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Analysis of Wood Pellet Quality from Calliandra Callothyrsus, Gliricida Sepium, and Sawdust as New and Renewable Energy

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Abstract Wood pellets are an new and renewable energy sources evolved in several developed countries such as Europe, America and Japan. Raw materials of the pellets can be obtained from various types of biomass, including agricultural waste and various types of wood. The purpose of this study is to analyze the quality of the wood pellet from *Calliandra Callothyrsus, Gliricida Sepium*, and sawdust waste. The pelleting method is applied in creating the pellet by utilizing a Russian-made pellet machine with a capacity of 500 kg in a day. In this case, the quality of the wood pellets is identified from physical and chemical test results. It is then adjusted to the SNI 8021-2014[c] standard quality. Physically, the test variables identified are pellet diameter, pellet length, L/D ratio, moisture content, particle density, bulk density, combustion rate, and calorific value. The results of pellets' physical analysis demonstrate homogeneous shapes and sizes, and the water content, density, and calorific value that have satisfied the SNI standard. In terms of calorific value, the wood pellet from *Calliandra Callothyrsus* provides the highest caloric with 4387 cal/g compared to the other sources. It is followed by *Gliricida Sepium* with 4351 cal/g. Then, Sawdust is the lowest calorie around 4206 cal/g. From the chemical point of view, the quality of the wood pellets is able to be identified due to ash content, levels of flying matter, and the amount of carbon bound based on ASTM D. 5142-02. The basic material type influences the amount of ash content in the wood pellet. The higher the ash content is, the poorer the quality of the pellet is. Meanwhile, The highest ash content is obtained in *Gliricida Sepium* which is 1.11%. This could be inversely proportional to the proportion of carbon bound. The higher the amount of carbon bound is, the higher the calorific value is. In fact, the better the quality of the wood pellet is. The highest amount of bound carbon was found in wood pellets of *Calliandra Callothyrsus*, which was 10.83%. Overall, the three types of the wood pellet fulfill the quality of SNI standards. However, the best quality wood pellets are wood pellets made of *Calliandra Callothyrsus*

Keywords: renewable energy, wood pellet, calorific value

1. Introduction

An energy crisis is caused by massive use of energy. The crisis has become a threat to society because of its dependence on fossil energy for decades. Serious problems have emerged such as the depletion of petroleum reserves followed by the instability of petroleum prices and the emergence of greenhouse gas pollution. The greenhouse gas pollution causes damage to the ozone layer which has an effect on environmental damages. Currently the natural destruction is the main focus of various aspects in science areas. It is necessary to develop and implement new and renewable energy to minimize the risk level.

The alternative and sustainable energy sources attract a lot of attention from various groups. This energy is expected to be able to meet future energy needs because of its abundant availability and environmentally friendly. Renewable energy sources include biomass, solar energy, wind energy, tidal energy, ocean wave energy, and OTEC (Ocean Thermal Energy Conversion) [1]. Biomass is one of sustainable energies from biological materials or living organisms such as wood, agricultural waste, and forest residues. Wood is an alternative energy commonly used since ancient times. But the characteristics of wood are less favorable. Because, it produces a lot of smoke and ash, high water content, and low heat. To minimize these conditions, technological innovations in making wood pellets made from wood as a substitute for fuel.

Many researches have been done related to the usage of biomass as a renewable sources of energy. Among the results of research conducted by Lubis et al [2]. making wood pellets from peanut shells has a calorific value (4644 kcal / kg). This wood pellet has a higher heating value than a mixture of peanut shells and bagasse wood. The various types of wood frequently utilized as wood pellets are *Acacia wrightii* and *Ebenopsis ebano*. The usage of this wood species as an unprocessed material for pellets because it has a high density, low ash content, high heating value, and its quality meets the international standard of wood pellets [3].

The Pellet made of timber is widely used in developed countries such as Europe, America and Germany. The advantages are plentiful availability, short renewal periods, low levels of ash and toxic substances, and relatively high heating value. This is supported by research conducted by Acda and Devera [4], when wood pellets are burned producing low pollution emissions. In addition, the lumber pellets have a good quality if they are used as biofuels [5]. Therefore, it is important to identify the quality of wood pellets from various types of renewable energy sources that are environmentally friendly. The identification is carried out to optimize the benefits of wood and wood waste.

