Proximate Analysis of Rice Husk Waste Briquettes and Dried Leaves as Alternative Fuel

***Syaiful Mansyur*[1]**
***Andri Prasetyo Nugroho*[2]**

[1]*Program Studi Teknik Industri, Universitas Proklamasi 45, Jl. Proklamasi No.1, Yogyakarta*
[2]*Program Studi Teknik Lingkungan, Universitas Proklamasi 45, Jl. Proklamasi No.1, Yogyakarta*
[2]*Korespondensi penulis: andri.prasetyo.n@up45.ac.id*

Article Info: *Received: June 24, 2025; Accepted: November 05, 2025; Available online: November 09, 2025*
DOI: *10.30588/jeemm.v9i2.2310*

***Abstract**: One of the uses of rice husk waste is to make it into fuel, not only to replace firewood as fuel for cooking in the household but also to grill various types of food tailored to its application. Then, to optimize rice husk into fuel, it needs to be compacted or densified into charcoal briquettes, because with a good densification process, the calorific value of rice husk can be higher than before it is compacted. Densification of biomass or other solid fuels can increase the energy density, making it more efficient as an energy source. In this study, an experimental analysis process was carried out to optimize the briquette-making process so that it could improve combustion efficiency and quality according to Indonesia standards. The results showed that the addition of dry leaf charcoal to make briquettes of a mixture of rice husks and leaves significantly, with a value of F = 0.0346, can increase the calorific value of briquettes according to Indonesian Standards. For proximate test values of water content and volatile content, significant values of 0.039 and 0.012 were obtained, respectively, so these results show the effect of adding dry leaves and reducing the percentage of husk charcoal significantly. While other test results, namely the value of ash content and bound carbon, did not have a significant effect both when adding leaf charcoal and reducing husk charcoal with a significance value of 0.21 and 0.054, respectively, this is because husk charcoal has silica, which can increase ash content, and the physical structure of the two materials is less dense.*
Keywords: *Proximate analysis, Calorific value, Briquette, Charcoal Husk*

Abstrak: Salah satu pemanfaatan limbah sekam padi adalah menjadikannya sebagai bahan bakar. Bahan bakar yang dimaksud bukan hanya sekedar untuk mengantikan peran kayu bakar sebagai bahan bakar untuk memasak dalam rumah tangga, namun dapat di aplikasikan sebagai bahan bakar untuk memanggang berbagai macam jenis makanan yang disesuaikan dengan pengaplikasiannya. Kemudian, untuk mengoptimalkan sekam padi menjadi bahan bakar perlu dilakukan pemadatan atau proses densifikasi menjadi arang briket, karena dengan proses densifikasi yang baik, nilai kalor sekam padi dapat menjadi lebih tinggi dibandingkan sebelum dipadatkan. Densifikasi biomassa atau bahan bakar padat lainnya dapat meningkatkan kepadatan energi, membuatnya lebih efisien sebagai sumber energi. Pada penelitian ini proses analisis ekperimental dilakukan untuk mengoptimalkan proses pembuatan briket untuk kemudian dapat meningkatkan efisiensi pembakaran dan berkualitas sesuai standar-SNI. Hasil penelitian menujukkan penambahan arang daun kering untuk membuat briket campuran sekam padi dan daun secara signifikan dengan nilai F = 0,0346 dapat menambah nilai kalor pada briket sesuai standar-SNI, untuk nilai uji proksimat kadar air dan kadar volatile diperoleh nilai signifikan masing-masing 0,039 dan 0,012; sehingga hasil ini menujukkan pengaruh penambahan daun kering dan pengurangan persentase arang sekam berpengaruh secara signifikan. Sedangkan hasil uji lainnya yaitu nilai kadar abu dan karbon terikat tidak berpengaruh signifikan baik saat dilakukan penambahan arang daun dan pengurangan arang sekam dengan nilai signifikansi masing-masing 0,21 dan 0,054; hal ini karena baik arang sekam memiliki komposisi kimia silika yang dapat meningkatkan kadar abu dan struktur fisik yang dari kedua meterial yang kurang padat.
Kata Kunci: Analisis Proksimat, Nilai Kalor, Briket, Arang Sekam

