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The Potential Biopellets from Rice Husk as an Alternative Fuel

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A B S T R A C T

One of Indonesia's biggest waste crops, husk rice, has not yet been fully exploited. Husk rice has a high lignocellulose content, increasing its potential as a renewable energy source, particularly in the form of biopellets. The procedure of creating biopellets is the focus of this study. biopellets made from husk rice and evaluate their quality using proximal, ultimate, value, density, and heat criteria. The study's stages include drying the raw material, milling it to a uniform size, using a pellet mill for pelletization, and testing the biopellets for quality in compliance with SNI 8951:2020. The study's findings revealed that rice husk biopellets have sufficient calories and low water content after undergoing optimal drying. However, the high relative ash content is the main problem in using it as a feedstock for co-firing, necessitating quality enhancement through chemical treatment or blending with other biomass. Overall, biopellets derived from husk rice have the potential to serve as an environmentally acceptable and cost-effective alternative energy source for household and industrial use.

Contribution to Sustainable Development Goals (SDGs):
SDG 11: Sustainable Cities and Communities
SDG 13: Climate Action
SDG 15: Life on Land

1. INTRODUCTION

Global energy demand continues to rise in tandem with population growth and industrial activity. However, reliance on fossil fuels such as coal, petroleum, and natural gas poses a variety of challenges, including greenhouse gas emissions, air pollution, and an unstable energy supply [1]. This condition motivates numerous countries, including Indonesia, to develop more ecologically benign and long-term renewable energy resources. Biopellets are a renewable energy source that is increasingly being developed. Biopellets are small, crowded cylinders formed by the biomass compression process. Biopellets are made from a variety of biomass waste, including sawdust, rice husks, oil palm empty fruit bunches (EFB), palm kernel shells, sugarcane bagasse, straw, and other agricultural waste [2]. Pelletization enhances biomass's energy density, reduces water content, and improves combustion characteristics, making it more efficient than raw biomass. Furthermore, its consistent shape makes biopellets easy to store, transport, and use in various combustion systems, such as biomass stoves, industrial boilers, and co-firing schemes in Steam Power Plants (PLTU).

In addition to offering a sustainable energy option, the production of biopellets is strategically important because it contributes to reducing agricultural and plantation waste that is not fully utilised [4]. The process of turning garbage into biopellets lowers carbon emissions, supports the transition to a cleaner energy system, and strengthens the local economy. However, the properties of the raw materials, production method, water content, calorific value, and ash content all significantly impact the quality of biopellets [5]. To ensure the final product meets national and international quality standards, biopellet research is crucial, notably to support the widespread use of biomass energy [6].

The availability of fossil fuels continues to decline as the country's energy needs rise. In coal-fired power plants, co-firing biomass is a successful strategy for energy transition. Due to its ability to reduce carbon emissions, Indonesia relies heavily on biomass and coal [7]. However, to meet material burn solid requirements, such as high heat value, low water content, and an adequate ash standard, the quality of biomass must be improved throughout the pelletization process.

Biomass is a sustainable energy source that produces clean energy with low NOx levels and zero carbon emissions [8]. Sugar cane, rice husks, empty palm bunches, palm kernel (EFB) shells, and coconut pulp are examples of biomass that can be obtained from plantations and the agricultural sector. These materials have a significant potential as standard biopellets. Numerous studies have examined the properties of each biomass type; however, there remains a lack of comparative analysis of various biomass types for co-firing applications [9]. Organic components employed in the composition of biopellets include cellulose, hemicellulose, and lignin, which can occur in any area of the body [10]. To assess the acceptability of biomass as a material for pellet burning, this publication compiles extensive comparisons from numerous studies currently available.

2. MATERIALS AND METHODS

This research was conducted to determine the physical and chemical characteristics of biopellets produced from various types of biomass, as well as to evaluate their suitability as an alternative material for burning based on SNI 8951:2020. Stages of the methodology that include raw material collection, sample preparation, pelletization, testing, and data analysis.

Rice husks, empty oil palm bunches (EFB), sugarcane pulp, coconut pulp, and palm kernel shells are examples of agricultural and plantation waste that can be used to produce biomass feedstock. After being freshly gathered, each type of biomass is sifted to remove contaminants such as stones, dirt, and other foreign material.

The biomass will first be dried in an oven at 60–105°C until the water content is less than 10%–12%. The goal of drying is to enhance the pelletization's quality. Following the drying process, biomass will be ground into a uniform size using a grinder with a mesh size of 40 to 60. The adhesive ingredient—specifically, oil—was then added, and the mixture was well combined. A pellet mill machine operating at high pressure (150–250 bar) and temperature (80–120 °C) will be used to pelletize powder biomass that has been evenly mixed with glue. After being cooled, the biopellets are chopped to a consistent length of ±10–20 mm.

