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EFFECT OF EXTRACTION TEMPERATURE AND TIME ON THE PERCENTAGE YIELD OF OIL EXTRACTED FROM LEMON PEEL USING HYDRO-DISTILLATION TECHNIQUE

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ABSTRACT

Citrus is commonly grown world-wide and generates a lot of waste materials that are disposed after processing. Utilizing these wastes into value added products will be economically beneficial. In this work, effect of extraction temperature and time on lemon peels was investigated using hydro-distillation technique to extract essential oil (EO) from lemon peel. The optimum extraction temperature and time, the weight and percent EOs yield by hydro-distillation obtained are 96 ^{o}C and 60 minutes, 2.27 g and 0.38% and 2.22 g and 0.37%, respectively. Temperature and time have significant effects on the yield of the oil. Essential oils extracted from lemon peels have substantial applications in the manufacturing of pharmaceutical and food industries, flavouring agents, medicines, pharmaceuticals, food flavour additives, cosmetics, domestic household products and natural antimicrobials etc.

Keywords: Lemon peel, temperature, time, hydro-distillation, essential oil, optimum, citrus fruits

INTRODUCTION

Essential oils are fatty liquids that comprise esters and other aromatic compounds that make up the distinct scent of a plant [1,2]. Essential oils are concentrated majorly in glands scattered throughout the fruit peels and leaf of the plant [2]. Most productive essential oils that are extracted from citrus fruits are usually rich in the plant as well. Citrus fruits have relatively high amount of essential oil when compared to non-citrus fruits, which make them one of the easiest fruits to extract oil from.

Citrus fruits cultivation has been an important economic activity presently in some parts of the world because of its health benefits and flourishes in any season particularly during spring [3]. Citrus fruits require sun during the ripening stage. The fruits take between 6-8 months to ripen after fertilization. Citrus fruits include grapefruit, lemon and lime, oranges, and tangerine

among other fruits [3, 4]. The production of citrus fruit is common and is grown particularly in countries around the Mediterranean [3].

Today, Nigeria extensively grows citrus fruits from moderate to tropical zones within the northern and southern part of the country. Plate 1 shows an image of a lemon citrus fruit.

Plate 1: Lemon citrus fruit

In the processing for citrus juice, the peels generated annually remain as a waste which litter the environment and cause environmental pollution [5]. One of the products from citrus peel is essential oil which is an aromatic liquid characterized by the scent it produces from the citrus peels.

Worldwide citrus output increased from 115.18 million tons to 178.48 million tons from 2010 to 2015 and citrus peel amounted for 25%–40% of the total fruit weight [6]. The world production of oranges as at 2018 is 49.3 million tons [5]. Amongst world leading producers of citrus fruits, Nigeria is positioned ninth and first in Africa producing 3.33 million tons of citrus fruits [5]. In spite of Nigeria been the leading producer of citrus fruits in Africa, production of essential oils is very low, as virtually all the essential oils utilized by various industries are imported.

The presence of the essential substance, limonene, in citrus peels has drawn the attention of industries or essential oil producers to this product, which has cancer and aromatherapy significances, biological, antioxidant, antimicrobial properties and herbal fragrance [7]. They also exhibit antibacterial, antifungal, and insecticidal properties [5].

The main constituent of citrus essential oil is limonene [7]. Limonene concentration in citrus essential oils varies between 30% and 99% depending on the species of plant, 30–40% in bergamot, 40–75% in lemon and 68–98% in sweet orange [5, 7]. The range of oil content of citrus peels is between 0.5-5.0% (w/v) [5].

There are about 140 major citrus producing countries with an estimated world's citrus production to about 115.6 million tons in 2012 [3]. Lemon is one of the most generally used or consumed fruits globally due to its health and nutritional benefits to mankind.

Essential oils are concentrated mainly in secretory cavities scattered throughout the fruit peels, accounting for about 1–3% fresh weight on the average which are released when rubbed with hand, heated or otherwise stimulated [1, 7]. Quality and quantity of essential oils extracted from citrus peels are affected by several factors such as nature of the fruit, origin, genotype, soil condition, age, climate, plant organ, vegetative cycle, and the extraction process [5].

