: A parametric and comparative study. Sep. Sci. Technol.; **47**(13):1963-1970.

Dubey, V.S.; Mallavarapu, G.R. and Luthra, R. (2000). Changes in the essential oil content and its composition during palmarosa (*Cymbopogon martinii* (Roxb.) Wats. var. *motia*) inflorescence development. Flavour Fragr J., **15**(5):309-314.

Dutta, S.; Munda, S.; Lal, M. and Bhattacharyya, P.R. (2016). A short review on chemical composition, therapeutic use, and enzyme inhibition activities of *Cymbopogon* species. Indian J. Sci. Technol., **9**(46):1-9.

Edris, A.E. (2007). Pharmaceutical and therapeutic potentials of essential oils and their individual volatile constituents: A review. Phytother. Res., **21**(4):308-323.

Ekpenyong, C.E.; Akpan, E. and Nyoh, A. (2015). Ethnopharmacology, phytochemistry, and biological activities of *Cymbopogon citratus* (DC.) Stapf extracts. Chin. J. Nat. Med., **13**(5):321-337.

EL-Kamali, H.H.; EL-Nour, R.O. and Khalid, S.A. (2010). Molluscicidal activity of the essential oils of *Cymbopogon nervatus* leaves and *Boswellia papyrifera* resins. Curr. Res. J. Biol., **2**(2):139-142.

Fernandes, C.N.; De Souza, H.F.; De Oliveria, G.; Costa, J.G.M.; Kerntop, M.R. and Campos, A.R. (2012). Investigation of the mechanisms underlying the gastroprotective effect of *Cymbopogon citratus* essential oil. J. Young. Pharm., **4**(1):28-32.

Figueirinha, A.; Paranhos, A.; Pérez-Alonso, J.J.; Santos-Buelga, C. and Batista, M.T. (2008). *Cymbopogon citratus* leaves: Characterization of flavonoids by HPLC-PDA-ESI/MS/MS and an approach to their potential as a source of bioactive polyphenols. Food Chem., **110**(3):718-728.

Francisco, V.; Figueirinha, A.; Neves, B.M.; García-Rodríguez, C.; Lopes, M.C.; Cruz, M.T. and Batista, M.T. (2011). *Cymbopogon citratus* as source of new and safe anti-inflammatory drugs: Bioguided assay using lipopolysaccharide-stimulated macrophages. J. Ethnopharmacol., **133**(2):818-827.

Ganjewala, D. and Luthra, R. (2007). Essential oil biosynthesis and metabolism of geranyl acetate and geraniol in developing *Cymbopogon flexuosus* (Nees ex Steud) Wats *mutant* cv. GRL-1 Leaf. Am. J. Plant. Physiol., **2**:269-275.

Ganjewala, D. and Luthra, R. (2007). Inhibitors of essential oil biosynthesis in *Cymbopogon flexuosus* Nees ex. Steud. mutant cv. GRL-1 leaves. Am. J. Plant. Physiol., **2**: 227-232.

Ganjewala, D.; Gupta, A.K. and Muhury, R. (2012). An update on bioactive potential of a monoterpene aldehyde citral. J. Biol. Act. Prod. Nat., **2**(4):186-199.

Gbenou, J.D.; Ahounou, J.F.; Akakpo, H.B.; Laleye, A.; Yayi, E.; Gbaguidi, F.; Baba-Moussa, L.; Darboux, R.; Dansou, P.; Moudachirou, M. and Kotchoni, S.O. (2013). Phytochemical composition of *Cymbopogon citratus* and *Eucalyptus citriodora* essential oils and their anti-inflammatory and analgesic properties on wistar rats. Mol. Biol. Rep., **40**:1127-1134.

Hacke, A.C.M.; Miyoshi, E.; Marques, J.A. and Pereira, R.P. (2020). Anxiolytic properties of *Cymbopogon citratus* (DC.) Stapf extract, essential oil and its constituents in zebrafish (*Danio rerio*). J. Ethnopharmacol., **260**:113036.

Han, X. and Parker, T.L. (2017). Lemongrass (*Cymbopogon flexuosus*) essential oil demonstrated anti-inflammatory effect in pre-inflamed human dermal fibroblasts. Biochim. Open., **4**:107-111.

