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Research Article

Analysis of Biocharcoal Briquette Characteristics with the Addition of Trembesi (*Samanea saman*) Dry Leaf Bioadditives

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Abstract

Biocharcoal briquettes are new and renewable biomass energy products. The addition of rain tree leaf bioadaptive to biocharcoal briquettes can increase high carbon compounds. By adding these materials, it can increase the calorific value and produce better energy. The main ingredients in this study were coconut shells, corn cobs, tapioca flour, and betel leaf bioadditives. The research characteristic test was conducted to determine the levels of bound carbon, ash content, volatile matter content, calorific value, and water content. The results showed that the best composition was BBB 4 with a volatile matter content of 0.921%, water content of 2.0%, ash content of 7.9%, calorific value of 5943 cal/g, and bound carbon of 89.179%.

Keywords: *Biocharcoal briquettes, bio charcoal, bioadditive, trembesi leaves.*

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INTRODUCTION

Indonesia is an agricultural country that has abundant energy resources that can be utilized, both renewable and non-renewable energy. Energy is an important factor and strategy in the development process, so that new renewable energy continues to be improved [1],[2]. The development of new and renewable energy (EBT) is increasingly being increased by the government, this is evidenced by the issuance of Government Regulation Number 79 of 2014 and Presidential Regulation Number 22 of 2017 and has been realized by 11.31% in 2020 [3]. Indonesia has an abundant agricultural sector that can be utilized. Indonesia has an agricultural sector. In 2020, the agricultural and plantation sector is estimated at 146.7 million tons per year in 2020 [4]. The abundant agricultural and plantation sectors produce unused waste such as rice husks, corn cobs, coconut shells, wood chips, dry leaves, and other organic wastes [16]. Abundant agricultural waste can be managed into biomass energy, the products of biomass energy are bio gas (gas), bio fuel (liquid), and char (solid) [5],[6].

Biomass energy is the designation of compounds in organic matter that can be utilized into energy [7]. One of the biomass energy products in the form of charcoal is a dense porous material containing 85-95% carbon compounds (C) which can be used as fuel because it produces heat energy [8]. Conventional char products have the disadvantages of being difficult to ignite and producing a lot of ash, which can cause health problems [9],[10]. Biochar briquettes are the result of further processing of conventional charcoal which has the same superior dimensional value, high calorific value (heat energy), low ash content, and material that is resistant to long-term ignition compared to conventional charcoal [11]. Biocharcoal briquettes utilize lignocellulose or cellulose, hemicellulose, and lignin compounds in organic materials. According to research, 25-30% hemicellulose, coconut shells contain 25-30% cellulose, and 30-40% lignin, while corn cobs contain 38.1% cellulose, 35.9% hemicellulose, and 16.7% lignin [12]. The proximate content of coconut shells is 11.5% water content, 1.02% ash content, 83.01% volatile matter content, and 20.40 kJ/kg calorific value [12]. The proximate content of corn cobs is 7% water content, 1.6% ash content, 84.3% volatile matter content, and 18.00 kJ/kg calorific value [13].

The results of the characteristics of biochar briquettes are greatly influenced by the presence of raw materials for making briquettes. Calorific value, water content, and ash content are the characteristics of biochar briquettes which are determining factors for the quality of biochar briquettes. By adding saponin to dry leaf bioadditives, it can bind water better. Bioadditives are additional materials that affect one or more characteristic factors of biochar briquettes. Rain tree leaf bioadditives have a high saponin content of 3.98% [14], [15]. Saponin is one of the compounds that can be used as a bioadditive in biochar briquettes, because it can bind water or a saponification reaction occurs (soap formation) [16]. The addition of bioadditives can increase or decrease the characteristics of biochar briquettes, so that very good quality biochar briquettes are obtained so that they can be met according to national standards (SNI) [22]. From the results of this study, the results can be improved according to national standards (SNI). This study showed that saponin in dry leaf bioadditives binds water better.

METHODS AND ANALYSIS

Materials

The main materials used in this study were coconut shells, corn cobs, tapioca flour, and trembesi leaf bioadditives. The method used in this study was the experimental method. The experimental method is a method of finding several causes and effects between several related factors. In this experimental study, researchers varied the mixture of dry trembesi leaf bioadditives with coconut shell and corn cob biochar, to obtain the best briquette characteristics.

