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REVIEW ARTICLE

New extension technologies, value addition and utilization of lemongrass (*Cymbopogon flexuosus* L.) essential oil

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ABSTRACT

Lemongrass (Cymbopogon flexuosus) is a perennial grass that belongs to the family Poaceae. It is cultivated in India, Bangladesh, Nepal, China, Sri Lanka and many other Asian countries for its essential oil. Presently, India is the largest producer of the lemongrass oil due to the combined efforts of CSIR laboratories like CSIR-CIMAP, CSIR-IIIM and CSIR-NEIST under the CSIR Aroma Mission programme. The crop is widely cultivated today in various parts of the country like Uttar Pradesh, Rajasthan, Bihar, Punjab, Chhattisgarh, Assam, Meghalaya, Manipur, Gujarat, Uttrakhand and Jharkhand, etc. The life span of the lemongrass plant is 4-5 years, which can extend up to 6-7 years, depending upon the agronomical practices followed during cultivation. Lemongrass may yield 60 - 100 Kg essential oil per acre of the land annually, helping the farmers to earn a net profit of Rs. 40,000 - Rs. 45,000 from the second year of cultivation onwards. The oil yield and quality depend on the geographic location of cultivation and the crop genotype used. The crop needs low irrigation and is not affected by grazing by wild animals because of the deterrent property of its essential oil present in the leaves. Mostly, the leaves are distilled using hydro-steam distillation for the extraction of essential oil. Other distillation methods can also be applied as per the demand of industries. The oil of lemongrass has diverse uses, especially in fragrance, flavour and pharmaceutical industries. The leaves are used in green tea for reducing toxicity in the blood. This review compiles the existing practices of value addition of lemongrass essential oil through various distillation methods and its uses in various industries.

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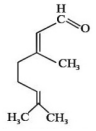
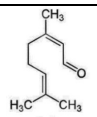
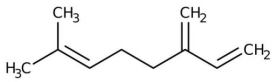
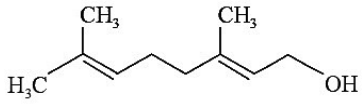
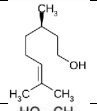
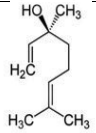
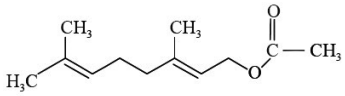
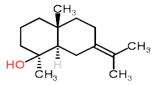
INTRODUCTION

Cymbopogon is a genus belonging to the family Poaceae, which has around 120 species that are widely cultivated in tropical and subtropical regions of the world. The essential oil of

lemongrass spp is widely used in cosmetics, pharmaceutical, agriculture and food flavour industries. *Cymbopogon flexuosus* is a long, standing grass which is weaker than other species of lemongrass. Leaf blades are linear in shape which is tapered towards the sheath and the bush can reach to a height of 45-90 cm with a girth width of 1.5 cm. In *C. flexuosus,* flowering takes place at the matured stage of growth and hence due to shorter harvesting times no flowering is seen during commercial cultivation. Lemongrass shows the highest oil content where the day temperature ranges from 25-30°C and the annual rainfall is 2500-3000 mm. However, rapid growth is obtained when exposed to sunlight on a sandy loam soil [23]. This perennial plant is usually cultivated as a ratoon crop. The crop can be harvested at 4 to 6 months after planting, followed by successive harvesting at 2-3 months interval. The crop is harvested at 20 cm above the ground level. On dry basis, lemongrass contains 0.5-1.5% of essential oil which may vary widely with habitat, genetic diversity and treatment of culture. The leaves of lemongrass possesses strong lemony characteristic odour due to its major component citral which is a combination of two geometric isomers geranial (citral a) and neral (citral b) [18]. These two isomers occur together and are used as raw material for the production of â-carotene, vitamin A and ionone [3]. The amount of citral content present in lemongrass determines

Table-1. Major Components present in *C. flexuosus* and their chemical structure with relative average percentage

COMPONENTS	CHEMICAL STRUCTURE	PERCENTAGE
CITRAL A (GERANIAL)		43.95%
CITRAL B (NERAL)		31.05%
MYRCENE		7.68%
GERANIOL		5%
CITRONELLOL		0.40%
LINALOOL		0.60%
GERANYL ACETATE		1.06%
JUNIPER CAMPHOR		1.56%