There are various techniques for the extraction of essential oils from citrus plants, such as cold press, steam distillation, solvent extraction, water, organic solvent extraction, hydro-distillation [5] as well as organic solvent extraction and supercritical CO_2 [7].

Essential oils extracted from citrus has different recipe of natural constituents and has substantial applications in the manufacturing of pharmaceutical and food industries, flavouring agents, medicines, pharmaceuticals, food flavour additives and natural antimicrobials [5], as well as cosmetics, and domestic household products [7]. The residue of lemon peels after oil extraction can be used to improve soil fertility since they are rich in nitrogen, phosphorus and potassium [7].

Therefore, the main objective of this study is to investigate the effect of extraction temperature and time on the percentage yield of essential oil from lemon peels using hydro-distillation technique.

MATERIALS AND METHODS

Material Sourcing and Preparation

Wholly ripened fresh lemon fruits were purchased from a commercial orchard in Samaru market, Zaria, Kaduna State, Nigeria. The lemon fruits were washed to remove dirt, peeled manually, then shredded to sizeable pieces using citrus peel shredder, dried for 2 hours at 45 ^{o}C in an oven and then stored at room temperature for further use. The research was carried out at the National Research Institute for Chemical Technology (NARICT), Zaria, Kaduna State, Nigeria.

Extraction of Essential Oil

Hydro-distillation is a modification of steam distillation, for the extraction of essential oil from dried lemon peels. The method of hydro-distillation of essential oil extraction employed by He-Shuai et al [6] was adopted for this work. About 600 g of lemon peels was rinsed with clean water and oven dried at 45 ^{o}C for 2 hours, then immersed in 2000 ml of distilled water in a

distillation flask; heat was supplied to the flask using a temperature-controlled heating mantle. The experiment was carried out at a temperature of 88 ^{o}C for 60 minutes. The distillation time, solid to solvent ratio (lemon peels and distilled water) were kept constant throughout the experiment, while varying the temperature of distillation at an interval of 2 ^{o}C from 88 ^{o}C to 98 ^{o}C. In the second phase of the experiment, the distillation temperature and solid to solvent ratio (lemon peels and water) were kept constant and varying the distillation time at an interval of 15 minutes from 15 to 75 minutes. The steam generated ruptured the lemon peels oil glands and on passing through the condenser, was condensed as a result of counter flow of oil-steam and cooling water. The condensate, which is a mixture of oil and water, were collected in a conical flask. The mixture formed two distinct layers of oil and water. The oil which is less dense than water float at the top, and was easily separated using a separating funnel. Figure 1, shows hydro-distillation set-up for essential oils extraction from citrus fruit peels.

Figure 1: Hydro-distillation set-up for lemon peels extraction of essential oil

Figure 2 shows process flow diagram of essential oil extraction from lemon peels.

