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DISTILLATION OF ESSENTIAL OILS FROM THE LEAVES AND STEMS OF CITRONELLA (Cymbopogon Winterianus) USING A SOLAR ENERGY-BASED VAPOR DISTILLATION APPARATUS WITH PHOTOVOLTAIC METHOD

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ABSTRACT

The photovoltaic method with solar panel modules with a capacity of 100 Wp can absorb heat and convert it into electrical energy up to 100 watts / hour and is used for the citronella oil refining process which requires 57,550 Kj of energy. By using 4 solar cell panels, within 4 hours the power generated is able to meet these energy needs. Based on the test results of the design of the distillation device using solar cells, the efficiency of energy absorption cannot be absorbed up to 100%, due to the occurrence of lost energy but this can be overcome with a longer absorption time. In testing citronella oil with variations in drying time and distillation time, it was found that the optimum time to produce the highest percentage of citronella oil yield was at a drying time of 18 hours with a distillation time of 6 hours, namely 1.20%. From the laboratory tests produced, citronella oil with variations in drying time and operating time has a density value ranging from 0.8751gr/ml to 0.8831gr/ml and the best GC-MS test results obtained the amount of citronellol in the sample as much as 15.73% and the amount of geraniol as much as 28.57% has met the Indonesian National Standard (SNI) 2385-2006.

***Keywords*:** *Solar Cell, Photovoltaic, Citronella Oil, Solar Panel*

INTRODUCTION

Indonesia is one of the countries that produces the largest essential oil in the world. Essential oil is also a foreign exchange earning commodity and one of the essential commodities withry high prospect is citronella oil among 12 essential oils exported by Indonesia. According to Bisoffi, the composition of essential oils is very complex about 40 or more compounds, mainly terpenoids, namely sesquiterpenes - sesquiterpenes and esters.[1] The demand for citronella oil is quite high and tends to increase, but the price remains stable. The development of citronella oil exports is relatively high ranging from 9-10% where BPS (Central Bureau of Statistics) export data shows that the contribution of citronella oil to revenue in essential oil exports is around 6.89%, the third largest after patchouli oil (patchouli oil) about 60% and vetiver oil (vetiver oil) around 12.47%.[2]

Generally, citronella oil is produced by 3 methods, namely distillation, extraction, and pressing. Here I want to try the distillation method because the distillation method is a simple and cheap technology to apply, especially for farmers from North Aceh and Lhokseumawe. The distillation method uses a solvent medium of water, steam or water-vapor mixture. The steam distillation method is the most widely used process.

Solar Cell is a renewable energy source that is rapidly increasing its energy source to become more powerful. This system converts sunlight directly to produce electricity immediately it is said to be renewable energy. Of all the renewable energy sources, solar energy is abundantly available in many countries.[3]

During periods of lower temperatures the energy generated by the panels (Photovoltaic) will also have favorable consequences for the ambient air.[4] This energy also has the potential to address several social, economic and environmental issues through this renewable energy. Therefore from ancient times some humans have utilized solar energy, radiant light, and heat from the sun and the technology continues to evolve today.[5]

Solar-based distillation is clearly possible to operate with lower operating costs, thereby increasing revenue, especially in producing essential oils that require high operating costs. Of the various types of distillation processes used worldwide to extract essential oils from plant materials, commonly used processes include hydro distillation, steam distillation and water distillation, steam distillation is considered to be the most profitable process.[6]

This research was conducted to determine the drying time on the yield and quality of citronella oil in the distillation process, determine the effect of distillation time on the yield and quality of citronella oil produced and determine the capacity of the solar cell and the amount of power consumption used for the distillation process of citronella oil.

METHODOLOGY

Time and Location of Research

This research was conducted from January to March 2023. This research was conducted at the PT Fugha Pratama Mandiri Workshop and the Chemical Technology Laboratory, Lhokseumawe State Polytechnic.

Research Tools and Materials

The tools used are a set of distillation tools, 100ml beaker glass, 100ml measuring cup, pH meter, 100Wp solar panel, 12V 200Ah battery, DC-AC inverter, heating element, alcohol meter, stirrer and scales. The materials used in this research are citronella leaves and stems, water and distilled water.