2. Research Method

The fabrication of wood pellets uses several sources of biomass, including *Calliandra Callothyrsus, Gliricida Sepium*, and sawdust. Sawdust comes from wood industry residues from various types of wood. These three materials are abundant and have a short renewal period.

Figure 1. Raw materials for making wood pellets: left) *Calliandra callothyrus* trees; middle) *Gliricida sepium* trees; and right) sawdust waste

Raw materials of the wood pellet are processed utilising two machines, including the chopper and the pelleting machine. The materials in the form of wood have to be changed firstly into powder particles by applying the chopper machine. The powder is then treated using the pelleting machine (production capacity of 500 kg/day) into wood pellets. These pelleting activities are an innovation of

biomass compaction technology, where wood particles are transformed into more compact solids.

(a) **(b)**

Figure 2. Wood Pellet Equipment (a) Wood Chopper Machine (b) Pelletting Machine

The wood pellets were tested for their physical and chemical properties by several methods in accordance with the desired characteristics. Physically, measurement of pellet length and diameter using the European analysis standard EN 16127: 2012, water content using ASTM D. 3173, particle density and bulk density with EN 15150: 2012 and EN 15103: 2010, and heating values using the ASTM D. test standard. 5865. Meanwhile, testing chemical properties such as ash content, levels of flying matter, and the amount of carbon bound apply the ASTM D. test standard 5142-02. Then, the results of all tests are compared with the standard SNI 8021-2014c wood pellet.

3. Results and Discussion

Processing of *Calliandra Callothyrsus, Gliricida Sepium wood,* and sawdust into wood pellets was successful. Physically, the shape and size of the pellets fabricated from the three types of materials are homogeneous. The diameter and length of each pellet can be seen in table 1. In addition, each wood pellet has different color characteristics from each other (Figure 3). Where the color of wood pellets from sawdust is the darkest (dark brown), while the lightest color is *Calliandra Callothyrsu*s wood (light brown). The color difference occurs due to distinctions in each element characteristic contained in the source of primal materials. The majority sources of the sawdust are identified from mahogany wood. The mahogany wood has the characteristic darkbrown.

In terms of the physical characteristics, the three varieties of wood pellets have fulfilled SNI standards (table 1). The wood pellet density test results demonstrated that the highest wood pellet density from *Calliandra Callothyrsus* wood was 1.32 g / cm3. The density rate of a substance is influenced by the kind and characteristics of the wood used [6]. Physical properties such as density, moisture content and pellet length will affect its mechanical endurance [5]. This will facilitate the handling, storage and transportation [7]. In addition, the density also has an impact on the heating value produced (Figure 4). The higher the density is, the higher the heating value is

Figure 3. Wood pellets from various types of raw materials

Table 1. Test results of wood pellet physical properties

Control Variable	SNI Standard	*Calliandra calothyrsus*	*Gliricidia sepium*	Sawdust
Diameter (mm)	-	6,43	6,37	6,41
Lenght (mm)	-	46,5	44,9	37,4
L/D	-	7,23	7,05	5,83
Moisture Content (%)	Maks 12	5,13	5,62	5,23
Particle Density (g/cm^3)	Min. 0,8	1,32	1,25	1,24
Bulk Density (kg/m^3)	-	739,2	633,6	624
Calorific Value (Cal/g)	Min. 4000	4387	4351	4206
Combustion Rate (gr/minute)	-	11,73	12,10	14,33

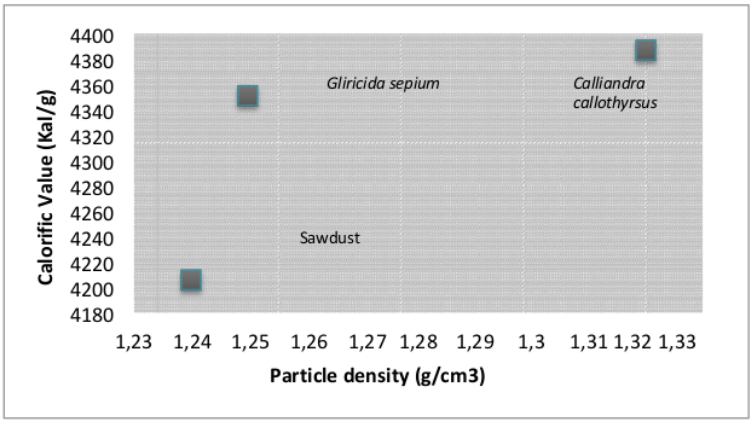

Figure 4. Graph of relationship between particle density and wood pellet calorific value

Density is the ratio of mass per volume. The higher the density is, the denser a component is. In other words, the smaller the porosity that is formed when the density is high. So that, the amount of heat produced will also be higher because the element takes longer to burn out.

