

Biopellet Synthesis of Waste Rice Plant (*Oryza sativa* sp.) as a Environmentally Friendly Alternative Fuel Substance

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Abstract: The abundance of rice straw and rice husks in Indonesia is a potential source of biomass that can be converted into biomass pellet (biopellets). Pelletization can improve the quality and burning characteristic of the biomass. Bio-pellet is an alternative energy that can substituted low grade coal from biomass sources. The purpose of this study is to improve the quality of biopellets. Pellet made with some variation of the biomass. Biopellet consists of a mixture of the rice straw and husks, the rice straw and bran, the rice husks and bran with a ratio of 1:1. The test of biopellet included moisture content, volatile matters, ash, substances, fixed carbon and calorific value. The results showed a mixed type of biomass affects the characteristics biopellet. Based on the physic chemical properties, biopellet of the husk+bran mixture and the rice straw+bran have better quality than other biopellet. The biopellet of husk+bran has 4138 kcal/kg of calorific value. The biopellet of the straw+bran have the lowest consumption rate that is 0.60 kg/h. Additionally, the biopellet of the straw+bran has 3223 kcal/kg of calorific value.

Key words: Straw, biomass, biopellet, alternative fuel, biopellets, pelletization

INTRODUCTION

Energy and food was a basic need for human life, so that, its availability is necessary. The use of fuel energy was increasing rapidly followed by declining availability of fossil fuels. It affects the restriction of subsidized fuel. Therefore, need to look for other sources of fuel especially environmentally friendly renewable fuel. An alternative source of alternative fuels was biomass fuel for agricultural waste because it was easy to obtain, its availability was abundant and could be renewed. The use of biomass fuels sources of agricultural waste was the right choice with the consideration that the majority of Indonesian society is based on the agricultural sector.

From the agricultural sector could be obtained many types of biomass agricultural waste was quite abundant. According to Abdullah (2009) and Bailis *et al.* (2007) biomass of potential agricultural waste as an alternative energy source include wastes of rice crops (straw, husk), corn waste (cobs, stems, leaves), waste palm (shell, fiber, empty bunches), peanut shells soil, bagasse sugarcane, coconut waste (coir, shell, leaf) and soybean stover. Among the agricultural wastes, rice straw biomass is available in considerable amounts compared to other agricultural wastes. This was also supported by the

increase of rice production from year to year (Fig. 1), so that, the rice plant waste also increased (Bassam and Maegaard, 2004).

Rice production in Indonesia in 2012 was 69.06 mln. tons of Grain Dried Milled (GDM) and in 2013 the temporary figure is about 71.29 mln. tons of GDM (Anonymous, 2014). According to Prihandana and Hendroko (2007) that the ratio between grain weight and grain straw ratio during harvest was generally between 2-3. In grain milling, husk waste was produced about 20 and 10% of bran according to Haryadi. Based on the data of grain dried milled production from rice harvest year 2012-2013 (Table 1) could be produced average of straw waste about 105.27, husk 14.04 and bran 7.02 mln. tons/year that was potentially as alternatives fuel.

Biomass could be used as fuel for cooking or other thermal processes. The potential of biomass energy in Indonesia was estimated to be 49.810 MW (50 GW) derived from various biomass of agricultural, forestry, plantation and solid waste or municipal waste. According to Sudrajat (1984) that the biomass potential ranks second after water potential. But the realization as a power plant only reached 445 MW or about 0.89%. As a fuel, biomass still has sufficient calorific value and when used as pellets and gasified will produce high energy output (Kusumaningrum and Munawar, 2014).

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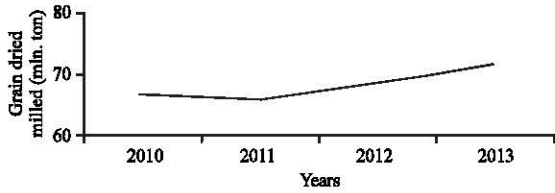


Fig. 1: Production of unhusked rice mill in Indonesia

Table 1: Production of Dry Milled Grain (DMG) and wastewater biomass of rice plants (million tones)

Years	Dried paddy*	Straw	Husk	Bran
2012	69.06	103.59	13.81	6.91
2013	71.29 (ASEM)	106.94	14.26	7.13

*Not milled yet

So far, agricultural biomass was still regarded as a waste that has no economic value and was often destroyed by burning. It seems that biomass has not been fully utilized. In China, straw biomass was partly used directly as fuel. Its use per capita of 146 kg/year (Ramsay, 1982) meanwhile in Indonesia, straw and chaff was used as fuel for burning bricks or pottery in boilers and also for household energy purposes. According to Saptoadi (2011) the use of biomass as fuel directly there were weaknesses in physical properties such as low energy density and handling, storage or transportation problems. To overcome these problems could be by making biomass in a more practical form that was a solid form called a pellet (biopellet).

