Physical Properties of Varied Composition of Peanut Shell and Palm Oil Shell's Briquettes

by Arinda Ristawati

Physical Properties of Varied Composition of Peanut Shell and Palm Oil Shell's Briquettes

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Abstract. This research aims to determine the physical properties of briquettes made from peanut shell (KKT) and palm oil shell (CKS) waste. The manufacturing process is carried out using a briquette press with a pressure of 70 N/m^2, and each KKT and CKS is measured at 100 mesh. Two grams of starch adhesive and 15 ml of water are used in the process. This research method involves varying the quantities of KKT and CKS with the following ratios: S1(18:0), S2(16:2), S3(14:4), S4(12:6), S5(10:8), S6(8:10), S7(6:12), S8(4:14), S9(2:16), S10(0:18). The results of this research show that the lowest density of briquettes, 708.38 kg/m^3, was produced by sample S6, while the highest density, 876.91 kg/m^3, was produced by sample S3. The lowest elastic modulus of briquettes, 7 MPa, was recorded for sample S6, and the highest elastic modulus, 60 MPa, was observed for sample S10. Similarly, the lowest ultimate strength of briquettes, 1.35 MPa, was found in sample S6, while the highest ultimate strength, 6.03 MPa, was achieved in sample S10.

1. Introduction

Energy availability is one of the main problems in the world today. Every year, the demand for energy increases in tandem with the rise in human activities that rely on fuel oil derived from plant and animal fossils [1]. This must be promptly addressed by introducing renewable, abundant, and cost-effective alternative energy sources that are accessible to entire communities [2].

One solution to problems related to energy scarcity is processing biomass into fuel. Some biomass with considerable potential includes agricultural waste, industrial waste, and household waste. Biomass can be processed and used as an alternative fuel, such as in the production of briquettes. Briquettes offer economic advantages due to their simple production, high calorific value, and the sufficient availability of raw materials in Indonesia, allowing them to compete with other fuels [3]. Furthermore, briquettes serve as an alternative fuel resembling charcoal with reasonably high density. As a novel form of fuel, briquettes are a straightforward material both in the manufacturing process and in terms of the raw materials used, indicating that briquette fuel holds significant potential for development [4].

A considerable amount of research has been conducted on briquettes, encompassing studies on various raw material combinations. These include investigations on a mixture of pine and peanut shells for briquette production [5], research on a blend of peanut shells and corn stover as briquette material [6], the creation of briquettes from corn cobs, corn stems, soybean shells, peanut shells, rice husks, and rice straw [7], the examination of the impact of shelled nut shell warming rates utilizing the TG-FTIR (Thermo gravimetry Fourier-transform infrared spectroscopy) method [8], and the utilization of palm oil shell waste as a raw material for briquette production [9]. Additionally, there are studies on designing briquette stoves using raw materials such as palm shells, durian skins, and coconut shells [10], producing briquettes from palm oil shell waste and acacia shell waste using the response surface method [11], creating briquettes from waste peanut shells using the pyrolysis method [12], forming briquettes from palm oil shells and mango shells [13], and manufacturing briquettes from sawdust, coffee skins, khat waste, and dry grass, with binders made from clay and paper waste [14]. Other research focuses on the utilization of rice husk waste as a material for briquette production [15], making briquettes from food waste using pyrolysis techniques [16], investigating heating methods for coal briquette samples [17], analyzing the burning characteristics of corn straw briquettes using thermogravimetry analysis [18], exploring the use of palm oil shells as a source for charcoal briquettes [19], and utilizing rice husks and palm shells as raw materials for charcoal briquettes with starch adhesive [20]. Lastly, there is an analysis of the effect of torrefaction time on the quality of bio-briquettes from palm oil shells [21].

Peanuts (Arachis hypogaea L.) are the second most important legume crop after soybeans in Indonesia. Approximately 20-30% of peanuts exist in the form of shells. The supply of peanuts to the peanut-based food industry per industrial unit can amount to covering up to 1.25 tons of clean peanut seeds per day. However, this process generates a significant amount of peanut shell waste. Disposing of or burning such waste requires a substantial area. Therefore, peanut shell waste, which boasts a high cellulose content of 63.5%, can be utilized and holds the potential to serve as raw material for producing bio briquettes [22].

