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EXPLORING THE MULTIFACETED APPLICATIONS AND INCOME-ENHANCING STRATEGIES IN LEMONGRASS CULTIVATION: A COMPREHENSIVE REVIEW

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ABSTRACT

A well-known and highly valued cultural plant, lemongrass (Cymbopogon citratus) has a long history of usage in aromatherapy, cooking, and traditional medicine. This in-depth review study attempts to give a full overview of lemongrass, taking into account its botanical features, phytochemical makeup, pharmacological activities, and medicinal uses. The taxonomic division, geographic range, and physical characteristics of lemongrass are clarified in the botanical portion of this paper. The essential kinds of lemongrass are distinguished, and their adaptation to diverse environmental situations is emphasised. The broad variety of bioactive components found in lemongrass, such as citral, citronellal, myrcene, and limonene, are highlighted by the phytochemical makeup of the herb, which is discussed in the section that follows. These ingredients give lemongrass its characteristic scent and are the basis for all of its beneficial pharmacological activities. The pharmacological component of this paper explores lemongrass's possible medicinal uses, including its antibacterial, anti-inflammatory, antioxidant, anti-cancer, and antidiabetic characteristics. The study also explores the mechanisms behind these actions, elucidating the interactions of lemongrass constituents with biomolecules and cellular processes. In-depth research is done on the medicinal uses of lemongrass, including its integration into both conventional and alternative medical systems across the world. It has been demonstrated that lemongrass is effective in treating a variety of health issues, including skin problems, anxiety, and digestive problems. This study also examines lemongrass's safety profile and any potential risks associated with its ingestion, emphasising the need for responsible use and care in particular groups.

Keywords: Cymbopogon citratus Stapf., Lemon grass, pharmacological profiling, phytochemicals, Farmer, Income

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INTRODUCTION

Lemon grass is a tall shrub with broad, unevenly striped leaves. It has a distinctive aroma that is smokey, sweet, herbaceous, and lemony. The herb Cymbopogon flexuosus is frequently used to make soups, curries, and drinks. This plant has a relaxing quality. Cymbopogan flexuosus, a tall sedge endemic to the area, with a delicious scent. It belongs to the Poaceae family. It grows in many tropical and subtropical regions of South East Asia, Africa, and other continents. According to Manzoor et al. (2013), the grass known as lemon grass (Cymbopogon citratus) is a native of Pakistan, India, and Sri Lanka. It is frequently referred to as citronella grass. Approximately 140 species of the genus Cymbopogon may be found in semi-arid and tropical parts of the Asian, American, and African continentsThere are just a few species of lemon grass found in Australia and Europe. Lemon grass is sometimes referred to as "Squinant" in English, in addition to having many other regional names. As a result of their ability to generate volatile oils, members of the Cymbopogon genus are often referred to as aromatic grasses (Kumar et al., 2009; Adhikari et al., 2013). It is grown on 4000 acres of land in India, with an approximate yearly yield of 250 t. The crop is widely grown in underdeveloped, marginal, and wastelands as well as along bunds as living mulch. The plant's well-ramified roots assist in conserving soil and water (Joy et al., 2006). Except for the foothills of Sikkim and Arunachal Pradesh, it is typically produced in the Western Ghats (Kerala, Maharashtra), Karnataka, and Tamil Nadu states (Tzortzakis et al., 2007). A tall perennial grass with the common name "lemongrass," Cymbopogon citrates. It is a member of the Cymbopogon genus of fragrant grasses and has essential oils with a delicate lemon flavour. Lemongrass is widely utilised as a vital health ingredient in Asia. It is used as a central nervous system sedative in India (Schaneberg et al., 2002). Consumer awareness of and concern over the use of synthetic chemicals in food additives is increasing. Thus, natural additives may be used to preserve food, and they are increasingly being used as preservatives to extend the shelf life of different food products. In fact, according to Trujillo et al. (2013), essential oils not only exhibited antibacterial action in vitro against a number of foodborne pathogens but also in the food systems. Numerous culinary products regularly employ lemon grass as a flavouring ingredient. Lemongrass essential oils were shown to have strong antibacterial activity in addition to an appealing citrus flavour, making them suitable for use in culinary applications. Food items still have significant drawbacks, though. Its powerful, lingering scent has a significant influence on both the consumer's approval of food and its organic leptical properties (Graü et al., 2009At larger doses, this exhibits toxicological effects (Liggins and Burt, 2004). In order to prevent toxicological effects, customer rejection, and to take into consideration the economic factors, the concentration of essential oils in food items must be reduced (Ahmad et al., 2012; Wifek et al., 2016).

