Nigerian Research Journal of Chemical Sciences **(ISSN: 2682-6054)**
Vol. 7, 2019

EFFECTS OF PARTICLE SIZE ON THE YIELD OF ESSENTIAL OIL EXTRACTED FROM EUCALYPTUS (*CITRIODORA*)

*[1]Akuso, S. A., [1]Kabiru M., [1]Victor O., [1]Abubakar, G.,[1]Nwobi, B. E., [2]Apugo-Nwosu, T. U., and [1]Batari, M. L.

[1]National Research Institute for Chemical Technology (NARICT), Zaria, Kaduna State

[2]Department of Chemical Engineering, Michael Okpara University of Agriculture, Umudike, Abia State

*Corresponding author: alkaliakuso@gmail.com or alkalisamuel1962@yahoo.com

ABSTRACT

The effect of particle size onvolume and yield of oil extracted from eucalyptus leaves (*citriodora*) with time was studied using steam distillation technique via apilot plant. The effect of particle sizesof 10, 20, 30, 40 and 50 cm of the eucalyptus leaves were used to find the best particle size that could achieve maximum oil yield. The results showed that particle size of 10 cm for 60 minutes extraction gave the highest percentage yield of oil (0.6177 wt %) compared to particle size of 50 cm with percentage yield of oil (0.3291 wt %) for the same extraction time of 60 minutes.The results showed that, increasing extraction time beyond sixty minutes had no effect on the amount and yield of the oil as long the capacity of the tank remains constant. Physicochemical properties of the extracted oil revealed that;refractive index at 25^{o}C was 1.4425, specific gravity at 25 ^{o}C was 0.9015 and acid value was 19.465ml/gram.

Keywords: Essential Oil, Eucalyptus (*citriodora*) leaves, extraction, oil yield, particle size, steam distillation technique.

INTRODUCTION

Essential oils are volatile, natural base products, which are found in spices, aromatic and medicinal plants. The extraction of essential oils is well known from ages when pure essential oil and crude extract of essential oil bearing plants, herbs and grasses were in use for various medicinal and fragrances, flavors, preservatives and insect repellants purposes [1-2], flavoring chemicals, aromatic in pharmaceutical products, food, perfume and industrial [3].

Eucalyptus plant is commonly grown in tropical and sub-tropical regions because of its resistance to many pest and adaptability to various climatic conditions. These include South Africa, China, CongoRepublic, Angola, India and West Africa. The plant has up to 700 species and can grow as high as 40 m tall in an altitude of 600m. The principal component of the essential oil extracted from eucalyptus*citriodora* leaf is cineola which is up to 70 - 80%. The oil is mainly used in medicinal, industrial and perfumery applications. The yield of essential oil is naturally constrained (usually less than 2%) but with high market value [4]. Eucalyptus oil has many biological effects such as, antiviral, antifungal and antibacterial components and also uses against the effect of influenza, cold, arthritis and other respiratory infection, rhinitis and sinusitis [3, 5].

Inspite of the abundant deposit of untapped raw materials for the production of essential oils, Nigeria is still importing essential oils to meet the demand of the end users of the product. This study aimed at investigating the effect of particle size on the yield of essential oil from plant material eucalyptus (*citriodora*) leaves by steam distillation using pilot plant.

MATERIALS AND METHODS

Material Sourcing and Preparation

Fresh eucalyptus *citriodora* leaves were obtained from National Research Institute for Chemical Technology (NARICT) plantation in Zaria, Kaduna State, Nigeria. The leaves were pretreated and freed from foreign (dirt) materials. 15 kg each of the eucalyptus leaves of particle sizes of10, 20, 30, 40and 50 cmwere weighed for five batch operations. Figure 1 shows picture of eucalyptus *citriodora* leaves plant.