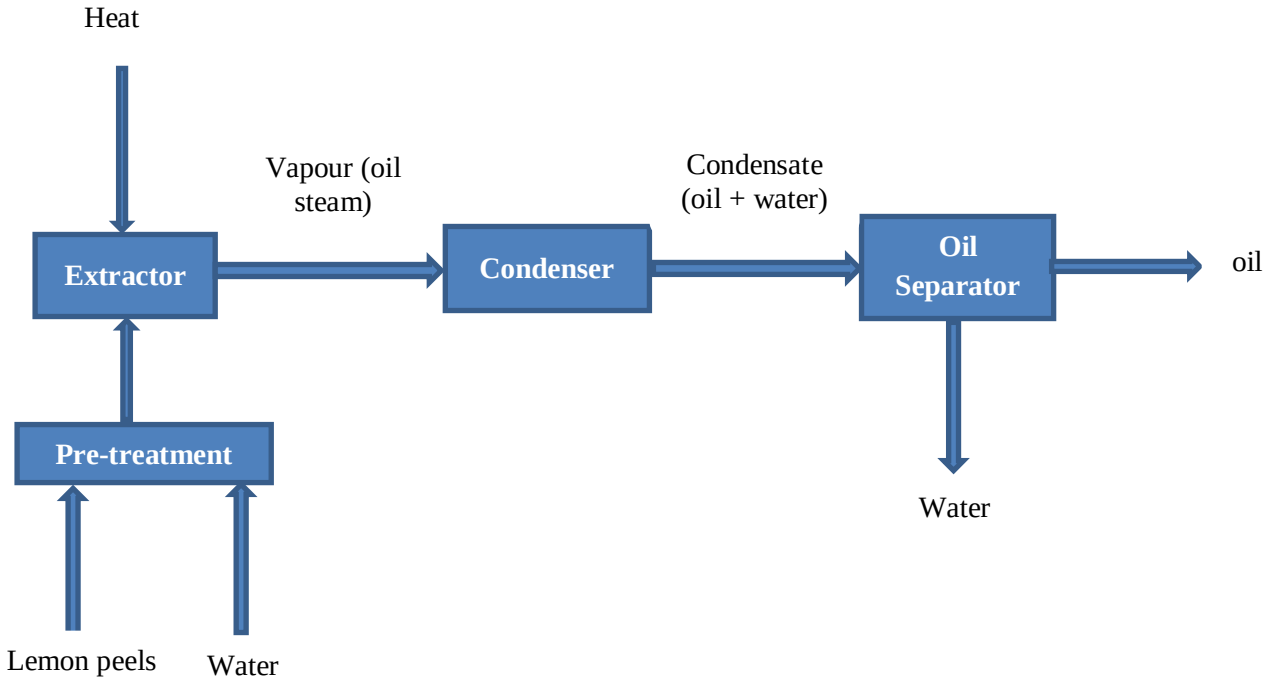

Figure 2: Process flow diagram of hydro-distillation of essential oil extraction from lemon peels

RESULTS AND DISCUSSION

The effect of temperature on percentage yield of the extracted essential oil from lemon peels was studied at different temperatures of 88, 90, 92, 94, 96, and 98 ^{o}C per batch operation, while other parameters (time and solid to solvent (lemon peels: water) ratio), were held constant until equilibrium was attained. The results obtained were presented graphically as shown in Figure 3.

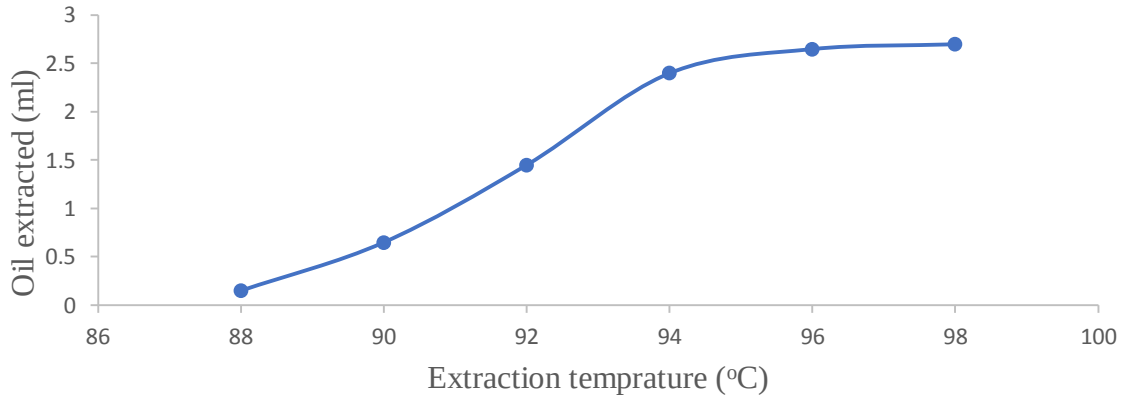

Figure 3: Effect of hydro-distillation temperature on the yield of essential oil from lemon peels

Figure 3 shows that as temperature increases the amount of the oil extracted increases proportionally to temperature of 96 ^{o}C. On further increase in temperature to 98 ^{o}C, the quantity of oil extracted was not significant compared to the previous temperatures. Also, after extrapolation of the values of temperatures of 100, 102, and 104 ^{o}C, the difference in quantity of oil obtained remained constant (0.05 ml). Equation 1 is the extrapolation formula used to extrapolate the two endpoints (x_1, y_1) and (x_2, y_2) temperatures.

$$\mathbf{y3 = y1 + \frac{(x3 - x1)}{(x2 - x1)} * (y2 - y1)} \qquad 1$$

where, y_1, y_2 and y_3 are oil yield, while x_1, x_2 and $x_3$are temperature values.

