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QUALITY OF BIOBRICKETS FROM A MIXTURE OF PALM OIL (ARENGA PINNATA) AND WATER HYACINTH (EICHHORNIA CRASSIPES) WITH 10 TONS PRESS PRESSURE

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ABSTRACT
The purpose of this study was to analyze the quality of charcoal biobriquettes from a mixture of palm fruit shells (*Arenga pinnata*) and water hyacinth (*Eichhornia crassipes*) under a pressure of 10 tons, which included moisture content, density, ash content, volatile matter, bound carbon and heating value. The research method includes preparation of test samples, testing the characteristics of biobriquettes using the SNI test method. 06-3730-1995 covering moisture content, density, ash content, volatile matter, bound carbon and heating value. Biobriquettes use 10% tapioca adhesive and 10 tons of pressure with 5 treatments (A: 100% palm shell charcoal; B: 75% palm shell charcoal + 25% water hyacinth charcoal; C: 50% palm shell charcoal + water hyacinth charcoal goiter 50% ; D: palm shell charcoal 25% + water hyacinth charcoal 75%; E hyacinth charcoal 100%) and 3 replications. The results showed that bioricket made from a mixture of palm fruit shells and water hyacinth with a pressure of 10 tons had physical properties, namely water content ranging from 3.3952-8.8377% with a density of 0.6488-1.0363 g/cm³, chemical properties namely ash content 1.4440-14.4133%, volatile matter 34.9767- 47.6800% and heating value 4282.0-5614.05 cal/g.

KEY WORDS
Biobriquettes, palm fruit shells, water hyacinth, alternative energy.

National energy needs are increasing along with the rapid growth of Indonesia's population, while petroleum reserves as the main source of national energy are dwindling. The total population of Indonesia as of September 2020, based on the results of the 2020 population census, reached 270.2 million in 2016, there was an increase in the population of 32.56 million people or an average of 3.26 million people each year. Data from the Ministry of Energy and Mineral Resources noted that Indonesia's energy consumption in 2017 reached 1.23 billion Barrels Oil Equivalent (BOE), up 9% from the previous year. Meanwhile based on its designation, the largest national energy is used for household needs, reaching 382.94 million BOE or 31% of the total. Then the second largest for the transportation sector 361.7 million BOE or around 29.31% and the third for industry with 273.86 million BOE or 22.19% of total national energy consumption. This condition has spurred the government to continue to seek and develop new alternative energy sources that can be renewed so that energy fulfillment is no longer solely dependent on petroleum.

Biobriquettes are an alternative energy source that can be developed to address the challenge of depleting energy sources derived from petroleum. The raw materials for biobriquettes or biomass charcoal briquettes come from biomass charcoal such as wood, coconut shells, woodworking industry waste and agro-industrial waste such as palm fruit/and fro processing waste (bunches and fruit shells) and various other natural wastes containing cellulose and lignin.

Biobriquette raw materials are very abundant in the wetlands of South Kalimantan, for example palm trees. Palm trees grow throughout the area in South Kalimantan and have many benefits. Apart from taking the sap to be processed into brown sugar, the palm tree also produces a fruit called fro. Processing palm fruit to and fro produces waste in the form of fruit shells. Processers of fruit and fro usually let the palm fruit waste accumulate or throw it into the river without further utilization.

Another biobriquette raw material available in South Kalimantan is water hyacinth. Water hyacinth is a water weed that can be found in many wetlands in South Kalimantan. Biobriquettes from a mixture of biobriquettes from fro and water hyacinth processing waste can be a new source of energy for communities around wetlands, for example for household needs. The people of South Kalimantan generally meet their household energy needs by using Liquified Petroleum Gas (LPG) for cooking purposes. The existence of LPG is often rare in the market and the price is soaring, the price of 3 kg LPG even reaches IDR 50,000/tube. Biobriquettes from a mixture of fro and water hyacinth processing waste can be processed using simple technology, so that it can be carried out by the wider community.

