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Briquette from Candlenut Shell Charcoal and Polypropylene Plastic Waste From The Kefamenanu Landfill

Pemanfaatan Sampah Plastik Polipropilen dari Tempat Pembuangan Akhir (TPA) Sampah Kefamenanu dan Arang Cangkang Kemiri Sebagai Campuran Bahan Baku Pembuatan Briket

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ABSTRACT

This research aimed to determine the optimum composition of polypropylene plastic and candlenut shell charcoal in briquettes production. The percentage of briquette mixture was CK100:0PP, CK75:25PP, CK50:50PP, CK25:75PP and CK0:100PP. The moisture content of the briquettes obtained was as follows CK100:0PP (6.33%), CK75:25PP (4.18%), CK50:50PP (2.63%), CK25:75PP (1.90%) and CK0: 100PP (0.77%). Ash content was CK100:0PP (0.51%), CK75:25PP (18.82%), CK50:50PP (9.09%), CK25:75PP (3.26%) and CK0:100PP (1.74%). The level of flying substances was CK100:0PP (33.53%), CK75:25PP (51.52%), CK50:50PP (52.37%), CK25:75PP (60.99%) and CK0:100PP (72.96%). Fixed carbon was CK100:0PP (59.63%), CK75:25PP (25.48%), CK50:50PP (35.91%), CK25:75PP (33.85%) and CK0:100PP (24.52 %). Calorific value was CK100:0PP (2,902.31 cal/gr), CK75:25PP (9,292.45 cal/gr), CK50:50PP (8,155.53 cal/gr), CK25:75PP (9,094.69 cal/gr) and CK0:100PP (10,808.30 cal/gr). Compressive strength was CK75:25PP (50.31 Kgf/cm2), CK50:50PP (44.67 Kgf/cm2), CK25:75PP (36.11 Kgf/cm2) and CK0:100PP (33.85 Kgf/cm2). The optimum composition of briquettes from a mixture of polypropylene plastic and candlenut shell charcoal was CK25:75PP.

Keywords: Briquettes, Candlenut Shells, Polypropylene Plastic.

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1. INTRODUCTION

The upward trend of oil prices can be attributed to its status as a non-renewable resource. One potential solution to address this issue is the implementation of numerous and cost-effective renewable energy sources (Arni *et al*., 2014). The energy source that has the criteria described previously is energy from biomass. Indonesia is an agricultural nation with abundant agricultural products, but its downstream processing generates considerable waste. This is a problem due to the lack of processing of agricultural waste.

One potential method of waste management is the production of briquettes derived from waste materials, which can serve as a viable alternative fuel source for local communities (Septhiani & Septiani, 2015). The adhesive type utilized, namely starch, influences the overall quality of briquettes. Starch has a tendency to elevate the moisture content. According to Masturin (2002), the calorific value of briquettes can be reduced by an increase in moisture content.

Plastic waste has been proposed as a viable alternative glue that does not compromise the calorific value (Muhammad, 2016). Polypropylene plastic waste from mineral water packaging increases over time. The cause of this issue can be attributed to individuals' irresponsible disposal of drinking glasses and the suboptimal state of waste management practices. One potential approach to addressing this issue involves reusing it as a primary resource in the production of briquettes.

In this research, briquettes will be made from candlenut shells with polypropylene plastic as the adhesive. Prior research has not examined the combination of polypropylene plastic and candlenut shells as ingredients of briquettes. Therefore, this study aimed to contribute valuable insights into the ideal composition of such briquettes.

2. RESEARCH METHODOLOGY

2.1. Tools and Material

The tools used were an analytical balance, bomb calorimeter, briquette press, stainless steel pan, pressing tool, pestle and mortar, 40-mesh sieve, furnace, oven, desiccator, porcelain cup, and Universal Testing Machine (UTM). The materials used were candlenut shells and polypropylene plastic.

2.2. Methodology

Raw material preparation included cleaning candlenut shells and washing polypropylene plastic. The polypropylene plastic and candlenut shells underwent a sun-drying process lasting three days in order to reduce their moisture content. The dried candlenut shells were put into the kiln. The furnace temperature was set at 400°C. The burning or carbonization process lasted for 2 hours. The charcoal obtained was pulverized with a pestle and mortar. The finely ground charcoal was then sieved with a 40-mesh sieve.

