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Efficiency of photovoltaic technology for Citronella oil distillation

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Abstract. Utilization of solar rays is currently very intensively carried out as renewable energy by utilizing endless energy due to its use, namely sunlight. Solar Cell or commonly called Photovoltaic system is a module that is used to absorb heat which is exposed to sunlight which is converted into electrical energy. The magnitude of the potential of sunlight that can be absorbed depends on the cell size and absorption of a solar cell against sunlight. In order to optimize the use of solar panels, a control system is needed that can control the position of the solar panel to always follow the direction and position of the sun automatically. Using modules (solar panels) with a capacity of 100 Wp can absorb heat converted to electricity as much as 100 watts/hour. This is a big advantage if it is able to be applied as a conventional electric substitute. In Southeast Asia in Aceh especially the sun shines from 09.00 a.m. until 15.00 a.m. this is a big advantage, by using a solar cell that has a capacity of 100 Wp for ± 5 hours a day when exposure to sunlight can produce power of 650 Watts/day. If the solar cell is used as many as 48 units of solar cells, then in a day can produce as much as 24,000 watts of electrical energy. This potential electrical energy can commonly use to facilitate the distillation of essential oils.

Keywords. Solar cell; Photovoltaic; Distillation essential oil

1. Introduction

In the industrial world, distillates of essential oils are known as fragrance oils. Just as the essential oil industry in Indonesia is still carried out by entrepreneurs who have a large capital, because the essential oil extraction and distillation process requires equipment at very expensive prices, so essential oils have not become a household industry with a small scale of production. For this reason, it is necessary to develop cheaper process equipment that is affordable to the home industry and can generate profits for

the entrepreneurs, so that the essential oil industry can be more popular so that natural resources, especially in the plantation sector can be utilized optimally and can also become new jobs that absorb human Resources. This essential oil is used in food, medicine and cosmetics, etc. And it is an income business for the farming community [1].

Scented lemongrass oil is one type of essential oil that is widely produced in Indonesia and is also an export commodity, especially in the Aceh Province. Scented lemongrass oil is generally produced with 3 methods, namely the method of distillation, extraction, and pressing. Here I want to try with the Distillation Method. Where this method can be done with a medium of water, steam or water-steam mixture [2,3]. This is because the distillation or distillation method is a cheap and simple technology to be applied to our farmers, especially farmers from North Aceh and Lhokseumawe. For the condition of farmers in Indonesia, the method of steam distillation is the most widely used by farmers today.

Distillation or distillation itself is the process of separating a component from a mixture, which is a mixture has more than one component. The principle of distillation separation is by way of the law based on differences in boiling points, and can only be done on substances that are volatile (rapidly evaporating) [4,5]. As for distillation, which is commonly used as an energy source for heat or steam, it generally uses conventional wood fuel, gas, which functions to heat the mixture of substances that want to be separated based on the boiling point difference [6]. However, in this research, the researchers want to replace the thermal energy source or the steam is from an electric heater, where the electricity source comes from sunlight that changed using solar cell (photovoltaic).

The problems faced today are the heat sources used in general using conventional fuelwood, gas and electricity that are increasingly diminishing incapacity. Therefore, researchers want to use sunlight as a heat source in the distillation process by utilizing solar energy using solar panels commonly referred to as photovoltaic (solar cell) systems. The solar energy is one of alternative energy that is growing rapidly nowadays as a substitute for energy from fuelwood, gas, conventional electricity as a power plant [7-10]. To take advantage of the potential of solar energy, the equipment currently used is commonly called photovoltaic (solar cell) or solar panels. The magnitude of the potential of sunlight that can be absorbed depends on the cell size and absorption of a solar cell against sunlight [11]. To optimize the use of solar panels, a control system is needed that can control the position of the solar panel to always follow the direction and position of the sun automatically [12,13]. This system is called tracking solar cell so that the efficiency of the utilization of sunlight can be increased.