Biobriquette processing is done by processing the available raw materials into charcoal first. The charcoal is then crushed and sieved to make it uniform, then it is mixed with an adhesive such as starch. The charcoal and adhesive mixture is then printed to form briquettes with cylindrical, egg or cube shaped molds. The development of biobriquettes from a mixture of fro (palm shells) and water hyacinth processing waste to become regional superior products must be balanced by knowing the quality of the biobriquettes produced. In previous research, the process of processing biobriquettes from a mixture of palm fruit shells and water hyacinth was carried out by printing and manual pressing. The resulting characteristics did not meet the quality standards of biobriquettes based on SNI 06-3730-1995 (Indonesian National Standard). The quality of the biobriquette is that it has a moisture content of 9.3767-9.9933%, density 0.5070-0.6777g/cm³, ash content 16.1967-22.7167%, volatile matter 31.0000-57.6667%, bound carbon 14.9567- 36.4300% and calorific value 3.396 - 4.382 cal/g.

Improving the quality of biobriquettes from a mixture of palm shells and water hyacinth must continue to be pursued so that they meet good quality and meet SNI standards so that the biobriquettes can be used by the community to meet the energy needs of households and SMEs. One of the efforts to improve the quality of biobriquettes can be done by engineering the production process, namely by providing the right pressure. Based on a literature study conducted by the research team, applying 10 tons of pressure can produce quality biobriquettes that meet SNI standards (Hendra, 2207).

The purpose of this study was to analyze the quality of the biobriquettes mixed with palm fruit shells and water hyacinth by applying 10 tons of pressure and to determine the characteristics of the biobriquettes, which include moisture content, density, ash content, volatile matter, bound carbon and calorific value.

METHODS OF RESEARCH

The materials used in this study were palm from processing waste in the form of palm fruit shells from the Kandangan and water hyacinth areas in the Sipai Martapura River area. Other ingredients used are tapioca flour as an adhesive and water.

The equipment used is a carbonizer, a 40-60 mesh filter, a mortar, a briquette press, a furnace, a bomb calorie meter, oxygen, a stopwatch, a thermometer and a measuring cup.

Test Sample Preparation:

- Providing raw materials in the form of palm fruit shells and water hyacinth. Drying the raw materials to dry in the sun for ± 1 week;
- The raw material is then converted into charcoal through a carbonization process. Raw materials are charcoaled separately (not mixed). The authoring process uses a direct combustion system using a furnace (iron can). The processing time for each raw material is different, palm fruit shells require 2 hours to process, while the water hyacinth process is shorter, namely 1 hour;
- Make charcoal powder. The charcoal produced from the carbonization process is then crushed using a mortar to produce palm fruit shell charcoal powder and water hyacinth charcoal powder;

- Sieve the coconut shell charcoal and water hyacinth charcoal so that they are uniform in size. The sieving process uses a 40-60 mesh sieve, the charcoal powder to be used is charcoal powder that passes the 40 mesh sieve and is retained in the 60 mesh sieve;
- Mixing charcoal powder from kolang-klaing processing waste and water hyacinth charcoal with the composition according to the treatment;
- Gives tapioca flour adhesive as much as 10%. Tapioca adhesive is made by heating water on the stove to a temperature of 700C then adding tapioca flour to the water and stirring it slowly until an adhesive gel is formed;
- Printing charcoal bioricket into a cylindrical mold with a diameter of 3 cm and a height of 4 cm, then pressed with a pressure of 10 tons;
- Drying Biobriquettes. The printed biobriquettes were then taken out and air-dried for a week and ready to be tested;
- Testing the quality of biobriquettes. Testing the characteristics of biobriquettes was carried out at the Forest Product Technology Laboratory and Workshop of the ULM Faculty of Forestry. The characteristic parameters of biobriquettes from palm shells and water hyacinth to be tested include moisture content, density, ash content, volatile matter, bound carbon and calorific value based on ASTM D 5142 – 02;
- Data on the results of testing the characteristics of biobriquettes from palm fruit shells and water hyacinth were tabulated and tested through Box and Whisker Plots. The results of testing the characteristics of the biobriquettes obtained were then compared with national biobriquette standards as well as the characteristics of other biobriquettes such as biobriquettes from coconut shells, sawn waste or waste of empty palm oil bunches.

Table 1 – Composition of Raw Materials for Biobriquette Palm Fruit Shells and Water Hyacinth

Treatment	Composition	
	Palm fruit shell	Water hyacinth
A	100%	0%
B	75%	25%
C	50%	50%
D	25%	75%
E	0%	100%

Figure 1 – Palm and water hyacinth shell biobriquettes

The scheme for processing biobriquettes from palm fruit shells and water hyacinth is as follows.

