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Pyrolyzed Bio Charcoal Briquettes Of Solid Waste From Lhokseumawe Patchouli Oil Refinery

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ABSTRACT
The availability of petroleum fuels derived from fossils is decreasing along with the increase in human population. This study aims to create bio charcoal briquettes derived from solid waste of patchouli oil refining. Research on the use of the by-products of the pyrolysis process on solid waste from patchouli oil refining for making bio charcoal briquettes was carried out using temperature variables of 300, 350 and 400 °C, raw material weights of 600, 1200 and 1800 grams and pyrolysis time variables of 60, 90, 120 and 150 minutes. Solid waste that has first been cut into small sizes, dried in the sun first and then put into a pyrolysis device to be carbonized according to predetermined variables. The results of pyrolysis were then put into a desiccator to cool for 30 minutes and then tested for moisture content, ash content, fly content, bound carbon content, calorific value, SEM test, and combustion rate. The best research results obtained were at a temperature of 400 °C, a raw material weight of 600 and a time of 150 minutes with a thermal value of 5,291 cal/g, a moisture content of 5.77%, an ash content of 4.28%, a volatile matter content of 9.11% and a bound carbon content of 77.42% and a combustion rate of 0.1841 grams/minute. The obtained calorific value shows that patchouli solid waste bio charcoal can be used as an alternative fuel that can be renewed and fulfils SNI 01-6235-2000.

Keywords: *Briquettes, bio charcoal, solid waste, pyrolysis.*

1. INTRODUCTION

Alternative energy sources from biomass obtained from the food crop sector and the plantation sector have received a lot of attention from researchers in the last period. This is because fossil energy resources are depleting and alternative energy sources must be found immediately. In addition, the high population growth rate also results in high energy consumption.

Many studies have suggested that biomass energy will contribute significantly to the overall energy supply as the price of fossil fuels increases in the future. The use of biomass as an energy source is particularly attractive because it is an energy source with zero net CO_2 emissions, and therefore does not contribute to an increase in greenhouse gas emissions, which also means that biomass is carbon neutral [1].

Biomass sources can come from plants, trees, grasses, yams, agricultural waste, forest waste, manure, and livestock manure. One biomass waste from the agricultural sector that is abundant in the Lhokseumawe area is patchouli solid waste. The area of patchouli plants in Lhokseumawe is 42.59-64.67 ha, solid waste from the patchouli oil refinery industry amounts to around 98-98.5% of the raw material [2].

Indonesia has three types of patchouli plants that can be distinguished through morphological characters, oil content or quality and resistance to biotic and abiotic stresses. The three types of patchouli are Pogostemon cablin Benth (Aceh Patchouli), Pogostemon hortensis Packer (Java Patchouli), and Pogostemon heyneanus Benth (Soap Patchouli) [3].

Among the three types of patchouli plants that are often used commercially is Pogostemon cablin Benth or often referred to as Aceh patchouli. The striking characteristics of Aceh patchouli are its rounded leaves like a heart, the lower surface of which has hairs so that the leaves look pale, and Aceh patchouli oil has higher patchouli alcohol levels than other types of patchouli [4].

Patchouli is a type of fibrous-rooted plant, the shape of the leaves varies from round to oval and the stem is woody with a diameter ranging from 10-20 mm. The branching system is numerous and cascades around the intermediate stem (3-5 branches per level). After the plant is 6 months old, the height can reach one metre with a branch radius of approximately 60 cm wide. A qualitative characteristic that can distinguish the three Aceh patchouli varieties is the colour of the stem base. The Tapak Tuan variety has a green stem base colour with a hint of purple, the Lhokseumawe variety is more purple and the Sidikalang variety is the most purple.

Patchouli leaves contain tannins, saponins, flavonoids, terpenoids, and steroids. The constituent components of its essential oil, namely sesquiterpenes and patchouli alcohol. The chemical substance that is thought to have potential as a repellant is patchouli alcohol. Patchouli alcohol (PA, $C_{15}H_{26}O$) in addition to being used as a repellant can also function as a raw material for binders (fixatives) and as a flight control agent (etheric) for perfumes so that the fragrance lasts longer. What is meant by "flight" here is the volatile nature of the oil, with the addition of patchouli oil (etheric) to the perfume, the resulting smell is more durable. The evaporation of patchouli oil is the slowest when compared to other essential oils [5].

