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| RESEARCH ARTICLE

Fatty Acid Methyl Ester as an Additional Ingredient in Rice Husk Bio-Pellets to Improve Product Quality

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| ABSTRACT
The depletion of fossil energy reserves and the emission of fossil energy which is not environmentally friendly causes the need to use renewable energy as an alternative. Biopellet is a biomass-based renewable energy in Indonesia. Bio-pellets are produced from a large biomass base. Thus, bio-pellets have the potential and promise to continue to be used as fuel by humans. The literature review covers the characteristics of rice husk bio-pellets and the application of bio-pellets as fuel with the addition of Fatty Acid Methyl Ester (FAME) as an additive to rice husk bio-pellets. Bio-pellets can be made by mixing biomass with an adhesive with a concentration of 15% (w/w), then stirring until homogeneous and put into a pellet mill to be printed. The pellets were dried in the oven for 30 minutes. Characteristically, bio-pellets meet SNI 8021-2014 for the parameters of ash content, fixed carbon content, calorific value, moisture content, and volatile matter content. Applying bio-pellets as a furnace also shows good performance of heat, efficiency, and emission parameters. In conclusion, biopellet is a biomass-based renewable energy fuel with current and promising potential.

| KEYWORDS
Biopellet, Caloric Value, FAME, Fixed Carbon, Rice Husk.

| ARTICLE INFORMATION
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1. Introduction
Energy use in Indonesia is still dominated by non-renewable energy derived from fossils, especially oil and coal. Still, over time, the availability of fossil energy is dwindling, and anticipating this new renewable energy is the best alternative (Putri et al., 2020)(Ploetz et al., 2016). So all energy sources must be controlled by the state and utilized and exploited optimally for the greatest prosperity of the Indonesian people to realize one of the ideals of the Indonesian people, namely to promote public welfare (Wahyono et al., 2021). Indonesia is an agricultural country where most of the population makes rice a staple food, and rice production is evenly distributed throughout the country (Bow et al., 2022).

There are three types of renewable energy: liquid, solid, and gas. Renewable energy may be produced as liquid, solid, or gas, including bioethanol, biodiesel, bio-pellets, bio-briquettes, and biogas (Rusdianasari et al., 2022). One of Indonesia's many sources of renewable energy (Susumu et al., 2018). The potential for biomass resources in Indonesia is estimated to be about 146.7 million tonnes/year by Acda's Zentrum für rationelle Energieanwendung und Umwelt (ZREU) (Mancini et al., 2020). Rice husks, bagasse, soybean stover, peanut shell waste, palm oil mill waste, coconut stems and fronds, and agricultural corn waste (corncobs, stalks, corn (Bow et al., 2021) (A. Damayanti et al., 2021), and leaves) can all be used to produce biomass, which can then be used as an alternative fuel. Burning biomass generates biogenic CO_2, which is less harmful to the environment than burning fossil fuels, which

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generate fossil CO_2 (Yunsari et al., 2019). An inexpensive and practical energy source, biomass fuel is made from wood waste (Rusdianasari et al., 2023).
A total of 15 million tonnes of rice husk waste are produced annually by the 60,000 rice grinding machines that are dispersed across Indonesia (Lisowski et al., 2019). Some rice milling machines with big capacities can generate 10–20 tons of waste rice husk per day (Suryaningsih et al., 2018). Waste is frequently understood to be leftovers or waste products from the manufacturing of agricultural goods (Wulandari et al., 2022). As long as rice husks aren't used more frequently, they'll continue to pollute the environment (Warji et al., n.d.). The possible use of rice husk as a biofuel includes making it into bio-pellets as a replacement for solid fuel biomass energy (Rochmad, 2021).

Research on bio-pellets made from rice husk, a possible and promising source of biomass-based renewable energy fuel, is the goal of this study (Rivai Suhendra F, 2021). The study discusses the properties of bio-pellets and how Fatty Acid Methyl Ester (FAME), an addictive chemical, was added to bio-pellets to increase quality (Irawan et al., 2021). based on the use of bio-pellets as fuel in small-scale enterprises and the national bio-pellet standards for Indonesia (Rusdianasari et al., 2022).

