Utilization of Several Agricultural Wastes Into Briquette as Renewable Energy Source

10.18196/pt.v10i2.13773

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ABSTRACT

Tobacco stems contain 56.10% cellulose content, 15.11% lignin, 22.44% hemicellulose, and 44.61% total organic carbon, which can be used as a source of energy or fuel. This study aimed to utilize tobacco stems in a briquette form as alternative energy. The materials used in this study were tobacco stem waste, rice husk, wood charcoal, and coconut shell. The treatments used in this study consisted of T1 (100% of tobacco stems), T2 (80% of tobacco stem + 20% of coconut shell), T3 (80% of tobacco stem + 20% rice husk), and T4 (33.33% of tobacco stems + 33.33% of rice husk + 33.33% coconut shell). The fastest combustion rate was found at T3, 0.12 gram/sec, while T1 and T2 had the same combustion rate. T4, a mixture of various materials, had no significant difference compared to T1, T2, and T3. The highest calorific value of tobacco stem briquettes was in T4 (4127 Kcal/kg), and the lowest was in T1 (2343 Kcal/kg). The combustion rate of these tobacco stem briquettes was longer than that of charcoal briquettes, whose average burning rate is 0.234 grams/second. Overall, this study provides an overview of the best combination to create briquettes from agricultural waste.

Keywords: Briquettes, Tobacco stem, Utilization, Waste

ABSTRAK

Batang tembakau mengandung 56,10% selulosa, 15,11% lignin, 22,44% hemiselulosa, 44,61% total karbon organik yang dapat digunakan sebagai sumber energi atau bahan bakar. Penelitian ini bertujuan untuk memanfaatkan batang tembakau menjadi bentuk briket sebagai energi alternatif. Bahan yang digunakan dalam penelitian ini adalah limbah batang tembakau, sekam padi, arang kayu, dan tempurung kelapa. Perlakuan yang digunakan dalam penelitian ini adalah; T1: 100% batang tembakau, T2: 80% batang tembakau + 20% tempurung kelapa, T3: 80% batang tembakau + 20% sekam padi dan 33,33% batang tembakau + 33,33% sekam padi + 33,33% batok kelapa. Laju pembakaran tercepat terdapat pada T3 yaitu 0,12 gram/detik, sedangkan T1 dan T2 memiliki laju pembakaran yang sama. T4, yang merupakan campuran berbagai bahan, tidak berbeda nyata dengan T1, T2, dan T3. Nilai kalor briket batang tembakau hasil penelitian tertinggi pada T4 sebesar 4127 Kkal/Kg dan terendah pada T1 sebesar 2343 Kkal/Kg. Laju pembakaran briket batang tembakau ini lebih lama dibandingkan briket arang yang rata-rata laju pembakarannya 0,234 gram/detik. Secara keseluruhan, penelitian ini memberikan gambaran kombinasi terbaik untuk menciptakan briket dari limbah pertanian.

Kata kunci: *Briket, Batang Tembakau, Pemanfaatan, Limbah*

INTRODUCTION

The world's energy needs are still dominated by fossil energy, which is increasingly limited. Renewable energy sources are needed to reduce dependence on fossil energy. Biomass energy has a high potential due to its abundant availability worldwide. Biomass waste is found in the agricultural sector. Agricultural waste, which has a carbon content, has the potential to be used as an alternative energy source called briquettes. Agricultural waste, such as husk, straw, and coconut shells, has a carbon content of 1.33%, 2.71%, and 18.80%, respectively (Pancapalaga, 2008). One of the largest agricultural wastes humans often ignore is tobacco stem waste. With a population range of 22,000 trees per hectare and an estimated weight of 0.5 kg of tobacco stems, Indonesia will generate more than 2 million tons of tobacco stem waste (Handayani et al., 2018). Tobacco stems contain

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Article History
Received: 24 jan 2022
Accepted: 10 Aug 2022

56.10% cellulose, 15.11% lignin, 22.44% hemicellulose, and 44.61% total organic carbon (Amirudin et al., 2020).