TAXONOMICAL CLASSIFICATION

Kingdom : Plantae

Division : Magnoliophyta

Class : Liliopsida

Order : Poales

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Family	:	Poaceae
Genus	:	Cymbopogon Spreng
Species	:	citratus

Figure 1: Lemongrass
Source: Khandagle and Vaibhav (2022)

MORPHOLOGICAL DESCRIPTION OF CYMBOPOGON

Lemon grass is a monocotyledonous perennial grass that may reach heights of 6 feet and widths of 4 feet. It develops in clumps. It has 3 foot long, long, thin, drooping brilliant green leaves that range in width from 1.3 to 2.5 cm. Simple leaves have complete edges. On spikes, flowers sprout. It has a long inflorescence that measures 30 to 60 cm. Cymbopogon is the name given to this fragrant grass by the flower arrangement. Southeast Asia is home to many Cymbopogoncitratus species (Viabhav et al., 2013; Kumar et al., 2010; Shah et al., 2011).

Leaves: The 3 ft (0.9 m) long, 0.5-1 in (1.3-2.5 cm) broad, and gently drooping tips of the strap-like leaves. The brilliant bluish-green, evergreen leaves smell like citrus when crushed. The majority of leaves sprout from the ground without a stem. (Shah et al., 2011; Ross, 1999).

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

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Flowers: The lemongrass plants you are likely to come across are cultivars, and they seldom create blooming panicles or normally don't produce blooms.

Inflorescence: The partial inflorescences are paired spikelet racemes that are subtended by spathes, and the inflorescences are 30–60 cm long and nodding.

CHEMISTRY

Cymbopogon citratus, sometimes known as lemon grass, belongs to the poaceae family. It is a medicinal plant that contains chemicals that can inhibit the growth of infections and boost the body's natural defences against infectious disorders. This fragrant plant is cultivated to yield essential oils for commercial usage and is utilised in the manufacturing of perfume. It is utilised in many pharmaceutical industries to prepare soaps, deodorants, and colognes due to its pleasant scent (Costa et al., 2011). Citral monoterpenes, an isomeric combination of neral and geranial, and myrcene, all of which have medicinal and antibacterial properties, make up its main constituents. The monoterpenes from citral have anti-fungal and anti-microbial properties. According to Costa et al. (2011), these qualities in agronomy draw attention.

CHEMICAL COMPOSITION

Because it contains more citral than other plants, lemongrass (Cymbopogon citratus) is well recognised. Early or late lemongrass harvesting has an impact on the essential oils and citral concentration. Temperature, light output, soil moisture, fertiliser, and maturity all had an impact on the essential oils and citral components. The plant transitions from the vegetative to the reproductive stage as it ages. The yield of plant biomass and the output of essential oils are closely connected. The ratio of young to older leaves determines whether essential oils are of higher quality and contain more citral (75%) when harvested at a particular time. Different processes, such as solvent, rapid solvent dense CO_2 and the Soxhlet, solidphase matrix, and super-critical fluid extraction techniques, are typically used to get lemongrass essential oils. Due to the intricacy of the essential oil components, modern methods like high performance liquid chromatography in combination with gas chromatography (HPLC-GC) are the recommended analytical method. A sample may be separated into broad classes using HPLC, which can then be added to a gas chromatograph (GC) for even greater separation (Wifek et al., 2016).