Figure 1: Eucalyptus *citriodora* leaves

Extraction of Essential Oil

The experimental pilot plant set-up for steam distillation extraction as shown in Figure 2 issituated at National Research Institute for Chemical Technology (NARICT), Zaria-Kaduna State, Nigeria. The plant consists of cylindrical tank still, condenser, steam generation and cooling water units. 25 litres of water was charged into the steam generation unit of the tank still which is situated directly at the bottom of the tank still. The oil extraction chamber is separated from the boiler section by a stainless steel weir mesh. 15 kg of the leaves was then charged into the tank still from the top and the lid was properlytight to avoid steam-oil leakage. The fuel used is fire wood as source of energy to generate the steam used in the extraction.The extraction time of the process was sixty minutes per batch operation.

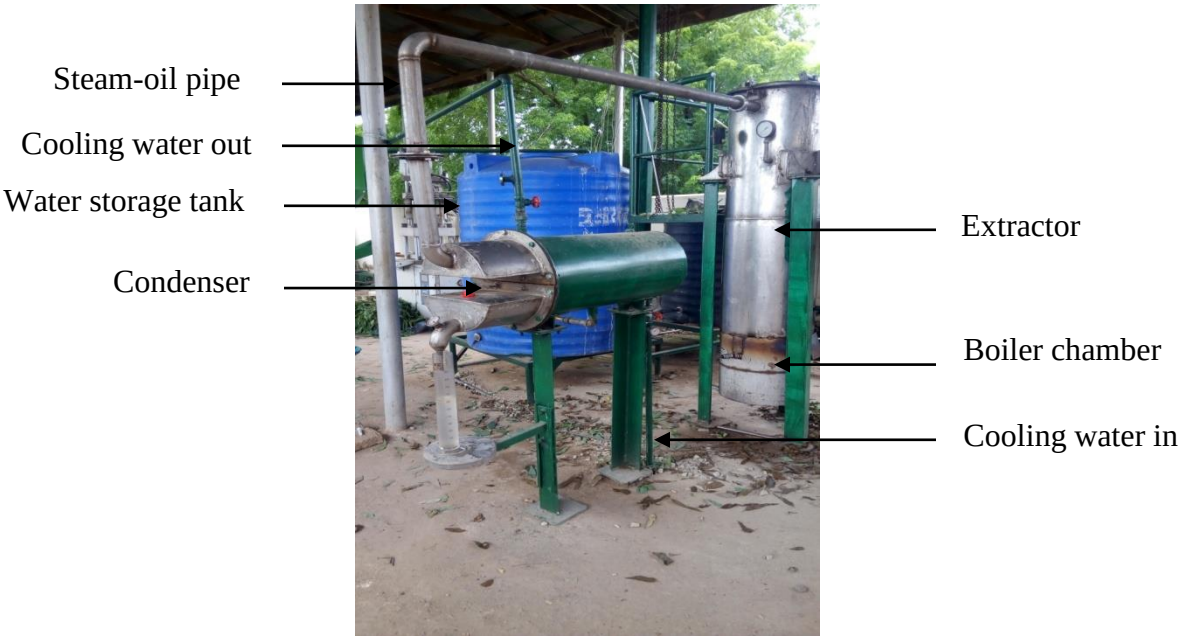

Figure 2: Essential oil extraction pilot plant set-up

The steam generated from the boiler section travelled across the packed bed of leaves and ruptured the plant cell and extracted the oil which was carriedaway by the stream of steam to the condenser. The flow of steam-oil mixture in the condenser and cooling water was counter current for effective condensation. The condensate (oil-steam water mixture) was collected in a separating flask at various time intervals and separated through decantation process as shown in Figure 3. The volume of oil collected weredetermined every sixty minutes and recorded.

Figure 3: Separating process of essential oil and water

The blockdiagram for the extraction of essential oil using steam distillation pilot plant is as shown in Figure 4 below.

