Physical and Mechanical Analysis of Paddy Leaves Charcoal Briquettes

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Physical and Mechanical Analysis of Paddy Leaves Charcoal Briquettes

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Abstract. Paddy leaves can be used to make charcoal briquettes and good as renewable energy sources. The charcoal briquettes were pressed at a pressure range of 50 – 90 bars using the cold press machine. This paper reports the physical and mechanical properties of charcoal briquettes produced from paddy leaves. The moisture content of paddy leaves charcoal briquettes was calculated after dried in an oven at 80°C until the briquettes reached a constant weight. Then, the paddy leaves charcoal briquettes were subjected to the Compression Test with a maximum load capacity of 500kg and crosshead speed of 0.305 mm/min until the briquettes came to a failure as for the investigation of its compressive strength. The average moisture content of paddy leaves charcoal briquettes were in the range of 7-8%. The lowest value of moisture content was 7.32%, recorded by CB5 charcoal briquette sample which, contributed to the highest value of its compressive strength. Its compressive strength was 2.176 MPa. The investigation showed that CB5 was the best charcoal briquette, and the compressive strength was affected by the moisture content in the paddy leaves charcoal briquettes.

1. Introduction

The paddy leaves are good biomass candidates that can be converted as renewable energy sources. Paddy leaves are considered a lignocellulosic biomass that contains 38% cellulose, 25% hemicellulose, and 12% lignin [1]. In particular, lignocellulosic agricultural crops waste has huge unutilized energy generation potential.

Currently, after harvesting session, open field burning is a major practice for disposal of rice residues, in order to prepare the land piece for the next cycle of rice cultivation process. Unfortunately, this practice leads to air pollution and harmful to the environment. Besides, the depletion of renewable resources to produce energy has alarmed many countries to take proactive actions to preserve their country's prosperity. The environmental pollutions are among the issues that called for many countries to find alternatives to ensure a sustainable living environment [2]. One of the measures is to reuse the natural waste materials such as paddy leaves as new renewable energy alternative.

Briquetting process is a great idea to make paddy leaves useful as a renewable energy. Briquetting is the process of conversion of agricultural waste into uniformly shaped briquettes that are easy to use, transport and store [3]. The use of tapioca starch as a binder in this briquetting procedure helps to improve the briquettes quality. Binder also potentially acts as an adhesive.

In order to make charcoal briquettes, the paddy leaves are converted to paddy leaves char. It is in black powder form. This procedure involved combustion process. The combustion process will covert paddy leaves biomass to useful char for the production of paddy leaves charcoal briquettes.

The purpose of this research is to investigate the physical and mechanical properties of paddy leaves charcoal briquettes. The physical property is involved the moisture content of paddy leaves and paddy leaves charcoal briquettes. Besides, the compression strength was studied to analyze the ability of briquettes to resist the force before briquettes break. The important information of this research is the combustion temperature uses to produce char is at low temperature which is below than 300 °C at different combustion time using a universal oven.

2. Materials and Methods

2.1 Materials Preparation

The paddy leaves used in this research study were obtained from the Muda Agricultural Development Authority (MADA) Kodiang, Kedah. Paddy leaves used in this research are from MR297 rice seeds. Dried paddy leaves were taken from paddy field after harvesting session. The paddy leaves were packed together in form of cylindrical roll shape. Paddy leaves feedstock was carefully sorted manually to remove impurities such as wood, sand and any other unwanted material. Next, the paddy leaves were cut into 10 cm long and post dried in an oven for 24 hours at 80°C in order to reduce the moisture content. Then, the paddy leaves were reduced in size by cutting until they reached uniform size (5 mm).

The starch used was made from tapioca starch which was purchased from a local grocery state. The brand of tapioca starch used in this study was Kapal ABC Brand Tapioca Starch. Kapal ABC Brand Tapioca Starch has soft and fine texture in powder form. The moisture content of tapioca starch was 7.13%. The tapioca starch was dried in an oven at 80°C for 24 hours as to avoid excessive moisture during the production of charcoal briquettes. About 2.1 g of starch flour was mixed with 43 wt% (12.9 g) of water in the beaker. The mixture of starch and water was heated about 80°C for 5 minutes until it coagulates and becomes gel or paste. Then, 7 wt% of total 30 g of the charcoal composition was used to prepared the starch paste.

2.2 Combustion Process

A universal oven was used to obtain the paddy leaves char during the combustion process. The temperatures used were range between 220-260 °C in normal atmosphere. About 100g of paddy leaves were packed closely in the covered aluminum container before combustion process. The combustion process was held for 4 h to obtain the char. Lastly, the size of char obtained after combustion process has been reduced by grinding and sieving. The maximum size of char was 63 μm.