Tobacco is an agricultural plant commodity with high economic value as devised in the cigarette industry sector. East Java is one of Indonesia's largest tobacco producer provinces, with a land area of 108,524 ha in 2015 (Director General of Plantation, 2017). Tobacco leaves are used in the cigarette industry, and the wastes are in the form of leaf stems and tobacco leaf bones. The stems go to waste or are left in the fields to fertilize the soil. However, tobacco stems contain nicotine, which can be a hazardous waste due to soil penetration and cause pollution (Bareschino et al., 2021). The nicotine content of tobacco stems is 0.53 ppm (Obidziński et al., 2017). Sustainable agriculture is agriculture whose management is based on meeting needs without compromising the interests of future generations. Efforts that can be made are post-harvest processing and waste management (Indahsari & Negoro, 2020). The utilization of tobacco waste is still not managed properly, so there needs to be an effort that can be used to treat waste into a material that is beneficial and not harmful to the environment, one of which is processing it into briquettes.

Briquetting is the technology used to convert all agricultural and forestry wastes into solid fuels. Briquettes are formed in cylindrical logs using high mechanical pressure without chemicals or binders (Kanagaraj et al., 2018). Briquettes have a higher thermal value, lower ash content, a more uniform rate of combustion, and are less expensive than coal. Briquettes with low moisture and a high density improve boiler efficiency (Aishwariya & Amsamani, 2018).

Good quality briquettes have standards so they can be used to their needs. Briquette quality is generally determined by physical and chemical properties such as water content, ash content, volatile substances, carbon content, density, compressive resistance, and calorific value (Ren et al., 2019). Because the biomass component of the briquette burns at a lower temperature than the coal, the volatile matter in the coal, which would otherwise be released as smoke at a low combustion temperature, is completely burned (Promdee et al., 2017).

Mixing the raw materials of tobacco stem waste with other raw materials with higher specific gravity than tobacco stems is necessary to produce briquettes with world trade standard quality. This research is expected to determine the composition of briquettes to increase the use value of tobacco plant (*N. tabacum L.*) waste as one of the fuels from renewable energy sources and as an alternative energy substitute for fossil energy. Tobacco waste processed into a briquette can be used as alternative energy by utilizing carbon sources from lignocellulose of tobacco waste, primarily the stems and leaves that are not used. Mixtures of other materials, such as rice husks and coconut shells, are known to improve the quality of tobacco waste briquettes. Thus, in this study, the production of tobacco waste briquettes was given a mixture of these materials.

MATERIALS AND METHOD

The research was conducted from September 2019 – April 2020 by Poultry Research in collaboration with Universal PT Tempu Rejo. All tobacco stem waste materials were provided by Universal PT Tempu Rejo and then processed into briquettes.

Briquette samples were made by adding the same amount of adhesive to each treatment. The adhesive used was 10% tapioca flour with 3000 psi press pressure. The treatments used in this study were T1 (100% of tobacco stems), T2 (80% of tobacco stem + 20% of coconut shell), T3 (80% of tobacco stem + 20% rice husk) and T4 (33.33%

