PAPER NAME

Sofi'i_2022_IOP_Conf._Ser.__Earth_Environ._Sci._1012_012062 (1).pdf

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WORD COUNT

3509 Words

CHARACTER COUNT

17780 Characters

PAGE COUNT

8 Pages

FILE SIZE

1.3MB

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REPORT DATE

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Energy Consumption for Patchouli Oil Extraction Using Ohmic Heating

To cite this article: Imam Sofi'i *et al* 2022 *IOP Conf. Ser.: Earth Environ. Sci.* **1012** 012062

Energy Consumption for Patchouli Oil Extraction Using Ohmic Heating

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Abstract. Currently, the process of releasing patchouli oil is carried out by extraction, water-steam distillation, and hydrodistillation. A new method for extracting patchouli by hydro distillation using electric voltage by ohmic heating has not been widely used. This paper aims to determine the energy requirements for extraction using ohmic heating. The method used is to make an extraction tool using electricity and extract the dried patchouli leaves. The electricity used for extraction is AC electricity with voltages of 90 V, 100 V, and 110 V. The ratio of patchouli to water is 1:12. Observations were made on changes in voltage and electric current during the extraction process, the length of the extraction process, and the yield of patchouli oil. As a comparison, water distillation extraction method was used using an electric stove heater. The experimental results show that the energy consumption during the extraction process starting from the lowest is 3584.7 kJ (voltage 90 V), 3488.96 kJ (voltage 100 V), 3313.77 kJ (voltage 110 V) and 4386.69 kJ (voltage 220 V). The highest oil yields were 5.10 g (voltage 100 V); 3.15 g (voltage 90 V); 2.00 g (voltage 110 V); and 1.00 g (voltage 220 V). Patchouli oil extraction using ohmic heating provides higher yields and lower energy than electric stove heating.

1. Introduction

Essential Oil is one of the plantation commodities that has high export value and has provided foreign exchange for Indonesia. Essential oils have various benefits, including as fragrances (in cosmetics, body care products), aromatherapy oils, rubbing oils (for colds, body warmers, carminatives), air fresheners, insect repellent, antiseptics, biological pesticides and others. There are about 70 types of essential oils circulating in the world market.

Patchouli is one of the essential oil-producing plants that are in demand by the people of Indonesia and abroad. In international trade, patchouli oil is known as Patchouli Oil. Patchouli oil is used as an ingredient in the manufacture of cosmetics, pharmaceuticals, and aromatherapy. Patchouli oil functions as a binder / fixative agent and pharmaceutical.

Indonesia is a major producer of patchouli oil in the world and controls about 95% of the world market. Currently, around 85% of Indonesia's essential oil exports are dominated by patchouli oil with a volume of 1,200-1,500 tons/year. The export destination countries are Singapore, United States of America, Spain, France, Switzerland, United Kingdom, and other countries.

The process of releasing patchouli oil is an important factor so that the extracted oil is maximal but still meets quality standards. Currently, the process of releasing patchouli oil is carried out by extraction, water-steam distillation, and hydro distillation. The steam-hydro distillation method produces a better yield of patchouli oil compared to the conventional method using hydro distillation. New method for patchouli extraction using microwave distillation [1], supercritical CO2 and

IOP Conf. Series: Earth and Environmental Science 1012 (2022) 012062 doi:10.1088/1755-1315/1012/1/012062

pressurized hydrodiffusion technique method [2]. The new method requires expensive equipment investment even though it gives higher yields, so it is necessary to look for other new methods that are simpler and cheaper.