Jirovetz, L.; Buchbauer, G.; Eller, G.; Ngassoum, M.B. and Maponmetsem, P.M. (2007). Composition and antimicrobial activity of *Cymbopogon giganteus* (Hochst.) Chiov. essential flower, leaf and stem oils from Cameroon. J. Essent. Oil. Res., **19**(5):485-489.

Jummes, B.; Sganzerla, W.G.; da Rosa, C.G.; Noronha, C.M.; Nunes, M.R.; Bertoldi, F.C. and Barreto, P.L.M. (2020). Antioxidant and antimicrobial poly-α-caprolactone nanoparticles loaded with *Cymbopogon martinii* essential oil. Biocatal. Agric. Biotechnol., **23**:101499.

Kanjilal, P.B.; Pathak, M.G.; Singh, R.S. and Ghosh, A.C. (1995). Volatile constituents of the essential oil of *Cymbopogon caesius* (Nees ex Hook, et Arn.) Stapf. J. Essent. Oil Res., **7**(4):437-439.

Karami, S.; Yargholi, A.; Sadati Lamardi, S.N.; Soleymani, S. and Shirbeigi, L. (2021). A review of ethnopharmacology, phytochemistry and pharmacology of *Cymbopogon* species. Res. J. Pharmacogn., **8**(3):83-112.

Katiki, L.M.; Chagas, ADS.; Bizzo, H.R.; Ferreira, J.F.S. and Amarante, A.F.T.D. (2011). Anthelmintic activity of *Cymbopogon martinii*, *Cymbopogon schoenanthus* and *Mentha piperita* essential oils evaluated in four different *in vitro* tests. Vet. Parasitol., **183**(1-2):103-108.

Ketoh, G.K.; Koumaglo, H.K.; Glitho, I.A. and Huignard, J. (2006). Comparative effects of *Cymbopogon schoenanthus* essential oil and piperitone on *Callosobruchus maculatus* development. Fitoterapia, **77**(7-8):506-510.

Khalid, M.; Alqarni, M.H.; Shoaib, A.; Wahab, S.; Foudah, A.I.; Aljarba, TM.; Akhtar, J.; Alamri, MA. and Ahmad, S. (2022). Antiobesity action of *Boerhavia diffusa* in rats against high-fat diet-induced obesity by blocking the cannabinoid Receptors. Plants, **11**(9):1158.

Khanuja, S.P.; Shasany, A.K.; Pawar, A.; Lal, R.K.; Darokar, M.P.; Naqvi, A.A.; Rajkumar, S.; Sundaresan, V.; Lal, N. and Kumar, S. (2005). Essential oil constituents and RAPD markers to establish species relationship in *Cymbopogon* Spreng. (Poaceae). Biochem. Syst. Ecol., **33**(2):171-186.

Khushtar, M.; Siddiqui, H.H.; Dixit, R.K.; Khan, M.S.; Iqbal, D. and Rahman, M.A. (2016). Amelioration of gastric ulcers using a hydroalcoholic extract, of Triphala in indomethacin-induced wistar rats. Eur. J. Integr. Med., **8**(4):546-551.

Kotb Elmahallawy, E. and Agil, A. (2015). Treatment of leishmaniasis: A review and assessment of recent research. Curr. Pharm. Des., **21**(17):2259-2275.

Kpoviessi, S.; Bero, J.; Agbani, P.; Gbaguidi, F.; Kpadonou-Kpoviessi, B.; Sinsin, B.; Accrombessi, G.; Frédérich, M.; Moudachirou, M. and Quetin-Leclercq, J. (2014). Chemical composition, cytotoxicity and *in vitro* anti-trypanosomal and antiplasmodial activity of the essential oils of four *Cymbopogon* species from Benin. J. Ethnopharmacol., **151**(1):652-659.

Kumar, A.; Akhtar, J.; Badruddeen.; Khan, M.I.; Ahmad, M. and Verma, N. (2023). Scrutinizing glycyrrhizin and its derivatives in the management of respiratory disorders including SARS-CoV (COVID-19). Ann. Phytomed., **12**(1): 23-30.

Kumar, R.; Usmani, S.; Singh, B.; Prakash, O.; Verma, P.; Wahab, S.; Khatoon, S. (2022). Comprehensive review on phytopharmacological perspectives of *Pithecellobium dulce* (Roxb.) Benth, **11**(1):115-120.