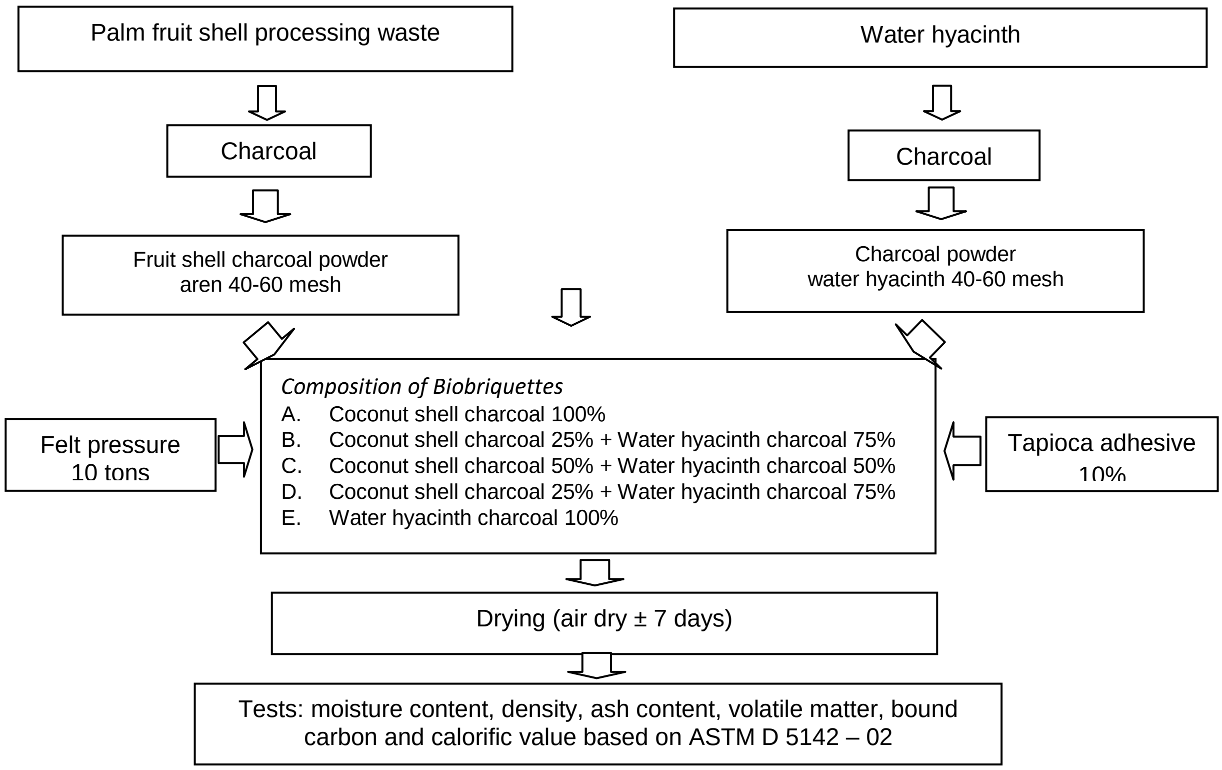

Figure 2 – Schematic of the Process of Processing Biobriquettes of Palm Fruit Shells and Water Hyacinth

RESULTS AND DISCUSSION

The results of the recapitulation of quality testing of biobriquettes mixed with palm fruit shells and water hyacinth can be seen in Table 2.

Table 2 – Characteristics of Sugar Palm and Water Hyacinth Shell Biobriquettes

Parameter	Treatment				
	A	B	C	D	E
Water content (%)	8.8377	8.3431	6.5305	4.2507	3.3957
Density (g/cm³)	1.0363	0.8810	0.8623	0.8086	0.6488
Ash Content (%)	14.4133	24.1700	17.5833	8.3933	1.4400
Fly Substance %)	34.9767	36.8567	44.0967	56.7967	47.6800
Bonded Carbon Content (%)	32.7723	29.6897	31.7855	28.8927	40.4848
Calorific Value (cal/g)	4282.37	3704.99	4367.17	5206.11	5614.05

Note:

A. Coconut shell charcoal 100%;
B. Coconut shell charcoal 75% + Water hyacinth charcoal 25%;
C. Coconut shell charcoal 50% + Water hyacinth charcoal 50%;
D. Coconut shell charcoal 25% + Water hyacinth charcoal 75%;
E. Water hyacinth charcoal 100%.