Solid waste from patchouli oil refinery is commonly found in the patchouli oil refinery, especially in Lhokseumawe city. The large volume of patchouli distillation solid waste has not been optimally utilized. By utilizing these wastes into useful products and have real added value. Some previous researchers tried to use the waste for incense-making materials, because it has a distinctive aroma. By drying the pulp, it is then ground and ready to be used as raw material for making stick-shaped incense. The pulp is mixed with adhesives, onggok flour, coconut shell flour, colourings and other fragrances. All these ingredients are mixed to make dough and then moulded into sticks [6].

Waste from the distillation of patchouli oil ranges from 98-98.5% of the raw material, oil distillation waste in addition to being used as compost can also be used as material for making incense and mosquito coils and the remaining water from the distillation after being concentrated can be used as raw material for aroma therapy. With the diversification of the use of patchouli oil processing waste, it is expected to increase the economic value of patchouli farming.

Research that has also been done by Usmiati et al (2012) through the use of solid waste of citronella oil distillation as an active ingredient combined with patchouli oil distillation waste in the manufacture of insect repellents affects the burning time, moisture content and weight, but has no effect on the level of hardness of the incense. The combination of citronella oil distillation waste with patchouli oil distillation waste based on the ratio of 4:4 and 5:3 is more effective in repelling house fly insects. If the disinfectant in patchouli waste is fractionated in the form of liquid smoke, it is certainly more effective. This method has never been done by previous researchers. Pyrolysis is the decomposition of materials, due to heat coming from outside or generated by the process and is often also interpreted as a devolatilization process. The pyrolysis process takes place in the absence of oxygen or air. The parameters that affect the pyrolysis reaction speed have a very complex relationship, so that the mathematical model of the pyrolysis reaction speed equation formulated by each researcher always shows a different empirical formulation [7]. Pyrolysis products are not only influenced by temperature and time, but also by the heating rate. Liquid smoke from pyrolysis and the smell is pungent, for that it still needs further processing, which is made saturated and stable when used as a disinfectant.

Bio charcoal briquettes can be defined as regular or irregularly shaped blocks made from organic waste charcoal that has been printed in such a way that has a high calorific value (Jain, 2014). Briquettes are combustible materials formed from the process of compressing or compressing materials into a solid form and used as fuel, where the briquettes produced must have strong properties and adhere to each other so that the briquettes are not easily destroyed (Urgel, 2014). Briquettes can be used for household purposes (cooking, heating, baking) and also industrial purposes (Agro industry, food processing) in urban and rural areas (Maninder, et al., 2012). The advantages obtained from the use of bio charcoal briquettes include very low cost and more efficient, higher heat, long enough coal flame, safe non-toxic [8].

2. RESEARCH METHODS

In carrying out the research, some of the steps prepared and implemented by the researcher include:

2.1. Preparation of Tools and Materials

The materials and equipment used in this research are solid waste from patchouli oil refinery from Kilometer VIII Village, Simpang Keuramat sub-district, North Aceh district, distilled water, tapioca starch, pyrolysis reactor, oven, charring tool, 50 mesh sieve, watch glass, beaker, stirrer, stopwatch, measuring cup, measuring flask.

2.2. Working Procedure

This research consists of four stages, namely the stage of analyzing the initial characteristics of patchouli before and after distillation, preparation of solid waste raw materials from patchouli oil distillation, pyrolysis process, printing, then the analysis stage. Experimental variations were carried out on pyrolysis time and pyrolysis temperature as shown in Figure 1.

Figure 1. Pyrolysis equipment circuit

The manufacture of bio charcoal briquettes was carried out by pyrolysis method using starch as the adhesive. Raw materials as much as 1200 grams are then put into the pyrolysis reactor, then close the reactor tightly. Turn on the stove, wait until the temperature is 300 °C and keep the temperature constant for 90 minutes. After completion, turn off the tool, then cool the charcoal until it cools, after it cools, open the reactor to take the charcoal from the pyrolysis tool. Then weigh 30 grams of tapioca flour, dissolve 100 ml of water and put it in a pot. After that, the pot is heated to boiling or the solution thickens while stirring. Then take the prepared charcoal and mix it with the adhesive solution as much as 20% of the weight of the charcoal. After the material is fully mixed, it is printed using a hydraulic press with a pressure of 300 kg/cm2 held for 2 minutes, after which the bio briquettes are removed and cylindrical in shape, after which the bio briquettes are baked for 60 minutes at 105 °C. Then analyze the quality of the briquettes including moisture content, ash content, fixed carbon, volatile matter content, and calorific value. The analysis stages carried out are analysis of water content, analysis of ash content, analysis of fly matter content, analysis of fixed carbon, analysis of calorific value, analysis of combustion rate, and SEM analysis.

