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The Effect of Variations in the Composition of Cocoa Shell Charcoal and Peanut Shell Charcoal on Briquette Characteristics

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***Abstract**. Agricultural biomass such as cocoa husks and peanut shells have great potential as raw materials for briquettes to support the provision of sustainable alternative energy. This study aims to evaluate the effect of variations in the composition of these two materials on the characteristics of briquettes, including calorific value, moisture content, ash content, and burning time. The study was conducted using a completely randomized design (CRD) with five treatment compositions (KC_1=100:0, KC_2=70:30, KC_3=50:50, KC_4=30:70, KC_5=0:100) and three replications. Data were analyzed using Analysis of Variance (ANOVA), and if significant effects were found, the analysis was continued with Duncan's Multiple Range Test (DMRT) at the 5% level. The results showed that a high proportion of cocoa husk resulted in higher moisture content (15.78%) and lower calorific value (3867 kcal/g), while a high proportion of peanut husk increased the calorific value to 5340 kcal/g and burning time to 84.8 minutes, but was accompanied by higher ash content (17.57%). The balanced mixture of KC_3 (50:50) and KC_4 (30:70) proved to offer the best compromise, with moisture content <10%, calorific value >4400 kcal/g, burning time >78 minutes, and ash content still within an acceptable range. Therefore, while pure peanut shell briquettes (KC_5) demonstrated the highest performance, the blended formulations (KC_3 and KC_4) provide a more sustainable balance between performance and material efficiency.*

***Keywords** - Briquettes; renewable energy; peanut shells; cocoa shells; biomass waste;*

INTRODUCTION

Biomass or organic waste can be utilized as an alternative energy source. The direct use of biomass as fuel is inefficient and causes air pollution due to smoke from combustion. Therefore, biomass needs to be processed into briquettes, which are charcoal in a specific shape produced through a compression process with the addition of a binder [1]. The benefits of the briquetting process include achieving a higher calorific value compared to direct combustion of the material and minimizing smoke formation when used [2]. Generally, the biomass material used for briquette production is coconut shells; however, based on the potential of available waste in the environment, there are numerous types of biomass materials that can be used to make briquettes.

One type of biomass with great potential for use as briquettes is cocoa husks and peanut shells. Indonesia, particularly West Nusa Tenggara, where the majority of the population earns their livelihood from agriculture, has 266,478 hectares of rice fields [3]. The area of plantation land is no less extensive than rice field land, covering 173,761 hectares, with 8,152 hectares producing cocoa and 3,754 hectares producing cashews [3]. Amidst the degradation of forests due to logging, the processing of cocoa and cashew fruits has become a new issue, generating waste that has not been optimally utilized [4]. Cocoa fruits consist of approximately 74% fruit peel, 2% placenta, and 24% seeds [5]. The cocoa fruit peel is the largest component of the cocoa fruit. The cocoa pods and pulp left after the beans are removed become a source of organic waste that causes odor and pollution in the plantation itself. As cocoa bean production increases, the amount of cocoa pod waste also increases, becoming waste for the plantation itself. Therefore, it is highly suitable to process this cocoa waste into briquettes.

In previous studies, the production of cocoa shell briquettes still had shortcomings, namely the failure to achieve the calorific value of cocoa shell briquettes in accordance with SNI standards, such as the calorific value that briquettes must have, which is 5000 cal/g [6]. Suprapti's research [7], researched cocoa fruit shells for charcoal briquettes, producing a calorific value of 4163 cal/g. Sandra [8] studied the effect of compression force on the characteristics of cocoa husk bio-briquettes (*Theobroma cacao L.*), achieving a maximum calorific value of 4,509 kcal/g. Laondi [9] investigated the impact of variations in charcoal particle size on the characteristics of cocoa husk charcoal briquettes, achieving a maximum calorific value of 4,607 kcal/g. In another study, Sinaga [10] investigated the production of briquettes from cocoa shells using cassava peel adhesive, resulting in a maximum calorific value of 4375 kcal/g. Based on this, additional materials are needed to increase the calorific value from different charcoal materials that have a high calorific value or meet the SNI standard of < 5000 kcal/g. One way to increase the calorific value of cocoa husk charcoal is by adding peanut shell charcoal as raw material for briquette production. Along with cocoa husk waste, peanut shells are also only used for their contents as food, such as salted peanuts, while the shells are generally discarded or burned when they accumulate in large quantities on the land [11].

