Extraction of essential oil from Cymbopogon citratus

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Abstract: Plant extracts are used in many industries for various applications. The process of extraction is chosen carefully in these industries as the biological oils that are obtained from plants are more sensitive to degradation than synthetic chemicals.
In this study, Cymbopogon citratus has been extracted using two processes of extraction – steam distillation and solvent extraction. The yields from the two processes and the quality of the oil obtained have been compared. The process of solvent extraction has been performed using two different solvents and the importance of choice of solvent has been discussed. Also, the role of extraction time and moisture content in solvent extraction has been demonstrated in the experiments.

Index Terms **– Cymbopogon, solvent extraction, steam distillation**

I. INTRODUCTION

Lemongrass, also known as citronella grass or fever grass, is a perennial plant which belongs to the family Poaceae and genus Cymbopogon of Kingdom Plantae. It is found in the tropical and sub-tropical regions of Asia, Africa and Australia. The lemony odour of the plant, which is also a very strong characteristic of its essential oil, is due to the high citral content, a combination of neral and geranial isomers, in its leaves. This makes the oil aromatic and fragrant. The various different components found in the essential oil impart diverse functionality to it. Lemongrass leaves yield 1-2% of essential oil on dry basis and the chemical composition can vary widely upon the genetic diversity.

The genus Cymbopogon comprises of about 180 species, sub-species and varieties which are widely distributed across all continents, although all species are not edible or fit for medicinal usage. Native to different places, species differ in their applicability and relevance in the commercial and medicinal usages. For example, C. excavatus Hoscht, which is native to South Africa, is used as insecticides, whereas C. ambiguous, native to Australia, is more useful for Headache remedy, chest infections, muscle cramp and Scabies. The two most prevalent species of Cymbopogon found in India are East-Indian Lemon Grass (*Cymbopogon flexuosus*), also called Cochin Grass or Malabar Grass and West-Indian lemon grass (*Cymbopogon citratus*). The species used in this paper is C. citratus. One of the best species of Cymbopogon, C. citratus is known by various different colloquial names around the world such as citronelle or verveine des indes in France and xiang mao in China. C. citratus is an evergreen clump forming plant which grows about 1-1.5 m long with long and thin leaves having a width of about 5-10 mm. The plant does not produce seeds and is propagated by means of root division. It is a highly commercially viable plant and is utilized by many industries around the world.

Lemongrass oil contains around 75-85% of citral and the quality of the oil is generally determined by its citral content. A number of bioactive compounds, like nerol, citronellal, terpinol, geraniol, and borneol are found in the oil, each having its own therapeutic activity making it useful for various medical conditions. Components such as citral, nerol and citronellal are examples of natural products called terpenes which are associated with the characteristic pleasant smell of various plants such as rose, lavender, mint, pine and lemon. Terpenes have 10 carbon atoms with double bonds or rings and aldehyde, ketone, or alcohol functional groups.

Citral is diuretic in nature, i.e. it imparts no biochemical changes to the body. Traditionally, lemongrass has been a part of many therapeutic and medicinal activities in Ayurveda and is used in food, beverages and medicines in many parts of India. It is used by various industries, namely pharmaceutical, perfumery, cosmetic, food, soap and detergent. Its antibacterial, antidiarrheal, anti-inflammatory, antimalarial, antiprotozoal, and antifungal activities make it very useful in the pharmaceutical industry. The essential oil also has neurobehavioral effect and is used as a sedative. The sweet lemony smell of the oil helps relieve stress, anxiety, irritability and insomnia, and prevent drowsiness, making it an ideal ingredient of aroma therapy. It is used as insect repellent and air freshener. It is also used in the manufacturing of various cosmetic products such as soaps, perfumes, shampoos, lotions and tonics.

Various methods, like steam distillation, fractional distillation, liquid liquid extraction, supercritical fluid extraction are used for the production of essential oil from C. citratus. The quality and quantity of the oil produced differs with each method. The two most conventional methods are steam distillation and hydro distillation. Many novel techniques are being investigated to produce better quality oil with better optimization of resources. Examples of such techniques are pressurized liquid extraction using nitrogen and supercritical extraction using CO2 under high pressure. Essential oil is a biological product, which is more susceptible to degradation; hence maintaining factors such as temperature during separation becomes important.

II. MATERIALS AND PROCEDURE

2.1 Leaves of lemongrass

Lemongrass (Cymbopogon citratus) leaves were freshly cut and collected. For better results, the leaves were cut very finely to get larger contact area for better yield of essential oil.

