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CHARACTERISTICS OF BIOPELLETS FROM LAMTORO (*Leucanea leucocephala* Lam) AND GAMAL (*Gliricidia sepium* Jacq) AT DIFFERENT PARTICLE SIZE AND COMPOSITION

Karakteristik Biopelet dari Tanaman Lamtoro (Leucanea leucocephala Lam) dan Gamal (Gliricidia sepium Jacq) pada Berbagai Variasi Komposisi dan Ukuran Partikel

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ABSTRACT

Energy needs continue to increase, resulting in energy reserves decreasing yearly, especially those made from fossil fuels, which are non-renewable energy, so their availability is limited. Therefore, efforts are needed to find alternative energy sources that can be developed. An energy source that can be produced is biomass. Gamal (*Leucanea leucocephala*) and Lamtoro (*Gliricidia sepium*) plants are biomass often used as alternative raw materials for energy, namely biopellets, because they have high calorific value. This study aimed to determine the characteristics of biopellets from *L. leucocephala* and *G. sepium* with various compositions and particle sizes. The composition of the *L. leucocephala* and *G. sepium* raw materials is 1:1, 1:2, and 2:1 with a particle size that is passed 40 mesh retained 60 mesh, passed 60 mesh retained 80 mesh, and passed 80 mesh retained 100 mesh. Quality testing of biopellets based on SNI 8951:2020 includes density, moisture content, fly content, ash content, fixed carbon, and calorific value. The results showed that the biopellets were following SNI 8951:2020, namely the average value of density, moisture content, and ash content, for the parameters of the value of the flying substance content and fixed carbon were not in accordance. Statistics have shown that particle size significantly affects density, ash content, volatile matter, and fixed carbon. The composition affects the moisture content, fixed carbon, volatile matter content, and ash content. The best biopellets were produced in the treatment with 80 mesh particle size and 2:1 composition.

Keywords: Biomass; Composition; *L. leucocephala*; *G. sepium*; Particle Size

A. INTRODUCTION

Population growth continues to increase, causing energy needs also to grow. Fossil-based energy, such as coal, oil, and natural gas, is well-known in Indonesia and is used for generating electricity and transportation. This energy is non-renewable energy, so its availability is limited. Therefore, efforts need to be made to find abundantly available fuel. Biomass energy, which can be renewed quickly and easily obtained, is an alternative energy source currently being developed. (Zikri et al., 2018)

Biomass is organic material produced from photosynthesis in the form of products or waste. Biomass is also used as an energy source (fuel). The biomass potential that can be used as an energy source is enormous. The potential for biomass as an energy source in Indonesia is 146.7 million tons annually (Parinduri and Parinduri., 2020). Biomass energy sources are renewable, so that energy availability will be sustainable. Examples of biomass are trees, grass, tubers, agricultural waste, forest waste, and livestock manure. One of the biomass products for energy is biopellets (Parinduri and Parinduri., 2020)

The types of plants commonly used as energy sources are *G. sepium* and *L. leucocephala*. *G. sepium* and *L. leucocephala* are plants that overgrow and are highly adaptable to the environment, so they can be developed to meet energy needs (Hudaedi., 2018). As energy source plants, *G. sepium* and *L. leucocephala* have advantages, including clean, renewable, sustainable, and environmentally friendly energy. Apart from that, less ash from combustion is also produced (Cahyono et al., 2008). In several places, such as Waai Village in Ambon, South Sumatra, East Nusa Tenggara, *G. sepium* and *L. leucocephala* plants are also cultivated as energy producers (Watimmena and Imlabla., 2021; Balai PSI LHK Palembang., 2019, Prima et al., 2017). Research (Oyelere and Oluwadare., 2019) revealed that *L. leucocephala* is suitable for use as fuel because it has good properties and a high calorific value. Research (Ulhaq et al., 2021) shows that *G. sepium* is used as energy fuel for the ABC PLTU, mixed with *G. sepium*. In previous research (Ilham et al., 2022), *G. sepium* and *L. leucocephala* were used as biobriquettes. Based on this research, biomass is used as briquettes, charcoal, or as a mixture for power generation raw materials.

