# Parametric Study on the Extraction of Essential Oil from Lemongrass (*Cymbopogon Citratus*)

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## Abstract

Due to the numerous benefits of essential oil, its demand is increasing globally. Despite this, one of the challenges involved with the essential oil extraction from lemongrass is the low oil yield, the current work investigated the effect of operating parameters contact time (1-5 h), particle size (0.5-2.5 cm) and volume (100-300 ml) on the yield of essential oil from lemongrass (*Cymbopogon citratus*) using Soxhlet extraction to determine the best operating conditions resulting in highest oil yield. The results show that as the particle size increased from 0.5cm to 2.5cm, the yield of lemongrass oil decreased from 1.62 to 1.225%. Conversely, as the contact time and solvent volume increase, the oil yield also increases. Considering the results from different operating parameters, contact time imparted much on the oil yield, and the maximum yield of lemongrass oil is 1.7% obtained using 100g of dried lemongrass, particle size of 0.5cm and contact time of 5hr. This information will serve as important resources to the essential oil industry.

## 1. Introduction

The recovery of natural product such as plants oil dates back to Egyptian and Mesopotamian times, where manufacturing of perfumery, pharmaceutical and waxes products was the major trade and occupation [1]. Such oils are known as essential oil. Currently, essential oil of lemongrass has gained attention in the recent times. Due to the growing concern of consumers over the ingredients from natural sources and the awareness about potentially harmful synthetic spices additives, the desire for essential oils globally is increasing. Lemongrass (*Cymbopogon Citratus*) is a medicinal perennial plant which has long, thin leaves and predominantly cultivated in the tropics and subtropics like Nigeria, India, Thailand, Australia and Oceania South America [2, 3]. Lemongrass plant belongs to Graminae (Poaceae) family and genus *Cymbopogon*. The Graminae (*Poaceae*) family has more than 700 genera and about 11,000 species as reported in the work of [4]. According to [5], lemongrass plants persist for many growing season and it produces essential oil. These oils are volatile and odoriferous aromatic, and are located in the cells, ducts and glands of leaves, barks, roots, buds, flowers and fruits of most plants. The essential oil from the lemongrass constitutes of 1-2% on dry basis and the chemical composition depends largely on genetics. It contains many organic compounds like phenol, citral, geranial, terpenoids, benzenoids and other nitrogenous compounds which help in metabolic process of plant. The lemony characteristic flavour is due to the presence of citral which is the most dominant constitutes. Lemongrass essential oil has found broad applications in food (culinary), pharmaceutical/medicinal and perfumery/cosmetics industries [3]. It has a sweet, refreshing aroma, antifungal/antibacterial properties [6, 7].

Usually, essential oil is extracted from the lemongrass using hydrodistillation (HD), steam distillation, steam and water distillation, maceration, enfleurage, empyreumatic (or destructive) distillation [8-10]. The method used for extraction may influence the composition of the extract as a result of thermal degradation, hydrolysis and water solubilization of

the fragrance components [11]. The use of organic solvent could also contaminate the fragrance of the oil and this might be dangerous if such fragrance is to be consumed as food. These problems can be overcome by using methods such as microwave-assisted extraction, ohmic-assisted hydrodistillation, subcritical water, ultrasound-assisted extraction and microwave-assisted hydrodistillation [12-16]. Carbon dioxide extracts are solvent-free and do not undergo thermal degradation as steam distilled oil do, although its application is constrained by its low polarity [17]. Some of the extracts are usually thick as it contains fats, resins and waxes giving rise to high molecular weight which depending on the final product might not be desirable [18]. These methods help to reduce the extraction time, increase yield and reduce the cost of the operation. The yield of oil from the plant is usually small. At the moment, researchers are investigating the possibilities of increasing the yield, because of its numerous benefits and the absence of side effects when ingested.

However, not much work have been done on investigating the impact of some operating parameters on the yield of essential oil from lemongrass leaves using Soxhlet extraction method, as most of the studies in this area has been centred on steam distillation method. Besides, some operating parameters affecting Soxhlet extraction of lemongrass oil using ethanol as solvent is scarce in literature. Therefore, this work aimed at extracting oil from lemongrass with Soxhlet extractor apparatus using ethanol as solvent and as well investigating the effects of particle size, contact time and volume of solvent on the percentage oil yield to identify optimum condition for extraction of lemongrass oil.