Solar cells with technological advancements are becoming very common today. As we know the solar cell is a device that converts sunlight directly into electricity and the advantage is that sunlight can be obtained every day freely. The use of solar cells is very wide in the world, as an example of the most common use in calculators and replaces battery functions. As long as the light is available, the calculator can function forever [14]. Larger solar cells are also used to provide power for traffic lights, telephones, street lights, homes, ships, solar electric cars that can operate without oil, and so on [15,16]. In this case, the researcher wants to use solar power for the process of distillation of citronella oil (volatile).

2. Methodology

2.1. Materials

Solar Panel 100 Wp (1200x540x30mm), 12V 100Ah Battery, Solar Charge Control, DC-AC Inverter, Element Heater, Distillation Device Scented lemongrass (distilled kettle), Erlenmeyer 100 ml, 100 ml measuring cup, Leaves of Citronella 3 Kg, and aquadest.

2.2. Density analysis

Weigh Blank Picnometer, Fill empty pycnometer with 10 grams of lemongrass oil distillate. Furthermore, the value of the weighing pycnometer content of fragrant lemongrass is reduced by an empty pycnometer. The results of the two values are the density values of the fragrant lemongrass. This treatment was done by varying the mixing time (0, 1, 2 and 3 days) and distillation time (2, 4 and 6 hours).

2.3. Analysis of index bias

Drop the sample to be examined for the refractive index at the place of the refractometer sample. Cover tightly and let the light pass through the solution and the prism so that the light on the screen in the tool is divided into two. Slide the boundary mark by rotating the control knob, so that it intersects the intersection point of two intersecting diagonal lines visible on the screen. Observe and read the refractive index scale indicated by the scale screen needle through a microscope. The two-colour result screen has been arranged so that it gives two colours that have clear and firm colours. This treatment is done by varying the mixing time (0, 1, 2 and 3 days) and distillation time (2, 4 and 6 hours).

2.4. Gas Chromatography-Mass Spectrometry (GC-MS) analysis

GC-MS was associated with a mass spectrometer (Agilent 5975C) using DB-1MS capillary columns (30 x 0.25 mm D 0.25 µm thick layer). The injector temperature and detector are set at 250 ° C Oven temperature are programmed at 60 ° C for 3 minutes, raised at 3 ° C / min to 240 ° C and then held for 10 minutes. Helium as a gas carrier is set at a flow rate of 1.2 mL/minute. The volume of the sample injected is 1.0 µL. This treatment varied the mixing time (0, 1, 2 and 3 days) and distillation time (2, 4 and 6 hours).

3. Results and discussion

The photovoltaic system that is used consists of an electric element device that has 2000 watts of energy absorption with varying time usage, ie 2, 4 and 6 hours. Then the energy needed for this system is 4000, 8000 and 12,000 Watts.

The time of daylighting takes place from 09.00 to 15.00 with the time of irradiation for ± 5 hours. For the use of Solar Cell, here we use a solar cell with a capacity of 100 Wp. With the consideration of the energy needed as much as 4000 watts, 8000 watts and 12000 watts with the consideration that there is no sunlight caused by rain or rain, energy-saving is applied for 2 days, then 4000 watts x 2 = 8000 watts, 8000 x 2 = 16000 watts and 12000 x 2 = 24,0000 watts of energy needed. Set at the largest usage of 24,000 watts. So with 24,000 watts of power with a time of irradiation for 5 hours/day with a capacity of 100 Wp solar cell, the number of solar cells needed is 24,000: (5 x 100) = 48 units of solar cells needed. The power storage using batteries with a capacity of 12V / 100 Ah used to deliver the generated energy by 24,000 watts. The number of batteries needed to store electric current is 24,000: 1200 = 20 Units with a 12V / 100 Ah capacity, and to control excessive electric current or decide the distribution of electrical energy produced by the solar cell stored in the battery. Then we use the controller as a safety against damage to the solar cell and battery damage due to the supply of excessive electrical energy. One of the stages to extend the life of a Photovoltaic device.

