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SUPPLEMENTARY MATERIAL TO

Effect of microwave power level and processing time on the quality of palm shell charcoal (*Elaeis guineensis* Jacq.) briquettes

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EXPERIMENTAL

Research procedure

The source of palm shell biomass waste comes from PT. Tani Prima Makmur, Lerehoma Village, Anggaberi District, Konawe Regency. Making charcoal briquettes begins with sample preparation, adhesive material, and ignition material. Sample preparation involves drying palm oil shell waste in the sun to remove the waste's water content and speed up carbonization. Adhesive preparation involves drying the sago in the sun and sifting it using an 80-mesh sieve. Preparation of ignition material involves collecting wood or twigs and drying the ignition material until it is scorched so that it can start a fire in the carbonization process.

The carbonization process is a precise and careful procedure. 45 kg of dried palm oil shell waste was weighed and then carbonized using a carbonization reactor. This reactor, a device with a limited air supply system, ensures that the palm oil shells are burned without further burning. The weighed palm oil shells are put into the carbonization reactor until it fills 75% of the reactor volume, then the reactor is closed to reduce the amount of oxygen entering the reactor. The ignition material is put into the furnace and ignited until it ignites. The reactor temperature is measured every two minutes using an infrared thermometer to maintain the stability of the carbonization rate. The carbonization process of palm oil shells can be observed through the reactor chimney, providing a clear indication of the process's precision and care. When the chimney emits thick and dense smoke, it indicates that the palm oil shells have been carbonized, and when the smoke coming out of the chimney begins to thin and is clear in color, it indicates that the carbonization process has been completed.

Then, the finely ground charcoal is sieved using an 80-100 mesh sieve by arranging the two sieves with the 80 mesh sieve positioned above the 100 mesh sieve. The charcoal powder that passes through the 80 mesh sieve and remains on the 100 mesh sieve is the charcoal that

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will be used for the following process. The sieving process is carried out to ensure the resulting charcoal powder has a uniform or homogeneous particle size.

The sifted palm shell charcoal powder was then weighed using a digital scale in the amount of 5 g and stored in a porcelain cup to be activated using a microwave furnace (SHARP R-21D0(S)-IN, China) with a chamber capacity of 23 liters, five adjustable power levels, operating at 220V and 50Hz. The activated palm shell charcoal is then mixed with the prepared sago adhesive. The composition of charcoal powder and adhesive material uses a ratio of 9:1, namely 9 g mass of charcoal and 1 g mass of adhesive material with 4 ml of distilled water solvent which has been heated at a temperature of 100°C. Mixing charcoal powder with adhesive aims to ensure that the charcoal particles bond together, have a good particle arrangement and do not crumble easily. The results of mixing charcoal powder and adhesive are then printed and compacted using a hydraulic press printing machine. The use of a hydraulic press printing machine is to ensure that the charcoal and adhesive mixture is compacted uniformly and with sufficient pressure, which is crucial for the structural integrity of the final product.

Gravimetric method (lignin, cellulose, and hemicellulose content)

To determine the lignin, cellulose, and hemicellulose content, the sample is first determined for Neutral Detergent Fiber (NDF) and Acid Detergent Fiber (ADF) content (Van Soest, 1985).

- Neutral Detergent Fiber (NDF)

$$\text{NDF content} = \frac{\text{b} - \text{a}}{Sample\ mass} \times 100\%$$

1. Weigh the sample approximately 0.4 grams, then put it into a 50 ml test tube
2. Add 40 ml of ADF solution, then close the tube tightly
3. Boil in boiling water for 1 hour while shaking occasionally.
4. Filter with sintered glass No. 1 of known weight (a gram) while being held with a vacuum pump.
5. Wash with approximately 100 ml of boiling water and 50 ml of alcohol.
6. Oven at 1050 C for 8 hours or leave overnight
7. Cool in a desiccator for approximately a half-hour, then weigh (b grams)

- Acid Detergent Fiber (ADF)

$$\text{ADF content} = \frac{\text{b} - \text{a}}{Sample\ mass} \times 100\%$$

1. Weigh the sample approximately 0.2 grams
2. Put it into a 50 ml test tube
3. Add 30 ml of NDF solution, then close the tube tightly
4. Boil in boiling water for 1 hour (shake occasionally)
5. Filter into sintered glass No.1 of known weight (a gram) while being sucked with a vacuum pump
6. Wash with approximately 100 ml of hot water (sufficient)
7. Wash with approximately 50 ml of alcohol
8. Oven at 1050 C for 8 hours or leave overnight
9. Cool in a desiccator for a half-hour, then weigh (b grams)

Lignin

Lignin is a combination of several closely related compounds containing carbon, hydrogen, and oxygen, but the proportion of carbon is higher than that of carbohydrate compounds.

$$\text{Lignin content} = \frac{\text{c} - \text{d}}{Sample\ mass} \times 100\%$$

1. Sintered glass containing ADF is placed on a Petri disk
2. Add 20 ml of 72% H2SO4, stir to ensure that the fibre is wetted with 72% H2SO4 and leave for 2 hours 20
3. Suck with a vacuum pump while rinsing with enough hot water
4. Oven for 8 hours at a temperature of 1000 C or leave overnight
5. Put in a desiccator, then weigh (c gran); put in an electric furnace or heat to 5000 C for 2 hours, let it cool slightly, then put in a desiccator for a half hour, then weigh (d)

Cellulose

$$\text{Cellulose content} = \%\ \text{ADF} - \%\ \text{Lignin} - \%\ \text{Insoluble ash}$$

Cellulose is the main component of plant cell walls. Cellulose is a glucose polymer with ß -1,4 glucoside bonds in a straight chain.

Hemicellulose

$$\text{Hemicellulose content} = \%\text{NDF} - \%\text{ADF}$$

Hemicellulose is a group of heterogeneous polysaccharides with low molecular weight. Hemicellulose is usually between 15 and 30 per cent of the dry weight of lignocellulosic materials (Taherzadeh, 1999). Hemicellulose is relatively more straightforward to hydrolyze with acid into monomers containing glucose, mannose, galactose, xylose and arabinose. Hemicellulose binds cellulose fibre sheets to form microfibrils that increase cell wall stability.

Table S1. Test results

Test Results	Hemiselulosa	Cellulose	Lignin
Repetition	Results (%)	Results (%)	Results (%)
1	12.24	25.83	42.22
2	12.12	25.92	42.21
3	12.17	25.90	42.18
Mean	12.18	25.88	42.20
Standard Deviation	0.06	0.05	0.02
Method Precision (%RSD)	0.50	0.18	0.05
%CV Horwits	10.983	9.805	9.109
	1.21767E-05	2.58833E-05	4.22033E-05
	-4.914471583	-4.586979795	-4.374653246
	3.457235791	3.293489897	3.187326623
0.67x% CV horwits	7.36	6.57	6.10