The use of electric voltage to assist the extraction process is still not widely used. High-voltage or medium-voltage electricity when exposed to biological cells will cause damage. Cells exposed to electricity with a certain field strength will cause the cell to undergo electroporation, namely the cell membrane becomes porous. With porous cell conditions, some of the contents of the cell will be easy to remove or come out by itself. The use of low or medium voltage electricity with a large enough electric current when applied to an electrolyte solution will cause heat. Heating due to alternating electric current is known as ohmic heating

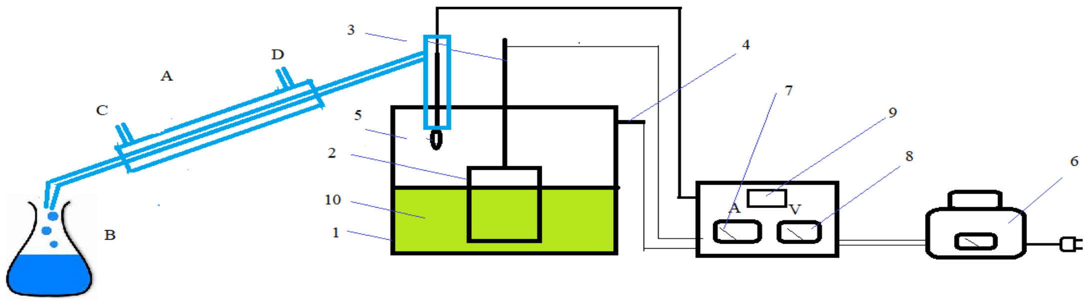
Ohmic heating works by utilizing alternating electric current between two electrodes. Electrodes commonly used are made of stainless steel. The use of the ohmic heating method in the heating process is currently still limited to heating. Products that can be heated using ohmic heating must have electrical conductivity. Ohmic heating is operated using alternating current electricity with a low frequency of 50 - 60 Hz [3].

In its application, the ohmic heating method can also be used for heating the process of refining essential oils including patchouli. Essential oils are agricultural commodities that have electro-chemical properties, namely they contain negative electric charges (electrons) and positive electric charges (protons) which are arranged in a balanced way, when given an electric potential difference, an electric current will flow through the material [4].

The heating process using electricity is a process that requires energy. The energy sourced from electric current is influenced by the magnitude of the voltage and current and the duration of its use. This energy consumption needs to be known in the patchouli extraction process using alternating electric current. By knowing the amount of electrical energy consumption, it will be possible to choose which extraction method will provide maximum patchouli oil yield at a low cost. The purpose of the study was to determine the amount of energy consumption required for patchouli extraction using ohmic heating.

2. Methods

The research was carried out from June-August 2021 at the THP Polinela Laboratory. The equipment used are: ohmic heating extraction equipment, step down transformer, thermocouple, voltmeter, ammeter, digital camera, distillation equipment, and analytical balance. The material used is the leaf patchouli with varieties of Sidikalang and aquades



1. outer stainless pot
2. inner stainless pot
3. positive electrode
4. negative electrode
5. thermocouple
6. step down transformer
7. electric current display
8. voltage display
9. temperature display
10. mixture of water and patchouli

A condensate/coolant
B. patchouli distillate
C. input line

Figure 1. Patchouli leaf extraction scheme using ohmic heating

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2.1. Research Procedure

Measuring the moisture content of patchouli leaves to be extracted, weighing 100 grams of dry patchouli and chopping it with a size of 0.5 – 1 cm and adding 1200 ml of distilled water or a ratio of 1: 12. Put it into the extraction equipment as shown in the picture. Heat the patchouli in a pan using ohmic heating. Connect the equipment to an AC power source. Set the voltage to 90 V, 100 V and 110 V as appropriate. For comparison, extraction of patchouli with electric stove heating. Observations were made on time, temperature, voltage and electric current during the process, measuring the yield of the extraction results.

3. Results and Discussion

3.1 Extraction

One method of extracting patchouli leaves is hydro distillation extraction. Extraction of hydro distillation is done by heating the raw material of a certain size of patchouli in a container/pan. Patchouli leaves and water are mixed together in a tightly closed container/pan. On the lid there is a small hole as a steam channel. The steam coming out of the pan is connected to a condenser/coolant to allow condensation to occur. The heaters used are generally oil stoves or electric stoves, for large scale use firewood. The principle of distillation is the evaporation of a mixture of materials with different boiling points. The vapor formed is cooled in a condenser to become a liquid phase. Furthermore, the liquid will form layers based on its specific gravity. The liquid is separated to take the material as desired. In patchouli oil extraction, the oil part is above the water.