Furthermore, a chemical identification was carried out with a proximate analysis. the analysis results indicated that the lowest moisture content of wood pellets was found in *Calliandra callothyrsus*, around 5.13%. The value of water content affects the amount of smoke produced by wood pellets. The higher the water content is, the more smoke is produced [7]. The resulting smoke caused by combustion is first focused on the evaporation of water in the pellet [8]. Consequently, low water content will point to good quality wood pellets.

Table 2. Test results of the chemical properties of wood pellets

Control Variable	SNI Standard	*Calliandra calothyrsus*	*Gliricidia sepium*	Sawdust
Ash Content (%)	Maks. 1.5%	0.91	1.11	0.74
Volatile Matter (%)	Maks. 80%	83.13	82.96	84.39
Fix Carbon (%)	Min. 14%	10.83	10.31	9.64

The amount of ash contained in wood pellets also has an effect on the quality of the pellet. It is a residual combustion process that does not have carbon elements and has no heating value. The amount of ash content will affect the flying substances produced. Where the lower the ash content, the higher

the amount of flying substance in wood pellets (Table 2).

The quantity of ash, water content, and flying substances can affect the number of carbon bound to the wood pellet. The amount of carbon bound is directly proportional to the value of the heat produced (Figure 5). The higher the carbon content is bound, the higher the heat value. Bonded carbon is influenced by the number of non- carbon compounds that evaporate during the combustion process [9]. From the results of the study, the highest carbon bound in *Calliandra callothyrsus* wood was 10.83% with a total heat of 4387 cal/g.

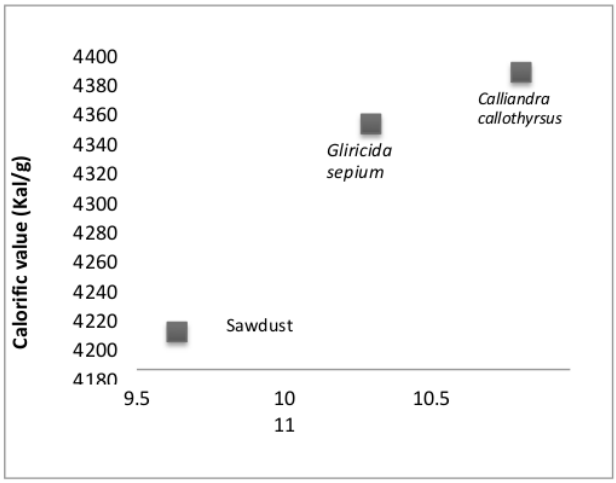

Figure 5. Graphic Relationship between the amount of carbon bound and the caloric value of wood pellets

Overall, a heating value is greatly affected by physical and chemical properties of wood pellets. The heating value synergizes with the amount of heat produced by the material during the combustion process. In addition to the particle density, the amount of water content, ash content, and bound carbon which directly exert influence on the results of the heating value.

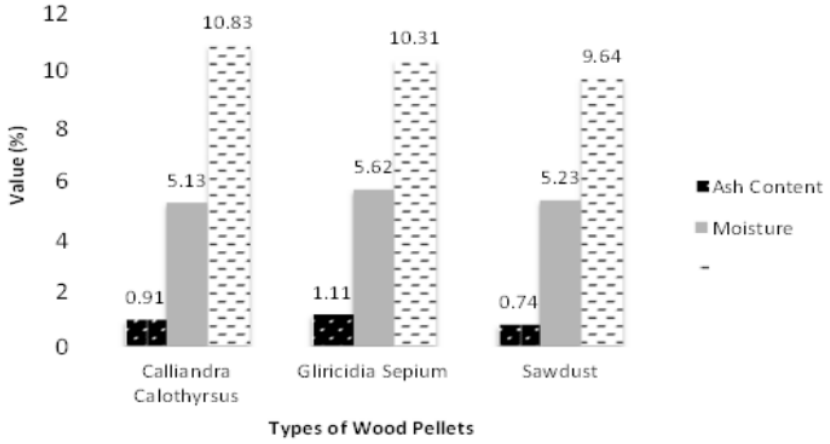

Figure 6. Percentage diagram of proximate analysis of three types of wood pellets

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