PHYTOCHEMICAL CONSTITUENTS OF LEMONGRASS

Lemongrass is another name for the plant Cymbopogon, which belongs to the Poaceae family (Valduga et al., 2019). Lemongrass is a perennial grass that grows up to one metre tall and has several stiff, green stalks that shoot out from short, rhizomatous roots (Kumar et al., 2010). In the Philippines and Indonesia, a perennial fragrant grass known as Cymbopogon citratus is frequently planted. Additionally, it is grown throughout Asia and America, notably in the tropical parts of both of those continents (Manvitha et al., 2014). Although Pakistan is one of several tropical and subtropical countries where the plant is produced, it is primarily an indigenous herb to India (Manvitha et al., 2014). There are several species of lemongrass around the world: Cymbopogon citratus (C. citratus), C. bombycinus, C. refractus, C. nardus, and C. ambiguus

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COMPOSITION OF LEMONGRASS PRODUCTS

The two primary biologically active components of lemongrass are extracts and essential oils, which have quite different chemical make-ups. The potential cardiovascular benefits of these products have been investigated in vitro, ex vivo, and in vivo. According to Carlson et al. (2001), the major components of lemongrass essential oil, which makes up between 1% and 2% of the herb's total dry weight, are terpenes and terpenoids (alcohols, ketones, and esters). Recent studies (Machraoui et al., 2018; Majewska et al., 2019) have a comprehensive list of the chemicals that have been so far discovered in lemongrass. Vitamins A, B_2, riboflavin, B_3, niacin, B6, pyridoxine, B9, folate, and minerals including potassium, calcium, silica, and phosphorus are also present (Firdaus et al., 2015), in addition to protein, carbs, and fat (Aftab et al., 2019).

TRADITIONAL USES OF LEMON GRASS

- Lemongrass leaves are said to contain a significant amount of oil, and this oil is said to provide a variety of medicinal benefits, including antibacterial, carminative, fungicidal, analgesic, antiseptic, astringent, bactericidal, and antidepressant effects. Due to its capacity to serve as an antibiotic and antiseptic, it can be used to treat ringworm and athlete's foot. Methicillin-resistant Staphylococcus aureus (MRSA) infection is well-inhibited by lemongrass. It can be used to treat gastro-enteritis, indigestion, and colitis. It aids in reducing the signs and symptoms of a headache, a body ache, nervous tiredness, and a condition linked to stress. Infections like sore throats, laryngitis, bronchitis, etc. are frequently treated with its infusions (Joseph et al., 1960).
- Alves et al. reported its use for cure of gastrointestinal problems (Alves et al., 1960).
- Decoction of lemongrass leaves is used as diaphoretic in fever (Chopra et al., 1958)
- According to studies on lemongrass, it revitalises the body and promotes excellent health. It enhances digestion and prevents chemically caused carcinogenesis by adjusting the liver and intestine's xenobiotic-metabolizing enzymes. (Nambiar et al., 2012).
- Lemon grass tea is commonly used to combat flu, fever, pneumonia (Nambiar et al., 2012).

LEMONGRASS AND GUT MICROBIOTA

The modulation of the gut microbiota and its activities with adequate dietary methods is anticipated to be able to achieve the desired optimal health and performance of human and animal health (Ali et al., 2021). As a result, phytochemicals have the ability to promote health by creating a healthy gut habitat. Since there are no residual or toxicity problems, phytochemicals are regarded at the industrial level as vital food and feed additives. Phytobiotics are a class of phytochemicals that are used to alter the gut ecology by producing anti-microbial, anti-inflammatory, and antioxidant responses. This improves the gut system's capacity to absorb nutrients at their highest levels. The small intestine is where many nutrients are digested and absorbed in the intestinal environment. A variety of bacteria are heavily concentrated in the cecum, where they are principally in charge of fermenting nutrients that the ileum was unable to absorb. Plant oils and extracts have long been utilised in medicines, complementary medicine, natural remedies, and food preservation (Cottrell et

al., 2022). The development and maintenance of gut flora and digestive processes are aided by the bioactive chemicals found in dietary lemongrass. Comparative to the control groups, dietary lemongrass increased the number of helpful bacteria while decreasing the burden of harmful bacteria. (Alagawany et al., 2021; Al-Sagheer et al., 2018). In the ileum and cecum, they discovered that dietary lemongrass promoted the proliferation of Lactobacillus species while suppressing Campylobacter species and E. coli. Lemongrass contains pinene, which has a variety of antibacterial properties. (Leite et al., 2007).

