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Study of Distillation Method and Time on the Quality of Basil (*Ocimum sanctum* L.) Essential Oil

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ABSTRACT

"Basil" or basil has economic value both in fresh form, simplicia and essential oil. This research aims to evaluate the method and duration of distillation in making essential oil from basil. Two distillation methods, namely steam and boil distillation, are carried out with different distillation times (1 hour, 2 hours, and 3 hours). The parameters observed were physical characteristics which included oil volume, yield, pH, distillation rate, color, aroma and spots. The results show that the best distillation process time is 2 h for both distillation methods. Steam distillation for 2 hours produced the best essential oil of 1.1 ml, yield 0.11%, pH 5.78, distillation rate of 0.53 ml/h, pale yellow color, strong aroma, clean spots. Meanwhile, water boiled distillation for 2 h produced 1.2 ml of essential oil, 0.12% yield, pH 6.31, distillation rate of 0.60 ml/h, brown color, weak aroma, very spotty. Distillation of basil leaf essential oil using the steam method for 2 h was determined as the best treatment based on the highest essential oil yield, smallest pH, highest distillation rate, clearest color, most distinctive aroma, and cleanest stain.

1. INTRODUCTION

"Kemangi" or basil (*Ocimum basilicum*) is a plant that is very popular among Indonesian people and has the potential to be a commodity with promising economic value, both in fresh form, simplicia and essential oil (Silalahi, 2018). Basil plants are shrubs that grow upright with a quite lush appearance. Basil leaves are generally consumed as a fresh vegetable or used as a flavoring in several traditional recipes. Basil is also used as simplicia (raw material for herbal medicines) and extracted to extract its essential oil. In traditional medicine, basil plants are often used to relieve fever, rhinitis, fatigue, muscle spasms, and can help with wounds caused by stings (Putri *et al*., 2021). The chemical content of basil can be found in the flowers, leaves, and stems (Gunawan & Mulyani, 2004). (Kicel *et al*., 2005) identified 57 compounds representing 90–94% of the basil oil with the main constituents including 1,8-cineole (up to 33%), β-bisabolene (up to 20%), and methyl chavicol (up to 12%). Furthermore, they noted that the composition varied according to plant development with the highest chemical content is found in leaves. Basil has anti-cancer, anti-oxidant, fungal, microbial, analgesic and inflammatory properties (Behera *et al*., 2012). The leaf extract solution is also good for gargling and effectively inhibits the development of anaerobic bacteria thereby reducing levels of volatile sulfur compounds, which cause bad breath (Tallamma, 2014). Basil leaf oil is also rich in eugenol, a compound that has antibacterial activity. The eugenol content in basil ranges from 40% to 71% (Prakash & Gupta, 2005). The chemical compositions depend on the season, eco-climatic zones, geographical location, and edaphic factors (Pandey *et al*., 2014; Prakash & Gupta, 2005). Several studies show that basil oil has antibacterial abilities

against bacteria that cause odor on feet, such as *Staphylococcus epidermidis* and *Bacillus subtilis* (Purnamaningsih & Supadmi, 2020; Parahita, 2013). Apart from eugenol, basil contains pharmacological elements such as ocimene, alphapinene and geraniol (Kardinan, 2003). Extract of basil leaves was also reported to have a larvicidal effect on *Anopheles aconitus* mosquito larvae with lethal concentration values LC_{50} of 0.779% and LC_{99} of 2.203%, and the larval death rate increased as the extract concentration increased (Hasanah, 2010).

The distinctive fragrant smell indicates the presence of essential oils in basil. Essential oil is a type of vegetable oil that has many benefits. One of the main characteristics of essential oils is that they evaporate easily and have a distinctive aroma (Silalahi, 2018). Global demand for essential oils continues to increase along with the increasing development of modern industries such as the perfume, cosmetics, food, aromatherapy and pharmaceutical industries (Feriyanto *et al*., 2013). The global essential oil market share will reach USD 23.74 billion in 2023 and is expected to grow at a rate of 7.6% for the period 2024 to 2030 (Grand View Research, 2023).

