Evaluation of Binder Effects on Sawdust-Based Briquette for its Suitability as a Heating Energy Source

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ABSTRACT

The demand for alternative energy sources to replace fossil fuels has been increasing due to various reasons including environmental concerns, resource depletion, energy security, economic benefits, technological advancements, rising energy demands, and health benefits, among others. Therefore, this study examined how variation in binder type and proportion in sawdust-based briquette affect its suitability as heating energy source. Cassava and corn starches, at two different percentage proportions (20 and 25%), were used as binders for the sawdust-based briquettes. The briquettes were produced through sequential process of sawdust charring, char and binder mixing, as well as, briquetting the sawdust char using locally fabricated briquette machine. The results obtained from the briquette characterization based on green density, moisture content, and burning rate; indicated that the green density of briquette is higher with cassava starch compared to corn starch at both concentrations while briquette made with corn starch has significantly higher moisture content compared to briquette made with cassava starch. Furthermore, Briquettes with cassava starch have a higher burning rate compared to those with corn starch, though the difference is not substantial. Cassava starch briquettes tend to have higher green density, lower moisture content, and higher burning rates compared to corn starch briquettes with 25% cassava starch appear to be the most suitable for fuel because they offer higher green density (0.76 g/cm^3) that provides more fuel per unit volume; lower moisture content (8.73 %) that results in more efficient burning; and a relatively moderate burning rate (0.76 g/min) that ensures sustained heat output.

Keywords: Energy, Waste valorisation, Sawdust, Briquette characterization, Fuel suitability

INTRODUCTION

Recently, there has been a strong global push to identify alternative energy sources to replace fossil fuels (such as crude oil, natural gas, and coal) due to the numerous challenges associated with their use. These challenges include greenhouse gas emissions, non-renewability, and rising fuel prices, among others [1, 2]. One potential alternative is biomass waste, including agricultural residues like corn cobs and sawdust [3, 4]. Agricultural residues, in their raw form, have a large volume and low bulk density, making them difficult to handle, transport, and store. However, these challenges can be addressed by densifying the residues into briquettes, which enhance their physical, mechanical, combustion, storage, and transport properties [5-10]. Densification reduces the volume of agricultural residues by 8–10 times and increases their density to approximately 1000–1200 kg/m³ [11-17]. Agricultural residues, when processed into briquettes, are an effective fuel source, and their emissions do not contribute to anthropogenic greenhouse gases [18]. Unlike emissions from traditional coal briquettes, the carbon released by biomass briquettes was recently absorbed from the atmosphere, rather than being sequestered deep in the earth during the carboniferous period, as is the case with coal. The use of biomass briquettes has been steadily rising as industries recognize their potential to reduce pollution. Briquettes are versatile and can be used in various applications, such as cooking, heating, and industrial uses, due to their ability to ignite easily and burn with a steady flame for extended periods [19]. They offer high

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burning efficiency, produce minimal smoke and odour, and are also highly available, easy to store, and transport.

Briquetting is a pre-treatment method used to produce uniformly sized feedstock with enhanced energy density, as well as improved handling, transport, and storage characteristics. The quality of the briquettes, particularly their density and durability, is influenced by both the physical and chemical properties of the feedstock and the briquetting conditions. Application of binders in briquette production is to enhance the cohesion and mechanical properties of the briquette components, thereby improving the briquette strength and calorific value. The performance of briquettes is often influenced by the quality of the binding agent used (20,21). There are various types of binding agents used in briquette production, which can be categorized into organic and inorganic binders. Organic binders (cassava starch, wheat starch, corn starch, among others), are naturally occurring substances, often derived from plants and animals. These binders are commonly used in biomass briquette production because they are readily available, biodegradable, and non-toxic. Organic binders, such as cassava starch and molasses, are particularly effective in improving the durability and combustion properties of briquettes due to their adhesive qualities, which help bond fine particles together. Inorganic binders (lime, clay, kaolin, calcium oxides), in contrast, are chemical-based and offer greater stability under high temperatures and pressures. These binders are often used in industrial applications where higher structural integrity is necessary, such as in coal briquetting. Inorganic binders improve the water resistance of briquettes, making them ideal for storage and transport, especially in humid conditions. However, some inorganic binders may release harmful emissions during combustion, which raises concerns regarding environmental sustainability. The choice of binder depends on the type of feedstock, the intended application of the briquettes, and the desired combustion characteristics. For instance, organic binders like cassava flour are preferred for biomass briquettes intended for household cooking due to their cleaner combustion, while inorganic binders like cement are used for industrial briquettes that require higher durability under mechanical stress.