Patchouli oil extraction using ohmic heating is basically the same as extraction using hydro distillation. In ohmic heating extraction, the raw materials for patchouli and water are mixed together in a container/pan. The heating source used is AC electric current. The container/pan is made of stainless material and functions as a negative electrical terminal or negative electrical electrode and the lid as a positive electrical terminal or positive electrode. Heating occurs because of the electric current in the patchouli and water. A mixture of patchouli and water serves as a conductor that carries an electric current. This process can be used to generate heat from the product by converting electrical energy into heat energy quickly without the need for heating media.

The use of ohmic heating in the extraction process has been carried out by several researchers. Several studies using Ohmic Heating include extraction of apple juice from apples [5], extraction of rice bran oil and bioactive substances from rice bran [6], extraction of polyphenols from red grape pomace [7] and extraction of food coloring from black rice bran [8], extraction of phytochemical compounds from potato [9], extraction of pectin from orange juice waste [10] and extraction of essential herbal oils [11].

Patchouli oil extracted using ohmic heating as shown in table 1. The treatments used were different voltages. The highest yield occurred at a voltage of 100 V which was 1.70% and the lowest was at a voltage of 110 V at 0.77%. The use of different voltages results in different oil yields. The use of an electric stove as a heater produces the lowest yield of 0.33% compared to the use of ohmic heating.

Table 1. Patchouli oil yield from ohmic heating extraction.

Treatment	Oil yield (gram)	content (%)	Extraction time (minute)
OH 90 V	3.15	1.05	175
OH 100 V	5.10	1.70	150
OH 110 V	2.00	0.67	140
KO 220 V	1.00	0.33	105

The use of ohmic heating for patchouli extraction gives higher yields than the use of heating using an electric stove. In ohmic heating, heating occurs due to the movement of electrons in a mixture of water and patchouli leaves which functions as a conductor. This movement of electrons will cause heat which results in cell damage so that the material contained in it will come out. In addition, the electric voltage exposed to a mixture of water and patchouli leaves also causes electroporation, namely the formation of pores in the patchouli cell. With the formation of pores, it will facilitate the release of chemical substances in the cells, including oil.

The advantage of heating using the ohmic heating method compared to conventional heating using an electric stove is that the ohmic method in addition to causing a heating effect, can also cause cell wall permeabilization in essential oil commodities. Increased cell wall permeabilization can accelerate the reaction process, increase the rate of diffusion through the cell wall, and increase the extraction yield.

The magnitude of the electric voltage used in patchouli extraction gives different results. This shows that the magnitude of the stress affects the oil yield. Increasing the voltage from 90 V to 100 V indicates an increase in extraction yield, but with increasing voltage to 110 V, the yield decreases. There is an optimum value of using electric voltage in patchouli extraction with a mixed ratio of 100 grams of patchouli and 120 grams of distilled water (1:12 ratio). This phenomenon indicates that there is an optimal voltage or electric field for extraction. An increase in the voltage higher than the optimal value will not increase the extraction yield. This phenomenon was also studied by [6] who conducted research on rice bran extraction using ohmic heating where the addition of a certain amount of voltage did not increase the yield or there was an optimal stress for rice bran extraction. Research on the use of ohmic heating for drying shows that the electric field strength and end point temperature significantly affect the drying rate and that optimal values exist for each treatment parameter [12].

3.2. Energy Consumption

Patchouli extraction requires energy which is used to heat the liquid and patchouli so that the oil can be extracted. The ohmic heating extraction method uses alternating current electricity as a heat generator. Heating occurs by itself due to the flow of electric current in an equipment called an ohmic heater. According to [13], Ohmic heater or also called joule heater is equipment that uses the electrical resistance of the liquid itself to generate heat. Heat is generated directly in the liquid itself by joule heating. As a result of alternating electric current (I) passing through the resistance of the material (R) it will produce energy generation which causes the temperature to rise.