The raw materials were subsequently measured by employing different proportions of polypropylene plastic and candlenut shells, namely 100:0, 75:25, 50:50, 25:75, and 0:100 (gram/gram). The plastic material melted within a designated machine and candlenut shell charcoal was introduced afterward. The two components were thoroughly blended and homogenized, subjected to printing via a briquette press, and compressed. The briquette mixture was dried using an oven at 105°C for 2 hours.

2.3 Briquette Quality Test Procedure

2.3.1 Moisture content

$$\text{Moisture content (\%)} = \frac{\text{Wo} - W}{\text{Wso}} \text{ x } 100\% \text{ ....(1)}$$

Note:
W_o = mass of sample and cup before drying (gr)
W = mass of sample and cup after drying (gr)
W_{so} = initial mass of sample (gr)

2.3.2 Ash Content

$$\text{Ash content (\%)} = \frac{\text{Wo}}{\text{Wdso}} \text{ x } 100\% \text{ ....(2)}$$

Note:
W_o = mass of sample after ashing (gr)
W_{dso} = mass of sample before ashing (gr)

2.3.3 Volatile Content

$$\text{Volatile content (\%)} = \frac{\text{Wo} - W}{\text{Wo}} x \text{ 100 \% ....(3)}$$

Note:
W_o = initial mass of sample (gr)
W = final mass of sample (gr)

2.3.4 Fixed Carbon

$$\text{FC} = 100\% - (\text{KA}+\text{ZT}+\text{X}) \text{ ....(4)}$$

Ket : FC = bound carbon content (%)
KA = moisture content (%)
ZT = level of evaporated substance (%)
X = ash content (%)

2.3.5 Calorific value

$$NK = \frac{k(T2-T1)}{T2} \text{ x . } 100\% ....(5)$$

Note: NK = calorific value (Kal/g)
T2 = final temperature (^{0}C)
T1 = initial temperature (^{0}C)
K = tool coefficient (Kal/C)
X = Mass of sample

2.3.6 Compressive strength

$$P = \frac{F}{A} ....(6)$$

Note: P = compressive strength of briquette (kgf/cm^2)
F = briwuitte load (kgf)
A = The cross-sectional area of the briquette (cm^2)

3. RESULTS AND DISCUSSION

3.1 Moisture content

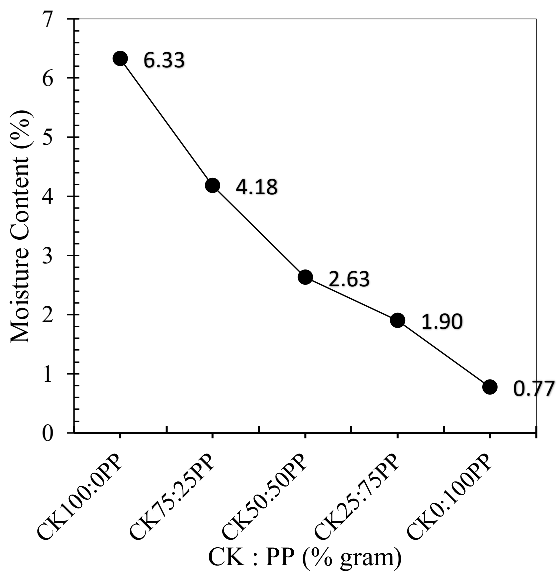

Figure 1. The moisture content of briquettes from candlenuts shells and polypropylene plastic

According to the data presented in **Figure 1**, there is a negative correlation between the polypropylene plastic content in the briquettes and their moisture content. As the polypropylene plastic content increases, the moisture content of the briquettes decreases. There is a direct correlation between the concentration of candlenut shell charcoal and the corresponding rise in moisture content. This phenomenon occurs due to the hydrophilic nature of charcoal, which enables it to effectively absorb water, in contrast to polypropylene plastic, which lacks the ability to absorb water. Yuliah (2017) stated that charcoal can absorb water because it has hygroscopic properties that can absorb water and has pores. Polypropylene plastic cannot absorb water (Suyitno, 1990). Faizal *et al.* (2018), who made briquettes from kapok fruit skin using polyethylene plastic, supported this. The results show that the moisture content in the briquettes decreases with the addition of polyethylene plastic. Malo *et al.* (2018) similarly asserted that plastic has the characteristic of being non-absorbent to water, resulting in a low moisture content.

The moisture content value of all briquettes with the composition variations above meets the Indonesian National Standard (SNI), namely ≤ 8%.