## 2. Materials and Methods

Fresh lemongrass leaves were harvested from a private garden in Ozoro located at 5° 32′ 18″ N, 6° 12′ 58″ E, Delta State, Nigeria. The Reagents used were of analytical grade. 250ml Shuniu GG-17 Soxhlet extractor was used for extracting the oil, and Setra analytical weighing balance BL-410s was used to measure the weights of the materials.

### 2.1. Sample preparation

Sample was washed and dried for eight (8) hours in an oven to reduce the moisture content. The dried lemongrass leaves were kept in a sealed bag to avoid direct sunlight. Thereafter, the dried lemongrass leaves were cut with a knife into various sizes of 0.5cm, 1.0cm, 1.5cm, 2.0cm and 2.5cm so as to increased contact area of the plant matrix.

### 2.2. Experimental procedure

100g of 0.5cm particle size lemongrass samples was measured using weighing balance. The weighed sample was put into extractor thimble and 300ml of ethanol was added into the flask. The heating mantle was set at a pre-determine temperature according to the boiling point of the solvent use for the experiment and the extraction was conducted for 1 hr. Thereafter, the experimental set up was dismantled and mixtures of solvent and extracted oil obtained were placed on rotary evaporator set at speed of 110 rpm. This was done to enable the recovery of solvent from sample by evaporation under reduced pressure. Thereafter, extracted oil was kept in desiccators for 25 minutes and weight of oil extract was determined using digital electronic weighing balance. The above steps were repeated for five (5) times at one (1) hour time intervals considering the effects of operating conditions/parameter as stated below;

a) **Effects of particle (solid material) size** on oil yield was done by using 300ml of different solvents and 100g each of particle size- 0.5, 1.0, 1.5, 2.0 and 2.5cm of lemongrass sample for 1 hour.

b) **Effect of contact time** on yield was done using 300ml of different solvents and 100g of 0.5cm particle size lemongrass sample. Five different contacts duration of one (1) hour intervals was used to study effect of extraction time on yield.

c) **Effect of volume of solvent to solid ratio** on oil yield was performed using 100g of 0.5cm particle size lemongrass sample for 100, 150, 200, 250 and 300ml solvent for 1 hour.

The percentage oil yield was evaluated by gravimetry. The difference in final weight (beaker + extract) and initial weight (weight of empty beaker) was recorded as essential oil weight. The percentage oil yield was calculated using Equation 1.

$$\text{Oil yield} = \frac{\text{Weight of extracted oil}}{\text{Weight of lemongrass sample}} \times \frac{100\%}{1} \tag{1}$$

## 3. Results and Discussion

### 3.1. Effect of particle size on lemongrass oil yields

Experiments were conducted using 100g of different particles (lemongrass) sizes 0.5, 1.0, 1.5, 2.0 and 2.5cm, and 300ml of ethanol to investigate the effect of particle size on the yield of lemongrass oil by solvent extraction. The result obtained is presented in Figure 1 and it shows that the yield of lemongrass oil decreases with increase in particle size. The maximum yield was 1.625% obtained using 0.5 cm of lemongrass and this is in agreement with the findings of [19].
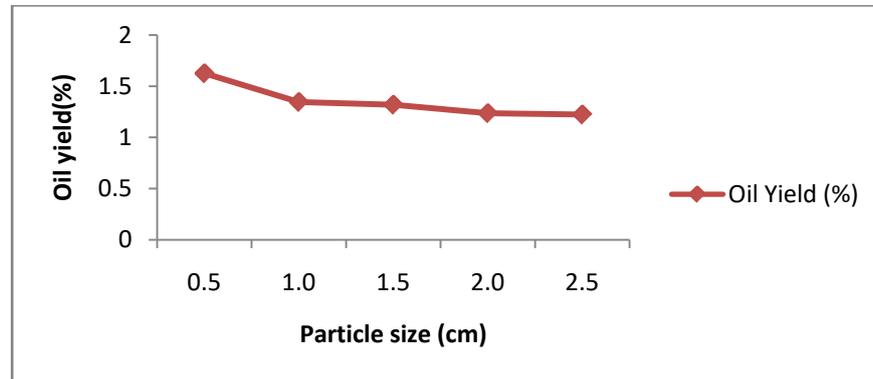
**Figure 1. Effect of particle size on yield of oil using 100g of lemongrass, 300ml of ethanol and contact time of 1 hour.**