In this study using alternating current electricity from PLN with a voltage of 220 V and a frequency of 50 Hz. The electric voltage is lowered according to the treatment. The tool used to reduce the voltage is a step down transformer with a large voltage of 0 - 220 V. The voltage used in this study for extraction using ohmic heating there are 3, namely 90 V, 100 V and 110 V with a fixed frequency while for electric stoves using a voltage of 220 V.

The electrical energy requirements during the patchouli extraction process from each voltage are as shown in Table 2. The largest electrical energy required in the extraction process using an electric stove is 4,386.69 kJ, while the lowest is in the use of ohmic heating with a voltage of 110 V of 3,313.77 kJ. In ohmic heating, the higher the voltage, the less energy is required.

Electrical energy is needed from the beginning of the extraction until the extraction results do not drip. The length of the extraction process from each stress is different. The shortest extraction process occurs in the use of an electric stove, which is 105 minutes. The longest extraction process occurs at the use of 90 V voltage of 175 minutes. The length of the extraction process is influenced by the amount of electric voltage used. The higher the voltage, the shorter the extraction process.

Table 2. Electrical energy consumption during extraction.

Treatment	Energy (kJ)	Energy/gram oil (kJ/g)	extraction time (menit)
OH 90 V	3,584.70	1,138.00	175
OH 100 V	3,488.96	684.10	150
OH 110 V	3,313.77	1,656.89	140
KO 220 V	4,386.69	4,386.69	105

The energy requirement for extraction of each gram of oil is different. The lowest energy consumption per gram occurs at a voltage of 100 V, which is 684.10 kJ/gram, while the largest energy

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consumption at a 220 V voltage treatment using an electric stove is 4,386.69 kJ/gram. The use of heating for extraction in the form of ohmic heating requires lower energy than heating using an electric stove. Energy for extraction in the form of ohmic heating is more efficient because heat is not wasted.

The graph of energy development during the patchouli extraction process from each treatment is as shown in Figure 2 to Figure 5. Energy consumption per minute in the extraction process using ohmic heating from the three voltages shows almost the same pattern. In the early minutes it shows an increase in energy consumption and at certain minutes it reaches its peak. After that down to the end of the extraction. In extraction using electric stove heating, the energy required per minute is relatively the same until the end of the extraction process. The development of electrical energy consumption in extraction using ohmic heating depends on the conductivity of the electrolyte liquid. According to [14], in the conventional heating system, the thermal conductivity of the particles controls the heating rate, while in the ohmic heating process, the electrical conductivity is the controlling factor. Electrical conductivity becomes a complex function of temperature and time, which will be directly reflected in the ohmic heating rate.