Briquette Making

The manufacture of biocharcoal briquettes is divided into three stages, namely: preparation stage (making biocharcoal and bioadditives), production stage (making briquettes), and experimental stage (characteristic test). Coconut shell and corn cob materials were carbonized for 4 hours at a temperature of 400 ^oC. Biochar and dry leaf

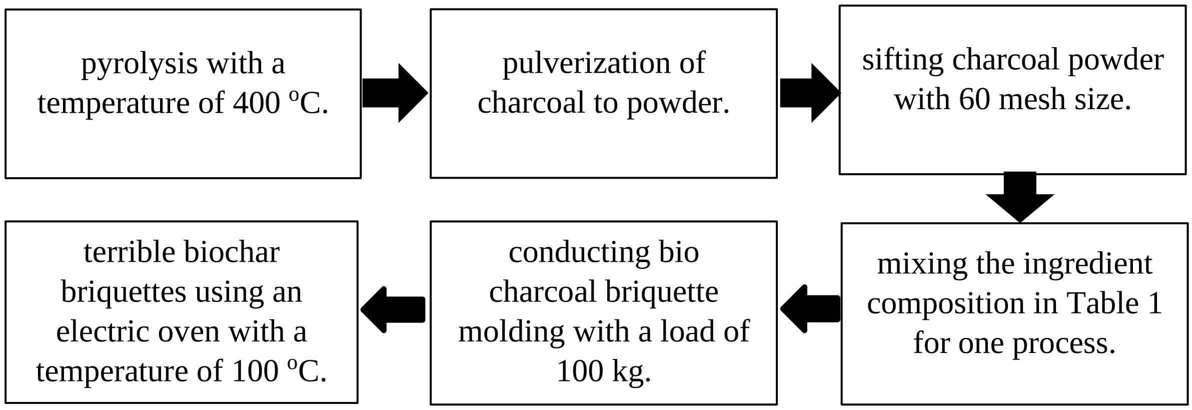

Figure 1. Process scheme for making biocharcoal briquettes.

Table 1. Composition of biochar briquette material

Sampel	Briquette Mix Composition (%)			Tapioca flour (%)
	Coconut Shell	Corn Cob	Rain Tree Leaves	
BB	70	30	0	10
BBA 1	70	30	20	10
BBA 2	70	30	25	10
BBA 3	70	30	30	10

bioadditives are ground and sieved using a sieve with a particle size of 60 mesh. Molded using hollow iron with a side size of 2.5 cm with a compressive strength of 100 kg. Test samples BBB 1 (0 % bioadditive), BBB 2 (20 % bioadditive), BBB 3 (25 % bioadditive), BBB 4 (30 % bioadditive) composition of the mixture of these ingredients Table 1.

Biocharcoal briquettes that have been printed and dried using an electric oven at 100 °C for 6 hours, then the briquettes are ready to be tested for characteristics [23]. Testing the characteristics of biochar briquettes consists of moisture content, ash content, volatile substance content, calorific value, and bound carbon content. In the figure, the scheme of the briquette making process is as follows: Making charcoal by pyrolysis method at 400°C. Crushing charcoal into fine charcoal powder. Filtering charcoal powder with a 60 mesh sieve size. Mixing the ingredients (coconut shell, corn cob, tapioca flour, trembesi leaves) as in Table 1. 5. Molding the briquettes into cubes with a compressive strength of 100kg. Finally, drying the briquettes in an electric oven at 100°C.

Briquette Quality Testing

Data on quality testing of bioarang briquettes with the addition of dry leaf bioadditives have characteristics including, ash content, volatile substance content, water content, calorific value and bound carbon content in accordance with SNI 01-6235-2000 standards [22].

Moisture Content

Moisture content is the water content of solid fuel (briquettes). High moisture content in briquettes can make it difficult to ignite and can affect combustion temperature. Moisture content in briquettes has two contents, namely free water in the form of particles that do not fill the pore cavity in the fuel, while the other bound water content is the water content that is bound and fills the pore space in the fuel structure. Water content to determine the water contained in biocharcoal briquettes [17],[18]. The procedure for testing water content is as follows. Weighing a 1 g sample of biocharcoal briquettes in a porcelain cup of known weight. Putting the sample into the oven with a temperature of (115 °C ± 5 °C) for 3 hours. Cooling the sample in a desiccator. Lastly, finding out the final weight of the measurement by weighing the sample. Moisture content was calculated using the equation (1):

$$Moisture\ Content\ (\%) = \frac{A-B}{B} \times 100\% \quad [1]$$

A is material before drying (gram) and B is Material after drying (gram).