HERBAL USES OF LEMONGRASS

An oral decoction is given for sore throat treatment. Cymbopogon leaves, C. citratus, include a lemon leaf, have the usual harsh flavour of its main compound, cirtal, which is highly valuable to the business, and are an exacting anti-inflammatory, diuretic, and sedative drug. However, certain perfumes may degrade, hydrolyze, or become water-soluble as a result of these conventional methods.

Antifungal activity

Excellent Lemongrass Oil anti-fungal effects have been reported by Vibhav S. et al. (2013) and Asaolu MF et al. (2009). Pathogens are more resistant to undiluted lemongrass, mushrooms, benzoic acid, nystatin, or tinea fax than they are to commercial fungicides. Another in vitro study found that lemongrass oil killed bacteria with the best effectiveness and had the most inhibitory effect on Candida biofilm development (Pontes et al., 2019). High citral concentration is associated with antifungal action. Sticky germ tubes exhibit growth inhibition in the presence of oil. The Candida tropicalis and Aspergillus niger both shown strong anti-fungal activity in response to the lemongrass oils. A synergy of monoterpenes and other substances including cymene, terpene, and linalool has been indicated as the effective lemongrass inhibitor for the Candida species. (Manvitha et al., 2014).

Anti-inflammatory activity

In studies using lip polysaccharide activated dendritic cells, a Cymbopogon citrate leaf infusion has been utilised to treat inflammatory illnesses, particularly in the gastrointestinal system. The Cymbopogoncitratus (DC), a typical beverage used to treat inflammatory diseases, is discussed in this paper. We looked at the leaves of the Stapf infusion. Luteolin O, C and O, C- glycosides were identified and categorised by magnet resonances from the Cassiaoccidentalin B structure, which the lemongrass completely characterises for the first time. In lipopolysaccharide-stimulated macrophages, luteolin and its glycosides were investigated for their anti-inflammatory properties. Comparatively less cytotoxic than luteolin itself are luteolin glycosides. Although luteolin's anti-inflammatory activities are diminished by glycosylation, which is greater than Cg, luteolin 7-O—glucopyranoside has been observed to suppress the production of inflammatory mediators without having any cytotoxic effects (nitric oxides and IL1). Therefore, it has been demonstrated that luteolin glycosides are a less harmful alternative to the anti-inflammatory drugs now on the market, with prospective uses in the pharmaceutical and dietary supplement sectors. It creates relationships between

structure and action for the creation of non-toxic anti-inflammatory luteolin glycosides. This work has information that is helpful (Manvitha et al., 2014).

Anti-Cancer Activity

The anti-cancer properties of Cymbopogon citratus have also been studied. Its distinctive oil could provide a potent defence against some cancers. According to animal research, Cymbopogon citrate oil suppresses cancer tumours when administered directly, and the larger the oil dose, the better the results. The results of the experiment indicate that the oil may have a potentially useful anti-cancer impact by causing the apoptotic process, which lowers the viability of tumour cells. Microscopy was used to detect this. According to extensive study, lemongrass can cause cancer cell apoptosis, also known as programmed cell death, and inhibit the spread of cervical cancer cells and other types of cancer cells. Lemongrass oil and citral emulsion are good prospects for use as anti-cancer drugs (Ribeiro et al., 2017).