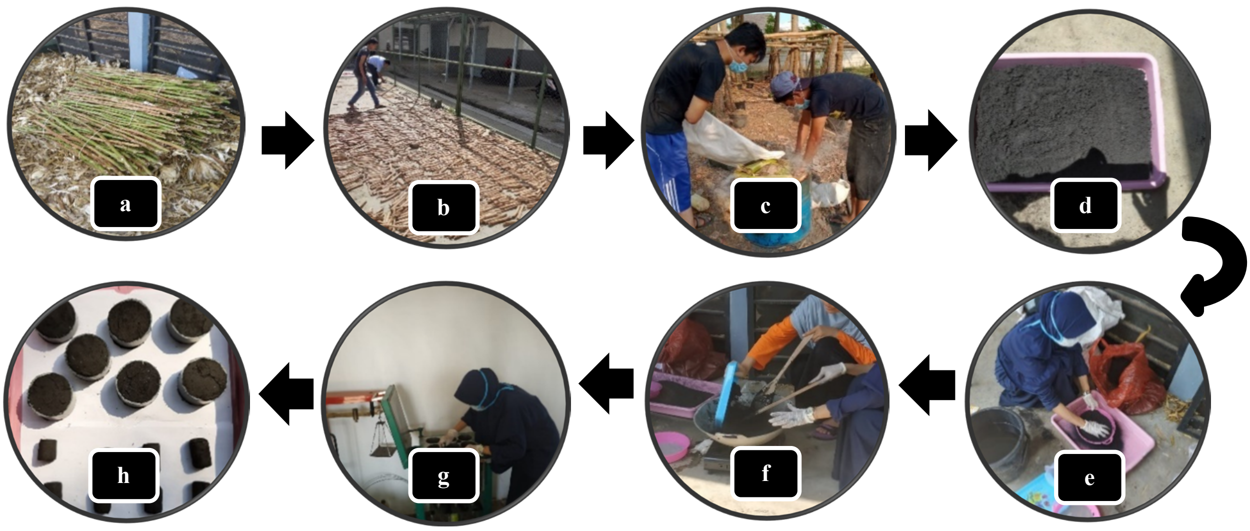

Figure 1. The production process of agricultural waste briquettes: a. Fresh tobacco stem waste; b. Drying tobacco stem; c. Charcoal process; d. Charcoal of several agricultural wastes; e. Charcoal sifting process; f. Briquette process; g. Press machine; h. Briquette

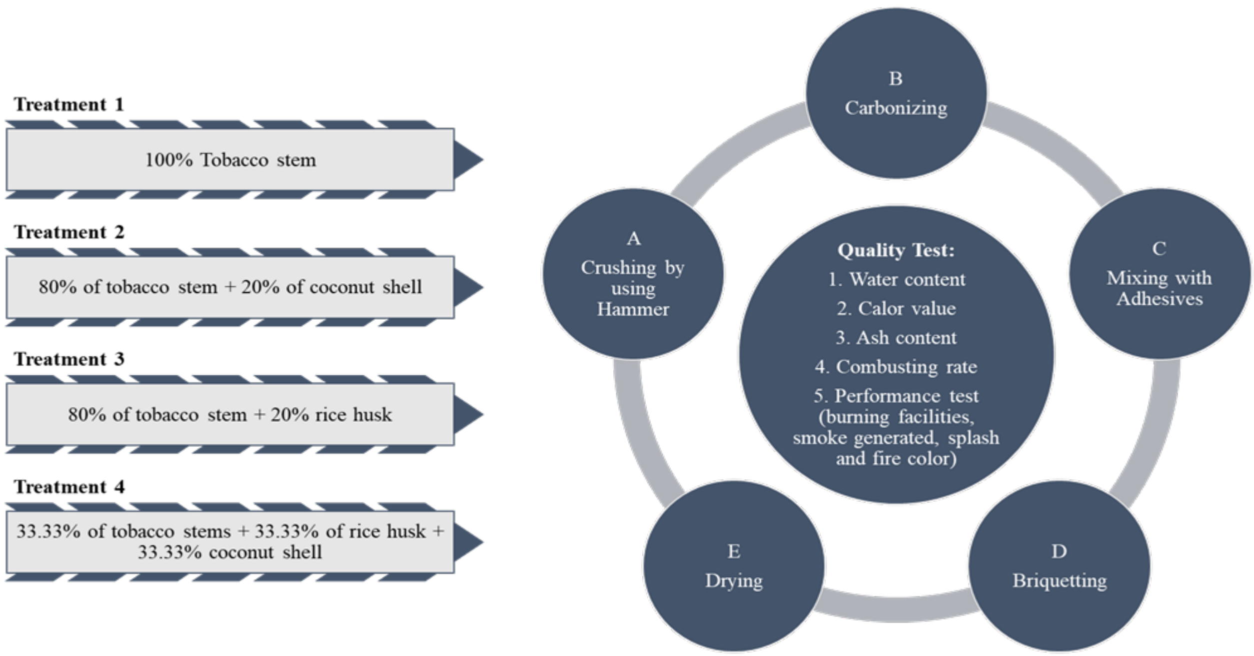

Figure 2. Road map research.

of tobacco stems + 33.33% of rice husk + 33.33% coconut shell) (Figure 1).

The raw materials prepared include dry tobacco stems, rice husks, and coconut shells (Figure 3). Using dry ingredients can accelerate the drying process compared to wet ingredients because they have low water content. The carbonizing process was done using a 250L can. The carbonizing was performed by burning crushed material in a closed 250L can with a slit for gas exchange, then it burnt on combusting stove. The sifted charcoal of tobacco stem, rice husks, and coconut shells was mixed with tapioca flour adhesive by 10% of raw material per unit of briquette according to each treatment.