The data in table 2 shows the recapitulation of the test results for the mixture of palm fruit and water hyacinth shell biobriquettes. The test results showed that only some of the characteristics met the SNI standards. This can happen because the raw material for this biobriquette mixture does not consist of any type of wood. Sugar palm and water hyacinth shells have not so high levels of cellulose and lignin that affect biobric quality, especially density, bound carbon and calorific value. The process of printing biobriquettes using 10 tons of pressure has shown better quality of biobriquettes compared to biobriquettes using manual pressure, which greatly affects the cohesiveness and density produced.

The average moisture content of the biobriquettes mixed with palm fruit shells and water hyacinth from 3 replicates can be seen in Figure 3.

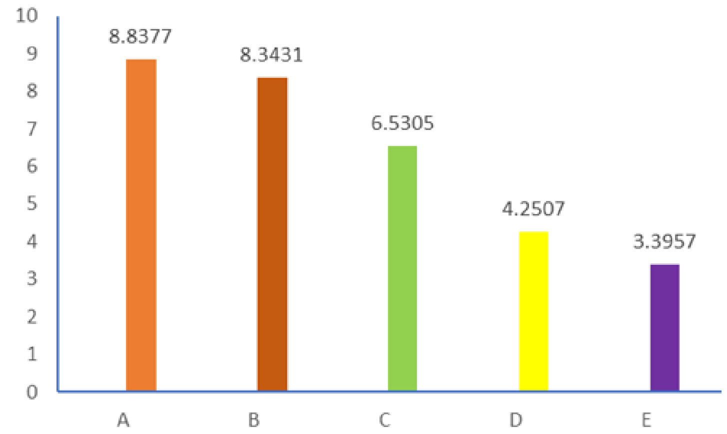

Figure 3 – Moisture content of palm fruit and water hyacinth shell biobriquettes: A. Coconut shell charcoal 100%; B. Coconut shell charcoal 75% + Water hyacinth charcoal 25%; C. Coconut shell charcoal 50% + Water hyacinth charcoal 50%; D. Coconut shell charcoal 25% + Water hyacinth charcoal 75%; E. Water hyacinth charcoal 100%.

The graph in figure 3 above shows the water content of the biobriquettes mixed with palm fruit shells and water hyacinth ranging from 3.3957 – 8.8377%. The addition of water hyacinth charcoal causes the water content of the biobriquettes to decrease. The addition of water hyacinth charcoal which has a lower specific gravity than palm fruit shells causes an increase in the volume of palm fruit shell charcoal powder in treatments B, C, D and E so that there is a difference in the ability of the mixture of palm fruit shells and water hyacinth in absorbing the adhesive mixture with water. The water content of the biobriquettes mixed with palm fruit shells and water hyacinth, namely C, D and E treatments, has met the Indonesian National Standard (SNI) which requires a moisture content of ≤ 8%.

Besides being determined by the physical properties of the raw materials used, the amount of water content is also determined by the carbonization process, namely the amount of air, temperature and carbonization process. Rapid carbonization will cause the water content contained in the raw material to remain high, which will affect the quality of the resulting charcoal briquettes. The water hyacinth carbonation process takes place faster than the sugar palm shell carbonation process.

Charcoal has the ability to absorb enormous water from the air around it. The ability to absorb water is affected by the surface area of the charcoal pores and is influenced by the level of bound carbon contained in the charcoal briquettes, the greater the ability of charcoal briquettes to absorb water from the surrounding air (Earl, 1947) in (Rustini, 2004).

Density is the ratio between the weight and volume of the sample. The testing data for the average density of biobriquettes mixed with palm fruit shells and water hyacinth can be seen in the following Figure 4.