2. Literature Reviews

Rice husk is a hard coating that covers the caryopses, which are made up of two interlaced pieces termed lemma and palea (R. Damayanti & Riski Nanda, n.d.). Rice husk is a biomass that may be utilized for a variety of purposes, including industrial raw materials, animal feed, and energy or fuel (Goembira et al., 2021b). The rice milling process typically yields 20-30% of the grain weight. Rice husk contains cellulose (31.4 - 36.3%), hemicellulose (2.9 - 11.8%), and lignin (9.5 - 18.4%) as major components (Goembira et al., 2021a).

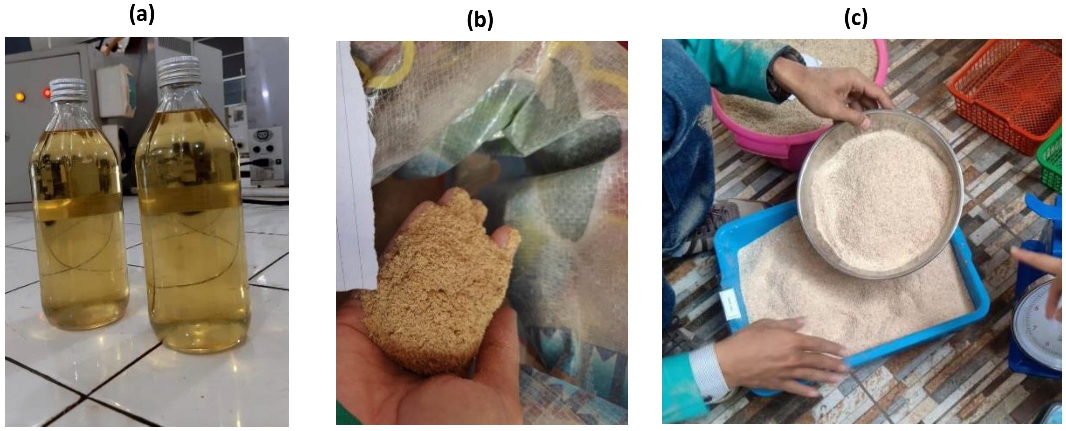
Cellulose and hemicellulose are polysaccharides that may be broken down into monosaccharides and used to create useful chemicals, one of which is ethanol (Cui et al., 2021). Husk has a bulk density1 of 125 kg/m3 and a calorific value of 3,300 k. calories per kilogram (Iskandar et al., 2020). Husk has a bulk density of 0.100 g/ml and a caloric value ranging from 3,300 to 3,600 kcal/kg (Bazargan et al., 2015). Furthermore, the utilization of rice husks for ethanol manufacturing aids in the management of agricultural waste. The rice milling process typically yields 20-30% husk, 8-12% bran, and 50-63.5% milled rice, according to initial grain weight data (Wahyono et al., 2021). When rice is converted into bio-pellets, chemicals are added to increase fuel quality (Bow et al., 2022). FAME (Fatty Acid Methyl Ester) is the additive utilized. FAME (Fatty Acid Methyl Ester) contains unsaturated double bonds and can be utilized as a bioplasticizer. FAME, or biodiesel, is non-toxic and biodegradable in water (Akhter et al., 2021). According to the fuel's proximate study, the heating value of pure FAME is 39.82 MJ/kg (Manique et al., 2012).

3. Methodology

3.1 Materials

Rice husks were obtained from PT. Belitang Harvest Raya in Belitang, South Sumatra, Indonesia, as a byproduct of rice goods. FAME was produced from liquid fuel received from PT. Kilang Pertamina Internasional RU III in Palembang, South Sumatra, Indonesia. To treat solid waste, each item is placed through a pelletizer. All biomass feed stuffs were dried at 29 C room temperature. All additional substances utilized in the investigation were obtained from the Energy Engineering Laboratory at Politeknik Negeri Sriwijaya.

(a) **(b)** **(c)**



Figures 1. (a) Fatty Acid Methyl Esters; (b) Rice Husk before drying process; (c) Rice Husk after drying process.

3.2 Pelleting Process

To produce pellets for this research, a laboratory size pellet machine (Figure 2) with a production capacity of 250-300 kg/hour, depending on the kind of raw material, was used.