Peanut shells contain 88.57% dry matter, 10.87% crude protein, 2.03% crude fat, 61.3% crude fiber, and 20.27% BETN. The TDN content of peanut shells is 31.7% [12]. The high dry matter content of peanut shells makes them a potential candidate for use as high-quality briquettes. Several studies on peanut shells have also shown that they meet SNI standards when used as briquettes. For example, Wahyudi [13] studied charcoal briquettes made from peanut shells through a carbonization process, yielding calorific values ranging from 5,500 kcal/g to 6,000 kcal/g. Furthermore, in 2022, Febriani [14] conducted an analysis of the quality of peanut shell charcoal briquettes using jackfruit seeds as a binder, which produced a calorific value of 5,150 kcal/gram. In 2023, Kusyanto [15] utilized peanut shells and bamboo as raw materials for bio-briquette production using the carbonization method, yielding a calorific value of 5000 kcal/g to 7000 kcal/g.

This study aims to analyze the effect of adding peanut shell charcoal to cocoa shell charcoal in briquette production on the resulting characteristics, including moisture content, calorific value, ash content, and burn time, to obtain an ideal mixture formulation with parameters compliant with SNI standards. This research provides novelty by optimizing two types of underutilized agricultural waste from West Nusa Tenggara, Indonesia, namely cocoa shells and peanut shells, which have not been combined previously in briquette production. The integration of these local biomass resources not only reduces agricultural waste but also supports the regional energy diversification program toward sustainable bioenergy utilization.

METHODS

The research method used was an experimental method using a completely randomized design (CRD) with five treatments and three replicates, resulting in 15 experimental units. Each experiment was symbolized by (K) and peanut shells were symbolized by (C). The treatments in this study used a mass ratio of cocoa shell charcoal powder mixed with peanut shell charcoal powder (KC1=100:0, KC2=70:30, KC3=50:50, KC4=30:70, and KC5=0:100). Tapioca flour was used as a binder at 10% of the raw material. The briquette dimensions used were made using a mold with a diameter of 40 mm. The charcoal powder size was 40 mesh. The parameters tested in this study were moisture content (ASTM D-3173), ash content (ASTM D-3174), calorific value (ASTM D-5865), and density/hardness. The data obtained were analyzed statistically using *Analysis of Variance* (ANOVA). If the calculated F value was ≥ the table F value, the analysis was continued with *Duncan's Multiple Range Test* (DMRT) at the 5% level.

A. Time and place of research:

The research was conducted.from March to August 2025. The research was conducted.at the Phenomena Laboratory of Mataram University and the Chemistry Laboratory of the Faculty of Agriculture, Muhammadiyah University Mataram.

B. Equipment and Materials:

The materials used in this research are cocoa husks and peanut shells. Additional supporting materials include tapioca flour (Rose Brand) as a binder. The equipment used in this research includes a briquette mold, a drum for carbonization, an analytical balance, a bomb calorimeter to measure calorific value, trays, a mortar for grinding, a 50-mesh sieve, a stove, a spatula, a desiccator, porcelain dishes, an oven to measure moisture content, a furnace to measure ash content, crucibles, sieves, pots, stirrers, beaters, bases, briquette molds, and other supporting tools such as knives, writing tools, plastic, and others.

