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PATCHOULI BRICKS:A Green Energy Innovation From Waste For Sustainable And Eco-Friendly Agriculture

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Abstract

This study aims to investigate the process of utilizing patchouli waste as a raw material for briquette production and to assess the potential of patchouli waste as an environmentally friendly alternative energy source. The study was conducted from March to July 2026 at the Faculty of Agriculture, Halu Oleo University, specifically in the front yard of the Agribusiness Department Student Association Secretariat. This study is an applied research project using a descriptive approach. Primary data were obtained directly from the patchouli briquette production process, while secondary data were obtained through a literature review. Data collection techniques included observation, documentation, and a literature review. Data analysis was conducted descriptively by examining the potential of patchouli waste, the briquette production process, moisture content, and yield. The results showed that waste from patchouli distillation can be utilized to produce briquettes through the following stages: waste collection, preparation of materials and equipment, drying, carbonization, charcoal grinding, mixing with tapioca flour as a binder, molding, and final drying. In a single mixing process, 0.5 kg of patchouli waste charcoal powder, 0.08 kg of tapioca flour, and 0.4 liters of water were used, yielding 0.748 kg of dry briquettes. The resulting briquettes were solid in form, black in color, and sufficiently strong. Test results showed a briquette moisture content of 10.52% and a yield of 9.35%. These results indicate that patchouli distillation waste has the potential to be utilized as a raw material for alternative energy through briquette production and can provide added value through the more productive and environmentally friendly use of agricultural byproducts

Keyword: patchouli briquettes, patchouli waste, green energy, alternative energy, sustainable agriculture

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INTRODUCTION

The ever-increasing demand for energy and dependence on fossil fuels highlight the need to develop alternative energy sources derived from renewable resources. One such energy source with significant development potential is biomass derived from agricultural and agroindustrial waste. Utilizing agricultural waste as an energy source not only provides an alternative fuel but also helps mitigate environmental problems caused by the accumulation and open burning of waste. One form of biomass utilization is briquettes—a solid fuel produced through the processing and compaction of biomass materials, making it easier to store, handle, and use. Indonesia possesses significant biomass potential, estimated at 146.7 million metric tons per year—equivalent to 49,810 MW—making biomass a strategic opportunity for development as a renewable energy source while supporting the sustainable utilization of local resources (Hambali *et al*., 2007; Primadanty, 2023).

One potential but underutilized source of biomass is the solid waste resulting from the distillation of patchouli leaves. Patchouli is an essential oil-producing plant of significant economic value and is one of Indonesia's flagship commodities in the essential oil trade. Patchouli oil is widely used in the perfume industry as a *fixative* because it helps maintain the strength and longevity of fragrances. Indonesia is one of the world's leading suppliers of patchouli oil, contributing approximately 90% to the global supply (Ginting *et al*., 2023). This high level of patchouli distillation activity generates a significant amount of residue. Waste that is not properly managed is typically simply piled up around the distillation site or burned directly, potentially causing environmental pollution while simultaneously resulting in the loss of economic value from biomass that still contains organic matter and energy. Riwayati (2010) explains that patchouli leaf distillation residue can be processed into biobriquettes through specific treatments, making this waste a potential alternative fuel source.

The utilization of patchouli waste into briquettes is increasingly relevant because distillation residues still possess calorific value that can be harnessed as an energy source. Sugiarto and Sulistyo (2010) demonstrate that patchouli distillation residue possesses calorific value and has the potential to be reused as an alternative fuel in the patchouli oil production process. This utilization can foster a more efficient energy use model, as waste from the production process can be recycled as an energy source to support production activities. Furthermore, briquettes are more compact, relatively easy to store, and more practical to use than biomass in its original form. Thus, processing patchouli waste into briquettes has the potential to provide dual benefits: reducing the waste burden while simultaneously producing an alternative energy source with both practical and economic value.

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Technically, this potential has been supported by a number of previous studies examining the use of patchouli waste as a raw material for briquettes. Santika *et al*. (2023) demonstrated that solid waste from patchouli oil distillation can be processed into biochar briquettes, and that their quality is influenced by the weight of the raw material and the pyrolysis temperature. Setyanto *et al*. (2016) also demonstrated that adjusting the *setting level* in the briquette production process using patchouli leaf distillation waste as raw material affects product quality, particularly physical characteristics and combustion efficiency. Meanwhile, Maryono *et al*. (2013) showed that binder composition is a key factor influencing briquette quality, including moisture content, strength, and burn time. Sobari's (2022) research even demonstrated that solid patchouli distillation waste can also be utilized as a compost raw material, indicating that patchouli residues have various potential applications and can be developed into value-added products in line with their characteristics.