Biopellets are a type of solid biomass fuel. The advantages of biopellets are that they have high density and are easy to store and handle. The main factors that influence the strength and durability of biopellets are moisture content, particle size, compression conditions, amount of adhesive, and treatment after the production process (Lehman et al., 2012). Several studies related to biopellets have been carried out, including by (Mustamu et al., 2018), regarding research on biopellets from eucalyptus and gondorokeum waste producing a calorific value of 5097 kcal/kg (Istiani et al., 2021) making biopellets from candlenut shells using a mixture of sago stems and sawdust obtained a calorific value of 4182 cal/g; (Chairina et al., 2022) Biopellets from melinjo seed shell waste produce a calorific value of 17302 j/g, (Prasetyo et al., 2022) biopellets from rice husks and teak sawdust produce a calorific value of 17.28 MJ/kg.

The particle size of biopellets affects the density of the biopellets, so the smaller the particle size, the resulting density will be high and cause the resulting calorific value to be high and vice versa. If the particle size is large, the resulting density and calorific value will be low (Nuriana et al., 2022). Based on the above, it is necessary to analyze the characteristics of biopellets from *G. sepium* and *L. leucocephala* with different particle sizes and composition variations to obtain biopellets that meet the Indonesian National Standards.

B. METHODS

Material Preparation

The materials used in this research were two types of shrubs, which were *L. leucocephala* and *G. sepium,* and a tapioca adhesive. *L. leucocephala* and *G. sepium* are chopped into flakes/chips and dried until the moisture content is less than 12%. After that, the chips were ground using a hammer mill and sieved to obtain particles as material for making biopellets. The particle sizes used in this research were 40 mesh passes retained 60 mesh, 60 mesh passes retained 80 mesh, and 80 mesh passes retained 100 mesh. The treatments in this research included particle size and composition variations between *L. leucocephala* and *G. sepium*. Table 1 shows the treatments in this study.

Table 1. Conceptual matrix of treatment in research

Particle Size	***L. leucocephala* composition: *G. sepium***				
	1:1	**1:2**	**2:1**	**1:0**	**0:1**
40-60 mesh	A1	A2	A3	A4	A5
60-80 mesh	B1	B2	B3	B4	B5
80-100 mesh	C1	C2	C3	C4	C5

Mixing Process

Tapioca flour was weighed at 5% of the raw material per unit weight and then mixed with hot water. Next, the adhesive mixture was mixed with *G. sepium* and *L. leucocephala* particles with a 1:1, 1:2, 2:1, 1:0, and 0:1 composition for each particle size treatment.

Molding and Drying Process

The dough mixed well was weighed ± 1.2 g and then molded using a manual pellet press. The tool specifications are 12 mm in diameter and 13 mm long with a single hole. After that, the biopellets were dried in an oven at a temperature of 65°C for 24 hours (Lamanda et al., 2015).

Testing

Biopellets produced from various variations in particle size and composition were tested, including density, moisture content, ash content, volatile matter, fixed carbon, and heating value based on SNI 8951:2020 (BSN, 2020) (Table 2).

Table 2. Standard specifications for biomass pellets for power plants

Parameters	Min/max units	Quality	Test Method
Density	g/cm3, min.	0.5	SNI 8021
Ash content	% weight, max.	4	SNI 06-3730
Moisture content	% weight, max.	12	SNI 01-1506
Volatile substance levels	%, max.	70	SNI 06-3730
Fixed carbon content	%, min.	14	SNI 06-3730
Net calorific value	kcal/kg, min.	4040	SNI 01-6235

Data analysis

All treatments in this study, as in Table 1, were carried out five times. Next, it was analyzed using the Split-Plot sample test (Islam et al., 2000) by comparing biopellets with different percentages of mixture composition and particle size ratios.