Essential oils can come from various parts of plants, such as flowers, leaves, seeds, fruit, wood stems, bark, roots or rhizomes with different characteristics. Therefore, the processing (extraction) method to obtain essential oils is also different (Fatimura & Fitriyanti, 2021). There are two ways to make essential oil, namely distillation and extraction. Generally, essential oils can be made by distillation. Distillation is a process of boiling biomass which is heated to boiling point, then evaporated and saturated steam is applied to separate the essential oil, so that the result is essential oil (Effendi & Widjanarko, 2014). According to BSN (2014), essential oil distillation can be grouped into two, namely water or boiled distillation, and steam distillation. Distillation with water (boiled) is a distillation process where dry essential leaves are placed in a kettle filled with water and heated, then the steam that comes out is channeled through a pipe connected to a condenser (cooler). Steam turns into water, which is actually a mixture of water and oil, will drip down the end of the pipe and is collected in a container. Meanwhile, indirect steam distillation (steamed) is a distillation process similar to a water distillation system, but between the feedstock leaves and the water there is a perforated screen. The feedstock leaves are placed on top of the screen, while the water is below it. Factors that influence the yield of essential oils are the type of raw material, size, pH, quality of the raw material, equipment used, accuracy, distillation implementation, place of growth, and length of distillation (Syamsul *et al*., 2016). Based on this description, this research was conducted with the aim of determining the effect of the distillation method and the length of the distillation process on the yield of essential oil from basil leaves. It is hoped that the research results will provide an appropriate method for extracting basil leaf oil so that its economic potential can be explored more widely.

2. MATERIAL AND METHODS

2.1. Experimental design

The research was conducted to evaluate two factors, namely the distillation method and the distillation time. There are two methods of distillation, namely steam distillation and boiled distillation. Meanwhile, the distillation time consists of 1, 2, and 3 hours. The stages and implementation of making essential oil from basil leaves are as follows.

2.2. Withering Basil Leaves

Basil leaves were obtained from traditional markets and selected fresh. Before processing, basil is cleaned and the leaves are separated from the stems. After that, the basil leaves were withered naturally for 24 h. The withering process was carried out by placing basil leaves evenly on a drying mat, then air-drying them without being exposed to direct sunlight and only using the air in a closed room. Withering in this way can reduce the evaporation of essential oils, so that essential oils can be produced properly (Nirwana, 2021).

2.3. Size Reduction

Basil leaves that have been withered were reduced in size by chopping them to a size of approximately 5 mm. This aims to maximize the oil glands in the leaves so they can open as much as possible, making it easier for the oil to come out during the distillation process. Apart from that, chopping makes the leaf cell walls open and is easily penetrated by steam so that the essential oil extraction process can take place optimally and minimize yield losses (Nugraheni *et al*., 2016).

2.4 Distillation Process

This distillation process was carried out using apparatus as depicted in Figure 1. In short, the distillatory was constructed of 4 main elements, namely burner or stove (A), reactor tube or boiler (B), distribution pipe (C), and reflux condenser (D). Burner functions as a heat source to boil and evaporate water and raw materials in the reactor tank. In this research, the burner used a gas stove with LPG fuel. The reactor tube functions as a container for heating raw materials. The reactor tube was cylindrical in shape and has a lid tightened using bolts so that it can be opened or closed. The distribution pipe was made of heat-resistant glass that connects to the condenser functions to channel gas from the reactor tube to the condenser. The last part was tube condenser, changed steam into a liquid phase. In order to function properly, cool water was flowed through the outer part of the condenser tube as a cooling medium.

The reactor or tube was filled with 4 L of clean water and 1 kg of basil leaves, then closing it until it is completely sealed and steam does not leak. The steam output pipe is connected to the distribution tube which is channeled to the condenser. Next, the water in the condenser is drained, the heater is turned on. The distillation process is carried out in two ways, namely steam distillation (steam-hydro distillation) or boiled distillation (hydro distillation). In steam distillation, basil leaves are steamed over boiling water. Meanwhile, in boiled distillation, basil leaves are boiled in boiling water in a submerged position.

