

Phytochemical Contents of Essential Oils from *Cymbopogon* Species: A Tropical Medicinal Plant

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Abstract

Natural resources especially medicinal plants possess the potentials to sustain all existence on earth. *Cymbopogon*, a globally cultivated herb, possesses high contents of diverse essential oils for medicinal and economic purposes including treatment of malaria and candidiasis. Notable species include *Cymbopogon citratus* and *C. flexosus* having citral as the main chemical compound. Numerous compounds of these species include limonene, citronella, geranyl acetic derivatives, elemol, among others. Phytochemical analysis of these essential oils is usually done by the gas chromatography-mass spectrometry (GC-MS) method sequel to obtaining them through solvent extraction, hydrodistillation, supercritical CO₂ extraction, chromatography among others. Although the supercritical CO₂ extraction method gives greater quality yields void of toxic wastes with preserved thermal stability compared with other methods, its high-working pressure generates issues of safety risks and costs. Quantitative determination is done using spectrophotometric, chromatographic, and Folin-Ciocalteu methods. In comparison with other chromatographic techniques employed, gas chromatography exhibits greater efficiency by quantifying and determining the presence of various components at low concentrations. This prominently economical plant with potent ethnobotanical benefits hinged on the essential oils phytochemicals is faced with diverse extraction challenges; thus, improvement in the extraction and quantification techniques is key to the harvest of pure yields of lemon grass essential oils.

Keywords

- Cymbopogon
- essential oils
- phytochemicals
- plants
- extraction
- chromatography

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1. Introduction

Medicinal plants play an important role in a healthy society. Restoration of practices and knowledge related to medicinal plant resources is part of an important strategy related to biodiversity conservation, knowledge of new drugs and improving the living standards of rural populations [1]. The Gramineae family includes the genus *Cymbopogon*, which encapsulates herbs that are globally recognized for possessing high essential oil content. Its species are broadly distributed across the globe where they are utilized for diverse purposes. Both the commercial and medicinal uses of its differential species have been well authenticated [2].

Additionally, the ethnopharmacology corroboration reveals the presence of an expansive array of properties possessed by these species, which establishes their utilization for pest control for cosmetics and anti-inflammatory media. Species of *Cymbopogon* may also envelope potentials as potent antitumor and chemopreventive drugs [3]. *Cymbopogon flexuosus* and *Cymbopogon citratus* are the two main species vastly farmed for their essential oils in various parts of the world [4]. It is cultivated in the subtropical and tropical regions of the world and widely used in the agriculture, cosmetics, flavor, food, pharmaceutical industries [1]. It is a member of the aromatic grasses containing essential oils with lemon flavor. Its species are tufted perennial C4 grasses with several hard stems emerging from a short, rhizomatous base [5] with a citrus flavor, dried to powder or freshly used. The name *Cymbopogon* is derived from the Greek words “kymbe” (boat) and “pogon” (beard), referring to the flower spike arrangement [5]. The species *C. citratus* is identified by many international common names, such as West Indian lemon grass or lemon grass (English), citronelle or verveine des indes (French), hierba limon or zacate de limón (Spanish), xiang mao (Chinese), capimcidrao, or capim-santo (Portuguese), and locally, there are more than 28 indigenous names identified from different countries of the world [4]. Other common names of *C. citratus* include lemongrass, barbed wire grass, citronella grass, fever grass, and tanglad [6]. *C. citratus* thrives best in sunny, warm, humid conditions of the tropics and grown in a wide range of soil types, from rich loam to poor laterite. Although calcareous and water-logged soils adversely affect growth [7], those cultivated on sandy soils have higher leaf oil yields and higher citral content [8]. *C. citratus* is believed to have originated from Malaysia, and it is now widely grown in Central and South America, regions in Africa, Southeast Asia, and the Indian Ocean Islands, both on subsistence and commercial scales particularly in South-east Asia. It is an aromatic, evergreen, perennial grass that produces multiple stiff stems emerging from a short rhizome-like rootstock and grows to approximately 1.5 m tall. Although it rarely produces florets, the leaflets are blue-green, erect, and linear and exude a characteristic lemon flavor when crushed [9]. The *C. citratus* is positioned as one of the most globally distributed genera that are usually utilized in all parts of the globe [3]. The plant, which can be dried and powdered, or used fresh, has been employed in diverse activities that include food flavoring, in teas, soups, with poultry, fish, beef, seafood, and curries. Reports have validated its global diverse health benefits, including the fact that lemongrass leaves and other parts can be infused to treat nausea, stomach aches, constipation, and a variety of stomach infections as well as to prevent ulcers [4]. *C. flexuosus* (Poaceae) is described as a native, tall perennial aromatic grass (sweet smelling sedge) with growth confined to specific patches of subtropical parts of Asia, Africa, and America. *Cymbopogon flexuosus*, also known as the Cochin or Malabar grass, is native to Sri Lanka, India, Thailand, and Burma. It is naturalized in numerous parts of the tropical and subtropical Southeast Asia and Africa [10, 11]. Consequently, it has received significant global demand due its varied range of applications in differential industries. Reports reveal that *Cymbopogon flexuosus* include more than 140 with 52 of them growing in Africa, 45 in India, 6 in Australia, 6 in South America, 4 in Europe (only in Montenegro), 2 in North America, and the others in South Asia. It is utilized as a medicinal tea, in preparation of soups, curries, and starting agent for vitamin A synthesis and has been known to be both perfumery and flavorful with the therapeutic characteristics [10]. *C. flexuosus* is a C4 grass endowed with industrial importance and abundant medicinal properties, and utilized for its essential oil (EO) production [11]. India is a significant exporter and the major producer of lemongrass oil. The essential oil comprises citral (i.e., a mixture of neral and geranial), geraniol, limonene, and geranyl acetate among others and is well-recognized for their antimicrobial, anticancer, and allelopathic activities [11, 12]. These essential oils are employed in the production of eco-friendly pesticides [3, 11]. In addition, lemongrass is an important source of several vitamins (A, B1, B2, B3, B5, B6, folate, and vitamin C) and essential minerals (calcium, copper, iron, magnesium, manganese, potassium, phosphorous, zinc) [11]. The above-listed properties cause lemongrass to be an industrially preferred crop due to its enormous potential in the fields of medicine, cosmetics, food, and biotechnology [13]. In furtherance, a couple of studies published that lemongrass essential oil can be utilized as biofuel; thus, it is regarded as an energy grass [14].