Ash Content

Ash content is the combustion residue of a charcoal. Ash content is a mineral that cannot burn completely, namely clay, silicate, calcium, and magnesium, high ash content will reduce the quality of a briquette [25]. Ash content aims to determine the residual combustion of biochar briquettes or does not have carbon compounds (C) to produce energy [17],[19]. The procedure for testing ash content is as follows. Weigh the empty cup to determine its mass. Weigh the empty cup and sample as much as 1 gram. Putting the cup and the sample into the furnace, raising the temperature to 450-500 °C for 1 hour, and continuing the temperature of 700-750 °C for 2 hours, and finally ashing with a temperature of 900-950 °C for 2 hours. Finally, weighing the cup and ash to determine the final weight. Ash content was calculated using the equation (2):

$$Ash\ Content\ (\%) = \frac{B-A}{C} \times 100\% \quad [2]$$

A is weight of empty cup (gram), B is weight of empty cup and ash content (gram), and C is initial weight of sample (gram).

Volatile Matter Content

Vaporized substance content (KZM) is a process of evaporating materials without oxygen at a temperature of 950 ± 2 °C. Determination of evaporated substance content is done by putting the material that has been calculated water content, then heated at a temperature of 950 ± 2 °C to determine the remaining weight. The difference in weight is calculated as the substance that evaporates. The heating time is approximately 7 minutes [21]. Volatile Substance Content aims to determine the content of flammable compounds in biochar briquettes [24][25]. The testing procedure for volatile substance content is as follows: Weighing a 2-gram sample into a porcelain or platinum cup. Heating the sample to a temperature of 950 °C for 7 minutes. Cooling the sample in a desiccator. Lastly, weighing the sample to determine the weight that has been lost. Volatile substance content is calculated using the formula (3):

$$Volatille\ matter\ (\%) = \frac{W_1-W_2}{W_1} \times 100\ \% \quad [3]$$

W_1 is material that has been dried (gram), W_2 is material that has been heated to 950 °C, and KZM is volatile substance content (%)

Calorific Value

Calorific value is one of the properties to determine the quality of biocrush briquette products. According to SNI 01-6235-2000 calorific value is very important to determine the quality of briquettes. The higher the calorific value of a briquette, the better the quality produced. Calculation of calorific value of briquettes using a bomb calorimeter in the laboratory. Calorific value is the effort of a material to increase 1 temperature at a weight per unit gram [6],[10],[15],[27].

The calorific value testing procedure is as follows: turn on the power heater and pump button. Set the temperature to be used (15 - 20 ℃). Install the bomb head, gas hose and flush tank. Then press START PRETEST, and press START. Flow oxygen into the calorimeter bomb at a pressure of 30 bar. Prepare and weigh ingredients weighing 0.8 - 1.2 grams (accuracy 0.0001 gram). Install the air bomb on the calorimeter then add 1250 ml of cooling water. Close the calorimeter cover, then turn on the water stirrer and observe the temperature changes. Finally, turn off the bomb calorimeter when finished. The calorific value and energi equivalen (gross calori value) are calculated using the formula (4-5):

$$CV_{db} = \frac{CV_{adb}}{\frac{(1-RM)}{100}} \quad [4]$$

$$\frac{(Ee \times \Delta T) - e1 - e2 - e3}{A} \quad [5]$$

CVdb is Calorific Value on dry basis (cal/gram), CVadb is Calorific Value in air dried basis (cal/gram), RM is Residual Moisture (water content) (%), Ee is Equivalent Energy (cal/°C), ΔT is Initial and final temperature difference (°C), e1 is Acid Correction (cal), e2 is Fuse Correction (cal), and e3 is Sulfur Correction (cal).

Fixed Carbon

Bound carbon content (FC) is the amount of carbon compounds (C) in briquettes, in addition to the fraction of ash content and volatile substance content [25]. The testing procedure is as follows: after testing the water content, ash content and volatile substance content. Calculate the formula for the bound carbon. Bound carbon content is calculated using the formula (6):

$$FC\ (\%) = 100\% - (KZM \mp KAB + KA)\% \quad [6]$$

KZM is volatile matter content (%), KAB is ash content (%), KA is moisture content (%), and FC is bound carbon content (%).