C. RESULTS AND DISCUSSION

Density

The size, level of homogeneity of the materials making up the biopellets, and the pressure during pressing influence the density (Damayanti et al., 2017), where density is the ratio between the mass and its volume. Figure 1 shows the results of density calculations in this study. Biopellet density based on particle size and composition of the *L. leucocephala* and *G. sepium* mixture ranges from 0.58 g/cm³ to 0.73 g/cm³. Based on particle size, the highest density value was obtained at particle size 80-100 mesh (0.74 g/cm³), while the lowest density value was obtained at particle size 40-60 mesh (0.58 g/cm³).

Based on the composition of the *L. leucocephala* and *G. sepium* mixture, the highest density value was obtained at a ratio of 0:1 (0.74 g/cm³). In comparison, the lowest density value was obtained at a ratio of 1:1 (0.58 g/cm³). The density values obtained experience fluctuations. The research showed that each treatment complied with SNI 8951:2020 (0.5 g/cm³). From the results of statistical tests, it was found that particle size and the interaction between particle size and composition had a p-value (0.000) ≤0.05, which means that particle size and the interaction between particle size and composition had a significant effect on density.

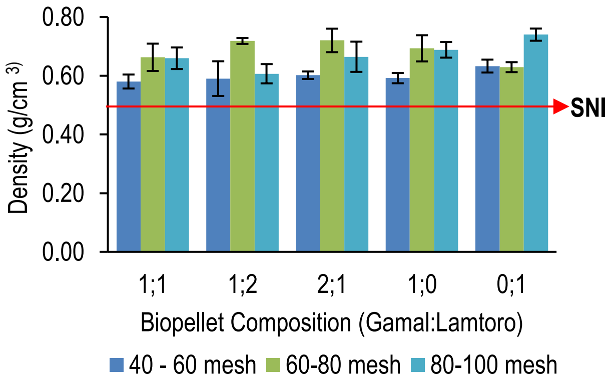

Figure 1. Biopellet density based on particle size and composition of the *L. leucocephala* and *G. sepium* mixture

Particle size 60-80 mesh provides the best density for making biopellets compared to other particle sizes. Biopellets from *G. sepium* have a higher density than biopellets from *L. leucocephala* because the specific gravity of *G. sepium* (0.6-0.9) is higher than that of *L. leucocephala* (0.6-0.8). According to Winata (2013), specific gravity can influence the density of biopellets. The density itself is influenced by the particle size of the material, where the coarser or larger the particle size, the lower the density. This is because the pores produced are large and filled with air, so the resulting density is low, and the resulting biopellets will stretch and vice versa. This statement is supported by research by Munawar et al. (2014), which states that several factors that influence biopellet density are particle size and pellet size. A coarser particle size and a smaller specific gravity result in a lower density.

Moisture content

Moisture content is the moisture content contained in the material expressed in percent. Moisture content is an important parameter determining pellet quality (Thoyeb et al., 2021). The results of moisture content calculations in this study can be seen in Figure 2. Figure 2 shows moisture content value based on particle size and composition of the *L. leucocephala* and *G. sepium* mixture, ranging from 7.57% to 9.17%. Based on particle size, the highest moisture content value was obtained at particle size 40-60 mesh (9.17%), while the lowest moisture content value was obtained at particle size 60-80 mesh (7.57%). Based on the comparison between *L. leucocephala* and *G. sepium*, the highest moisture content value was obtained at a ratio of 1:1 (9.17%). In contrast, the lowest moisture content value was obtained at a ratio of 0:1 (7.65%). Combination factors have an authentic influence on moisture content. The 1:0 combination is not significantly different from the 1:2 and 2:1 combinations but is substantially different from the 0:1 and 1:1 combinations. The 1:2 combination is not significantly different from the 2:1 and 1:1 combinations. The research results showed that the moisture content values for all treatments met SNI 8951:2020 (≤12%).