In supplying electric current from the battery to the electrical element (Heater on the distillation device) the Inverter used as a safety and connecting to control the energy supplied from the battery to the electrical element as a heater. Figure 1 and figure 2 show the photovoltaic circuit diagrams.

Figure 1. Photovoltaic circuit without distillation.

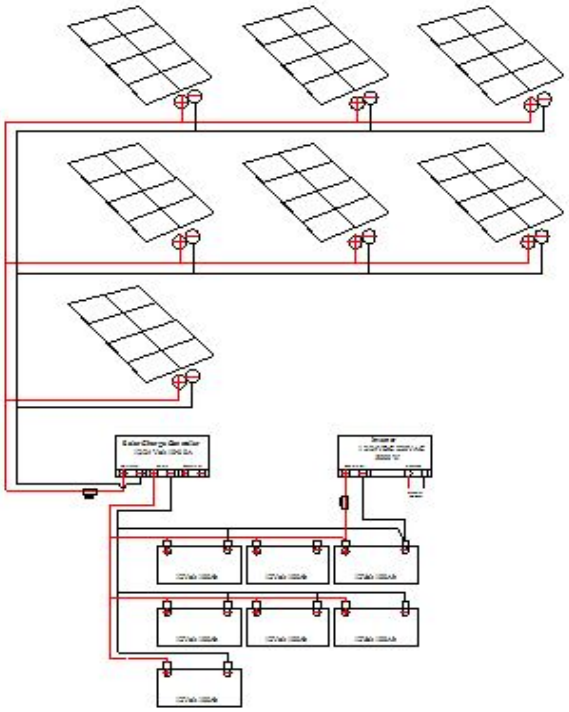

Figure 2. Photovoltaic circuit.

3.1. Density analysis

Fragrant citronella oil is carried out during distillation at 2, 4 and 6 hours with the drying time being carried out i.e without drying and with a drying of 1, 2 and 3 days. From the results of the distillation, the citronella oil yield is fragrant, which is then tested using a pycnometer. Table 1 summarises the results of citronella oil density.

Table 1. Results of citronella oil density.

Distillation Time (Hours)	Lemongrass Oil Density Fragrant (kg/cm^3)			
	Drying Time (Days)			
	0	1	2	3
2	0.8885	0.8895	0.8889	0.8875
4	0.8884	0.8894	0.8887	0.8878
6	0.8885	0.8892	0.8888	0.8877

Figure 3 depicts the distillation graph the value of citronella oil fragrance. The graph plotted with the distillation time at the time of drying analysis using a pycnometer, which obtained with the results of fragrant lemongrass oil.

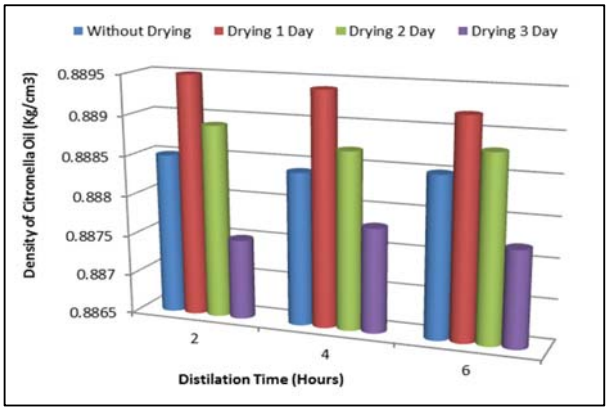

Figure 3. Distillation graph for the value of citronella oil fragrance.

The distillation from the fragrant citronella obtained the highest value at the time of distillation 2 hours with a drying time of 1 day, which was 0.8895 kg / cm3. Because the leaves of citronella are not too dry, so the oil produced can be distilled well and at the lowest value at the time of distillation 2 hours with a drying time of 3 days, which is 0.8875 kg / cm3, because the leaves of fragrant citronella are too dry so that the oil content obtained is less.

3.2. Analysis of index bias

The refractive index of a substance is a measure of the speed of light in a liquid compared to when it is in the air [17]. The refractive index is one of several important optical properties of the medium. In the field of chemistry, measurement of the refractive index is widely used, among others, to determine the concentration of the solution [18] and to know the composition of the ingredients of the solution. Refractive index used to determine the quality of a solution. Table 2 summarizes the result of citronella oil density.

