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Review Article

An Update on Pharmacological activities of herbal plant *Cymbopogon citratus*

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Abstract

Herbs and other natural plant products have medical significance because of the phytochemical components in them that have specific physiological or pathological effects on the human body. Lemon grass, also known as citronella grass, is a member of the Poaceae family and is a member of the *Cymbopogon* genus. The word "Cymbopogon" is derived from the Greek word "Kymbe-Pogon," which means "boat-beard." In tropical nations, particularly in Southeast Asia, the herb *Cymbopogon citratus*, Stapf (lemon grass), is widely used. Due to the substantial amount of citral in its oil, this grass has a distinct lemon scent, which is one of its distinguishing characteristics. According to studies on its phytoconstituents, the herb contains tannins, saponins, flavonoids, phenols, anthraquinones, alkaloids, deoxysugars, and a variety of essential oil constituents. The nutritional, therapeutic, and cosmetic properties of C. citratus have made it a widely consumed plant around the world. However, research indicates that other species might be useful pharmaceutically. *Cymbopogon citratus* is intensively studied for its pharmacological effects.

Keywords: Lemongrass, *Cymbopogon citratus*, phytochemical, physiological, pathological, pharmacological effects.

Introduction:

Medical herbs have become an important part of the global health system for both humans and animals, serving as possible materials for preserving good health as well as a source of therapeutic help in disease[1]. Throughout human history, plants have served a variety of functions[2]. In order to prevent and treat illnesses, as well as to promote health and healing, medicinal plants are studied and used in herbal remedies. It is a substance or preparation made from a plant or plants that is used for any of these goals. The earliest type of medical treatment that humans have ever used is herbal medicine. There are various medications on the market that promise to treat the signs of a variety of issues, from depression to the common cold and flu[3]. Lemongrass and citronella grass are common names for the *Cymbopogon citrates* staff. This species is a member of the Poaceae family, which consists of about 500 genera and 8,000 plant species[4]. It is a tall, perennial grass with fragrant, fibrous roots and rhizomes that has medicinal properties. It belongs to the Poaceae family, which is well-known for producing a lot of oil. Dense clusters of green, slightly leathery leaves arise from short underground stems[5]. The monoterpene-rich essential oils produced by Cymbopogon species include citral, citronellal, citronellol, linalool, elemol, 1,8-cineole, limonene, geraniol, -carophyllene, methyl heptenone, and geranyl acetate and formate[6]. This review article includes information on earlier studies on the phytochemical and pharmacological properties of lemongrass.

Taxonomical Classification:

Kingdom: Plantae

Division: Magnoliophyta

Class: Liliopsida

Order: Poles

Family: Poaceae

Genus: Cymbopogon

Species: citrates

Common names:

Table 1: Various common names of lemon grass:

Brazil	Capim-cidrao, Capim-santo
Egypt	Lemon grass
English	Lemongrass, Citronella, Squinant
Ethiopia	Tej-sar
Hindi	Sera, Verveine
Indonesian	Sereh
Italian	Cimbopogone
Malaysia	Sakumau
Mexico	Zacate limon
Swedish	Citrongräss
Thailand	Ta-khrai
Turkish	Limon out
USA	Citronella

Parts Used:

Leaves and whole plant.

Figure 1: Lemon grass

Synonyms(s):

Lemon grass stalk, Andropogon citratus .

Botanical Description:

Lemon grass is a monocotyledonous perennial grass that can reach heights of 6 feet and widths of 4 feet. It develops in clumps[7].

Morphological description of *Cymbopogon citratus:*

Leaves: The gently drooping tips of the strap-like leaves are 0.5-1in (1.3-2.5 cm) wide and roughly 3 ft (0.9 m) long. The vivid bluish-green, evergreen leaves have a citrus scent when crushed. Leaf arrangement: most emerge from the soil, usually without a stem, Leaf type: simple, Leaf margin: entire, Leaf shape: linear, Leaf venation: parallel, Leaf type and persistence: fragrant, Leaf blade length: 18–36 in, Leaf color: green, Fall characteristic: showy.

Flowers: The lemongrass plants you will probably come across are cultivars, and they rarely generate floral panicles or do not normally produce blooms.

Inflorescences: Inflorescences are paired racemes of spikelets that are subtended by spathes and are 30–60 cm long and nodding[8].