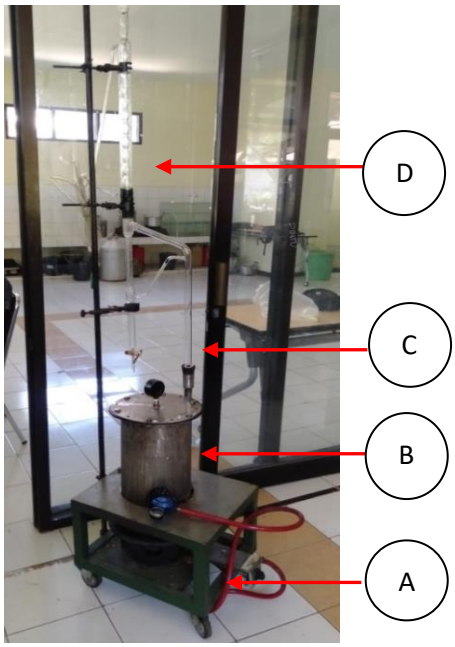

Figure 1. Distillator apparatus to extract essential oil: (A) burner, (B) reactor; (C) distribution pipe; (D) condenser.

2.5 Purification Process

The essential oil that has been produced is then purified so that its quality does not decrease. The purification process is carried out using a mixture of $MgSO_4$ which functions to bind water.

2.6. Observation and Measurement

2.6.1. Oil Yield

Yield is a ratio of the amount (quantity) of oil produced from extraction to the raw materials used and is expressed in percent (%). Oil yield was calculated using Equation (1) (Marjoni, 2014; BSN, 2014):

$$R = (h/b) \times 100 \quad (1)$$

where h is the weight of the oil produced (g), and b is the weight of the processed basil leaves (g).

2.6.2 Acidity Level (pH)

The degree of acidity or pH is used to express the level of acidity or basicity of a substance, solution or object. Normal pH has a value of 7, while a pH value <7 indicates acidity, and a pH value >7 indicates the substance has alkaline properties. pH 0 indicates the lowest degree of acidity, and pH 14 indicates the highest degree of acidity. The degree of acidity of essential oils was measured using a pH meter which had been calibrated using a pH calibrator.

2.6.3. Distillation Rate

Distillation rate is used to determine the speed of the distillation process that occurs. The distillation rate reflects the amount of steam that condenses into the liquid phase during a certain time. In this study, the time intervals used were 1 hour, 2 hours, 3 hours. In accordance with SNI 8028-1-2014, the distillation rate was calculated by dividing the weight of the condensate by the length of the distillation process (BSN, 2014).

2.6.4. Organoleptic Test

The organoleptic test is conducted to determine panelists' preferences about color, aroma, and stain parameters of essential oils (Setyaningsih *et al*., 2010). The panelists involved in this testing were 15 untrained panelists. The essential oils tested by the panelists were six samples which had previously been coded with three different digit numbers. The organoleptic test parameters were as follows:

a. Color: basil essential oil from our research was observed and compared with pure basil essential oil.
b. Aroma: the essential oil was smelled and was compared whether they smell the same as the plant they come from.
c. Stain: essential oils were tested by dropping them on filter paper and observing the results. If after leaving it for 5 seconds there are no spots then the results obtained are essential oil. However, if there are still spots after the specified time, then the essential oil obtained is still mixed with other components.

2.7. Data Analysis

The data obtained was subjected to a two-way ANOVA test using the SPSS 25 application. The use of two-way ANOVA was to determine the effect of the distillation method and time span on the characteristics of basil leaf essential oil. There were six treatment combinations in the basil leaf essential oil distillation research. Each treatment was measured four times on each observation variable. If the results of the analysis show that there is a real difference in the method and length of time factors, then proceed with the Duncan test at a significance level of 95%. Presentation of analysis data using diagrams created using Microsoft Excel 2016 and then analyzed descriptively.

2.8. Determining the Best Treatment

Determination of the best treatment used a scoring system method with a range of 1–6. The highest score was given if the characteristics of the essential oil best meet the criteria for each research variable. Then the scores for each treatment were totaled to obtain the best quality of essential oil. Parameters used in the scoring process were as follows: oil volume, yield, pH, distillation rate, color, aroma, and stain.