Table 2. Results of citronella oil density.

Distillation Time (Hours)	Refractive Index of Citronella Oil			
	Drying Time (Days)			
	0	1	2	3
2	1.4656	1.4638	1.4626	1.4618
4	1.4655	1.4635	1.4624	1.4619
6	1.4646	1.4636	1.4625	1.4614

Measurement of refractive index used in the industry to determine physical parameters in the form of concentration, temperature, pressure and others [19]. The solution refractive index is a very important characteristic parameter and several related parameters such as temperature, concentration, etc., [20] estimated from that. Refractive index and viscosity have many benefits in daily life, for example as the quality parameter of cooking oil where the oil that has the best quality is an oil that has a high refractive index and viscosity [21]. Figure 4 shows the index bias graph for the value of citronella oil fragrance.

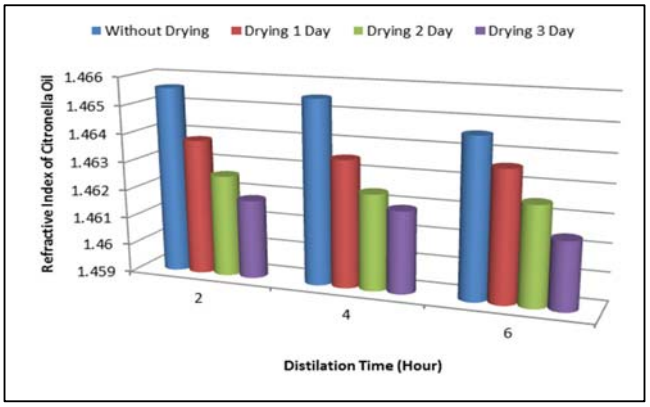

Figure 4. Index bias graph for the value of citronella oil fragrance.

From the results of the chart plot above, it can be seen that the highest value at the time of distillation is 2 hours with a drying time of 0 days, which is 1.4656. Because the leaves of citronella used are still fresh, so the oil produced has a purity that is better than the others. And at the lowest value at the time of distillation 6 hours with a drying time of 3 days which is 1.4614, because the leaves of citronella are too dry so that the oil content (purity) of the oil produced is reduced (not in the best condition).

3.3. Gas Chromatography-Mass Spectrometry (GC-MS) analysis

Gas chromatography-mass spectrometry (GC-MS) is a combination method between gas chromatography and mass spectrometry that aims to analyse various compounds in a sample. Gas chromatography and mass spectrometry have their respective working principles, but both can be combined to identify a compound both qualitatively and quantitatively.

Gas chromatography is one of the chromatographic techniques that use the principle of mixture separation based on differences in the speed of migration of its constituent components. Gas chromatography is usually used to identify a compound found in a gas mixture and also determine the concentration of a compound in the gas phase. This method is one of the separations that at the same time can analyze organic and inorganic compounds that are non-volatile and volatile [22,23].