Phytochemical Constituents:

According to the region of origin, the chemical makeup of Cymbopogon citratus essential oil differs. Compounds including hydrocarbon terpenes, alcohols, ketones, esters, and primarily aldehydes have been consistently recorded. Citral makes up the majority of the essential oil, which is 0.2-0.5% of the West Indian lemon grass oil. When two stereoisomeric monterpene aldehydes are combined to form citral, the trans isomer geranial (40–62%) predominates over the cis isomer neral (25–38%). Chemical composition of the primary components in lemongrass essential oil[8]. Besides these variations, numerous types of chemicals, including as tannins, saponins, flavonoids, alkaloid phenols, and anthraquinones, can be consistently detected. The essential oil contains several components that have not yet been discovered, such as citral, myrcene, geranial, geraniol, limonene, burneol, citronello, nerol, neral, terpineol, elemicin, caffeic acid, apigenin, luteolin, kaempferol, quercetin, chlorogenic acid, and geranyl acetate[9].

Flavanoids: luteolin 7-O-glucoside (cynaroside), isoscoparin, quercetin, kaempferol, isolated elimicin, catechol, chlorogenic acid, caffeic acid and hydroquinone, eugenol, and eugenol methylether**.**

Mineral content: Potassium (K), sodium (Na), magnesium (Mg), man- ganese (Mg), iron (Fe), zinc (Zn), phytate and phosphorus (P), Calcium to Phytate (0.05), Phytate to Zinc (9.6).

Terpenoids: Cymbopogonol and cymbopogone.

Proximate analysis: Crude fiber (9.28%), crude fat, crude ash, crude protein and 5% carbohydrate.

Essential oil: Mycrene, genariol, citronellol, αoxobisabolene, neointermediol (7.2%), selina- 6-en-4-ol (27.8%), α cadinol (8.2%), methyheptenone (1.2%), decanal (0.25%) and naphtalene (0.79%), β-eudesmol (45%), cubebol (4.7%), humulene (4%), sabinene, geranyl acetate, citronella, mentha-1(7), limonene (19.33%), mentha-1(7),8-dien-2-ol trans.

Tannins: Prothocyanidins, C. citratus from Nigeria showed about 0.6% of tannins.

Alkaloids: Contain about 0.52% alkaloids from 300 g plant material[8].