3. RESULTS AND DISCUSSION

3.1. Oil Amount and Yield

Based on Figure 2, it can be seen that the boiled method yields more essential oils than the steamed method. With a distillation time of 1 h, the steam method gets 0.9 ml of essential oil and the boiled method gets 1.05 ml, while the steam method gets 1.05 ml of distillation for 2 h and the boiled method gets 1.20 ml. Increasing the distillation time to 3 h did not improve the yield of essential oils, where the steam distillation method produced 0.95 ml and the boiled method 1.20 ml. The yield of essential oils is influenced by the distillation method chosen. Referring to the amount of the oil obtained, it is more appropriate to extract basil leaf oil using the boiled method rather than the steamed method.

The duration of 1 h and 2 h produces oil with a quite large difference compared to the time period of 3 h. This is possible because 1 h is not enough time for the oil to completely evaporate, there is still oil content remaining in the material. In contrast to the time period of 2 h to 3 h, the addition of oil does not experience such a big difference

because the oil from the ingredients has completely evaporated. The longer the distillation time, the greater the opportunity for the solvent to come into contact with the material so that the extracted substance will also increase until the solution becomes saturated and the extract power decreases so that additional time will not provide a significant increase in concentration (Effendi & Widjanarko, 2014).

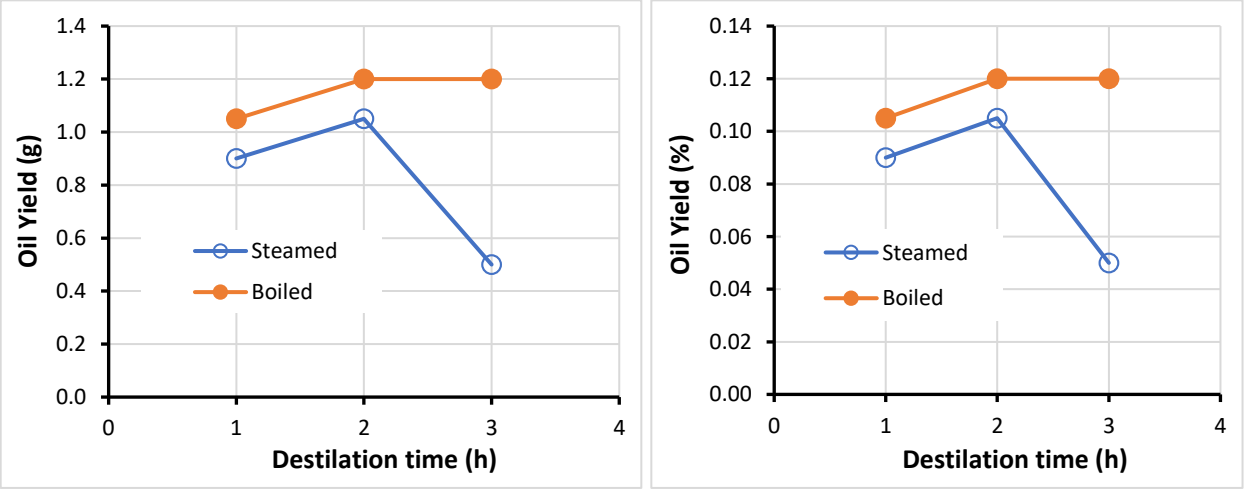

Figure 2. Effect of distillation methods and time on the yield of essential oil resulted from basil leaves

According to Nugraheni *et al*. (2016) the length of withering and drying will affect the yield of essential oils. The oil yield will increase due to the increasing amount of heat received by the material to evaporate the oil cells from the material and the more steam associated with the oil cells in the material network, so that more oil is extracted (Ekasari, 2020). Apart from that, the oil yield percentage is influenced by the processing time because the longer the distillation takes, the higher the yield produced (Nirwana, 2021). It can be seen from Figure 1 that a distillation time of 2 h produces a higher oil yield than the oil yield with a distillation time of 1 h. However, a distillation time of 3 h did not result in an increase in oil yield and the results were not much different from distillation for 2 h. This can happen because the longer the distillation time, the higher the yield obtained and the oil content in the raw material will decrease so that for a certain length of distillation the oil yield will not increase (Ekasari, 2020). Based on Figure 2, it can be seen that the yield of essential oils in steam distillation for 1 hour is 0.09%. The oil yield increased to 0.11% after 2 h. However, with a distillation time of 3 h, the oil yield was only 0.10%. The distillation using boiled water produces slightly higher oil yield than that of steam distillation, namely 0.11% with 1 h, and 0.12% (2 h and 3 h).