The properties of the briquettes, including green density, moisture content, and burning rate; play a significant role in determining the suitability of the briquettes as fuel. (14; 22; 23). Green or compressed density refers to the compactness or the mass per unit volume of the briquette before it is dried or burned. It is determined immediately after the briquette samples are ejected from the mould by measuring the mass and dimensions of the briquettes. Higher green density indicates a more tightly packed briquette, which usually means more material is present in a given volume, leading to higher energy content and longer burn time. The moisture content of a briquette refers to the amount of water present in the briquette, typically expressed as a percentage of the total weight. The moisture content can affect the briquette combustion efficiency, durability, and overall performance. The moisture content of feedstock material is determined through the hot air oven drying method which involves drying the material at a temperature of 103°C ± 2°C for one hour or until a constant weight loss is achieved (24, 25). High moisture content in briquettes makes them harder to ignite and reduces their overall energy efficiency. When moisture is present in the briquette, a portion of the energy produced during combustion goes into evaporating the water, rather than being used to release heat. Lower moisture content means the briquette burns more effectively because more of the energy is used to produce heat rather than evaporating water. Burning rate refers to how quickly the briquette burns. A moderate burning rate is typically desired for optimal fuel use. If the burning rate is too high or the briquette burns too quickly, the briquette will provide less heat over a short period. Conversely, a slower burning rate can provide sustained heat but may be less practical if quick heating is required.

Numerous research studies have been conducted to explore the briquette-making potential of various biomass materials. For instance, Oladeji [7] investigated the fuel characteristics of briquettes made from corncob and rice husk residues, while Obi et al. [15] focused on fuel briquettes produced from a blend of rice husk and palm oil mill sludge. Ajimotokan et al. [26] studied the physico-mechanical properties of composite briquettes made from corncob and rice husk, and Sabo et al. [27] worked on the preparation and characterization of biomass briquettes made from coconut shell and corncobs. Mitchual et al. [6] examined briquettes made from maize cobs and Ceiba pentandra at room temperature and low compacting pressure without the use of a binder. Inuwa et al. [28] researched the production and optimization of briquettes from sugarcane bagasse, using blends of waste paper and clay as binders. Additionally, Waluyo et al. [23] analysed the mechanical, and

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proximate properties of biochar briquettes made from jackfruit crust while Oyelaran et al. [29] Investigated the effects of binding ratios on densification characteristics of groundnut. Moreover, Onwugbuta et al. [30] studied the production of briquette from sawdust and waste paper using manual briquetting machine. Meanwhile, there has not been much work done on the binding effects of cassava and corn starches on sawdust-based briquette for its suitability as

heating energy source. The purpose of this project was to investigate how variations in binder type (cassava and corn starches) and binder proportion (20% and 25%) in sawdust-based briquettes influence their effectiveness as a heating energy source. This study is significant because utilizing waste materials like sawdust for heating helps promote sustainability by reducing the costs, effort, time, and energy that would otherwise be spent on fossil fuels for the same purposes. Converting waste into energy helps minimize the amount of waste sent to landfills, thereby reducing greenhouse gas emissions. It also addresses deforestation by offering an alternative to wood-based fuels. Furthermore, this approach has the potential to create jobs, particularly in local communities, by generating opportunities in the collection, processing, and distribution of waste-based briquettes. Ultimately, this project contributes to a cleaner environment, job creation, and the long-term pursuit of sustainable energy solutions.