I. Introduction

The rice husk is the outer protective layer of the rice grain. When rice is processed to obtain rice, the rice husk will be separated from the rice. This rice husk consists of the outer husk, a fiber layer, and a thin layer that coats the rice seeds (Dahdah et al., 2020). Although rice husk is often considered agricultural waste, it has the potential to be utilized in various applications. The ratio between rice husk and rice (whole rice) varies depending on several factors, such as rice variety, milling process, and farming methods. In general, the ratio of milled dry grain (MDG) per kilogram yields 64% rice, 23% rice husk, then bran and rice bran around 10%, and the rest is other impurities (Sugiharto & Lestari, 2021; Yusriani et al., 2015). Rice husk can be used as biomass fuel, a raw material in organic fertilizer production, an insulation material, and in various other applications. Utilization of rice husks helps reduce the environmental impact of agricultural waste and supports the concept of sustainable agriculture (Ríos-Badrán et al., 2020). According to the infographic from the Central Bureau of Statistics (BPS) (Badan Pusat Statistik, 2024) throughout Indonesia, agricultural rice products can produce about 54.75 million tons of GKG (Gabah Kering Giling), so there are about 126 million tons of husks that can be utilized. The utilization of rice husk waste in Indonesia is usually processed into katul as a food ingredient or mixture in animal feed; if the animal feed is sufficient, it can be used again as an addition to plant fertilizer after the husk is nested. From these two types of utilization, it turns out that the husk waste is still very much needed so that later the husk waste can be used as a substitute fuel for liquid gas (Udjianto et al., 2021). Dried leaves refer to leaves that have long fallen or fallen from trees, undergone natural drying, and are one type of organic waste that is commonly found in tropical areas, such as in Indonesia. Dried leaves have significant benefits as a base material in compost production, which is a sustainable solution to manage organic waste and support environmentally friendly agriculture. One biomass that can be used as gasoline fuel is teak leaves. Leaves have a very short residence time, so they can be converted into other forms, such as fuel that has a longer burning time. Teak leaves have ingredients with a moisture content of 8%, an ethanol content of 8.1%, and a moisture content of 6.2%. ash content of 5.1%, water-soluble ash of 1.3%, and acid-insoluble ash of 3.2%. Examination of teak leaf chemicals explains that teak leaves contain catecholate tannins, gallic tannins, saponins, flavonoids, steroids/triterpenoids, and quinones (Puspita et al., 2024).