3.2. Oil pH

Based on Figure 4, it can be seen that the pH of essential oil from basil leaves has a range between 5.29 - 6.31. This value is still considered safe if touched by human skin. The pH requirement for a good typical preparation according to the natural pH of human skin is 4.5 - 6.5 (Anastasia & Romadhonni, 2019). The pH value of essential oils from the 1 hour steam distillation method was 5.29, 2 hours 5.78, and 3 hours 5.51. Meanwhile, the pH of the oil produced through boiled distillation is higher, namely 6.22 for the 1 hour process, 6.31 (2 hour process), and 6.33 (3 hour process). The essential oil produced from steam distillation is more acidic than boiled distillation oil.

3.3. Distillation Rate

Based on Figure 4, it can be seen that the steam distillation rate value, with a time of 1 hour, is 0.9 ml/hour. This value decreases as the distillation time increases, namely to 0.5 ml/hour at 2 hours, and decreases again to 0.3 ml/hour at 3 hours of distillation time. The boiled distillation rate value for 1 hour was 1.1 ml/hour, 2 hours was 0.6 ml/hour, and 3 hours was 0.4 ml/hour. Based on these results, it shows that the steam distillation rate value is lower than boiled distillation. According to Sato (2012), the low heat transfer coefficient means that oil contained in solids will be

slower to absorb heat from water vapor. The result is that the rate of oil evaporation will decrease so that the rate of oil distillate recovery will also decrease. The rate of oil recovery with the higher steam rate is followed by a decrease in the oil composition in the distillate, where with a higher steam rate the distillate composition will contain more water. A larger solids load in the distillation column will increase the rate of oil recovery in the distillate. With a greater solid load, the contact time between water vapor and oil will be longer so that heat transfer will be greater, resulting in more oil evaporating.

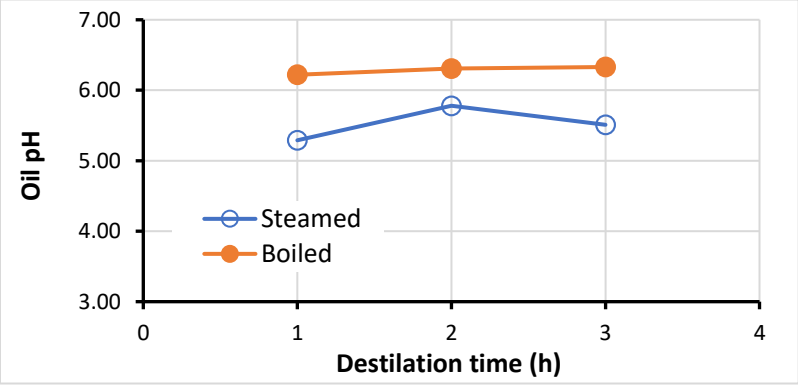

Figure 3. Effect of distillation methods and time on the pH value of essential oil from basil leaves