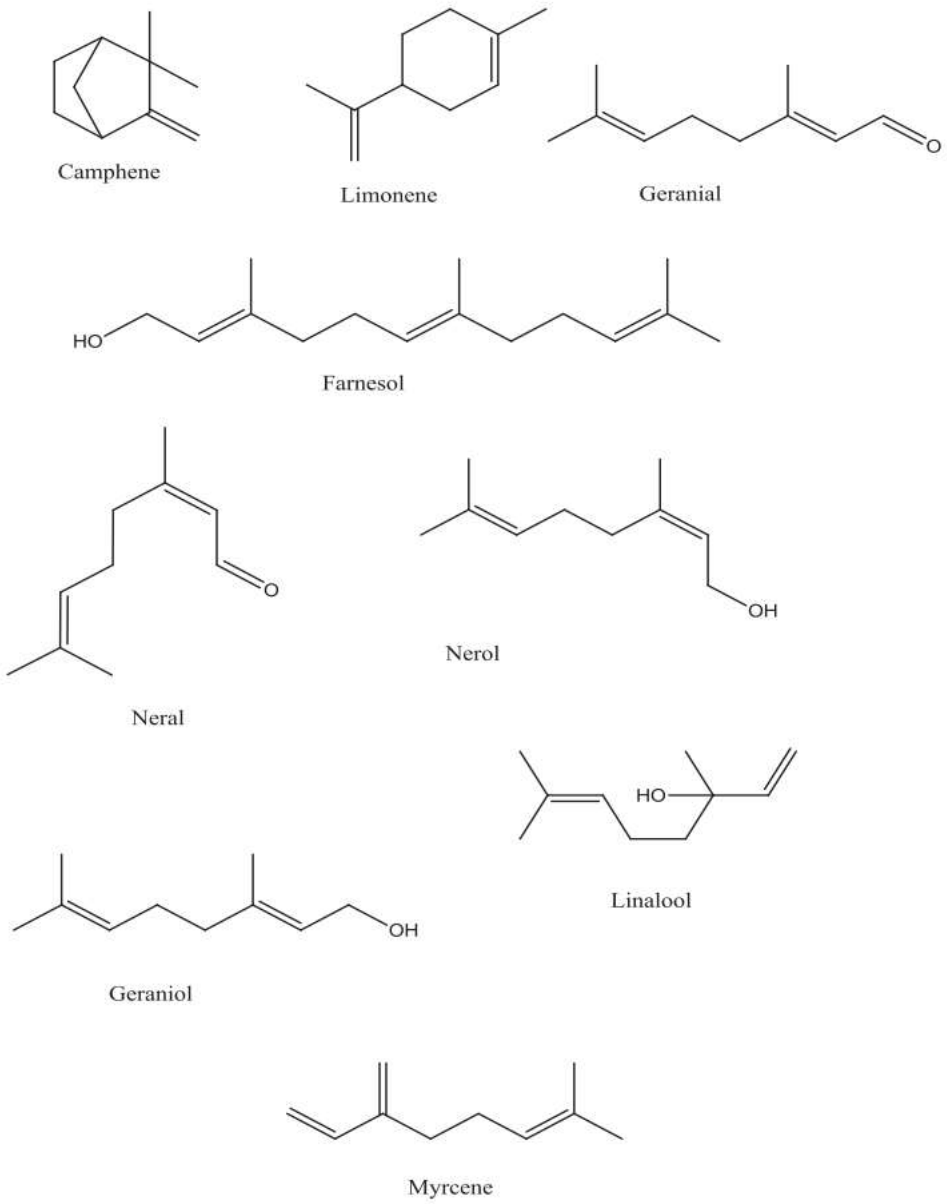

Figure 2: Chemical structures of important constituents of lemongrass essential oil[10]

Lemongrass oil extraction:

Flowers, herbs, trees, and a variety of other plant materials are used to make essential oils. A variety of chemical substances can be found in these oils. The primary chemical component of such essential oils is terpenes linked to aldehydes, alcohols, and ketones. Citronella oil has uses in the pharmaceutical business in addition to being used to make fragrances, soaps, cosmetics, and detergent. This essential oil's extraction is considered to be a clean technique. On a dry weight basis, the essential oil in lemon grass ranges from 1 to 2 percent. Citronella oil is another name for lemongrass oil. The traditional techniques for obtaining it are steam and hydro distillation. Yet, these processes take a long period. Innovative Microwave-Assisted Hydro distillation (MAHD) shortens extraction times while maintaining product quality [7].

Traditional Uses of Cymbopogon citratus (Lemongrass):

Historically, a variety of medical conditions have been treated with lemon grass. This is because it creates a huge spectrum of secondary metabolites [7].

The oil has been employed in traditional medicine as a vermifuge, diuretic, antispasmodic, and aromatic tea. Although it has numerous benefits in aromatherapy, citronella oil is most famous for its ability to naturally repel insects [11].

They act as deodorants in a variety of items, including candles, local soaps, perfume, and other insect repellents [12].

For painful muscles and joints, it can be used as massage oil. Fever, intestinal parasites, digestive issues, and monthly irregularities are among the traditional uses [11].

Pharmacological appraisals of Cymbopogon citratus:

Although many pharmacological studies based on the constituents have been conducted, there is still a great deal of potential for exploration, exploitation, and use. The results of these studies are given below:

1. **Antibacterial activity:** Only when acetone and hexane were used as extraction solvents did the stem extract of this plant exhibit antibacterial activities against Staphylococcus aureus strains [13].

2. **Antimicrobial activity:** The ethanolic extracts of lemon grass leaves showed promising antibacterial properties against Staphylococcus aureus. The action is caused by flavonoids and tannins that can be present in the extract. The action is caused by flavonoids and tannins that are present in the extract [4].

3. **Antioxidant activity:** Due to their pharmacological action, phenolic acid and flavonoids play an important role in the natural scavenging of free radicals and as natural antioxidants. The plant's phenolic acids demonstrated its anti-oxidant characteristics [4].

4. **Antinociceptive Effect:** Cymbopogon citratus essential oil exhibits strong antinociceptive properties. We can infer that the essential oil acts both at the peripheral and central levels based on data obtained with three separate experimental models of nociception (hot-plate, acetic acid-induced writhings, and the formalin test)[14].

5. **Hypocholesterolemic Effect:** When the plant extract was administered to the mice, the increased cholesterol concentration was considerably reduced. It was discovered that this reduction depended on the dose. This outcome demonstrates the extract's potential for lowering cholesterol levels [14].

6. **Antimutagenic activity:** 80% ethanol was used to extract lemon grass (Cymbopogon citratus Stapf). In the Salmonella mutation test, the extract was not determined to be mutagenic, either with or without metabolic activation. However, it was discovered that the extract had antimutagenic capabilities against chemically induced mutations in Salmonella typhimurium strains TA98 and TAlOO. The extract of lemon grass suppressed the mutagenicity of AFB, Trp-P-l, Trp-P-2, Glu-P-1, Glu-P-2, IQ, MNNG, and AF-2 in a dose-dependent manner but had no effect on the mutagenic activity of benzo[a]pyrene [15].

