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OPTIMIZATION THE PERFOMANCE OF PHOTOVOLTAIC PANELS FOR CITRONELLA OIL DISTILLATION

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ABSTRACT

Photovoltaic system is a module that is used to absorb heat that is exposed to sunlight which is converted into electrical energy. The purpose of this research is to use a solar panel with a capacity of 100 wp to absorb heat which is converted into electrical energy as much as 100 watts/hour which is later expected to be a substitute for conventional electricity which will be used for the refining process. The treatment was carried out by varying the drying time of citronella leaves 0, 1, 2 and 3 days and the time for citronella oil distillation operation for 1.5, 3, 4.5 and 6 hours. By using a solar cell that has a capacity of 100 wp for 6 hours a day when exposed to sunlight it can produce power of 600 watts / day. Testing of distilled citronella oil using the photovoltaic method, the best density was obtained at a distillation time of 1.5 hours with a drying time of 1 day of 0.8889 kg/cm3. Refractive index testing, drying time of 1 day with a distillation time of 1.5 hours the value obtained is 1.4655. The more the chain components with the oxygen group are also distilled, the density of the oil will increase so that the incoming light is more difficult to refract. The yield of lemongrass oil at a drying time of 3 days with a distillation time of 6 hours the value obtained was 2.30%. Drying and withering the amount of material that can be distilled per distillation increases, so that the refining of the material in a dry state is more efficient. The best distillation time is 6 hours, this occurs due to the longer a material receives heat, the more evenly distributed the diffusion process causes the distillation process to be more efficient and greatly affects the yield and oil yield.

Keywords: Photovoltaic, Distillation, Essensial Oil, Density, Yield

1. INTRODUCTION

Indonesia is rich in essential oil-producing plants. As is known, essential oils are useful as raw materials for making cosmetics, aromatherapy and so on. Essential oils are made from distillation of plant parts such as leaves, fruit, seeds, flowers, roots to all parts of the plant. Essential oil is a potential agro-industry export commodity that contributes to the country's foreign exchange. One of the essential plants that are widely available in Indonesia, especially in Aceh, is an area that has a strategic area for cultivating essential oil-producing plants including citronella, nutmeg, agarwood, coffee, and patchouli. Gill et al. (2017), Rihayat et al. (2018).

Essential oil is a commodity in the agribusiness sector that has a good market and strong competitiveness in foreign markets. However, it seems that there are still many plants that produce essential oils that have not been worked on to be ready for investment. For example, citronella plant.

The results of the distillation of essential oils are known as fragrant oil seeds. As with the essential oil industry in Indonesia, it is still carried out by entrepreneurs who have large capital, because the extraction and distillation processes require expensive equipment. This is another drawback of the current system, namely the optimization of energy has not been controlled electronically to determine the length of distillation time. Zulkifli et al. (2018).

In the process of refining essential oils, many energy sources come from fuel oil (BBM), fuel gas (BBG), firewood and electricity from PLN (State Electricity Company). The energy source that is often used is an energy source that is less environmentally friendly and its availability can be disrupted at any time because of its large amount of demand. Therefore, the process of refining essential oils utilizes sufficient alternative energy sources such as solar energy sources that can be available in the long term because the energy comes from the sun.

In this case, the distillation process (refining) which is often used as a source of heat or steam in general, uses BBM, BBG and PLN which functions to heat a mixture of substances to be separated based on differences in boiling points. However, in this study, researchers want to replace the source of heat or steam energy from electric heaters, by absorbing solar heat as a source of electricity using a solar cell that will be used in this essential oil refining process, as renewable energy that is friendly to the environment does not cause pollution and does not require costs. There are many who can use this energy, it is enough when procuring the equipment, the rest is only doing maintenance on the tool as a replacement energy for fuelwood, diesel and gas. Kültürela and Tarhan (2016)

According to the International Renewable Energy Agency (IRENA), photovoltaic system technology has surpassed Concentrated Solar Power (CSP) technology. As the photovoltaic cell is exposed to direct sunlight to generate electricity, the surface temperature of the photovoltaic panel increases, resulting in a significant decrease in the photovoltaic output power. To optimize the use of solar panels, a control system is needed that can control the position of the solar panels so that they always follow the direction and position of the sun automatically. This system is called tracking solar cell so that the efficiency of sunlight utilization can be increased. Khudhair et al. (2018), Luyben (2017).

