The correlation of ultimate analysis and calorific value on palm oil briquettes using durian seed adhesives

Seri Maulina¹,²*, M. Sarah¹,², E. Misran¹,², M. F. Anita¹

¹Department of Chemical Engineering, Faculty of Engineering, Universitas Sumatera Utara, Indonesia
²Sustainable Energy and Biomaterial Center of Excellence, Faculty of Engineering, Universitas Sumatera Utara, Indonesia

*E-mail: maulina_harahap@yahoo.com

Abstract. Palm fronds are one of the wastes produced from oil palm plantations that have high potential and are suitable for use as raw material for biomass as renewable energy through carbonization and briquetting processes. Durian seeds contain amyllose and amylopectin which can be used as an adhesive to improve the physical quality of the briquettes produced. Palm fronds are carbonized at 300°C for 90 minutes. The charcoal produced is mashed with a ball mill. The gluing process is carried out using an adhesive from durian seeds with a concentration of 5%, 15% and 25% with a char: adhesive ratio of 30:70, 50:50, and 70:30 and compressed at a pressure of 100 kg/m². Ultimate analysis and calorific value are carried out to test the performance and quality of bio-charcoal briquettes.

1. Introduction
Indonesia's dependence on fossil energy (petroleum, natural gas, and coal) in meeting domestic energy needs is still high. Based on data from the National Energy Board in 2014, fossil energy contributed 94.3% of the total national energy needs of 1,357 million SBM (barrels of oil equivalent). To reduce the excessive use of fossil energy (petroleum, natural gas and coal), it is necessary to develop an alternative energy that can be used as a substitute fossil fuels. Biomass renewable energy is one alternative energy that is used as a substitute palm oil for fossil fuels.

Indonesia is the country with the largest plantations in the world. In 2017, there were approximately 14.03 million hectares of oil palm plantations, which made the availability of oil palm plants and their waste very large and abundant, one of which was the oil palm fronds [1]. Oil palm frond waste can be reduced by processing it into products and increasing its economic value such as making fuels in the form of bio-charcoal briquettes.

Briquette is a combustible biomass fuel that is formed from the pressing or compression process by using an adhesive to increase the fuel value [2]. The process of making briquettes is a process of converting biomass residue into a solid block with a high pressure or low pressure process with the addition of an adhesive to produce fuel with a high calorific value. [3]. Renewable energy sources must be utilized effectively to meet the rapidly increasing energy demand. Biomass energy has a greater potential than other forms of energy, because it is renewable and has a lot of availability [4].

The purpose of this research is to utilize the oil palm frond waste into a new alternative renewable energy fuel in the form of bio-charcoal briquettes.

2. Materials and Method
This research used oil palm fronds as a raw material to manufacture briquette which obtained from local palm plantation in Sumatera Utara, Indonesia. In addition, other materials used in this research were starch as a binder and aquadest (H₂O).

This research was conducted using a carbonization process at 300°C for 90 minutes to produce bioo-charcoal. Before the carbonization process is carried out, the fronds are cut into small size using a chopper machine. Charcoal produced from the carbonization process is mashed using a ball mill, it is
desirable to obtain a particle size of 100/140 mesh. The gluing process was carried out using 5%, 15% and 25% durian seed flour with a char: adhesive ratio of 30:70, 50:50, 70:30. Bioarang briquettes are pressed using hydraulic press with a pressure of 100 kg/m², and dried in the oven for 3 hours. Ultimate analysis and calorific value were carried out to highlight the performance and quality of wood charcoal briquettes.

3. Result

3.1. Ultimate Analysis
Bio-charcoal briquette ultimate analysis includes carbon (C), Hydrogen (H), oxygen (O), Nitrogen (N) and sulfur (S) content. The ultimate analysis results can be seen in Table 1.

| Adhesive Concentration | Ratio Charcoal : Adhesive | 5%       | 15%       | 25%       | 5%       | 15%       | 25%       | 5%       | 15%       | 25%       |
|------------------------|---------------------------|----------|----------|----------|----------|----------|----------|----------|----------|----------|
|                        | 30:70                     | 50:50    | 70:30    | 30:70    | 50:50    | 70:30    | 30:70    | 50:50    | 70:30    | 50:50    | 70:30    |
| C                      | 56,14                     | 56,44    | 57,57    | 56,59    | 57,76    | 58,57    | 53,61    | 56,47    | 57,52    | 4,555    | 4,331    |
| H                      | 4,555                     | 4,331    | 3,880    | 4,138    | 4,007    | 4,027    | 4,763    | 4,312    | 4,021    | 33,526   | 33,24    |
| O                      | 33,526                    | 33,24    | 32,514   | 33,293   | 32,127   | 31,364   | 35,926   | 33,315   | 32,508   | 0,81     | 0,77     |
| N                      | 0,81                      | 0,80     | 0,77     | 0,82     | 0,81     | 0,80     | 0,79     | 0,79     | 0,76     | 0,227    | 0,192    |
| S                      | 0,227                     | 0,192    | 0,186    | 0,191    | 0,187    | 0,181    | 0,193    | 0,172    | 0,163    |