7. **Anthelmintic activity:** Nematodes that parasitize animals have a significant economic impact. Phytotherapy is an option for the management of parasites. In this work, a Meriones unguiculatus (gerbil) model was used to assess the effectiveness of *Cymbopogon citratus* decoction (CcD), C. citratus essential oil (CcEo), and citral against Haemonchus contortus utilising in vitro egg hatch test (EHT), larval development test (LDT), and in vivo tests. In gerbils that had been intentionally infected with 5,000 third-stage H. contortus larvae, the impact of 800 mg/kg CcEo was assessed. For CcD, CcEo, and citral, respectively, the effective doses necessary to block 50% (EC50) of egg hatching were 0.46, 0.14, and 0.13 mg/mL. For CcD, CcEo, and citral, the EC50 values in the LDT were 5.04, 1.92, and 1.37 mg/mL, respectively. Compared to the control group, the H. contortus population in the group receiving C. citratus essential oil decreased by 38.5% (P 0.05). These findings imply that it would be able to manage the H. contortus parasite of tiny ruminants with C. citratus essential oil[16].

8. **Hypoglycemic and hypolipidemic effects:** The goal of this research was to investigate how the single, daily oral administration of *Cymbopogon citratus* Stapf. (CCi) fresh leaf aqueous extract in normal, male Wistar rats for 42 days affected their blood sugar and cholesterol levels. Over 42 days, measurements of the rats' average weights were obtained every two weeks. To measure fasting plasma glucose (FPG), total cholesterol, triglycerides, low-density lipoproteins (LDL-c), very low-density lipoproteins (VLDL-c), and high-density lipoproteins (HDL-c), blood samples from the rats were taken on day 43 through cardiac puncture while they were under halothane anaesthesia. The Up and Down Procedure statistics programme (AOT425StatPgm, Version 1.0)'s limit dose test was used to conduct an acute oral dosage toxicity study of CCi at a dose of 5000 mg/kg body weight/oral route. Findings of this study revealed that CCi reduced FPG and lipid parameters in a dose-dependent manner (p 0.05), increased plasma HDL-c in a dose-dependent manner (p 0.05), and had no effect on plasma triglycerides (p > 0.05) levels. Acute oral toxicity tests revealed that CCi had a low level of toxicity and may thus be deemed largely safe upon initial administration. This demonstrates the safety of its folkloric usage in those who may have Type 2 diabetes[17].

9. **Anti-inflammatory activity**: *Cymbopogon citratus* extract and its polyphenols inhibited the cytokine production on human macrophages. This supports the anti-inflammatory activity of Cy polyphenols in physiologically relevant cells. Concerning the effect on the activation of NF-κB pathway, the results pointed to an inhibition of LPS-induced NF-κB activation by Cy and PFs. CGA was identified, by HPLC/PDA/ESI-MSn, as the main phenolic acid of the Cy infusion, and it demonstrated to be, at least in part, responsible by that effect. Additionally, it was verified for the first time that Cy and PFs inhibited the proteasome activity, a complex that controls NF-κB activation, having CGA a strong contribution. Conclusions: The results evidenced, for the first time, the anti-inflammatory properties of *Cymbopogon citratus* through proteasome inhibition and, consequently NF-κB pathway and cytokine expression[18,19].

10. **Antiprotozoal activity:** Leishmania amazonensis was subjected to the inhibition activity of the essential oil (EO) of C. citratus and changes in its morphology and ultrastructure. The findings demonstrated that EO had much more antiproliferative action than citral against promastigotes, axenic amastigotes, and intracellular amastigote forms of L. amazonensis, and that this activity was dose-dependent. Both substances had no harmful effects on the J774G8 macrophage strain. As compared to untreated cultures, the promastigote forms of L. amazonensis experienced striking morphological and ultrastructural changes. After 72 hours of incubation, promastigotes treated with EO and citral at concentrations corresponding to the IC50 (1.7 and 8.0 g/ml) and IC90 (3.2 and 25 g/ml) showed these modifications under light, scanning, and transmission electron microscopy. This study showed that the essential oil of C. citratus, which is high in citral, has potential antileishmanial characteristics and is a viable candidate for future investigation to create a novel antiprotozoal medication. [20].

