HALABAN (VITEX PUBESCENS VAHL) CHARCOAL AND COAL BOTTOM ASH BRIQUETTES WITH PRESSURE VARIATIONS

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Halaban (*Vitex Pubescens vahl*) charcoal and coal bottom ash briquettes with pressure variations

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Abstract. Moisture content, ash content and heating value have been measured on briquettes which were made from a mixture of halaban charcoal and coal bottom ash with variations in pressures and form factor. Factors that influence the characteristics of briquettes were powder fineness and pressure. And so both materials were made in the form of powder on a 250 mesh sieve and pressure variations (150, 200, 250, 300, and 350) kg / cm^2. The composition of the mixture of halaban charcoal and coal bottom ash was with a ratio of 90%: 10%, while 5% of starch adhesive was added. Briquettes were made in the form of solid cylinders and hollow cylinders. From the measurements, the moisture content, ash content and heating value of solid cylinder briquettes were yielded 3.831-5.892%, 7.178-10.507% and 5,607.467-5,732.033 cal/g, respectively. While for hollow cylinder briquettes were 4.564-5.621%, 8.688-11.191% and 5,620.833-5,685.100 cal/g. All briquette samples meet Indonesian national standards requirements for moisture content and heating value, but not all briquette samples meet the requirements for ash content. Higher pressure gave lower water and ash content, but higher heating value. Based on the results, it is recommended that the pressure given in making the briquette was 200 kg/cm^2. This is based on consideration of the highest heating value obtained when the pressure was 200 kg / cm^2.
Keywords: coal bottom ash, halaban charcoal, briquettes, pressure, hollow cylinder

1. Introduction

At present, the dependence on fossil fuels such as oil and gas continues to increase along with the development of technology and human culture. While the source of fossil fuels continues to decrease because of its nature is not easily formed. Therefore the alternative energy sources were needed. Indonesia has a lot of potential in developing alternative energy, one of which is briquettes.

Briquettes are solid fuels that can be formed from mixing organic waste with adhesives and other substances. Briquette production in Indonesia has a good prospect to be developed, because there are enough raw materials in the form of waste such as coconut shells, rice husks, sawdust and others. The advantages of briquettes compared to ordinary charcoal are that briquettes have higher heat, odorless and more durable when stored [1]. Good quality briquettes should have a smooth texture, not easily broken, hard, safe for humans and the environment and have good ignition properties.

The results of Amin study [2], found that all wood can be used as raw material for making biobriquettes. One of the types of wood that can be used as raw material for briquettes is halaban wood. The advantages of hlaban charcoal compared to other charcoal are that the fire from charcoal is flat and perfect and the smoke does not fly [3]. From the selection process of halaban wood charcoal quality produced waste which amounts to around 6 tons per day [4]. The waste has not been utilized optimally.

Besides halaban wood charcoal waste, there is a large amount of coal bottom ash waste. The bottom ash of the coal is obtained from the Steam Power Plant (PLTU) which uses coal as a boiler fuel to produce steam to rotate turbine and produces electricity. From burning coal, about 5% of solid pollutants are produced in the form of ash. Ash waste from the combustion process consisting of fly ash and bottom ash reaches 160 tons per day with the main composition being SiO_2, Al_2O_3, Fe_2O_3, CaO, MgO, alkali, and other ingredients [5].

Sulistiyaningkarti and Utami [6] conducted a research on the manufacture of charcoal briquettes from corn cobs organic waste using variations in types and percentages of adhesives obtained from tapioca flour adhesives. The percentage of 5% adhesives had better quality in terms of moisture content, ash content and heating value compared to the percentage of adhesive of 10% and 15%. The research conducted by Mahdie uses charcoal waste materials from several types of wood by varying the starch adhesives was also obtaining for the best heating value when using 5% adhesive [4].

Fatriani [7] conducted a study of the quality of charcoal briquettes from a mixture of mangrove wood and *api-api* wood at various pressures (125, 150, 175) kg/cm^2. The results obtained were the charcoal briquettes would have good quality if higher pressure is given. Research on the effect of pressure variations and material composition on the physical properties of charcoal briquettes was also conducted by Setiowati and Tirono [8]. The results of the most optimum briquettes obtained by comparing the composition of 100% coconut shell material using a pressure between 100-150 N / cm^2 with a density test value of 0.634 g/cm^3, mechanical strength 43.167 N/cm^2 and burning time of 64.39 minutes. Haryanti, N.H et al. (2018) conducted a study using rubber seed shells and coal bottom ash with pressure variations. The results obtained were the increasing pressure would decreases the moisture content and heating value [9].