The pelleting process is continuously carried out by putting dry rice husks into the funnel. Before putting the rice husk pellets into the funnel, 50 grams, 100 grams, and 200 grams of FAME are added to the feeding. After making the pellets, they can cool for several hours on a dry concrete floor to guarantee physical stability. Experiments were carried out 24 hours a day at a temperature of 27-29°C and a relative humidity of 50-60%. During the pelleting process, production capacity is estimated as kg/hour by weighing the pellets kept in the vessel for 60 seconds.

(a) **(b)**

Figures 2. (a) The process of feeding rice husk into the pelletizer funnel; (b) bio-pellets product of rice husk

3.3 Characterization Analysis of bio-pellets

The Indonesian National Standard test method (SNI) 8951: 2020 is used for bio-pellet characterisation, as stated in Table 1. Meanwhile, the conventional shape of the product is cylindrical, measuring 0.3 - 0.5 cm in diameter and 2 - 4 cm in length.

Table 1. Characterization analysis of bio-pellets according to SNI 8951: 2020(Iskandar et al., 2020).

No.	Parameters	Methods	Units	standard
1	Ash Content	Burn samples in the furnace at 650 °C for 5 hours	%	<1.5
2	Fixed Carbon Content	100% - (fixed carbon content + ash content + water content)	%	>14
3	Caloric Value	Feed samples into Bomb Calorimeter	cal/g	>4,000
4	Water Content	Dry samples in an oven with a temperature of 105 °C for 3 hours	%	<12
5	Volatile Matter Content	Burn samples in the furnace at 950 ° C for 10 minutes	%	<80

4. Results and Discussion

To make sure stability, pellet samples were kept in a room with a temperature of 27-29°C and a relative humidity of 55-60% for three days. The moisture level of the pellets was tested immediately after the pelleting process and after 3 days to examine the influence of ambient conditions on the pellets, as shown in Figure 3, which represents the real biopellet.

4.1 Characterization of Rice Husk Bio-pellets

A homogenous process of rice husk and additives to form bio-pellets was carried out to analyze the features of the rice husk bio-pellets. The dry rice husk is loaded into the shovel pelletizer and then combined with FAME additives at various ratios to obtain the best amount.

Figures 3. Rice Husk Bio-pellets

Table 2. Additives Absorption Test in Rice Husk Bio-pellets

Sample(Rice Husk + Additive)	Initial	Proximate Analysis				
		***Moisture Content* (%)**	***Fly Ash Content* (%)**	***Volatile Matter* (%)**	***Fixed Carbon* (%)**	***Caloric Value* Cal/g**
No additives	Blanks	4,24	14.01	48,52	33,23	2589,3237
FAME, 50 gr	BioPelet-A	4,23	13.74	48,69	33,34	2658,7244
FAME, 100 gr	Bio-pellets-B	4,23	13.68	49,10	33.00	3133,6585
FAME, 200 gr	BioPelet-C	4,23	13.50	48,66	33,60	4083,9170

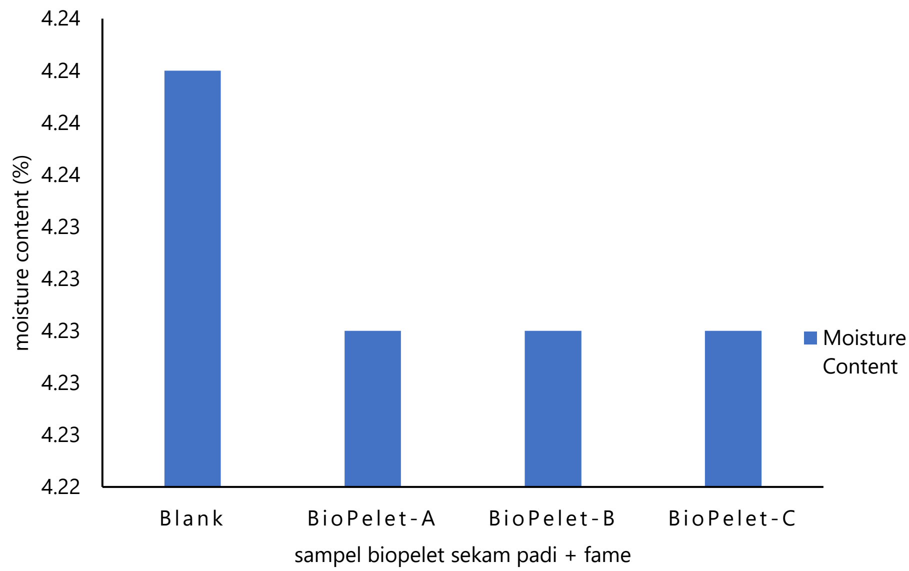
This study intends to increase raw material quality in order to achieve SNI 8951: 2020 criteria for bio-pellets. The rice husk raw material is blended with FAME additions in three different weight ratios: 950 gr rice husk: 50 gr FAME, 900 gr rice husk: 100 gr FAME, and 800 gr rice husk: 200 gr FAME.