Advances in solar cell technology are becoming very common nowadays. As is well known that solar cells can convert sunlight into electrical energy. The most common use of solar cells in calculators and replace battery functions. Usually for the provision of power for traffic lights, telephones, house lights, roads, electric cars and so on. In this study, researchers want to use solar power for the process of refining essential oils, the raw material used is citronella. Pawel et al. (2018) , Rahul et al. (2016).

2. METHODOLOGY AND CHARACTERIZATION

2.1. METHODOLOGY

The materials used are citronella plants and water. while the equipment used is a 100 wp solar panel, 12 v 100 ah battery, solar charge control, ac-dc inverter, element heater, a set of distillation equipment, 10 kg of citronella.

The raw materials or materials used in this study are citronella plants that have been harvested. at first the citronella leaves were dried for 3-4 hours for 1, 2, and 3 days and those without drying. after that weighed as much as 10 kg for the distillation process. furthermore, for the essential oil refining process, the kettle used for the distillation process is cleaned first, then enter 50 liters of distilled water into the kettle, enter the raw materials used into the kettle as much as 10 kg, then the heater is turned on to reach 100^{o}c, the process is stopped when the distillation time is 1.5 , 3, 4,5 and 6 hours have been completed then the distillation process is complete, the samples obtained are put into a separating funnel and allowed to stand for 1 hour until the water and essential oil are separated. the essential oil that has been obtained will be analyzed. Ranjay et al. (2017) , Shih et al. (2017)

2.2. CHARACTERIZATION

The characterization used for the essential oil testing process from the distillation process is calculating density, citronella oil yield analysis and refractive index analysis.

2.2.1. DENSITY ANALYSIS

To calculate the density, first weigh the empty pycnometer, then fill the empty pycnometer with 10 grams of citronella oil distillate, then subtract the mass of the pycnometer that has been filled with an empty pycnometer, then obtain the density. The results of the two values are the density value of citronella. The treatment was carried out by varying the drying time 0, 1, 2 and 3 days and the distillate time 1.5, 3, 4.5 and 6 hours. Yang et al. (2018), Rihayat and Suryani (2010)

2.2.2. REFRACTIVE INDEX ANALYSIS

To perform an analysis of the refractive index, the sample to be tested is first dripped with a refractometer sample. Then close the lid tightly let the light pass through the solution and through the prism so that the light on the screen in the device is divided into two. After that, Move the boundary mark by turning the adjustment knob, so that it intersects the point of intersection of the two diagonal lines that intersect each other visible on the screen. Then, observe and read the refractive index scale indicated by the needle of the scale screen through the microscope. Furthermore, the display results in two colors that have been arranged in such a way that it provides two colors that have clear and crisp colors. Rihayat et al. (2018) , Gavahian et al. (2018).

2.2.3. OIL YIELD ANALYSIS

Calculate the weight of citronella to be distilled (input), then calculate the final weight of citronella oil obtained (output).

$$\text{Yield (\%)} = \frac{\text{Weight of refined oil (output) x 100\%}}{\text{Weight of distilled citronella (input)}}$$

3. RESULTS AND DISCUSSIONS

Citronella oil is produced from the distillation process by utilizing sunlight using a solar cell (Photovoltaic). The photovoltaic system used consists of an electrical element (heater) which has an energy absorption power of 2,000 watts with varying operating times, namely 1.5 hours, 3 hours, 4.5 hours and 6 hours. Then the energy required for this system is 3,000, 6,000, 9,000 and 12,000 (watts). The energy required for this system is taken at the maximum energy, which is 6 hours, thus the total energy requirement for the electrical element (heater) is 2000 watts x 6 hours = 12,000 Watts. And a pump that has an electric energy absorption capacity of 125 watts/hour, so the amount of electrical energy required for a pump is 125 watts/hour x 6 hours = 750 watts. Thus the total electrical energy requirement for the lemongrass oil refining process is 12,000 watts + 750 watts = 12,750 watts. Analysis of the performance of the photovoltaic system regarding the calculation of power before application will thus facilitate the process of preparing solar cells for its application which is to calculate the total power used x usage time. Gupta et al. (2018) , Gurung and Qiao (2018).