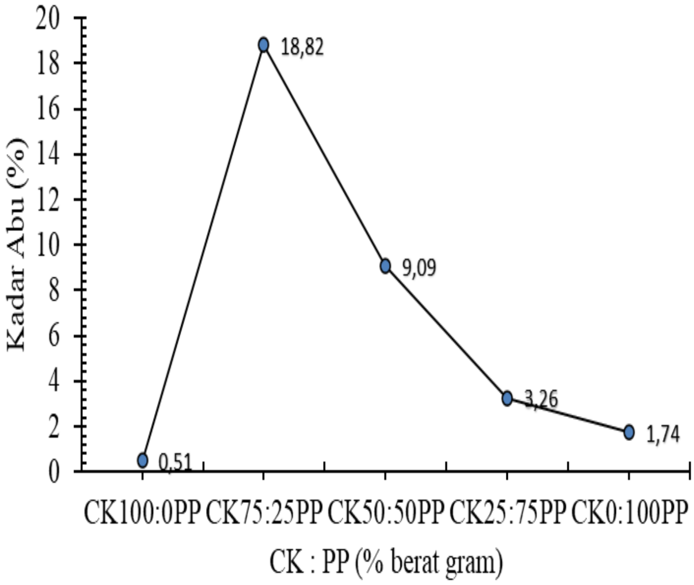

Figure 2. Ash content of briquettes from candlenut shells and polypropylene plastic

3.2 Ash Content

Figure 2 shows that the ash content of candlenut shell briquettes with polypropylene plastic with a composition of 100% candlenut shells is the lowest compared to all compositions. This happens because briquettes without PP adhesive cannot form perfectly when printed. This situation causes the solid to come into contact with air, which is likely to absorb water from the air. This will cause the weight of these briquettes to be less than 1 gram. When subjected to combustion, the quantity of residual ash produced is lower in briquettes that do not contain polypropylene (PP) plastic. This data is supported by data on briquette moisture content, which is relatively high for a 100% briquette charcoal composition.

The briquettes comprising 75% candlenut shells and 25% polypropylene exhibited the highest ash content value. This number decreases as the proportion of PP plastic in the briquettes increases. The evidence indicates that the shells of candlenuts play a role in ash production. It shows that candlenut shells contribute to producing the ash. The inorganic material in the shell cannot be burned into gas, so it becomes ash. PP plastic in briquettes comprises propylene monomer, which does not contain ash constituents (Tidana Syah, 2021). The introduction of propylene leads to complete combustion, resulting in the generation of carbon dioxide gas. Consequently, the inclusion of polypropylene plastic in the sample leads to a reduction in its ash content. According to the findings of Sawir (2016), it was determined that briquettes derived from plastic waste have a relatively low ash percentage, ranging from 0.27% to 3.90%. Furthermore, Trihadiningrum (2007) discovered that briquettes derived from lignocellulosic and plastic exhibited a relatively low ash level, ranging from 0.02% to 2.13%. The study conducted by Muhammad (2016) showed that the utilization of polypropylene plastic adhesive in the production of briquettes resulted in a reduced ash content compared to briquettes manufactured using starch adhesive. The ash content that conforms to the SNI criteria consists of a mixture comprising 25% candlenut shells and 75% polypropylene plastic, as well as a composition solely composed of 100% polypropylene plastic.

3.3 Volatile Content

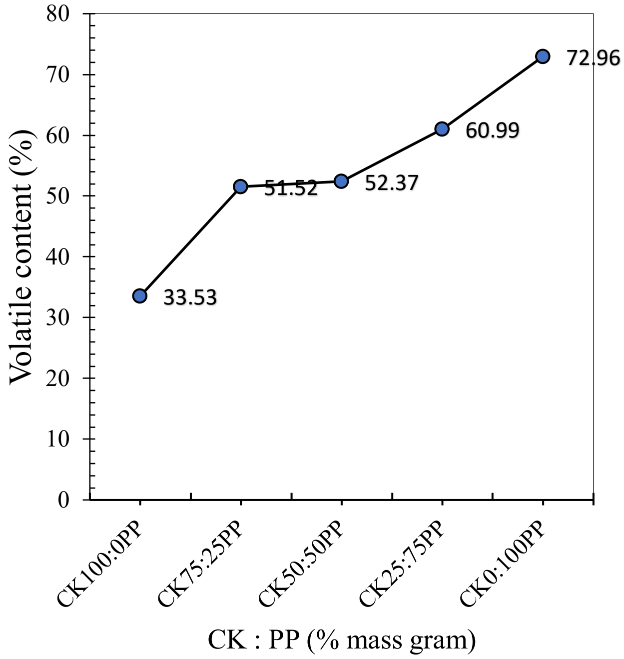

Figure 3. Levels of volatile substances in briquettes from candlenut shells and polypropylene plastic