The process of making charcoal briquettes involves important steps in creating the density and sturdiness of the briquettes. The compression process is a critical stage in creating an effective contact relationship between the surface of the material to be bonded and the adhesive. Once the adhesive is mixed and pressure is applied, the adhesive, which is still in its liquid state, will begin to flow and spread itself across the surface of the material. At the same time, along with this flow, the adhesive also transfers from the surface area that has been coated with the adhesive to the surface area that has not been exposed to the adhesive. In this context, gluing becomes a key element that aims to unite the charcoal particles to form a compact and sturdy structure. The choice of adhesive material is a determining factor in the success of charcoal briquette manufacturing (Mansyur & Apriani, 2023; Nath et al., 2023). To meet SNI standards as household fuel, it is necessary to add other materials to increase the calorific value of rice husk briquettes. In this study, dry leaves were chosen because it is known that dry leaves are biomass materials that are located anywhere, so they are easy to obtain. In addition to the effect of briquette raw materials, the compaction process through compression also affects the energy value of a briquette (Mansyur & Apriani, 2023). Then, proximate testing is carried out to find out about the energy content and combustion characteristics of a material (Tambaria et al., 2019). Briquetting is a step in the briquetting process where the raw materials, which are generally solid powders or flakes, are compressed into a certain shape before going through the combustion stage. Briquettes must be charred first because charring helps produce briquettes with a high density and uniform shape. This process makes it possible to create a more efficient and easy-to-use solid fuel. Charcoal is a solid substance that contains pores and is formed through the combustion process of materials that contain the element carbon. Good-quality carbon in the form of charcoal is characterized by a black color with a bluish flame, has a gloss on the fragments, can burn without producing smoke, does not splatter, has no odor, and can continue to burn without blowing. Some factors that affect the quality of charcoal include temperature, water content, material size, and specific gravity (Sukarta & Ayuni, 2016). Charcoal briquettes are a type of solid fuel produced by compressing materials containing lignin, which acts as a natural binder. These briquettes have a high carbon content, a high heating value, and can burn for a long time. Briquettes have advantages as a fuel because the manufacturing process involves the compaction of combustible materials, making them denser, harder, and more compact than firewood or other biomass. With densities reaching around 1229 kg/m3, briquettes are much more resistant to heat than firewood or other biomass fuels, which have densities of only around 60–180 kg/m3. In addition, briquettes are the result of processing solidified biomass waste, so they tend to be more economical than gas or electricity when used as fuel (S Mansyur, 2022). Proximate analysis of these waste briquettes is key to understanding their combustion characteristics and energy potential. Proximate analysis of rice husk and dry leaf waste briquettes addresses the main components, including moisture content, ash content, volatile content, and carbon content. Moisture content reflects combustion efficiency; ash content provides information on mineral remains after combustion; volatile content affects the combustion process; and carbon content gives an idea of the potential energy that can be generated(Ishii & Furuichi, 2014; Rahmiati & Fajri Hasibuan, 2018; Udjianto et al., 2021). Previous studies have shown that briquettes from agricultural waste have a lower environmental impact compared to fossil fuels, reducing greenhouse gas emissions and reliance on non-renewable resources. Some studies have also revealed that optimization of briquette composition can improve combustion efficiency, reduce environmentally harmful emissions, and provide comparable or even better performance than conventional fuels (Tambaria et al., 2019).

II. Materials and Method

The research method was designed to provide a holistic understanding of the proximate properties of rice husk waste briquettes and dried leaves as alternative fuels.

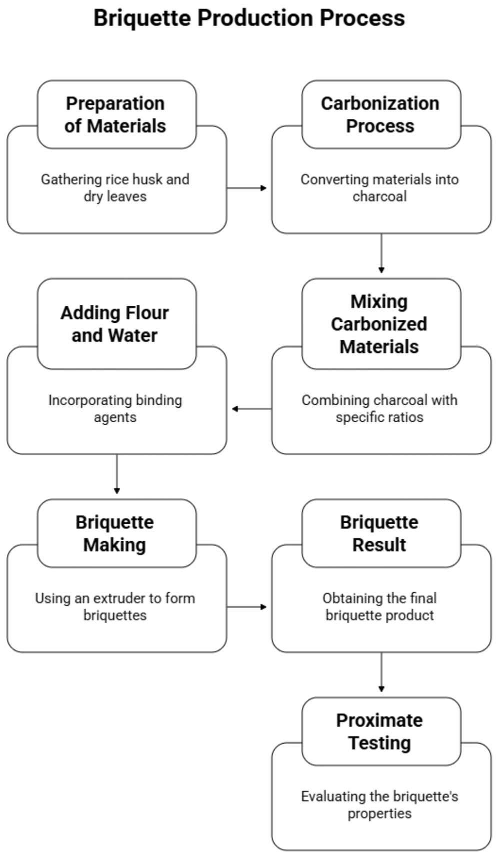


Figure 1. Research plan

Samples of rice husk waste and dried leaves were collected from local agricultural areas. Sample selection was done randomly to ensure the representativeness of the waste generated. Then, the samples were charred separately using conventional methods. The charred raw materials were then mixed in certain proportions according to the experimental design. The briquetting process involves mixing the selected raw materials with the addition of adhesive according to a predetermined ratio (Table 1).