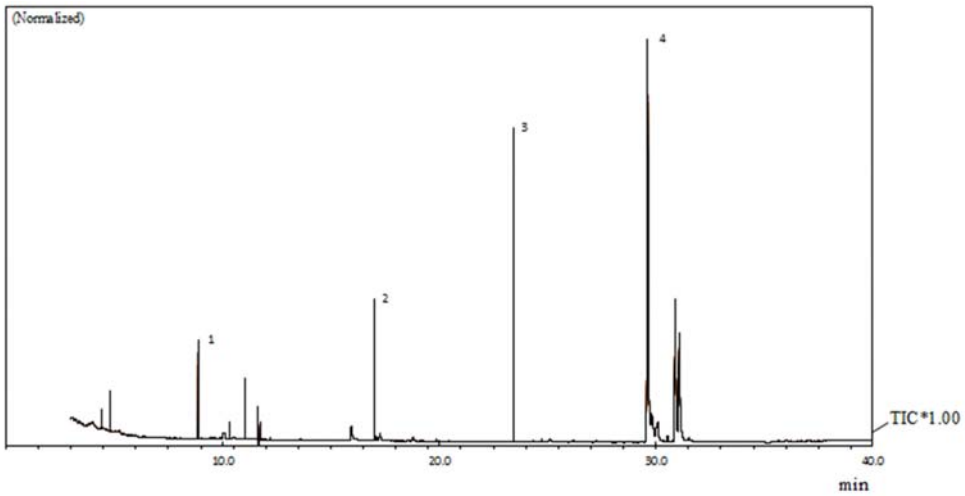

Figure 5. Results of gas chromatography-mass spectrometry (GC-MS) analysis of citronella oil is fragrant.

Likewise, from the findings in the sample obtained the highest number of compounds with a percent indication of the composition of the main compounds having high levels, among others Geraniol 47.32%, eugenol 34.01%, Germacrene-D 10.32% and Citronella 8.35% in distillation for 2 hours and without drying produce fragrant citronella oil products with good purity.

4. Conclusion

Purification of essential oils using heating from electricity produced by utilizing sunlight is very effective compared to heating using firewood because it is more efficient in energy use, environmentally friendly and the refining process is faster. The highest density analysis value at distillation is 2 hours with 1-day drying time, which is 0.8895 kg / cm3, and the highest refractive index value is at 2 hours distillation time with 0 days drying time, which is 1.4656. GC-MS analysis showed Geraniol 47.32%, eugenol 34.01%, Germacrene-D 10.32% and Citronella 8.35% in distillation for 2 hours and without drying producing citronella oil with good purity.

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References

[1] Gill.D.J, Roca.L, Zaragoza.G & Berenguel.M 2017, 'A feedback control system withreference governor for a solar membrane distillation pilot facility' Journal Of Renewable Energy Vol.120 P. 536-549.

[2] Gavahian.M, Lee.Y.T, Chu.Y.H 2018,'Ohmic-assisted hydrodistillation of citronella oil from Taiwanese citronella grass: Impact on the essential oil and extraction medium' Journal Of Innovative Food Science and Emerging Tehnologies Vol. 18 P 466-8564.

[3] Esmaeili.H, Karami.A, Maggi.F 2018, 'Essential oil composition, total phenolic and flavonoids contents, and antioxidant activity of Oliveria decumbens vent. (Apiaceae) at different phenological stages' Journal of Cleaner Production, Vol 198, P 91-95.

[4] Gupta.V.S, Singha.D.B, Mishrab R.K, Sharmac.S.K, G.N. Guptaa.T.V.S, Singha.D.B, Mishrab R.K, Sharmac.S.K &Tiwarid .G.N. 2018, 'Development of characteristic equations for PVT-CPC active solar distillation system' Journal Of Desalination Vol.445 P.266-279.

[5] Filiptsova.O.V, Gazzavi-Rogozina.L.V, Timoshyna.I.A, Naboka.O.I, Ye.V.D, Ochkur.A.V 2017, 'The Essential oil of resemary and its effect on the human image and numerical short-term memory' Journal Of Eqyptian Journal Of Basic And Applied Sciences Vol.4 P 107-111.

[6] Luyben.W.L.2017, 'Control of heat-integrated extractive distillation processes' Journal Of Computer & Chemical Engineering Vol. 111 P 267-277.

[7] Kumar.R, Sharma.S, Sharma.S, Kumar.N, 2016, 'Drying methoda and distillation time affects essential oil content and chemical compositions of Acorus calamus L. In the western Himalayas' Journal Of Applied Research on Medicinal and Aromatic Plants Vol.3 P 136-141.

[8] Kültürela.Y, Tarhan.S 2016,'A solar distillery of essential oils with compound parabolic collectors (CPCs)' Journal Of Agricultural Sciences Vol.31 P 72-83.