The graph in Figure 4 above shows the briquette density which varies in each treatment, namely 0.6488 g/cm^3 to 1.0363g/cm^3. The density of the biobriquettes decreased with increasing water hyacinth charcoal composition in the biobriquettes. Water hyacinth has a lower specific gravity than the palm fruit shell. The density of biobriquettes is largely determined by the specific gravity of the material used as raw material. High specific gravity will produce charcoal briquettes with a density that tends to be high. In addition, the density is also influenced by the amount of pressure and the size of the powder. The greater the pressure given, the higher the resulting density. Great pressure will cause the adhesive to enter into the pores of the charcoal and fill the empty space between the charcoal powders so that it will produce a high density (Suprianto, 2003). The small size of the powder causes the surface area of the powder to be small so that if combined it will form a dense arrangement with small pores. The greater the pressure and the smaller the powder size, the harder it will be to burn the charcoal briquettes, because the charcoal briquettes are getting harder and denser. This biobriquette mixed with palm fruit shells and water hyacinth has used a 10 ton pressure and gave better results than the density of the biobriquette mixed with palm fruit shells and water hyacinth without pressure.

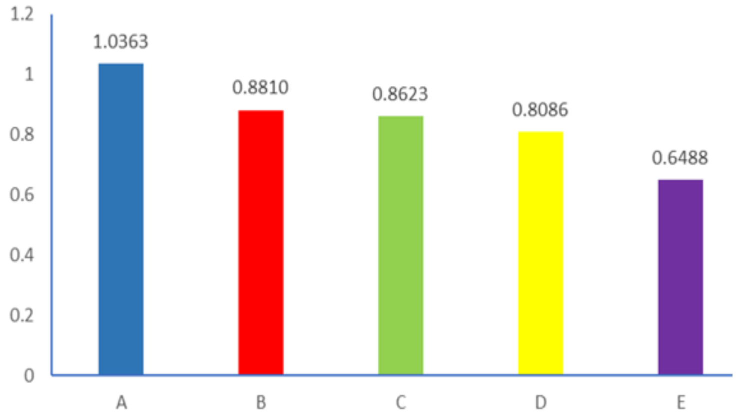

Figure 4 – Density of Biobriquettes of Palm Fruit Shells and Water Hyacinth: A. Coconut shell charcoal 100%; B. Coconut shell charcoal 75% + Water hyacinth charcoal 25%; C. Coconut shell charcoal 50% + Water hyacinth charcoal 50%; D. Coconut shell charcoal 25% + Water hyacinth charcoal 75%; E. Water hyacinth charcoal 100%.

The density of the biobriquette mixed with palm fruit shells and water hyacinth has met the SNI standard which requires a density of 0.44 g/cm3. The size of the charcoal powder used is uniform and meets the standards for making biobriquettes, namely the charcoal powder passes through a 45 mesh sieve and is retained on a 60 mesh sieve. The pressure used in printing the biobriquettes is 10 tons which is good enough and the amount of pressure can be increased to increase the density of the resulting biobriquettes.

The high or low density value is influenced by the specific gravity of the raw material used. Briquettes with a density that is too low can result in the briquettes being quickly used up in combustion because the weight of the briquettes is lower (Hendra and Winarni, 2003).

Ash is the remaining part of the combustion results, in this case it is the residue from burning charcoal briquettes. One of the constituent elements of ash is silica. According to Jamilatun (2011), the ash contained in solid fuel is a non-combustible mineral left behind after the combustion process and the accompanying reactions are complete. Ash will reduce the quality of solid fuel because it can reduce the heating value.

Testing the ash content in the manufacture of briquettes greatly affects the quality of the briquettes. The higher the ash content in the manufacture of briquettes, the quality of the briquettes will decrease. The ash content also affects the remaining combustion, the higher the ash content, the faster the briquettes will burn. The data from the average test results for the ash content of the biobriquettes mixed with palm fruit shells and water hyacinth can be seen in the following Figure 5.

The graph in figure 5 above shows that the addition of water hyacinth charcoal caused a decrease in the ash content contained in the biobriquette mixed with palm fruit shells and water hyacinth. The lowest ash content was 1.4400% in treatment E, while the highest ash content was 24.1700% in treatment B.

The ash content of charcoal briquettes is also affected by the carbonization process, especially the maximum temperature and duration of authoring (Sudrajat, 1982) and is influenced by the type of raw material, namely its specific gravity and hardness. These two factors greatly determine the nature of the resulting charcoal briquettes. The process of coagulating palm fruit and water hyacinth shells takes a shorter time when compared to the wood pulping process; it is suspected that this has contributed to the high ash content of the biobriquettes of water hyacinth and palm fruit shells.