Following cold production, an analysis is conducted to determine whether or not the biopellets meet the required quality standards. Proximate, ultimate, value tests, heat (heating value), density test, hardness test, and durability index are among the parameters examined. Proximate and ultimate testing are conducted using the following techniques:

Table 1. Proximate and ultimate analysis method

Proximate Analysis	
Moisture	BS ISO 11722:2013
Ash content	BS/ISO 11722:2010
Volatile matter	BS/ISO 562:2010
Fixed carbon	By Difference
Gross calorific value	BS/ISO 19579:2006
Ultimate Analysis	
Carbon (C)	ASTM D 5373-21
Hydrogen (H)	ASTM D 5373-21
Nitrogen (N)	ASTM D 5373-21
Total sulphur (TS)	BS/ISO 19579:2006

Table 2. Standard Specifications for Biopellets

No.	Test parameters	Unit	Quality		
			Premium	Standard	Utilities
1	Density	g/cm ^{3} ,min	5	5	5
2	Ash content	%weight,max	13	3	4
3	Water content	%weight,max	95	10	12
4	Volatile substance content	%,max	72	71	70
5	Fixed carbon content	%, min	17	16	14
6	Calorific value	Kcal/kg, min	4.3	4.3	4.04
7	Total sulfur content	%,max	5	5	1
8	Hardgrove grindability index	HGI, min	32	32	32
9	Ash fusion temperature: IDT	°C, min	1.2	1.18	1.15

3. RESULTS AND DISCUSSION

According to the aforementioned data, South Sumatra Province produced rice over three years, from 2019 to 2021. 2020 was the year with the highest rice production in South Sumatra, at 2.74 million tons. This rise indicates that the potential rice husk, which accounts for 15–20% of the overall rice weight, also peaked during the year.

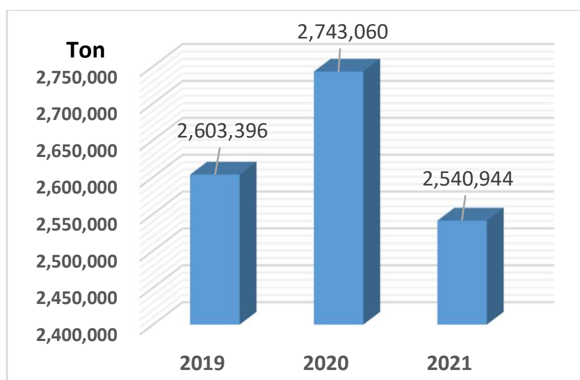

Figure 1. Production of rice in the southern province of Sumatra

Although it is still below 2020 levels, 2.63 million tons of paddy were produced in 2019, indicating significant potential for rice husk production. By 2021, rice output had dropped to about

2.56 million tonnes, indicating a decline in the supply of rice husk as waste biomass. Overall, this graph indicates that South Sumatra's potential for rice husk is comparatively high each year, ranging from 500 thousand to more than 600 thousand tons, and is significantly impacted by variations in rice output. These large husks have the potential to be used as fuel and for other biomass energy needs. Regular biopellets, briquettes, or ash husk-based silica production.

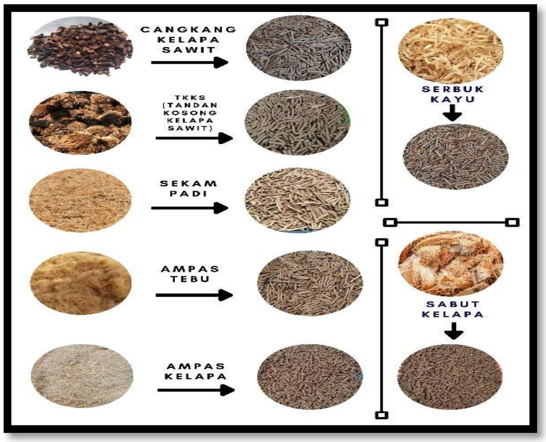

Figure 2. Biopellets made from biomass

Table 3. Biomass Analysis Values

Analysis	Rice Husk	Shell palm oil	EFB
Water content	7.08	8.09	11.98
Ash content	10.93	5.44	6.53
Calorific value	3.216	4.582	4.034

3.1. Water Content

According to the analysis's findings, rice husk has a lower water content of 7.08% than other materials. When combustion occurs, a low water content can be beneficial because it reduces energy loss from evaporating water, improves pelletization efficiency, and yields stronger, denser biopellets. The biomass with the highest EFB, however, demonstrates a more intensive drying procedure to meet SNI standards (<12% for grade B pellets).

3.2. Biomass Ash Content

At 10.93% of other ingredients, rice husk has the best ash content. High silica content, a hard surface, and a high mineral content are the reasons for the high ash content. Ash can lead to slagging, fouling, and the accumulation of crust on the stove, making it a significant problem when employed in combustion at the fire level.

