FRIM
TIMBER TECHNOLOGY BULLETIN
NO. 108, 2021
ISSN: 139-258

# BAMBOO PELLET: ITS POTENTIAL AND APPLICATIONS

Rafidah J, Puad E, Mahanim S @ MA & Shaharuddin H

## INTRODUCTION

Demand for the production of solid fuel such as pellet, charcoal and briquettes from biomass materials has increased due to the tremendous interest to replace the consumption of fossil fuels These solid fuels are produced with the intention to reduce the dependency on the fossil fuels resources (Sette et al. 2016). Recently, the market for pellets is increasing rapidly for domestic applications as well as for combined power and heat generation. In general, biomass materials in original form are very difficult to handle, transport and store due to their high moisture content, low bulk density and irregular shape or size where the transport efficiency and storage space are very depending on the bulk density (Liu et al. 2013).

Biomass pellets are one of the alternative energies that have excellent properties. Turning biomass materials into pellets via pelletizing process could reduce material waste and generate high value-added products. They could enhance the bulk density with regular shape and size and have low moisture content that would make them easy to transport and store. Pellets with higher density can reduce the transportation cost with higher efficiency during energy conversion (Carone et al. 2011).

Bamboo is one of the potential feedstocks that can be utilized to produce pellets. It is a renewable, cost effective and eco-friendly resource that can be an alternative to fossil fuels. Bamboo is a useful plant, and it is from a family of grass. It is a fast-growing species that grows faster than wood. It can grow up to over 1 meter per day. Matured bamboo can be harvested in 4 years, depending on the species of bamboo. Dwivedi et al. (2014) reported that more than 1200 species of bamboo can be found all over the world, and around 400 species are mainly from China. According to Liu et al. (2016), bamboo is a main type of biomass that has been cultivated widely in China, and it is used as a potential feedstock for bioenergy production. Bamboo alone has low bulk density, but by mixing it with other types of woody biomass the bulk density can be enhanced and meet the standard requirements for commercial pellets. In general, bamboo has been used to produce household products, and the application has grown into industry level due to the increase in demand in pulp and paper industry, furniture, construction and others (Benjamin et al. 2012).

**Figure 1** Pellet from Bamboo

Pellets produced from biomass materials such as bamboo give many advantages to the environment and economy (Figure 2). Biomass pellets are renewable, environmentally friendly, clean and efficient like using fossil fuels with high calorific value.