[9] Khudhair .M.A, Ajeel.F.N, Mohammed.M.H.2018, 'Engginering and Design of simple models from dye-sensitive of solar cells and photovoltaic cells of solar applications: Theoretical study' Joeurnal Of Chemical Physics Letters Vol.713 P 166-171.

[10] Yang.Z, Li.W, Chen.X, Su.S, Lin,G, Chen J. 2018, 'Maximum effeciency and parametric optimum selection of a concentrated solar spectrum splitting photovoltaic cell-thermoelectric generator system' Journal Of Energy Conversion and Management Vol. 174 P 65-71.

[11] Gurung.A, Qiao.Q. 2018, ' Solar Charging Batteries: Advance, Challenges, and Opportunities' Journal Of Joule Vol. 2 P 1217-1230.

[12] Rahul.S.S, Tejaswi.P.N, Sandeep.Y.M, Krishna.K.H. 2016, 'Two Stage Operational Amplifier with a Gain Boosted, Source Follower Buffer' Journal of Engineering Trends and Technology (IJETT) Vol.34 P 256-259.
[13] Bisoffi.A, Forni.F, Lio.M.D, Zaccarian.L. 2018, 'Relay-based hybrid control of minimal-order mechanical systems with applications' Journal Of Automatica Volume 97 P 104-114.
[14] Gao.D.Z & Sun.K. 2016, '16:DC-AC Inverters' Journal Of Electric Renewable Energy Systems Pages 354-381.
[15] Caritte.R.M, Cheung.K, Malik,M. 2018, 'Alternative approaches and dynamic analysis considerations for detecting open phase conductors in three phase power systems' Journal Of Electric Power Systems Research Vol 163 P 59-65.
[16] Shih.Y.M., Enriquez.A.C,c., Hsiao.T.Y,Trevino.L.M.T. 2017, 'Echanced differential evolution algorithm for coordination of directional overcurrent relays' Journal Of Electric Power System Research Vol 143 P 365-375.
[17] AllahReza Moradi Garoosi, Mehrzad TahamouliRaudsari, Behrokh Hosseini Hashemi. 2018, 'Experimental evaluation of rigid connection with reduced section and replaceable fuse' Journal Of Structures Vol 16 P 390-404.
[18] Pawel Ludowski, Thomas Wulf, Alexandros Roumpies, 'The pole connector for miniature circuit breakers used in photovoltaic applications' Jounal Of Applied Thermal Engineering Vol 99 P 1057-1070.
[19] Ranjay Singh, R.C. Bansal, Arvind R. Singh, 'Optimization of an isolated photo-voltaic generating unit with battery energy storage system using electric system cascade analysis' Journal Of Electric Power Systems Research Vol 164 P 188-200.
[20] Wahid.A, Junaidi, Arsyad.M.I, 2016, 'Analisis kapasitas dan kebutuhan daya listrikuntuk menghematt penggunaan energi listrik di fakultas teknik universitas tanjungpura.
[21] Rihayat, T., Salim, S., Zaini, H., Salmiyah., Rahmawati, C,A., Kurniati., Irawan, Y., Zaimahwati. 2017. Synthesis, Characterization and Microbial Protection of Palm Oil Based Polyurethane / Bentonite / Chitosan as Paint and Coating Material. International Conference on Sustainable and Renewable Energy Engineering
[22] Rihayat, T., Suryani., Zaimahwati., Salmyah., Sariadi., Fitria., Satriananda., Putra, A., Fona, Z., Juanda., Raudah., Safitri, A., Mawaddah., Nurhanifa., Riskina, S., Syahputra,W. 2019. Composition on Essential Oil Extraction from Lemongrass Fragrant by Microwave Air Hydro Distillation Method to Perfume Dermatitis Production. Materials Science and Engineering. Vol. 506
[23] Zulkifli, Rihayat, T., Suryani., Facraniah., Habibah, U., Audina, N., Fauzi, T., Nurhanifa., Zaimahwati., Rosalina. 2018. Purification Process of Jelantah Oil using Active Chorcoal Kepok's Banana. International Seminar on Chemistry. Vol. 2049.