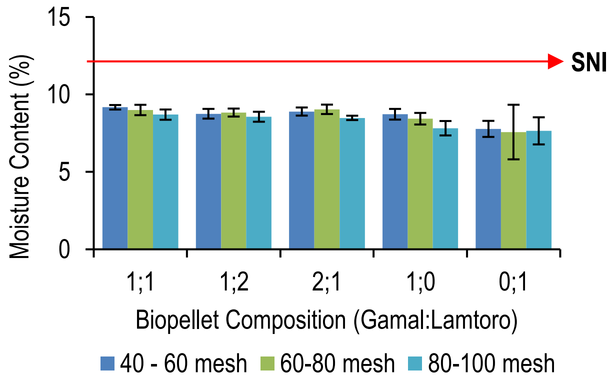

Figure 2. The moisture content of biopellets based on particle size and composition of the *L. leucocephala* and *G. sepium* mixture

The increase in the *L. leucocephala* mixture shows increased moisture content. This is because *L. leucocephala* powder has a higher moisture content than *G. sepium* powder, so adding *L. leucocephala* powder will increase the moisture content. In research, Qadri et al. (2018) stated that the higher the addition of sawdust to biopellets, the higher the moisture content obtained. Density also influences moisture content, where the higher the density, the lower the moisture content produced. The fine particles can fill empty pores, reducing the water molecules in the pores. In this study, the density of *L. leucocephala* was lower than that of *G. sepium*.

Volatile Substance Level

The volatile matter content is calculated by the percentage of weight lost when the biopellets are heated without air contact (Iriany et al., 2023). The results of the test for volatile matter levels in this study can be seen in Figure 3. The research results showed that the levels of volatile substances based on the particle size and composition of the *L. leucocephala* and *G. sepium* mixture ranged from 76.02% - 80.71%. Based on particle size, the highest level of volatile matter was obtained at particle size 40-60 mesh (80.71%), while the lowest value of volatile matter content was obtained at particle size 60-80 mesh (76.03%). Based on the comparison between *L. leucocephala* and *G. sepium*, the highest value of volatile matter content was obtained at a ratio of 1:2 (80.71%). In contrast, the lowest value for vapor content was obtained at a ratio of 1:0 (76.03%). Particle size and combination and the interaction between particle size and combination significantly affect the level of evaporated substances. The results showed that the 2:1 combination was not significantly different from the 1:1 combination but was substantially different from the 1:0, 1:2, and 0:1 combinations. The 1:2 combination is not substantially different from the 0:1 combination but is significantly different from the 1:0, 2:1, and 1:1 combinations. Based on Figure 3, it can be seen that the levels of volatile substances produced are high, so they do not meet SNI 8951:2020 (≤70%).

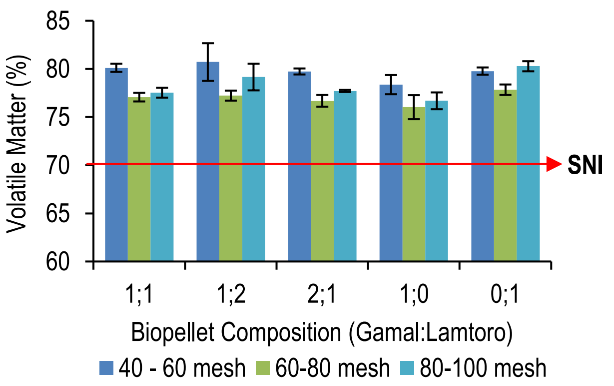

Figure 3. Volatile content of biopellets based on particle size and composition of the *L. leucocephala* and *G. sepium* mixture

Ash Content

The inorganic substances remaining after the combustion process are known as ash content. The principle of ash content determines the ratio between the amount of material remaining and the amount of material burned (Thoyeb et al., 2021).