Antiglycation activity

According to Gasparovic et al. (2010) and Nomoto et al. (2012), glycation stress is the alteration of cell proteins by non-enzymatic/irreversible interactions with reducing sugars. A non-enzymatic event called glycation occurs when free amino groups in proteins interact with reducing sugars. (Biworo et al., 2015) The Maillard reaction is the name of this process. The reaction happens when a reducing sugar's carbonyl group and an amino group from an amino acid come into contact. According to Sadowska et al. (2015), the accumulation of glycation products is linked to a number of disorders, most notably diabetes and diabetic nephropathy, microangiopathy, and atherosclerosis. Sari et al. investigated the anti-glycation capacity of ethanol and ascorbic acid extracts of C. citratus on hydrogen peroxide. The anti-glycation potential of the ethanol extract was comparable to that of ascorbic acid. The findings indicate that the glycation process might be inhibited by C. citratus leaves extract (Sari et al., 2017).

Antimutagenicity

According to several studies (Meevatee et al., 1993; Pimsaeng, 1993; Vinitketkumnuen et al., 1994), the ethanolic extract of lemon grass exhibits an antimutagenic activity. It also slows the growth of fibrosarcoma cells transplanted into mice in conjunction with the prevention of lung metastasis (Puatanachokchai, 1994). According to Suaeyun et al. (1997), the plant extract inhibits the growth of azoxymethane-induced DNA adducts and abnormal crypt foci in the colon of rats. 344 male Fischer rats were exposed to the plant extract, which had inhibitory effects on the early stages of hepatocarcinogenesis after the introduction of diethylnitrosamine (Puatanachokchai et al., 2002).

INDUSTRIAL APPLICATIONS OF LEMONGRASS

According to some reports, the oil can improve the flavour of particular seafood in addition to enhancing the flavours of wines, sauces, confections, spices, and tea leaves. In Southeast Asian countries including Indonesia, Vietnam, Malaysia, Thailand, Pakistan, and the Philippines, lemongrass is a widely utilised culinary herb. Due to its fragrant, lemon-scented properties, it can be utilised fresh, powdered, or dried. Despite being difficult to eat, the lemongrass pseudostem may be pulverised and used to foods or grilled rubs. In the

pseudostem, the oil glands that contain fragrant oils are released if it is bruised or added whole. According to Majewska et al., 2019 the lemongrass leaves and stalks have a faint lemon flavour. Due to its mild citrus flavour, lemongrass is an often used primary ingredient in Thai and other Asian cuisines, including Indonesian and Malaysian. In Latin American and African countries, this aromatic herb is frequently used to prepare curries, chicken, seafood, soups, and teas (Ordevi et al., 2015). Recently, interest in lemongrass has been shown by other countries, including Thailand. Herbal teas frequently include dried lemongrass leaves as a lemon flavouring. Lemongrass is a diuretic and does not affect the body's biochemistry, in contrast to ordinary tea. In Thailand, a popular beverage known as "Takrai" is usually made with lemongrass, claim Nambiar and Matela (Nambiar et al., 2012). In addition, lemongrass is widely used to make seafood soups, curries, and marinades. The essential oil from the Cymbopogon genus is used in perfume, palm arosa oil, and soap among other commercial applications. Glycerol, lemongrass, and lemon balm oil are all components of various unique formulas for lemongrass products used in the cosmetic business. Lemongrass essential oil has been shown to repel insects, allowing it to be used as an insect-repellent lotion (Silva et al., 2020). The antioxidant qualities of this oil are extremely advantageous to the beauty industry since they may be used to prevent a number of oxidative stress-related skin conditions. Due to the fact that oxidative stress is connected to chronic degenerative conditions of a degenerative nature that speed up ageing, this chemical can also be used as an anti-aging cream. A detailed examination of lemongrass's bioactivities that are pertinent to its potential aesthetic advantages has also been done in the recent past (Ali et al., 2022).

STRATEGIES FOR DOUBLING INCOME IN LEMONGRASS CULTIVATION

Doubling the income of lemongrass-cultivating farmers requires a multifaceted approach that leverages value addition, market access, sustainable practices, and innovative technologies. Firstly, farmers can focus on value addition by processing lemongrass into high-value products such as essential oils, teas, and herbal extracts. Essential oils, in particular, have significant demand in the pharmaceutical, cosmetic, and aromatherapy industries. By investing in small-scale distillation units, farmers can directly produce and sell these oils, thereby capturing more of the value chain. Additionally, diversifying into producing lemongrass-based teas and extracts can open up new revenue streams. This move toward value-added products not only enhances income but also mitigates the risk associated with raw lemongrass price fluctuations in the market.

