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# Determination of Essential Oil Yield from Extraction and Distillation in Lemon Peel (*Citrus lemon*) and Kaffir lime peel (*Citrus hystrix*)

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## Abstract

*Essential oils are vegetable oils that give plants their distinctive aroma and contain essential ingredients. The purpose of this study was to determine the yield of essential oil of lemon peel and kaffir lime peel by extraction and distillation. The method used in distillation is simple distillation, and for extraction, it is maceration. The results showed that the water content of the lemon peel was 3.37%. For the kaffir lime peel, it was 2.72 % when compared to the Indonesian National Standard (SNI), which was not appropriate because the water content had a value of 7 - 14 %. The yield of essential oil obtained from the distillation of lemon peel was 2.29 % and kaffir lime peel 1.02 %. The yield of essential oil obtained from the extraction of lemon peel was 1.07%, and kaffir lime peel was 1.32%. The identification test of the distilled essential oil did not show any stains on the filter paper, which indicated that the result obtained was essential oil. In contrast, the identification test of the extracted essential oil showed the presence of stains on the filter paper, which indicated that the results obtained were not essential oils. To determine the quality of the essential oil produced by characterizing the refractive index, color, and odor tests. The results obtained show that the refractive index for the distillation of lemon peel is 1.3381, and for kaffir lime peel is 1.4698. The refractive index for the extraction of lemon peels is 1.3812, and kaffir lime peels is 1.369. When compared with SNI 8028-1:2014, it is generally not appropriate because it has not reached 1.507, except that the distillation of kaffir lime peels meets the requirements of SNI, while the color and smell are in accordance with SNI.*

**keywords:** Extraction, essential oils, lemon (citrus limon), lime(citrus hystrix), steam distillation

## Introduction

Biological diversity in Indonesia includes some species found in several essential oil-producing plants, which until now have not been able to be utilized optimally (Martha et al., 2021). Indonesia produces 40-50 types of essential oil-producing plants, and of the 80 types of essential oils traded in the world, only some of these essential oils enter the world market, including patchouli, citronella, agarwood, cloves, jasmine, ylang, eucalyptus, sandalwood, and vetiver (Ariani et al., 2022). At the same time, the imported essential oils can be produced in Indonesia, for example, bergamot, orange, lemon, lime, citrus, geranium, jasmine, lavender, peppermint, cornmint, and vetiver.

Oranges are one of the fruits that have the potential to produce essential oils. Lemon has biological potential as an antibacterial, antidiabetic, anticancer, and antiviral (Dev & Mol, 2023). The flavonoids in lemons have the benefit of preventing attacks from pathogens, including bacteria, fungi, and viruses (Abakpa & Adenaike, 2021). In addition, the content of essential oils, alkaloids, sesquiterpenes, and other terpene compounds has an antibacterial and antifungal function. Kaffir lime has a very attractive essential oil to be used as an active ingredient in a preparation, such as an essential oil (Suresh et al., 2021).

Essential oils can be obtained from the extraction and distillation processes (Saldaña-Mendoza et al., 2022). which is done with solid fats, this extraction process is used specifically for extracting flowers, in terms of obtaining high-quality and high oil yields. The method used this time is extraction using a solvent and distillation.

Some previous research on essential oils was conducted by Daryono et al. (2023), who examined the extraction of essential oils from lemon peel using microwave pretreatment and steam-water distillation. Aprilyanie et al. (2023) and Fadila et al. (2024) also conducted a comparison between hydrodistillation and hydrostim distillation methods on the yield and aroma characteristics of lemon peel oil. Several methods of essential oil extraction and distillation were conducted, but direct comparison between the two methods, especially for lemon and kaffir lime peels, is still limited.

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Based on these reasons, the authors feel the need to conduct a study to determine the yield of essential oils of lemon peel and kaffir lime peel through extraction and distillation.

## Methods

### *Research design*

This research is experimental in applying the extraction and distillation methods. Maceration extraction is an extraction method by immersing the material in a solvent that is in accordance with the active compound to be taken with low heating or without a heating process. Distillation of water, or simple distillation, is a method for separating chemicals based on differences in the speed or ease of evaporation of the materials.

### *Tools and materials*

The tools used in this research include: a set of water distillation equipment, an electric bath, a beaker, a vacuum evaporator, a 250 mL Erlenmeyer, a dropper, a measuring cup, a stirring rod, a spatula, an evaporating dish, a thermometer, a separating funnel, a digital balance, and an oven.

The materials used in this research are lemon peel and kaffir lime peel yang diperoleh dari Pasar Kota Palu, akuades, NaCl, technical ethanol, $Na_2SO_4$ anhydrous, filter paper, and tissue.

### *Research procedure*

### *Preparasi sampel*

The samples were washed using clean water and then sliced into thin slices. Then it is dried in an oven at a temperature of around 45 ºC for ± 15 hours. Then grind it using a blender (Setiyoningrum et al., 2018).

