

Characteristics of Ampel bamboo as a biomass energy source potential in Bali

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Abstract. Currently, non-renewable fossil energy dominates utilization of the world energy need for many applications. Efforts has been developed to find alternative renewable energy sources, due to fossil energy availability is diminishing. And one of renewable energy source is from biomass. The aim of this research is to determine characteristics of the Ampel bamboo (*Bambusa vulgaris*) as an energy potential of biomass. The Ampel bamboo's characteristics possessed are evaluated based on its chemical composition; moisture, volatile, ash, and fixed carbon through proximate analysis; and also carbon, hydrogen and nitrogen content through ultimate analysis. From the Thermo-gravimetric analysis (TGA) indicates that Ampel bamboo contains of about 18.10% hemicelluloses, 47.75% cellulose and 18.86% lignin. While from the ultimate analysis results in the content of carbon, hydrogen, and Nitrogen of Ampel bamboo are 39.75%, 5.75% and 0% respectively. With such characteristics, it indicates that Ampel bamboo has an attractive potential as a renewable energy source.

Keywords: Biomass, bamboo, characteristics, potential, renewable energy

1. Introduction

Currently, fossil fuels, which are non-renewable energy sources, are major energy sources of the world for many application sectors. Even more than 80% of the global total energy is obtained by burning fossil fuels, which 58% are consumed by the transport sector [1]. Petroleum is still predicted to dominate the world's primary energy mix by 2050. In Indonesia, fossil fuels contribute for 94% of the national energy mix, with proportion of 47% oil-based, 21% natural gas and 26% coal [2]. However, the availability of fossil-based energy could not compete with the growth of energy consumption by an average of 7% per year [2]. To anticipate shortages or energy crisis in the future, it has been intensively done much effort to look for alternative energy sources such as water, wind and solar energies and energy from biomass. All types of these energies are renewable energy and are easy to find in Indonesia.

In Indonesia, source of biomass energy has a promising prospect due to the amount is abundant with high quality and environmentally friendly. Biomass is biological material produced or material obtained from plants containing lignin and cellulose so called material lignocelluloses. Biomass energy is the only renewable carbon energy with low sulphur, ash, and nitrogen contents as well as CO₂ emissions are close to zero [3]. Utilization of biomass as an energy source can be directly done through combustion to produce heat or be indirectly used after converting to various forms of biofuels [4, 5] either in the form of a solid, liquid or gas [6]. This conversion process can be undertaken through the pyrolysis process, gasification and fermentation of organic material. This last method is



commonly used for producing biogas [7]. Biomass has been widely applied in various fields. Their implementation depends on the chemical composition and physical characteristics of the macromolecules of the biomass [8]. Xingxing Gu et al [9] utilized bamboo biomass to manufacture activated carbon that is used as a cathode material of Li-S battery. Huang T et al [10] produced also bamboo activated carbon as a cathode material for super capacitor [10]. Biomass is also used to produce activated carbon and applied for energy storage. Here, activated carbon behaves as an adsorbent for adsorption of methane using adsorbed natural gas (ANG) technology. Coconut shell [11], sorghum and wheat [12] and sugarcane molasses [13] are some examples of biomass converted into activated carbon and used as adsorbent for ANG technology. Longbo Jiang X Y et al [14], investigated pellets made of straw biomass mixed with plant waste. It is concluded that mix of straw and plant waste can produce good quality pellets. Converting of biomass into fuel is summarized by H Zayed et al [15]. In their study is mentioned that ethanol produced by lignocelluloses biomass has some advantages compared to ethanol produced by edible sources (sugars and starch). Lignocelluloses biomasses are rich in carbohydrates and available with low and stable price. In addition, they are mainly waste materials and non-competitive with food chain. Those research indicate that biomass have become an interesting topic investigated in order to provide alternative energy source in the future.

Ampel bamboo (*Bambusa vulgaris*), as shown in Figure 1, is a biomass that could potentially be used as a source of energy in Bali, Indonesia. This bamboo is very easy to find in almost all districts in Bali, even more this bamboo is also well cultivated in a few region. Potential energy produced by biomass depends on the chemical compositions and properties of the biomass raw material used. In this study, the chemical compositions and properties of Ampel bamboo and its potential as a renewable alternative energy source were evaluated.



Figure 1. Ampel bamboo

2. Method

2.1. Material

The studied bamboo in this research is Ampel bamboo (*Bambusa vulgaris*). It is collected from the area around Petang district, Badung regency, Bali. Tests conducted include the chemical compositions, proximate and ultimate tests. Bamboo is cut to small pieces specimens (5 x 5 mm), dried under the sunlight for 6 days. Specimens are hence dried in the electric furnace at temperatures of 80°C for 1 hour. The drying process in the electric furnace is repeated until there is no weight change of the specimens. Subsequently, the specimens were formed into powder and prepared each 10 grams for chemical compositions, proximate and ultimate tests.