RESULTS AND DISCUSSIONS

Test Results of Biocharcoal Briquette Characteristics.

Testing the characteristics of biocharcoal briquettes by varying four types of samples consisting of BBB 1 (0% additive), BBB 2 (20% additive), BBB 3 (25%) and BBB 4 (30%). Testing the characteristics of biochar briquettes consisting of water content, ash content, volatile content, calorific value, and bound carbon can be seen in Table 2. From the results of Table 2, the characteristics of biocharcoal briquettes can affect the quality of biocharcoal briquettes and can also be influenced by the raw materials used. Characteristic testing is expected to have a calorific value according to the SNI 01-6235-2000 standard [22]. The calorific value is very important to determine the quality of the briquettes. The higher the calorific value of a briquette, the better the quality produced.

Moisture Content

The water content test aims to determine the water content contained in biochar briquettes BBB 1, BBB 2, BBB 3, and BBB 4. High water content can affect the calorific value and combustion rate. High water content can affect the calorific value, this is because the water content trapped in the briquette will require more energy to evaporate it, and to burn it [2],[28]. The results of the water content test are shown in Figure 2.

Based on Figure 2, it can be seen that the water content decreased with the addition of bioadditives. The results of testing the characteristics of water content with samples BBB 1, BBB 2, BBB 3, and BBB 4 were 3.9%, 3.7%, 3.1%, and 2.0%, respectively. These results have met the SNI 01-6235-2000 standard with a maximum figure of 8%. The high-

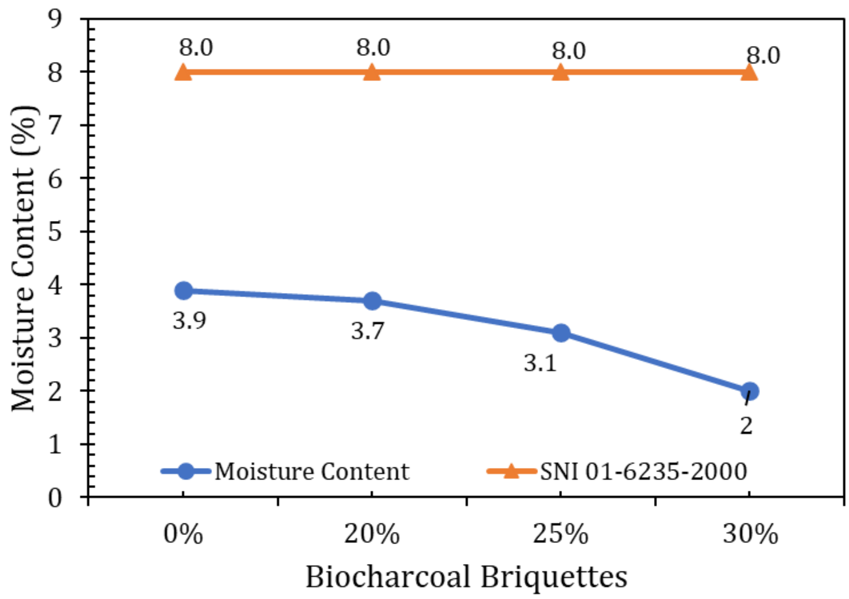

Figure 2. Graph of Moisture Content Vs Biocharcoal briquettes

Table 2. Characteristics of biocharcoal briquettes.

Characteristic test	**Sample**				**SNI 01-6235-2000**
	BBB 1	**BBB 2**	**BBB 3**	**BBB 4**	
Moisture Content (%)	3,9	3,7	3,1	2,0	<8
Ash Content (%)	12,1	9,7	8,7	7,9	<8
Volatile Matter Content (%)	0,879	0,902	0,913	0,921	<15
Calorific Value (cal/g)	5417,32	5706,65	5730,51	5943,00	>5000
Fixed Carbon (%)	83,120	85,598	87,287	89,179	>77

est water content result in the BBB 1 composition was 3.9% and the lowest water content result in the BBB 4 composition was 2.0%.

The low water content results are due to the saponin content in the trembesi leaf bioadditive, resulting in the saponification process (binding water). Factors that affect moisture content include small (fine) particles, density, and adhesive composition. Small (fine) particles are related to the density value of a biochar briquette, so that the pores are tighter and the ability to absorb less water [29]. Adhesive composition affects the water content, because the adhesive (tapioca starch) contains hydroxyl groups that can bind and retain water [30].