Pelletization was a process of drying and biomass formation using high pressure to produce cylindrical solid biomass. This process aims to produce biomass fuel with a smaller volume and higher energy density. This pellet form facilitates the storage, transportation and conversion into electrical energy or other chemical energy more efficient (Ramsay, 1982).

Biopellet was one form of biomass energy and was first produced in Sweden in 1980 made from raw wood powder which was industrial waste (Nugrahaeni, 2008). In some countries in Europe such as Germany, Canada and Austria already use wood waste biopellet as industrial boiler fuel and space heater during Winter. Biomass in pellet form could be used directly as solid fuel. The advantages of biopellet as fuel include high density, easy in storage and handling. Solid fuel (biopellet) was quite efficient and environmentally friendly. Biopellets could also function as fuel substitutes for kerosene or gas. The existence of biopellet would become a solution to overcome the scarcity of fuel especially in villages or coastal areas. In an effort to explore the potential of biomass of agricultural waste as an environmentally friendly alternative fuel, it is necessary to improve the quality of biopellet production to produce biomass fuel with optimal combustion performance.

MATERIALS AND METHODS

Experimental section: Biopellet production using crusher machine with capacity of 30 kg/h and moulding machine with a capacity of 20 kg/h. The process begins with the sorting of raw materials. The raw materials used were agricultural waste especially rice plants in this case was straw. Then drying or drying under the Sun. The dried straw was put into a crusher machine for size reduction followed by mixing of raw materials of rice crops (chopped straw, husks and bran). Percentage of mixture of two types of biomass 50%, i.e., straw+bran, straw+husk and husk+bran. As an additive was a 5% tapioca solution. The mixture of the material was inserted into the biopellet moulding machine. Biopellets are produced in the sun or dried under the sun. Before applied to biomass stoves, the characteristics of the biopellet were first measured, including the specific gravity, moisture content, ash content, volatile, calorific value and bound carbon content of the biopellet.

Biopellet performance test was performed using UB-03 biomass stove. These stoves were fueled by biomass such as small pieces of wood or wasted branches, corncobs, biomass pellets and so on. Biomass stoves are very efficient because they use turbulent combustion systems which could save up to 80% of biomass usage compared to other stoves using firewood. The performance test uses the Water Boiling Test (WBT) method. Water boiling test was a rough simulation method of a cooking process that could be used to find out how well the heat energy was transferred to the cookware (Anonymous, 2014). With WBT method could be measured the rate of fuel consumption and combustion efficiency.

RESULTS AND DISCUSSION

Biopellet characteristics: Production of 4 kinds of biopellets from raw materials of rice plants (straw, husk, bran) was presented in Fig. 2.

Of the three mixed biopellets, it appears that biopellets with extra bran have higher density and denser performs. This was because the added bran had a smaller size than the size of the husk. The addition could increase the biopellet density because the cavity between the straw particles arrangement was filled by the smaller bran particle size, thus, increasing the biopellet mass per unit volume. The results of the physicochemical biopellet properties were listed in Table 2.

Water content: The lowest average biopellet water content in straw was 0.31%. This was due to straw

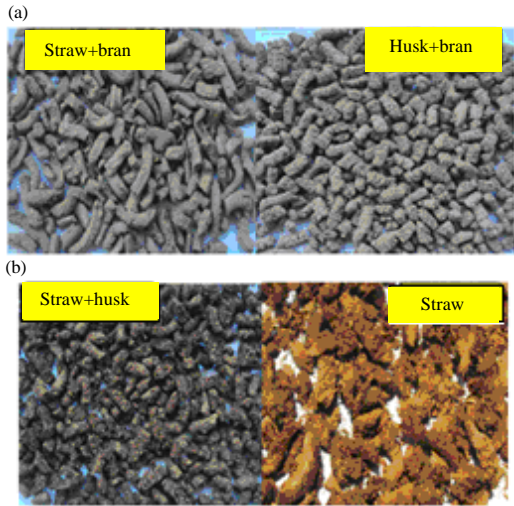


Fig. 2: a, b) Biopellet mixed biomass of rice plant waste

Table 2: Physicochemistry physical properties of biopellets

Biopellet	Water content (%)	Ash content (%)	Volatile (%)	Bond carbon (%)	Calorific value (kcal/kg)
Straw	0.31	36.50	25.14	38.37	3123
Straw+Bran	2.12	31.20	17.32	51.48	3322
Straw+Husk	1.59	29.59	30.32	40.08	3220
Husk+Bran	1.68	23.72	25.41	50.87	4138

biopellet more porous than mixed biopellet, so that, at the time of drying a lot of water was evaporated. Biopellet water content effect on burning calorific value, illumination, combustion power and amount of smoke during combustion (Ramsay, 1982). The ease of burning on straw biopellets was faster than mixed biopellets.