METHODOLOGY

Experimental materials

The sawdust used as the feedstock for briquette production was sourced from sawmills near Lagos State University, Epe campus, Lagos, Nigeria. This sawdust consisted of shavings from mahogany wood, commonly used in furniture making (Plate 1). Both cassava starch and corn starch were utilized as binders in the briquette production process. A weighing balance, measuring cylinder, pot, gas cylinder, beaker, and turning stick were also utilized during the briquette production process. Clean, empty containers were used for mixing the feedstock with the binder. Additionally, a manual briquette machine was designed and fabricated (Plate 2) for briquette production .

Plate 1. Sawdust shavings

Plate 2. Manual briquetting machine

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Experimental procedure

The feedstock material for briquette production was first sorted to remove impurities like sand and stones, then sun-dried for three days to reduce its moisture content. After drying, the material was weighed and placed into a biochar reactor to be burned into charcoal. Once filled, the upper chamber of the reactor was sealed with a metallic cap to prevent oxygen from entering. After the charring process was completed, the biochar was removed from the reactor and stored in a clean, covered container to prevent it from turning into ash. Once cooled, the biochar was ground into a fine powder and stored separately in a zip-locked polythene bag to prevent moisture absorption for future use.

Cassava starch and corn starch that were both used as binding agents were gelatinized by mixing 200 g of each binder thoroughly with 280 mL of distilled water to form a uniform, jelly-like starch gel. Afterward, 420 mL of boiling water was added to the mixture and continuously stirred while heat was applied to make it gelatinous. The powdered sawdust char was weighed using an electronic balance and combined with the binders at 20 and 25% weight percentage ratios. The mixture was thoroughly combined in a clean container using mechanical stirring. The resulting mixtures were then poured into prepared moulds in the briquette machine and manually compressed. The mixtures were held in the moulds for 5 minutes before they were ejected from the mould. The mass and dimensions of the briquette products (Plate 3) were measured

Plate 3. Briquette products

using a digital weighing balance and a meter rule, respectively. The briquettes were then sun-dried for 1-2 days to reduce moisture content, followed by drying at room temperature. After drying, the briquettes were packed and sealed for further use and characterization, including determination of green density, moisture content and burning rate.

RESULTS AND DISCUSSION

Research findings

The summary of the results obtained from the experimental work for briquette production from sawdust are shown in Tables 1. The data in the table compares the effects of different binder types (cassava starch and corn starch) at two different percentages (20% and 25%) on the properties of sawdust-based briquettes. The properties evaluated are green density, moisture content, and burning rate.

Table 1. Effects of binder type and composition on sawdust-based briquette properties

Briquette Properties	**20% Cassava Starch**	**25% Cassava Starch**	**20% Corn Starch**	**25% Corn Starch**
Green Density (g/dm^3)	0.65	0.76	0.42	0.74

Moisture Content (%)	9.34	8.73	22.77	16.54
Burning Rate (g/min)	0.69	0.76	0.64	0.7

Regarding green density, the briquettes produced using 20 and 25 % cassava starch binder had green density of 0.65 g/dm³ and 0.76 g/dm³, respectively, while the briquettes produced using 20 and 25 % corn starch binder had green density of 0.42 g/dm³ and 0.74 g/dm³, respectively. The green density was higher with cassava starch compared to corn starch at both concentrations. Increasing the binder concentration (from 20% to 25%) generally increases the green density, though the increase is more significant with cassava starch.