2.2. Apparatus

The equipment used to determine of carbon, fixed carbon, volatile, ash and moisture contents was Thermo-Gravity Analysis (TGA) 701 machine which is based on ASTM D7582MVA method. Ultimate test was carried out using a CHN628S machine based on ASTM D7582 Biomass. This test is performed to determine the content of carbon, hydrogen and nitrogen. The chemical composition (lignin, hemicellulose, cellulose and silica) is performed using analysis of Van Soest. This method is also known as the USDA (United State Department of Agriculture).

3. Results and discussion

The chemical and properties data of Ampel bamboo are shown in Table 1, Table 2 and Table 3. In order to make a comparison, the properties of coal and common biomass data, which is summarized by Stanislav V V et al [6], is presented in Table 4. From Table 1 it can be seen that Ampel bamboo contains of 47.75% cellulose, 18.10% hemicellulose, 18.86 lignin, and 1.78% silica. According to Li et al [16] and Dence C W [17], in general, the content of alpha cellulose and lignin of bamboos are in the range 40-50% and 20-26% respectively. The cellulose composition of Ampel bamboo is currently on such range, but it is slightly lower for its lignin content. Meanwhile, it has low content of silica. Silica is impurity and undesired in combustion process. Low silica content can also reduce erosion-abrasion and slagging problem during biomass processing. With such chemical compositions, Ampel bamboo has good potential as a source of energy.

Table 1. Chemical compositions of Ampel bamboo.

Sample	Hemi cellulose (%)	Lignin (%)	Cellulose (%)	Silica (%)
Ampel bamboo	18.10	18.86	47.75	1.78

Table 2. Proximate analysis of Ampel bamboo.

Sample	Moisture (%)	Volatile (%)	Ash (%)	Fix Carbon (%)
Ampel bamboo	7.61	74.30	8.69	9.41

Tabel 3. Ultimate analysis of Ampel bamboo.

Sample	C (%)	H (%)	N (%)
Ampel bamboo	39.751	5.752	0

Proximate analysis of Ampel bamboo show that it contains of 7.61% moisture, 74.30% volatile, 8.69% ash and 9.41% fixed carbon. All of these values are included in the range of common biomass values compiled by Stanislav V V et al, as shown in Table 4. Compared with coal, Ampel bamboo has higher volatile but lower fix carbon and carbon. High volatile cause a low ignition temperature; faster oxidation of volatile than char can increase the burning of which produces better and faster burnout material with a lower unburned carbon in the ash [18]. In addition a high volatile content in the biomass provide a more stable flame for mixed fuel [19]. However, combustion of high volatile biomass content is fast, difficult to control and require a larger reactor volume to obtain complete combustion and low emission of pollutants such as CO [20]. Ampel bamboo contains of 8.69% ash which is compared to ash content of common biomass (0.1 - 34.3), as shown in Table 4, it is relatively low. This is an advantage for yielding higher quality of fuel because it can increase the heating value and can be easier in conversions of thermochemical and biochemical [21].

Tabel 4. Proximate and ultimate analysis of coal and common biomass, summarized by Stanislav V V et al [6].

Sample	Proximate (%)			Ultimate (%)			
	Moisture	Volatile	Ash	Fix Carbon	C	H	N
Coal	0.4 - 20.2	12.2 - 44.5	5.0 - 48.9	17.9 - 70.4	62.9 - 86.9	3.5 - 6.3	0.5 - 2.9
Biomass	2.5 - 62.9	30.4 - 79.7	0.1 - 34.3	6.5 - 35.3	42.2 - 60.5	3.2 - 10.2	0.1 - 12.2

The lower carbon content of Ampel bamboo is an advantage in reducing CO₂ emissions during biomass conversion. Carbon dioxide constitutes the main agent of global warming among greenhouse gas emissions, despite that its global warming potential is 25 and 300 times weaker than the CH₄ and N₂O respectively [22]. On the other hand, a low carbon content and higher proportion of H and O of biomass resulted in reduction of energy values of biofuels compared to fossil fuel. This is because C-O and C-H bonds have lower energy contained than C-C bonds. The results of ultimate analysis also showed that the nitrogen content of Ampel bamboo is zero. It is also very advantageous in the combustion process, as it can reduce emissions of NO_x (NO, NO₂), N₂O, ammonia (HN₃) and pollution of ozone [18].

4. Conclusion

Biomass is a renewable energy source with a promising prospect. Ampel bamboo is one of biomass with qualified chemical composition and properties as a source of energy. Low ash, nitrogen, silica and moisture contents and high volatile content of Ampel bamboo make it has potential for producing a better quality fuels and friendly environment. In addition, Ampel bamboos are very easy to find due to they thrive and well grow in almost all districts in Bali.

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