Leite, B.L.; Bonfim, R.R.; Antoniolli, A.R.; Thomazzi, S.M.; Araújo, A.A.; Blank, A.F.; Estevam, C.S.; Cambui, E.V.; Bonjardim, L.R.; Albuquerque Junior, R.L. and Quintans-Júnior, L.J. (2010). Assessment of antinociceptive, anti-inflammatory and antioxidant properties of *Cymbopogon winterianus* leaf essential oil. Pharm. Biol., **48**(10):1164-1169.

Lorenzetti, B.B.; Souza, G.E.; Sarti, S.J.; Santos Filho, D. and Ferreira, S.H. (1991). Myrcene mimics the peripheral analgesic activity of lemongrass tea. J. Ethnopharmacol., **34**(1):43-48.

Mahabir, D. and Gulliford, M.C. (1997). Use of medicinal plants for diabetes in Trinidad and Tobago. Rev. Panam. Salud Públ., **1**(3):174-179.

Makhaik, M.; Naik, S.N. and Tewary, D.K. (2005). Evaluation of anti-mosquito properties of essential oils. Journal of Scientific and Industerial Research, **64**:129-133.

Mathew, S.; Chittattu, G.J. and Thomas, J. (1996). OD-468-A lemongrass chemotype rich in geranyl acetate. Indian Perfumer, **40**(1):9-12.

Moreira, F.V.; Bastos, J.F.; Blank, A.F.; Alves, P.B. and Santos, M.R. (2010). Chemical composition and cardiovascular effects induced by the essential oil of *Cymbopogon citratus* DC. Stapf, Poaceae, in rats. Rev. Bras. Farmacogn., **20**:904-909.

Nath, S.C.; Sarma, K.K.; Vajezikova, I. and Leclercq, P.A. (2002). Comparison of volatile inflorescence oils and taxonomy of certain *Cymbopogon taxa* described as *Cymbopogon flexuosus* (Nees ex Steud.) Wats. Biochem. Syst. Ecol., **30**(2):151-162.

Negrelle, R.R.B. and Gomes, E.C. (2007). *Cymbopogon citratus* (DC.) Stapf: chemical composition and biological activities. Rev. Bras. Pl. Med., **9**(1):80-92.

Nguefack, J.; Tamgue, O.; Dongmo, J.L.; Dakole, C.D.; Leth, V.; Vismer, H.F.; Zollo, P.A. and Nkengfack, A.E. (2012). Synergistic action between fractions of essential oils from *Cymbopogon citratus*, *Ocimum gratissimum* and Thymus vulgaris against *Penicillium expansum*. Food Control, **23**(2):377-383.

Noor, S.; Latip, H.; Lakim, M.Z.; Syahirah, A. and Bakar, A. (2012). The potential of Citronella grass, *Cymbopogon nardus* as biopesticide against plutella xylostella. In: Proceedings of the UMT 11th International Annual Symposium on Sustainability Science and Management, Kuala Terengganu, Malaysia, **911**:190193.

Padalia, R.C.; Verma, R.S.; Chanotiya, C.S. and Yadav, A. (2011). Chemical fingerprinting of the fragrance volatiles of nineteen Indian cultivars of *Cymbopogon* Spreng. (Poaceae). Rec. Nat. Prod., **5**(4):290.

Paviani, L.; Pergher, S.B.C. and Dariva, C. (2006). Application of molecular sieves in the fractionation of lemongrass oil from high-pressure carbon dioxide extraction. Braz. J. Chem. Eng., **23**:219-225.

Pereira, G.L.D.C.; Almeida, T.C.; Seibert, J.B.; Amparo, T.R.; Soares, R.D.D.O.A.; Rodrigues, I.V.; Bianco de Souza, G.H.; Dos Santos, O.D.H. and da Silva, G.N. (2021). Antitumor effect of *Cymbopogon densiflorus* (Linneu) essential oil in bladder cancer cells. Nat. Prod. Res., **35**(23):5238-5242.

Phillips, S.M. and Zhen-Lan, W. (2005). Notes on grasses (Poaceae) for the flora of China, VI. New combinations in Stipeae and Anthoxanthum. Novon., pp:474-476.