According to data from the Ministry of Agriculture in 2017, the area of oil palm plantations in Jambi Province could reach 1.8 million hectares. One potential rural waste that can be processed into alternative fuel is palm oil shells. This waste consists of the innermost part of the oil palm fruit, which has a hard texture. Due to this characteristic, in its processing, palm oil shells are not converted into oil and only become industrial waste. The utilization of palm oil shells is not yet optimal, considering its significant potential. In 2004, the processing of 53.762 million tons of fresh palm fruit bunches into Crude Palm Oil (CPO) generated a substantial amount of waste in the form of shells and fiber, totaling 10.215 million tons. Apart from that, palm oil shells are an agricultural waste suitable for use as bio-briquettes, given that the calorific value of the shells is higher in briquette form than when palm oil shells are burned directly as boiler fuel [23].

The abundance of peanut shell and palm oil shell waste in Indonesia has prompted researchers to study briquettes made from these two wastes, offering a potential solution to the increasing scarcity of fuel. The author hopes that briquettes derived from waste peanut shells and palm oil shells can assist the government in addressing energy limitations. Subsequently, these briquettes could be utilized as fuel on both an industrial and household scale.

2. Methodology

The flow diagram of this research can be seen in Figure 1 below:

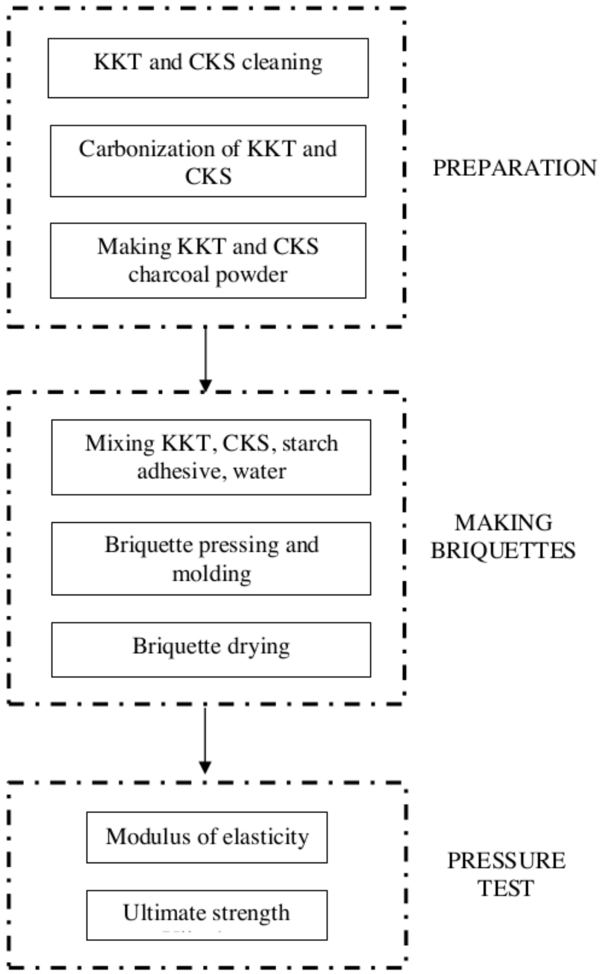

Figure 1. Research flowchart of peanut shell and palm oil shell waste briquettes

The stages of the research process in Figure 1 explain the preparation of ingredients for making briquettes, such as peanut shells, palm oil shells, starch adhesive, and water. The roasting process involves placing cleaned peanut shells and palm oil shells into separate roasting furnaces and drums, where 1 kg of peanut shells is burned for 1 hour, and 3 kg of palm oil shells are burned for 8 hours. The finished and cooled charcoal is then crushed with a pestle until it reaches a smooth consistency. Subsequently, the crushed charcoal is sifted through a 100-mesh sieve to achieve a uniform grain size. The finely and evenly distributed charcoal powder is then weighed as needed, with the composition as shown in Table 1, and subsequently used to create briquette samples.

Table 1. Samples based on the composition of peanut shells (KKT) and palm oil shells (CKS)

Sample	KKT (gr)	CKS (gr)	Adhesive (gr)
S1	18	0	2
S2	16	2	2
S3	14	4	2
S4	12	6	2
S5	10	8	2
S6	8	10	2
S7	6	12	2
S8	4	14	2
S9	2	16	2
S10	0	18	2

The process of mixing charcoal powder with adhesive involves heating 2 gr of starch with 15 ml of water over three candles for three minutes until glue forms. Subsequently, the charcoal powder from peanut shells and palm oil shells is mixed with the adhesive prepared according to Table 1. The printing process is then carried out using a press machine for each sample with a pressure of 70 N/m^2. Finally, the briquettes are printed, and their dimensions, including initial mass, initial diameter, and initial length, are measured using a caliper. Afterward, the briquettes are dried in the sun at room temperature for a week. The dry briquettes are then individually measured for their final mass, final diameter, and final length using a caliper.