3.3. 3.3 Calorific Value Biomass

The most crucial factor in figuring out how well a material burns is its calorific value. With a mark of 4,582 kcal/kg, shell palm oil has the greatest heat of the three materials. Husk paddy has the lowest energy content at 3,216 kcal/kg. Compared with biomass wood and palm oil, the value of heat husk low rice is affected by its high ash content and higher biomass energy density. However, rice husks can also be processed into higher-quality biopellets by combining them with other biomass and adding additives like lignin, starch, or FAME.

According to the data, rice husk is a good material for basic biopellets for house ladders, but it is not ideal for industrial boilers without further treatment. Shell palm oil has a higher heat height and cleaner combustion, making it perfect for industrial-grade biopellets. To improve the efficacy of biopellets made from rice husk, TKKS can be utilized as a co-feedstock.

3.4. Implementation Biopellets

The outcome of producing biopellets from base rice husk can be used as a substitute for burning materials. Burned from stove biopellets, biopellet rice husk can be utilized as an ingredient. The stove biopellets rice husk application is as follows:

Figure 3. Using biopellets as a substitute for material burning

4. CONCLUSION

Rice husks are abundant in Indonesia and have great potential as an alternative fuel, according to research on the potential of biopellets made from them. Testing the properties of biomass (rice husks, palm kernel shells, and EFB) generally revealed notable variations in moisture content, ash content, and calorific value. Due to its low moisture content (4.24%), rice husk can be pelletized and burned. However, because of its silica content, which can lead to slagging and fouling issues during industrial combustion, its ash content is exceptionally high (14.01%). Without further processing, rice husk's low calorific content of 2,589 kcal/kg makes it unsuitable for industrial energy requirements. In general, rice husks can be used as a raw material for domestic biopellets, like those used in stoves. However, adding chemicals or blending them with other biomass is necessary to increase the quality of biopellets for industrial usage or co-firing. The best option for producing premium biopellets remains palm kernel shells. EFB is a useful blending ingredient that can enhance the properties of rice husk biopellets.

REFERENCE

[1] LK Akhmad Rizal, Rusdianasari, "Fatty Acid Methyl Ester as an Additional Ingredient in Rice Husk Bio-Pellets to Improve Product Quality," pp. 29–36, 2023, doi: 10.32996/jmcie.

[2] FA and YB Joko Triatmoko, "Comparison Moisture of Biopellets from Sugarcane Bagasse and Coconut Dregs as Raw Materials for Co-Firing Power Plant," pp. 34–39, doi: 10.32996/jmcie.

[3] LK Riztamala Diana, Rusdianasari, "The Effect of Palm Shell and Empty Fruit Bunch Composition Ratio on the Quality of Biopellets for The Effect of Palm Shell and Empty Fruit Bunch Composition Ratio on the Quality of Biopellets for Co-firing," pp. 0–7, doi: 10.1088/1755-1315/1228/1/012006.

[4] SMB Monoarfa, R. Djafar, S. Akuba, and S. Haluti, "Design and Construction of a Biopellet Printing Machine from Rice Husks," vol. 7, no. November 2022, pp. 51–56.

[5] JT Kimia *et al.* , "UTILIZATION OF RICE HUSK WASTE AS AN ALTERNATIVE MATERIAL IN MAKING BIOPELLETS Mauliza Asri, Eddy Kurniawan*, Novi Sylvia," vol. 2, no. June, pp. 57–65, 2022.

[6] TWW Istaniaha, Amar Ma'ruf, Ridwan Rachmat, "Characteristics of Biopellets from Wood Powder and Rice Husk Istaniah," vol. 10, pp. 262–272, 2024.

 https://doi.org/10.29165/ajarcde.v9i3.844

[7] AR Rusdianasari, Leila Kalsum, Abu Hasan, Hengky Saputra, Riztamala Diana, *Assessment of the Co-firing in a Portable Boiler Using* . Atlantis Press International BV, 2024. doi: 10.2991/978-94-6463-386-3.

[8] AS and FA Rusdianasari, Iwan Arissetyadhi, Leila Kalsum, Yohandri Bow, "Characterization of Empty Fruit Bunch of Palm Oil as Co-firing Biomass Feedstock," vol. 7, no. 1, pp. 3–7, 2023.

[9] KW Dhimas Mardyanto Prasetyo, Febriana Tri Wulandari, “Characteristics of Biopellets Made from Rice Husk and Sawdust,” vol. 05, no. 62, pp. 137–150, 2022, doi: 10.22219/avicennia.v5i2.21597.

[10] DD Firmansyah, MH Bahri, and A. Abidin, “Analysis of the Characteristics of the Calorific Value of Rice Husk Biopellets and Tapioca Flour as Adhesives with Variations in Natural Zeolite Additives,” vol. 3, no. 1, pp. 406–412, 2024.