11. **Antibacterial activity:** All the test organisms, with the exception of P. aeruginosa, were shown to be resistant to lemongrass. Gram positive organisms were discovered to be more susceptible to lemongrass oil than gramme negative ones. In contrast to the Agar Diffusion Technique, the Broth Dilution Method revealed that Lemongrass oil inhibited the test organisms at lower doses. While the examined organisms, particularly gram-negative pathogens, had demonstrated significant tolerance to many antibiotics, lemongrass oil was found to inhibit them even at lower concentrations. Lemongrass oil is therefore efficient against bacteria that are resistant to medication. It is possible that using lemongrass oil can help cure illnesses brought on by bacteria that are resistant to many drugs [20].

12. **Antidiarrhoeal activity:** Three experimental diarrhoeal models in mice—castor oil-induced diarrhoea, MgSO4-induced enteropooling, and charcoal meal test—were used to investigate the antidiarrheal claims of C. citratus extract and its primary component, citral. In mice's faeces output, the effects of the extract and citral were also noticed. The

800 mg/kg, p.o. dosage of plant extract markedly decreased the output of faeces by 53.44% and provided 59.00% protection against diarrheal episodes following castor-oil challenge. The MgSO4-induced intestinal fluid secretion and gastrointestinal motility in the charcoal meal test were both considerably reduced by the same amount of extract. Citral shown an almost identical effectiveness to that of Loperamide, a common antidiarrheal medication, in all of the experimental models. Hence, the study confirms the existence of antidiarrheal activity in Cymbopogon citratus, which may have therapeutic advantages in treating human beings with diarrheal illnesses[21].

13. **Antihypertensive activity:** According to recent findings, the aqueous extract used in this study exhibits antihypertensive activity against ethanol and sucrose-induced hypertension in rats by enhancing biochemical and oxidative status and by shielding the liver, kidney, and vascular endothelium from damage brought on by prolonged consumption of ethanol and sucrose. When ethanol and sucrose were consumed together, it significantly (p 0.001) raised the blood pressure and heart rate in comparison to rats administered with distilled water. Under ethanol and sucrose feeding, the levels of total cholesterol, LDL-cholesterol, triglycerides, atherogenic index, glucose, proteins, AST, ALT, creatinine, potassium, sodium, and albumin increased while the levels of HDL-cholesterol declined. Prolonged ethanol and sugar consumption markedly lowered the activities of catalase (CAT), superoxide dismutase (SOD), reduced glutathione (GSH), and nitrites while increasing malondialdehyde (MDA) levels. Histological examination of rats given alcohol and sugar treatment revealed, among other things, vascular congestion, inflammation, tubular clarity, and thickening of the vessel wall. The hemodynamic, biochemical, oxidative, and histological deficits brought on by prolonged ethanol and sugar intake were avoided by administering the aqueous extract or nifedipine[22].

14. **Antimalarial activity:** In accordance with this study, P. chabaudi AS and P. berghei ANKA are resistant to the antimalarial effects of the whole C. citratus plant. C. citratus's antimalarial efficacy was dose-dependent, with 1600 mg/kg showing more antimalarial activity than 3200 mg/kg. The entire plant shown greater antimalarial activity as a preventative measure than CLQ and the herbal infusion. This research complements ongoing efforts to create whole plant treatments for the treatment of malaria and other infectious illnesses common in resource-poor populations by demonstrating the potential of the C. citratus plant as an alternative therapy against malaria[23]. In mice infected with chloroquine-sensitive Plasmodium berghei, the antiplasmodial effects of ethanolic leaf extracts of Chromolaena odorata and Cymbopogon citratus were assessed. In a four-day early infection test and in an infection that had already been established, C. odorata and C. citratus both showed blood schizontocidal activity that was substantial (p 0.05), with a long mean survival time that was equivalent to that of the common medicine chloroquine (5 mg/ kg/ day). The continuous weight growth and minor rise in PCV levels of the treated groups compared to the untreated groups are additional signs of the effectiveness of both treatments. The extracts from both plants had anti-plasmodial action that was substantial (p 0.05) and may be used to create novel, efficient malaria treatments[24].