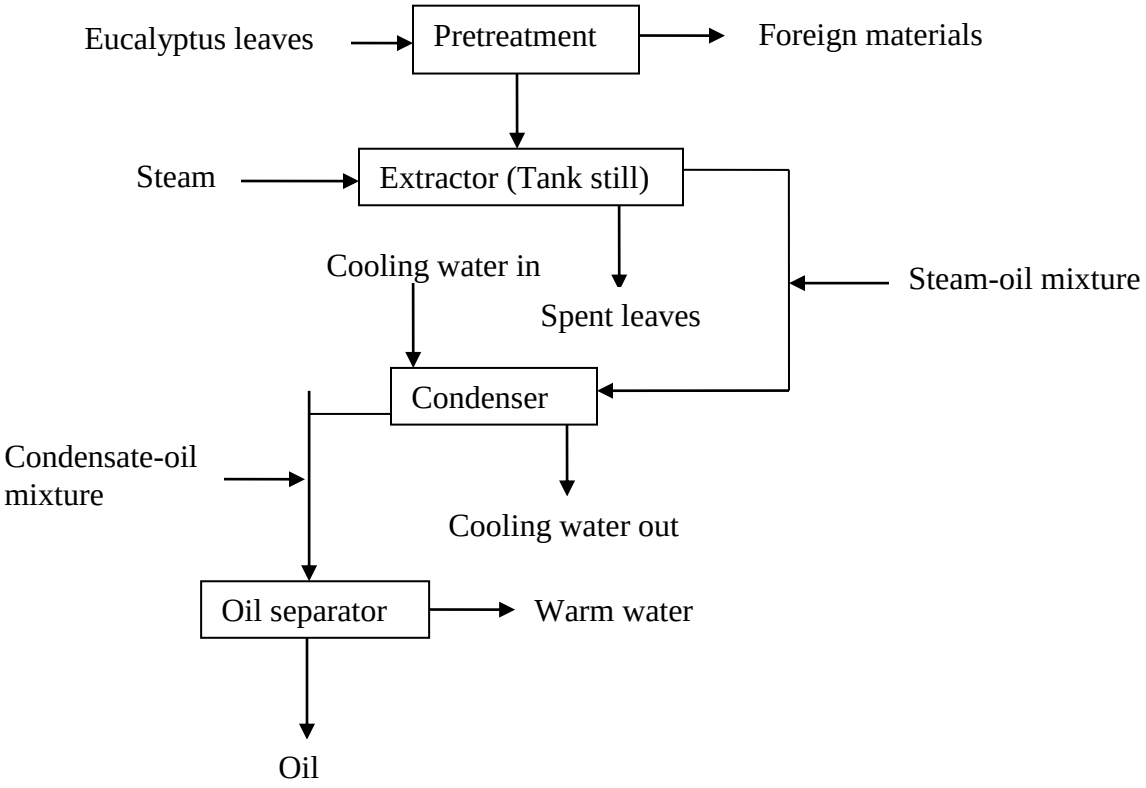

Figure 4: Block diagram of essential oil extraction

Determination of Physicochemical Properties of the Extracted Oil

Physicochemical properties of the extracted essential oil from eucalyptus leafy plant such as refractive index, specific gravity, solubility in ethanol and acid value were determined according to the methods described by [3, 6].

RESULTS AND DISCUSSION

Effect of Particle Size on Oil Volume

The effect of particle size was studied for five different samplesof 10, 20, 30, 40and 50 cmper batch of production cycle of sixty minutes until equilibrium was reached. As seen from Table 1 below that the amount of essential oil extracted was higher for particle size of 10 cm when compared to the largest particle size of 50 cm. This shows that particle size has a significant effect on the amount of oil extracted as long the capacity of the tank still remains constant. The higher the particle size the more the packing density of the plant material in the tank still which results in resistance to flow of steam and oil across the packed bed. In each extraction circle, the oil collected, extraction time, weight andyield of oil were all recorded as shown in Table 2 below. The same procedure was repeated for 20, 30, 40, and 50 cm of particle sizes of leaves.The weight (wt) and percentage yield (%) of the extracted oil was calculated using Equations (1) and (2) below.