Although these various studies have demonstrated the potential of patchouli waste as a raw material for energy and other useful products, research that positions patchouli briquettes as part of green energy innovation from the perspectives of sustainable agriculture, waste management, and economic value enhancement still needs to be strengthened. Previous research has largely focused on the technical aspects of briquette production and characteristics, such as pyrolysis temperature, material composition, binders, calorific value, and physical quality. In fact, the utilization of agricultural waste as an alternative energy source is not only related to the material's ability to generate energy but also to its contribution to waste reduction, resource efficiency, the creation of added value, and reduced dependence on fossil fuels. Therefore, an approach is needed that links the technical aspects of patchouli waste utilization with its ecological and economic benefits so that patchouli briquettes can be viewed as part of a biomass utilization system that supports sustainable agriculture.

Given these conditions, the development of briquettes made from patchouli distillation waste holds promise as a green energy innovation capable of transforming agricultural residues into a value-added energy source. This utilization has the potential to reduce the accumulation and open burning of waste, provide an alternative fuel based on renewable resources, and increase the economic value of byproducts from patchouli distillation activities. Thus, the research titled "Patchouli Briquettes: Green Energy Innovation from Agricultural Waste for Sustainable and Environmentally Friendly Agriculture" is important to examine the utilization of patchouli waste as a raw material for briquettes while strengthening the concept of biomass utilization in support of waste management, energy diversification, and more sustainable agriculture.

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METHOD

This study was conducted from March to May 2026 at the Faculty of Agriculture, Halu Oleo University, specifically in the front yard of the Agribusiness Department Student Association Secretariat. The study employed an experimental method with quantitative descriptive analysis to utilize solid waste from patchouli distillation as a raw material for biomass briquettes. The materials used were solid waste from patchouli leaf distillation and tapioca flour as a binder. The equipment used included a carbonization device, a grinder, a sieve, a digital scale, a mixing container, briquette molds, and a dryer.

The briquette production process began with the collection and cleaning of the patchouli waste, after which the material was dried to reduce its initial moisture content. The dried waste is then carbonized into charcoal, cooled, ground, and sieved to achieve a relatively uniform particle size. The charcoal powder is then mixed with the tapioca starch binder according to the specified composition until homogeneous. The mixture is placed into molds and compacted, after which the briquettes are dried until they reach a relatively stable condition. Weighing was performed at each stage to determine changes in material mass during the processing. Primary data were obtained through observation, measurement, and documentation during the research process, while secondary data were obtained from scientific journals, books, and publications relevant to biomass, briquettes, patchouli waste, alternative energy, and sustainable agriculture.

The parameters observed included the weight of the raw material, the weight of the carbonized charcoal, the weight of the briquettes after molding, the weight of the briquettes after drying, the yield, and the moisture content. The yield was calculated using the following equation:

$$R = \frac{B_p}{B_b} \times 100\%$$

Notes:

R = yield (%),

Bp = weight of the product obtained (g), and

Bb = initial weight of the raw material (g).

The moisture content of the briquettes was calculated based on the change in sample mass before and after drying using the equation:

$$KA = \frac{a - b}{a} \times 100\%$$

Notes:

KA = moisture content (%),

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a = sample mass before drying (g), and

b = sample mass after drying (g).

The measurement data were analyzed using quantitative descriptive statistics and presented in tabular form to illustrate the yield, moisture content, and characteristics of the processed patchouli waste briquettes. These results were then interpreted based on relevant literature to assess the potential of patchouli waste as a source of biomass energy and an alternative use for agricultural waste that supports sustainable agriculture.

RESULTS AND DISCUSSION

Utilization of Patchouli Waste as Briquette Raw Material

Solid waste from patchouli distillation obtained from Landipo Village, North Moramo Subdistrict, South Konawe Regency, consists of a mixture of leaves and stems left over from the distillation process. A total of 8 kg of patchouli waste was used as the initial raw material. Before processing, the waste was sorted to remove soil and other foreign materials, resulting in a cleaner and more uniform raw material. This step is crucial because the presence of impurities can affect the carbonization process and the characteristics of the final product. Distillation waste, which has not been optimally utilized to date, offers the potential to be converted into a value-added product through processing into solid fuel.

The utilization of patchouli waste in this study was carried out through a series of processes: drying, carbonization, grinding, mixing with a binder, molding, and final drying. This sequence demonstrates the conversion of biomass from waste form into solid fuel that is easier to handle and use. Biomass processing through pretreatment and compaction is necessary because lignocellulosic materials have a complex structure; thus, the characteristics of the material and the treatments applied during processing will affect the quality of the resulting product (Anindyawati, 2010).

The research results show that patchouli waste can be utilized as the main raw material for briquettes using tapioca flour as a binder. This utilization aligns with the findings of Sugiarto and Sulistyo (2010), who demonstrated that patchouli distillation residue still possesses calorific value and can therefore be utilized as an alternative fuel.