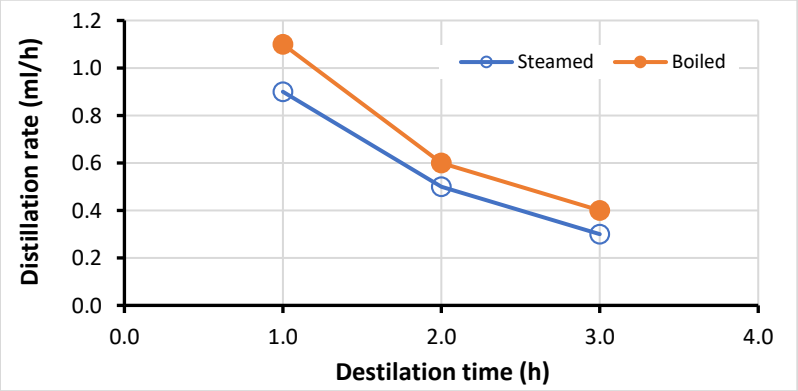

Figure 4. Effect of distillation methods and time on the distillation rate

3.4. Organoleptic Test of Basil Leaf Oil

3.4.1. Color

Color is a determining factor in the quality of a product. The organoleptic score for the color of basil leaf essential oil can be seen in Figure 5. The data above shows that K3 essential oil has the highest color value, namely 5. The research results showed that the essential oil produced from the K3 treatment (steamed for 3 hours) had the highest score, namely 5. This is because the K3 essential oil has a darker yellow color compared to the essential oil from other treatments. The lowest color score was obtained by essential oil from treatment R3 (boiling for 3 hours) where the oil sample had a dark color. The dark brown color of essential oils affects the quality of the essential oil. According to Effendi & Widjanarko (2014), a dark brown color can be formed due to the burn process. It can be concluded that the difference in distillation methods (steaming vs. boiling) produces essential oils with different colors. In the steaming method, the ingredients are not in direct contact with water which does not cause burning or scorching, while the boiling method allows dirt to be carried away by the steam in the condenser and if the distillation process is too long it can cause burning which causes the color of the essential oil to become cloudy or dark.

Good basil leaf essential oil has the characteristic odor of basil plants, has a spicy taste, tends to be clear and yellowish in color (Syamsu *et al*., 2019). The quality of essential oils is determined by the natural characteristics of each oil and the foreign ingredients mixed in it (Nugraheni *et al*., 2016). Distillation of essential oils using the steam method produces clearer oil which is relatively more preferred by panelists than those of boiling water distillation method (hydro distillation). This is in accordance with another study conducted by (Rubiyanto & Fitriyah, 2016).

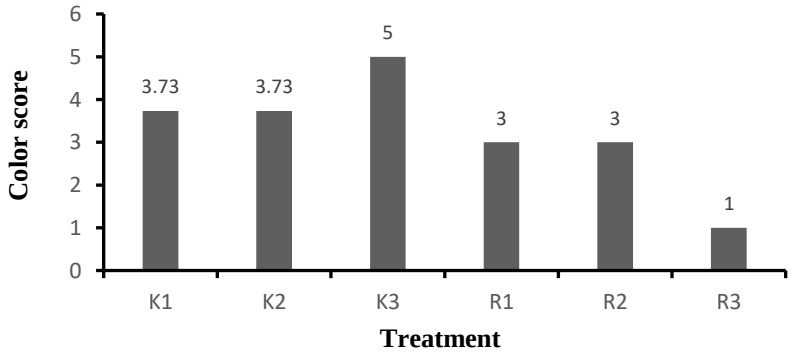

Figure 5. Organoleptic score for color of essential oils extracted from basil leaves. (Notation for treatments are K for steam distillation; R for boiled water distillation; 1, 2, and 3 are distillation duration in hour).

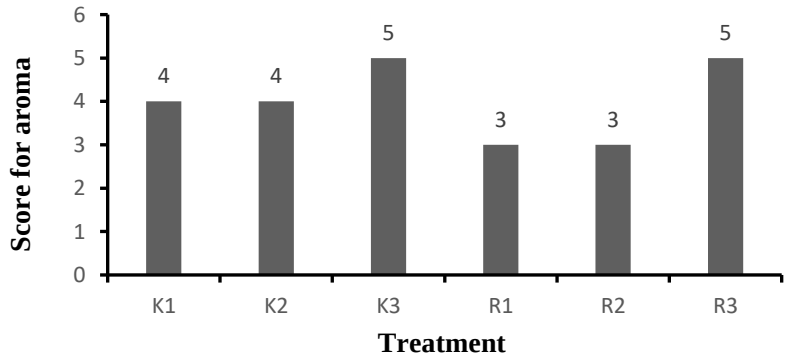

Figure 6. Organoleptic score for aroma of essential oils extracted from basil leaves. (Notation for treatments are K for steam distillation; R for boiled water distillation; 1, 2, and 3 are distillation duration in hour).