According to Himawanto (2005), the inclusion of a higher proportion of plastic in briquettes could enhance the combustion process, resulting in improved ignitability of the briquettes. Nevertheless, elevated volatile matter concentrations within briquettes may adversely affect human health. Volatile matter comprises noxious gases, specifically carbon monoxide, methane, and carbon dioxide, which have detrimental effects on the human body. The volatile matter content of all briquette compositions fails to comply with the SNI standard, which specifies a maximum limit of 15%.

3.4 Fixed Carbon

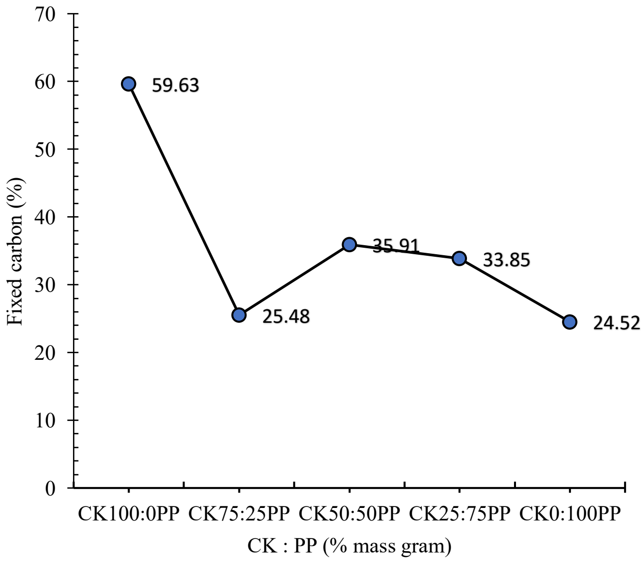

Figure 4. Fixed Carbon of Briquettes from Candlenut Shells and Polypropylene Plastic

Figure 4 shows that the value of carbon bound to briquettes from candlenut shells and polypropylene plastic from composition CK100:0PP to composition CK75:25PP fluctuates. The highest percentage of fixed carbon was found in 100% candlenut shell charcoal composition. This phenomenon occurs due to the higher density of carbon in the cellulose structure of the candlenut shell, as compared to plastic. The carbon in plastic is more easily burned and evaporated, so briquettes containing plastic have a lower fixed carbon value than 100% candlenut shell charcoal. This is supported by Asip *et al*. (2014) research on the production of briquettes from coconut shells, palm shells, and LDPE plastic. Their research indicates that the carbon value of briquettes containing plastic will be lesser. This low fixed carbon value occurs because plastic has a high volatile matter value, namely 99.73%. The composition of CK75:25PP briquettes shows an anomaly in the graphic trend. The possible cause is the uneven distribution of polypropylene and candlenut shell charcoal in the briquettes due to the low adhesive content being unable to disperse the briquette particles properly.

3.5 Calorific value

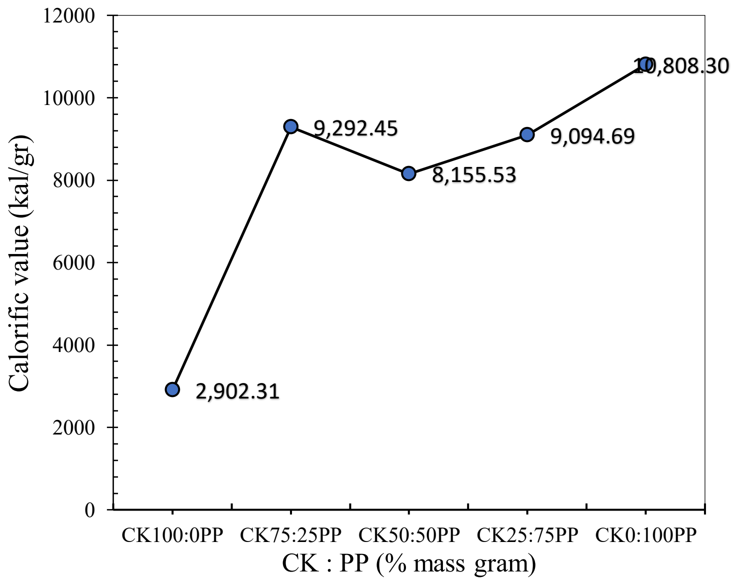

Figure 5. The calorific value of briquettes from candlenut shells and polypropylene plastic