The sun irradiation time in a day lasts from 10.00 to 16.00 with energy absorption time for 6 hours. For the use of Solar Cells here we use a solar cell with a capacity of 100 Wp. Taking into account the energy required as much as 12,750 watts. Thus the energy required to set the maximum usage is 12,750 watts. So with a power of 12,750 watts with a irradiation time of 7 hours / day with a solar cell capacity of 100 Wp, the number of solar cells needed is 12,750: (6 x 100) = 21.25 (22) solar cell units needed, with consideration of energy saving 2 times the electrical energy required. Gao and Sun (2016)

Based on the journal Experimental study of photovoltaic panel installation configurations for lighting structures where the energy requirement for lighting in the home garden is based on the amount of power required, where the number of lamps used in the garden is 11 units with energy absorption per unit of 80 watts/hour with lighting time (use) for 10 hours, then the total electrical energy needed is 11 units x 80 watts x 10 hours = 8,800 watts. Then the need for solar cells to produce 8,800 watts of electrical energy with the formula Scn (Solar cell needs) = Ten (total energy needs) / (It(irradiation time) x Csc(Capacity solar cell)) = 8,800 / (5 x1000) = 1 ,76 (2 units of solar cells needed). Garoosi et al. (2018)

For power storage using a battery (Battery) with a capacity of 12V/100 Ah to distribute the energy produced as much as 12,750 watts, then the number of batteries needed to store electric current is 12,750: (12 x 100) = 10.6 (11) Unit batteries with 12V/100 Ah capacity. In this case, according to the calculations contained in the journal Experimental studies of photovoltaic panel installation configurations for lighting structures where the battery needs as a medium for storing electrical energy, the number of batteries used depends on the battery capacity and electrical energy to be supplied, where the batteries they use are 24v. 250 ah so the total battery needs / battery capacity (8,800: (24 x 250) = 1.46 (2 units of batteries used). Hustings et al. (2022).

In this study, the results of the tests that have been carried out will be presented. The results of the test were carried out using distillation products without using the photovoltaic method and distillation using photovoltaic. The treatment determined for the product yield was the same, with drying treatments, namely without drying (0 days), 1 day, 2 days and 3 days. And the variation of distillation time is 1.5 hours, 3 hours, 4.5 hours and 6 hours. The following are the observations of Density Analysis, Yield Analysis and Refractive Index obtained.

3.1. DENSITY ANALYSIS

Citronella oil was refined for 1.5 hours, 3 hours, 4.5 hours and 6 hours with drying times of 0, 1, 2 and 3 days. From the results of the distillation of citronella oil, it was then tested using a pycnometer. Table 1, Table 2

Table 1

Table 1 Results of Distillation of Citronella Oil Without Using Photovoltaic

Distillation Time	**Fragrant Lemongrass Density Fragrance**			
(Hour)	**Drying Time (Days) (Kg/cm³)**			
	0	1	2	3
1,5	0,8568	0,8675	0,8548	0,8522
3	0,8596	0,8641	0,8535	0,8536
4,5	0,8555	0,8639	0,8553	0,8549
6	0,8574	0,8621	0,8582	0,8574

Table 2

Table 2 Results of Distillation of Citronella Oil Using Photovoltaic

Distillation Time	**Fragrant Lemongrass Density Fragrance**			
(Hour)	**Drying Time (Days) (Kg/cm³)**			
	0	1	2	3
1,5	0,8778	0,8889	0,8878	0,8855
3	0,8776	0,8883	0,8875	0,8861
4,5	0,8775	0,8885	0,8873	0,8860
6	0,8774	0,8881	0,8872	0,8858

Distillation of citronella, the highest value was obtained at a distillation time of 1.5 hours with a drying time of 1 day, namely 0.8675 kg/cm3 which was obtained from distillation without using a solar cell while a value of 0.8889 kg/cm3 resulted from distillation using a solar cell. From the two distillation results, both are close to the determined SNI standard, but in distillation using a solar cell the density gain is closer to the specified standard. This happens because the citronella leaves are not too dry, so the oil produced can be distilled properly. The lowest value at the distillation time of 1.5 hours and drying 3 days, without a solar cell is 0.8522 kg/cm3 and with a solar cell is 0.8855 kg/cm^3 .