Moreover, improving market access is crucial for enhancing farmers' incomes. Farmers can collaborate to form cooperatives, enabling them to negotiate better prices, access larger markets, and reduce transportation costs through bulk selling. Cooperatives can also provide farmers with better access to credit facilities and training programs, empowering them to improve their farming practices and produce higher-quality crops. Further, embracing digital platforms and e-commerce can enable farmers to reach broader markets directly, bypassing intermediaries who often take a significant share of profits. This direct-to-consumer model can be particularly effective for niche products such as organic or sustainably sourced lemongrass, which can command premium prices.

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Implementing sustainable farming practices can also play a pivotal role in doubling income. Lemongrass is known for its hardy nature and ability to grow in less fertile soils with minimal inputs, making it a suitable crop for sustainable agriculture. Farmers can adopt organic farming practices, such as using natural fertilizers and pest control methods, which can reduce input costs and increase market appeal among health-conscious consumers. Additionally, practicing intercropping with lemongrass can maximize land use and yield. For instance, integrating lemongrass with other crops like ginger, turmeric, or even vegetables can provide farmers with multiple income streams while improving soil health and reducing the risk of pest infestations. Moreover, lemongrass cultivation has been found to aid in soil conservation and can be part of an agroforestry model, which promotes environmental sustainability and increases resilience against climate change impacts.

Technological advancements, particularly in precision agriculture, can further enhance productivity and profitability. Leveraging tools such as remote sensing, drones, and mobile applications can help farmers monitor crop health, optimize irrigation, and manage pests more effectively, leading to higher yields and reduced costs. Training and extension services can play a vital role here by educating farmers on the latest agricultural techniques and technologies. Additionally, partnerships with research institutions and agritech companies can introduce farmers to innovative practices and products, such as drought-resistant lemongrass varieties or advanced organic pest control solutions. Exploring niche markets, such as organic, fair trade, or eco-friendly certifications, can provide a significant boost in income. Products labeled with such certifications often sell at higher prices in international markets. By investing in obtaining these certifications, farmers can differentiate their products and attract a premium customer base. Furthermore, engaging in agro-tourism, where farms are opened to visitors for educational tours and experiences, can provide additional income. Through these comprehensive strategies, lemongrass farmers can significantly increase their earnings and secure a sustainable livelihood.

CONCLUSION

The tropical regions of America and Asia currently have extensive cultivation of the Sri Lankan and South Indian native Cymbopogon citratus. In addition to being used as a flavouring and fragrance component, the plant is also utilised in folk medicine as an antispasmodic, hypotensive, anticonvulsant, analgesic, antiemetic, antitussive, antirheumatic, and antiseptic as well as a therapy for neurological and gastrointestinal diseases and fevers. The plant is also utilised as an antioxidant, antimicrobial, and antidiarrheal, although the specific mechanisms behind the various bioactivities have not been well investigated. Numerous phytoconstituents found in Cymbopogon citratus, including terpenoids, essential oils, flavonoids, and phenolic compounds, may be the cause of the plant's diverse range of biological effects. As a result, we are able to separate out certain pure phytopharmaceuticals, which may then be employed as lead compounds to create new drugs with potent therapeutic effects. Standardisation of the extracts, phytopharmacology of various extracts, isolation and characterization of active phytopharmaceuticals, clarification of the mechanism of action of the isolated compounds, and clinical trials of the compounds are all crucial for the development of high-quality herbal medicines. The primary healthcare system in both

developed and developing nations is becoming increasingly interested in plants with therapeutic potential as a result of the shifting global landscape. In order to screen the compounds responsible for various bioactivities and to clarify the molecular mechanism of action, the knowledge will aid scientists and researchers.

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