Regarding moisture content, the briquettes produced using 20 and 25 % cassava starch binder had moisture content of 9.34 and 8.73%, respectively, while the briquettes produced using 20 and 25 % corn starch binder had moisture content of 22.77 and 16.54%, respectively. Briquettes made with corn starch had significantly higher moisture content compared to those made with cassava starch. As the binder concentration increases, the moisture content decreases, which is expected since higher binder levels can reduce the porosity of the briquettes and retain less water.

Regarding burning rate, the briquettes produced using 20 and 25 % cassava starch binder had burning rate of 0.69 and 0.76 g/min, respectively, while the briquettes produced using 20 and 25 % corn starch binder had burning rate of 0.64 and 0.70 g/min, respectively. Briquettes with cassava starch binder had a higher burning rate compared to those with corn starch, though the difference is not substantial. Increasing the binder concentration increases the burning rate slightly for both types of starch.

Comparison of the two types of binder used for the briquette production indicates that cassava starch briquettes tend to have higher green density, lower moisture content, and higher burning rates compared to corn starch briquettes. Increasing the binder concentration (from 20% to 25%) generally improves the properties (density and burning rate), while slightly reducing moisture content. Corn starch briquettes have lower green density and higher moisture content compared to cassava starch briquettes. Increasing corn starch content also reduces moisture content slightly and slightly increases the burning rate. In general, cassava starch appears to be a more effective binder for sawdust-based briquettes, producing better overall properties (density, moisture, and burning rate).

The properties of the briquettes, such as green density, moisture content, and burning rate; play a significant role in determining the suitability of the briquettes as fuel. Higher green density indicates a more tightly packed briquette, which usually means more material is present in a given volume, leading to higher energy content and longer burn time. Higher green density briquettes (like those made with 25% cassava starch) are more efficient as they contain more fuel mass in the same volume and will likely burn for a longer period, releasing more energy. Lower green density (like the 20% corn starch briquette) could lead to faster burning and potentially less energy output per unit volume since it may contain more air and less actual fuel. Therefore, higher green density briquettes (e.g., 25% cassava starch) are typically more suitable as fuel because they burn longer and provide a higher energy output compared to those with lower density.

High moisture content in briquettes makes them harder to ignite and reduces their overall energy efficiency. When moisture is present in the briquette, a portion of the energy produced during combustion goes into evaporating the water, rather than being used to release heat. Lower moisture content means the briquette burns more effectively because more of the energy is used to produce heat rather than evaporating water. Briquettes with high moisture content (like the 20% corn starch briquettes with 22.77 % moisture) will burn inefficiently, producing more smoke, lower heat output, and requiring more time to dry before they can be used effectively as fuel. Therefore, briquettes with lower moisture content (such as the cassava starch briquettes) are generally more suitable for fuel because they will burn more efficiently, produce more heat, and create less smoke.

A briquette with a moderate burning rate is typically desired for optimal fuel use. If the burning rate is too high (i.e., the briquette burns too quickly), the briquette will provide less heat over a short period. Conversely, a slower burning rate can provide sustained heat but may be less practical if quick heating is required. Briquettes that burn at a moderate rate (like those made with 20% cassava starch, burning at 0.69 g/min) are usually considered optimal for heating because they provide steady, sustained heat without burning too fast and depleting fuel too quickly. Higher burning rates (e.g., the 25% cassava starch with 0.76 g/min) may result in faster fuel consumption, which can be less efficient in scenarios where long, steady burns are needed. Therefore, moderate burning rates are generally more desirable for fuel use. While slightly higher burning rates (like those observed in 25% cassava starch) can be effective in some contexts (e.g., quick heat), moderate to slow burning rates are preferred for sustained energy output.