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2. Phytochemicals of essential oils of *Cymbopogon* species

The essential oils of *Cymbopogon* are identified by monoterpene constituents including citral, limonene, geraniol, citronellol, elemol, b-carophyllene, citronellal, 1,8 cineole, linalool, methylheptenone, geranylformate, and geranyl acetic acid derivation. Essential oils are typically chemically characterized by GC-MS [1, 15, 16, 17]. The plant *C. citratus* is abundant in bioactive substances. Flavonoids, alkaloids, saponins, tannins, and phenolic compounds, such as quercetin, luteolin, apiginin, isoorientin 2'-O-rhamnoside, and kaempferol, have been isolated and identified from the plant's leaves [18, 19]. These phytochemicals have been reported to be beneficial, especially in the pharmaceutical, food, health, and agricultural industries [20, 21]. Alcohols, aldehyde, ketones, esters, and terpenes are predominantly the other compounds found in *C. citratus* [20]. It also consists of 1–2 percent essential oil on a dry basis with the chemical composition varying greatly depending on the habitat, genetic diversity, and agricultural treatment of the crops. Longifolene (V4) (56.67%) and selina-6-en-4-ol (20.03%) are the constituents of volatile oil from the roots [22]. Although the primary chemical constituent of lemongrass essential oil is citral, borneol, geraniol, geraniol, β -myrcene, limonene, neral, geranyl acetate, alpha-terpenol, estragole, methyleugenol, citronellal, careen-2, farnesol, (+)-cymbodiactal, proximadiol, methyl heptenone, terpinolene, pinene, linalool, linalyl acetate, and β -caryophyllene have also been reported [5, 22]. Citral (3, 7-dimethyl-2, 6-octadien-2-al) refers to the natural mixture of two isomeric acyclic monoterpene aldehydes, that is, geraniol (citral A or trans citral) and neral (citral B or cis-citral) [20], which have same molecular formula ($C_{10}H_{16}O$) but different structures [23, 24, 25, 26]. The various components of *C. flexuosus* are significantly recognized due to the high concentration of aromatic essential oil, which contain many secondary metabolites, particularly monoterpenes (citral) and sesquiterpenes (caryophyllene) [11, 27]. Lemongrass is used in a variety of traditional Asian dishes and beverages, and also in high-end perfumes, pharmaceuticals, and biomedical applications [28]. The antibacterial, insecticide, larvicide, antitumoral, and cytotoxic characteristics of *C. flexuosus*' essential oil make it popular in alternative medicine [20]. The main constituents of the essential oil of *C. flexuosus* are Z-citral (-citral), geraniol, and -geraniol (-citral), with citral contributing significantly to the oil's antibacterial properties.