Table 1. Briquette Composition Process

Test Stage	Briquette Composition			
	Charcoal Husk (%)	Charcoal Leaf (%)	Flour (%)	Water (%)
1	60	40		
2	70	30	5	30
3	80	20		

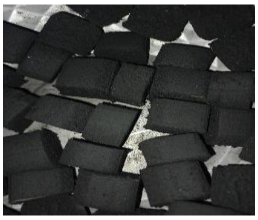
The total weight of husk charcoal and foliage charcoal weighs 650 grams and 210 grams, respectively, from which weight will be taken according to the experimental design described in the research flow design. The determination of the adhesive, in this case, starch, is 5% of the total weight of charcoal, as is the percentage of water used, which is 30% of the total weight of charcoal. The homogenized mixture was then compressed using a briquette molding extruder machine. The formed briquettes are then dried to remove any remaining water that may still be present after the manufacturing process. At this stage, the composition of the briquettes. Drying can be done naturally or by using an oven at a suitable temperature. Proximate analysis is carried out to determine the main components of the briquettes, namely moisture content, ash content, volatile content, carbon content, and calorific value.

III. Results and Discussion

a. Mixing the material

b. Forming process

c. Briquette out from mold



d. Briquette result

e. Drying process

Figure 2. Briquette making process

This image shows a series of stages in the briquette-making process. The process begins with material mixing (a), where ingredients such as rice husk charcoal and ground dry leaves are mixed with adhesive. Then, this mixture is continued to the molding process (b) using an extruder machine, which then produces an elongated shape from the machine as seen in the process of the briquette leaving the machine (c). After exiting, the elongated shape is cut into pieces of uniform size, resulting in a briquette after cutting (d), and the final stage shown is the drying process of the briquette (e) to remove moisture content so that the briquette is ready to be used as fuel.

In this study, information on the overall proximate values of moisture content, ash content, volatile content, carbon content, and calorific value is useful for comparing the quality of briquettes with other fuels, selecting the most efficient fuel, and supporting the development of better briquettes. In addition, these tests also help ensure that briquettes meet applicable quality standards. After conducting the research, the proximate test values and results are shown in Table 2.

Table 2. Proximate and Calorific Value Test of Briquette

No. of test	Materials /ratio	Moisture content (%)	Volatille matter (%)	Ash content (%)	Carbon content (%)	Calorific value (kCal/kg)	Reference
1	Husk charcoal 60%	6.16	8.65	38.73	46.46	5464.54	This study
	Leaf charcoal 40%						
2	Husk charcoal 70%	6.58	12.04	38.30	43.09	5352.93	This study
	Leaf charcoal 30%						
3	Husk charcoal 80%	7.10	15.66	36.65	40.59	5218.05	This study
	Leaf charcoal 20%						
4	Indonesia Standard (SNI)	8	15	8	77	5000	
S1	Sugarcane, 1 corn cob, 1 rice husk, 1 (coal briquette)	5.77	14.34	34.09	50.66	6372.41	(Nagarajan & Prakash, 2021)
S2	Rice husk briquette coal	-	-	-	-	4726.76	(Adu-Poku et al., 2022)
S3	Rice husk briquette	14	40.50	3.97	46.37	4225.18	(Saeed et al., 2021)

Table 2 above shows the characteristics of each briquette that has been tested. When referring to the SNI standard used, the briquettes studied do not comply with the SNI. The ash content of the briquettes studied is still very high compared to the SNI-standard set, which ranges between 36% and 38%. This is influenced by the chemical composition and physical structure of the charcoal-making material, where the chemical composition of rice husks tends to contain more silica (SiO2) because silica is one of the components that usually increases ash content in fuel. As for the physical structure, rice husk has a more porous and lightweight structure. This structure can affect the combustion process and the amount of ash produced. In line with the fixed carbon content, which has a value between 40% and 46% lower than the SNI, which is 77%, this is also influenced by the chemical composition and physical structure of the material. Combining several biomass materials to make briquettes can increase the calorific value of the biomass. (Akolgo et al., 2021)