Economic feasibility analysis of cassava starch and corn starch as binders in sawdust-based briquettes for heating energy

The economic feasibility analysis evaluates both the cost and performance of cassava starch and corn starch as binders in sawdust-based briquettes. Assumptions to be considered for the economic feasibility analysis include: the consideration of sawdust-based briquette production as the study application, 1,000 kg of briquette production per month as the scale of production, average market prices of cassava and corn starches taken as $ 0.52/kg and $ 0.31, respectively; and consideration of raw material cost, processing cost, transportation and distribution costs, as the total cost incurred. The manufacturing process involved charcoal production, binder mixing and briquetting. Estimated processing cost (including labour, energy, equipment wear, among others) for each kg of sawdust-based briquette is assumed to be $ 0.30 for both cassava starch and corn starch briquettes. Transportation and distribution costs depend on the distance from production to market and are estimated at $ 0.05 per kg for both cassava starch and corn starch. Cassava starch and corn starch were used at two different binder concentrations: 20% and 25%. The briquettes were produced by charring sawdust, mixing it with the binder (cassava or corn starch), and compressing the mixture using a locally fabricated briquette machine.

It should be noted that the key parameters for economic feasibility analysis include binder performance, costs of production and energy potential. For costs of production, evaluation is based on raw material cost, processing and transportation costs for both starch types, to determine which starch is more economically viable for use in sawdust briquette production (Table 2). In the case of energy potential, the burning rate and efficiency of the briquettes formed with each binder are essential to evaluate their potential as a heating energy source. Regarding binder performance, briquettes made with cassava starch showed higher green density, which indicates better fuel density and more energy per unit volume. Briquettes made with corn starch exhibited higher moisture content, which may reduce the burning efficiency. Cassava starch briquettes showed a slightly higher burning rate, ensuring sustained heat output. Overall, cassava starch-based briquettes are more suitable for use as a heating source due to their higher green density and lower moisture content. They offer higher energy per unit volume and more efficient combustion, making them more efficient for heating.

Although cassava starch briquettes cost approximately more than corn starch briquettes, they offer better performance in terms of green density, moisture content, and burning rate. If the primary goal is to maximize heating efficiency and ensure sustained energy output, cassava starch is more cost-effective despite the higher initial binder cost. The additional investment in cassava starch is justified by its superior performance, resulting in more efficient and effective heating energy. For industrial-scale production of sawdust briquettes as a heating

Table 2. Production Costs of 1000 kgof Sawdust based briquette

S/No	Category	Details	Cassava Starch	Corn Starch
1	**Raw Material Cost**	Average price per kg	$0.52	$0.31
		Percentage by weight used	25%	25%
		Amount required for 1,000 kg of briquettes	250 kg	250 kg
		Cost of starch	250 kg × $0.52 = **$130**	250 kg × $0.31 = **$77.5**
2	**Processing and Manufacturing Costs**	Processing cost per kg of briquettes	$0.30	$0.30
		Processing cost for	1,000 kg ×	1,000 kg ×

		1,000 kg	\$0.30 = **\$300**	\$0.30 = **\$300**
3	**Transportation and Distribution Costs**	Transportation cost per kg	\$0.05	\$0.05
		Transportation cost per 1,000 kg	1,000 kg × \$0.05 = **\$50**	1,000 kg × \$0.05 = **\$50**
	Total Cost per 1,000 kg		**\$130 + \$300 + \$50 = \$480**	**\$77.5 + \$300 + \$50 = \$427.5**

energy source, cassava starch should be considered despite the higher cost, as it provides a more efficient fuel source. However, corn starch could still be used for cost-conscious markets with less stringent performance requirements.

The practical applicability of the findings from this study extends across multiple sectors, from renewable energy

production to local economic development, waste management, and environmental sustainability. It has the potential to create a positive impact by providing an affordable, efficient, and sustainable heating solution, especially in regions facing energy challenges. Moreover, by utilizing locally available materials (sawdust, cassava, and corn), the study promotes a circular economy, reduces waste, and enhances energy security while contributing to the broader goal of reducing carbon footprints and environmental degradation