Table 3

Table 3 Based on International Quality Standards (SNI)		
Parameter	**Distillation by Utilizing Sunlight Using Solar Cells (Photovoltaic)**	**SNI 06-3953-1995**
Color	Pale Yellow to Brownish Yellow	Pale Yellow to Brownish Yellow
Specific Gravity, 25°C (gr/cm3)	0.862 – 0.882	0.875 – 0.893
Refractive Index, 20°C	1.415 – 1.472	1.466 – 1.475

The results of the analysis of the quality of citronella oil with the influence of various variables on the quality standard (SNI) are presented in Table 3. In Table 3 shows that most of the existing parameters ranging from color, refractive index and density show numbers that are in accordance with the applicable quality standards (SNI).

3.2. REFRACTIVE INDEX ANALYSIS

The refractive index of a substance is a measure of the speed of light in a liquid compared to when it is in air. In the field of chemistry, the measurement of refractive index is widely used, among others, to determine the concentration of a solution and to determine the composition of the ingredients of the solution. The refractive index can be used to determine the quality of a solution. Table 4. Results of the refractive index of citronella without using photovoltaic.

Table 4

Table 4 Results of Fragrant Lemongrass Refractive Index Without Using Photovoltaic				
Distillation Time (Hour)	**Citronella Oil Refractive Index**			
	Drying Time (Days)			
	0	1	2	3
1,5	1,4362	1,4459	1,4381	1,4375
3	1,4381	1,4447	1,4393	1,4374
4,5	1,4373	1,4454	1,4411	1,4365
6	1,4425	1,4445	1,4439	1,4351

Table 5

Table 5 Results of the Refractive Index of Citronella Using Photovoltaic				
Distillation Time (Hour)	**Citronella Oil Refractive Index**			
	Drying Time (Days)			
	0	1	2	3
1.5	1.4639	1.4655	1.4625	1.4617
3	1.4636	1.4654	1.4623	1.4618
4.5	1.4635	1.4646	1.4625	1.4619
6	1.4636	1.4645	1.4624	1.4615

The refractive index of a solution is the most important characteristic parameter and several related parameters such as temperature, concentration etc. and refractive index measurements can be used in industry to determine the parameters of concentration, temperature, pressure and so on. Refractive index and viscosity have many benefits in everyday life Rodriguez-Gomes et al. (2022). Figure 1. Shows the Refractive Index Graph for the Aroma Value of Citronella Oil.

Figure 1

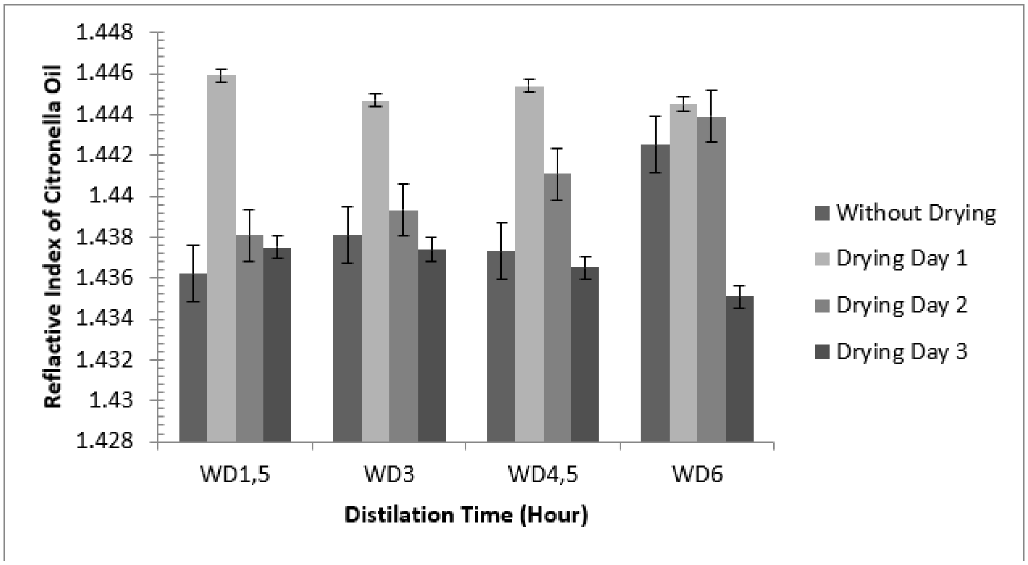

Figure 1 Refractive Index Graph for Assessing the Fragrance of Citronella Oil Without Using Photovoltaic