The physical shape of the bio-pellets after manufacturing was solid, dark brown, and the diameter of the pellet was 4 mm, as shown in Table 2. The factors were used to create the bio-pellets, which were then examined for proximate features such as moisture content, fly ash content, volatile matter, fixed carbon, and calorific value.

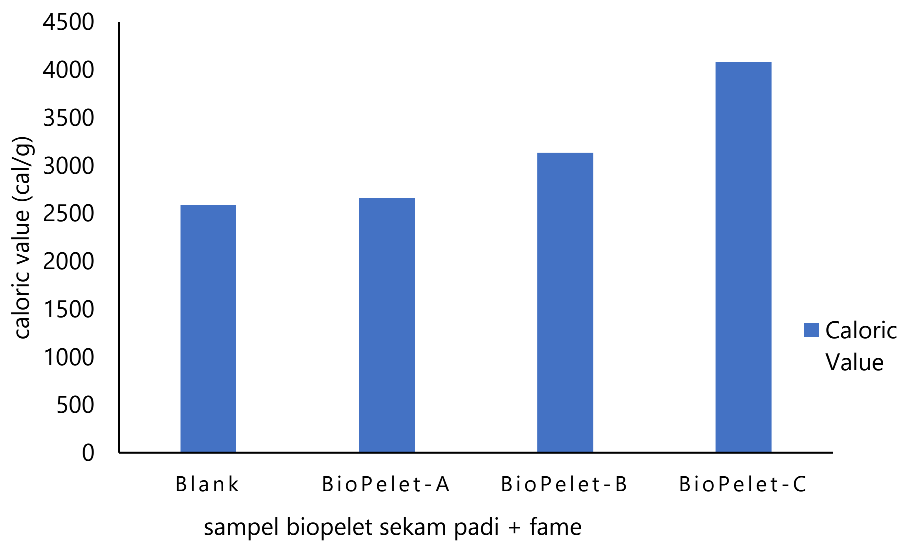
4.2 Moisture Content and Caloric Value

Correlation between Figure 4 and Figure 5 bio-pellet with 1 composition of rice husk up to 1,000 grams and 3 compositions of a mixture of rice husk and FAME based on mass ratio.

The mass ratio in the homogenous process in Biopellet-A, for example, which is 950 gr of rice husk and 50 gr of FAME, raises the calorific value. However, it is not significant when compared to Biopellet-C since the amount of FAME in Biopellet-C is lower. This occurred because the calorific content of FAME raw material is already high at 9,403.1052 Cal/gr, whereas rice husk is only 2,589.3237 Cal/gr. The difference between the blank sample and Biopelet-C is a twofold increase in calorific value and a twofold decrease in water content. The moisture content of a substance is the quantity of water it contains (Garca et al., 2013). The water content is inversely proportional to the calorific value, so a decrease in the water content will cause an increase in the calorific value (García et al., 2013). Then all sample variables added by FAME can meet the characteristics of increasing the calorific value of the fuel. However, the calorific value also correlates with the impurities, carbon, and volatile matter content (Rusdianasari et al., 2022). The low calorific value is due to the high ash, high volatility, and small fixed carbon content. The calorific value of bio-pellets is influenced by the energy content of the biomass, moisture content and ash content of the bio-pellets (A. Damayanti et al., 2021). The calorie content is an important variable in determining the quality of bio-pellets. The higher the caloric content, the higher the quality of the bio-pellet (Lubis, 2018).