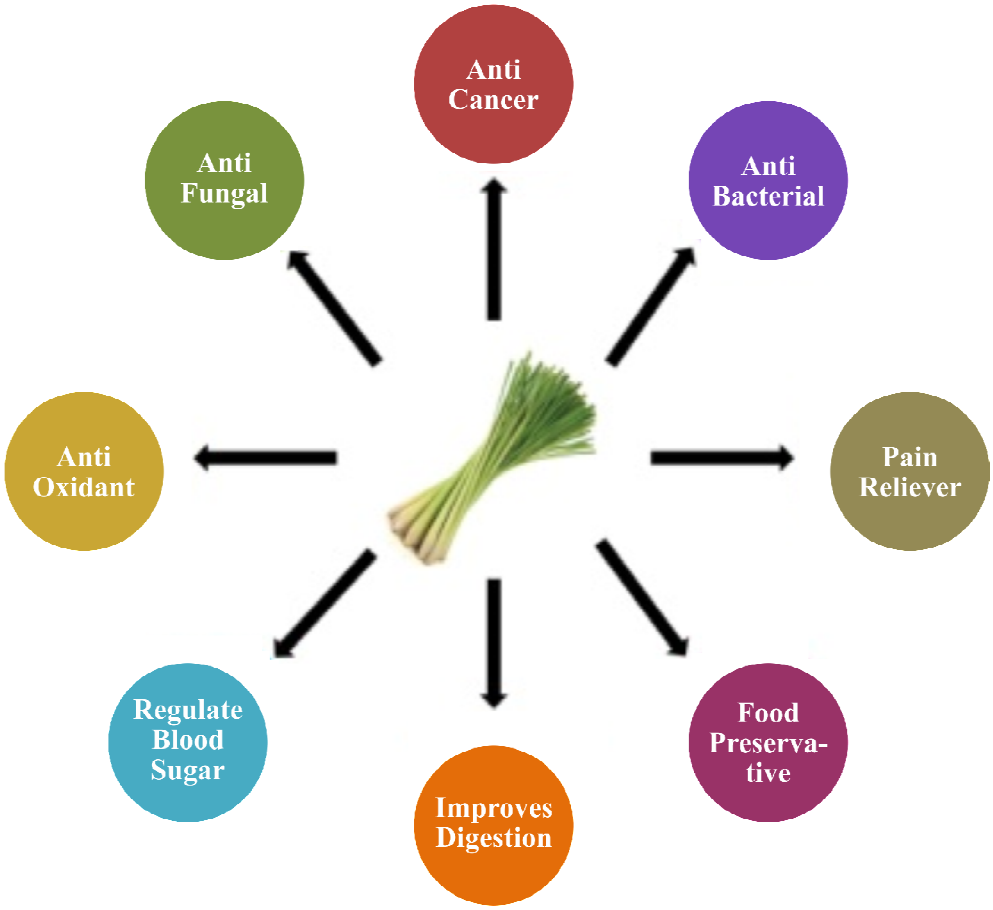


Figure 1: Activity and utility spectrum of lemongrass oil

the quality of oil [21]. Apart from citral, lemongrass oil also contains minute quantities of geranyl acetate, geraniol, monoterpene olefins such as myrcene and limonene (Table 1). Essential oil extracted from the leaves of lemongrass contains a wide range of biological activities like anti-bacterial [2], anti-oxidant, anti-fungal and anti-cancer [24]. Owing to these biological properties, lemongrass oil can also be used as a food preservative [13] and herbicide [4].Recent findings are also pointing out that lemongrass oil can be used as an alternative fuel for diesel (Fig. 1) [1].

Lemongrass oil is extracted by numerous methods, like hydro-distillation [5], steam distillation, microwave assisted hydro-distillation (MAHD), solvent extraction, dense carbon dioxide extraction and super-critical fluid extraction [16]. Among these methods, hydro-distillation and steam distillation are the most common procedures for extracting the lemongrass oil because the cost of water in hydro-distillation is much cheaper than the solvents like methanol, hexane, etc. Other disadvantages of solvent extraction are that the use of solvents (methanol and hexane) can destroy the therapeutic properties of lemongrass oil and the separation of oil needs heating, unlike steam distillation in which the separation of oil and water takes place by gravity.