3. RESULT AND DISCUSSION

3.1. Preliminary Analysis

The chemical composition contained in solid waste from patchouli oil refinery can be seen in Table 1, it can be seen that solid waste from patchouli oil refinery is a collection of millions of organic fibers that can be used in the industrial world. The results of the patchouli characteristics test before with patchouli after refining as shown in Table 2, where this data can be used to determine the potential of the conversion process from patchouli plants into various products and one of them as an energy source.

Table 1. Analysis Of Patchouli Lignocellulose Content

Raw Materials		Hemiselu losa, %	Selu losa, %	Lignin, %
Condition	Morphology			
Before Distilation	Mixed	17	12	38
	Leaves	24	15	28
	Trunk	21	29	41
	Branch	27	29	31
After Distilation	Mixed	25	30	19
	Leaves	19	27	38
	Trunk	15	29	40
	Branch	15	35	32

Table 2. Patchouli Proximate Analysis Result Data

Raw Materials		Water Content, %	Ash Content, %	Flying Substances, %	Fixed Carbon, %	Thermal Value, KJ/Kg
Condition	Morphology					
Before Distilation	Mixed	5,57	8,69	81,96	3,38	15575
	Leaves	3,88	10,66	81,26	4,18	15649
	Trunk	5,56	8,96	84,32	1,14	15637
	Branch	3,90	9,49	85,51	1,08	15509
After Distilation	Mixed	8,41	17,68	69,95	3,95	13142
	Leaves	6,96	18,97	70,54	3,51	13668
	Trunk	5,66	14,47	77,03	2,83	13316
	Branch	4,68	16,60	78,11	0,59	14352

3.2. Water Content

The results of the analysis of water content in patchouli waste bio charcoal briquettes as shown in Figure 2.