15. **Antianxiety activity:** Mature zebrafish were administered C. citratus EO, E1, CIT, and/or GER (by immersion). The light-dark test was used to examine the anxiolytic effects. The coadministration of flumazenil (FMZ), a GABAA receptor antagonist, allowed for additional investigation of the mechanism underlying the anxiolytic effects. Using spectrophotometric tests, the total polyphenols (phenolic and flavonoid chemicals) present in E1 were quantified. Zebrafish had a preference for the bright side of the tank, indicating that all substances under investigation had a notable anxiolytic effect at the highest doses. Moreover, the anxiolytic effect exhibited by EO, E1, CIT, and GER was negated by pre-treatment with FMZ, indicating that GABAergic receptors were implicated in this action. The synergistic activity on the anxiolytic effect found in the light-dark test was demonstrated by the relationship between CIT and GER at the lowest examined concentrations. In addition, it was established that E1 included phenolic and flavonoid chemicals, which may have contributed to the impact that was seen. According to the results of this study, zebrafish, a very inexpensive animal, can serve as a suitable substitute for evaluating the anxiolytic effects of C. citratus and its associated chemicals in animal models. Moreover, the impact that the samples demonstrated may have been caused by GABAA receptor activity. The acquired results may support the ethnopharmacological usage of C. citratus as a medicinal plant for the treatment of anxiety disorders in traditional medicine[25].

16. **Hepatoprotective activity:** The significant reduction (p0.05) in the elevated levels of ALT, AST, ALP, LDH, TB, and MDA in serum and liver homogenates, the rise in TP and GSH levels in serum and liver homogenates, and the improvement of liver histo-pathological changes all point to C. citratus attenuating liver damage caused by H2O2 administration. The extract's effects were comparable to those of vitamin C, which served as a benchmark for antioxidants. In male rats, C. citratus may effectively reduce oxidative stress brought on by H2O2 and prevent liver damage[26].

17. **Acaricidal activity:** The essential oil from the leaves of Cymbopogon citratus has acaricidal activities (lemongrass) 25 mature mites were placed on filter paper that had been soaked in plant extract, and they were then subjected to a range of concentrations (50 percent, 25 percent, 12.50 percent, 6.25 percent, and 3.13 percent) and exposure times (24 hours, 48 hours, 72 hours, and 96 hours) [27].

18. **Anti-glycation action:** Ascorbic acid and ethanol extracts of C. citratus have anti-glycation action against hydrogen peroxide. The ethanol extract is equally effective in preventing glycation as ascorbic acid. The results showed that the glycation process was suppressed by the presence of C. Citratus leaves extract[28].

19. **Dermal protective activity:** The methyl nicotinate (MN) skin model was used in the current investigation to examine the potential anti-inflammatory effects of C. citratus essential oil (EOCC) in human skin in vivo. To achieve this goal, it may be investigated that skin contact with MN generates a disruption that sets off the generation of reactive oxygen species and elicits a brief microinflammatory reaction. After informed permission, 14 volunteers of both sexes were chosen. On each forearm, three spots (3 cm 3 cm) were marked. A polyacrylic acid gel containing 5% EOCC was applied twice daily for 14 days to one randomly selected location. The rest of the region served as a control. Findings showed that the EOCC-treated location had a definite protective effect. When compared to the other locations, the MN response had noticeably less transepidermal water loss, blood perfusion, erythema, and edema. Also, the methodology provided offers a novel tool for examining the clinical effects of

these compounds on human skin, adding to the body of research supporting the utility of employing these items for human health. [29].

20. **Anti-obesity:** Liposomal and hypoglycemic drugs both include lemon grass. To manage the levels of glucose, lipids, and fat in the blood serum, it has been used in traditional and Ayurveda medicine. This may help prevent obesity and hypertension. Tea is the most common way to drink it[30].

Conclusion:

The leaves, stems, and roots of C. citratus are frequently employed in herbal therapy. Its essential oils are frequently used in aromatherapy and are thought to be safe for human ingestion.

The vast variety of pharmacologic and physiological effects of C. citratus have been demonstrated by accumulating data to be the result of the phytochemicals contained in this plant, which explains why it has medicinal uses. However, additional empirical research examining C. citratus' impact on people is required to support its application in medicine. The majority of the research that are now accessible are animal-based and could not be helpful for evaluating its therapeutic potential in people. An overview of C. citratus' effects in both healthy and diseased stages is given in this review. A variety of bioactive chemicals are produced by Cymbopogon sp., a fragrant grass that also has a wide range of medicinal uses. Due to its strong smell, it has already found use in the cosmetic and perfumery sectors. More investigation is required to determine whether C. citratus interacts with other medications and how that would affect their pharmacokinetics and bioavailability, given that the plant is typically ingested along with other biologically active compounds. Future uses of lemon grass in herbal medicine may be made possible by the herb's medicinal properties and its essential oil.

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