Conversely, the bigger particle size will yield very little oil at initial stage of extraction process but because they have large surface area to continue, oil yield will be increasing as extraction time increased until when the extraction process is completed. This observation also agreed with findings of [20, 21]. [22] has also observed that extraction rate increase with decrease in size of particles and this is in agreement with result presented in Figure 1. According to [23], higher oil yield is usually obtained from smaller particle size due to the bigger interfacial area of the solid. Furthermore, reports have showed that if the particle sizes are tiny, the percentage oil yield becomes small in quantity. This trend could be as result of the assembly of the fine particles which reduces the effective surface area available for the free flow of solvents towards the inner core of solid particles. According to [21], for three different particle size ranging from<0.5mm, 0.5-0.75mm and >0.75mm, higher oil yield was reported for intermediate particle sizes suggesting that decreasing particle size below certain size does not increase percentage oil yield instead a decrease may be observed.

### 3.2. Effect of extraction time on lemongrass oil yield

This was evaluated at extraction time 1-5 h using 300ml of ethanol, and 100g of lemongrass with a particle size of 0.5 cm. The result obtained is presented in Figure 2. The figure shows that the yield increased as the extraction time increases until after 4 h, when it tends to be constant. This means that the extraction rate was high at the beginning of the process and slow towards the end. The trend is in agreement with those obtained by [24, 25]; and [16], although, the current optimum yield of 1.653% is greater than 1.46% obtained by [16] using microwave-assisted hydrodistillation at 90 minutes extraction time. This difference could be attributed to the extraction time and method of extraction used. The result validates the Fick's second law of diffusion which states that final equilibrium is achieved by the solute concentrations in plant matrix and in the solvent after a certain period of time [26, 16].
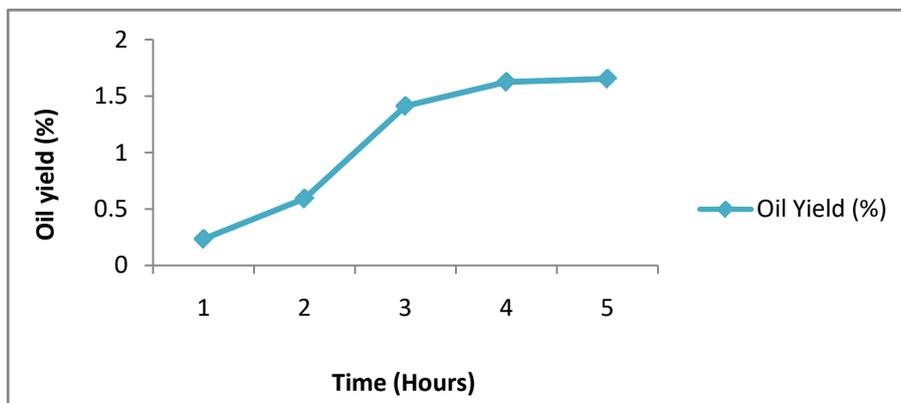


**Figure 2. Effect of extraction time on the yield of lemongrass oil extracted for 1-5 h using 300 ml of ethanol, and 100g of lemongrass with a particle size of 0.5 cm.**

### 3.3. Effect of ethanol volume on lemongrass oil yield

This was conducted using ethanol volume of 100, 150, 200, 250 and 300 ml, extraction time of 1 hour and 100g of 0.5 cm particle size lemongrass sample. The result obtained is presented in Figure 3. This shows that the yield of the lemongrass oil increases with increasing solvent volume leading to a maximum yield of 1.619% obtained after 1 hr. The effect is probably due to increased mass transfer as this, increases with concentration gradient. The result obtained was corroborated with that presented by of [27, 28].
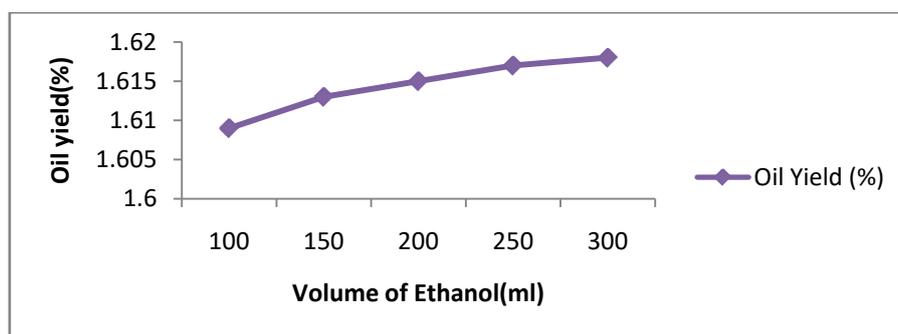
**Figure 3. Effect of volume of ethanol on lemongrass oil yield using 100 g of lemongrass and at 1.**