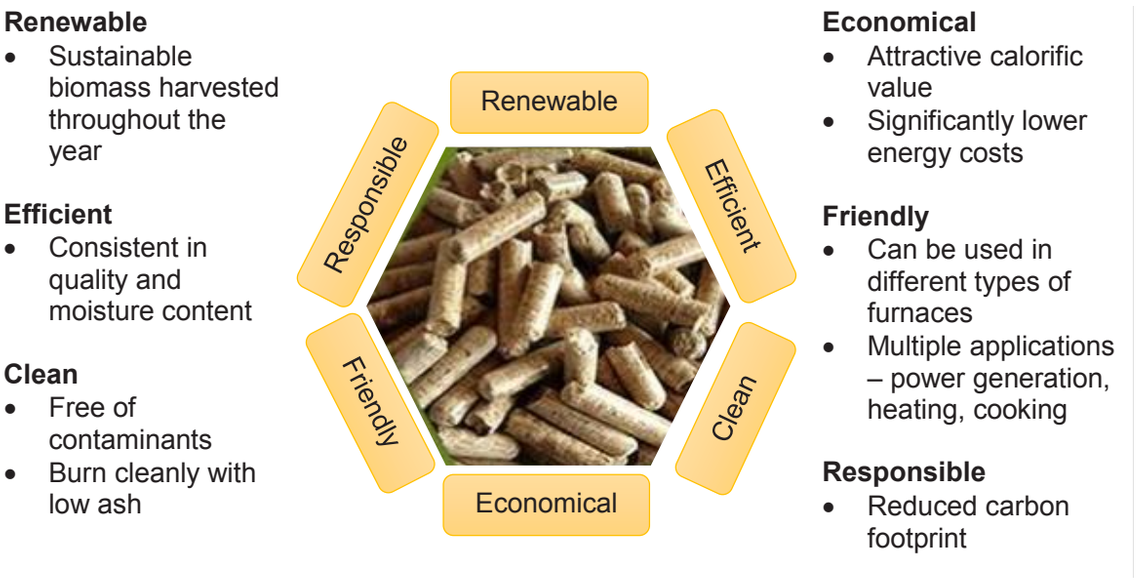


**Figure 2** The advantages of pellets produced from biomass (Anon.[1] 2021)

## Production of Bamboo Pellet

Green bamboo of 10 meters length is cut into short tubes which will later be split into sections. The sectioned bamboo will be ground into small size fibers. These bamboo fibers will be dried in the oven until the moisture content is between 12% to 15% (Figure 3). Dried bamboo fibers are ready to be pelletized to produce pellets.

**Figure 3** Green bamboo being processed into fibers

Pellets are produced through the compression of bamboo fibers using molds according to the desired size. The high compressive pressure will cause the pellet temperature to increase and the lignin content will act as a natural adhesive to bond the fibers together. The pellet diameter is approximately 6 mm with a length of up to 25 mm. The pellet machine used will automatically cut the pellet according to the desired length. The pellet production process is shown in Figure 4. According to Sudhagar et al. (2006), pellets are in cylindrical form and extremely dense with length size between 5 to 40 mm and diameter that ranges from 6 to 8 mm.


**Figure 4** Bamboo Pellets Production Process

## Bamboo Pellets Properties

Bamboo pellets have almost similar properties as compared to commercial pellets that are normally produced using woody biomass materials. Table 1 shows the comparison of the physical, chemical and energy properties of bamboo pellets with commercial pellets and guiding standard of pellets according to DIN51731 (1996). According to Liu et al. (2014), bamboo pellets have higher combustion and heat release rates due to larger particle sizes, and due to this bamboo pellets are suitable as a new biomass solid fuel. They have the potential to be developed as a substitute to commercial pellets. Pelletizing of bamboo increases its bulk density and improves its flammability properties as compared to direct burning of raw bamboo.

Density is an important indicator to evaluate the quality of pellets. Transport, handling and storage efficiencies are affected by the bulk density of pellets such that higher bulk density leads to greater transport efficiency and lower storage space (Liu et al. 2016). Bamboo pellets have bulk density lower than commercial pellets but almost similar with respect to the guiding value of pellets from biomass which is more than 600 kg/m$^3$. The percentage different of density between bamboo and commercial pellets is less than 5% which is insignificant.

Moisture content of bamboo pellets is almost similar to commercial pellets and meets the standard requirement (<12%). According to Sukarta et al. (2018), an average moisture content (MC) of the commercial pelleted product is 10%–12%, and it is important to measure the MC to determine the quality of pellets as fuel. High MC lowers the calorific value, thus reducing the conversion efficiency and performance of pellets as fuel for energy (Obernberger et al. 2004).

**Table 1** Comparison of properties of bamboo pellets with commercial pellets

| Properties | Bamboo Pellets | Commercial Pellets | Guiding value DIN51731 (1996) |
|---|---|---|---|
| Length (mm) | 35.0 | 28.7 | <50 |
| Diameter (mm) | 6 - 8 | 8.0 | 4-10 |
| Moisture content (MC) (%) | 6.0 | 7.3 | <12 |
| Volatile Matter (VM) (%) | 77.9 | 79.7 | - |
| Ash content (%) | 1.1 | 1.2 | <1.5 |
| Fixed carbon (FC) (%) | 14.2 | 14.9 | - |
| Durability (%) | 98.0 | 98.0 | - |
| Calorific value (MJ/kg) | 20.1 | 19.7 | 17-19 |
| Density (kg/m$^3$) | 1102 | 1069 | - |
| Bulk Density (kg/m$^3$) | 599 | 631 | >600 |

