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Utilizing Mushroom Baglog Waste for the Production of Charcoal Briquettes as an Alternative Energy Source

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***Abstract*—Mushroom baglog waste is an organic waste generated from mushroom cultivation, and its volume is quite substantial. This waste poses significant environmental risks if not properly managed, such as soil and air pollution due to decomposition, which produces methane gas. Innovative management of baglog waste can be achieved by converting it into briquettes, offering a sustainable solution for biomass energy production. This study aims to empower communities by transforming mushroom baglog waste into charcoal briquettes as an alternative energy source. Without proper management, baglog waste can have negative environmental impacts. This study employs a research and development (R&D) approach, identifying community needs for environmentally friendly energy sources. The methods used include training the community to produce high-quality briquettes from this waste, along with testing the product's quality and economic viability. The best results indicated that the briquettes achieved a calorific value of 2,786 kcal/g, a moisture content of 13.98%, and a flash point of 167°C, making it an efficient alternative fuel. Additionally, the economic analysis indicated a break-even point (BEP) at 102 briquette units, with a benefit-cost ratio (BCR) of 1.47, signaling considerable profit potential. User acceptance testing, conducted using the System Usability Scale (SUS), resulted in an average score of 83.5, demonstrating high user satisfaction with the product. This research is expected to serve as a foundational step in raising environmental awareness and creating economic opportunities for communities through renewable energy innovation.**

***Keywords*—Alternative Energy, Baglog Waste, Briquettes, Mushroom, Organic Waste.**

I. INTRODUCTION

Mushroom baglog waste is a byproduct or organic waste generated from mushroom cultivation, and its quantity is quite significant [1-2]. This waste has a negative environmental impact if not managed properly, leading to soil and air pollution due to decomposition that produces methane gas [3]. This situation highlights an urgent need for solutions to reduce the accumulation of such waste. One innovative approach to managing baglog waste is by converting it into briquettes, which not only reduces existing waste but also offers significant environmental benefits [4-5]. Adopting this approach aligns with sustainable waste management practices and can raise environmental awareness within the community.

The utilization of mushroom baglog waste as an alternative energy source is highly important in the current era [6]. This process can serve as an innovative form of biomass energy production that is environmentally friendly. The production of briquettes from baglog waste not only provides an alternative to fossil fuels but also contributes to reducing the consumption of non-renewable energy. Innovation in producing briquettes from mushroom baglog waste not only enhances the economic value of the waste but also creates a useful new product [7-8]. By producing briquettes, the market value of baglog waste can increase, while also opening business opportunities for communities involved in its production [9]. This process is expected to improve technical skills and knowledge within the community, ultimately contributing to local economic development.

The process of producing briquettes from mushroom baglog waste is relatively simple and can be implemented locally, making it an appealing option for addressing waste issues while simultaneously creating new sources of income [10]. In this study, local communities were trained to process baglog into high-quality briquettes that can be marketed as alternative fuel. This research not only addresses environmental concerns but also empowers communities by creating new business opportunities. It is expected to serve as a stepping stone toward community empowerment while supporting the transition to more sustainable energy sources. The aim is to ensure that the utilization of baglog waste can be carried out sustainably, delivering long-term positive impacts on both the local economy and the environment.

II. LITERATURE REVIEW

The utilization of agricultural waste into value-added products has become a focus of numerous studies aimed at addressing environmental issues. One promising waste material is mushroom baglog waste, a byproduct of mushroom cultivation, typically composed of sawdust and other organic materials [11-12]. This waste is often discarded and underutilized, posing potential environmental and pollution risks.

Several previous studies have demonstrated the potential of converting mushroom baglog waste into charcoal briquettes as an alternative fuel source. One study explored the conversion of oyster mushroom baglog waste into charcoal briquettes. The process involved the carbonization of the waste at specific temperatures for several hours, followed by the addition of binding agents such as starch. The resulting briquettes exhibited moisture content, ash content, and calorific value that met industry standards, establishing them as a potential environmentally friendly alternative fuel and a solution to agricultural waste management [13].

In line with this research, another study on the use of oyster mushroom baglog waste for charcoal briquette production also yielded promising results. The waste was carbonized and combined with a binding agent, producing high-quality briquettes. The analysis revealed that these briquettes offered significant calorific value, with low emissions and ash content, positioning them as a sustainable and eco-friendly fuel alternative for energy needs [14].