PRODUCTION AND VALUE ADDITION

Microwave Assisted Hydro-Distillation (MAHD)

In order to save the environment, researchers have developed “green techniques” for the extraction of essential oil, like steam distillation, hydro-steam distillation, maceration activate thermal degradation and solubilisation of some fragrance components. These techniques are in great use in industries and laboratories because of the fast transfer of energy, effective heating and

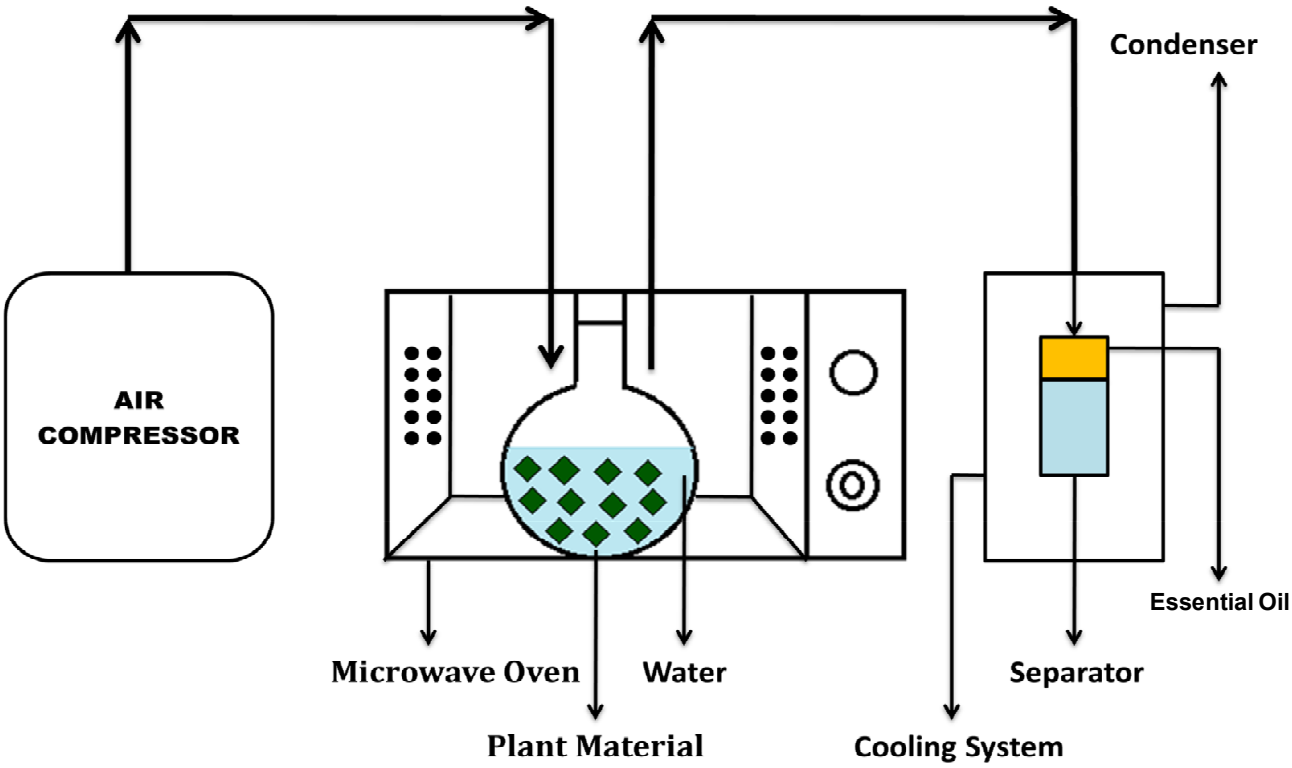


Figure 2: Lay out of set up for microwave assisted hydro-distillation of aromatic plants

environment friendly extraction conditions. MAHD is another advanced hydro-distillation technique where the microwave radiations are the heating source (Fig. 2), that which alters the polarity of solvents [20]. The ability of solvents to absorb microwave energy plays a very significant role in extraction efficiency. Methanol is known to be the best extraction solvent as it has the capacity to heat under microwaves [6]. There are certain optimum operating conditions of MAHD such as water to plant material ratio, microwave power and extraction time that can greatly influence the yield and quality of oil [12]. In one of the experiments conducted on *Cymbopogon flexuosus* it was found that MAHD has great advantage over conventional hydro-distillation, in which induction time and the extraction time are much higher than the MAHD, as the heat generated through microwaves accelerates the extraction process. However, the components of lemongrass oil and their concentration obtained by both the methods remain unchanged [9].