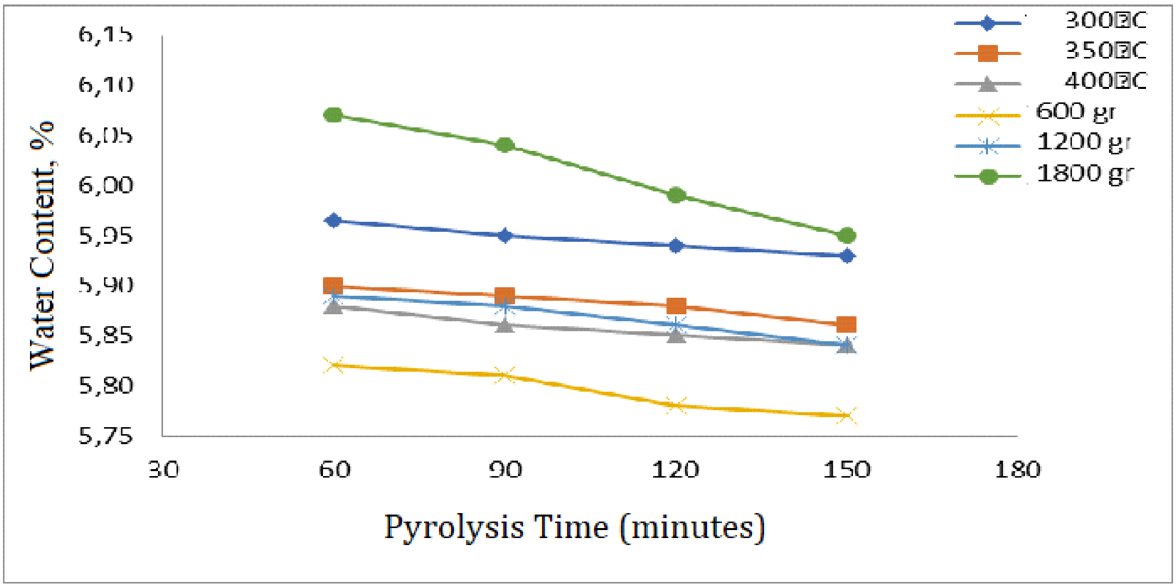

Figure 2. Relationship Between Temperature, Time and Weight on Water Content

In Figure 2, the results of analysis and testing of patchouli solid waste bio charcoal briquettes that have been carried out, the lowest water content is obtained at 5.77% at a raw material weight of 600 grams, a pyrolysis temperature of 400 °C and a pyrolysis time of 150 minutes. While the highest water content was obtained at 5.97% at a raw material weight of 1200 grams, a pyrolysis temperature of 300 °C and a pyrolysis time of 60 minutes. The graph decreases with increasing material weight and pyrolysis time, this is in accordance with the theory where the longer the pyrolysis time, the water content will decrease. The longer the pyrolysis time, the more open the pores of the charcoal will be which results in the water content in the material decreasing, thus giving a very large influence on the speed of water transfer [9].

Based on the test results, the value of water content produced ranged from 5.77% - 6.07%. The results showed that briquettes with variable weight of raw materials, temperature and pyrolysis time met the SNI 01-6235-2000 standard, namely a maximum moisture content of 8%.

3.3. Ash Content

Ash is inorganic substances in the form of metals or minerals that are the residue of combustion. The lower the ash content, the better the quality of the briquettes produced. The results of the analysis of ash content in patchouli waste biochar briquettes as shown in Figure 3.