Santika et al. (2023) also demonstrated that solid waste from patchouli oil distillation can be processed into biochar briquettes, while Setyanto et al. (2016) showed that adjusting process conditions plays a role in determining the characteristics of briquettes made from patchouli distillation leaf waste. These findings reinforce the results of this study, which indicate that

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patchouli waste is not merely a production residue but can be developed into a biomass energy feedstock.

The Carbonization Process and Formation of Patchouli Briquettes

The processing of patchouli waste begins with drying the material for 2–3 days using sunlight. Drying is performed to reduce the moisture content prior to the carbonization process. The dried material is then carbonized for 15 minutes in a wok under controlled combustion until black charcoal is produced. During carbonization, the material is carefully monitored to prevent it from burning completely into ash. The resulting charcoal is subsequently cooled before being ground into a fine powder.

Carbonization is a critical stage because it transforms biomass into a material with a higher carbon content. The carbonization result, characterized by its black color, indicates that the patchouli waste has transformed from the initial biomass into charcoal. This transformation is necessary because charcoal serves as the primary component in briquette formation and influences the product's combustion characteristics. These findings align with the research by Santika *et al*. (2023), which demonstrated that pyrolysis conditions affect the quality of biochar briquettes derived from solid waste from patchouli oil distillation.

The cooled charcoal was then ground for approximately 10 minutes and sieved to obtain a relatively uniform particle size. Grinding and sieving were performed to ensure the charcoal powder could mix more evenly with the binder. Particle size is one factor that can affect the density and physical strength of the briquettes, as more uniform particles allow for better bonding during compaction. After the grinding and sieving process, 500 grams of charcoal powder were obtained for use in the mixing process.

The charcoal powder was then mixed with 80 grams of tapioca starch that had been dissolved in 400 ml of water. Tapioca flour was used as a binder to bind the charcoal particles so that the mixture could be shaped into more compact briquettes. Mixing was carried out until all ingredients were homogeneous and had a moldable consistency. In this study, the mixing time was not specifically recorded; instead, the homogeneity of the mixture served as the basis for determining when the mixing process was complete. Once the mixture was homogeneous, the material was placed into a mold and compacted to produce uniform briquettes.

The use of a binder plays a crucial role in forming the briquette structure. Maryono *et al*. (2013) demonstrated that the binder composition can influence briquette characteristics, including strength, moisture content, and burning time. Therefore, the use of tapioca flour in this study not only serves to bind the charcoal particles but also supports the formation of

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briquettes with better physical strength. After molding, the briquettes were dried for 2–3 days in the sun to reduce their moisture content before the product characteristics were observed.

Physical Characteristics and Moisture Content of Patchouli Briquettes

The observations showed that the resulting briquettes were cube-shaped, blackish in color, had a fairly dense texture, and did not crumble easily when held. These characteristics indicate that the mixing, molding, and drying processes were able to produce a relatively compact product. The cube shape also ensures uniformity in size, facilitating handling and storage. Meanwhile, the blackish color is a characteristic related to the formation of charcoal during the carbonization process.

Table 1. Physical Characteristics of Patchouli Briquettes

No.	Parameter	Observation Result
1	Shape	Cube
2	Color	Blackish
3	Texture	Relatively dense
4	Physical condition	Not easily crumbled

The fairly dense texture of the briquettes indicates that the charcoal particles and binder form sufficiently strong bonds after molding and drying. This is important because briquettes with a structure that is too brittle are more prone to damage during storage and transport. The use of tapioca starch as a binder is believed to contribute to the formation of bonds between particles. However, this study did not conduct compressive strength testing; therefore, the mechanical strength of the briquettes cannot yet be quantified.

In addition to physical characteristics, moisture content is one of the key parameters in determining the quality of biomass fuel. In this study, the average weight of the briquettes before drying was 19 grams, and after drying, it became 17 grams. Based on this change in weight, the moisture content was calculated using the equation:

$$KA = \frac{a - b}{a} \times 100\%$$

Notes:

KA = moisture content (%);

a = mass of the sample before drying (g);

b = mass of the sample after drying (g).

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Thus:

$$KA = \frac{19 - 17}{19} \times 100\% = 10{,}53\%$$

The calculation results show that the moisture content of the briquettes is 10.53%. The mass loss of 2 grams indicates that water evaporated during the drying process. Moisture content affects a fuel's ability to ignite and sustain combustion because some of the thermal energy is first used to evaporate the water contained in the briquette. Therefore, drying is a crucial step in producing briquettes with properties better suited for use as fuel.

The measured moisture content also indicates that moisture remains in the product even after drying under sunlight. Differences in moisture content compared to other studies may be influenced by the type of raw material, binder composition, the amount of water used in mixing, particle size, drying method, and environmental conditions during the drying process. Putra and Hidayat (2022) identified moisture content as one of the key parameters in briquette testing because it is closely related to combustion characteristics. Thus, the results of this study show that drying for 2–3 days has reduced the moisture content of the briquettes, although further optimization is still needed to achieve a lower moisture content.

