Analysis of biomass briquettes based on carbonized rice husk and jatropha seed waste by using newspaper waste pulp as an adhesive material

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Abstract. Biomass waste that has not been utilized properly is rice husk and jatropha seed waste, and there is a future need for efficient utilization of these wastes. Rice husk is the outermost part of the rice seed, the rice milling process produced 20% - 30% of the waste as rice husks. Jatropha shell waste is a de-oiled part of jatropha seed after the oil extraction process for biodiesel production, and produced 70% of waste. As biomass, both materials are potential sources of carbon that can be utilized as an alternative energy sources such as bio-briquettes. The method used in this research is experimental method including drying of the biomass material sample, carbonization process, refine and filtration using 40 mesh sieve (420 μm). The composition of the selected charcoal mixture is 80:20 and 50:50, and the addition of the newspaper waste pulp as an adhesive material with variations of 8% and 12% by weight. Characterization is done by using the mass density test, proximate test and calorific value test. After going through pressure printing and drying process, the briquettes with 8% addition of newspaper waste pulp adhesives has the highest heat energy content, equal to 5,650 cal/g.

1. Introduction
Scarce resources of fossil fuels increases need to be anticipated by finding alternative energy sources. Alternative energy sources that are widely developed and researched today are agricultural waste biomass fuel [1]. According to Data Energy Outlook Indonesia, biomass has a reserve of 434,000 GW or equivalent to 225 million barrels of petroleum. Biomass potential is very large if used as an alternative energy source as a substitute for fuel oil, especially for household energy needs [2].

Biomass derived from agriculture and forestry wastes are a useless material and is usually discarded to disrupt the environment. Biomass waste can be utilized as an alternative fuel source, by converting it into a charcoal that has a higher calorific value than biomass through pyrolysis [3]. In order to utilize it as fuel, the waste can be processed into solid fuel in the form of briquettes. Each material has certain properties to be used as a briquette, but the most important is that the material must have high thermal properties [4].

The biomass waste used in this research is rice husk (Oria sativa) and jatropha seeds (Jatropha curcas), the reason for choosing rice husk as the main ingredient because of its very abundant amount and not yet optimal in its utilization. Jatropha seed pulp is a waste product from biodiesel and castor oil production. In general, jatropha seed only produces 30% of oil, while the remaining 70% is to be a jatropha seed pulp released out as a waste. Jatropha seed pulp has an optimal calorific value of 6,343.49 cal/g [5].
Making briquettes generally require the addition of an adhesive to enhance the physical properties of briquettes. In general, the addition of an appropriate amount of adhesive agent to the manufacture of briquettes will increase the calorific value of the briquette [6]. In this research, the type of adhesive used is newspaper waste pulp. Newsprints are made of pure wood fibers, cellulose, adhesives and other chemical elements. Based on research conducted by Patabang [2], with an adhesive variation of 7%, 10% and 15%, indicating that the percentage of adhesives affects to water content, ash content, volatile content, carbon content and calorific value of charcoal briquettes. In this research, variety of adhesive used is 8% and 12% of the total weight of charcoal material. Briquettes resulting from the pyrolysis process, which is a thermal process with a little oxygen or no oxygen at all. To meet the quality standards, the resulting briquettes must remain comparable with the SNI 01-6235-2000 standard [7].

The hypothesis of this study is that alternative fuel, such as charcoal briquettes can be made from biomass wastes, by using the appropriate type and percentage of adhesive will produce better quality charcoal briquettes. Variations of adhesive type and adhesive percentage will produce briquettes that have different characteristics, moisture content, volatile content, ash content, carbon content and the caloric value.

2. Methods
The method used in this research is the experimental method implemented in the laboratory. The procedure was performed according to Marino, Sudden & Rahmwati [4], by modifying the type of sample and adding a various adhesive percentage to determine the effect of adhesive percentage of the thermal properties of the briquettes.

2.1. Materials selection and tools
The materials used in this research are rice husk, jatropha seed, newspaper waste as an added adhesive agent and water used as a solvent. The tools used include an analytical balance, stove, furnace, oven, 60 mesh sieve, crusher, clamp, desiccator, carbonization drum, briquette molding pressure tool and bomb calorimeter.