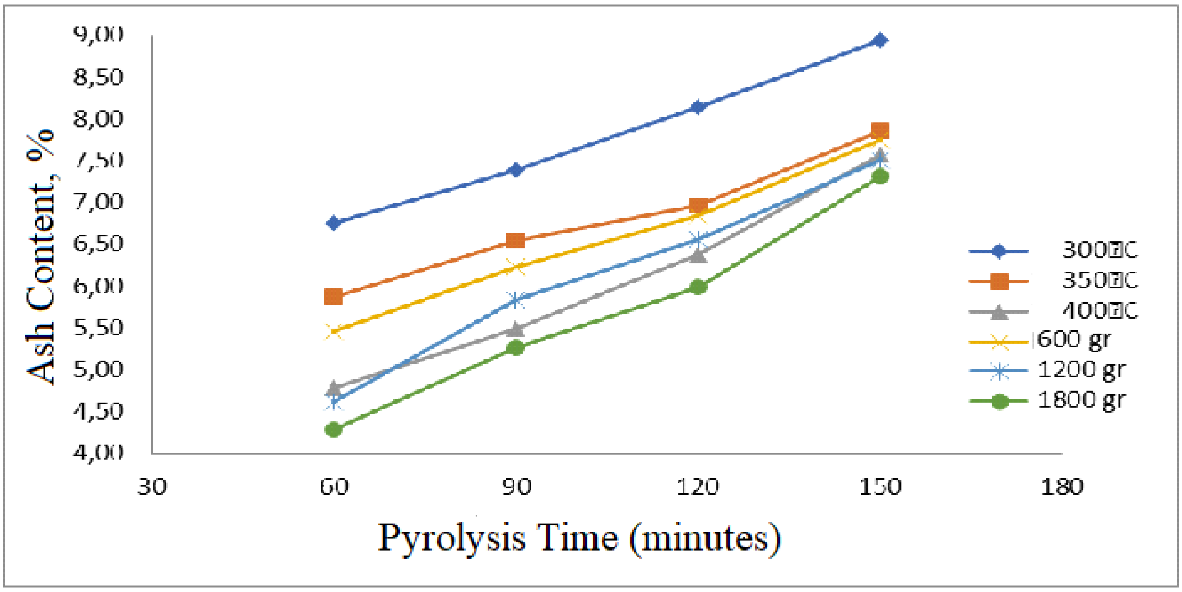

Figure 3. Relationship Between Temperature, Time and Weight on Ash Content

The results shown in Figure 3 show that temperature and pyrolysis time greatly affect the ash content of the briquettes produced. The longer the pyrolysis time, the higher the ash content. In the results of the analysis and testing of patchouli solid waste bio charcoal briquettes that have been carried out, the lowest ash content was obtained at 4.28% at a raw material weight of 1800 grams, a pyrolysis temperature of 350 °C and a pyrolysis time of 60 minutes. The highest ash content was 8.93% at 1200 grams of raw material, 300 °C pyrolysis temperature and 150 minutes pyrolysis time. The increase in ash content due to the addition of materials, temperature and time used is also increasing which is inversely proportional to the decreasing water content. The high and low levels of volatile substances in briquettes are caused by the perfection of the carbonization process, time and temperature. The longer the combustion time and the higher the carbonization temperature, the more volatile substances are wasted so that when testing the level of volatile substances, low results will be obtained.

The ash content value shows the amount of residue from the end of the combustion process in the form of mineral substances that are not lost during the combustion of pyrolysis process. In accordance with the statement of Sudarmaji et al. (1997), that the ash content depends on the type of material, method of ignition, time and temperature used during combustion. Ash contained in solid fuels is a mineral that cannot burn and is left behind after the combustion process or accompanying reactions are complete. Ash plays a role in reducing the quality of fuel because it reduces the calorific value [10].

Based on the test results, the ash content value produced ranged from 4.28% - 8.93%. The results showed that the briquettes with variable temperature and time met the SNI 01-6235-2000 standard, which is a maximum ash content of 8%.

3.4. Volatile Matter Content

Volatile substances in bio charcoal briquettes are compounds other than water, ash and carbon. Volatile matter consists of hydrocarbons, methane, and carbon monoxide. High levels of volatile matter in bio charcoal briquettes will cause more smoke when the briquettes are lit. The more volatile matter content in the briquette, the easier it is to burn and ignite. The amount of vapour content affects the combustion rate.

According to Hendra (2007) in Sundari (2009) the high and low levels of volatile substances of bio charcoal briquettes produced are influenced by the type of raw material, so that the type of raw material has a significant effect on the levels of volatile substances of bio charcoal briquettes [11].

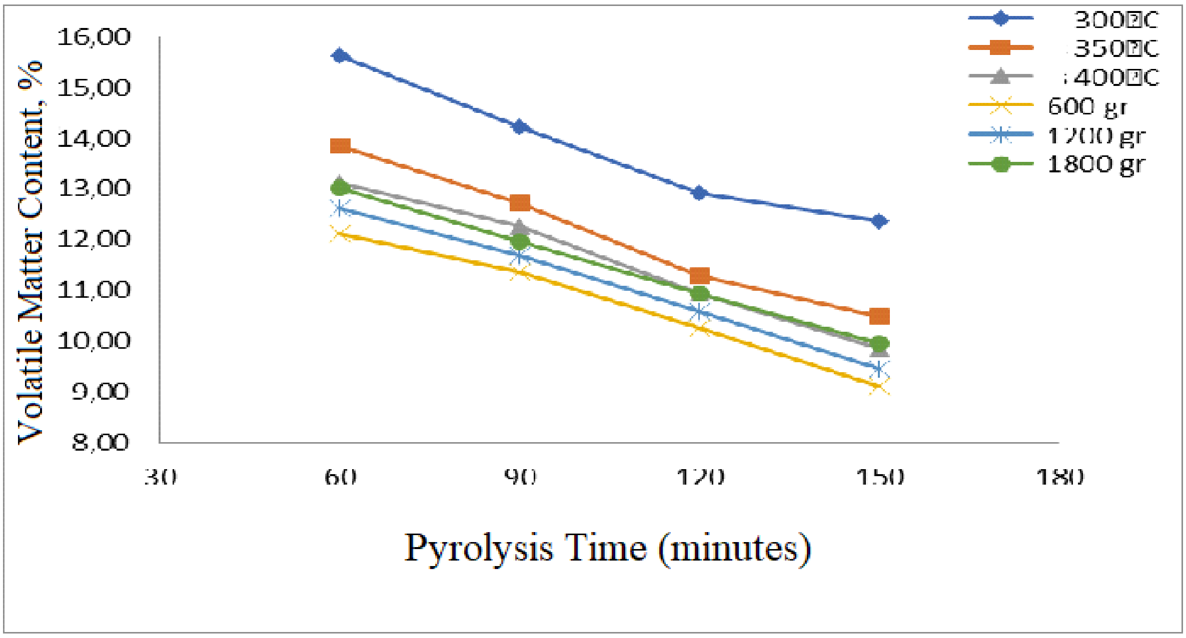

Figure 4. Relationship of Temperature, Time and Weight to Volatile Matter Content