Figure 3. Raw material of briquette waste: a. Tobacco stem and leaf charcoal; b. Rice husk charcoal; c. Coconut shell charcoal

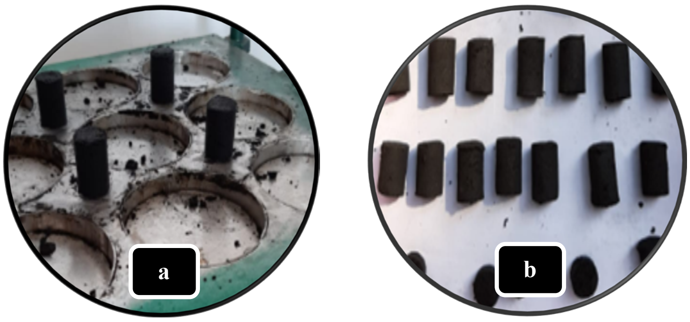

Figure 4. a. Pressing briquette; b. Briquette size, 2.25 cm x 3.25 cm

Each treatment mixed with the adhesive material (tapioca flour) was stirred evenly until the entire briquette dough turned black. After homogenization, the mixed materials were pressed using a pressing machine. The diameter size of briquettes was 2.5 cm with a length of 3.5 cm. The drying temperature used was 60 °C for 24 hours (Figure 2). The purpose of drying is to reduce the water content in briquettes by the provisions of the applicable briquette water content according to SNI 01-6235-2000 of 8%.

The sample's water content was determined using the oven method by weighing the material with an analytic scale of 5 grams in an aluminum dish. The material was then dried in the oven at a temperature of 105 °C until constant weight was achieved (4 hours), cooled in a desiccator, and weighed again (Ekpete & Horsfall, 2011). Density is influenced by the amount of pressure applied, affecting the efficiency of burning briquettes as fuel. According to Falemara et al., (2018), briquette mass density is calculated by weighing the briquette sample and then dividing the weight by the volume of the briquette sample. The density of briquettes can be expressed by the formula density (g/cm^3).

The sample was weighed (5 grams), put into a porcelain dish, and then heated until no smoke was generated. It was then blown in the furnace at 600 °C to become ash, cooled in the desiccator, then immediately weighed after reaching room temperature. The burning rate of the samples was determined at a certain mass of charcoal briquette combusted in the air. The stopwatch was set, and the total time required for the samples to burn completely to ashes was recorded (Kongprasert et al., 2019). The calorific value of biomass fuel is the amount of heat energy that can be released in each unit of mass of the fuel when it burns completely (in units of Kcal/Kg). The principle of determining calorific value is measuring the energy generated in the combustion of one gram of charcoal by measuring changes in fluid temperature at a fixed volume performed in a closed vessel (Simiyu et al., 2017).

RESULTS AND DISCUSSION

The quality of the briquettes from tobacco waste is presented in Table 2. Figure 4a shows the tobacco stem briquette processing using a pressing machine. Cylindrical briquettes are produced because it has higher density and produces higher energy. Figure 4b shows the briquette drying process after pressing with a machine.

Based on the result, the water content of tobacco stem waste with the addition of various materials showed significantly different results. The T4 showed the lowest water content, followed by T2, T1, and T3. The water content of T2 and T4 briquettes was more moderate than 8%, as required by the minimum wood charcoal briquettes. The standard minimum percentage of water content, according to SNI 01-6235-2000, explained that the water content of briquette is 8% (Radam et al., 2018). The highest water content (8.62%) was obtained in the T3, a mixture of 80% tobacco stem waste and 20% rice husk. Similar to the research conducted by Saeed et al., (2021), the water content in rice husks ranged from 6% - 10%.

According to Nurek et al., (2019), the material with low moisture shows a weaker interaction between particles. The increase in humidity (to a certain value) strengthens this effect, but the mechanical properties deteriorate, adversely affecting the agglomeration process. The disturbance of the compaction process causes this by the increased amount of generated steam. Previous research showed that the water content of tobacco waste briquettes in Indonesia was lower than the tobacco stem briquettes made in Henan, China, which was 10.84% (Xinfeng et al., 2015).

Ash content of all treatments showed a significant difference. Ash content of T1, T2, T3, and T4 45.93%, 31.69%, 36.83%, and 37.73%, respectively. Ash content of T2 is the lowest than others, but this result is different from the study conducted by Bot et al., (2021), who reported that the ash content in coconut shells was 10.02%, lower than the results of this study. Ash generated from this study do not meet the standards set by SNI 01-6235-2000 (<8%), Japanese (3-6%), and ISO 17225 (3.3-11.7%) for bio-briquettes standards (Ifa et al., 2020). High ash content is caused by high silica content in the material, which is nondegradable. This silica causes low heating and carbon values (Putri & Andasuryani, 2017).