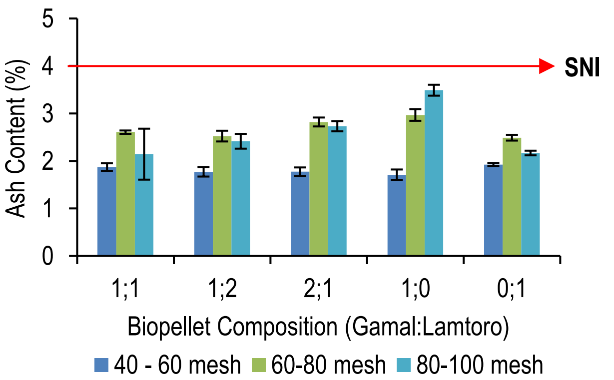

Figure 4. Biopellet ash content based on particle size and composition of the *L. leucocephala* and *G. sepium* mixture

The results of the ash content test in this study can be seen in Figure 4. The ash content value based on particle size and composition of the *L. leucocephala* and *G. sepium* mixture ranged from 1.71% – 3.49%. Based on particle size, the highest ash content was obtained at particle size 80-100 mesh (3.49%), while the lowest ash content value was obtained at particle size 60-80 mesh (1.71%). Based on the comparison between *L. leucocephala* and *G. sepium*, the highest ash content value was obtained at a ratio of 1:0 (3.49%). In contrast, the lowest ash content value was obtained at a ratio of 1:2 and 2:1 (1.77%). Particle size and combination have a significant effect on ash content. Based on Figure 4, it can be seen that the ash content produced meets SNI 8951:2020 (≤4%). The ash content values obtained in this study had large particle sizes, producing less ash content compared to smaller particle sizes. This aligns with research by Alfajriandi (2017), which states that the smaller the particle size, the higher the ash content produced. The size and pressure are factors in the ash content of the biopellet, so the finer the particle size, the lower the ash content produced.

Fixed Carbon

Fixed carbon content can be defined as residual biomass carbon other than evaporated substances and ash. Determination of carbon content aims to determine the value or magnitude of the pure carbon content contained therein (Maulana et al., 2017). The results of the bonded carbon content test in this research can be seen in Figure 5.

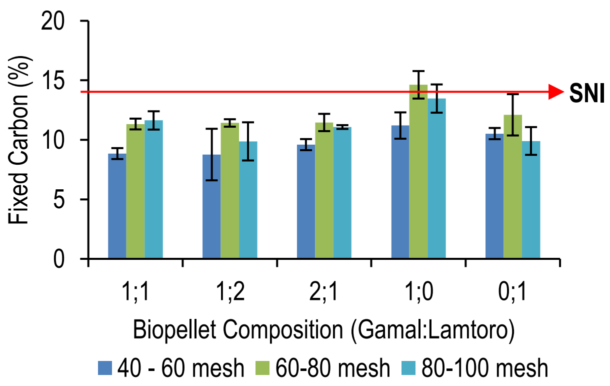

Figure 5. Biopellet fixed carbon content based on particle size and composition of the *L. leucocephala* and *G. sepium* mixture

The research results show that the fixed carbon content value based on particle size and composition of the *L. leucocephala* and *G. sepium* mixture ranges from 8.76% - 14.62%. Based on particle size, the highest fixed carbon content was obtained at particle size 60-80 mesh (14.62%), while the lowest fixed carbon content value was obtained at particle size 40-60 mesh (8.76%). Based on the comparison between *L. leucocephala* and *G. sepium*, the highest ash content value was obtained at a ratio of 1:0, namely 14.62%. In contrast, the lowest value for volatile matter content was obtained at a ratio of 1:2, 8.76%. Particle size and combination have a significant effect on the fixed carbon content. The 1:2 combination is not significantly different from the 1:1, 2:1, and 0:1 combinations but is substantially different from the 1:0 combination. The 1:0 combination is significantly different from other combinations. Based on Figure 5, it can be seen that the fixed carbon content produced is only *L. leucocephala* with particle size 40-60 mesh, which meets

SNI 8951:2020 (≥14%), while the other treatments do not meet SNI 8951:2020. This is thought to be due to the high levels of evaporating substances, which means that the carbon content bound to the biopellets is low. This opinion is supported by research conducted by Lamanda et al. (2015), which states that high levels of fixed carbon have low levels of volatile matter and ash and vice versa.