Environmental Impact and Sustainability Assessment of sawdust-based briquettes

When assessing the sustainability of sawdust-based briquettes as an alternative heating source, it is critical to consider the emissions produced during combustion. Biomass combustion, although regarded as more environmentally friendly compared to fossil fuels, still results in the release of pollutants that can affect air quality, human health, and contribute to climate change. The combustion of sawdust-based briquettes generates several types of emissions including carbon dioxide, particulate matter, carbon monoxide, volatile organic compounds, nitrogen oxides and sulphur dioxide. Although biomass combustion releases carbon dioxide into the atmosphere, it is considered carbon neutral in the long term, as the carbon dioxide released during combustion is theoretically absorbed by the plants during their growth cycle. This means that over the life cycle of biomass, there is no net increase in CO_2 emissions if managed sustainably.

By improving combustion efficiency, optimizing briquette composition, and adopting cleaner production and burning technologies, the environmental impact of biomass combustion can be significantly reduced. Hence, for biomass briquettes to be a truly sustainable heating solution, careful attention must be paid to the emissions produced, alongside efforts to ensure the sustainable sourcing of materials and the adoption of low-emission technologies.

Evaluation of durability and handling properties of sawdust-based briquettes through mechanical strength testing

In addition to the environmental impact and combustion efficiency, mechanical strength testing plays a crucial role in determining the practical relevance of sawdust-based briquettes as a viable fuel source. Mechanical strength is a critical factor in the performance of briquettes because it influences handling and transportation of briquettes, storage of briquettes, burning efficiency, and durability. The mechanical strength of the briquettes is directly related to their practical usability in real-world applications.

Comparison of sawdust briquettes with other biomass fuels such as rice husk and sugarcane bagasse

To fully assess the potential of sawdust-based briquettes as an alternative heating source, it is important to compare their performance, environmental impact, and sustainability with other commonly used biomass fuels, such as rice husk and sugarcane bagasse. Both rice husk and sugarcane bagasse are abundant agricultural by-products, similar to sawdust, and are frequently used in energy production, especially in regions where these materials are readily available. Sawdust-based briquettes, rice husk briquettes, and sugarcane bagasse briquettes all have their unique advantages and limitations when compared to each other. Regarding combustion efficiency; sawdust-based briquettes, particularly those with cassava starch as a binder, tend to have moderate burning rates and combustion efficiencies. All the three materials offer carbon-neutral combustion if sourced sustainably. However, rice husk and bagasse briquettes may produce more particulate matter and nitrogen oxides compared to sawdust. Sawdust-based briquettes made with cassava starch tend to produce fewer emissions due to better moisture content control.

Rice husk and sugarcane bagasse briquettes generally offer higher energy density and longer burn times, making them ideal for more sustained heating needs. Sawdust-Based Briquettes, especially those made with cassava starch, generally have good crushing strength, high durability, moderate impact resistance. Although rice husk and sugarcane bagasse briquettes tend to have higher crushing strength, durability, and high impact resistance, compared to sawdust; superior green density, lower moisture content, and better burning efficiency of sawdust briquettes with cassava starch highlight the competitive advantages of sawdust briquettes in comparison with other biomass feedstocks. These comparisons strengthen the relevance of this study and provide a comprehensive framework for understanding the viability of sawdust briquettes as an alternative energy source.

Industrial applications and commercialization strategies for sawdust-based briquettes

Sawdust-based briquettes have several promising industrial applications due to their renewable nature, relatively low cost, and favourable combustion characteristics. Many industrial facilities, such as textile mills, paper mills, and food processing factories, require substantial amounts of heat for their operations. Sawdust briquettes can serve as a cost-effective and environmentally friendly alternative to coal and other fossil fuels. They can be used in boilers, furnaces, and dryers to generate heat for various manufacturing processes. In the production of bricks, tiles, and ceramics, high-temperature heat is required for firing. Sawdust briquettes, with their controlled burning rate and heat output, can replace traditional fuels like coal and wood. They offer a cleaner, more sustainable fuel option for these energy-intensive industries. Large-scale biomass power plants can utilize sawdust-based briquettes as a feedstock for energy generation. When processed and compressed into briquettes, sawdust has a relatively high energy density, making it a suitable option for combustion in biomass power generation facilities.