Furthermore, a third study reinforced these findings by analyzing the conversion of mushroom baglog waste into charcoal briquettes through carbonization. The waste, consisting of sawdust and other organic materials, was subjected to specific temperatures during the production process. The results showed briquettes with excellent calorific value, low ash content, and environmentally friendly emissions, making them a sustainable alternative fuel and a creative solution to agricultural waste management [15].

Based on the literature review above, it can be concluded that the conversion of mushroom baglog waste into charcoal briquettes presents a promising solution for agricultural waste utilization while providing an environmentally friendly alternative fuel source.

III. Research Method

This research is an applied study employing a research and development (R&D) approach, with the aim of creating an efficient and environmentally friendly charcoal briquette product. The R&D method focuses on problem-solving through the development of new products [16-17], followed by testing the developed products [18]. In the initial phase, the researchers must identify both the needs and challenges, particularly in utilizing ear mushroom baglog waste as an alternative energy source. This approach also includes a pre-research study to analyze relevant literature and technology to ensure that the resulting product meets user expectations. Supported by accurate data and information, this research is expected to produce innovations that are not only commercially viable but also environmentally sustainable.

Fig. 1. R&D Stages

As outlined in Fig. 1, the steps involved in the development of charcoal briquettes through the R&D approach encompass several stages. First, the researchers identify the problem to determine the raw materials to be used, such as ear mushroom baglog waste and starch. Following this, materials are collected, and a charcoal briquette prototype is designed using carbonization techniques. Prototype testing aims to evaluate the quality of the briquettes, including assessments of calorific value, ash content, and emissions produced during combustion. After analyzing the results, modifications, and improvements are made to enhance product quality based on user feedback. This R&D approach ensures that the final product not only meets quality standards but also responds to user needs [19-20], thereby adding value to waste management and providing a sustainable alternative energy source.

IV. Results And Discussion

A. Process of Making Charcoal Briquettes from Baglog Waste

The making of briquettes from wood ear mushroom waste involves various variations in the ratio between waste and starch solution to test the effectiveness of the briquettes when mixed and not mixed with the starch solution. Table I shows a comparison showing the variation in the use of wood ear mushroom waste in combination with starch solution. There are five variations: A with a ratio of 1:0 (300g of mushroom baglog waste), B using a ratio of 1:1 (300g of baglog waste and 300g of starch), C with a ratio of 1:2 (300g of baglog waste and 600g of starch), D with a ratio of 2:3 (300g of baglog waste and 450 starch), and E with a ratio of 3:2 (300g of baglig waste and 200g of starch).

TABLE I. Comparison of Mushroom Baglog Waste and the Addition of Starch Adhesive

No	Sample Variations	Comparison	Baglog Waste (g)	Starch (g)
1.	A	1:0	300	-
2.	B	1:1	300	300
3.	C	1:2	300	600
4.	D	2:3	300	450
5.	E	3:2	300	200

After planning the mixture ratio process as shown in Table I, the next step is the production of charcoal briquettes. The process begins with the collection of mushroom baglog waste, followed by the removal of its contents. The baglog waste is then subjected to burning and grinding. Once the mushroom baglog waste has been ground, the carbonization process is carried out. Starch also needs to be carbonized before being mixed with the mushroom baglog waste. After both materials are carbonized, they are finely ground and sieved to obtain a uniform powder. The two powders, derived from the mushroom baglog waste and starch, are then mixed in the proportions indicated in Table I.

Once the mushroom baglog waste and starch are mixed, water amounting to 10% of the total mass is added, and the mixture is stirred until homogeneous. The briquette mixture is then molded into cylindrical shapes with a diameter of 4 cm and a height of 5 cm, using a compaction pressure of 100 kg/cm². The molded briquettes are subsequently dried to reduce their moisture content. The physical characterization of the briquettes is performed to assess their quality. This includes evaluating the calorific value, moisture content, flash point, and ash content. These parameters—calorific value, moisture content, and ash content—are each measured using a bomb calorimeter. A visual documentation of the briquette production process can be found in Fig. 2.