CO_2 supercritical extraction

CO_2 supercritical extraction is one of the most modern technologies used for the extraction of essential oils where carbon dioxide is used as a solvent. The supercritical fluid extraction (SFE) is done at relatively low critical pressure (74 bars) and temperature (305K). Moreover, CO_2 is non-flammable, non corrosive, non toxic, easily available in high purity and can easily be removed from the extract [22]**.** One disadvantage with CO_2 is that it lacks polarity analysis [19]**.** Temperature and pressure have a very significant effect on the quality of essential oil. SFE was done for both stem and leaves of lemongrass where the extraction conditions like temperature and pressure were studied at 1300 psi at 308 K, 1300 psi at 323 K, 1700 psi at 308K and 1700 psi at 323K. The yield of the extracted oil for both stem and leaves were almost same at all operating conditions except at 1300 psi and 308K. It was concluded that with increase in pressure and decrease in temperature, the extraction yield will increase for both stem and leaf oil of lemongrass [11]**.**

Steam distillation

Steam Distillation is one of the most commonly used techniques for the extraction of essential oils. In this technique, water steam is passed through the leaves of lemongrass and when ambient pressure at 100°C becomes equal to the total vapor pressure, the volatile components with boiling points ranging from 150°C - 300°C evaporate out at a temperature near to water. Recently, Lim et al [15], performed the extraction of lemongrass oil using steam distillation where the steam distiller was modified to a pressure cooker. Distillation unit comprises of an electric hot plate, modified pressure cooker, condenser and collection tank. Factors affecting the yield of lemongrass oil are plant to water ratio, distillation time, drying conditions, etc [15].

Hydro-steam distillation (Field distillation unit)

Hydro-steam distillation is mostly used for commercial extraction of bulk oil of aromatic crops like lemongrass, menthol mint, citronella, basil, etc. In this process, the distillation unit is divided into three main parts i.e. still or tank made up of mild steel or stainless steel, condenser and receiver-cum-separator made up of stainless steel. The condenser is shell and tube type, with more than 50 - 100 thin stainless steel pipes covered by a shell made up of mild steel. The still or tank is divided into two parts i.e. false bottom perforated grid and actual bottom. The perforated grid is settled on 1.6 - 1.8 feet or more height form the actual bottom, the space between actual and false bottom is filled by water. The material which is to be distilled loaded on the perforated grid for distillation. During the operation of the unit, water level should be maintained at a specified level after every batch of distillation. Most of the Indian farmers are using the design and prototypes of this type of unit developed by CSIR-CIMAP for the extraction of the essential oils from aromatic herbs. The operation cost is comparatively cheaper than steam distillation.

Fractional distillation of lemongrass

Essential oils are volatile components extracted by techniques like steam distillation and hydro-distillation of the whole plant material. It is a complex mixture of hundred of components which posses a different characteristic feature. Fractional distillation unit is used to separate these components into a single isolate. In this process, the oil is redistilled in vacuum and the individual constituents separate out one after the other on the basis of difference in their boiling points. Lemongrass oil has high content of oxygenated monoterpenes and less quantity of sesquiterpene hydrocarbons, oxygenated sesquiterpenes and monoterpene hydrocarbons. Apart from the aldehyde citral (65-80%), the essential oil of *Cymbopogon* species contains minute quantities of geranyl acetate, geraniol and monoterpene olefins such as myrcene in *C. citratus* and limonene in *C. flexuosus* [17]. A sample of *Cymbopogon flexuosus* possess major constituents like Geranial-Citral a (43.95%), Neral-Citral b (31.05%), myrcene (7.68%), geraniol (5%), citronellol (0.40%), nerol (3.14%), geranyl acetate (1.06%), linalool (0.60%), citronellal (0.21%), juniper camphor (1.56%), alpha-pinene (0.90%), iso-caryophyllene (0.63%), etc. Essential oil and citral contents are highly affected by some factors like geographical location, intensity of light, temperature, moisture content in soil, fertilizer and the maturity stage [26].