Research conducted by Aisha, et al. used bamboo waste for making briquettes [10]. From the research, the highest combustion time was produced with pressure of 500 kg/cm^2 and the lowest at pressure of 100 kg/cm^2. Research on briquettes with coal bottom ash waste, fly ash and halaban wood charcoal has been carried out by Haryanti, et al. [11]. The material was crushed to pass a 250 mesh sieve with a composition of halaban wood charcoal and coal bottom ash mixture 100: 0, 90:10, 80:20 and 70:30 and adhesive 5% of starch. The mixture was pressed at 150 kg/cm^2. The results showed that the moisture content, ash content and heating value of briquettes averaged between 2.9-4.1%; 0.3-25% and 4749-6621 cal/g. The best mixture composition of halaban wood charcoal and coal bottom ash was 90%: 10% in accordance with SNI No. 01-6235-2000 about Briquette Quality Standard., concerning the Quality of Wood Briquettes.

Based on previous research, it is necessary to continue research on variations in pressure on the manufacture of halaban charcoal and coal bottom ash briquettes. The composition of the mixture of halaban charcoal and coal bottom ash with a ratio of 90%: 10% which passes the 250 mesh filter uses adhesive 5% of starch with variations pressure of (150, 200, 250, 300, and 350) kg/cm^2. Halaban wood charcoal samples were taken from Ranggang Village in Takisung District, Tanah Laut Regency, South Kalimantan Province and coal bottom ash was came from Asam-asam power plant (PLTU). This study aims to obtain the characteristics of briquettes made from industrial waste of halaban wood and coal bottom ash, including analysis of moisture content, ash content, heating value with variations in the pressures given.

2. Experimental Methods

The material used is halaban charcoal waste from PT. Citra Prima Utama Banjarbaru with its industrial location at Ranggang Village, Pelaihari, Tanah Laut Regency, Kal-Sel and coal bottom ash waste from PLTU Asam-Asam, Tanah Laut regency, South Kalimantan. The tools used were measuring cups,

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filters, analytical balance sheets, furnaces and bomb calorimeter. This research is quantitative by utilizing waste materials for making briquettes. The study begins with a literature study, sampling in the field, followed by sample preparation in the laboratory followed by sample characterization.

Factors that influence the characteristics of briquettes are charcoal powder, carbonization temperature, powder fineness, and printing pressure. Therefore the material that will be used in making briquettes (halaban wood charcoal and coal bottom ash) was made in the form of fine powder, which passes through the 250 mesh sieve. The pressure variations used were (150, 200, 250, 300 and 350) kg/cm^2. The composition of the mixture of halaban wood charcoal and coal bottom ash with a ratio of 90%: 10%, while adhesive 5% of starch. Briquettes were made in the form of solid cylinders and hollow cylinders. The Briquette Quality Standard used is SNI No. 01-6235-2000, concerning the Quality of Wood Briquettes. SNI standards for the values of moisture content and ash content used in making briquettes are $\leq 8\%$, while the heating value is ≥ 5000 cal / g.

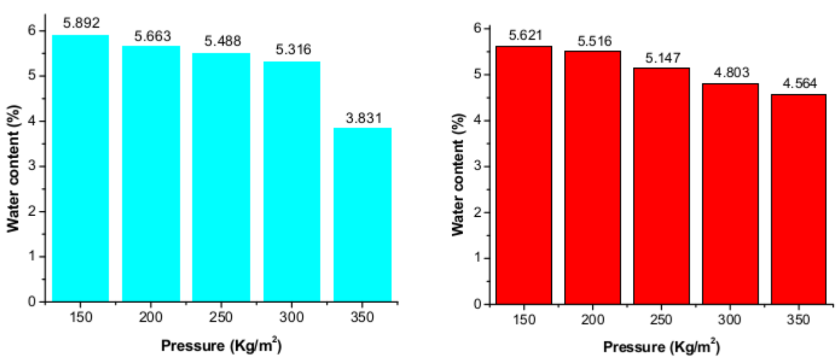
Characterization measurements carried out were analysis of moisture content, ash content and heating value. Analysis of moisture content and ash content was carried out at the Material laboratory FMIPA ULM, while the heating value analysis was carried out at the ESDM Banjarbaru laboratory.