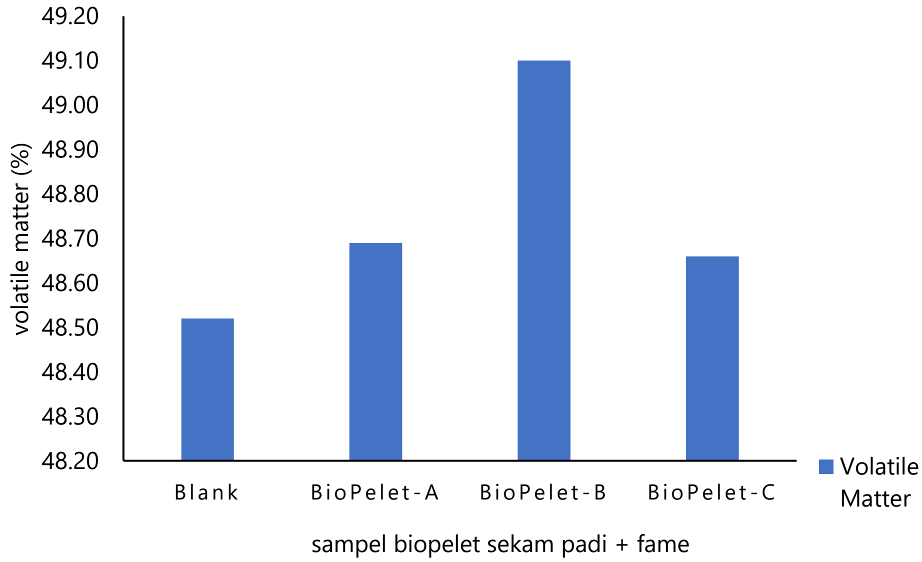
Figures 4. Moisture Content of Rice Husk Bio-pellets



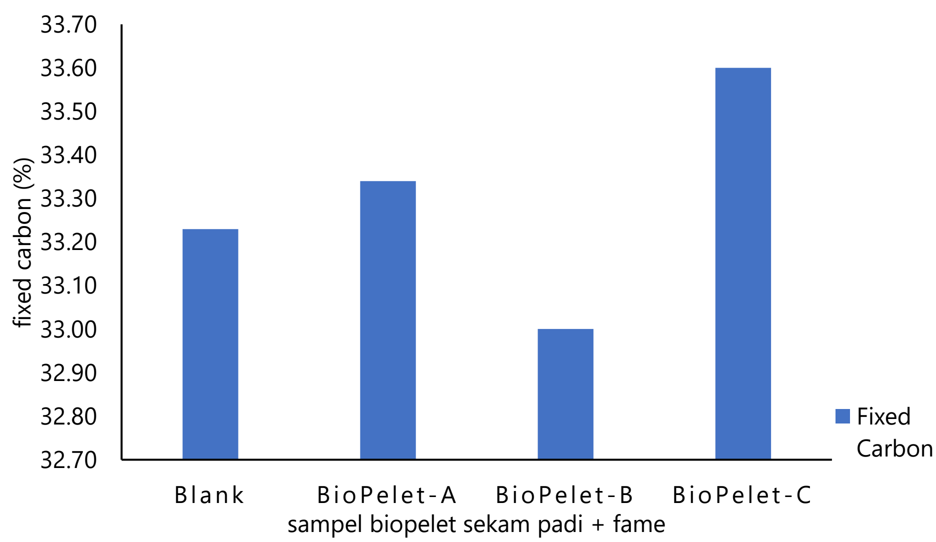
Figures 5. Caloric Value of Rice Husk Bio-pellets

4.3 Volatile Matter and Fixed Carbon

The diagram on the Biopelet-B samples in the graph below depicts a contrasting phenomenon. In comparison to the other three samples, the Biopelet-B samples had a larger volatile content than the Biopelet-A, Biopelet-C, and blank samples, with the lowest fixed carbon concentration in Figure 7.