Research Method

The research method used is to shrink the 100 Wp (Watt Peak) solar panel and assemble it then connected to the SSC (Solar Charger Controller) to convert solar energy into electric current then connected to the battery for storage of electric current when the weather conditions are cloudy then connect to the inverter which is to convert DC current into AC current then the heater outlet is connected to the inverter.

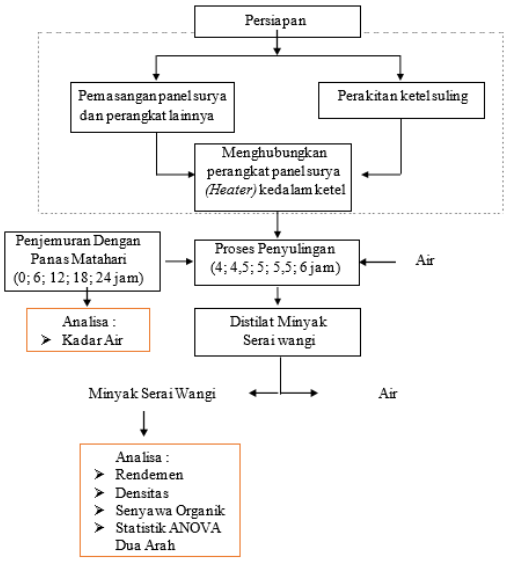

Figure 1. Research Flowchart

Moisture Content (SNI 06-2413-2002)

Testing the moisture content of the leaves and stems of citronella using the oven method by weighing an empty petri dish so that its weight is obtained and inserting 5 grams of citronella leaves into the petri dish. Then the petri dish and raw citronella were oven at 105 ℃ for 2 hours, then weighed the petri dish and citronella that had dried, so that the weight was obtained and calculated the moisture content in citronella with the equation (1).

$$\text{Moisture } \% = \frac{b-(c-a)}{b}\ x\ 100 \qquad (1)$$

Description:
a = Constant weight of the dry cup
b = Weight of initial sample

c = Constant weight of the cup and dry sample

Yield

The citronella oil that has been separated is transferred in a sample bottle (vial), each citronella oil obtained is calculated the yield. According to Rangana (1987), the yield value is the ratio of the mass value between the final product, namely the essential oil produced and the mass value of the initial raw material, namely citronella stems and leaves.[7] The yield is calculated by using the equation (2).

$$\text{Yield } \% = \frac{B-A}{C}\ x\ 100 \qquad (2)$$

Description:
A = Empty erlenmayer weight
B = Weight of erlenmayer and sample
C = Initial sample weight

Density

Density testing is done by cleaning the pycnometer by rinsing. The pycnometer is then dried and weighed and then filled with the resulting liquid with a temperature of about 25 ° C and the lid is installed. After that, the pycnometer is filled with liquid and make sure there is no air trapped in the pycnometer and then place it on an analytical scale to be weighed.[8] Calculate density using the equation (3).

$$\text{Density } (\rho) = \frac{Mass}{Volume} \qquad (3)$$

Analisis Senyawa Organik

The citronella oil obtained was analyzed using GC-MS equipment to determine the components of the constituent chemical compounds contained in citronella plants (Cymbopogon Winterianus) and the mass spectrum obtained from citronella plants (Cymbopogon Winterianus) can be compared with the mass spectrum of the comparator compounds listed in the database that has been programmed on the GC-MS tool.[9]

Data Analysis

Data analysis in this research was carried out by ANOVA (Analysis of Variance) statistical test using the IBM SPSS Statistic version 29 application with a 95% confidence level for yield and density parameters. The ANOVA statistical test in this study used a significance value of <0.05.[10]

RESULTS AND DISCUSSION

In this research, the energy needed to heat water in a tank weighing 25 kg is 57,559 kJ, for energy output consists of an electric element (heater) which has an energy absorption capacity of 2,000 watts/hour which means it takes 6 hours to meet power requirements, while the distillation time varies at 4; 4.5; 5; 5.5; and 6 hours. The heat absorption capacity of 1 solar cell panel is 100 Wp which in this design there are 4 panels which means that in one hour it can absorb 1,440 kJ of heat, based on theoretical calculations at a maximum time of 6 hours the panel can absorb 8,640 kJ of heat.