Table 1: Oil volume (ml) extracted at various particle sizes

S/N	Time (minute)	Oil volume (ml) at various particle sizes of leave				
		10 cm	20 cm	30 cm	40 cm	50 cm
1	10	21	17	13	11	9
2	20	55	48	31	27	21
3	30	78	67	44	40	37
4	40	95	84	56	52	48
5	50	105	91	66	61	56
6	60	107	93	67	62	57

Table 2: Oil yield (%) extracted at various particle sizes

S/N	Time (min)	Weight and oil yield at various particle sizes of leave (%)									
		10 cm		20 cm		30 cm		40 cm		50 cm	
		Wt	Yield	Wt	Yield	Wt	Yield	Wt	Yield	Wt	Yield
1	10	18.18	0.1212	14.72	0.0981	11.26	0.0751	9.53	0.0635	7.79	0.0520
2	20	47.63	0.3175	41.57	0.2771	26.85	0.1790	23.38	0.1559	18.19	0.1212
3	30	67.55	0.4503	58.02	0.3868	38.10	0.2540	34.64	0.2309	32.04	0.2136
4	40	82.27	0.5485	72.74	0.4850	48.50	0.3233	45.03	0.3002	41.57	0.2771
5	50	90.93	0.6062	78.81	0.5254	49.50	0.3810	52.83	0.3522	48.50	0.3233
6	60	92.66	0.6177	80.54	0.5369	58.02	0.3868	53.69	0.3579	49.36	0.3291

$$\text{Weight of oil} = \text{density of oil} \times \text{volume of oil} \quad (1)$$

$$\text{Oil Yield (\%)} = \frac{\text{Weight of oil}}{\text{Weight of leaves}} \text{ x } 100 \quad (2)$$

Effect of Particle Size on Oil Yield

The results presented in Figure 5 shows that the yield of the oil extracted decreases with increase in particle size. There was an increase in the oil yield to a maximum value of 0.6177 wt % due to reduction in particle size. Further increase in the particle size resulted in a decrease in the oil yield. It was also observed from Figure 5below that the minimum particle size of 10 cm has maximum oil yield whereas the larger particle size of 50 cm has minimum oil yield of 0.3291 wt %.This could be attributed to the factthat the smaller particle size has greater interfacial surface area between the leaves and surrounding space within the tank still and therefore the rate of diffusion of the oil-steam mixture was higher as compared with larger particle size that are high in packing density which resulted to less amount of oil being transferred from inside the larger particle to the surrounding tank still. The results were in agreement with the report obtained by [5-6].

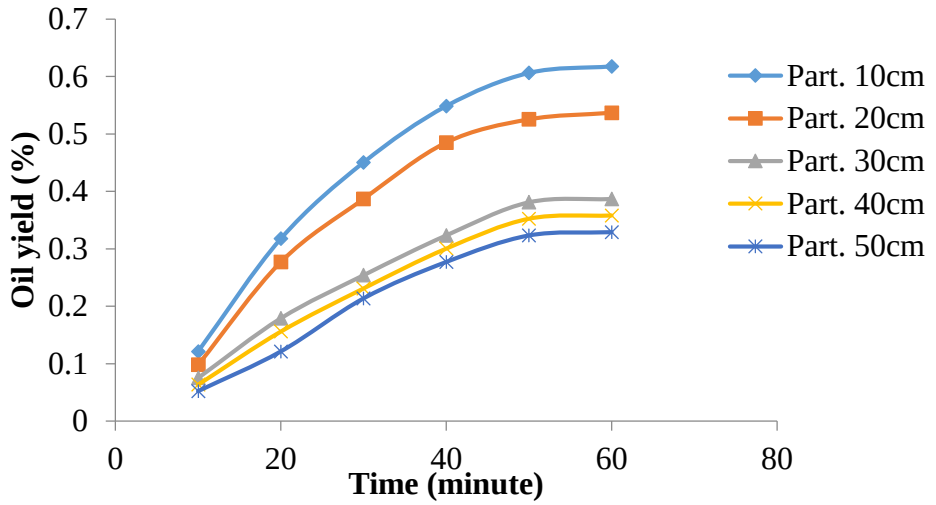

Figure 5: Effect of particle size on oil yield as a function of time.