Based on Figure 4 above, it can be seen that the results of analysis and testing of patchouli solid waste biochar briquettes that have been carried out, the lowest volatile matter is obtained at 9.11% at a raw material weight of 600 grams, a pyrolysis temperature of 350 °C and a pyrolysis time of 150 minutes. While the highest volatile matter was obtained at 15.64% at a raw material weight of 1200 grams, a pyrolysis temperature of 300 °C and a pyrolysis time of 60 minutes. This is in accordance with the results of Hendra and Darmawan (2000) research, that the size of the volatile matter content is determined by the time and temperature of charring. If the pyrolysis process is long and the temperature is increased, the more volatile matter content is wasted.

According to Nisandi (2007), the high and low levels of volatile matter are influenced by the temperature and length of charcoal processing. The pyrolysis process that runs perfectly will cause low volatile matter levels and the length of the charring process will evaporate as much volatile matter as possible so that low levels of volatile matter are obtained. According to Iskandar (2019). The smaller the volatile matter content, the better the briquette quality. The more the starch content increases, the greater the fly content obtained. This is due to the content of volatile matter such as CO, CO_2, H_2, CH_4 and H_2O contained in the starch adhesive and coconut shell charcoal used to evaporate. The level of volatile matter is also influenced by the combustion process [12].

The results of the analysis of flying substance levels in patchouli solid waste bio charcoal briquettes that have been given temperature and time variations range from 9.11% - 15.64%. The results showed that briquettes with variable temperatures and times met the SNI 01-6235-2000 standard, which is a maximum of 15% fly substance content.

3.5. Fixed Carbon Content

Carbon content is the amount of pure carbon contained in charcoal. The higher temperature in the carbonization process greatly affects the quality of the charcoal, including the carbon content. The higher the fixed carbon content, the lower the content of volatile substances [13].

The results of the analysis of fixed carbon content in patchouli solid waste bio charcoal briquettes as shown in Figure 5.