Based on fixed carbon value data, it is known that briquettes from 100% candlenut shells have the highest fixed carbon value. This data would theoretically show that the calorific value of 100% candlenut shell briquettes would be higher than other compositions. Contrary to theory, the investigation revealed that the utilization of 100% candlenut shells resulted in the lowest calorific value due to their high moisture content. Figure 5 shows that the calorific value of briquettes from a mixture of candlenut shell charcoal and polypropylene plastic increases with increasing polypropylene plastic content or decreases with increasing candlenut shell charcoal content. The observed trend indicates that the inclusion of PP plastic in briquettes increases their calorific value. This phenomenon occurs because of the nature of pure polypropylene, which burns quickly and has a high heating value. Saputera (2019) stated that the main PP raw material derivatives from petroleum processing and exhibit a high calorific value. This finding supports the observed upward trend in calorific value reported in the present study. This experimental fact is strengthened by the research of Asip *et al*. (2014), which shows that increasing LDPE plastic in briquettes increases the heating value. Apart from the above research, Septhiani and Septiani (2015) also confirmed that adding HDPE plastic significantly increased the calorific value of briquettes from 4703.27 cal/gr to 5009.16 cal/gr. The calorific value of all briquette compositions meets SNI except for the 100% candlenut shell composition.

3.6 Compressive strength

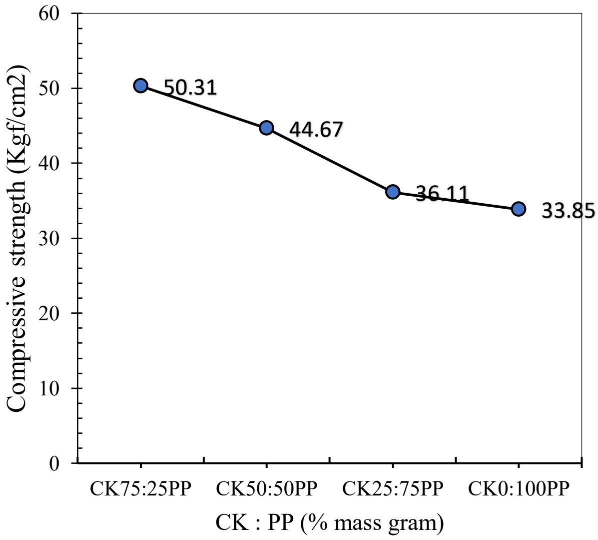

Figure 6. Compressive Strength of Briquettes from Candlenut Shells and Polypropylene Plastic

According to **Figure 6**, it can be observed that there is a negative correlation between the plastic content in briquettes and their resistance to external loads or pressure. In other words, increasing the content of candlenut shells increases the hardness of the briquette material. The briquettes comprising CK 75:25 PP had the highest compressive strength value, measuring 50.31 Kgf/cm2. Conversely, the briquettes composed of CK 0:100 PP demonstrated the lowest compressive strength, measuring 33.85 Kgf/cm2. This is due to the function of candlenut shell charcoal, which fills the spaces between polypropylene polymers and bridges the bonds between polymer molecules. It also indicates that the adhesion force between PP plastic and candlenut shell charcoal is stronger than the cohesion between polypropylene. Aside from that, the polypropylene itself is brittle when subjected to excessive loads, resulting in its susceptibility to breakage. When subjected to excessive loads, the brittle nature of polypropylene plastic was confirmed by Mujiarto (2005), who stated that PP has low-pressure resistance. According to Setiyadi *et al*. (2018), all briquette compositions in the study exhibit compressive strength values that comply with the SNI (≥20 kg/cm^2).

4. CONCLUSION

The optimum composition of briquettes from a mixture of polypropylene plastic and candlenut shell charcoal was a composition of 25% candlenut shells and 75% polypropylene plastic. This briquette had a moisture content of 1.90%, ash content of 3.26%, volatile matter of 60.99%, fixed carbon of 33.55%, the calorific value of 9094.69 cal/gram, and compressive strength of 36.11 Kgf/ cm^2.

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