Ash Content

The ash content test aims to determine the unburned combustion residue (ash) contained in biochar briquettes BBB 1, BBB 2, BBB 3, and BBB 4. High ash content can affect the calorific value results. Ash can reduce the calorific value, ash is composed of compounds that are difficult to burn such as silica, calcium, magnesium oxide [27]. The results of the ash content test are shown in Figure 3. From Figure 3 it is shown that the ash content decreased with the addition of bioadditives. The results of the ash content characteristic test with samples BBB 1, BBB 2, BBB 3, and BBB 4 were 12.1 %, 9.8 %, 8.7 %, and 7.9 %, respectively. These results meet the SNI 01-6235-2000 standard with a maximum content of 8 %. The highest ash content in the BBB 1 composition was 12.1 % and the lowest water content in the BBB 4 composition was 7.9 %.

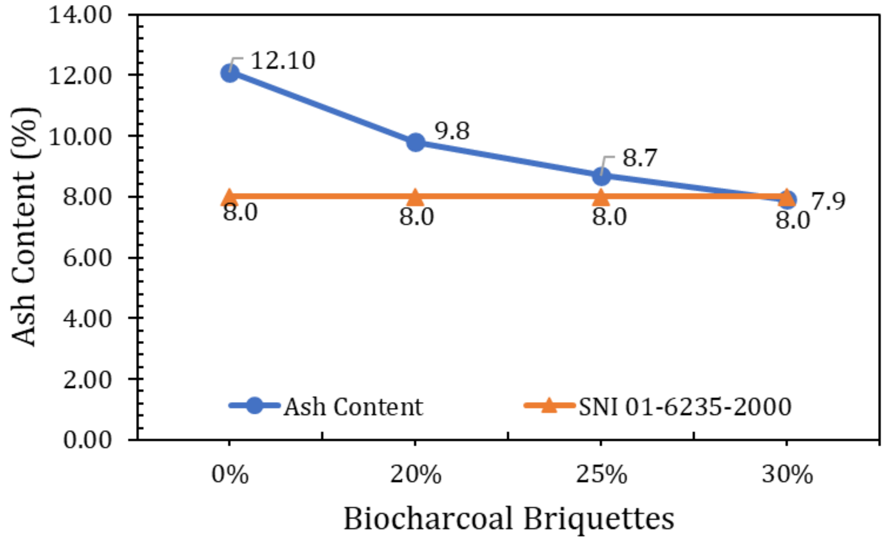

Figure 3. Graph of Ash Contenent Vs Biocharcoal briquettes.

The results of high and low ash content tests are influenced by the presence of raw materials for making briquettes [28]. High ash content can affect the quality of biochar briquettes, this is because the ash content blocks the entry of oxygen, thus affecting the combustion rate. High ash content is also influenced by compounds that are difficult to burn such as silica, magnesium oxide, SiO2, Al2O3, Fe2O3, CaO, and alkali.

Volatile Matter

The volatile substance content test aims to determine the content of volatile compounds other than water such as hydrogen (H), methane (CH4), carbon monoxide (CO) contained in biocharcoal briquettes BBB 1, BBB 2, BBB 3, and BBB 4. Volatile substance levels determine one of the quality parameters of biocharcoal briquettes. The presence of high volatile levels can make it easier to ignite biocharcoal briquettes [6],[30]. The test results of volatile substance content are presented in the Figure 4. Based on Figure 4, the volatile substance content increases along with the addition of bioadditives. The characteristic test results of volatile substance content with samples BBB 1, BBB 2, BBB 3, and BBB4, respectively, were 0.8795 %, 0.902 %, 0.913 %, and 0.921 %. These results meet the SNI 01-6235-2000 standard with a maximum of 15 %. The highest volatile substance content result in BBB 4 composition is 0.921%, and the lowest volatile substance content result in BBB 1 composition is 0.8795 %.