Effect of plant length and distillation time on the yield of lemongrass oil

In 2019, an experiment was performed to study the effect of material length on the yield of lemongrass oil.[25] *Cymbopogon citratus* was collected from Indonesia and was air dried before the extraction using hydro-distillation. To study the effect of material length, lemongrass leaves of different lengths (5cm, 10cm and 15cm) was taken for hydro-distillation which was performed at a temperature of 100°C for 165 minutes. It was observed that with increase in distillation time (up to 120 minutes), the yield of essential oil increases as it provides a longer contact between plant material and water, thus increasing the mass transfer [10]. On the other hand, the yield of oil increases with decrease in plant length from 15 cm to 10 cm as decreasing in plant length leads to higher surface area, thereby resulting in better extraction of oil [25].

Value-added new uses of lemongrass oil

Lemongrass oil as an alternative fuel for diesel

Due to the declining of non renewable resource like petroleum reserves there has been a great demand for biodiesel, as they are non-toxic, biodegradable, environment friendly and creates reduction of harmful emissions. In 2014 [27], an experiment was conducted to study biodiesel extracted from lemongrass oil through trans-esterification process using methanol and potassium hydroxide. Different proportions of diesel (B20, B40, B60, B80 and B100) were blended with lemongrass oil biodiesel. Apart from different proportions, the injection pressure was also changed with 200, 210, 230, 240 bars and the performance of each blend was investigated to study the emission characteristics. Various parameters such as oxides of nitrogen, smoke density, carbon monoxide, hydrocarbon and brake thermal efficiency against brake power of engine were studied. As compared to diesel, it was concluded that with increase in blend ratios Brake Specific Fuel Consumption (B.S.F.C.) decreases, emission of CO, hydrocarbon and smoke density is less for blend B20 with 240 bar injection pressure by 12%, 17%and 6.3% , NOx emission increases by 5.7% for B20 with 240 bar injection pressure [27].

Anticancer activity of lemongrass oil

Till now, only a few reports are available about the anticancer properties of lemongrass essential oil. It has been observed that the citral present in lemongrass oil is a new inducer of caspase-3 in tumour cell lines, which involves fragmentation of DNA and enhances caspase-3 catalytic activity, ultimately inducing apoptosis in various hematopoietic cell lines [7]. Kumar et al. reported the anti-cancer activity of isointermedeol, which is major component present in *C. flexuous,* in human leukaemia HL-60 cells [14]. This study revealed that in human leukaemia HL-60 cells isointermedeol induces apoptosis and was related with caspase activation and down-regulation of NF-êB expression. The caspase activation was through apical receptors and mitochondrial signalling pathways. As part of the mechanism, it was reported that after essential oil treatment, the cytochrome-c level increased which played a significant role in triggering apoptosis [14]. Sharma et al. [24] worked on human cancer cell lines HL-60, murine Ehrlich and Sarcoma-180 tumors in combination with electron microscopy for studying the anticancer activity of *C. flexuosus* essential oil. The study showed morphological variation supporting induction of apoptosis in cancer cell lines that were most likely activated by the lemongrass oil.

Lemongrass tea

Christopher et. al, reported the effects of lemongrass on Creatinine Clearance Rate (CCr) and Estimated Glomerular Filtration Rate (eGFR) in humans. A human trial was conducted where 55 men and 50 women aged between 18 to 35 years were orally given 2 gm, 4 gm and 8 gm of lemongrass powder on daily basis for 30 days. eGFR, creatinine, urea, pH, specific gravity and diuretic indices were tested at 0, 10 and 30 days after the start of treatment. It was observed that after 30 days the CCr and eGFR decreases significantly in both males and females. After 10 days CCr and eGFR remain unchanged in those subjects who were given 2 or 4 gm of lemongrass leaf powder whereas serum and urine creatinine level increases in both males and females. There was a significant increase in the serum urea in those who took 4 or 8 gm leaf powder for 30 days. It was concluded that lemongrass tea can play a significant role in reducing the toxicity in blood through kidney [8].

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