Measure the dimensional stability and density of each briquette using equations (1) and (2):

$$DS = 100 - [\left(\frac{(V_i - V_f)}{V_f}\right) x100] \tag{1}$$

where:
DS = dimensional stability (%)
V_i = volume of briquette before drying (mm^3)
V_f = volume of briquette after drying (mm^3)

$$\rho = \frac{m_f}{V} \tag{2}$$

where:
ρ = density of briquette after drying (gr/mm^3)
m_f = mass of briquette after drying (gr)
l_f = length of briquette after drying (mm)
r = circle radius of briquette after drying (mm)
π = constant $\frac{22}{7}$
A = area of a flat circle of briquette after drying (mm^2)
V = volume of briquette after drying (mm^3)

$$V = A\, x\, l_f \tag{3}$$

$$A = \pi\, x\, r^2 \text{ (the shape of the briquette is cylindrical)} \tag{4}$$

Measure the elastic modulus and ultimate strength values of each briquette using the Universal Testing Machine.

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3. Result and discussion

3.1 Physical properties of briquettes

Briquettes that have been dried for a week at room temperature can be observed in Figure 2. Upon closer inspection, briquettes with a higher composition of peanut shells than palm oil shells exhibit a flatter surface, specifically in samples S1, S2, S3, S4, and S5, in comparison to samples S6, S7, S8, S9, and S10. This difference may be attributed to the inhomogeneity of the mixture of KKT and CKS charcoal powder during the mixing process.

Figure 2. Briquette after drying

The results of measuring the physical properties of briquettes can be seen in Table 2.

Table 2. Physical properties of briquettes

Sample	Dimention		Mass		Volume		DS (%)
	Before drying	After drying	Before drying	After drying	Before drying	After drying	
S1	d_i = 42.10 l_i = 17.8	d_f = 42.50 l_f = 17.00	m_i= 29.15	m_f= 20.25	V_i=24788.4	V_f=24126.3	97.25
S2	d_i = 42.80 l_i = 16.50	d_f = 43.00 l_f = 16.10	m_i= 28.76	m_f= 20.10	V_i=23748.4	V_f=23389.8	98.46
S3	d_i = 42.90 l_i = 16.60	d_f = 42.70 l_f = 16.00	m_i= 28.66	m_f= 20.10	V_i=24004.2	V_f=22921.3	95.27
S4	d_i = 42.30 l_i = 16.30	d_f = 43.00 l_f = 15.90	m_i= 28.33	m_f= 20.05	V_i=22915.6	V_f=23099.2	100.79
S5	d_i = 41.10 l_i = 16.05	d_f = 42.80 l_f = 16.30	m_i= 28.19	m_f= 19.93	V_i=21899.4	V_f=23460.6	106.65
S6	d_i = 40.00 l_i = 15.20	d_f = 44.10 l_f = 17.10	m_i= 27.43	m_f= 18.51	V_i=19108.5	V_f=26129.9	126.87

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S7	d_i = 42.40 l_i = 15.20	d_f = 41.90 l_f = 16.30	m_i= 27.39	m_f= 18.56	V_i=21470.3	V_f=22484.3	104.50
S8	d_i = 41.10 l_i = 16.90	d_f = 42.20 l_f = 17.80	m_i= 28.71	m_f= 19.46	V_i=22430.2	V_f=24906.3	109.94
S9	d_i = 40.80 l_i = 16.40	d_f = 42.40 l_f = 17.30	m_i= 28.21	m_f= 19.04	V_i=21450.0	V_f=24436.6	112.22
S10	d_i = 40.00 l_i = 17.40	d_f = 42.30 l_f = 17.20	m_i= 27.04	m_f= 17.53	V_i=21874.2	V_f=24180.9	109.53

Note: m_i= initial mass (gr) m_f= final mass (gr)
d_i = initial diameter (mm) d_f = final diameter (mm)
l_i = initial length (mm) l_f = final length (mm)
V_i = initial volume (mm^3) V_f = final volume (mm^3)

From Table 2, it can be observed that there are differences in the dimensions of the briquettes when first removed from the mold and after drying, including variations in mass, diameter, and length. This indicates an influence resulting from a decrease in water content during the briquette drying process, causing the volume of the briquettes to either decrease or increase. The volume change allows for the determination of the dimensional stability of the briquettes. From Table 2, it is evident that the highest dimensional stability of briquettes is found in sample S6, with a KKT: CKS concentration of 8:10, at 126.87%. Conversely, the lowest dimensional stability is observed in sample S3, with a KKT: CKS concentration of 14:4, at 95.27%.