3.4.2. Aroma

The aroma of an essential oil product is determined by the ingredients and processing process used. Each essential oil product has a unique aroma. The aroma organoleptic test was carried out to determine the level of preference for the aroma of basil leaf essential oil. Figure 6 shows the aroma score of basil leaf essential oil. The aroma score of essential oils ranges from 3 to 5. Essential oils from K3 and R3 treatments have the highest favorite aroma score, namely 5. With a longer time, all the aromas contained in the material will come out as a whole, resulting in a distinctive aroma from the basil leaves. This is in accordance with (Parahita, 2013) who states that basil oil has a clear yellow color, a distinctive pungent odor, and evaporates easily.

3.4.3. Stain

Stain parameters are also an important factor in determining the quality of essential oils. The essential oil spotting score can be seen in Figure 7. Basil leaf essential oil from treatments K1 and K2 had the highest spot score (4) and was cleaner compared to other treatments. The essential oil spot score is influenced by the length of distillation which causes impurities or compounds that affect the color, odor and spots to be carried into the essential oil. Examination of essential oils is generally carried out by dropping one drop of essential oil on filter paper, if left alone, the essential oil will evaporate completely without leaving a transparent stain (Syamsu *et al*., 2019).

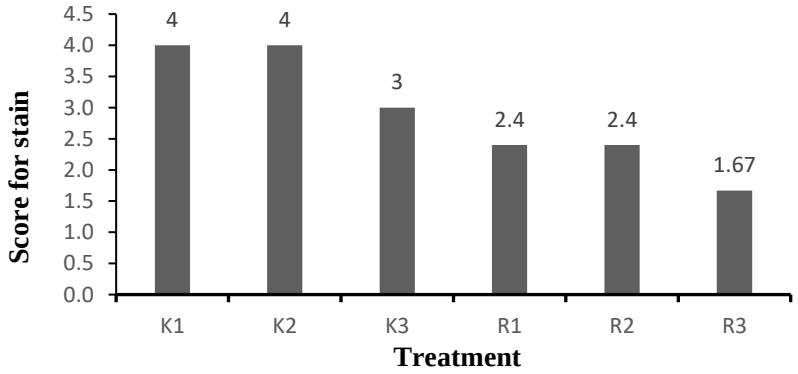

Figure 7. Organoleptic score for stain of essential oils extracted from basil leaves. (Notation for treatments are K for steam distillation; R for boiled water distillation; 1, 2, and 3 are distillation duration in hour).

3.5. The Best Treatment

Table 1 shows the scores to determine the best treatment for distillation of basil leaf essential oil. The best results were obtained from the steaming method with a distillation process time of 2 h which got a total score of 31. Meanwhile, the lowest results were given for oil obtained using the boiling method for 3 h which got a total score of 20. It can be concluded that to obtain good essential oil results, apart from paying attention to the characteristics of the oil, we must also apply the right distillation method and optimal distillation time.

Table 1. Scoring results for determining the best method and time for distillation of basil leaf essential oil

	Oil yield score	Distillation rate score	Total score
Steam	8	9	17
Water (boiled)	16	12	28
1 hour	5	11	16
2 hour	10	7	17
3 hour	9	3	12

4. CONCLUSIONS

Research has been conducted on the distillation of essential oils from basil leaves using the steam and water distillation method with a process time of one to three hours. Based on the results of the analysis of parameters and physical characteristics of essential oils, the steam distillation process with a time of 2 h is the best process which produces 1.1 ml of essential oil, 0.11% yield, pH 5.78, distillation rate 0.53 ml/h, pale yellow color, strong aroma, and clean stain. Meanwhile, for distillation using boiled water, the best result is also with 2 h process which produces 1.2 ml of oil, 0.12% yield, pH 6.31, distillation rate of 0.60 ml/hour, brown color, weak aroma, and the stain is very spotty.

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