Fig 2. Stages of Making Charcoal Briquettes from Baglog Waste

The results of the briquettes that have been completed and are ready to use can be seen in Figure 3 below with a description of the sample code.

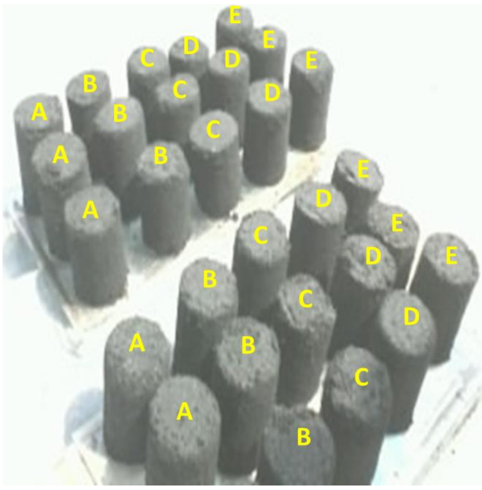

Fig 3. Results of Charcoal Briquettes from Baglog Waste along with Sample Code

B. Briquette Sample Testing

The next stage is to test and analyze the quality of briquettes as an important step in this study, focusing on the results of testing the calorific value, moisture content, briquette flame, and ash content. The test values of the briquettes that have been made can be seen in Table II.

TABLE II. TEST RESULTS OF BRIQUETTE FROM BAGLOG WASTE

No	Testing Name	Sample Code	Result
1	Calorie Testing	A	2,546 kal/gram
		B	2,233 kal/gram
		C	1,975 kal/gram
		D	2,186 kal/gram
		E	2,786 kal/gram
2	Moisture content Testing	A	15.02 %
		B	14.82 %
		C	29.32 %
		D	19.57 %
		E	13.98 %
3	Flash Point Testing	A	163 °C
		B	202 °C
		C	215 °C
		D	192 °C
		E	167 °C
4	Ash Content Testing	A	54.34 %
		B	42.26 %
		C	31.87 %
		D	37.15 %
		E	45.87 %

Based on the data illustrated in Fig. 4, the calorific value test for sample E showed the highest calorific value, reaching 2,786 kcal/g. Sample E utilized a 3:2 ratio. These results indicate the significant potential of the briquettes as an efficient and environmentally friendly alternative fuel. The calorific value is a key parameter that reflects the quality of charcoal briquettes, as it correlates with the amount of heat energy generated during combustion. The higher the calorific value of the briquettes, the greater the amount of heat energy produced.

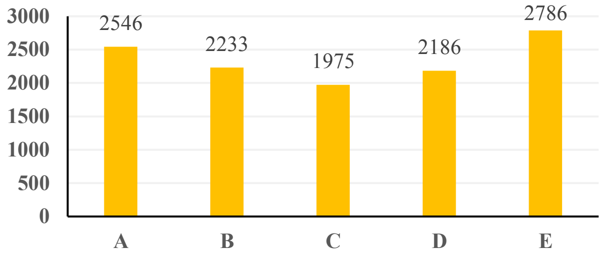

Fig 4. Calorific value of each sample (kal/gram)

Next, the moisture content was measured to determine the amount of water present in the briquettes after drying. The drying process was conducted by sun-drying the briquettes for two days, from 07:00 AM (GMT+7) to 05:00 PM (GMT+7). During this period, the average drying temperature observed at the research site ranged between 32°C and 36°C. The moisture content recorded was 13.98%, which falls within the ideal threshold for briquette production. This result was obtained from sample E, using a 3:2 ratio. A graphical representation of the moisture content test results can be seen in Fig. 5.

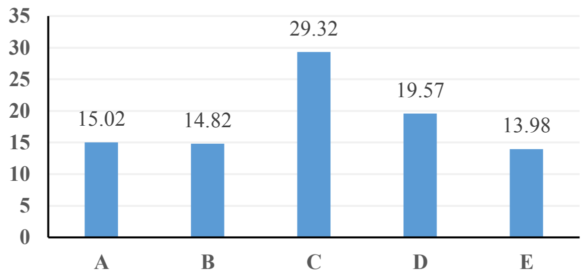

Fig 5. Percentage of Moisture content of each Sample

Based on the flash point tests, two briquette samples exhibited the lowest flash points, as illustrated in Fig. 6. The first was Sample A, with a flash point of 163°C, and the second was Sample E, with a flash point of 167°C. These results indicate that the briquettes can ignite efficiently at these temperatures. In contrast, other samples required higher temperatures to ignite, making those briquettes less practical for use due to their difficulty in combustion.