Table 1 presents the average percentages of Carbon (C), Hydrogen (H), Oxygen (O), Nitrogen (N), and (Sulfur (S). From Table 1, it can be seen that the carbon content is high in all variations in the ratio of charcoal to adhesive and concentration adhesive. The main composition of the fuel usually contains carbon by 30% - 60% [5]. The higher the percentage value of C in fuel, the higher the calorific value [6]. Element C in fuel has a very big role on the combustion power of bio-charcoal briquettes [7]. Oxygen content has decreased in all variations of the ratio of charcoal to adhesive, because in mixing process, the 30:70 ratio of the adhesives mixed perfectly into the pores of the charcoal while in the ratio of 50:50 and 70:30 the adhesive does not enter the pores of the charcoal perfectly resulting briquettes are not solid. For element O in the fuel is generally 30% - 40% [5]. The element O in this fuel indicates the oxygen content in the fuel, this is used as an indication the ease of ignition of the fuel. The higher the oxygen value in the fuel, the fuel does not require too much external oxygen to facilitate the ignition of the fuel because the oxygen content is quite high [6]. Hydrogen content decreased in all variations of the ratio of charcoal to adhesive, because the adhesive used also contains hydrocarbon elements. Hydrogen is the third bigger composition in the combustion process that is equal to 5% - 6% [5]. Hydrogen content is often associated with volatile substances, where a good bio-charcoal briquette must have a low amount of hydrogen, where a low hydrogen content will increase the flammability of the bioarang briquettes produced [8]. The element H is also used as a parameter for calculating the heat value and calculation in calculating moisture content [5]. Nitrogen and sulfur content decreased in all variations of the ratio of charcoal to adhesive. For nitrogen and sulfur content in ingredients even smaller than 1% [7]. Elements N and S are elements that cause pollution in combustion because these elements can react with the surrounding air so that it becomes NOx and SOx [6]. Fuel combustion pollution will be harmless if N and S levels do not exceed 1% of the mass percentage [7]. The most important element in combustion is the elements C and H the percentage of elements C and H are used as parameters for the calculation of heat value [5].
Element C which acts as a reactant reacts with oxygen on the surface of the particles to produce CO and CO2. CO2 is a product of combustion that is released back into the air after the combustion process [6].

In Table 1 it is known that the biomass briquettes produced for all variations contained C elements ranging from 53.61% - 58.57%, based on the theory that is directly proportional to the heating value. Element H ranges from 3.63% - 4.76%, based on the theory that the lower the hydrogen element in a fuel will increase the flammability of the briquettes produced. Element O ranges from 30.32% - 35.92%, based on the theory that the higher the element O in a fuel, it will facilitate the combustion process on the fuel produced. This is due to the fact that O will react with element C. Element N ranges from 0.76% - 0.82% and element S ranges from 0.163% - 0.193% and is in accordance with the theory, where fuel combustion pollution will be harmless if N levels and S does not exceed 1%.

3.2. Caloric Value
Analysis was carried out using the IKA C 6000 bomb calorimeter based on ASTM D1762-84-2013. The effect of concentration and adhesive ratio on the heating value can be seen in Figure 1.

The calorific value is the energy content or the amount of heat from the fuel obtained in combustion completely [9]. The calorific value greatly determines the quality of the briquettes produced [6]. The higher the calorific value, the better the quality of a briquette will be. The heating value is also obtained based on the amount of heat energy contained in the raw material and also the density of the bioarang briquettes produced [10] [11]. The higher the temperature or combustion temperature of raw materials to make charcoal in the briquetting process, the briquette heating value will be higher [12].

The chemical composition of raw materials is closely related to the heating value of charcoal briquettes especially the carbon content (C) [13]. The composition of ash-free organic biomass components is relatively uniform. The main components are carbon (C), oxygen (O), and hydrogen (H). Most biomass also contains a small amount of nitrogen (N) and sulfur (S). The composition of the biomass affects the characteristics of combustion. The heating value of the fuel decreases during combustion due to volatile matter during the combustion phase and because the ratio of hydrogen to carbon increases. The lowest level of fuel degradation occurs when the ratio of oxygen to carbon increases [12].