Calorific Value

Calorific value is the heat released from the combustion of a certain amount of fuel (mass). The products are ash, CO_2, SO_2, nitrogen, and water, excluding water that becomes steam (Damayanti, 2017). The higher the calorific value indicates, the better the fuel quality. The results of the calorific value test in this research can be seen in Figure 6.

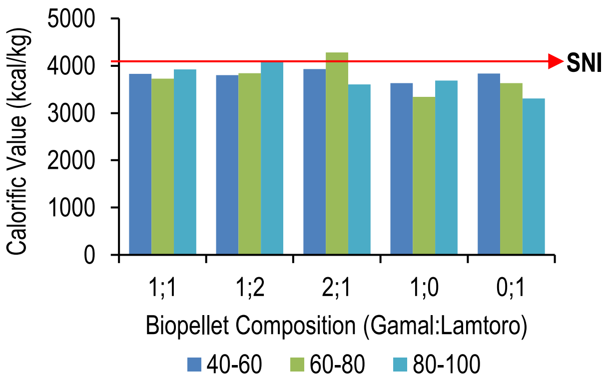

Figure 6. The calorific value of biopellets based on particle size and composition of the *L. leucocephala* and *G. sepium* mixture

The research results show that the calorific value based on particle size and composition of the *L. leucocephala* and *G. sepium* mixture ranges from 3309 kcal/kg to 4279 kcal/kg. Based on particle size, the highest heating value was obtained at pass particle size 60-80 mesh (4279 kcal/kg), while the lowest heating value was obtained at particle size 80-100 mesh (3309 kcal). Based on the comparison between *L. leucocephala* and *G. sepium*, the highest calorific value was obtained at a ratio of 2:1 (4279 kcal). In contrast, the lowest calorific value was obtained at a ratio of 1:0, 3309 kcal/kg. The calorific value produced in this study was not significantly different. Based on Figure 6, it can be seen that the calorific value produced is only a 2:1 ratio with the particle size 60-80 mesh and 1:2 with particle size 80-100 mesh, which meets SNI 8951:2020 (≥4040 kcal/kg). Other treatments do not meet SNI 8951:2020. Mixing *L. leucocephala* and *G. sepium* with a fine particle size increases the calorific value of the biopellets in this research. The moisture content influences the calorific value in the raw materials and adhesive used because if the moisture content in the raw materials and adhesive used is small, the calorific value and combustion rate produced will be higher. Still, if the moisture content is high, the calorific value and combustion rate will be higher. getting lower (Halawa and Harjanti, 2021). The calorific value of biopellets uses SNI 8951-2020, where the biopellets produced are used as fuel for steam power plants (PLTU), biomass power plants (PLTBm) with utility quality (low reactive levels towards boilers).

D. CONCLUSION

Based on the results of the research carried out, it can be concluded that the characteristics of biopellets from *L. leucocephala* and *G. sepium* have values for moisture content, density, and ash content that meet the standards. Indonesian National. Meanwhile, the fixed carbon content, volatile substances, and heating values do not meet the standards. Indonesian National. Particle size significantly affects density, ash content, volatile matter, and fixed carbon. Meanwhile, the combination of *L. leucocephala* and *G. sepium* affects moisture content, fixed carbon, volatile matter content, and ash content. The best biopellet are obtained with particle sizes 60-80 mesh. A composition of two parts of L. leucocephala and one part of G. sepium would provide a calorific value of 4279 kcal/kg.

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