Calorific value is the amount of energy per unit mass released upon complete combustion. Higher calorific value has high tendency to produce more energy. While fuel with low calorific value tend to burn inefficiently thus causing lots of exhaust and air-pollution. Liu et al. (2016) reported that calorific value of bamboo pellets was 18.5 MJ/kg which was higher than pine wood of 18.3 MJ/kg. Proximate analysis is also important to evaluate the quality of pellets. Pelletizing of bamboo will increase its fixed carbon which is an important property that has strong relationship with heating value or calorific value. From Table 1 it shows that bamboo pellets have almost similar FC content with commercial pellets. Other than that, ash content of bamboo pellets is less than standard requirement. However, it depends on the type of bamboo species used to produce pellets; for example, the ash content of pellets produced using Aur bamboo is 0.50%.

## Application of Bamboo Pellets

Bamboo pellets are a new green energy fuel that are mainly used to replace traditional fossil fuel (coal, oil and gas). Compared to gas, oil and electric heating, utilization of bamboo pellets to replace the conventional heating can save up to 50 percent of energy costs (Anon.[2] 2021). For small and medium industries, pellets have been used in boiler to generate electricity and steam. They produce less pollution with complete combustion. For domestic applications in cold climate countries, pellets are used in the furnace to produce heat and supply of hot water.

Bamboo pellets used for stoves and grill for cooking are clean and environmentally friendly and in no way contribute to global warming by increasing the greenhouse gas emissions. Moreover, bamboo pellets are used as animal bedding and pet litter to replace the pet sand that is very difficult to handle. Bamboo pellets can also be used as animal feed where they are in crispy form, light sweet flavour as well as possessing exceptional dietary value.


**Figure 5** Bamboo pellets applications (Anon.[3] 2021)

## REFERENCES


Anon.[1] 2021. The Latest in Clean Energy News | Renewable Energy World. https://www.renewableenergyworld.com/. Accessed on 03 June 2021

Anon.[2] 2021. http://www.bioenergy-machine.com/Bamboo Pellet Production. Accessed on 04 June 2021.

Anon.[3] 2021. Pellet Application-An Expanding Marketing Opportunity-Amisy Pellet Mill. http://www.wood-pellet-mill.com/Wood. Accessed on 03 June 2021

Benjamin E, Siegmar S, Zheke Z & Gero B. 2012. Suitability of Bamboo as an Energy Resource: Analysis of Bamboo Combustion Values Dependent on the Culm's Age. *International Journal of Forest Engineering*. 23. 114–121.

Carone MT, Pantaleo A & Pellerano A. 2011. Influence of process parameters and biomass characteristics on the durability of pellets from the pruning residues of *Olea europaea* L. Biomass Bioenergy 35: 402–410

DIN 51731. 1996. Testing of Solid Fuels—Compressed Untreated Wood, Requirements and Testing. Deutsches Institut fur Normung, Berlin.

Dwivedi A, Jain N, Patel P & Sharma P. 2014. The Versatile Bamboo Charcoal. International *Conference on Multidisciplinary Research & Practice* 129–131

Liu Z, Liu X, Fei B, Jiang Z, Cai Z & Yu Y. 2013. The properties of pellets from mixing bamboo and rice straw. *Renewable Energy* 55: 1–5

Liu Z, Fei B, Jiang Z, Cai Z & Liu X. 2014. Important properties of bamboo pellets to be used as commercial solid fuel in China. *Wood Science Technology* 48:903–917

Liu Z, Mi B, Jiang Z, Fei B, Cai Z & Liu X. 2016. Improved bulk density of bamboo pellets as biomass for energy production. *Renewable Energy* 86: 1–7

Obernberger L & Thek G. 2004. Physical characterisation and chemical composition of densified biomass fuels with regard to their combustion behaviour. *Biomass and Bioenergy* 27, 653–669

Sette Jr CR, Freitas PC, Freitas VP, Yamaji FM & Almeida RA 2016. Production and characterization of bamboo pellets. Bioscience Journal, 32(4): 922–930.