2.2 Choice of solvent for extraction

On the commercial scale, the success of the extraction is based highly on the choice of solvent. The choice is made on the basis of the physical and chemical properties of the solvent. These properties include selectivity, density, boiling point, viscosity, reactivity, solubility, distribution coefficient, recoverability, stability and interfacial tension. Availability and cost of the solvent are also important criteria that must be considered. For health and safety considerations, the solvent must be tested for flammability and toxicity and its disposal must not endanger the environment. The most frequently used organic solvents are aliphatic hydrocarbons (propane, butane, hexane), alcohols (methanol, ethanol, 2-propanol), hydrocarbons with a carbonyl group (acetone, methyl acetate) and halogen derivation (dichloro methane, dichloroethane, freons) The solvents used in this paper for experimentation are: acetone, toluene and methanol.

2.3 Solvent Extraction

20g of the sample of finely cut lemongrass was placed in a 250ml clean flat bottom flask. 100ml of Toluene solvent was poured into the flask and was kept undisturbed for six sets of time duration. These six sets were 15mins, 30mins, 45mins, 60mins, 75mins and 90mins. After the time duration of a particular set was over, the extract was decanted into another 250ml beaker. As the essential oil is soluble in methanol, 26 ml of methanol was added to extract it. The solution mixture was then transferred to 500ml separating funnel .The contents of the separating funnel were left undisturbed to allow it to reach equilibrium. The mixture separated into two layers because of the difference in their densities. The upper layer had methanol with the essential oil dissolved in it and the lower layer had toluene. A 250ml beaker was used to separate the lower Toluene layer. The upper layer was then poured from the separating funnel into another 250 ml beaker which was placed in a water bath. Heating of the water bath was done at 65^{o}C, the boiling point of methanol, to volatilize methanol and obtain the natural essential oil. An electronic weighing machine was used to weigh the extract and determine the yield. The weight of essential oil was the difference between the initial and the final weight of the beaker.

The same procedure was repeated with acetone as the solvent. 20g of the sample of finely cut lemongrass was placed in a 250ml clean flat bottom flask. 100ml of Acetone solvent was poured into the flask and was kept undisturbed for 6 sets of time duration. The extract was decanted into another 250ml beaker. 26ml of methanol was added to the extract. The solution mixture was then transferred to 500ml separating funnel .The content of the separating funnel, after being left undisturbed to reach equilibrium, separated into two layers. The two layers were poured into separate beakers. The upper methanol layer was heated to 65^{o}C to remove methanol and obtain the essential oil. The weight of the essential oil was observed and the yield was calculated.

The yield of extraction was compared for different situations using time and moisture content as parameters.

2.3.1 Moisture content- The procedure was performed on two different sets of lemon grass. The first set was dried in the sunlight for 6 hours to attain minimum moisture content (~0%) and the second set was freshly brought with general moisture content (~8%). Yield was calculated for each set and the readings of the experiment were plotted on the graph for comparison.

2.3.2 Time- The procedure was performed on 6 different sets of time period to understand the relationship between the time required for the lemongrass to mix with the solvent and the yield obtained.

2.4 Steam Distillation

20g of fresh lemongrass sample and 100ml of distilled water were placed in a 1 liter round bottom flask .The flask was fitted with a rubber stopper and was connected to a heater and a condenser . Water at 0^{o}C flowed counter currently to condense the incoming steam in the condenser. When the water started boiling, it started ripping out the essential oil from the lemongrass. The mixture of essential oil and water vapor was passed through the condenser where it condensed into liquid. The condensate was collected in a 500ml beaker and poured into a separating funnel where it formed two layers of liquid. The upper layer had the essential oil, while the lower layer consisted of water. To remove the water the tap of the funnel was opened. The oil was poured into a 100ml bottle from the separating funnel. To avoid vaporization the bottle was tightly closed. The weight of the oil was observed with the help of an electronic weighing machine and the yield was calculated.

2.5 Determination of yield

Yield of oil that obtained was calculated by:

$$\text{Yield of essential oil} = \frac{\text{amount of essential oil (g) obtained}}{\text{amount of raw materials (g) used}} \qquad (1)$$

III. RESULTS AND DISCUSSION

The industries that require plant extracts as raw material need procedures and methodologies of separation and purification that are capable of giving best quality and quantity of yield and are economically feasible.