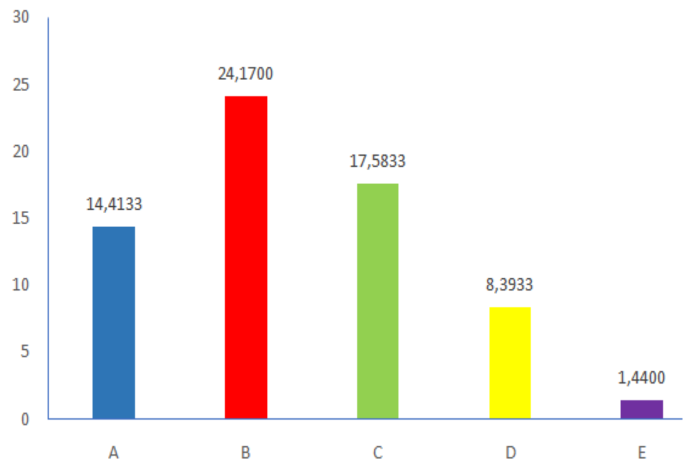

Figure 5 – Ash content of palm fruit and water hyacinth shell biobriquettes: A. Coconut shell charcoal 100%; B. Coconut shell charcoal 75% + Water hyacinth charcoal 25%; C. Coconut shell charcoal 50% + Water hyacinth charcoal 50%; D. Coconut shell charcoal 25% + Water hyacinth charcoal 75%; E. Water hyacinth charcoal 100%.

The average ash content that met the SNI ash content standard was treatment E, which was 1.4400%, where SNI required an ash content of ≤ 8%. The things that affect the ash content do not meet the standard according to Triono (2006), namely the addition of charcoal concentration will cause an increase in the value of the ash content of the briquettes and a decrease in the concentration of charcoal will decrease the value of the ash content of the briquettes.

Volatile matter is a substance that is lost when the test sample is heated in an electric furnace. Data from the average flying substance test results for water hyacinth biobriquettes and palm fruit shells can be seen in the following Figure 6.

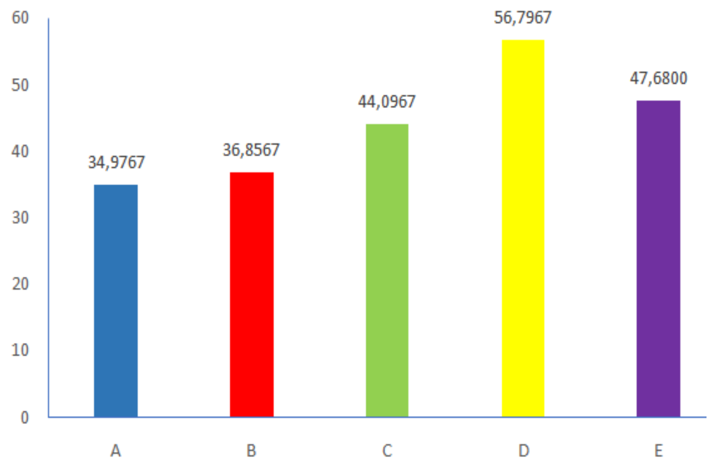

Figure 6 – Volatile matter content of palm fruit and water hyacinth shell biobriquettes: A. Coconut shell charcoal 100%; B. Coconut shell charcoal 75% + Water hyacinth charcoal 25%; C. Coconut shell charcoal 50% + Water hyacinth charcoal 50%; D. Coconut shell charcoal 25% + Water hyacinth charcoal 75%; E. Water hyacinth charcoal 100%.

The graph in Figure 7 above shows that the addition of water hyacinth charcoal causes an increase in the levels of volatile matter contained in the biobriquettes mixed with palm fruit shells and water hyacinth. The lowest volatile matter content was 34.9767% in treatment A, while the highest volatile matter content was 56.7967% in treatment D.