Solar Heat Absorption Capability with Solar Cells Theoretically

Before the research is done first calculated the ability of solar cells to absorb the heat used to heat the distillation kettle, the following graph is the relationship between the efficiency of heat absorption against time.

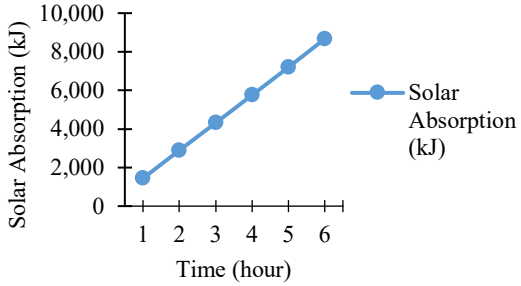

Figure 2. Theoretical Relationship Curve of Heat Absorption Efficiency to Time

Based on the curve, it can be seen that the longer the absorption time, the more heat energy is absorbed by the solar sell which will be converted into a source of electricity and is directly proportional. This is in accordance with the expected goal where the power needed for boiler heating can be supplied properly.

However, in reality it does not work that way, unfavorable weather often affects the process of absorbing solar heat to be not optimal, below is the heat absorption curve that is actually measured in the field, considering that the weather in recent months tends to be cloudy and rainy, so that absorption is not maximized according to the theoretical calculations that we expect.

Actual Solar Heat Absorption Capability with Solar Cells

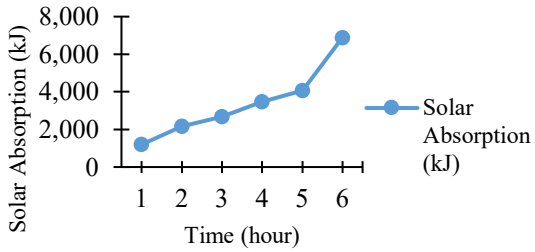

Figure 3. Relationship Curve of Heat Absorption Efficiency to Actual Time

Based on the curve above, it can be seen that the absorption of solar heat tends to be unstable, it is caused by the weather and can also be caused by lost energy, not all energy absorbed can be stored properly and maximally.

During the distillation process to control excessive electric current or disconnect the distribution of electrical energy generated by solar cells stored into batteries, the Controller is used as a safety against damage to solar cells and battery damage due to excessive electrical energy supply. One of the stages to extend the life of photovoltaic devices. In this case in accordance with the calculations contained in the journal Experimental study of photovoltaic panel mounting configurations for lighting structures written by Kulturela Y, et al.[11]

Yield Analysis

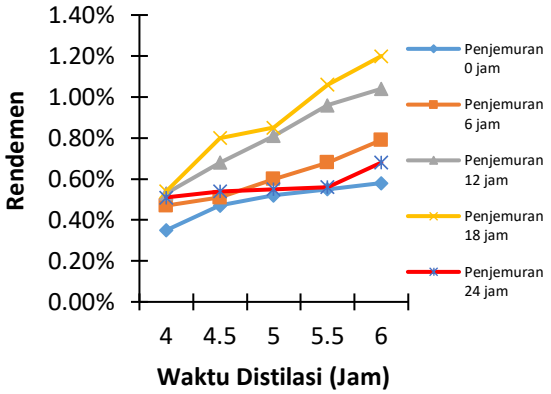

Figure 4. Graph of the effect of operating time using solar distillation on citronella oil yield

From the graph above, it can be seen that the amount of yield produced fluctuates. The highest yield was obtained as much as 1.20% with a distillation process for 6 hours and drying time for 18 hours. From the data, it can be seen that the efficient drying time for citronella is 18 hours because if the drying is done for less than 18 hours, the water content in the yield is more than the oil and if the drying is done for more than 18 hours, the oil in the citronella leaves will evaporate due to too long exposure to the sun. The best distillation time is 6 hours, this happens because the longer a material receives solar heat, the more evenly the diffusion process in the material causes the distillation process to be more efficient.