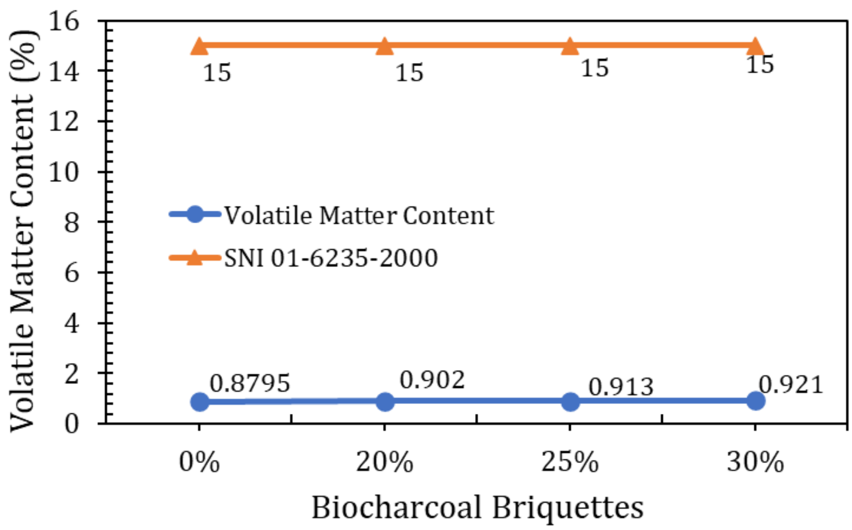

Figure 4. Graph of Volatile Material Content and Biocharcoal Briquettes.

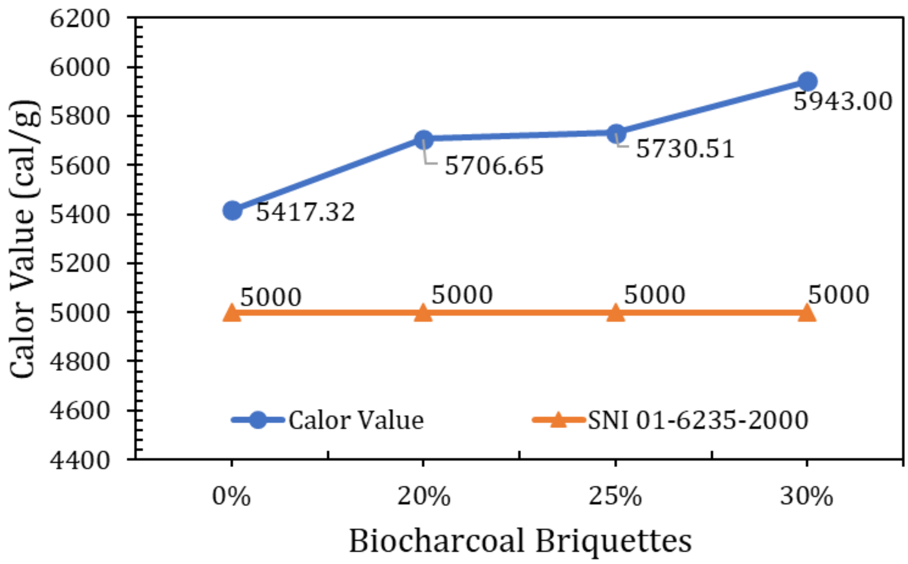

Figure 5. Graph of calor value Vs Biocharcoal briquettes.

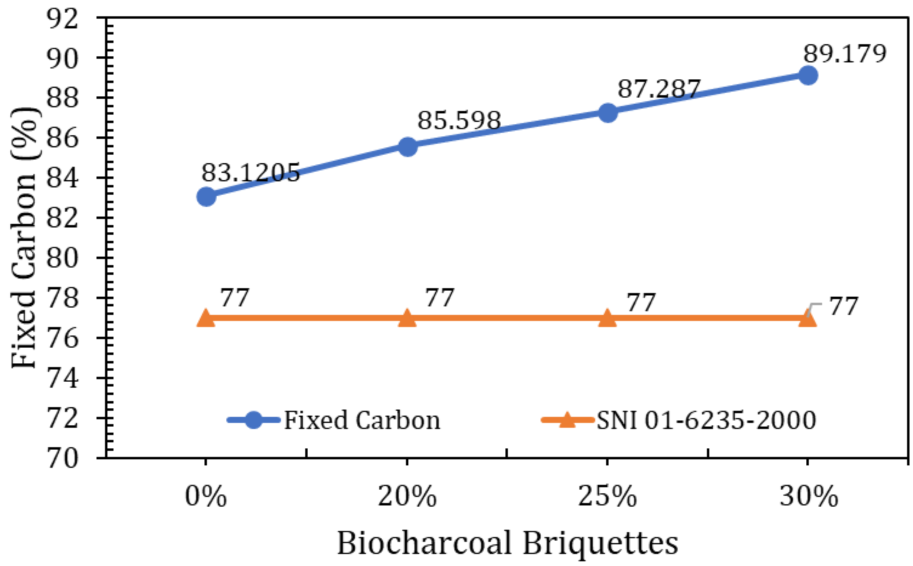

Figure 6. Graph of Fixed Carbon Vs Biocharcoal briquettes.

