Refining Citronella Oil (Cymbopogon Nardus L) by Utilizing Sunlight Using Solar Cells (Photovoltaics)

N Safitri1, R Syahputra1, K Y Putri2, T Rihayat3, Nurhanifa3

1 Department of Electrical Engineering, Politeknik Negeri Lhokseumawe, 24301, Aceh Indonesia
2 Department of Civil Engineering, Politeknik Negeri Lhokseumawe, 24301, Aceh Indonesia
3 Department of Chemical Engineering, Politeknik Negeri Lhokseumawe, 24301, Aceh Indonesia

Email: nellysafitri@pnl.ac.id

Abstract. Sunlight is one of the very abundant energy. In its use, many things can be applied such as converting the sunlight into electrical energy with the help of solar cells. In this research, 4 solar cells are used with a capacity of 1000 wp, so in a day they are able to produce 28,000 watts of electricity. This is a very potential electrical energy because it is commonly used to facilitate the process of refining essential oils. The results and the quality of oil obtained in refining research by utilizing sunlight using solar cells shows that the refining time of 6 hours is the best time for the refining process, while the 1 day drying time is better than 2 and 3 days. This is consistent with the oil yield obtained. The yield that has been produced is tested based on Indonesian National Standard (SNI) 2385-2006 through density and Bias Index tests.

1. Introduction
Essential oils are one of Indonesia’s export commodities usually used in the perfume, cosmetics, pharmaceutical and food industries. This oil is known as etheric oil, essential oil or volatility oil because it contains organic compounds which are volatile terpenes at room temperature without being decomposition. Essential oils have a bitter taste (pungent taste) and smell good in accordance with the smell of the original plant [1]. Citronella is a plant that has many benefits, including as a producer of essential oils. This plant is easily cultivated and does not require special treatment, so it is easy to develop. Citronella plants (Citronella), have several biological effects including antioxidant, antifungal, anti-bacterial and insect repellent activity [2].

The process of obtaining essential oils is known as distillation or distillation of oil-producing plants. In the commercial world, the method of distillation / distillation of essential oils can be in 3 ways, including:

1. Distillation with a Boiled System (Water Distillation)
2. Water and Steam Distillation
3. Direct Steam Distillation

The application of the method is based on several considerations such as the type of raw materials, oil characteristics, the process of oil diffusion with hot water, oil decomposition due to heat effects, production efficiency and reasons for economic value and production effectiveness [3].
Solar cells are a set of modules to convert solar energy into electrical energy. Photovoltaic is a technology that functions to convert or convert solar radiation into electrical energy directly. PV is usually packaged in a unit called a module. In a solar module consists of many solar cells that can be arranged in series or in parallel [4], [5]. Meanwhile, what is meant by solar is a semi-conductor element that can convert solar energy into electrical energy on the basis of the photovoltaic effect.

Solar cells are a set of modules to convert solar energy into electrical energy. Photovoltaic is a technology that functions to convert solar radiation into electrical energy directly. PV is usually packaged in a unit called a module. In a solar module consists of many solar cells that can be arranged in series or in parallel [6], [7]. Meanwhile, what is meant by solar is a semi-conductor element that can convert solar energy into electrical energy on the basis of the photovoltaic effect. Solar cells have become popular lately, in addition to the depletion of fossil energy reserves and the issue of global warming. The energy produced is also very cheap because energy sources (solar) can be obtained free of charge. Schematic image of a solar cell can be seen in figure 1.

![Schematic of a solar cell](image.png)

**Figure 1.** Schematic of a solar cell

Renewable energy has a very important role in fulfill energy needs. This is due to the use of fuel for conventional power plants over a long period of time which will deplete the source of petroleum, gas and coal which is running low and can also cause environmental pollution [8]. One of the efforts that has been developed is the Solar Power Plant (PLTS). PLTS or better known as solar cells (photovoltaic cells) will be more in demand because they can be used for a variety of relevant purposes and in various places such as offices [9], factories [10], housing [11], and others. In Indonesia, which is a tropical region has a very large solar energy potential with an average daily insulation of 4.5 - 4.8 KWh/m²/day [12]. However, the electrical energy produced by solar cells is strongly influenced by the intensity of sunlight received by the system.