Table 1. ANOVA statistical test results of yield

Source of Variation	*SS*	*df*	*MS*	*F*	*P-value*
Drying Times	0,579	4	0,144	16,379	1,636 x10^{-5}
Distillation Times	0,388	4	0,097	10,988	1,765 x10^{-4}
Error	0,141	16	0,008		
Total	1,108	24			

The ANOVA statistical test results showed a significant value at drying time of 1.636x10-5 and a significant value at

operating time of 0.000176584. Both values are smaller than the significance level of 0.05 so it can be concluded that there is a significant difference between drying time and operating time on the percentage yield produced in citronella oil distillation.

Analysis of Density

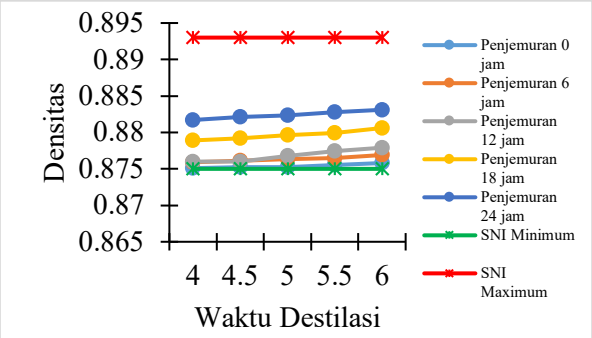

Figure 5: Graph of density values against distillation time

From the graph above, it can be seen that the density value does not exceed the SNI (Indonesian National Standard) range value and the density value above is very influential on distillation time and drying time. The highest density value of citronella oil obtained is at a drying time of 24 hours with an operating time of 6 hours. While the lowest citronella oil density value obtained is at 0 hours drying time at 4 hours operating time.

Tabel 1. Hasil uji statistik ANOVA densitas

Source of Variation	*SS*	*df*	*MS*	*F*	*P-value*
Drying Times	5,818x 10^{-6}	4	1,454 x10^{-6}	25,14 434	9,949 x10^{-7}
Distillation Times	1,655x 10^{-4}	4	0,413 x10^{-4}	715,3 086	8,189 x10^{-18}
Error	9,255x 10^{-7}	16	5,784 x10^{-8}		
Total	1,722x 10^{-4}	24			

The ANOVA statistical test results showed a significant value at drying time of 9.949x10-7 and a significant value at operating time of 8.189x10-18. Both values are smaller than the significance level of 0.05 so it can be concluded that there is a significant difference between drying time and operating time on the density produced in citronella oil distillation.

Analysis of Compounds Using GC-MS

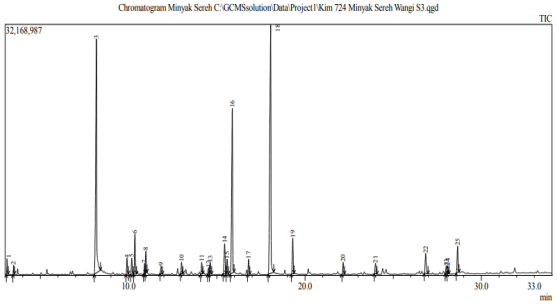

Figure 2. GC-MS graph of citronella oil distillation results

From the results of analysis using GC-MS, it shows that there are chemical compounds identified by GC-MS tools including Sitronellal, Geraniol and several other compounds in citronellal, based on the results of GC-MS obtained Citronellol 15.73%, and Geraniol by 28.57%.

CONCLUSIONS

1. Drying time has an influence on the yield produced where the less the drying time, the less the yield produced and the longer the drying time, the more the yield produced.
2. Distillation time has an influence on the resulting yield, where the faster the distillation time is carried out, the less yield is produced and the longer the distillation time is carried out, the more yield is obtained.
3. The heating capacity of 5 kg of citronella raw materials requires 57,559 kJ of electrical energy. By using 4 solar cell panels, within 4 hours the power generated is able to meet these energy needs.
4. In the results of citronella oil distillation, the lowest yield obtained was 0.35% at 0 hours drying time and 4 hours distillation time and the highest yield obtained was 1.20% at 18 hours drying time and 6 hours distillation time.

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