Figure 2

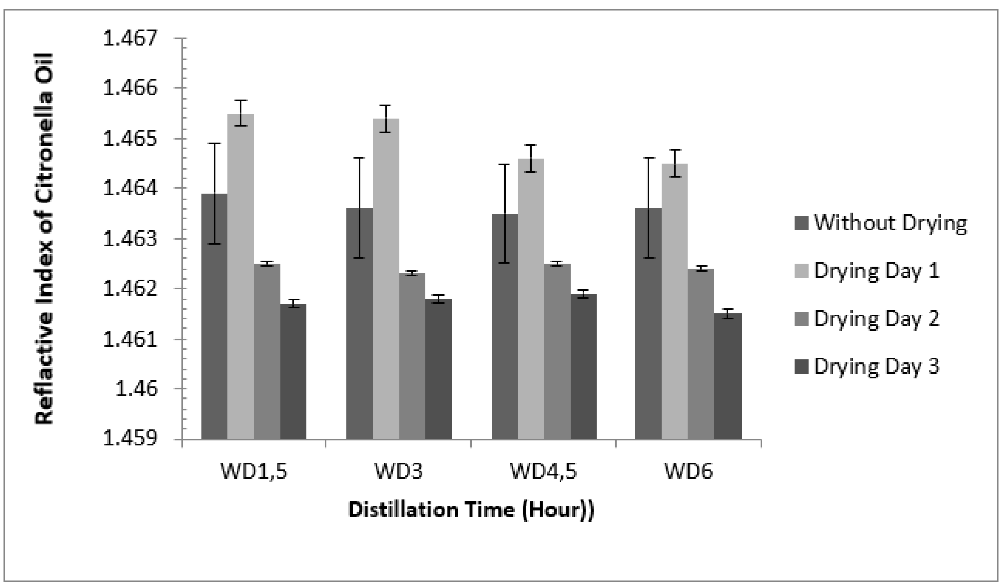

Figure 2 Graph of Refractive Index to Assess Fragrance of Citronella Oil by Using Photovoltaic

In the two graphs above, the distillation time is 1.5 hours with a drying time of 1 day, for the distillation process with a solar cell the value obtained is 1.4655, while in the distillation process without a solar cell the value obtained is 1.4459. From the acquisition of the refractive index analysis using solar cells and without solar cells, the value obtained in distillation with solar cells is greater than without the use of solar cells, this is because the absorption of heat energy from the sun using a solar cell of 12,750 watts is effectively used to essential oil refining process. Eddy et al. (2020) The citronella used as raw material also needs to be dried so that the water content contained in the citronella can be reduced and can also keep the components of the oil produced for the better. because the lemongrass leaves used are still fresh so the oil produced has a better purity. Drying time for 1 day will produce a higher refractive index value. This happens because the oil produced tends to be more viscous so that the water content contained in it is getting less and less. And for the lowest value in distillation with solar cells and without solar cells, it was obtained at 6 hours with a drying time of 3 days, namely 1.4615 and 1.4351, this is because the lemongrass leaves are too dry so that the resulting oil content is reduced. This happens because the oil produced tends to be more viscous so that the water content contained in it is getting less and less. And for the lowest value in distillation with solar cells and without solar cells, it was obtained at 6 hours with a drying time of 3 days, namely 1.4615 and 1.4351, this is because the lemongrass leaves are too dry so that the resulting oil content is reduced. This happens because the oil produced tends to be more viscous so that the water content contained in it is getting less and less. And for the lowest value in distillation with solar cells and without solar cells, it was obtained at 6 hours with a drying time of 3 days, namely 1.4615 and 1.4351, this is because the lemongrass leaves are too dry so that the resulting oil content is reduced.

The refractive index of essential oils is closely related to the components arranged in the essential oil produced. The more long-chain components such as sequiterpenes or components with oxygen groups are also distilled, the density of the essential oil medium will increase so that the incoming light will be more difficult to refract. This causes the refractive index of the oil to be larger. The more water content, the lower the refractive index. This is due to the nature of water which is easy to refract the incident light Dewi et al. (2017) , Nkurikiyimfura et al. (2020). Thus the use of solar cells in the essential oil refining process is effectively used because in addition to saving energy usage, it can also shorten the distillation time to be more efficient with good product results.