It can be inferred that the optimal temperature for the extraction was 96 ^{o}C. Any further increase in temperature beyond 96 ^{o}C has no significant effect on the oil yield. The results obtained from this work were in agreement with the findings of Mansour et al [7].

Effect of Hydro-Distillation Time on Yield of Lemon Peels Essential Oil Extraction

From the analysis done, it indicated that hydro-distillation time is an important factor which has the tendency to affect the yield of oil extracted from lemon peels. Hence, the effect of hydro-distillation time on the oil yield was investigated. The extraction time was studied from 15 minutes to 75 minutes, while the hydro-distillation temperature and solid to solvent (lemon peels and water) ratio were kept constant throughout the extraction process.

Figure 4 shows the effect of hydro-distillation time against oil yield.

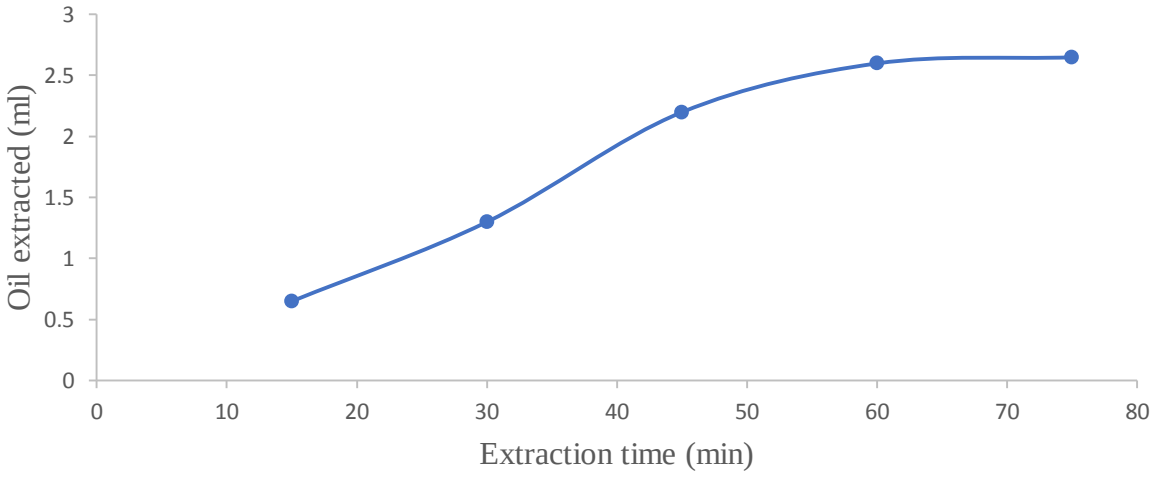

Figure 4: Effect of hydro-distillation time on the yield of essential oil from lemon peels

It was also observed from Figure 4, that as extraction time increases, the oil yield also increase significantly from 15 minutes to 60 minutes. On further increase in extraction time from 60 minutes to 75 minutes, the increase in the oil yield was not significant. This implied that extending extraction time beyond 60 minutes has less significant effect in the yield of the oil. Using Equation 1, extrapolating the extraction time at 90 and 105 minutes, the difference in the oil yield remained constant (0.10 ml). Any further increase in time beyond 75 minutes had no significant effect on the oil yield. The results obtained from this work were in agreement with previous findings [6, 7].

CONCLUSION

The optimum amount of oil obtained was at 96 ^{o}C and 60 minutes. It was also observed that, beyond the optimum temperature of 96 ^{o}C and extraction time of 60 minutes the oil yield was not significant. As such, extraction of the oil should not exceed the optimum parameters of 96 ^{o}C and 60 minutes. The weight and percent yield of lemon peel oil at extraction temperature of 96 ^{o}C was 2.27 g and 0.38% and at extraction time of 60 minutes was 2.22g and 0.37%, respectively. Essential oil extracted from lemon peels using hydro-distillation technique was successfully studied. Lemon peels are by-product generated in the processing of citrus fruits and constitute environmental pollution. These wastes contain value-added constituents and have substantial applications in the health sector, perfumery, cosmetics, food, pharmaceutical industries and the likes. The by-product generated from the extraction of essential oil from citrus (lemon peels) when decomposed would add value to the soil by enriching its fertility.

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