## 4. Conclusion and Recommendation

From findings of this research work, operating parameters/variables such as particle sizes, contact time, and solid to volume ratio affects oil yield of lemongrass oil extraction. For optimal yield of lemongrass oil using Soxhlet extractor with ethanol as solvent, particle size of 0.5cm, contact time of 5 hours and volume of 300ml gave the highest yield.

## References

[1] Bart, H. J. and Pilz, S. (2011). Extraction of Natural Products from Plants—An Introduction (ed.) industrial Scale Natural Products Extraction, 1st ed., Wiley- VCH Verlag GmbH & Co.

[2] Suryawanshi, M. A., Mane, V. B., and Kumbhar, G. B. (2016). Methodology to extract essential oils from lemongrass leaves: solvent extraction approach. *International Research Journal of Engineering and Technology (IRJET)*, 3(8), 1775-1780.

[3] Ganjewala, D. and Luthra, R. (2010). Essential oil biosynthesis and regulation in the genus Cymbopogon. *Natural Product Commun.*, 5: 163-172.

[4] Bertea, C. M. and Maffei, M. E. (2010). Essential oil-Bearing Grasses, Medicinal and Aromatic Plants Industrial Profiles. International Standard Book, (26) 978-0-8493-7857-7, Edited by Anand Akhila, CRC Press Taylor & Francis Group.

[5] Joy, P. P., Mathew, S., Skaria, B. P., Mathew, G., Joseph, A., and Sreevidya, P. P. (2006). Lemongrass. Aromatic and Medicinal Plants Research Station Odakkali, Asamannoor, Kerala, India, 1-32.

[6] Ukpong, I. G, Ettah, H. E., and Eshuong, E. E. (2016). Studies on mosquito repellent activity of cymbopogoncitratus (lemon grass) using human volunteers. *International Journal of Research—Granthaalayah*, 4(12), 41-47. https://doi.org/10.5281/zenodo.221591.

[7] Anaruma, N. D., Schmidt, F. L., Duarte, M. C, Figueira, G. M., Delarmelina, C., Benato, E. A., and Sartoratto, A. (2010). Control of Colletotrichum gloeosporioides (Penz.) Sacc. in yellow passion fruit using Cymbopogon citrates essential oil. *Brazilian Journal of Microbiology*, 41: 66-73. doi:10.1590/S1517-83822010000100012.

[8] Dhobi, M., Mandal, V., and Hemalatha, S. (2009). Optimization of microwave assisted extraction of bioactive flavonolignan-silybinin. *Journal of Chemical Metrology*, vol. 3, no. 1, pp. 13-23.

[9] Djouahri, A., Boudarene, L., and Meklati, B. Y. (2013). Effect of extraction method on chemical composition, antioxidant and anti-inflammatory activities of essential oil from the leaves of Algerian Tetraclinisarticulata (Vahl) Masters. *International journal of Industrial crops and products*, 44: 32-36. https://doi.org/10.1016/j.indcrop.2012.10.021.

[10] Joy, P. P., Thomas, J., Mathew, S., Jose, G., and Joseph, J. (2001). Aromatic plants. Tropical Horticulture Vol. 2. NayaPrakash, Calcutta, 633-733.

[11] Sibel, K., Sedef, N., Nural, K., Sahin, S., Gulum, S., and Beste, B. (2012). Microwave-assisted hydrodistillation of essential oil from rosemary. *Journal of Food Science and Technology*, 51(6): 1056-1065. doi:10.1007/s13197-011-0610-y.

[12] Wang, H., Liu, Y., Wei, S., and Yan, Z. (2010). Comparative seasonal variation and chemical composition of essential oils from the leaves and stems of Schefflera heptaphylla using microwave-assisted and conventional hydrodistillation. *Journal of Indutrial Crops and Product*, 36(1): 229-237. doi.org/10.1016/j.indcrop.2011.09.011.