Figures 6. Volatile Matter of Rice Husk Bio-pellets

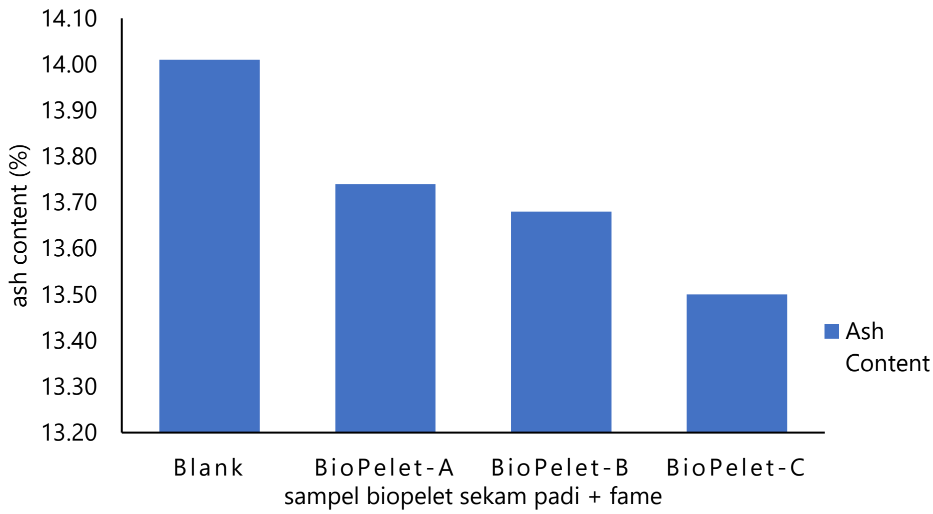


Figures 7. Fixed Carbon of Rice Husk Bio-pellets

This demonstrates that the higher the impurity concentration of the material, the lower the carbon content of the fuel. As a result, the Biopelet-B samples were unable to enhance all of the quality improvement attributes specified in SNI 8951:2020. Figures 7 and 5 show that the greater the carbon bonds, the higher the heating value, and the connection between carbon content and heating value is linear in Figure 5 (Albashabsheh, 2019; Mitchell et al., 2013). The carbon content of Biopelet-B is minimal. However, the calorific value of the Biopellet-B sample is still higher than that of Biopellet-A and blank due to FAME, which has a calorific value of 9,403.1052 Cal/g. The low carbon content number is assumed to be attributable to Figure 8's high ash content and Figure 6's volatile matter content. The fixed carbon content has a significant impact on the overall calorific value (Hardiansyah et al., n.d.). The higher the fixed carbon content, the higher the calorific value, and hence the quality of biopellet products (Rusdianasari et al., 2020).

4.4 Fly Ash Content

Ash in bio-pellets is a mineral that cannot be burnt after the combustion process, resulting in a deterioration in bio-pellet quality (Naufal Hidayat et al., n.d.). The presence of silica, magnesium, potassium, and calcium in ash influences the calorific value of combustion products (Acda, 2015). Rice husk biomass is rich in silica. The greater the silica level in the biomass, the higher the ash content; as a result, the caloric value of burning can be reduced (Mitchell et al., 2013).



Figures8. Fly Ash Content of Rice Husk Bio-pellets

According to the graph in Figure 8, the lower the ash content, the higher the carbon content in Figure 7 and the heating value in Figure 5, which is caused by carbon bonds from lignincellulose, which adds carbon bonds from FAME, which helps the combustion process to increase the heating value.

5. Conclusion

Rice husk biopellet with FAME meets SNI 8951:2020 specifications for ash content, fixed carbon content, heating value, moisture content, and volatile matter content. When employed as the primary energy source, rice husk biopellets can reduce the monthly usage of fossil fuels. Biopellets are a low-cost, high-quality, ecologically friendly, and cost-effective fuel. This implies that the Biopellet-C sample meets the SNI 8951:2020 calorific value parameter criteria. The relatively high silica content of rice husk, which keeps the fly ash value over 10%, is a constraint of this rice husk biopellet research. The higher the calorific content of rice husk, on the other hand, the faster it burns. The density of bio-pellets also influences their rate of combustion. As a consequence, rice husk biopellet products can be utilized as fuel for small-scale companies that produce food at home. It should be revisited in order to enhance the quality of fly ash and high volatile matter for industrial scale combustion operations.

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