3. Results and Discussion

The results of moisture content, ash content and heating value of briquettes made from a mixture of halaban charcoal and coal bottom wood waste with several variations of pressure are explained in the following review. Briquettes were made in the form of solid cylinders and hollow cylinders.

3.1. Moisture content of Briquette Made from Halaban Wood Charcoal and Coal Bottom Ash

Briquettes have hygroscopic properties, which are easy to absorb water from surroundings. The moisture content of briquettes needs to be known because the high moisture content in the briquette will cause the briquette to be difficult to ignite. The measurement of moisture content of briquettes was using the method in accordance with SNI 06-3730-1995 standards. The results of moisture content of solid cylinder and hollow cylinders with variations in pressures of (150, 200, 250, 300 and 350) kg/cm^2 can be seen in Figure 1.



(a) **(b)**

Figure 1. The moisture content average of **(a)** Solid cylinder briquette and **(b)** Hollow cylinder briquette, with pressure variation.

Moisture content is one of the characteristics of determining the quality of briquettes which affects the heating value of combustion. From the results obtained, the average moisture content of briquettes with a variation of pressure from 150 - 350 kg/cm^2 was in the range 3.831-5.892% for solid cylinder briquettes and 4.564-5.621% for hollow cylinder briquettes. The highest moisture content of solid cylinder briquettes was 5.892% at pressures of 150 kg/cm^2, while the lowest moisture content was 3.831% at pressures of 350 kg/cm^2. While the highest moisture content of hollow cylinder briquettes was 5.621% at pressures of 150 kg/cm^2, while the lowest moisture content was 4.564% at pressures of 350 kg/cm^2. The mean moisture content of hollow cylinder briquettes is smaller than the solid cylinder at pressures of (150, 200, 250, 300) kg/cm^2, except at pressures of 350 kg/cm^2.

From Figure 1, there is a significant relationship between pressure and the moisture content of briquette. From the results of the moisture content, it can be seen that the moisture content decreases with increasing pressure given. High pressure can cause briquettes to become more compact, high density, smooth and uniform, so that the briquette mixture material particles could fill the empty pores and reduce water molecules to enter the pores. Besides that with the presence of starch adhesives, then the halaban wood powder and 250 mesh coal bottom ash which joins the adhesive would be more tightly and united, so the briquettes would have smaller pores.

This corresponds to several studies that have been conducted. Darvina [12] stated that higher pressure would give lower moisture content. The research conducted by Risna [13] with variations in pressure 100, 70, and 30 (kg/cm^2) stated that the addition of pressure was directly proportional to the density value and the percentage of fixed carbon. The standard of moisture content value used is ≤ 8% (SNI No. 01-6235–2000) [17]. From the results of the briquette moisture content, all solid cylindrical and hollow cylindrical samples met SNI requirements.

3.2. Ash Content of Briquette Made from Halaban Wood Charcoal and Coal Bottom Ash

Ash content is a residual combustion process that has no carbon element or heating value. Measurements of ash content used a method in accordance with SNI 06-3730-1995. The results of ash content of briquettes in the form of solid cylinders and hollow cylinders with variations in pressure (150, 200, 250, 300, and 350) kg/cm^2 can be seen in Figure 2.