In this experiment, the difference in yield with different methodologies is demonstrated. Also, the role of parameters such as extraction time and moisture content of lemongrass in the yield percentage is observed and discussed.

3.1 Calculation and comparison of yields

Table 3.1: Comparison of the three methods used

Method Of Extraction	Weight Of Lemongrass	Amount Of Essential Oil Obtained	%Yield
Solvent extraction(Toluene)	20 gm	0.172gm	0.86
Solvent extraction(Acetone)	20 gm	0.115 gm	0.575
Simple steam distillation	20 gm	0.132 gm	0.66

Table 3.2: Extraction using Toluene as solvent

Time (minute)	15	30	45	60	75	90
Yield (0%moisture)	0.36	0.74	0.83	0.86	0.86	0.865
Yield (8%moisture)	0.35	0.72	0.80	0.84	0.84	0.85

Figure 1: Extraction using Toluene

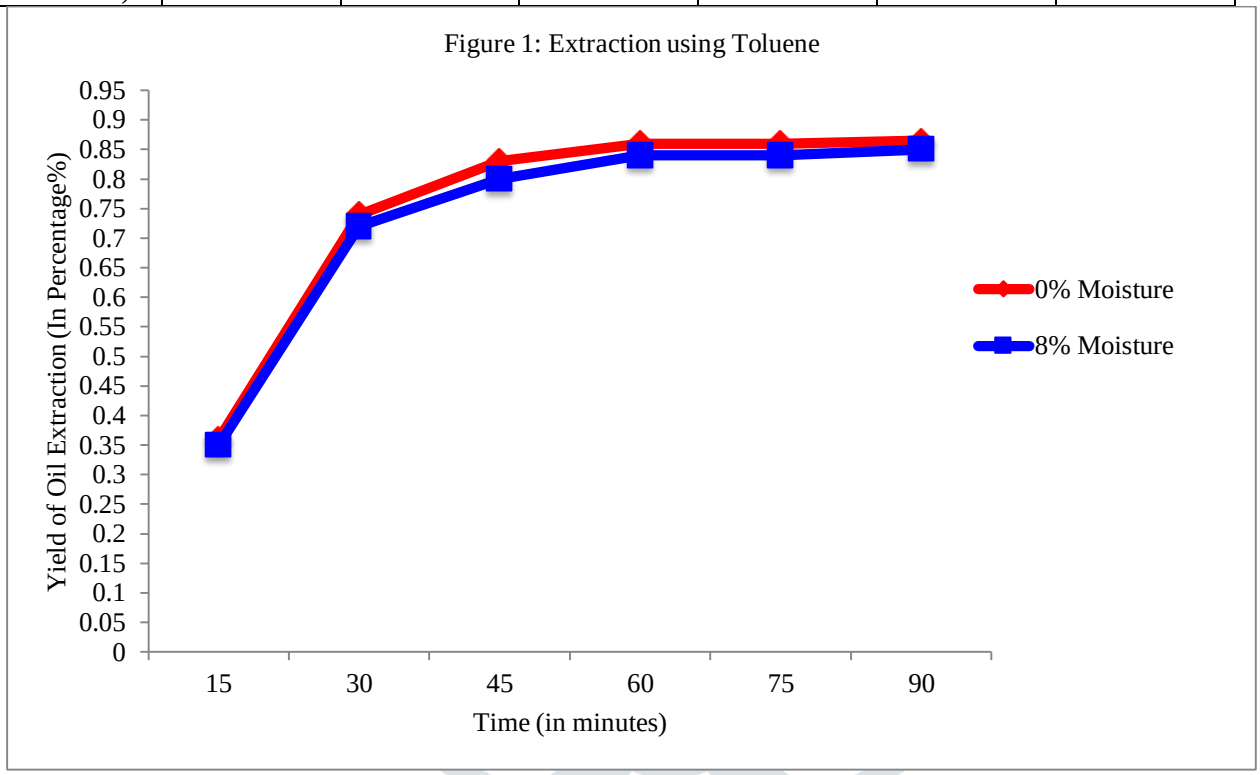
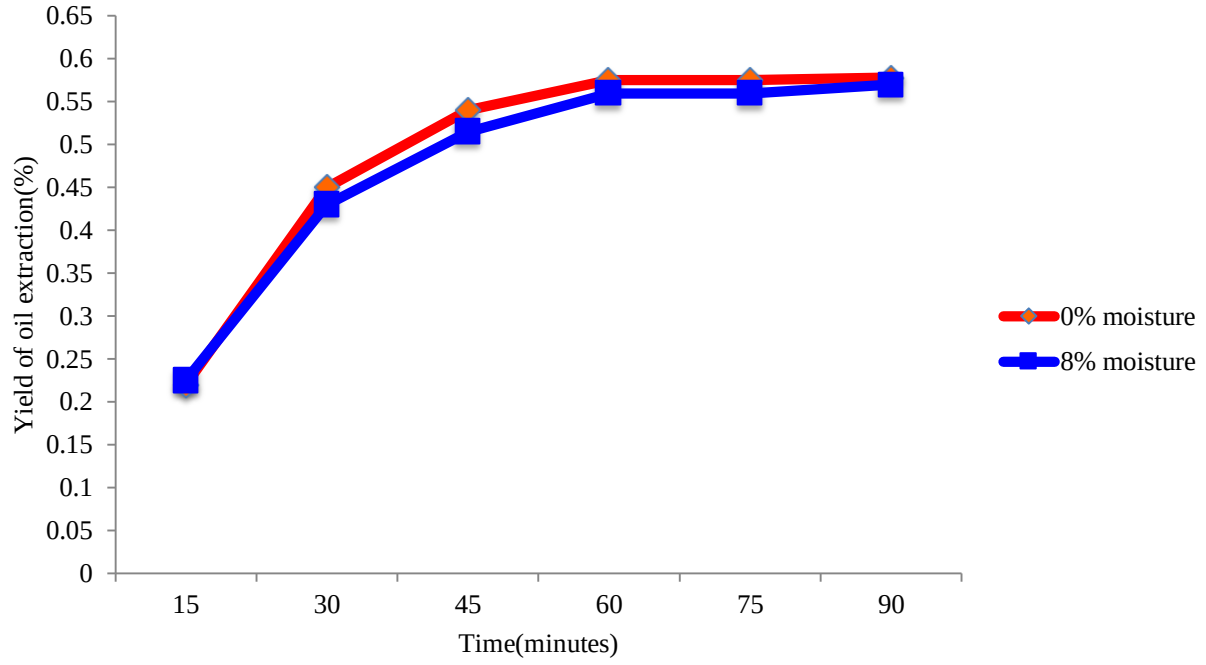