C. Research Stages:

The research stages can be described as follows:

a. Raw Material Preparation Stage: 1) Raw Material Collection: The research began with the preparation of tools and materials. In step 1, cocoa husks and peanut shells were collected from cocoa and peanut farmers in North Lombok Regency. The materials are then dried separately to reduce their moisture content for 3 days. Other materials include an adhesive made from a mixture of tapioca flour and water. 2) Pyrolysis: Step 2 involves pyrolyzing the cocoa shells and peanut shells using a pyrolysis drum. Carbonization (*pyrolysis*) is carried out by placing cocoa shells and peanut shells separately into a metal pyrolysis drum. The pyrolysis process lasts for 4 hours until all the materials are burned and the smoke emitted from the combustion drum becomes thin. The charcoal resulting from the combustion of the materials is ground into powder and then sieved using a 50-mesh sieve. 3) Sifting: In step 3, 10 g of tapioca flour is mixed with water at a ratio of 1:10. 100 ml of water is added to 10 g of tapioca flour while heating over low heat until the adhesive is fully cooked into a gel.

b. Briquette production stage: 1) Briquette mixture production: Step 1 Sifted charcoal powder is mixed with a binder to vary the charcoal composition, namely KC_1=100:0, KC_2=70: 25, KC_3=50:50, KC_4=25:70, and KC_5=

0:100 with a ratio of charcoal (cocoa husk (K) and peanut husk (C)) 80% and binder 20%. Mixing is carried out until it becomes a mixture. 2) Briquette molding: Briquette molding aims to produce uniform briquette shapes and facilitate packaging or use. The briquette mold used is a PVC pipe with a diameter of 40 mm and a height of 50 mm. 3) Briquette drying: The molded briquettes are dried under sunlight for 4 days.

c. The testing stages for the dried briquettes include testing their characteristics, such as moisture content, ash content, calorific value, and density. The experiment was conducted with three repetitions for each treatment.

d. The next stage of the process is data analysis and conclusions: 1) Data analysis is performed by analyzing the obtained data using technical analysis and statistical analysis using *Analysis of Variance* (Anova). If the results are significant, they are further tested using *Duncan's Multiple Range Test* (DMRT) at the 5% level.

To obtain the moisture content and ash content values, mathematical calculations were performed according to Putra [16] using the following equations:

1. Moisture Content= $\frac{a-b}{a}$ x100%

Notes:
a = mass of the sample before drying (grams)
b = mass of the sample after drying (grams)

For ash content analysis according to Dewi [17] the following equation can be used:

2. Ash Content= $\frac{wo}{wd}$ x100%

Notes:
wo = sample mass after incineration (grams)
wd = sample mass before incineration (grams).

RESULT AND DISCUSSION

The results of testing and analysis of each characteristic parameter of briquettes mixed with charcoal from cocoa shells and charcoal from peanut shells at each variation of adhesive concentration are described as follows.

1. Calorific value

The results of testing the calorific value of briquettes made from a mixture of charcoal from cocoa shells and peanut shells at various raw material mixtures can be seen in **Figure 1.**

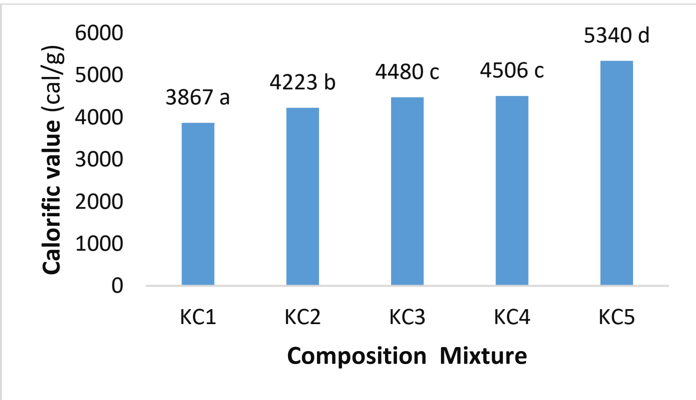

Figure 1. Calorific value (kcal/g) of briquettes produced from varying ratios of cocoa husk charcoal and peanut shell charcoal.