3.2 Density of briquettes

After measuring the dimensions of each briquette with a caliper, calculate the density of each briquette by dividing its final mass by the final volume using equation (1). The relationship between variations in briquette composition and density can be observed in Figure 3.

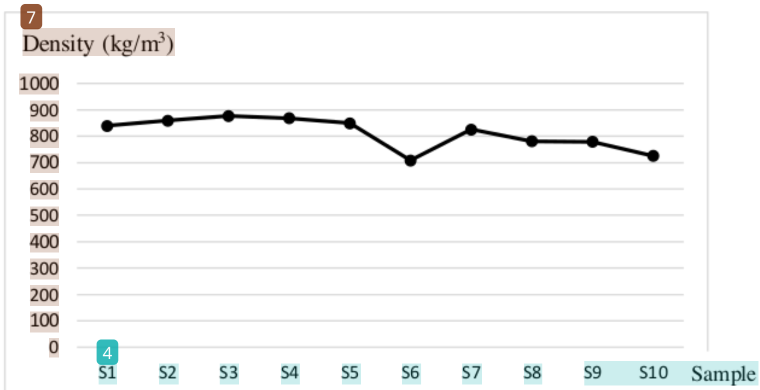

Figure 3. Graph of the relationship between variations in briquette composition and density

The density values of the briquettes in the study ranged from 708.38 kg/m^3 to 876.91 kg/m^3. The lowest density, 708.38 kg/m^3, was observed in briquettes treated with a composition of 8 gr of peanut shell charcoal powder and 10 gr of palm oil shell charcoal powder. On the other hand, the highest density, 876.91 kg/m^3, was recorded in briquettes treated with a composition of 14 gr of peanut shell charcoal powder and 4 gr of palm oil shell charcoal powder.

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The density values of the briquettes produced in this study should not exhibit significant differences among them, given that the overall concentration of each constituent material in the briquettes is the same. Furthermore, the briquette molds used in the manufacturing process have nearly identical dimensions, and uniform pressure is applied to all briquettes. Despite these factors, the graph in Figure 3 indicates variations in density among the briquettes. This discrepancy may arise from the uneven distribution of grains when the briquettes emerge from the mesh sieve, as a more uniform grain size strengthens the bonds between the particles composing the briquettes. Additionally, briquettes from sample S6 display a density value notably distinct from that of the other briquettes. This difference could be attributed to the less uniform mixture of peanut shell and palm oil shell charcoal grains during the mixing process, prior to forming the briquette mixture.

Figure 3 show that in general the higher the peanut shell content, the higher the briquette density value, this trend is evident from samples S1 to S5. Similarly, for samples S6 to S10, an increase in palm kernel shell content corresponds to a higher briquette density value.

3.3 Elasticity modulus of briquettes

The elastic modulus values of the briquettes were determined through compressive strength testing using a Universal Testing Machine (UTM). These values are presented in Table 3 and Figure 4.

Table 3. Elasticity modulus measurement

Sample	Elasticity modulus (MPa)
S1	8
S2	10
S3	20
S4	20
S5	20
S6	7
S7	10
S8	10
S9	20
S10	60