### *Determination of water content*

The cup is weighed first, the skins of mandarin oranges and lime peels were weighed as much as 2 grams together with a cup, then dried in an oven, at a temperature of 105 ºC for 30 minutes. The mandarin orange peel and lime peel were removed from the oven, put into a desiccator, and weighed. The treatment was repeated at 30-minute intervals until the sample weight was constant. The formula calculates the water content.

$$\text{Water content} = \frac{\text{initial weight} - \text{final weight}}{\text{Final weight}} \times 100\% \quad (1)$$

(Fakayode & Abobi, 2018)

### *Distillation of kaffir lime and lemon*

The orange peel is cut into pieces and then put into a beaker. Then the orange peel was weighed as much as 200 grams and put into a one-neck flask. Add to the flask 200 mL of distilled water. The distillation apparatus is assembled, and the distillation process is carried out until the orange peel oil is completely extracted (indicated by an increase in temperature). During the distillation process, the volume of water is kept constant by adding water little by little. The distillate was accommodated, and NaCl was added to facilitate the process of separating orange peel oil and water. The aqueous phase and orange peel oil were separated using a separating funnel. Next up, $Na_2SO_4$ anhydrous is added to the phase orange peel oil to reduce the water content in the oil. $Na_2SO_4$ was separated from the oil phase by filtering. Orange peel oil had its refractive index measured. Addition of $Na_2SO_4$. This is done until a constant index of refraction is obtained. orange peel oil was weighed and analyzed (Mercy et al., 2015).

### *Extract of kaffir lime and lemon*

The orange peel was cut into small pieces, then mashed using a blender, and weighed as much as 200 grams. Next, the orange peel is put into the one-neck pumpkin. 150 mL of technical ethanol was also added to a one-neck flask. The extraction process was carried out with constant stirring at 500 rpm for 3 hours. The extraction result is then filtered, and the filtrate is taken. Next, the filtrate was heated using a vacuum evaporator at 60 oC until all the ethanol had evaporated. Anhydrous sodium sulfate is added to the remaining oil to reduce the moisture content in the oil. Next up, Na2SO4 is separated from the oil phase by filtering (Setiyoningrum et al., 2018).

### *Determination of essential oil color*

Determination of the color of essential oils is done by comparing the color of the sample test with the color of the standard solution. 5 mL of the sample is put into a reaction tube and compared with the standard color solution, then observed and recorded whether the color of the test sample is the same or clearer (SNI 76633-2011).

### *Identification of essential oils*

Identification of essential oils is done to ensure that the oil obtained is essential. The results of the identification of essential oils indicate that there is no transparent stain on the filter paper because the essential oil evaporates at room temperature, which proves that the oil obtained is essential (Salim & Eisa, 2017).

### *Determination of refractive index*

First, connect the refractometer to a soft tissue. Drop a drop of essential oil on the working prism (no air bubbles are allowed in the drop). The working prism is closed with a light prism. Observed through binoculars by rotating the compensation ring until the right beam of green and yellow light is obtained horizontally. Turn off the light and record the read scale. Turn off the tool by pressing the off button and disconnect the tool contacts from the electricity. electricity**,** then turned on the tool by pressing the on button, allowed it to stand for 15 minutes, lowered the lamp and opened the working prism, cleaned the light prism and working prism with a wet tissue, and dried with a tissue (Samosir, 2018).

### *Essential oil odor test*

Determination of the odor of essential oils is done by the organoleptic method. 5 mL of the sample was put into the test tube and observed for the characteristic odor of essential oils or not (Rizqi et al., 2024).

### *Calculating essential oil yield*

$$\text{Rendemen\%} = \frac{\text{Weight Oils } (g)}{\text{Weight oil of orange peel sampel } (g)} \text{ x100\% } (2)$$

(Wahyuningsih, 2020).

## Results and Discussion

### *Data on water content*

**Table 1**. Determination of water content

| Sample Code | | Initial Weight (g) | Heavy End (g) | Rate Water (%) | Average | SNI |
|---|---|---|---|---|---|---|
| Lemon | I | 37.85 | 36.20 | 4.56 | 3.45 % | 7-14 % |
| | II | 55.65 | 54.01 | 3.04 | | |
| | III | 59.33 | 57.74 | 2.75 | | |
| Kaffir | I | 45.32 | 43.90 | 3.23 | 2.76 % | |
| | II | 56.29 | 54.88 | 2.57 | | |
| | III | 57.12 | 55.73 | 2.49 | | |

The result of the highest water content of orange peel is 4.56 % in lemon, and the lowest is 2.49 % in kaffir lime. This level of analysis aims to determine the water content in samples of lemon peel and kaffir lime peel. The moisture content of the sample is known by means of the initial weight of the sample minus the final weight of the sample, and comparing it with the initial weight of the sample, then multiplied by 100 %. The results of this study indicate that the water content of the lemon peel sample is lower than that of the orange peel kaffir.