2.3 Briquettes Fabrication

The paddy leaves char was then mixed properly with the starch paste in the container. An amount of 2 g of the mixed charcoal were put into a cylindrical stainless-steel mould (13 mm width and 13 mm height) as to make the briquettes. It is then pressed at a pressure range of 50 – 90 bars using the cold press machine model IMEC to produce paddy leaves charcoal briquette. These green charcoal briquettes were dried for 24 hours in an oven at a temperature of 80°C.

2.4 Physical and Mechanical Testing

2.4.1 Moisture Content

Weight of paddy leaves charcoal briquettes, before (green charcoal briquettes) and after post dried had been taken in order to gain the information on moisture characteristic of raw dried paddy leaves and paddy leaves charcoal briquettes. Moisture content percentage was determined as used by [4]. It was measured by the oven-dry method. The charcoal briquettes with the known weight was kept in the oven

80°C until it reached constant weight. Then, the oven-dried charcoal briquettes were weighed. The moisture content percentage was calculated using the formula:

$$\text{Moisture content percentage (\%)} = \frac{w2-w3}{w2-w1} \text{ x } 100 \text{ (\%)} \quad (1)$$

Where,
w1 = weight of container (g)
w2 = weight of container + sample (g)
w3 = weight of container + sample after drying process (g)

2.4.2 Compression Test

The compression test was carried out using Instron Universal Testing Machine by with the accuracy of 0.5% and a maximum load capacity of 500kg according to (ASTM D2166-85). The briquette sample was placed onto the horizontal metal plate; as shown in figure 1 at crosshead speed of 0.305 mm/min until the briquettes came to a failure.

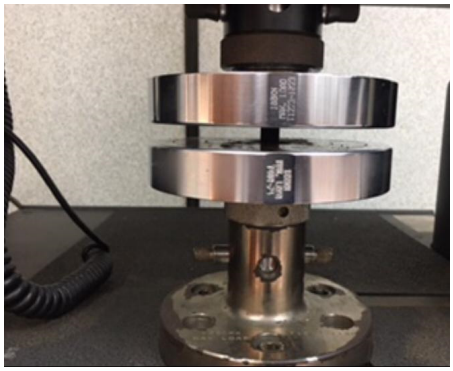

Figure 1. The briquettes samples placed onto the horizontal metal plate

3. Result and Discussion

3.1 Moisture Content

Moisture content and density test were conducted and calculated to examine the physical properties of paddy leaves charcoal briquettes. Table 1 shows combustion temperature and combustion time of paddy leaves for the production of charcoal briquettes and density of briquettes that has been used in this study.

Table 1. Combustion temperature and combustion time of paddy leaves for the production of charcoal briquettes at 0.836 g/cm³ of the density.

Samples	Combustion Temperature (°C)	Combustion Time (hours)	Density of Charcoal Briquettes (g/cm³)
CB1	220	4	0.836
CB2	230		
CB3	240		
CB4	250		
CB5	260		

The moisture of paddy leaves charcoal briquettes was determined by drying samples in an oven at 80°C until constant weight of the sample was reached. Based on figure 2, the moisture content of paddy leaves charcoal briquettes were affected by combustion temperature. The observation of my previous research was reported that dried paddy leaves feedstock moisture content was in the range of 8-10%, the resulted briquettes had an average moisture content in the range of 7-8% as shown in figure 2. Therefore, the briquettes samples of paddy leaves at 260°C (CB5) of combustion temperature recorded the lowest percentage of moisture content, which is 7.32% compared to the other samples. However, the chart also demonstrated that there was only sligthly different in the moisture content value of briquettes at different combustion temperature. This is due to the low value of moisture content of dried paddy leaves feedstocks.