Figure 1 shows that variations in the composition of cocoa husk charcoal (K) and peanut husk charcoal (C) have a significant effect on the calorific value of the briquettes produced, as indicated by the different letters at the peak of the graph. The lowest calorific value was obtained in KC_1 (100% cocoa husk) at 3867 cal/g, while the highest calorific value was obtained in KC_5 (100% peanut shell) at 5340 cal/g. These results align with the characteristics of the raw materials, where cocoa husks are known to have a relatively high lignocellulose content but produce relatively low calorific values (±4163–4607 cal/g) [9]. Conversely, peanut shells have higher dry matter and lignin content, resulting in higher calorific values, ranging from 5000–7000 cal/g [15].

Increasing the proportion of peanut shell charcoal in briquettes consistently increases the calorific value. In KC_2 (70:25), the calorific value increased to 4223 cal/g, and in KC_3 (50:50) and KC_4 (25:70), the calorific values increased to 4480 cal/g and 4506 cal/g, respectively. Although the difference in calorific value between KC_3 and KC_4 is not very significant, both show that the combination of the two materials can improve briquette performance compared to the use of cocoa shells alone. This is due to the synergy between cocoa shell charcoal and peanut shells, where peanut shells increase energy density while cocoa shells continue to provide good carbon structure.

The best results were obtained with KC_5 (100% peanut shells) with a calorific value of 5340 cal/g, which exceeds the minimum standard of SNI 01-6235-2000, which is ≥ 5000 cal/g. This proves that peanut shells have greater potential as a raw material for high-quality briquettes than cocoa shells. However, the use of a mixture remains relevant for simultaneously utilizing both types of agricultural waste to improve the quality of cocoa shell charcoal briquettes, particularly in cocoa and peanut-producing regions such as West Nusa Tenggara [18].

Thus, variations in the composition of cocoa husk charcoal and peanut shells significantly affect the energy quality of briquettes. A 50:50 to 25:70 (KC_3–KC_4) combination can be considered a balanced composition, while the full use of peanut shells (KC_5) provides the best results in meeting briquette quality standards according to SNI.

2. Moisture Content

Based on the results of this study, the moisture content of briquettes made from a mixture of cocoa shell charcoal and peanut shells with varying raw material mixtures can be seen in **Figure 2.**

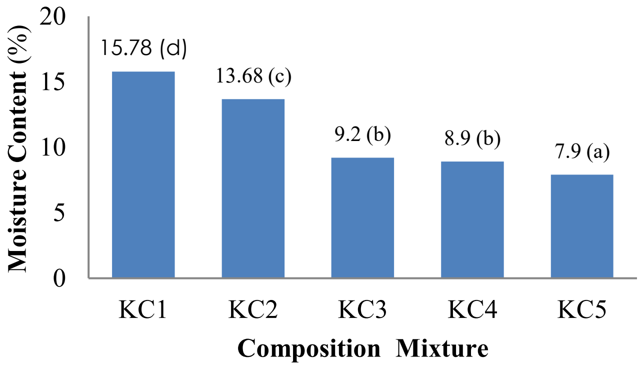

Figure 2. Moisture Content (%) of briquettes produced from varying ratios of cocoa husk charcoal and peanut shell charcoal.

Figure 2 shows that variations in the composition of cocoa husk and peanut shell charcoal have a significant effect on the moisture content of briquettes. The highest moisture content was obtained in KC_1 (100% cocoa husk) at 15.78%, while the lowest moisture content was obtained in KC_5 (100% peanut shell) at 7.9%.

The high moisture content in KC_1 is due to the hygroscopic nature of cocoa husks, which tend to easily absorb and retain moisture. This is in line with Suprapti's research [19], which reported that briquettes made from cocoa husks have a relatively high moisture content, thereby affecting combustion quality. In contrast, peanut shells have a higher dry matter content (±88.57%), resulting in briquettes with lower moisture content and better storage stability [20].

High moisture content in briquettes negatively impacts combustion quality, as the initial heat energy is used to evaporate water before the charcoal combustion process begins. This results in lower calorific value and less efficient combustion [21]. Conversely, a low moisture content (<10%) is highly recommended for producing briquettes with good quality, easy ignition, and high energy efficiency (SNI 01-6235-2000).