Table 3.3: Extraction using Acetone as solvent

Time (minute)	15	30	45	60	75	90
Yield (0%moisture)	0.22	0.45	0.54	0.575	0.575	0.58
Yield (8%moisture)	0.225	0.43	0.515	0.56	0.56	0.57

Figure 2: Extraction using Acetone



3.2 Observation

It was observed that the essential oil obtained was a viscous liquid and it was yellow to dark yellow in colour. It turned red on prolonged storage. Presence of water imparted a turbid appearance to the oil.

From the data of this experiment, it was observed that solvent extraction with toluene gave a better yield than steam distillation. The choice of solvent impacted the separation yield. The difference in the yields with Toluene and Acetone as solvents was because of the difference in the degree of solubility, density and boiling point. It was observed that the weight of the essential oil collected increases with increase in time of heating during separation.

The percentage of oil extracted increased rapidly within the first 30 minutes of initiating the process. With further increases in time, the mass transfer rate of oil to the liquid phase decreased until reaching equilibrium. After 60 minutes, the oil concentration in the liquid phase remained almost constant with further increase in time.

It was observed that lower level of moisture content in the lemongrass leaves lead to considerable increase in extraction efficiency.

IV. Conclusion

Essential oils from plants are heat sensitive, insoluble in water and tend to degrade and decompose at harsh conditions. The separation and purification methods used for such biochemical must give a good quantitative and qualitative yield without destroying the bioactive components of the oil.

With the correct choice of solvent, the method of solvent extraction tends to give a better yield than steam distillation. However the former is a more expensive process that the latter. Temperature must be optimum in the process of steam distillation. It must be high enough to vaporize the essential oil, but must not destroy it.

Solvent extraction is most commonly used in the industries for plants such as jasmine and hyacinth that are too sensitive for the heat of distillation process. Essential oil obtained from solvent extraction is highly concentrated and the fragrance is close to that of the material used. The disadvantage with solvent extraction is that traces of the solvent might be present in the finished product, which makes this process unsuitable for the production of therapeutic grade oils.

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