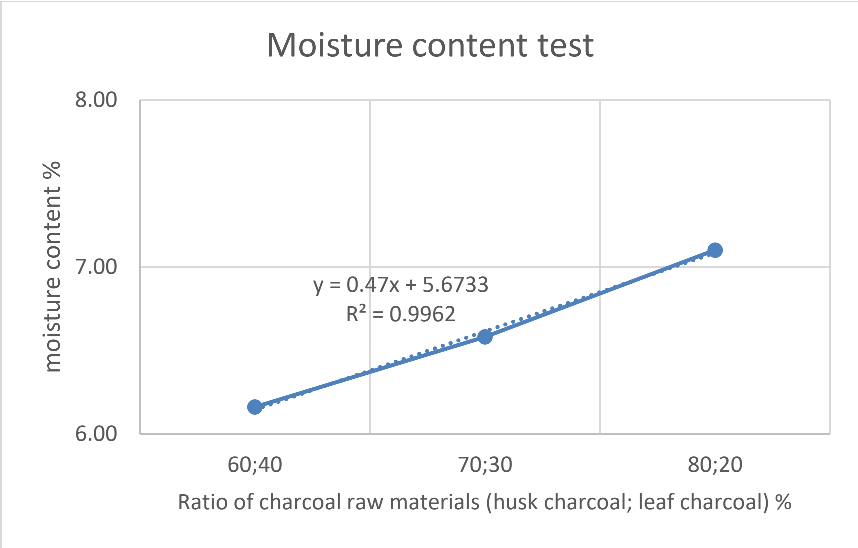


Figure 1. Regression Test of Moisture Content

In the regression equation y, it can be stated that the effect of dried leaf charcoal can reduce the moisture content in briquettes. The R-squared (R2) value of 0.99 indicates that about 99% of the variation of the y-axis (moisture content value) can be explained by the variation of the x-axis (ratio of briquette raw materials). The results of the F significance test obtained a value below 0.05, where F = 0.039, which means that the independent variable simultaneously affects the dependent variable. Then, the correlation test results show that the effect between the ratio of charcoal raw materials and the percentage value of water content is 0.998.

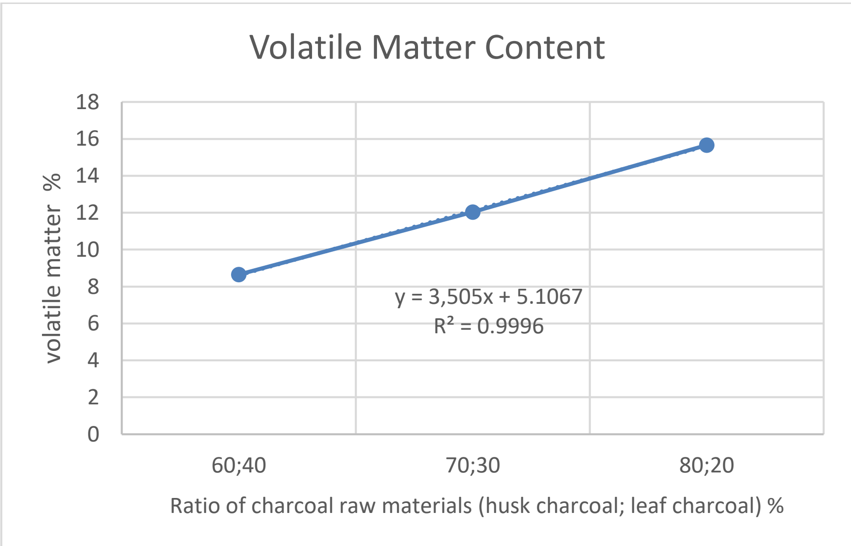


Figure 2. Regression Test of Volatile Matter

Just like testing the moisture content of briquettes, the percentage of volatile content is also influenced by the presence of dry leaf charcoal. Significant test results are F = 0.012, R2 value of 0.999 indicates that 99% of the model explains all variations in the data. The correlation test result obtained was 0.999.