Sudhagar M, Sokhansanj S, X B & Anthony T. 2006. Economic of producing fuel pellets from biomass. *Applied Engineering in Agriculture* 22: 1–6

Sukarta N, Sastrawidana IDK & Sri Ayuni NP. 2018. Proximate analysis and calorific value of pellets in biosolid combined with wood waste biomass. *Journal of Ecological Engineering* 19(3): 185–190.

## Back issues

Available on-line (http://info.frim.gov.my/cfdocs/infocenter/booksonline/index cfm?menu=ttb)

| | |
|---|---|
| TTB79 | Wood Coatings |
| TTB80 | Wood Properties of Two Selected Pioneer Species: Ludai (*Sapium* Sp.) and Mahang (*Macaranga* Sp.) |
| TTB81 | Grade Stresses and Strength Group of Plantation Timber: *Acacia mangium* |
| TTB82 | Aesthetically Pleasing Furnitures From *Maesopsis eminii* |
| TTB83 | MyWood-ID: Latest Technology In Wood Identification |
| TTB84 | Feasibility of Bakau (*Rhizophora* SPP.) for Glue Lamination |
| TTB85 | Delamination and Adhesion Strength of Selected Malaysian Timber for Glue Lamination: Pulai (*Alstonia* SPP.) |
| TTB86 | Wood Finishing: Finishes and Techniques |
| TTB87 | Mortise and Tenon Failures in School Furniture 2018 |
| TTB88 | Properties of Veneer And Moulded Chair From Sesenduk (*Endospermum diadenum*) |
| TTB89 | Surface Wettability of Some Malaysian Woods |
| TTB90 | Safety Precautions During Coating Process |
| TTB91 | Techniques of Pre-Ripping of Large Diameter Log using Chainsaw |
| TTB92 | Mathematical Algorithm to Optimise Bamboo Splitting for Strips Production |
| TTB93 | On-Site Mechanical Test of Timber Scaffold Board |
| TTB94 | Materials Balance in Extraction of Nanocellulose From Forest Pioneer Species |
| TTB96 | Usage Trend of Timber Based on Identification Services Usage Trend of Timber Based on Identification Services |
| TTB97 | Resistance of Kapur (Dryobalanops Spp.) Laminated Wood Against Delamination |
| TTB98 | The Effective Tooth Width of a Bandsaw Blade for Sawing Malaysian Timbers |
| TTB99 | Rapid and Environmentally Friendly Treatment of Rubberwood Using High Temperature Drying (HTD) |
| TTB100 | Route to European Strength Classes for Malaysian Timbers |
| TTB101 | Grade Stresses and Strength Group of 15-Year-Old *Tamarindus indica* |
| TTB102 | Mathematical Analysis of Bamboo Splitting using Twin Rip Saw for Strips Production |
| TTB103 | Nanocellulose: Versatile and Ageless Biopolymer for the Future |
| TTB104 | Diameter and Volumetric Computation of Plantation Sawlogs |
| TTB105 | Concept of Life Cycle Assessment (LCA) in Timber Industry |
| TTB106 | Mechanical Properties of Malaysian Timbers: The Weighted Mean and Combined Standard Deviation Values |
| TTB107 | Mass Timber Building (MTB): A New Green Revolutionised Building Industry |

Bamboo is a fast-growing species that has great potential as an energy resource in the future. Converting bamboo into pellets improves its physical and combustion properties. The quality of bamboo pellets produced are almost similar to commercial pellets with respect to DIN51731 standard. High calorific value of bamboo pellets (about 20 MJ/kg) shows that high energy is produced during combustion due to them being burnt efficiently and completely. Furthermore, transportation of bamboo pellets in uniform size and high bulk density (about 599 kg/m$^3$) could reduce the storage area. Bamboo has the potential as a feedstock for the production and development of commercial pellets.



Series Editor : Mohamad Omar MK & Ong CB
Managing Editor : Vimala S
Typesetter : Rohayu Y

Set in Times New Roman 11

Printed by Publications Branch, Forest Research Institute Malaysia
52109 Kepong, Selangor