The high and low levels of volatile substances are influenced by lignin, cellulose and hemicellulose compounds which are easily broken down into steam and water. The material must contain lignin, cellulose and hemicellulose compounds to produce good quality [20][33].

Calorific Value

The calorific value test aims to determine how much heat energy is produced in the test of BBB 1, BBB 2, BBB 3, and BBB 4 biochar briquettes in each unit mass of material in combustion. The calorific value determines one of the quality parameters of biochar briquettes [6],[32]. High calorific value gives a high temperature, while low calorific value gives the opposite temperature [10],[31]. The results of the calorific value test are shown in the Figure 5.

Based on Figure 5, it can be seen that the calorific value increases with the addition of bioadditives. The results of the calorific value characteristic test with samples BBB 1, BBB 2, BBB 3, and BBB 4 were 5417.32 cal/g, 5706.65 cal/g, 5730.51 cal/g, and 5943 cal/g, respectively. These results have met the SNI 01-6235-2000 standard with a minimum amount of 5000 cal/g. The highest calorific value in the BBB 4 composition was 5943 cal/g and the lowest calorific value in the BBB 1 composition was 5417.32.

The results of high calorific value can produce high heat energy, high heat energy can cause combustion to be almost perfect [10],[32]. The calorific value indicates the heat energy produced per 1 gram of biochar briquette mass. Factors that can affect the high and low calorific value are the results of water content, ash content, volatile content, and biochar briquette particle size. The small particle size affects the density value of biochar briquettes, because it shows that biochar briquettes are dense and filled with biochar particles [35][36].

Fixed Carbon

The test of bound carbon content aims to determine the content of carbon compounds (C) contained in biochar briquettes BBB 1, BBB 2, BBB 3, and BBB 4. Bound carbon content determines one of the quality parameters of biochar briquettes. The bound carbon content is directly proportional to the calorific value of the biocharcoal briquettes, the higher the bound carbon content, the higher the calorific value of the biocharcoal briquettes produced [29]. The test results of bound carbon content are presented in the Figure 6.

Based on Figure 6, the bound carbon content increases along with the addition of bioadditives. The characteristic test results of bound carbon content with samples BBB 1, BBB 2, BBB 3, and BBB4, respectively, were 83.1205 %, 85.598 %, 87.287 %, and 89.179 %. These results meet the SNI 01-6235-2000 standard with a minimum of 77 %. The highest volatile substance content result in BBB 4 composition is 89.179 %, and the lowest volatile substance content result in BBB 1 composition is 83.1205 %.

The results of the bound carbon content are directly proportional to the resulting calorific value. The high levels of bound carbon indicate that the heat energy produced by the biochar briquettes is high, so the calorific value is also high [15],[34]. Factors that affect high bound carbon levels include moisture content, ash content, and volatile substance content of the results are relatively small [10],[35].

CONCLUSIONS

The results of research on biocharcoal briquettes with bioadditives of dried trembesi leaves can be concluded as follows:

1. The addition of Bioadaptive rain tree leaves to biochar briquettes can increase high carbon compounds. By adding these materials, it can increase the calorific value and produce better energy.
2. The addition of saponin will reduce the water and ash content and accelerate the carbonization process of biochar briquettes which have higher carbon (C) compounds so that they can increase the calorific value and produce better energy.

Suggestions and Input

The limitations and decreasing number of energy sources, especially fossil energy in Indonesia, are the main factors as reasons for seeking New Renewable Energy (EBT) sources. Energy derived from biomass has great potential in Indonesia and has not been utilized optimally. Thus, research on biomass needs to be increased.

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DECLARATION OF CONFLICTING INTERESTS

The authors declare that they have no potential conflicts of interest regarding the research, authorship, and/or publication of this article.

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