2.2. Briquettes making procedures
Procedures include material preparation, carbonation, crushing and sieving of 40 mesh sizes and adding adhesives mixing process. The mixture charcoal composition of rice husk and jatropha seed waste is 80:20 and 50:50 and adhesive variation used is 8% and 12% by total mass. Adhesive newspaper waste pulp is made by cutting the newspaper into small pieces first and soaked overnight in water, then the water is removed and mashed to be pulped.

As shown in figure 1, the briquetting process uses a cylindrical mold of 2 cm in diameter (figure 1a, 1b, 1c). After that, the mold, then pressed with a pressing device using a pressure of 3 tons (figure 1d) for all types of briquettes. The briquette is released from the mold, then dried under sunlight for 8 hours, and then followed by drying in the oven at 50 °C during 300 minutes.

![Figure 1. Briquette making process: briquette mold (a), weighing the dough (b), insert the dough into briquette mold (c), pressing the briquette using compression device (d).]
2.3. **Determine the characteristics of briquettes**

Analysis of briquette quality includes the density, the proximate test (moisture content using ASTM D3173, volatile content using ISO 562:2010(E), ash content with ASTM D3174-11 and ISO 1171:2010 (E), fixed carbon using ASTM D 3172), and heat value testing in accordance with ASTM D5865-13.

3. **Results and Discussion**

3.1. **The making of briquettes**

Sample preparation by carbonization method is to obtain the charcoal which is composed of carbon as the main product of a closed chamber burning with a very little oxygen. The material that has been carried out by carbonization process, is rice husk and jatropha seed waste, as shown in figure 2.

![Figure 2. The result of carboniation process: rice husk (a) and jatropha seed waste (b)](image)

The carbonization process of rice husk is carried out in the carbonization drum using an average temperature of 131°C for 130 minutes, and the carbonization process of jatropha seed using an average temperature of 150°C for 120 minutes. The carbonization temperature is done by time interval every 10 minutes.

In the process of making briquettes, briquette dough with variations of rice husk mixture (RH): jatropha seeds (JS) 80:20 and 50:50 are divided into several samples each with ±10 g masses. The resulting charcoal briquettes have a cylindrical shape with a height of about 4 cm and a diameter of about 2 cm. The briquettes are quite hard, using a paper pulp adhesive with variations of 8% and 12% percentage. The resulting briquettes have 8/9 briquette variations. As seen in table 1 and figure 3. In briquette printing process required pressure of 3 tons and resulted in mass reduction. This is due to the addition of an adhesive material derived from newsprint materials in which the composition of the newspaper contained 80-85% mechanical pulp and 15-20% chemical pulp (sulfite) and has a tensile strength of newsprint to maintain elasticity when printed. With the addition of 12% adhesive material there is a significant mass shrinkage.

| Sample | Charcoal Composition | Adhesive (%) | Number of Samples | Mass before Compression (gr) | Mass after Compression (gr) |
|--------|----------------------|--------------|-------------------|------------------------------|-----------------------------|
| A1     | RH:JS 80:20          | 8%           | 8                 | ±10                          | 9                           |
| B1     | RH:JS 50:50          | 8%           | 8                 | 9                            |
| A2     | RH:JS 80:20          | 12%          | 9                 | 8                            |
| B2     | RH:JS 50:50          | 12%          | 9                 | 8                            |
3.2. Mass density test of briquettes
Physically the resulting briquette is quite good in terms of shape. Preliminary test is done by a mass density test which aims to know the density of briquettes. By calculating the ratio between weight and volume of briquettes, the mass density of briquettes can be seen in table 2.

| Sample | Charcoal Composition | Density (g/cm³) |
|--------|----------------------|----------------|
| A1     | Rice husk:Jatropha Seed 80:20 | 0.8725 |
| B1     | Rice husk:Jatropha Seed 50:50 | 1.1582 |
| A2     | Rice husk:Jatropha Seed 80:20 | 0.8802 |
| B2     | Rice husk:Jatropha Seed 50:50 | 0.9366 |
| Average: | | 0.9618 |

There are several factors that influence the density value that is the pressure given during briquette printing. In this study the pressure used in print briquettes of 5,000 Psi or 34 MPa, resulting in an average briquette density of 0.9618 g/cm³. This value is higher when compared to the density of commercial charcoal briquettes (0.44 g/cm³) and the equivalent of wood briquettes (0.88-1.04 g/cm³) [8].