Physicochemical Properties of Eucalyptus Oil Extracted

The physicochemical properties of eucalyptus oil extracted using steam distillation pilot plant were as shown in Table 3 below as determined according to the methods described by[3-4]. The results from this study indicated that refractive index was 1.4425, specific gravity was 0.9015 and acid value was 19.465 ml/gwhich are in agreement with the results obtained by [6-7].

Table 3: Physicochemical properties of eucalyptus oil extracted values and unit

Physical properties	Results	Unit	Standard values
Colour	Pale yellow	-	Pale yellow
Odour	Aromatic	-	Aromatic and camphoraceous
Taste	Spicy	-	Spicy
Solubility in alcohol	Soluble	-	Soluble in alcohol
Molecular formula	$C_{10}H_{18}O$	-	$C_{10}H_{18}O$
Refractive index at 25^{o}C	1.4425	-	1.4550 – 1.4670
Specific gravity at 25^{o}C	0.9015	-	0.9060 – 0.0.9250
Acid value	19.465	ml/gram	19.635

CONCLUSION

The results showed that the yield of oil was more with smaller particle sizes of eucalyptus leaves and vice versa. Particle size of 10 cm gave oil yield of 0.6177 wt %, while particle size of 50 cm gave less oil yield of 0.3291 wt % all within the same amount of time sixty minutes. Smaller particle sizes has high diffusion rate of the oil from inside the packed bed of materials compared with the larger particle sizes which resulted in low oil yield. From Figure 5, we can see that increasing time of extraction beyond sixty minutes has little or no effect on the amount and yield of the oil extracted. Physicochemical properties of the extracted oil were determined among other parameters has refractive indexat 25^{o}C was 1.4425, specific gravity at 25^{o}C was 0.9015 and acid value was 19.465ml/gram, these are in agreement with literature values obtained by [6-7].

ACKNOWLEDGEMENTS

The authors would like to express their deepest gratitude to the Director-General/CEO of National Research Institute for Chemical Technology (NARICT), Zaria for his moral and financial supports towards this project. The corporation and support by members of staff of Pilot Plants & Fabrication Technology Department, NARICT, Zaria are also highly appreciated.

RECOMMENDATION

A further study on the quality of extracted essential oil from the eucalyptus using GC-MS and HPLC should be investigated.

REFERENCES

1. Weiss, E. A. (1997). Essential Oil Crops, CAB International, USA.
2. Panda, H. (2011). *Essential Oils Handbook*, National Institute of Industrial Research, Delhi.
3. Khalid, M. A. & Tariq, M. N. (2018). Extraction of Essential Oil from Iraqi Eucalyptus Camadulensis Leaves by Water Distillation Methods. *International Conference on Materials Engineering and Science*, 454, 0121613.
4. UNIDO, (1983). *Practical Manual on Essential Oils Industry* (UNIDO, Vienna, Austria), 3-5.

5. Basma, A. A-M, Asrar, A. H. & Badoor, M. K. (2013). Extraction of Oil from Eucalyptus Camadulensis Using Water Distillation Method. *Iraqi Journal of Chemical and Petroleum Engineering*, 14(2), 7-12.
6. Galadima, M.S. (2004). *Design and fabrication of a pilot plant for steam distillation of essential oil*, M.Sc. thesis, Department of Chemical Engineering, Ahmadu Bello University, Zaria, Nigeria, 4-6.
7. Meaza, K. (2016). *Extraction and Characterization of Essential Oil from Eucalyptus Leaves Using Steam Distillation*, M.Sc Thesis. Addis Ababa University, Addis Ababa Institute of Technology, Department of Chemical Engineering, Ethopia.