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3. Economic importance of essential oils of *Cymbopogon*

C. citratus Stapf. (lemongrass) is a spice commonly used in tropical regions, particularly in Southeast Asia. The primary compounds identified in *C. citratus* essential oil include α -citral, β -citral, geraniol, nerol, citronellal, myrcene, terpinolene, geranyl acetate, and terpinol methylheptenone. Terpenes, alcohols, ketones, and certain flavonoids and phenolics have also found in the plant [29]. Scientific research has described the antibacterial, anticarcinogenic, anti-inflammatory, antifungal, antioxidant, antiprotozoal, antirheumatic and cardioprotective effects of *C. citratus* [30, 31, 32]. It has shown a marked suppression of fungal infections including athlete's foot, itching, ringworm, and yeast infections and has a synergistic effect by suppressing the growth of filamentous fungi by inactivating yeast cells [6, 33]. Citral, myrcene, and citronellal are secondary metabolites that have been isolated from lemongrass and characterized as antimalarials. They showed remarkable activity against *Plasmodium* sp. [34]. In HIV/AIDS patients, oral candidiasis brought on by *Candida albicans* has been demonstrated to be successfully treated with lemongrass essential oil in 1 to 5 days [35].

LCEO's pharmaceutical potential has been reported in rodents in a well-designed trial involving oral administration of EO's key ingredient, citral, in combination with the nonsteroidal anti-inflammatory drug naproxen to experimental rats. The combination of naproxen and citral showed comparable anti-inflammatory effects compared with naproxen alone, but with much less stomach adverse effects [36]. Citral from *C. citratus* is used as an additive in creams and ointments to treat local inflammation as it significantly inhibits inflammatory mediators. It has also been shown to inhibit neutrophil attachment generated by tumor necrosis factor (TNF)- α at a dose of 0.1% and lipopolysaccharide (LPS)-induced nitric oxide synthase (iNOS) and monooxidation-induced signaling pathways co-bind to receptors, thereby blocking the nuclear factor Kappa B (NF κ B) pathway, COX2 and peroxisome proliferators. It suppresses activated receptor alpha (PPAR α) by 60–70% and inhibits oral and tissue inflammation [6].

It has been reported to inhibit platelet composition and treat anxiety, gastrointestinal infections, diabetes, malaria, and pneumonia [25]. Tea made from lemongrass essential oil has been proven to have sedative, analgesic, anti-inflammatory, antipyretic, and antispasmodic properties. It has also been used as massage oil for relief of joint and muscle pain [37]. Diarrhea, stomach aches, and digestive issues can all be treated with lemongrass tea [38]. Lipid-lowering and hypoglycemic drugs may also contain lemongrass. In folk remedies and Ayurvedic medicines, it is used to control serum glucose, fat, and lipid levels and prevent obesity and high blood pressure. This plant has been used to keep blood sugar levels stable by secreting insulin (hyperinsulinemia). It lowers blood pressure that may result in hypertension [5]. It has been reported that citral (geraniol and neral), the main constituent of *C. citratus* essential oil, is cytotoxic to a number of human leukemia cell lines. This occurs by the activation of procaspase 3. It has also been proven to inhibit the proliferation of pathogenic food-borne bacteria including *Listeria monocytogenes* and *Salmonella* Typhimurium [4].

Essential oils from *C. citratus* have been used to control infections and insects. It is efficient against *Aedes aegypti*, *Phenacoccus solenopsis*, *Dermatophagoides* sp., and *Musca domestica*. *C. citratus* is used in herbal soaps to cure swelling, itching skin, and rashes [6]. It has also been demonstrated that lemongrass essential oil inhibits *Microsporum canis*. Shampoos containing citral were efficient against *Malassezia furfur*, a fungus found in dandruff [39]. Lemongrass essential oil has been noted to exhibit considerable resistance to pathogenic fungi that interfere with the release of mycotoxins during preservation of grains and other food products [40]. *Cymbopogon* is a common herb in tropical regions [30]. It is frequently used as a food ingredient for human consumption. Lemongrass is frequently used in Asian cuisine for its aroma. Industrially, they are important as part of beverages, baked goods, fragrances, pesticides, and preservatives [6, 41]. They can serve as deodorants for perfumes, local samples, candle repellents, and other insect repellents. It has been used as a repellent against snakes and other reptiles in some Asian and African countries [42, 43]. The potential of lemongrass as an effective substitute to antibiotic growth promoters was evaluated [44].

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