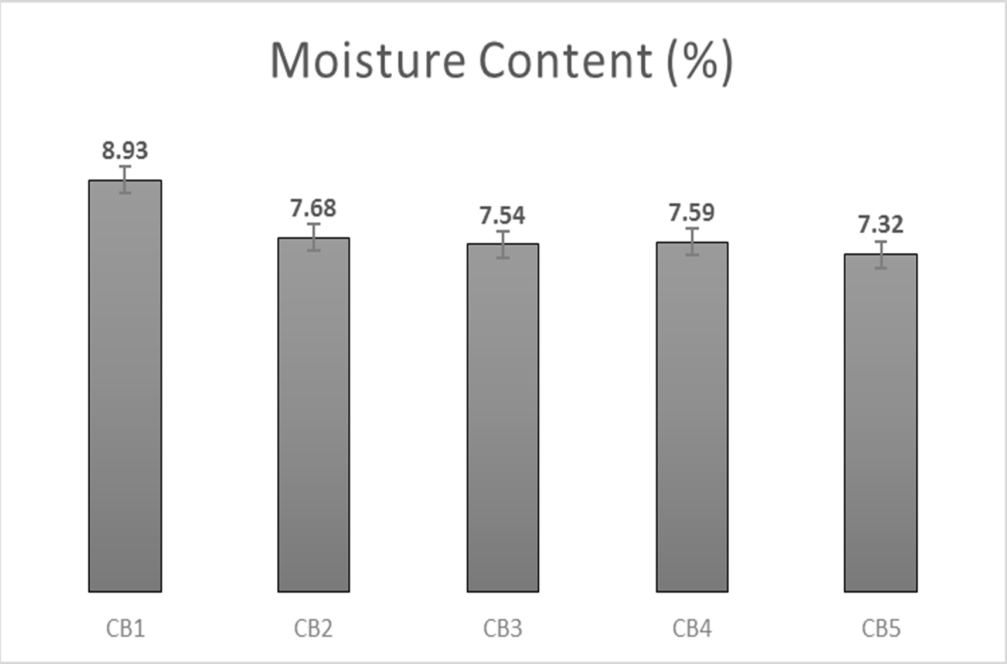

Figure 2. The moisture content of paddy leaves charcoal briquettes with different combustion temperature.

Moisture content is important property which can definitely affect the burning characteristics of charcoal briquettes. Previous research reported that they produced charcoal briquettes from rice husk with moisture content below 12%, which the value obtained was within the maximum limits of 15% of moisture content as recommended by Jamradloedluk and Wiriyaumpaiwong (2007) [4]. Moisture content also has an effect on the strength of briquettes. Aina et al. (2009) stated that moisture content is one of the main parameters that affacted the briquette quality [5].

3.2 Compressive Strength

Compressive strength results of the paddy leaves charcoal briquettes with different combustion temperature of paddy leaves char are demonstrated in figure 3. Results showed that briquettes compressive strength increased significantly with the increasing of combustion temperature. CB5 recorded the highest value of compressive strength that is 2.176 MPa while CB1 with the highest moisture content value recorded the lowest value of compressive strength that is 1.933 MPa.

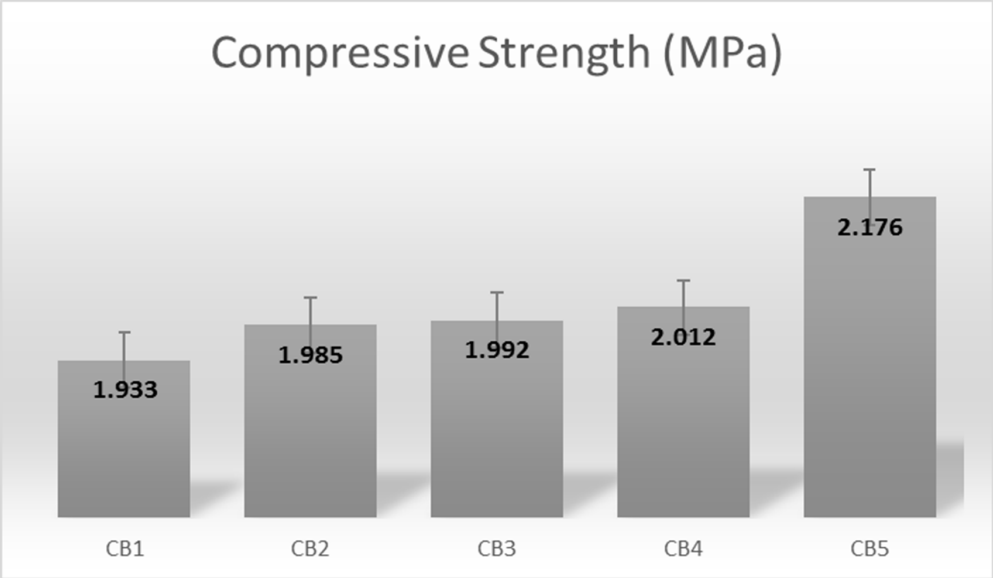

Figure 3. Compression strength of paddy leaves charcoal briquettes with different combustion temperature

The results proved that the briquettes strength were affected by their moisture content. However, we could not find any standard for paddy leaves charcoal briquettes compressive strength in the previous research since, there is no research had been done for the charcoal briquettes produce from paddy leaves.

4. Conclusion

The moisture content of paddy leaves charcoal briquettes was in the range of 7-8%. CB5 recorded the lowest value of moisture content that is 7.32%, due to the highest combustion temperature used to convert the paddy leaves into char. The research proved that, the moisture content is one of the important factor that affect the compressive strength of charcoal briquettes since, CB5 has the highest value of compressive strength. It was 2.176 MPa compared to CB1 with the compressive strength 1.933 MPa. Lowest value of moisture content, contributed to the highest value of compressive strength.

5. Acknowledgement

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