The calculation amount of power consumption, the number of solar panels and the number of batteries used can be mention in the following section [13]:

a. Calculation of power requirements (calculation of the device's electrical power can be seen on the label on the back of the device, or read from the manual).

b. Calculation of the number of modules needed:

\[
\frac{planned\ power}{power\ capacity\ module \times \ intensity\ of\ sunlight\ in\ a\ day}
\]

c. Minimum battery requirements (batteries are only used 50% to meet electricity needs), thus we multiply the power needs 2 x.

\[
\frac{planned\ power}{battery\ capacity} \times 2
\]
2. Material and Method

2.1. Refining of Citronella Oil
Photovoltaic equipment arranged according to the established scheme. The water is put into the pot as much as 25 liters based on principle 1:5. The chopped lemongrass leaves are put into a distilled pot. The pump is turned on to drain the cooling water then the heater is turned on until it reaches the refining temperature of 100°C and then the distillation process is stopped according to the specified time. After the distillation time is complete, the process is stopped [14].

2.2. Characterization of Citronella Oil

2.2.1. Density Test
Weigh the Empty Pycnometer. Fill the empty pycnometer with refined oil then weigh it again. Note the initial weight and finally weight then calculated using the formula:

\[ \rho = \frac{m}{V} \]

2.2.2. Refractive Index Test
The autorefractometer is turned on. The calibration process is carried out using distilled water, then citronella essential oil is dropped in the column. Press the "measure" button on the tool to measure the refractive index of the oil.

3. Result and Discussion
The distillation process of essential oils usually generated by utilizes the artificial heat generated from the combustion process both firewood and stoves. Therefore this study utilizes sunlight as a substitute for heat sources for distillation or commonly called photovoltaic. Photovoltaic technology always has more advantages compared to other technologies because it is pollution-free and unlimited solar energy [14]. Another advantage with photovoltaic technology is that it does not emit greenhouse gases during operations and is environmentally friendly. Intermittency of solar radiation can be a limitation for technology because it cannot supply electricity continuously during periods of sunlight, but this problem can be overcome by using battery storage. However, there is a need to understand the application of this technology to be feasible for its users [15].

3.1. Effect of Drying Time and Refining Time for Citronella Oil Yield
From the figure 2 below, it can be seen that the amount of yield produced has fluctuated. The highest yield was 0.84% with 6 hours distillation treatment and 1 day drying time. The efficient drying time for citronella oil is 1 day because the longer the drying time the oil content in plants will decrease. The best distillation time is 6 hours, this happens because the longer a material receives heat, the more even the diffusion process causes the more efficient distillation process.

The effect of drying time on yield proves that the condition of the material that produces a large% yield is when the condition of the material starts to wilt compared to the fresh material. So the condition and treatment of these materials can improve the process of % essential oil yields in accordance with the literature which states that the process of withering aims to reduce the water content in the material glands, so that the extraction process is easier to do and enumeration is an effort to expand the area of evaporation and contact with water so that the lemongrass oil fragrance is easier to extract.
Drying is the process of reducing the water content of a material until it reaches a certain water content. The basis of the drying process is the evaporation of material water into the air due to differences in the moisture content between the air and the dried material. For a material to become dry, air must have a moisture content or moisture lower than the material to be dried [16].

3.2. Density Test For Citronella Essensial Oil
Density defined as the ratio between mass and volume of material. In general, density is related to Viscosity, which is a denser liquid (high density) having a higher viscosity compared to a liquid whose its low. The value of density of citronella oil ranged from 0.8757. The effect of refining time on the density value shows that at the three heating time of material showed a significant effect on the density value.

From the figure 3, can be seen that the density value does not exceed the value of the SNI range and the density value above greatly affects the operation time and the drying time. The highest value of the density of citronella oil obtained at the time of 1 day drying with 6 hours operating time. While the lowest density of citronella oil values obtained at 3 days of drying at 4 hours of operation.
3.3. Refractive Index Test for Citronella Essential Oil

It can be seen in the graph that from 12 observed trial runs almost have the same refractive index value which is around 1.465, the refractive index obtained is in accordance with the Indonesian National Standard (SNI). From all the experiments, there were 2 trials whose refractive index value was higher than the others, with a refractive index value of 1.474, which was run at a distillation time of 5 and 6 hours at 3 days of drying. This shows that the drying time will affect the quality of the essential oils. At the highest citronellal volume, a refractive index of 1.465 was obtained in the experiment on one drying day and at 6 hours of refining time.

![Figure 4. Refractive Index Value](image)

The presence of high water content in oil produces a small refractive index because light is easily refracted in water compared to oil due to differences in liquid density. Therefore, essential oils with large refractive index have better purity and quality presented in figure 4.

4. Conclusion

From the result of this study some conclusion can be drawn: (1) The optimum time for refining essential oil were 6 hours distillation and 1 days drying time. (2) The highest value of the density of citronella oil is 0.88 obtained at the time of 1 day drying with 6 hours operating time. (3) At the highest citronellal volume, a refractive index of 1.465 was obtained in the experiment on one drying day and at 6 hours of refining time.

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