The adhesive will also affect the heating value of the briquettes because the water content in the adhesive so that the more the amount of adhesive used, the heating value will tend to decrease [14]. Adhesives have carbohydrate, amylose, and amylopectin molecules, which consist of elements of carbon, hydrogen, and oxygen [15].
The main composition of the fuel usually contains carbon by 30% - 60%, then oxygen by 30% - 40%. Hydrogen is the third major composition, which is 5-6% and nitrogen and sulfur is less than 1% [5]. In this study it is known that the biomass briquettes produced for all variations contained element C ranged from 53.61% - 58.57%, Element H ranged from 3.63% - 4.76%, Element O ranged from 30.32% - 35.92%, Element N ranges from 0.76% - 0.82% and element S ranges from 0.163% - 0.193% where fuel combustion pollution will be harmless if N and S levels do not exceed 1%.

In Figure 1 it can be seen that the highest calorific value is at the ratio of 70:30 concentration 25% that is equal to 6539 cal / gr with carbon element of 58.57% and the lowest heating value is found at 30:70 concentration of 5% that is equal to 5097 cal / gr with carbon element of 53.61%. This shows that the higher the percentage value of C in fuel, the higher the calorific value[6].

4. Conclusion

It can be concluded that the briquettes produced have met the SNI standards.

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References

[1] Maulina S, Handika G, Irvan, Iswanto AH 2020 Journal of the Korean Wood Science and Technology 48(4) 503-512.
[2] Chinyere D C, Asogwugw S N and Nwandikom G I 2014 An Evaluation of Briquettes from Sawdust and Corn Starch Binder J Int Sci Tech vol 2 no 7 321-919x.
[3] Irvan, Trisakti B, Maulina S, Sidabutar R, Iriany and Takriff MS 2018 Journal of Engineering Science and Technology 13(10) 3058 – 3070.
[4] Maninder, Kathuria R S and Grover S 2012 Using Agricultural Residues as a Biomass Briquetting : An Alternative Source of Energy IOSR Journal of Electrical and Electronics Engineering vol. 1 no. 5 11–15.
[5] Raju C A I, Praveena U, Satya M, Ramya Jyothi K and Prof Sarveswara Rao S 2014 Studies on Development of Fuel Briquettes using Biodegradable Waste Materials J. Int. Bioprocessing and Chemical Engineering vol 2 no 1 2348-3768.
[6] Ginting MHS, Irvan, Misran E, Maulina S. 2020 Potential of durian, avocado and jackfruit seed as raw material of bioethanol: A review IOP Conf. Ser: Mater. Sci. Eng. 801(1) 012045.
[7] Akowuah J O, Kemausuor F and Mitchual S J 2012 Physico-chemical characteristics and market potential of sawdust charcoal briquette International Journal of Energy and Environmental Engineering vol 3 no 1 1–6.
[8] Adekunle J, Ibrahim J and Kucha E 2015 Proximate and Ultimate Analyses of Biocoal Briquettes of Nigerian’s Ogboyaga and Okaba Sub-bituminous Coal British Journal of Applied Science & Technology 7 no 1 114–123.
[9] Irvan, Trisakti B, Maulina S, Daimon H 2018 Rasayan Journal of Chemistry 11 (1) 378-385.
[10] Onuakak I, Mohammed Dabo I, Ameh A, Okoduwa S and Fasanya O 2017 Production and Characterization of Biomass Briquettes from Tannery Solid Waste Recycling vol 2 no 17 1-19.
[11] Islam H, Hossain M and Momin A 2014 Development of Briquette from Coir Dust and Rice Husk Blend : An Alternative Energy Source International Journal of Renewable Energy Development vol 3 no 3 119-123.
[12] Irvan, Trisakti B, Maulina S, Daimon H 2018 Oriental Journal of Chemistry 34 (1) 161-168.
[13] Koricho S A, Leta S, Soromessa T and Khan M M 2017 Fuel Briquette Potential of Lantana Camara L. Weed Species and its Implication for Weed Management and Recovery of Renewable Energy Source in Ethiopia *IOSR J Environ, Sci Toxicol Food Technol* vol 32 no 3 2395-2415.

[14] Chitedze J, Monzerezi, Kalenga-Saka M, Steenkamp J J D 2012 Binding effect of cassava starch on the compression and mechanical properties of ibuprofen tablets *J Appl Pharm Sci* vol 2 31–37.

[15] Maulina S, Irvan, Trisakti B and Daimon H 2018 *Rasayan J. Chem, 11(3)* 1151-1158.