EFFECT OF PARTICLE SIZE AND TEMPERATURE VARIATION ON THE YIELD OF ESSENTIAL OIL FROM LEMON GRASS USING STEAM DISTILLATION†

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Abstract

A large number of plant materials contain essential oils which are a diverse group of natural products having extensive bioactivities and are therefore important sources of aromatic and flavoring chemicals in food, industrial and pharmaceutical products. One advancing method of essential oil extraction from plants is the steam distillation because it preserves the original qualities of the plant. It is generally believed that the smaller choppings of the plant raw material yield more essential oil than larger sizes. However, the amount of oil collection depends on its volatility and distillation time in the absence of airtight collection system. For very volatile essential oils, the longer the distillation time, the lesser the amount of oil to be collected. One way to reverse this trend is to use larger size particles of the plant raw materials. In this study, therefore, the steam distillation is used to extract oil from lemon grass leaves to examine the effects of the sizes of the leaves and temperature on the oil yield at increasing distillation time. The distillation was conducted in Clevenger apparatus in which boiling, condensing and decantation is done. The results show there is progressive increase of the essential oil yield from 0.51 to 0.84 as the particle size increases from 4 mm to 20 mm and the distillation time increases from 30 minutes to 120 minutes. Similarly, we observe that the oil yield increases as temperature increases from 10 to 50^{o}Cfor all the different sizes of the leaves.

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Keywords: Lemon grass leaves, Essential Oil, Particle Size, Extraction, Temperature, Distillation time

†***African Journal of Physics Vol.6, pp. 105-112, (2013)***

ISSN: PRINT: 1948-0229 CD ROM:1948-0245 ONLINE: 1948-0237

1. INTRODUCTION

Essential oils contain highly volatile substances that are isolated by a physical method or process from plants of a single botanical species [1,2]. The oils normally bear the name of the plant species from which they are derived. Essential oils are so termed as they are believed to represent the very essence of odor and flavor. Essential oil plants and culinary herbs include a broad range of plant species that are used for their aromatic value as flavorings in foods and beverages and as fragrances in pharmaceutical and industrial products [3-5]. Essential oils derive from aromatic plants of many genera are distributed worldwide [6,7]. There are also over 200 references to aromatics, incense and ointments in the Old and New Testaments [8]. Research has confirmed centuries of practical use of Essential Oils, and we now know that the 'fragrant pharmacy' contains compounds with an extremely broad range of biochemical effects [8,9]. There are about three hundred essential oils in general use today by professional practitioners [8 - 11]. Continual bombardment of viral, bacterial, parasitic and fungal contamination occurs in our body. Essential oils are a great benefit to help protect our bodies and homes from this onslaught of pathogens [11,12]. Immune system needs support and these essential oils can give the required endorsement [13 - 15]. More recently, medicinal plant extracts were developed and proposed for use in food as natural antimicrobials [15].

Steam distillation is used in the extraction of Essential Oil from the plant material. It is a special type of distillation or a separation process for temperature sensitive materials like oils, resins, hydrocarbons, etc. which are insoluble in water and may decompose at their boiling point. The fundamental nature of steam distillation is that it enables a compound or mixture of compounds to be distilled at a temperature substantially below that of the boiling point(s) of the individual constituent(s). Essential Oil contains components with boiling points up to 200°C or higher temperatures. In the presence of steam or boiling water, however, these substances are volatilized at a temperature close to 100°C at atmospheric pressure [2]. The implication is that temperature has effect on the extraction rate of essential oils while excessive heat may degrade thequality of the essential oil [3,4].Another parameter that can affect the yield of the extracted essential oil is the particle sizes of the plant raw materials [3,7]. For example, in their extraction of cumin oil by steam disllilation of cumin (Cuminumcyminum L) seed, Beiset. al. [7] obtained the largest percentage (2.8) of the oil by distillation of 0.177 mm and smallest percentage (1.4) from the largest particle size (0.710 mm) use. Thus the general consensus is that small particle sizes of the plant raw materials favours increase in yield of the extraction. This direct variation depends on the distillation time. The essential oils are very volatile and therefore the more time of extraction, the greater the probability of evaporation of the oils especially if the collection system is not airtight. Thus as we plan to show in this current study, for very volatile oils, it is preferable to use large sizes of the plant raw materials to obtain large extracted oil yield.