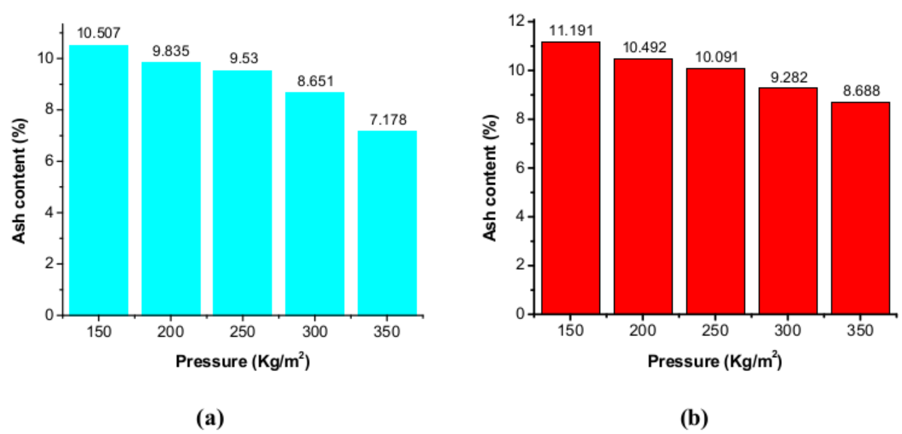


Figure 2. The average of briquette ash content (%) with pressure variation of: **(a)** Solid cylinder briquette; **(b)** Hollow cylinder briquette.

From the results obtained, the average ash content of briquettes in the form of solid cylinders and hollow cylindrical briquettes with variations in pressure of 150 - 350 kg/cm^2 were in the range of 7.178-10.507% and 8.688-11.191%. The highest ash content of the solid cylinder briquette was 10.507% at a pressure of 150 kg/cm^2, while the lowest ash content was 7.178% at pressure of 350 kg/cm^2. At hollow cylinder briquettes, the highest ash content ws 11.191% at pressure of 150 kg/cm^2 and the lowest was 8.688% at pressure of 350 kg/cm^2. The average ash content of the solid cylinder briquettes was smaller than the hollow cylinder briquettes at printing pressures (150, 200, 250, 300 and 350) kg/cm^2.

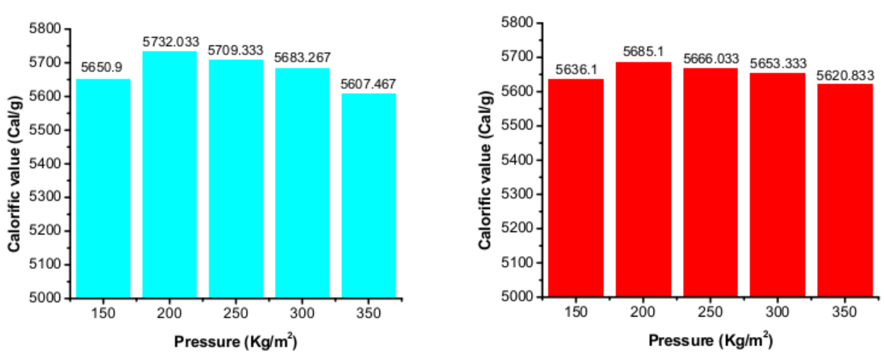
The briquette ash content is much influenced by the chemical composition of the briquette raw material itself. One of the constituent elements is silica. The silica content of coal bottom ash is known to be almost 60%. The higher the level of silica in a briquette constituent would produced more ash from the combustion process. Addition of coal bottom ash to the briquette mixture tends to increase the ash content [14]. The results of the study by Haryanti et al [15] in the preliminary test, the ash content of coal bottom ash was very high, which was 82.071%. Furthermore, the research carried out by Anetiesia et al [16] using coconut shell charcoal and bottom ash mixture, the highest ash content was obtained in briquettes with a mixture of 100% bottom ash with a value of 81.01% and the lowest was briquettes with 100% coconut shell charcoal with a value of 1.20%. High ash levels are at risk of forming mineral deposits during combustion, resulting in decreased quality of combustion and slowing down the combustion process.

From Figure 2, it can be seen that there was a significant relationship between the printing pressures when making the briquettes with ash content. Lower ash content would produce better briquettes. From the results of ash content, it can be seen that higher printing pressure would produce lower ash content. This is in line with Darvina's study [12] which stated that the ash content would decrease if the pressing pressure was increased.

The standard of ash content used in making briquettes is < 8% (SNI No. 01-6235–2000) [17]. From the results of the briquette ash content, not all solid cylinder briquettes and hollow cylinders samples met the SNI requirements. Solid cylinder briquettes at pressure of 350 kg/cm^2 with an ash content of 7.178% met SNI. The results of this study on ash content were still relatively low when compared with previous studies conducted by Slamet and Gunawan [18] which used a mixture of biomass briquettes (coffee shells, kapok shells, coconut shells) and bottom ash. The value of ash contents were ranges from 40.25% -62.12%.