Regarding domestic heating and cooking, sawdust briquettes offer a cleaner, safer, and more efficient alternative in regions where traditional firewood is scarce or unsustainable. They can be used in stoves, wood burners, and heating systems to provide affordable and reliable heating in homes. In many rural and urban areas, sawdust briquettes are being promoted as an alternative to firewood, charcoal, and liquefied petroleum gas for cooking. Their affordability, ease of use, and lower emissions make them an attractive option for low-income households in developing countries. Additionally, sawdust is commonly used as a soil conditioner or composting material. Briquetting sawdust into compacted forms can make it easier to transport and handle, reducing waste from sawmill operations while providing a sustainable option for improving soil quality. In colder climates, sawdust briquettes can be used to heat greenhouses where temperature control is critical for crop production. Sawdust briquettes, when produced from waste wood, contribute to waste reduction and energy generation. This makes them a suitable feedstock for waste-to-energy facilities, helping in the sustainable management of wood waste

Meanwhile, the commercialization of sawdust-based briquettes as an alternative energy source requires strategic planning and implementation to make them competitive in the marketplace. Several factors need to be addressed to ensure the successful adoption of briquettes on a large scale. Ensuring a consistent and reliable supply of sawdust is critical for large-scale production. Establishing partnerships with sawmills, furniture manufacturers, and wood processing facilities will provide a steady supply of raw materials for briquette production. Sawdust briquettes need to be efficiently transported from production facilities to end-users. This requires investment in storage facilities, transportation infrastructure, and distribution networks. The cost of sawdust briquettes needs to be competitive with other traditional fuels like coal, charcoal, and firewood. Strategies to achieve cost competitiveness include optimizing production processes, reducing energy consumption in briquette production, and leveraging economies of scale. Governments and environmental agencies can play a crucial role by offering subsidies, tax incentives, or grants for the development and commercialization of biomass briquettes. These incentives can help reduce the cost of production and make sawdust briquettes more affordable for consumers.

Overall, briquettes should meet specific quality standards regarding density, moisture content, and burning efficiency; to ensure consistent performance. Implementing standards that define the acceptable ranges for these properties will improve product reliability and consumer trust. In addition, to support the scalability of sawdust briquette production and its industrial application, technological advancements are necessary. The development of more efficient, low-energy-consuming briquette presses can lower production costs and enhance the overall quality of the briquettes. Research studies into more sustainable and locally available binders other than cassava or corn starch can reduce costs and improve the environmental footprint of briquette production. Developing technologies for improved combustion of biomass fuels, such as advanced stoves and burners, will also maximize the energy output from sawdust briquettes and reduce emissions.

CONCLUSION

This study investigated how variations in binder type and proportion affect the suitability of sawdust-based briquettes as a heating energy source. Cassava and corn starches were used as binders at two different proportions (20% and 25%) for the briquettes. Briquettes with high green density (e.g., 25% cassava starch) tend to be more efficient as they release more heat over a longer period and are better for fuel purposes. Lower moisture content (like the cassava starch briquettes) results in better fuel efficiency, as less energy is wasted evaporating water, and more heat is available for use. A moderate burning rate (as seen in the 20% cassava starch briquettes) is optimal for sustained heat production, which makes these briquettes more suitable as fuel. Based on the experimental results obtained, briquettes with 25% cassava starch appear to be the most suitable for fuel because they offer higher green density (0.76 g/cm^3), lower moisture content (8.73%), and a relatively moderate burning rate (0.76 g/min), resulting in more efficient burning and sustained heat output compared to those made with corn starch with higher moisture content that make them to be less efficient as fuel and require careful drying.

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