The mass density of briquettes made from tobacco waste is presented in Table 1. All treatments showed very low densities, with the highest value of 0.73 gram/cm^3 (T4), and the lowest value of 0.63 (T3). These results were supported by Lingureasa et al., (2017), reporting that the tobacco stem briquette density was 0.89 gram/cm^3. This study's results differed from Tanko et al., (2020), mentioning that the density of rice husks and coconut shells mixture ranged from 1.5 - 3 grams/cm^3, two

Table 1. Physical properties of agricultural waste briquettes

Treatments	Water Content (%)	Ash Content (%)	Mass Density (gram/cm^3)	Combusting Rate (gram/minute)	Calor Value (Kcal/kg)
T1	8.34^c	45.93^d	0.71^b	0.16^b	2343^a
T2	7.76^b	31.69^a	0.72^b	0.16^b	3782^c
T3	8.62^d	36.83^b	0.61^a	0.12^a	2997^b
T4	6.34^a	37.73^c	0.73^b	0.13^{ab}	4127^d

Note: 100% tobacco stem (T1), 80% of tobacco stem + 20% of coconut shell (T2), 80% of tobacco stem + 20% rice husk (T3), 33.33% of tobacco stems + 33.33% of rice husk + 33.33% coconut shell (T4). Means followed by different letters in the same column are significantly different based on Duncan's 5% test.

Table 2. Performance test of the briquettes

Treatments	Smoke Generated	Splash and Fire Color
T1	Negative	No fire
T2	Negative	No fire
T3	Negative	No fire
T4	Negative	No fire

Note: 100% tobacco stem (T1), 80% of tobacco stem + 20% of coconut shell (T2), 80% of tobacco stem + 20% rice husk (T3), 33.33% of tobacco stems + 33.33% of rice husk + 33.33% coconut shell (T4).

Figure 5. Briquette fire burn process

to four times denser than the results of this study. This density is influenced by the structure and size of the material. Smaller particle sizes can expand the surface area to the bond between particles, so it is related to briquette hardness. The higher the density, the higher the briquette hardness.

The combusting rate of the briquette shows how fast the briquette is burning. The fastest combustion rate in T3 was 0.12 gram/sec, while T1 and T2 had the same combustion rate. T4, a mixture of various materials, had no significant difference compared to T1, T2, and T3. The combustion rate of these tobacco stem briquettes was longer than charcoal briquettes whose average burning rate is 0.234 grams/second (Putri & Andasuryani, 2017). According to Aljarwi et al., (2020), the greater the pressure (solid), the higher the calorific value and the rate of combustion of the briquettes.

The highest calorific value of tobacco stem briquettes was obtained in T4, which was 4127 Kcal/kg, while the lowest was in T1 (2343 Kcal/kg). The results of the calorific value of T4 were similar to Suryaningsih & Nurhilal (2018). The calorific value in a mixture of rice husks and coconut shells ranged between 4107 - 4886 Cal/Gram. The calorific value of all treatments was lower than the SNI 01-6235-2000 standard for wood charcoal briquettes, which is a minimum of 5000 Kcal/kg (Radam et al., 2018). Purwono et al., (2010) explained that the heating value of charcoal briquettes from tobacco stems pyrolyzed for ninety minutes with a 4-ton pressure was 5438.9 Kcal/kg. A shorter pyrolysis time and greater pressure can reduce the caloric value of briquettes (Purwono et al., 2010).

In using briquettes, odor and visible smoke are not wanted. Briquettes should go through a burning test since these effects can be created using specific binders (Borowski et al., 2017). The briquette performance is presented in Table 2. The smoke generated by this briquette was negative, meaning no smoke was generated (Figure 5). Moreover, this briquette didn't have a splash when it was burned, and the flame did not appear.

CONCLUSIONS

The highest calorific value of tobacco stem briquettes was 4127 Kcal/kg, resulting in T4 (33.33% of tobacco stems + 33.33% of rice husk + 33.33% coconut shell), and the lowest water content also found in T4, which was 6.34. T3 resulted in the highest water content value compared to other treatments, which was 8.62%. All treatments do not generate smoke and sparks, so they can be used as briquettes for renewable energy. The implication of this research is to provide an overview of the best combination to create briquettes from agricultural waste.

ACKNOWLEDGEMENTS

The authors would like to thank the Poultry Research Team for collaborating with us in completing this research. We also thank the entire management of Universal PT Tempu Rejo, which always supports us in conducting this research.

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