The high and low levels of volatile matter are more or less influenced by the physical properties of the two raw materials for charcoal briquettes, namely palm fruit shells and water hyacinth. This is because the shells of the palm fruit have a higher density and specific gravity than water hyacinth. Factors of differences in the types of raw materials in this study tend towards the production process. This means that the difference in the type of raw material is an indication of the difference in the carbonization process. With a perfect carbonization stage, volatile substances in gaseous form such as CO, CO2, CH4 and H2 will be released through the decomposition of cellulose and lignin. Because of this carbonization process, the treatment of the composition of the raw material mixture shows a very significant effect on the volatile matter content.

The level of volatile matter is also related to the adhesive used, tapioca flour contains carbohydrates (amylose and protein) which are not burnt in the combustion process, so this material also causes an increase in the level of volatile matter. Bioricket with a high volatile matter content will reduce the amount of fixed carbon and the resulting calorific value, but the high volatile matter content will also facilitate the process of burning charcoal briquettes because some of the volatile matter is present in the form of flammable gases.

The volatile matter content of the resulting biobriquettes is still quite high when compared to charcoal briquettes from a mixture of sawdust of meranti wood and galam wood charcoal (25.40% - 29.40%), reed briquettes (50.97%), plant litter briquettes acacia (40.97%) and peat briquettes (45.85%).

All research treatments showed that none met the standard of flying substance content of SNI which required 15%. The content of high levels of volatile matter in charcoal briquettes will cause more smoke when ignited, if the CO value is high this is not good for health and the surrounding environment (Miskah, 2014). High levels of volatile matter will reduce the quality of briquettes because the more volatile matter, the lower the carbon content so that the resulting calorific value is lower and will cause a lot of smoke to be produced from its combustion (Hendra and Pari, 2000).

Fixed carbon content is the fraction of carbon that is bound in the biobriquette besides the water fraction, volatile matter content and ash content. The bonded carbon value is obtained from subtracting the 100% number from the number obtained from the sum of the moisture content, ash content, and volatile matter. The higher the carbon content bound to the charcoal, it indicates that the charcoal is good charcoal (Pari, 2002). The average bonded carbon content test is presented in the following Figure 7.

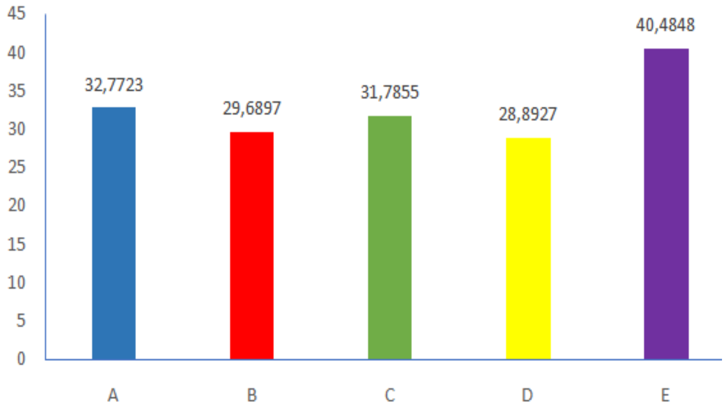

Figure 7 – Bonded carbon content of palm fruit and water hyacinth shell biobriquettes: A. Coconut shell charcoal 100%; B. Coconut shell charcoal 75% + Water hyacinth charcoal 25%; C. Coconut shell charcoal 50% + Water hyacinth charcoal 50%; D. Coconut shell charcoal 25% + Water hyacinth charcoal 75%; E. Water hyacinth charcoal 100%.

The graph in Figure 7 above shows the smallest bound carbon content in treatment D of 28.8927% and the highest in treatment E of 40.4848%. The addition of water hyacinth shell charcoal causes the bound carbon content to tend to decrease. The presence of bound carbon in the charcoal is affected by the values of ash content and volatile matter content.

The level will be of high value if the ash content and volatile matter content of the charcoal briquettes are low.

Bonded carbon affects the heating value of charcoal briquettes. The calorific value of charcoal briquettes will be high if the bonded carbon value is high. The higher the carbon content bound to wood charcoal, it means that the charcoal is good charcoal (Abidin, 1973) in (Masturin, 2002). All the average values of bound carbon content of biobriquettes as a result of the research did not meet the SNI standard which required ≥ 77%.

The calorific value is the transfer of heat energy from higher to lower. Data from the test results - the average calorific value of water hyacinth biobriquettes and palm fruit shells can be seen in the following Figure 8.