In the KC_3 (50:50) and KC_4 (25:70) mixture compositions, the moisture content decreased to 9.2% and 8.9%, respectively, which is close to the ideal SNI standard limit (maximum 8%). The best results were obtained in KC_5 with a moisture content of 7.9%, which meets the standard. Thus, increasing the proportion of peanut shells consistently reduces the moisture content of the briquettes while improving their quality as an alternative fuel.

3. Ash content

The results of ash content analysis in briquettes made from a mixture of cocoa husk charcoal and peanut shells with varying raw material mixtures are shown in **Figure 3.**

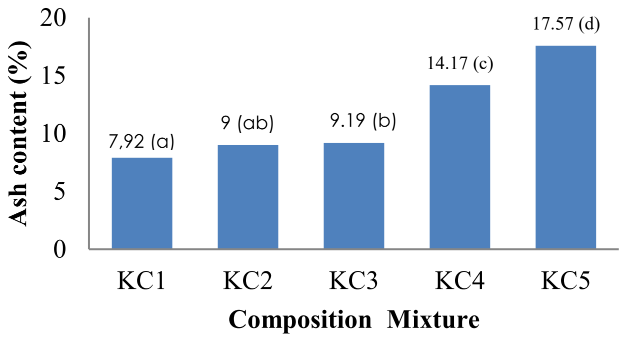

Figure 3. Ash content (%) of briquettes produced from varying ratios of cocoa husk charcoal and peanut shell charcoal.

Figure 3 shows that the composition of cocoa husk and peanut shell charcoal significantly affects the ash content of the briquettes produced. The lowest ash content was obtained in KC_1 (100% cocoa husk) at 7.92%, while the highest ash content was found in KC_5 (100% peanut shell) at 17.57%. In general, increasing the proportion of peanut shells in the mixture results in higher ash content. The ash content increases gradually from KC_2 (9%) and KC_3 (9.19%) to KC_4 (14.17%) and KC_5 (17.57%). This indicates that peanut shells have a higher content of inorganic minerals compared to cocoa shells, resulting in larger ash residues after combustion.

Ash content greatly affects the quality of briquettes. According to SNI 01-6235-2000, the maximum recommended ash content for charcoal briquettes is 8%. Therefore, only the KC_1 formulation (100% cocoa husk) meets this standard. Briquettes with high ash content tend to reduce calorific value because part of the fuel mass consists of non-combustible non-carbon components [22]. Additionally, high ash content can reduce combustion efficiency by blocking charcoal pores and hindering oxygen diffusion [23]. However, high ash content is not always detrimental, as ash can function as a combustion catalyst that maintains flame stability [24]. Therefore, the formulation of a mixture of cocoa husk charcoal and peanut shell charcoal needs to be adjusted. If the primary objective is to meet SNI standards for ash content, then a higher proportion of cocoa shells is recommended. However, if the focus is on flame duration and combustion stability, then using a larger amount of peanut shells still offers advantages, despite the trade-off of higher ash content.

The increasing ash content observed with higher peanut shell composition may be attributed to the higher mineral content, especially potassium (K), calcium (Ca), and silica (SiO_2), which remain as non-combustible residues after pyrolysis. These inorganic compounds influence the catalytic oxidation process during combustion, explaining the relatively stable flame even at higher ash levels [24].

4. Burning Time of Briquettes

This test was conducted to determine how long it takes for briquettes to burn completely. The results of the burning time of briquettes made from a mixture of cocoa husk charcoal and peanut shells in various raw material mixtures can be seen in **Figure 4.**

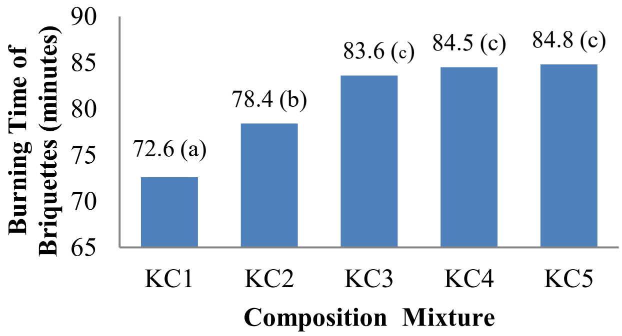

Figure 4. Burning time (minutes)of briquettes produced from varying ratios of cocoa husk charcoal and peanut shell charcoal.