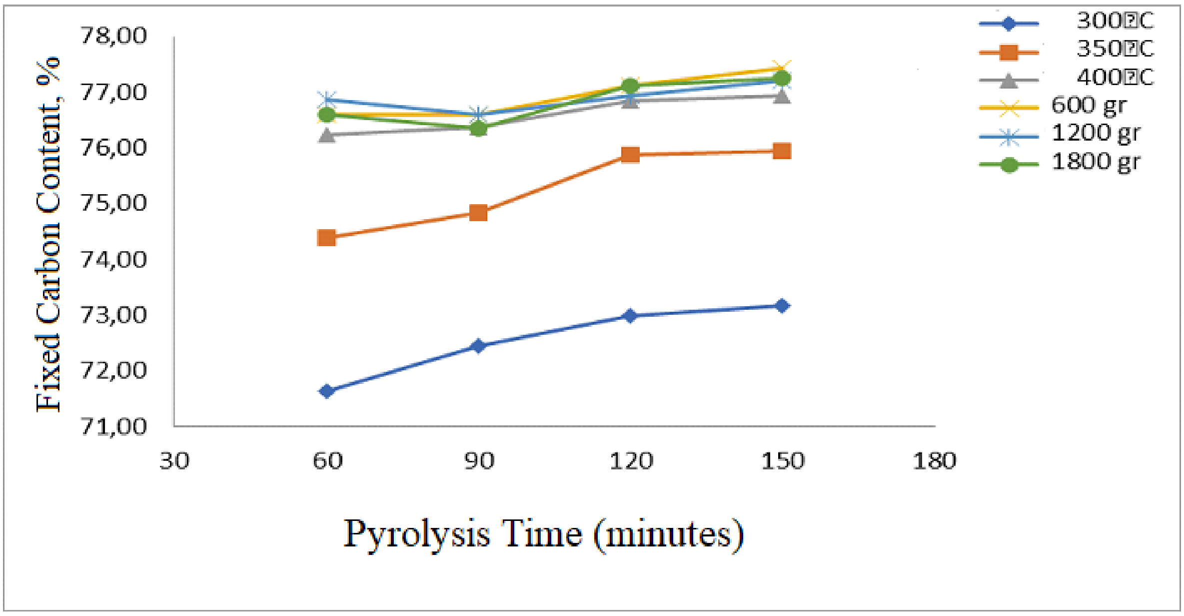

Figure 5. Relationship of Temperature, Time and Weight to Fixed Carbon

From Figure 5, it is known that the results of analysis and testing of patchouli solid waste bio charcoal briquettes that have been carried out, the lowest fixed carbon content is obtained at 71.64% at a raw material weight of 1200 grams, pyrolysis temperature of 300 °C and pyrolysis time of 60 minutes. While the highest fixed carbon content was obtained at 77.42% at a raw material weight of 600 grams, a pyrolysis temperature of 350 °C and a pyrolysis time of 150 minutes.

According to Usman (2007), the higher the level of fly substances, the lower the carbon content, and vice versa, the lower the level of fly substances, the higher the carbon content. Likewise, the higher the ash content, the lower the carbon content. The fixed carbon content shows the amount of elemental carbon content that is anchored in the briquette and has an influence on volatiles and carbonisation time. The higher the fixed carbon content, the lower the volatile matter content [14].

The results of the analysis of fixed carbon content in patchouli solid waste bio charcoal briquettes that have been given variations in material weight, temperature and time range from 71.64% - 77.42%. When compared with SNI 01-6235-2000 on charcoal briquettes, it fulfills the maximum bound carbon parameter of 77%.

3.6 Combustion Rate

Combustion velocity is the weight reduction per unit minute during combustion. Faster weight reduction gives greater speed. The greater the burning speed, the shorter the briquette will burn. The combustion speed value is obtained from the dry weight of the briquette divided by the time of burning the briquette until it runs out into ash [15].

The results of the combustion rate analysis on patchouli waste bio charcoal briquettes as shown in Figure 6.