Comparison of standard quality requirements of SNI 06-3532-1992 and test results on water content in samples of lemon I 4.56 %, lemon II 3.04 %, lemon III 2.75 %, purut I 3.23 %, purut II 2, 57 % and Prut III 2.49 % showed a number below 15 %, this is not in accordance with the quality requirements of the SNI 06-3532-1992 standard which has a range between 7-14 % and is still far from the minimum limit of SNI. In storage, it must always be maintained to avoid excessive moisture due to the nature of the tightly sealed pectin. Because if it rises, there will be damage caused by microbial activity (Lumuindong & Mamuaja, 2022).

### *Distillation results data of kaffir and lemons.*

**Table 2.** Essential oil distillation test result

| No | Sample | Sample Weight (gr) | Essential Oil Weight (gr) |
|---|---|---|---|
| 1. | Lemon Peel | 200 | 2.26 |
| 2. | Kaffir Orange Peel | 200 | 6.10 |

### *Extract the result data of kaffir and lemons*

**Table 3.** Essential oil extract test result

| No | Sample | Sample Weight (gr) | Essential Oil Weight (gr) |
|---|---|---|---|
| 1. | Lemon Peel | 200 | 2.13 |
| 2. | Kaffir Orange Peel | 200 | 2.63 |

### *Data on the color results of lemon and kaffir citrus peel essential oils*

The orange oil sample extracted was reddish-brown, and the distillate sample was clear (colorless). Color test results of orange peel oil samples, lemon, and kaffir lime. This test is based on direct visual observation using the eye senses. The results of the tests carried out showed that the color of the essential oil in the extraction results was brownish yellow, while the distillation results were pale yellow. In general, when compared with the Indonesian National Standard, the two samples of lemon and kaffir lime peel essential oils were still in accordance with the standard parameter specifications. The intensity of the color of the orange essential oil is also determined by the amount of color pigment contained in it. The color of the isolated oil is usually clearer when compared to the reddish color of the orange peel essential oil extracted from the extraction.

**Table 4.** Essential oil color results

| Oil Color Extraction Results | Oil Color Distillation Color | SNI |
|---|---|---|
| Brownish Yellow | Pale yellow | Pale yellow-Yellow Brown |

This test is also carried out by direct visual observation using the sense of smell. Based on the Indonesian National Standard, the quality requirement for citrus essential oils is the distinctive smell of lemon and kaffir lime. The odor of essential oils is one of the parameters used to determine the quality of citrus essential oils. Essential oils have different odors; generally, this smell is like the smell of the plant that produces it. Likewise, citrus essential oils, which have a characteristic smell of lime, can be detected by using the sense of smell (SNI 7633-2011).

The results of testing the smell of orange peel essential oil by means of isolated samples and the results of the extraction are put in a reaction tube. Then the resulting odor is smelled using the sense of smell in order to obtain a sample that has a distinctive citrus aroma according to the plant of origin. This indicates that, when compared with the Indonesian National Standard, the sample is appropriate. The distillation and extract samples were compared with the Indonesian National Standard the orange essential oil samples were in accordance with the standard parameters.

***Data essential oil identification results***

**Table 5.** Identification of essential oils

| Sample | Identification Results | SNI |
|---|---|---|
| Identification Extraction Results | Still leaving stains | The absence of stains indicates that the sample contains essential oil |
| Identification Distillation Results | Not leaving Stain | |

***Refractive index***

Research (Irwan & Rosyidah, 2019) about the potency of the essential oil of limes, the refractive index value for the fresh sample is 1.5989. Meanwhile, the dry sample is 1.4720. The refractive index of each essential oil is different; there is no SNI for the orange peel sample, so when compared with the SNI for patchouli oil, the lime peel essential oil meets the quality requirements, namely 1.507 – 1.515. However, the results obtained were 1.4698 kaffir lime peel distillation samples, 1.3381 lemon peel distillation samples, 1.3690 kaffir lime peel extraction samples, and 1.3812 lemon peel extraction samples. When compared, the results obtained have a difference of 1 and 2 points related to quality requirements; this is presumably due to differences in the samples used in extracting essential oils. It can be concluded that the refractive index is still less than the SNI figure.