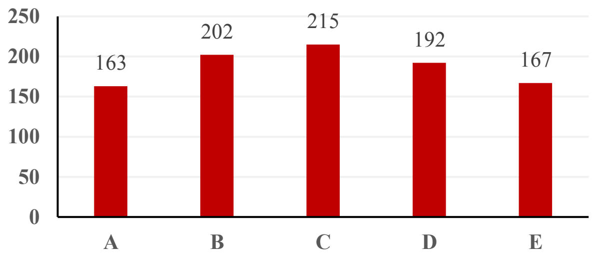

Fig 6. Sample Flash Point Test Results (°C)

The final test conducted was the ash content analysis, with the data presented in Fig. 7. Ash content refers to the residue or combustion waste that no longer has calorific value due to the absence of carbon elements. The amount of ash in briquettes is proportional to the inorganic elements present, such as silica, calcium, and magnesium. The purpose of measuring ash content is to determine the amount of ash produced by the materials used to make the briquettes. The analysis results showed that Sample A had the highest ash content at 54.34%, while Sample C had the lowest ash content at 31.87%. The composition of Sample A consisted of 100% charcoal from mushroom baglog waste. The high ash content in Sample A is attributed to the presence of calcium carbonate ($CaCO_3$) in the mushroom baglog waste. Calcium carbonate is an inorganic material that does not decompose during the combustion process.

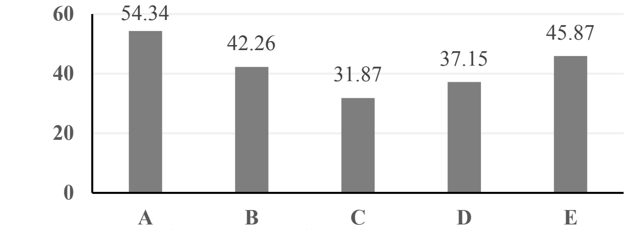

Fig 7. Percentage of Ash Content of Each Sample

C. Economic Analysis

Economic analysis of briquette production includes two important aspects, namely identification of Break Even Point (BEP) and Benefit-Cost Ratio (BCR). BEP calculates the number of units that must be sold to cover the total fixed costs, and can be calculated using the formula in Equation 1.

$$BEP\ (Q) = \frac{Total\ Fixed\ Cost}{Selling\ Price\ per\ Unit - Variable\ Cost\ per\ Unit} \quad (1)$$

$$BEP\ (Q) = \frac{5.089.000}{50.000}$$

=101.78

=102 Unit

Where:

BEP (Q) = Number of units that must be sold to reach the break-even point.

Total Fixed Cost = Fixed costs such as rent, employee salaries, and other fixed costs.

Selling Price per Unit = Selling price of each unit of briquettes.

Variable Cost per Unit = Variable costs directly related to briquette production, such as raw material and labor costs.

In this study, the Break-Even Point (BEP) was calculated and reported at 102 units of briquettes. This indicates that, to cover all initial production costs, at least 102 briquettes must be sold. Therefore, the BEP serves as a critical indicator for assessing the business's feasibility in generating profit.

Additionally, a Benefit-Cost Ratio (BCR) analysis was conducted to measure the ratio between benefits and costs. The BCR was calculated using the formula outlined in Equation 2.

$$BCR = \frac{Total\ Benefit}{Total\ Cost} \quad (2)$$

$$BCR = \frac{7.500.000}{5.089.000}$$

BCR = 1.47

Where:

Total Benefit = Total income generated from briquette sales.

Total Cost = Total amount of costs incurred, including fixed costs and variable costs.

In this study, the analysis revealed a Benefit-Cost Ratio (BCR) of 1.47. This indicates that for every IDR 1,000 (USD 0.064) invested, the business can generate revenue of IDR 1,470 (USD 0.094). With a BCR greater than 1, the business is considered viable for further development.