3.3. OIL YIELD ANALYSIS

From the two graphs below, it can be seen that the amount of yield obtained fluctuated. This happened because of the drying factor on the leaves of citronella after harvest. Suryani et al. (2018), Ridwan et al. (2018) Actually the best quality of the oil is obtained from the distillation of fresh leaves. Drying and withering of citronella leaves before being distilled at a certain time did not affect the oil yield. The drying and drying process that is too long can reduce the levels of citronella and total geraniol in the oil. However, the amount of material that can be distilled per distillation increases, so that the distillation of the material in the dry state is more efficient.

The highest yield in Figure 3 of the graph of distillation without using a solar cell is 1.66% with a drying time of 3 days, while the highest yield in Figure 4 of the graph of distillation using a solar cell is obtained at the time of drying on the third day, which is 2.30%. The yield of distillation using a solar cell is greater than that without a solar cell. This is because the absorption of solar heat by the solar cell is converted into constant electrical energy so that the heat produced is stable, therefore the use of solar cells results in greater yields without solar cells. The yields obtained from both samples with solar cells or without solar cells are indeed higher in product yield, however, the purity and quality of the oil is reduced. This is evidenced by the data from the lower density test results obtained on the third day of drying. Likewise with the results of the refractive index test obtained for drying on the third day the value obtained is smaller. Bisoffi et al. (2018), Esmaeili et al. (2018) The maximum increase in yield was due to the softening of leaf tissues when exposed to sunlight, making it easier to extract. The increase in the yield of citronella oil can be increased by conditioning and pre-treatment of raw materials such as withering and size reduction. Bisoffi et al. (2018) , Esmaeili et al. (2018) The maximum increase in yield was due to the softening of leaf tissues when exposed to sunlight, making it easier to extract. The increase in the yield of citronella oil can be increased by conditioning and pre-treatment of raw materials such as withering and size reduction. Bisoffi et al. (2018), Esmaeili et al. (2018) The maximum increase in yield was due to the softening of leaf tissues when exposed to sunlight, making it easier to extract. The increase in the yield of citronella oil can be increased by conditioning and pre-treatment of raw materials such as withering and size reduction.

Meanwhile, at the operating time or distillation time of 1.5 hours, 3 hours, 4.5 hours and 6 hours, the highest yield was obtained at 6 hours of distillation, distillation without solar cells the value obtained was 1.66% while using solar cells was 2 ,30%. The results of the distillation with treatment of 1.5 hours, 3 hours, 4.5 hours and 6 hours, indicate the oil at the time of distillation with a time of 6 hours of constant oil extracted. The increase in yield at a distillation period of 4.5-6 hours has been maximally extracted.

The yield of citronella oil depends on various factors, namely climate, soil fertility, planting age and distillation method. The longer the time of distillation of essential oils, the higher the yield obtained, but up to a certain time until the maximum composition of the material. The increase in yield is caused by the increasing amount of heat received so that the diffusion process evaporates the oil faster. Caritte et al. (2018)

Figure 3

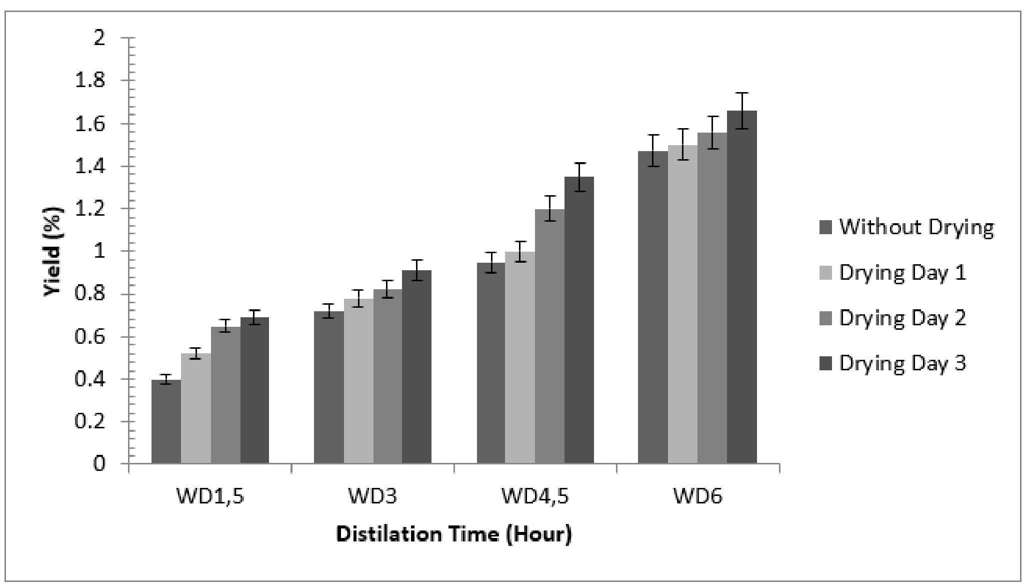

Figure 3 Graph of Effect of Drying Time and Distillation Time on Yield Produced Using Photovoltaic