Figure 4 shows that variations in the composition of cocoa husk and peanut shell charcoal have a significant effect on the burning time of briquettes. The lowest value was found in KC_1 (100% cocoa husk) at 73 minutes, while the highest value was found in KC_5 (100% peanut shell) at 84.8 minutes. Increasing the proportion of peanut shells consistently extends the burning time of the briquettes. In KC_2 (70:25), the burning time increased to 76 minutes, and further increased to 78 minutes in KC_3 (50:50). Significant increases were observed in KC_4 (25:70) and KC_5 (0:100), with burn times reaching 84.5 minutes and 84.8 minutes, respectively. These results indicate that peanut shell charcoal plays a crucial role in enhancing the combustion durability of briquettes.

The main factors affecting burn time are the fixed carbon content and volatile content of the raw material. Cocoa husks have a higher ash content and lower calorific value, resulting in a shorter burn time. Conversely, peanut shells have a higher lignin and crude fiber content, resulting in a more stable and longer burning process [25]. Additionally, the increase in burn time aligns with previous research by Wahyudi [13] and Febriani [14], who reported that briquettes made from peanut shells can burn longer than those made from cocoa shells. This is due to the denser carbon structure of peanut shells, resulting in a gradual burn that does not deplete quickly [26].

Thus, the higher the proportion of peanut shells in the mixture, the longer the burn time of the resulting briquettes. The formulations KC_3 (50:50), KC_4 (25:70), and KC_5 (0:100) can be considered optimal for producing briquettes with burn times that meet the standards for high-quality briquettes, while also supporting the use of agricultural waste as a sustainable alternative energy source. From a usage perspective, briquettes with longer burn times are highly desirable as they provide better energy efficiency and reduce the frequency of fuel replenishment during use. Therefore, careful consideration is needed in selecting the adhesive concentration within certain limits, which can serve as a simple yet effective strategy to enhance briquette performance in both household and small-scale industrial applications.

CONCLUSION

Based on the research results, it can be concluded that variations in the composition of cocoa husk charcoal and peanut husk charcoal have a significant effect on the characteristics of the briquettes produced. The lowest calorific value was found in KC_1 (100% cocoa husk) at 3,867 kcal/g, and the highest in KC_5 (100% peanut husk) at 5,340 kcal/g, where the KC5 formulation meets the SNI standard (≥ 5,000 kcal/g). The highest moisture content was found in KC_1 (15.78%) and the lowest in KC_5 (7.9%), while ash content increased with the addition of peanut shells, with the lowest value at 7.92% (KC_1) and the highest at 17.57% (KC_5). The burning time of the briquettes also increased with the addition of peanut shell composition, ranging from 73 minutes (KC_1) to 84.8 minutes (KC_5). Thus, the use of a mixture of cocoa husk charcoal and peanut shell charcoal can improve briquette quality, where the KC_3 (50:50) and KC4 (25:70) formulations provide a balance between calorific value, moisture content, ash content, and burning time, while the full use of peanut shell charcoal yields the best performance in meeting briquette quality standards. For further research, it is necessary to examine the effect of variations in adhesive concentration on briquette quality and production economics. This is important in order to determine the most efficient adhesive proportion that still meets SNI quality standards, while at the same time reducing production costs so that briquettes can be more competitive and useful at the household and small industry levels. The findings emphasize the potential of integrating local agricultural residues from cocoa and peanut production in West Nusa Tenggara to develop region specific bioenergy products that align with Indonesia's sustainable energy goals.

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