The analysis results, which demonstrate significant profit potential, suggest that producing briquettes from mushroom baglog waste is not only economically advantageous but also environmentally beneficial. This encourages entrepreneurs to consider investing in more efficient and sustainable technologies, thereby strengthening the local economy by creating new job opportunities.

D. User Acceptance Testing with the System Usability Scale (SUS)

User acceptance testing for the charcoal briquette product made from mushroom baglog waste was conducted using the System Usability Scale (SUS) method. This approach aims to assess the extent to which users are satisfied with the offered product. In this study, the sample consisted of 20 randomly selected respondents from the population, aged between 20 and 45 years, including both men and women. Users were asked to complete the SUS questionnaire, which included 10 questions regarding their experience with the briquettes, covering aspects such as ease of use, satisfaction with performance, and whether they would recommend the product to others. In Table III, there is data displaying the results of the SUS questionnaire evaluation from 20 respondents regarding the charcoal briquette product.

TABLE III. USER ACCEPTANCE TESTING WITH THE SYSTEM USABILITY SCALE (SUS) METHOD

Parameter	***Information***
Number of Respondents	20
Average SUS Score	83.5
Usability Standard	> 68
Description	Very good in terms of usability and meets user expectations
Product Acceptance	Positive
Recommendations for Development	Worth further development

The evaluation results from the questionnaire reveal an average System Usability Scale (SUS) score of 83.5 among 20 respondents. This score indicates that the charcoal briquette product performs exceptionally well in terms of usability and aligns with user expectations. Given that a SUS score above 68 is considered satisfactory, the briquette not only receives positive feedback from users but also demonstrates strong potential for market acceptance. These findings suggest the product warrants further development, as respondents reported comfort and satisfaction in its use. Additionally, the product holds promise for increasing public awareness about environmentally friendly alternative fuels.

E. Impact of Products on Society

The impact of the briquette product on the community is a significant focus of this study. Feedback from briquette users indicates a positive reception. Many users reported that the briquettes are easy to use, exhibit good combustion properties, and do not produce excessive smoke, making them a cleaner alternative compared to traditional firewood. Furthermore, this product aids the community in managing previously unused mushroom baglog waste, thereby creating opportunities for local economic development through small enterprises.

Users also provided input regarding the quality and packaging of the product, with a majority expressing a preference for more environmentally friendly and recyclable packaging. This reflects the community's awareness of the importance of environmental preservation while simultaneously seeking efficient solutions for energy needs. This research aims to facilitate the enhancement of product quality based on user feedback and to encourage further investigations to refine the use of alternative raw materials. This approach not only enhances the market value of the product but also positively impacts the improvement of the community's quality of life.

The primary innovation of this research lies in the conversion of mushroom baglog waste into charcoal briquettes as an alternative energy source. This approach is unique as it transforms agricultural waste, which is typically discarded, into a product of high economic value. The study employed research and development (R&D) methods, utilizing variations in the composition of baglog waste and starch adhesive mixtures, resulting in briquettes with a maximum calorific value of 2,786 kcal/g.

V. Conclusion

This study creates a circular economy model that builds economic value from waste. This product transforms agricultural waste into a sustainable energy source, making a positive contribution to local economic empowerment and environmentally friendly waste management. Moreover, this study successfully demonstrates the potential of utilizing mushroom baglog waste to produce high-quality charcoal briquettes. Test results indicate that the calorific value of the briquettes reaches 2,786 kcal/g, with moisture content maintained below 14%, establishing its viability as an environmentally friendly alternative fuel source. Furthermore, the analysis of mechanical properties reveals that the briquettes exhibit good stability, rendering them suitable for use as an alternative energy source.

From an economic perspective, the analyses of the Break Even Point (BEP) and Benefit-Cost Ratio (BCR) reinforce the feasibility of briquette production. With a minimum BEP of 102 units and a BCR of 1.47, this venture demonstrates the potential for significant profit, enticing entrepreneurs interested in developing renewable energy products. The positive impact on the community is reflected in user feedback and response testing using the System Usability Scale (SUS), where users acknowledge the benefits of the product not only in addressing energy needs but also in waste management. Through collaboration among academics, government, and the community, it is anticipated that innovations in briquette production can provide tangible solutions for waste management and the sustainable fulfillment of energy requirements.

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