Figure 4

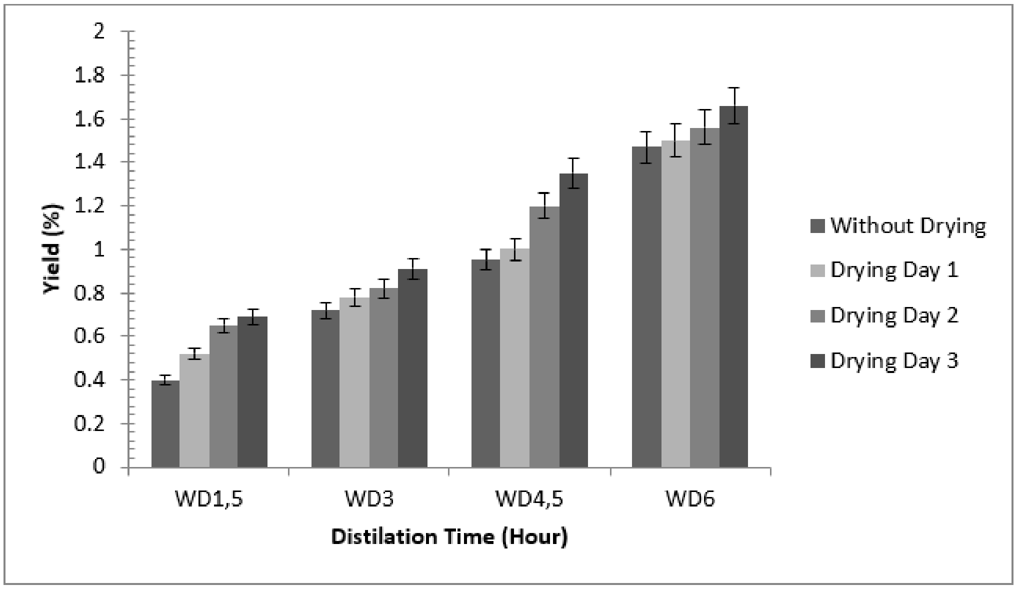

Figure 4 Graph of Effect of Drying Time and Distillation Time on Yield Produced Using Photovoltaic

4. CONCLUSION

From the results of the research that has been done, it can be said that, refining essential oils by utilizing alternative energy sources, namely sunlight, is effectively used. The use of solar cells to absorb sunlight into electrical energy is more efficient than the use of firewood for heating lemongrass oil, but it is also more environmentally friendly. In this study also carried out the results of the analysis for testing without using sola cells, the results obtained were the density analysis with an operating time of 1.5 hours and 1 day drying of 0.8675 kg/cm3. And for the analysis of the refractive index obtained the highest value at 1.5 hours of operation with a time of 1 day with the value obtained is 1.4459. While in the analysis of the yield of citronella oil with the highest product obtained at 3 days with a distillation time of 6 hours with a value of 1.66%. Furthermore, for the results of the analysis by refining using a solar cell, the results obtained are as follows. The value of the density analysis at an operating time of 1.5 hours with a drying time of 1 day was 0.8889 kg/cm3. And to analyze the refractive index of the highest value at an operating time of 1.5 hours with a drying time of 1 day the value obtained is 1.4655. The more long-chain components such as sequiterpenes or components with oxygen groups are also distilled, the density of the essential oil medium will increase so that the incoming light will be more difficult to refract. This causes the refractive index of the oil to be larger. The more water content, the lower the refractive index. This is because of the nature of water that is easy to refract the incoming light. While the yield of lemongrass oil at a drying time of 3 days with a distillation time of 6 hours the value obtained was 2.30%. The longer the time of distillation of essential oils, the higher the yield, but until a certain time limit the composition of the ingredients is maximized. The increase in yield is caused by an increase in the amount of heat received so that the diffusion process evaporates the oil faster.

CONFLICT OF INTERESTS

None.

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None.

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