**Table 7.** Refractive index results

| No | Test Sample | Refractive Index | SNI |
|---|---|---|---|
| 1 | Orange Distillation Lemon | 1.3381 | 1.507-1.515 |
| 2 | Orange Distillation Kaffir | 1.4698 | |
| 3 | Orange Ekstract Lemon | 1.3812 | |
| 4 | Orange Extract Kaffir | 1.3690 | |

The average value of the highest refractive index of citrus fruit peel essential oil was produced in the kaffir lime distillation treatment, which was 1.4698, and decreased in the lemon peel distillation, orange extraction, and kaffir lime extraction treatments. This is due to the polarity index of the solvent, which tends to be polar, extracting the compound. non-polar. This shows that not only the bioactive component compounds are extracted, but also the non-polar and polar components. Fresh orange essential oil is non-polar, so the refractive index is low. The difference in refractive index values is because non-polar solvents extract non-polar compounds and polar solvents such as ethanol extract polar compounds, because in citrus essential oils, there are a group of non-polar compounds such as terpenes, sesquiterpenes, sterols, and polar compounds such as aldehydes and esters. The value of the refractive index is also influenced by the presence of residual solvent in the extracted citrus essential oil (Prasetiyo, 2015).

The difference in the level of polarity of the solvent in extracting the sample essential oil is influenced by the ability of the solvent to dissolve the components in the sample. The solubility of a substance dissolved in a solvent depends on the degree of polarity of the solvent and the solute. Where polar components will dissolve in polar solvents and non-polar components will dissolve in non-polar solvents.

***Data essential oil odor test results***

The results test the smell of orange peel essential oil, the resulting odor, using the sense of smell to obtain a sample that has a distinctive citrus aroma according to the plant of origin. This indicates that, when compared with the Indonesian National Standard, the sample is appropriate.

**Table 8.** Essential oil odor test results

| Sample | Odor | SNI |
|---|---|---|
| Distillation Results | Typical Smell of Lemon, Orange, and Jeruk Purut | The result of the smell of essential oils is the typical smell of the sample, namely, orange. |
| Extraction Results | Typical Smell of Lemon, Orange, and jeruk Purut | |

***Data essential oil yield results***

Yield of kaffir lime essential oil and Lemon is the result of the distillation and extraction process. The average yield of essential oils ranges from 1-2 %. The highest yield obtained was in the lemon distillation sample with a yield percentage of 2.29%, while the lowest was in the kaffir lime distillation sample with a percentage of 1.02 %.

**Table 9.** Essential oil percentage results

| No | Sample | Oil Weight(g) | Skin Sample Weight Orange (g) | % Rendemen |
|---|---|---|---|---|
| 1 | Distillation orange kaffir peel | 2.26 | 200 | 1.13 |
| 2 | Distillation of orange and lemon peel | 6.10 | 200 | 3.05 |
| 3 | Extract the orange lemon peel | 2.13 | 200 | 1.07 |
| 4 | Extract orange kaffir peel | 2.63 | 200 | 1.32 |

Comparison of the yield test results with the quality standard requirements of SNI 8028-1:2014,

the results of the sample yield show that the sample yield from the kaffir lime peel distillation process is 1.13 %, lemon peel distillation 3.05 %, extraction 1.07 % and kaffir lime extraction 1.32 % when compared with SNI 8028-1:2014 The yield and distillation time of several types of essential oils that can be processed by steaming the kaffir lime leaves yields a percentage of min. 1.42 % with 3-4 hours of treatment. If seen with the existing data, the kaffir lime peel samples in the extraction and distillation treatment barely touched the number of SNI quality requirements, while those treated with lemon peel distillation, the percentage of yield produced met the standard or exceeded the minimum standard of yield percentage. The results obtained are in line with research conducted by Daryono et al. (2023), where, with pretreatment using microwave for 5 minutes and steam-water distillation process for 5 hours, an essential oil yield of 4.88% was obtained. This value far exceeds the minimum yield standard set in SNI 8028-1:2014, which is 1.42 %. This shows that, technically, the yield of essential oil from lemon peel has met the quantitative quality requirements and shows that lemon peel has a very high potential as a source of essential oil raw material.

The Indonesian National Standard (SNI) for kaffir lime and lemon peel oil does not yet exist, so the results of this study can be used as a reference in preparing the yield standards of kaffir lime and lemon

## Conclusions

Based on the results of the research that has been carried out, the percentage yield of kaffir lime and lemon peel essential oils through extraction and distillation, wherein kaffir lime peel distillation (1.02 %), lemon peel distillation (2.29 %), lemon peel extraction (1.07 %), and kaffir lime peel extraction (1.32 %). Different treatments resulted in different yield percentages, with the highest yield percentage in lemon peel distillation. The results of the refractive index obtained on the kaffir lime peel distillation sample were 1.4698, the lemon peel distillation sample was 1.3381, the kaffir lime peel extraction result was 1.3690, and the lemon peel extraction was 1.3812. When compared, the results obtained have a difference of 1 and 2 points related to quality requirements, namely 1,507-1, 515 SNI patchouli oil, because there is no SNI for the refractive index for orange peel samples, it is thought to be due to differences in the samples used in extracting the essential oil. It can be concluded that the refractive index is still less than the SNI figure.

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