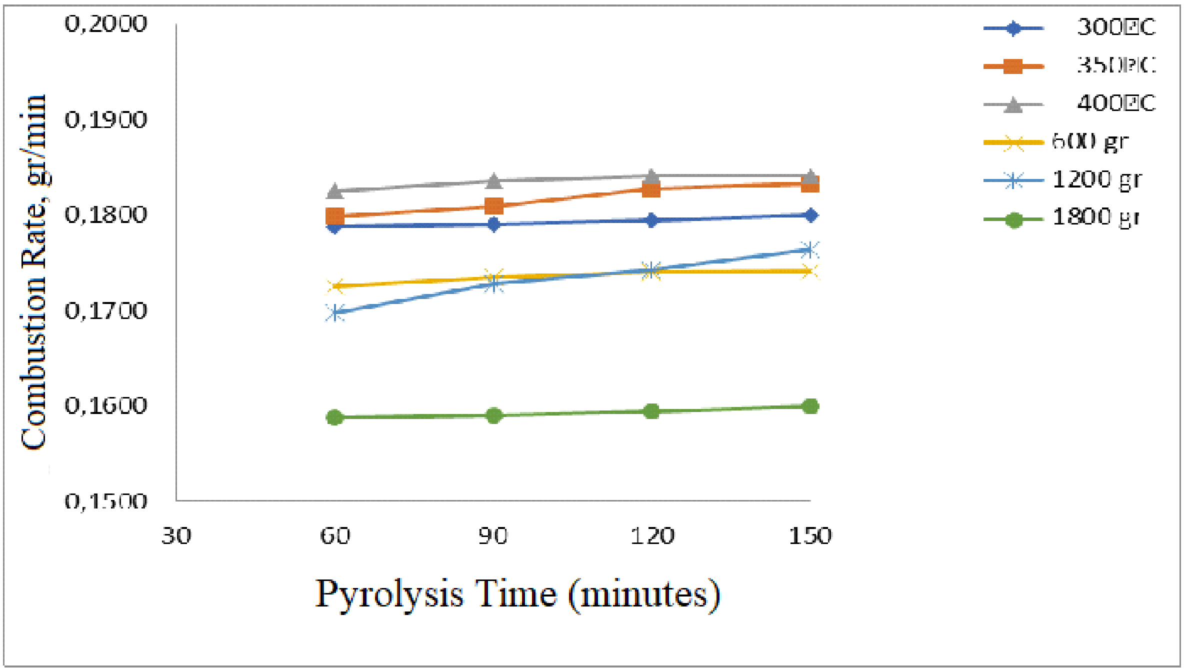

Figure 6. Relationship Between Temperature, Time, Weight and Combustion Rate

Figure 6 shows that the results of analysis and testing of patchouli solid waste bio charcoal briquettes that have been carried out, the lowest combustion rate is obtained at 0.1588 gr/min at a raw material weight of 1800 grams, pyrolysis temperature of 300 °C and pyrolysis time of 60 minutes. While the highest combustion rate was obtained at 0.1841 gr/min at a raw material weight of 600 grams, a pyrolysis temperature of 400 °C and a pyrolysis time of 150 minutes. Briquette combustion time depends on the mass of the briquette. Borman and Ragland (1998) in Rahman (2009) state that the burning rate of charcoal depends on oxygen concentration, gas temperature, Reynold's number, size and porosity of charcoal where wood charcoal has high porosity [16].

In the research of Syamsiro and Harwin (2006) the effect of the particle size of briquettes on the combustion rate shows that the smaller the particle size will reduce the combustion rate, this is because the density of the briquette becomes higher, so the porosity becomes lower and oxygen diffusion becomes slow. Combustion speed is the weight loss per unit minute during combustion. Faster weight reduction gives greater speed. The heavier the raw material, the longer the combustion rate. Meanwhile, the greater the pyrolysis time, the shorter the biochar briquette will burn. The combustion speed value is obtained from the dry weight of the bio charcoal briquette divided by the combustion time of the bio charcoal briquette until it runs out into ash [17].

Based on the results of the analysis of the combustion rate of patchouli solid waste bio charcoal briquettes that have been given temperature and time variations ranging from 0.1588 - 0.1841 gr/min. This shows that the burning rate of briquettes the higher the weight of the material, the temperature and the longer the pyrolysis time, the longer the burning rate.

3.8 Thermal Value

According to Santosa (2010), thermal value is a quantity or amount of heat either absorbed or released by an object. The thermal value affects the combustion rate. The higher the thermal value contained in a fuel, the better the fuel is used for combustion. The quality of bio charcoal briquettes is primarily determined by their thermal value which is calculated using a bomb calorimeter because the thermal value is a reference to whether the bio charcoal is suitable for use as an oil substitute fuel or not. If the thermal value is too small, the economic value of the bio charcoal will also be small so that it is not profitable if used as a substitute for fuel oil [18].

Based on the results of the thermal value test on bio charcoal briquettes, the thermal value obtained is 5291 cal/gr. When compared with SNI 01-6235-2000, the calorific value parameter produced is a minimum of 5000 cal/gram. So the thermal value of patchouli solid waste briquettes fulfills the SNI because it is more than the minimum standard that has been determined. It shows that the higher the temperature and pyrolysis time, the higher the thermal value of a briquette. This is because the higher the temperature, the more water content in the briquette will be evaporated [19]. The higher the thermal value of a fuel, the better the quality of the fuel.

4. CONCLUSIONS

Based on the research that has been done, it is concluded that the best variable is obtained at a temperature of 400 °C, a raw material weight of 600 and a time of 150 minutes with a heat value of 5,291 cal/g, a moisture content of 5.77%, an ash content of 4.28%, a volatile matter content of 9.11% and a bound carbon content of 77.42% and a combustion rate of 0.1841 grams/minute. The obtained thermal value of 5,291 cal/g shows that patchouli solid waste bio charcoal can be utilised as a renewable alternative fuel and meets SNI 01-6235-2000.

This research can be used as a reference for further research with the same topic of discussion or can continue research with a greater number of variables.

AUTHORS' CONTRIBUTIONS

All authors contributed to the study conception and design. Material preparation, data collection and analysis were
performed by Zainuddin Ginting, Adi Setiawan, and Khairul Anshar. Products characteristics was analyzed by Zainuddin Ginting and Ishak. The first draft of the manuscript was written by Khairul Anshar, Chalisna Wildani, Sri Widia Santika, and Cut Riski Milya. All authors read and approved the final manuscript.

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