Prasad, C.; Singh, D.; Shukla, O. and Singh, U.B. (2014). *Cymbopogon jwarancusa*: An important medicinal plant: A review. Pharma Innov., **3**(6):13.

Puatanachokchai, R.; Kishida, H.; Denda, A.; Murata, N.; Konishi, Y.; Vinitketkumnuen, U. and Nakae, D. (2002). Inhibitory effects of lemon grass (*Cymbopogon citratus*, Stapf) extract on the early phase of hepatocarcinogenesis after initiation with diethylnitrosamine in male Fischer 344 rats. Cancer Letters, **183**(1):9-15.

Quintans-Júnior, L.J.; Souza, T.T.; Leite, B.S.; Lessa, N.M.N.; Bonjardim, L.R.; Santos, M.R.V.; Alves, P.B.; Blank, A.F. and Antoniolli, A.R. (2008). Phythochemical screening and anticonvulsant activity of *Cymbopogon winterianus* Jowitt (Poaceae) leaf essential oil in rodents. Phytomedicine, **15**(8):619-624.

Ruphin, F.P.; Barthelemy, F.; Guy, R.; Oscar, R.A.; Adolphe, R.; Charles, A.; Marchioni, E.; Baholy, R. and Marcelin, S. (2016). Vasodilator effects of *Cymbopogon pruinosus* (Poaceae) from Madagascar on isolated rat thoracic aorta and structural elucidation of its two bioactive compounds. J. Pharmacogn. Phytochem., **5**(1):46-55.

Saeed, T.; Sandra, P.J. and Verzele, M.J. (1978). Constituents of the essential oil of *Cymbopogon jawarancusa*. Phytochemistry, **17**(8):1433-1434.

Samreeen, S. and Ahmad, Z.I. (2022). A review on phytochemistry, pharmacology and ethnobotanical uses of *Cichorium intybus* L. Ann. Phytomed., **11**(1):99-114.

Santin, M.R.; dos Santos, A.O.; Nakamura, C.V.; Dias Filho, B.P.; Ferreira, I.C.P. and Ueda-Nakamura, T. (2009). *In vitro* activity of the essential oil of *Cymbopogon citratus* and its major component (Citral) on *Leishmania amazonensis*. Parasitol. Res., **105**:1489-1496.

Santos, P.L.; Brito, R.G.; Oliveira, M.A.; Quintans, J.S.; Guimaraes, A.G.; Santos, M.R.; Menezes, P.P.; Serafini, M.R.; Menezes, I.R.; Coutinho, H.D. and Araujo, A.A. (2016). Docking, characterization, and investigation of α-cyclodextrin complexed with citronellal, a monoterpene present in the essential oil of *Cymbopogon* species, as an anti-hyperalgesic agent in chronic muscle pain model. Phytomedicine, **23**(9):948-957.

Sari, D.M.; Lestarisa, T.; Alexandra, F.D.; Jelita, H. and Thalib, I. (2017). Antioxidant and anti-glycation activity of ethanol lemongrass (*Cymbopogon citratus*) leaves extract. Int. J. Pharmacogn. Phytochem. Res., **9**(5):710-715.

Shah, G.; Shri, R.; Panchal, V.; Sharma, N.; Singh, B. and Mann, A.S. (2011). Scientific basis for the therapeutic use of *Cymbopogon citratus*, Stapf (Lemon grass). J. Adv. Pharm. Technol. Res., **2**(1):3.

Sharma, P.R.; Mondhe, D.M.; Muthiah, S.; Pal, H.C.; Shahi, A.K.; Saxena, A.K. and Qazi, G.N. (2009). Anticancer activity of an essential oil from *Cymbopogon flexuosus*. Chem. Biol. Interact., **179**(2-3):160-168.

Sharma, R.; Rao, R.; Kumar, S.; Mahant, S. and Khatkar, S. (2019). Therapeutic potential of citronella essential oil: A review. Curr. Drug Discov. Technol., **16** (4):330-339.

Soenarko, S. (1977). The genus *Cymbopogon* Sprengel (Gramineae). Reinwardtia, **9**(3):225-375.

Takaisi-Kikuni, N.B.; Tshilanda, D. and Babady, B. (2000). Antibacterial activity of the essential oil of *Cymbopogon densiflorus*. Fitoterapia, **71**(1):69-71.