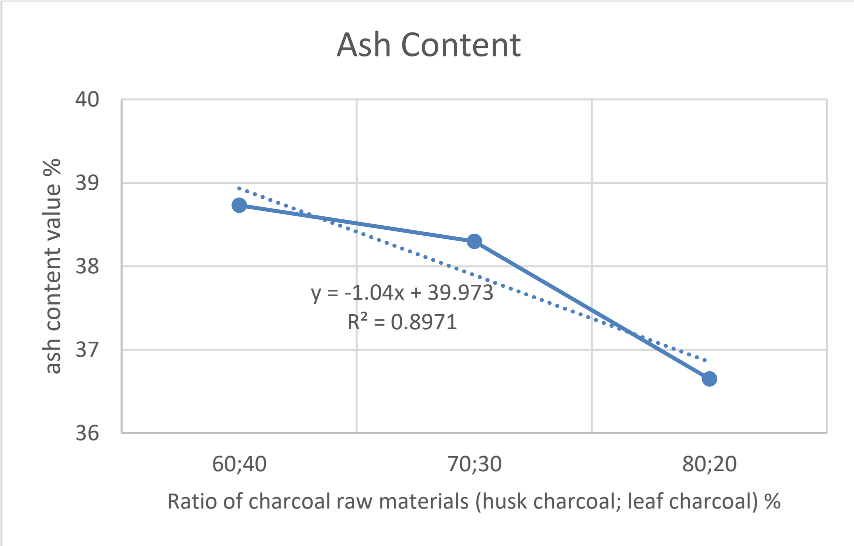


Figure 3. Regression Test of Ash Content

In contrast to the regression test results for moisture and volatile content, the ash content test was obtained with a negative coefficient value of x. The significant test result of ash content F = 0.210 means that there is no significant effect of adding leaf charcoal or reducing husk charcoal to reduce the percentage value of ash content. This is because these two briquette-making materials both have physical properties and chemical compositions that can increase the ash content of briquettes.

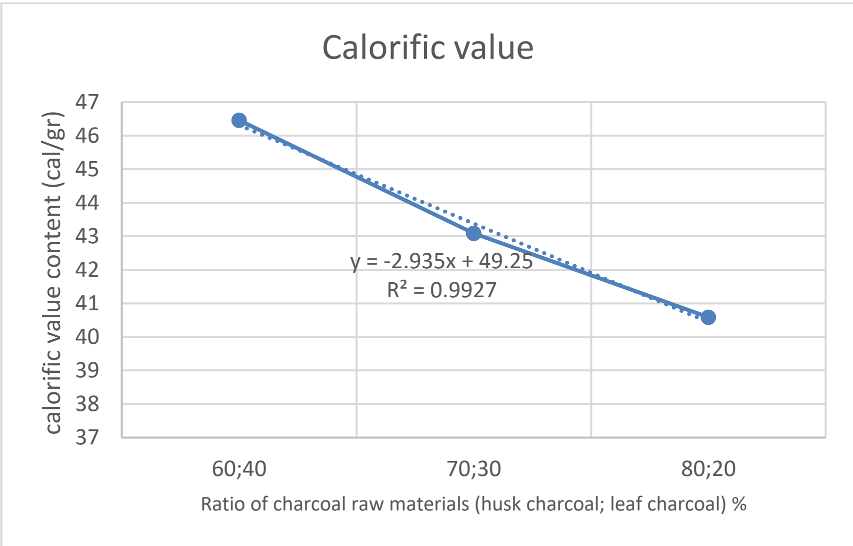


Figure 4. Regression test of calorific value

The addition of leaf charcoal as an additive can increase the calorific value of the briquettes. This happens because the calorific value of leaf charcoal itself can increase the overall calorific value of the briquette. The regression test results obtained a significant value of F = 0.0346, where the value of $F < 0.05$ can be interpreted as indicating that the independent variable simultaneously affects the dependent variable.

IV. Conclusions

The addition of leaf charcoal can increase the calorific value of briquettes, with a significance value of F = 0.0346. This is shown in the results of the linear regression test, where each percentage increase in leaf charcoal will increase the calorific value of briquettes with a correlation value of 99%. The results of the proximate test values of moisture content and volatile content obtained significant values of 0.039 and 0.012, respectively, so these results show that the addition of dry leaves and the reduction in the percentage of husk charcoal have a significant effect. Other test results, namely the value of ash content and fix carbon, did not have a significant effect either when adding leaf charcoal or reducing husk charcoal, with a significance value of 0.21 and 0.054, respectively. The density of the charcoal material used affects the percentage of ash content and bound carbon content in the briquettes. This happens because the husk has a high silica composition, where silica is one of the components that usually increases the ash content in fuel. The physical structure of rice husks and dry leaves that are not dense also has an effect.

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