[13] Mohsen, G., Asgar, F., Katayoun, J., and Mahsa, M. (2012). Comparison of ohmic-assisted hydrodistillation with traditional hydrodistillation for the extraction of essential oil from Thymus vulgaris L. *Journal of Innovative Food Science and Emerging Technology*, vol. 14, pp. 85-91.

[14] Mohammad, H. E., Fereshteh, G., and Soosan, R. (2007). Subcritical water extraction of essential oil from coriander seeds (Coriandrum sativum L). Journal of Food Engineering, vol. 80, pp. 735-740.

[15] Porto, C. D. and Decorti, D. (2009). Ultrasound-assisted extraction coupled with under vacuum distillation of flavor compounds from spearmint (carvone-rich) plants: Comparison with conventional hydrodistillation. *Ultrason Sonochem*, vol. 16, pp. 795-799.

[16] Ranitha, M., Abdurahman, H. N., Ziad, A. S., Azhari, H. N., and Thana Raj, S. (2014). A Comparative Study of Lemongrass (Cymbopogon Citratus) Essential Oil Extracted by Microwave-Assisted Hydrodistillation (MAHD) and Conventional Hydro-distillation (HD) Method. *International Journal of Chemical Engineering and Application*, 5(2): 104-108. Doi: 7763/IJCEA.2014.V5.360.

[17] Manjare, S. D. and Dhingra, K. (2019). Supercritical fluids in separation and purification: A review. *Mater Sci Energy Technol.*, 2(3): 463-484.

[18] Renkel, S. L. (1989). Personal communication.

[19] Shah, M., Shrivastava, P., and Singh, N. (2014). Microwave-assisted extraction of lemongrass essential oil: Study of the influence of extraction method and process parameters on extraction process. *Journal of Chemical and Pharmaceutical Research*, 6(11): 385-389. Available online www.jocpr.com.

[20] Akhihiero, E. T., Ayodele, B. V., and Akpojotor, G. E. (2013). Effect of particle size and temperature variation on the yield of essential oil from lemon grass using steam distillation. *African Journal of Physics*, 6: 105-112.

[21] Sayyar, S., Zainal, A. Z., Yunus, R., and Muhammad, A. (2009). Extraction of Oil from Jatropha Seeds-Optimization and Kinetics. *American Journal of Applied Sciences*, 6(7): 1390-1395.

[22] Sirisompong, W., Jirapakkul, W., and Klinkesorn, U. (2011). Response surface optimization and characteristics of rambutan (Nepheliumlappaceum L.) kernel fat by hexane extraction. *LWT Food Science and Technology*, 44 (9), 1946-1951.

[23] Sulaiman, S., Abdul Aziz, A. R., and Aroua, M. K. (2013). Optimization and modeling of extraction of solid coconut waste oil. Journal of Food Engineering, 114: 228-234. http://dx.doi.org/10.1016/j.jfoodeng.2012.08.025.

[24] Meziane, S., Kadi, H., and Lamrous, O. (2006). Kinetics study of oil extraction from olive foot cake. *Grasas Adeites*, (57): 175-179.

[25] Hazwan, H. M., Hasfalina, C. M., Hishamuddin, J., and Zurina, Z. A. (2012). Optimization and kinetics of essential oil from Citronella grass by ohmic heated hydrodistillation. *International Journal of Chemical Engineering and Applications*, vol. 3, pp. 173-177.

[26] Rodligues, C. E. C., Silva, F. A., Marsaioli, A. Jr., and Meirelles, A. J. A. (2005). Deacidification of Brazil nut and Macadamia nut oils by solvent extraction: Liquid-liquid equilibrium data at 298.2 K, J. Chem. Eng. *Data*, 50, 517-523.

[27] Ajala, O., Aberuagba, F., Olaniyan, A. M., and Onifade, K. R. (2016). Optimization of solvent extraction of shea butter (Vitellariaparadoxa) using response surface methodology and its characterization. *J Food Sci Technology*, 53(1): 730-738. doi: 10.1007/s13197-015-2033-7.

[28] Meziane, S. and Kadi, H. (2008). Kinetics and thermodynamics of oil extraction from olive cake. *Journal of American Oil Chemist Society*, 85, 391-396.