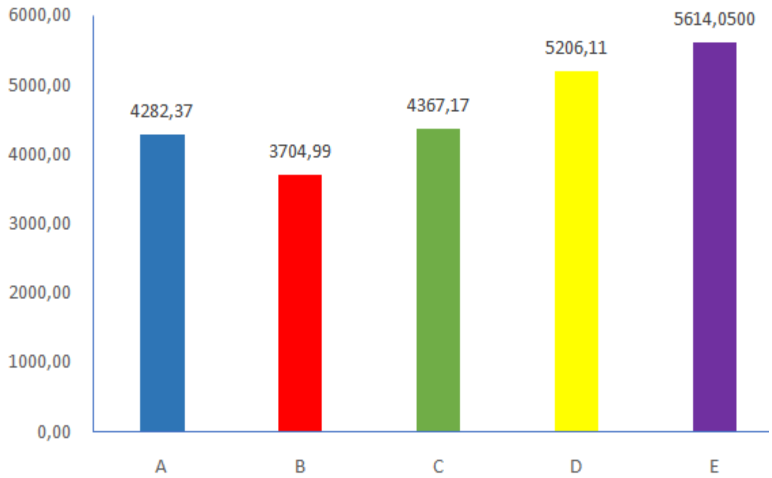

Figure 8 – Calorific Value of Coconut Shell and Water Hyacinth Biobriquettes: A. Coconut shell charcoal 100%; B. Coconut shell charcoal 75% + Water hyacinth charcoal 25%; C. Coconut shell charcoal 50% + Water hyacinth charcoal 50%; D. Coconut shell charcoal 25% + Water hyacinth charcoal 75%; E. Water hyacinth charcoal 100%.

The graph in figure 8 above shows the lowest calorific value of biobriquettes in treatment B of 3,704.99 cal/g and the highest calorific value in treatment E of 5,614.05 cal/g. The addition of water hyacinth charcoal causes an increase in the calorific value of the biobriquettes mixed with palm fruit shells and water hyacinth. The calorific value of biobriquettes is largely determined by the raw materials used in the carbonization process. Raw materials that have large cellulose and lignin will produce a large calorific value, but if the carbonization process is not carried out optimally it will produce a small calorific value, so the raw materials and the carbonization process are closely related to produce biobriquettes which have a high calorific value.

Sani (2009) states that the high calorific value is thought to be due to the low water content, high volatile matter content and high bonded carbon content. The calorific value of the briquettes greatly influences the quality of the briquettes produced. The higher the calorific value, the better the quality of the briquettes, the calorific value is affected by moisture content, density, ash content, volatile matter content, bound carbon content.

There were 2 (two) treatments that met the SNI standard which required a minimum of 5,000 cal/gr, namely treatment D and E whose calorific value was > 5,000 cal/gr. The calorific value of the research results is higher when compared to the calorific value of reed bioriket (3,528.01 cal/g) and lower than the calorific value of biobriquette from a mixture of sawdust of meranti wood and galam wood charcoal (5,502.40 – 6,424.64 cal/g).

Biobriquettes mixed with palm fruit shells and water hyacinth with a compression pressure of 10 tons have met several quality requirements for SNI charcoal briquettes, but not all treatments have met all the criteria required for the SNI quality. However, this biobriquette can still be used for household and MSME needs because of the calorific value produced. Some of the treatments have approached the SNI quality standards and treatments D and E have met the calorific value standards required by SNI. This biobriquette can still be used as an energy source in relation to reducing water hyacinth which increasingly fills wetland waters and reducing waste of palm fruit shells. Improving the characteristics of biobriquettes can be carried out in further research in the future by combining treatments with wood waste raw materials which have a higher specific gravity.

CONCLUSION

The characteristics of bioricket from a mixture of palm fruit shells and water hyacinth have physical properties, namely water content ranging from 3.3952-8.8377% with a density of 0.6488-1.0363g//cm³, chemical properties namely ash content 1.4440-14.4133% , volatile matter 34.9767- 47.6800% and calorific value 4282.37-5614.05 cal/g.

The biobriquette mixture of palm fruit shells and water hyacinth with a pressure of 10 tons has met some of the criteria for the Indonesian National Standard.

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