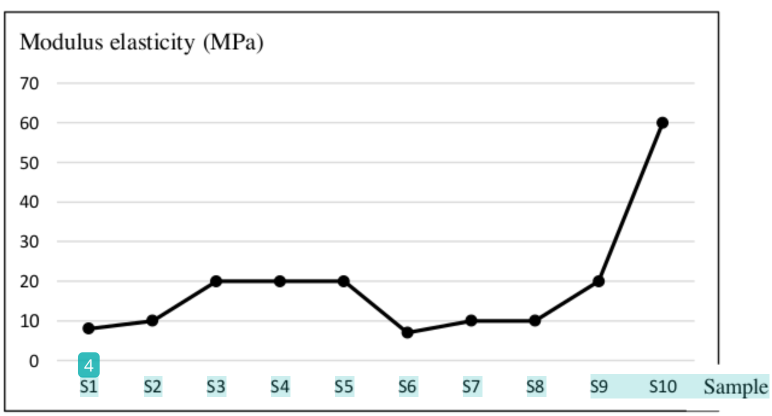

Figure 4. Elasticity modulus measurement

The elastic modulus values of the briquettes in the study ranged from 7 MPa to 60 MPa. The lowest modulus of elasticity observed in the briquettes was 7 MPa, produced by briquettes treated with a composition of 8 gr of peanut shell charcoal powder and 10 gr of palm shell charcoal powder. Conversely, the highest modulus of elasticity value in the briquettes was 60 MPa, achieved by briquettes treated with a composition of 0 gr of peanut shell charcoal powder and 18 gr of palm kernel shell charcoal powder.

From the graph in Figure 4, it is evident that the elastic modulus values of the briquettes in samples S1 to S5 increase, reflecting a higher composition of peanut shell charcoal powder compared to palm oil shell charcoal powder. Additionally, as shown in Figure 2, the surface topography of S1 to S5 briquettes is noticeably flatter than that of S6 to S10 briquettes. Furthermore, the graph in Figure 4 indicates that in samples S6 to S10, the composition of coconut shell carbon powder exceeds that of peanut shell carbon powder, resulting in an increased elastic modulus value.

3.4 Ultimate strength of briquettes

The ultimate strength values of the briquettes were determined through compressive strength testing using a Universal Testing Machine (UTM). These values are presented in Table 4 and Figure 5.

Table 4. Ultimate strength measurement

Sample	Ultimate strength (MPa)
S1	2.22
S2	2.13
S3	2.69
S4	2.31
S5	2.61
S6	1.35
S7	2.16
S8	3.10
S9	3.39
S10	6.03

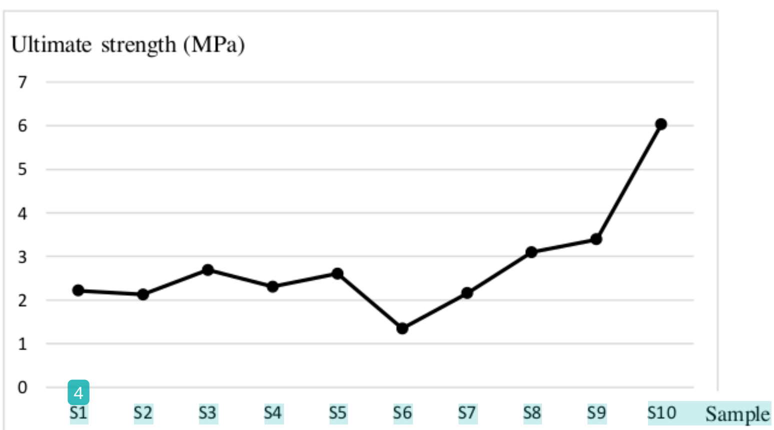

Figure 5. Ultimate strength measurement

The ultimate strength values of the briquettes in the research ranged from 1.35 MPa to 6.03 MPa. The lowest ultimate strength observed in the briquettes was 1.35 MPa, produced by briquettes treated with a composition of 8 gr of peanut shell charcoal powder and 10 gr of palm shell charcoal powder. Conversely, the highest ultimate strength value in the briquettes was 6.03 MPa, achieved by briquettes treated with a composition of 0 gr of peanut shell charcoal powder and 18 gr of palm kernel shell charcoal powder.

In alignment with the modulus of elasticity, Figure 5 also reveals that the ultimate strength values of the briquettes increase in samples S1 to S5, reflecting a higher composition of peanut shell charcoal powder compared to palm oil shell charcoal powder. Furthermore, as indicated in Figure 2, the dimensions of S1 to S5 briquettes exhibit a flatter surface compared to S6 to S10 briquettes. Figure 5 further illustrates an increase in the ultimate strength values for samples S6 to S10, where the composition of palm kernel shell charcoal powder exceeds that of peanut shell charcoal powder.

4. Conclusion

In conclusion, this research reveals that the lowest density of briquettes, 708.38 kg/m^3, was produced by sample S6, while the highest density, 876.91 kg/m^3, was achieved by sample S3. Similarly, the lowest elastic modulus of 7 MPa was observed in sample S6, while the highest elastic modulus of 60 MPa was found in sample S10. Additionally, the lowest ultimate strength of 1.35 MPa was recorded in sample S6, and the highest ultimate strength of 6.03 MPa was attained by sample S10.

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