Ash content: The average value of biopellet ash content from rice plant waste was between 23.72-36.49%. The highest value of ash content was ash content from straw biopellet. The amount of ash produced in the combustion process was influenced by the type of biopellet raw material. Straw biopellet contains more silica than straw mixed biopellet+bran or straw+husk. The higher the silica content of the biopellet raw material the higher the amount of ash produced. Ash was an undesirable component of the combustion process (Saptoadi, 2006) because it could reduce combustion efficiency (Grover *et al.*, 2002).

Volatile: The number of volatile substances in the biopellet was a parameter to know the amount of smoke produced during the combustion process. The highest volatile content of straw+husk mixed biopellet was 30.32% while the mixed straw+bran had a volatile of 17.3%. This indicates that the smoke produced during burning more in the straw+husk biopellet because the higher the

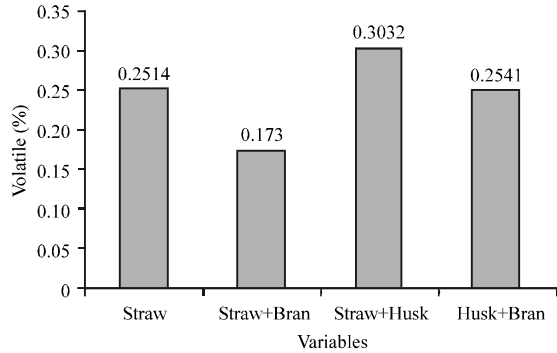


Fig. 3: Volatile substances from rice plant waste biopellet

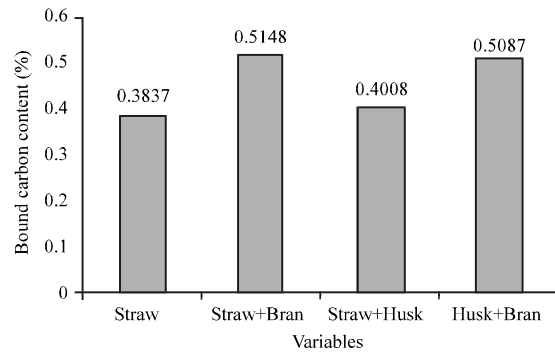


Fig. 4: Bound carbon content of rice plant waste biopellet

volatile percentage in the fuel the higher the amount of smoke produced (Jansen, 2011) and causes the biopellet burning efficiency to decrease (Makarim and Suyanto, 2007) (Fig. 3).

Bound carbon content: The highest bound carbon content on the mixed straw+bran biopellet is 51.48%. This shows that the compacted solid material component in straw+bran biopellet was more than any other biopellet. Bound carbon content was a Carbon (C) fraction present in the biopellet component components other than water, ash and volatile substances so that the carbon values were affected by moisture content, ash and volatile substances (Nurwigha, 2012). The result of carbon value in straw+bran biopellet was supported by lower percentage of water content, ash and volatile than straw+husk biopellet (Fig. 4).

Calorific value: Grover *et al.* (2002), Hendra and Pari (2000) states that the heating value was a parameter to determine the quality of biomass waste solid fuels. The higher the caloric value could be said the better the fuel quality. The highest heating value was in bran husk biopellet+bran was 4138 kcal/kg, followed by straw+bran biopellet, i.e., 3322 kcal/kg (Fig. 5).

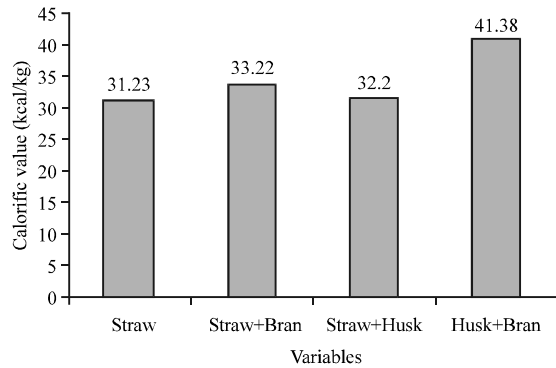


Fig. 5: Calorific value of rice plant waste biopellet

Table 3: Test rate of consumption of rice plant biopellet

Biopellet	Boiling time of 1 L of water	Used biopellet mass (g)	Rate of biopellet consumption (kg/jam)
Straw	4	70	1.05
Straw+Bran	5	50	0.60
Straw+Husk	5.5	70	0.76
Husk+Bran	3.8	50	0.79

Biopellet performance test: Water boiling test results for the four biopellets are listed in Table 3.

CONCLUSION

Biopellet of straw mixture+bran and husk+bran have better characteristic than straw or straw biopellet with calorific value 4138 and 3322 kcal/kg. The results of the performance test on straw biopellet+bran have the lowest consumption rate of 0.60 kg/h.

ACKNOWLEDGEMENTS

Researchers would like to thank the Directorate of Research and Community Services Directorate General of Higher Education Seminarian Education and Culture of the Republic of Indonesia which has funded this research by number: Number: 019/SP2H /PPM-MONO /K7/KM/2014 dated April 3, 2014.

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