2. PREPARATION OF RAW MATERIAL

The fresh lemon grass leaves (Cymbopogoncitratus) which are obtained from the Junior Staff Quarters of the University of Benin, was washed to remove all the dirt. The washed leaves were divided into two parts. One part was left to dry for two days under ambient temperature and the other part was allowed to dry for about 20 minutes in order to dry off the water from the surface. The leaves were then chopped to a size of 4 mm, 8 mm, 10 mm and 15 mm and 20 mm.

2.1 Experimental Setup:

The experimental setup is shown in Figure 1. The experiment was conducted in a Clevenger's Apparatus. Apparatus consist of one round bottom flask of 1000ml which is connected with another two way round flask which holds raw material. The top flask is connected with condenser through the connecter. The separating funnel is used for the separation of essential oil and water.

Figure1: Experimental set up for extraction of essential oil from Lemon grass by steam distillation

2.2 Experimental Procedure

150-200 g of each size of the cut pieces of lemon grassis boiled with 500 ml of distilled water in a Clevenger apparatus and the collection of the essential oil is done for 30 mins, 60 mins, 90 mins and 120 mins. The volume of essential oils was determined from a calibrated trap. Analysis of essential oil is done by using Gas Chromatography with Mass Spectrometer. The qualitative and quantitative analysis is done to know the constituents in the oil and the percentage of components present in the oil respectively, by doing so we can know the purity of that particular oil [3]. The essential oils in the distillate were dried over anhydrous Na_2SO4 and kept in the freezer.

3. RESULTS AND DISCUSSION

The effect of temperature on the yield of essential oil obtained from lemon grass leaves is shown in Figure 2. There is an increase in the oil yield from 0.53 to 0.75 when the temperature is increased from 10 to 50^oC for all the different sizes of the leaves. This observation can be explained from the fact that the heat and the steam generated at 50^oC has more rupture effect on the cell structure of the leaves thus allowing the release of more essential oil at that temperature. This is in agreement with the findings of [3] which study the effect of temperature on the yield of essential oil from chamomile varieties. Thus for this plant, the temperature of 50^oC is the optimal and beyond this temperature, the oil will be degraded [4]. Another observation in agreement with the literature is that the smallest particle size of 4 mm produces the largest amount of essential oil while the 15 mm size produces the smallest yield as clearly shown in Figure 2.

The essential oil yield variation along with particle sizes at different time of heating is shown in Figure 3. It is observed that as the distillation time is increased from 30 mins to 120 mins, the oil yield increases with the particle sizes. Clearly, the highest values of 0.51, 0.55, 0.58, 0.69, 0.84 essential oil yields are recorded at particle sizes of 4mm, 8mm, 10mm, 15mm and 20 mm at varying time of 30, 60, 90 and 120 minutes respectively while the lowest values of 0.45, 0.49, 0.51, 0.53 and 0.56 are obtained from the same particles sizes. This trend could be explained in term of the surface area of the lemon grass: the large particle sizes have more surface areas filled with the essential oil than lemon grass with small surface area. Therefore the small particle sizes will yield more oil at shorter distillation time but as the time increase, the oil yield will decrease as most of oil cells used. On the contrary, the large particle sizes will yield lesser oil in the beginning of the distillation but as have large surfaces to continue to yield more oil with increase in distillation time. This agreed with the findings of [10] which explained that the changes of the mean particle size have a relevant effect on the extraction yield.