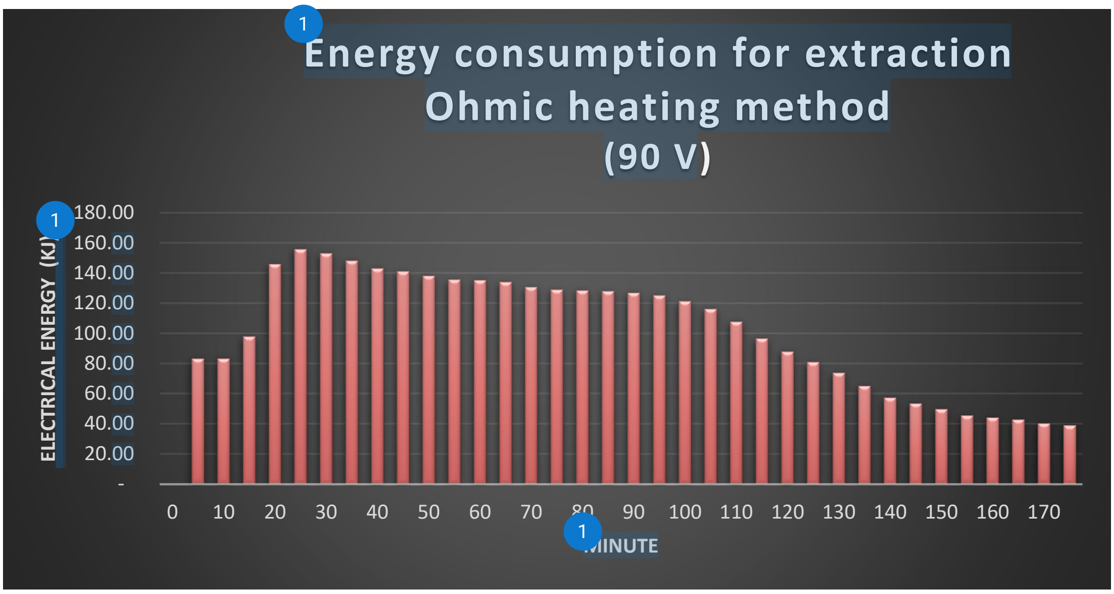

Figure 2. Electrical energy consumption of ohmic heating at a voltage of 90 V

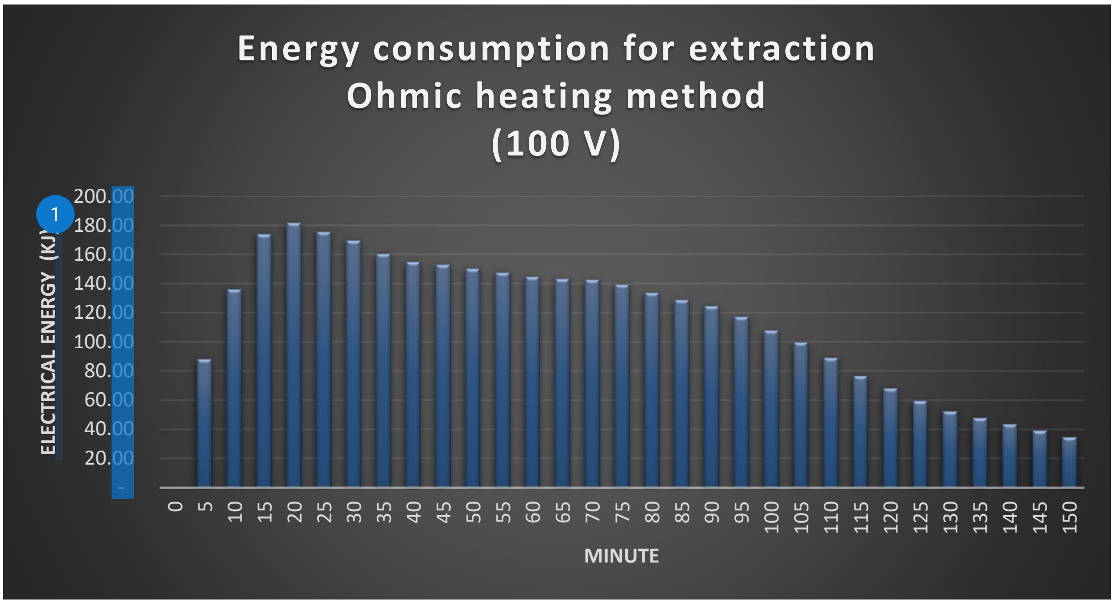

Figure 3. Electrical energy consumption of ohmic heating at a voltage of 100 V

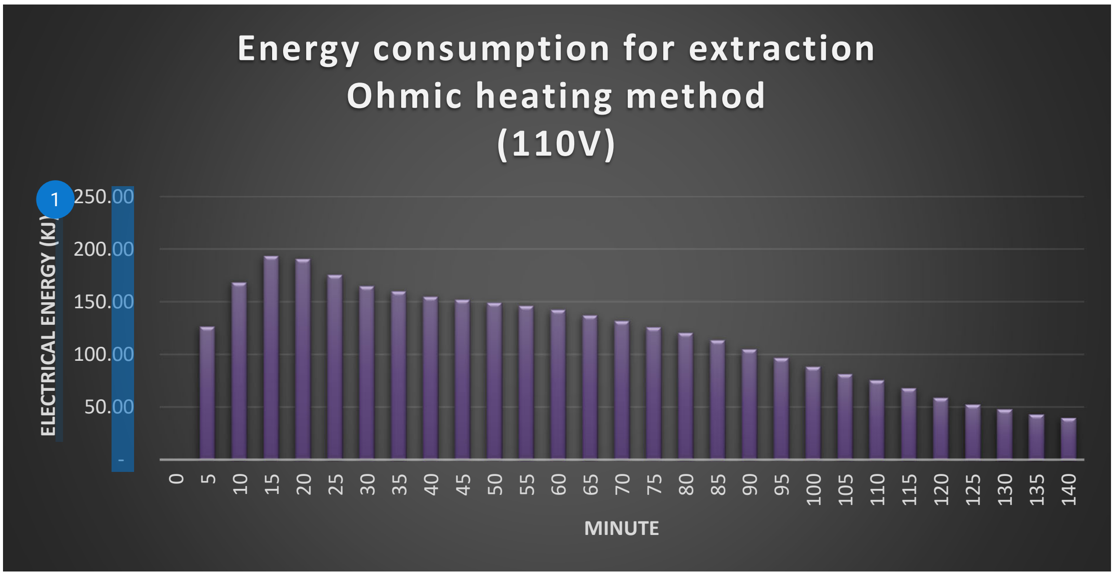

Figure 4. Electrical energy consumption of ohmic heating at a voltage of 110 V

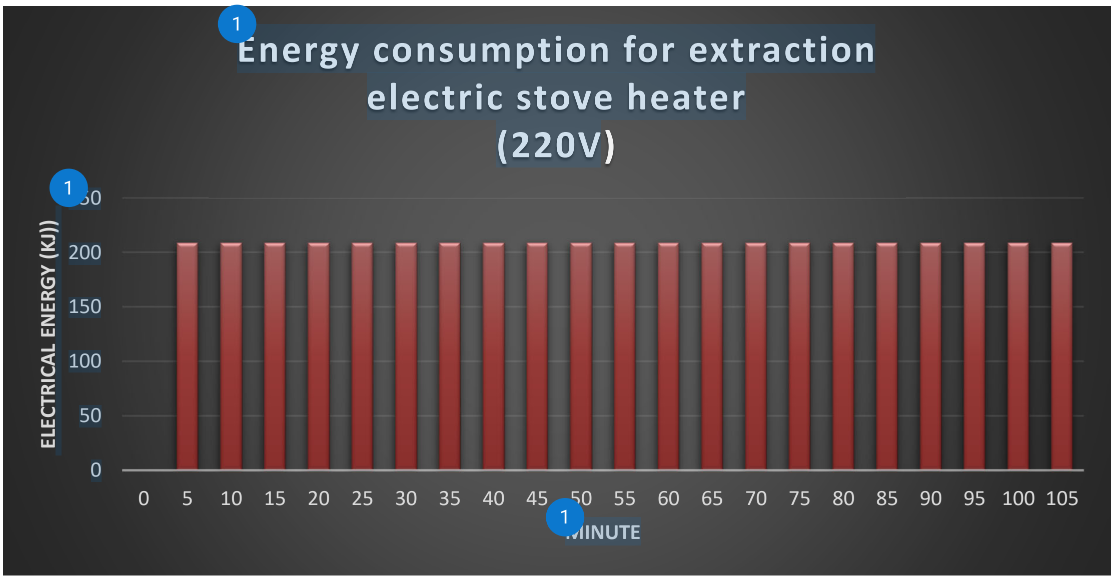

Figure 5. Energy consumption of an electric stove at a voltage of 220 V

4. Conclusions

The use of heating for extraction in the form of ohmic heating requires lower energy than heating using an electric stove. The lowest energy consumption per gram of oil was 684.10 kJ/gram at a voltage of 100 V while the highest energy consumption was 4,386.69 kJ/gram at the electric stove treatment. Energy for extraction in the form of ohmic heating is more efficient because heat is not wasted.

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