3.3. Heating value of Briquette Made from Halaban Wood Charcoal and Coal Bottom Ash

The main parameter in determining the quality of briquettes is the heating value. Higher heating value means better quality of the briquettes. Heating values in this study were measured by Bomb Calorimetry. The results of heating values for solid cylinder and hollow cylinders shape with variations in pressures of (150, 200, 250, 300, and 350) kg/cm^2 can be seen as followed in Figure 3.



(a) (b)

Figure 3. The average of briquette heating value (%) with pressure variation of **(a)** Solid cylinder briquette; **(b)** Hollow cylinder briquette.

From the results, the average heating value for solid cylinders and hollow cylinders with variations in the printing pressure of 150 - 350 kg/cm^2 was 5,607.467-5,732.033 cal/g and 5,620.833-5,685.1 cal/g. The mean heating value of solid cylinder briquettes was higher than hollow cylinder briquettes at printing pressures (150, 200, 250 and 300) kg/cm^2, except at printing pressures of 350 kg/cm^2. The results of preliminary tests conducted by Haryanti et al [15] obtained the heating value of halaban wood charcoal was 6,833.133 cal/g and coal bottom ash was 389.50 cal/g. The research conducted by Anetiesia et al. [16] using a mixture of coconut shell charcoal and bottom ash obtained the highest heating value on a mixture of 100% coconut shell charcoal and the lowest on briquettes with a mixture of 100% bottom ash with a value of 1,321.33 cal / g .

On solid cylinder briquettes, the highest caloric value was 5,732.033 cal/g at pressure of 200 kg/cm^2, and then the heating value will decrease with the increasing of pressure. So that the lowest heating value was 5,607.467 cal/g at pressure of 350 kg/cm^2. In hollow cylindrical briquettes, the highest heating value was 5,685.100 cal/g at pressure of 200 kg/cm^2 and the lowest was 5,620.833 cal/g at pressure of 350 kg/cm^2. The heating value will decrease in line with the addition of pressure (250, 300 and 350) kg/cm^2. High heating value briquette need less briquettes to produce combustion heat which means the use of briquettes would be more efficient.

From Figure 3, it can be seen that there is a significant relationship between the pressure given when making the briquette and the heating value produced. It seems, the highest pressure given (200 kg/cm^2) produced the highest heating value. And then the heating value would decrease with the addition of the pressure that was carried out (250 - 350 kg/cm^2). According to Darvina [12], higher pressure produced higher heating value.

The standard of heating value used in making briquettes is ≥ 5000 cal/g (SNI No. 01-6235–2000) [17]. If referring to Minister of Energy and Mineral Resources Regulation No. 047 of 2006 [19], the minimum heating value is 3500 cal/g. Thus from the results of the tests carried out, all briquette samples meet the SNI requirements. While for the recommended printing pressure is 200 kg/cm^2, because it produced the highest heating value of briquettes.

4. Conclusions

Moisture content, ash content and heating value of briquettes which were made from a mixture of halaban charcoal and coal bottom ash with variations in pressures of (150, 200, 250, 300, and 350) kg/cm^2 and form factor were already measured. From the measurements, the moisture content, ash content and heating value of solid cylinder briquettes were yielded 3.831-5.892%, 7.178-10.507% and 5,607.467-5,732.033 cal/g, respectively. While for hollow cylinder briquettes were 4.564-5.621%, 8.688-11.191% and 5,620.833-5,685.100 cal/g. All briquette samples meet Indonesian national standards requirements for moisture content and heating value, but not all briquette samples meet the requirements for ash content.

In the variation of pressure, the average moisture content and heating value of the solid cylinder briquettes was higher than the hollow cylinder briquettes, while the average ash content was smaller. Higher pressure produced low moisture content and ash content, and so the caloric value was high. Based on the results of the caloric value test, moisture content, ash content, it is recommended that the pressure given when making briquettes is 200 kg/cm^2. This is based on consideration of the highest heating value obtained when the pressure was 200 kg/cm^2.

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