Tavares, F.; Costa, G.; Francisco, V.; Liberal, J.; Figueirinha, A.; Lopes, MC.; Cruz, M.T. and Batista, M.T. (2015). *Cymbopogon citratus* industrial waste as a potential source of bioactive compounds. J. Sci. Food Agric, **95**(13):2652-2659.

Tchoumbougnang, F.; Zollo, PA.; Dagne, E. and Mekonnen, Y. (2005). *In vivo* antimalarial activity of essential oils from *Cymbopogon citratus* and *Ocimum gratissimum* on mice infected with *Plasmodium berghei*. Planta Medica, **71**(1):20-23.

Thakker, M.R.; Parikh, J.K. and Desai, M.A. (2016). Isolation of essential oil from the leaves of *Cymbopogon martinii* using hydrodistillation: effect on yield of essential oil, yield of geraniol and antimicrobial activity. J. Essent. Oil-Bear. Plants., **19**(8):1943-1956.

Tibenda, J.J.; Yi, Q.; Wang, X. and Zhao, Q. (2022). Review of phytomedicine, phytochemistry, ethnopharmacology, toxicology, and pharmacological activities of *Cymbopogon* genus. Front. Pharmacol., **13**:997918.

Toungos, M.D. (2019). Lemongrass (*Cymbopogon* Spreng) valuable grass but underutilized in Northern Nigeria.Int. J. Innov. Food Nutr. Sustain. Agric., **7**(2):6-14.

Tovar, L.P.; Pinto, G.M.; Wolf-Maciel, M.R.; Batistella, C.B. and Maciel-Filho, R. (2011). Short-path-distillation process of lemongrass essential oil: Physicochemical characterization and assessment quality of the distillate and the residue products. Ind. Eng. Chem. Res., **50** (13):8185-8194.

Velnar, T.; Bailey, T. and Smrkolj, V. (2009). The wound healing process: an overview of the cellular and molecular mechanisms. J. Int. Med. Res., **37**(5):1528-1542.

Verpoorte, R. and Memelink, J. (2002). Engineering secondary metabolite production in plants. Curr. Opin. Biotechnol., **13**(2):181-187.

Wang, X.; Tang, Y.; Xie, N.; Bai, J.; Jiang, S.; Zhang, Y.; Hou, Y. and Meng, X. (2022). Salidroside, a phenyl ethanol glycoside from *Rhodiola crenulata*, orchestrates hypoxic mitochondrial dynamics homeostasis by stimulating Sirt1/p53/Drp1 signaling. J. Ethnopharmacol., **293**:115278.

Wany, A.; Jha, S.; Nigam, V.K. and Pandey, D.M. (2013). Chemical analysis and therapeutic uses of citronella oil from *Cymbopogon winterianus*: A short review. Int. J. Adv. Res., **1**(6):504-521.

Wei, L.S. and Wee, W. (2013). Chemical composition and antimicrobial activity of *Cymbopogon nardus* citronella essential oil against systemic bacteria of aquatic animals. Iran. J. Microbiol., **5**(2):147.

Wright, S.C.; Maree, J.E. and Sibanyoni, M. (2009). Treatment of oral thrush in HIV/AIDS patients with lemon juice and lemon grass (*Cymbopogon citratus*) and gentian violet. Phytomedicine, **16**(2-3):118-124.

Zahra, A.A.; Hartati, R.; Fidrianny, I. (2020). Review of the chemical properties, pharmacological properties, and development studies of cymbopogon sp. Biointerface Res. Appl. Chem., **11**(3):10341-50.

Zhang, J.S.; Zhao, N.N.; Liu, Q.Z.; Liu, Z.L.; Du, S.S.; Zhou, L. and Deng, Z.W. (2011). Repellent constituents of essential oil of *Cymbopogon distans* aerial parts against two stored-product insects. Journal of Agricultural and Food Chemistry, **59**(18):9910-9915.

Citation **Gayyur Fatima, Mohammad Irfan Khan, Mohammad Ahmad, Badruddeen, Juber Akhtar, Manvi and Andleeb Khan (2023). An updated review on the phytsspharmacological significance of genus Cymbopogon Ann. Phytomed., 12(2):346-359. http://dx.doi.org/10.54085/ap.2023.12.2.44.**