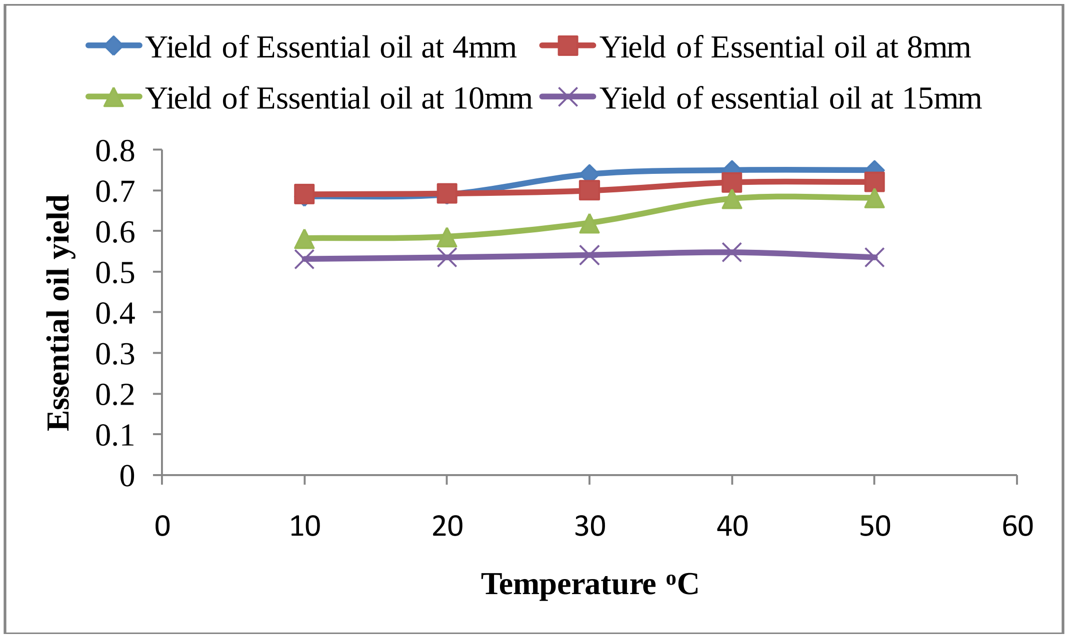

Figure 2: Effect of temperature on the yield of essential oil at different particle sizes

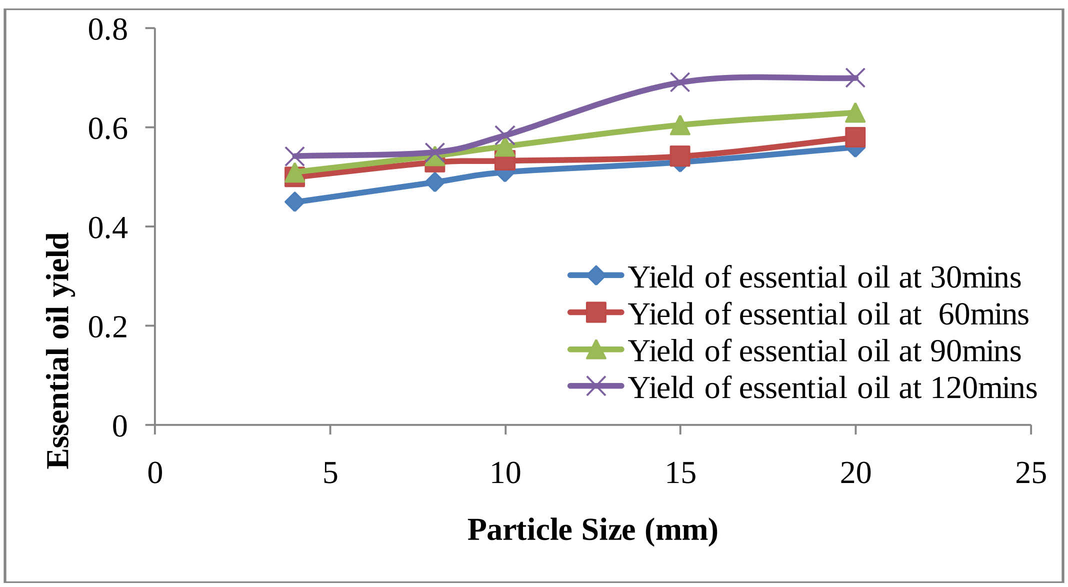

Figure 3: Effect of particle size on the yield of essential oil at different time

2. CONCLUSION

From this study, it was revealed that particle size, heating temperature and distillation time have influence on oil yield during steam distillation of lemon grass. Therefore, these process conditions must be carefully controlled during the extraction process to obtain maximum yield. These conditions would greatly help in carrying out detail process design and scale up for the commercial scale extraction of essential oil from lemon grass. It is hoped that the observations made here will be investigated for other plant raw materials from which essential oils can be extracted. This will help to theoretically model and even simulate how the process conditions can be used to maximaize the essential yield from the various raw plant materials at various sophistication of the steam distillation method. Therelevant of such extended studies is to provide the scientifical knowledge for the design and setting up of low investment and easily accessible and adaptable technologically viable essential oil industry. It is pertinent to point out that suchagrobased industry that involves cultivation anddistillation activities can be established as small scale production plants in rural areas where the raw materials are produced if the technology and the skills required are notsophisticated [16]. It follows that encouraging the small agrobased industry will be a viable strategy for poverty alleviation in Nigeria and other developing countries as it will create jobs in the production and procession of the plant raw materials into essential oils [17].

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