3.3. The characteristic of briquettes
To know the quality of briquettes produced it is necessary to do proximate test which includes moisture content, volatile matter content, ash content, and fixed carbon content. The result of the mixed briquette proximate test can be seen in table 3.

| Sample | Composition | Add Adhesive (%) | Moisture Content (%) | Ash Content (%) | Volatile Matter (%) | Fixed Carbon (%) |
|--------|-------------|------------------|----------------------|----------------|---------------------|------------------|
| A1     | Rice husk:Jatropha Seed 80:20 | 8% | 4.34 | 32.14 | 26.26 | 37.26 |
| B1     | Rice husk:Jatropha Seed 50:50 | | 3.85 | 23.78 | 43.87 | 28.50 |
| A2     | Rice husk:Jatropha Seed 80:20 | 12% | 4.41 | 32.53 | 25.23 | 37.83 |
| B2     | Rice husk:Jatropha Seed 50:50 | | 3.76 | 24.43 | 42.65 | 29.16 |
The water content of the briquettes is expected to be as low as possible so that the calorific value is high and easily ignited. Water content affects the quality of the resulting briquettes. The lower the water content the higher the calorific value and the burning power. Conversely, high water content causes the resulting caloric value to decrease, because the resulting energy is absorbed much to evaporate water. The water content of this briquettes is still below the water content of Indonesian commercial charcoal briquettes.

The main element of ash is silica and its effect is less favorable to the resulting calorific value. The higher the ash content, the lower the quality of the briquettes due to the high ash content can decrease the calorific value of briquettes. Table 3 shows a tendency to increase the ash content as the adhesive concentration increases. When compared with commercial charcoal briquettes, this briquette ash content levels are still higher.

Volatile matter as a result of the decomposition of the compounds in a material. High volatile matter in briquettes gives rise to more smoke when the briquettes are turned on. This is due to the reaction between carbon monoxide and alcohol derivatives \[9\]. The highest concentration of volatile matter was found in B1 sample, the mixture of rice husk and jatropha seed at composition 50:50 with 8% adhesive by 43.87%. The content of volatile matter of this mixed briquettes is quite high when compared to commercial charcoal briquettes. The content of volatile matter at commercial charcoal briquettes amounted to 16.14%, while the volatile content of this briquettes was between 25.23% - 43.87%.

### 3.4. The calorific value of briquettes

Based on the research, the test result of the briquette calorific value of rice husk mixtures with jatropha seed with the composition 50:50 is about 5,602 cal/g to 5,650 cal/g (table 4). By referencing to SNI 01-6235-2000 (Indonesian National Standard), where the required calorific value to meet the good quality of briquette is at least 5,000 cal/g, the resulting briquettes have met the standard. By comparing previous studies, the resulting calorific value is much greater than the calorific value generated by the rice husk briquettes alone, which is only 3,350 cal/g \[10\].

| Sample | Composition     | Add Adhesive (%) | Calorific Value (cal/g) |
|--------|-----------------|------------------|-------------------------|
| A1     | Rice husk:Jatropha Pulp 80:20 | 8%               | 4,820                   |
| B1     | Rice husk:Jatropha Pulp 50:50   |                  | 5,650                   |
| A2     | Rice husk:Jatropha Pulp 80:20   | 12%              | 4,776                   |
| B2     | Rice husk:Jatropha Pulp 50:50   |                  | 5,602                   |

In table 4, the amount of adhesive significantly affects the calorific value, as more adhesives are added, the water content and ash derived from the adhesive will increase the moisture content and ash content in the briquette. The more adhesives added will increase the content of the volatile substances derived from the adhesive material thereby decreasing the calorific value.

### 4. Conclusion

Alternative energy sources of charcoal briquettes can be made from raw materials of rice husk biomass waste mixed with jatropha seed waste as a means of reducing waste pollution. The best mixed charcoal briquettes are rice husk charcoal mixtures with jatropha seed at 50:50 composition and by using 8% of newspaper waste pulp as an adhesive agent, in this case the increasingly of the amount of adhesive percentage will decrease the calorific value. The best characteristics of mixed charcoal briquette (rice husk and jatropha seed waste) using 50:50 composition is: moisture content of 3.85%, volatile matter content of 43.87%, ash content of 23.78%, fixed carbon content of 28.50% and the calorific value is 5,650 cal/g. The addition of jatropha seed charcoal can increase the calorific value of rice husk from 3,350 cal/g to 5,650 cal/g for carbonized briquettes.
5. References

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