Yield of Patchouli Briquette Production

Yield is used to determine the percentage of briquette product obtained from the patchouli waste raw material used. In this study, 8 kg (or 8,000 grams) of raw material was used initially, and after the entire processing procedure, dry briquettes with a total weight of 748 grams were obtained. The yield was calculated using the following equation

$$R = \frac{B_p}{B_b} \times 100\%$$

Notes:
R = yield (%)
Bp = weight of the final product (g);
Bb = weight of the initial raw material (g).

Based on these data, the yield obtained is:

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$$R = \frac{748}{8.000} \times 100\% = 9{,}35\%$$

Thus, the yield of the produced patchouli briquettes is 9.35%. This means that for every 100 grams of patchouli waste used as the initial raw material, approximately 9.35 grams of briquette product are obtained after undergoing the stages of drying, carbonization, grinding, mixing, molding, and final drying.

The relatively low yield compared to the initial raw material mass is primarily due to mass loss during the drying and carbonization processes. During the drying stage, some of the water in the material evaporates, while during carbonization, volatile components are released from the biomass, resulting in a decrease in mass. Mass loss can also occur during grinding and screening due to particles that do not qualify for use in the molding process. Thus, the yield value not only reflects the efficiency of briquette formation but also indicates the extent of mass change during the biomass conversion process.

These results are consistent with Kholifah (2021), who demonstrated that essential oil distillation waste has the potential to be utilized as a raw material for biobriquettes because it still contains organic matter that can be converted into energy. Through processing, previously unused waste can be transformed into a new product that functions as a solid fuel. However, a yield of 9.35% cannot yet serve as the sole indicator for determining the technology's feasibility or the economic efficiency of production, as this study did not conduct a comprehensive mass balance analysis or a production cost analysis.

The Potential of Patchouli Briquettes as Green Energy and Agribusiness Value-Added

The research results show that waste from patchouli distillation can be converted into briquettes using relatively simple processing technology. Using waste as a raw material provides added value because residues that were previously likely to be piled up or burned directly can be utilized as an energy product. This is relevant to the development of biomass-based energy because the raw material comes from renewable resources and is a byproduct of agricultural and agroindustrial activities.

From an environmental perspective, the utilization of patchouli waste into briquettes has the potential to reduce the volume of unused waste and decrease the need for open-air waste burning. However, these benefits remain potential in this study because no direct measurements of emissions during combustion were conducted, nor was a carbon footprint comparison made with conventional fuels. Therefore, the contribution of patchouli briquettes

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to carbon emission reduction cannot yet be quantified. Emission testing and carbon footprint analysis are required to quantitatively demonstrate these environmental benefits.

From an economic perspective, processing waste into briquettes opens opportunities for the creation of byproducts from patchouli distillation activities. This system enables distillation operations to not only produce patchouli oil as the main product but also to utilize byproducts as energy sources. Waste that originally had no market value can gain added value after undergoing processing. This concept aligns with agribusiness and circular economy approaches that emphasize more efficient resource utilization and the reduction of waste generated during production processes.

This opportunity is particularly relevant because the briquette-making technology used in this study employs simple equipment, such as a wok for carbonization, a mortar and pestle for grinding, a sieve, a mixing container, and a molding tool. The use of simple equipment offers opportunities for implementation at the household or community business level, particularly in areas with patchouli distillation activities. Suryaningsih *et al*. (2019) demonstrated that converting agricultural waste into briquettes can serve as an activity that enhances the economic value for communities through relatively simple technology. Thus, patchouli briquette processing technology holds potential for further development at the community level.

From an agribusiness perspective, the conversion of patchouli waste into briquettes can create a new value chain encompassing raw material supply, processing, packaging, marketing, and product utilization. Distillers can supply the waste as raw material, while community groups or business units can process it into briquettes. The resulting products can be used internally or marketed to consumers in need of solid fuel. This development could expand revenue streams from patchouli distillation while improving the efficiency of byproduct utilization.

However, this study cannot yet conclude that patchouli briquettes are economically viable as an agribusiness venture. The study has not calculated production costs per kilogram, cost of goods sold, selling price, profit, break-even point, or investment feasibility.

Therefore, the economic opportunities discussed here represent potential based on the success of converting waste into a useful product. Further studies on financial aspects, market conditions, production capacity, raw material availability, and consumer acceptance are needed to determine the feasibility of developing a patchouli briquette business.

Comparison with Other Biomass Briquettes and Implications for Development

The characteristics of patchouli briquettes obtained in this study can be compared, to a limited extent, with the results of studies on briquettes made from other biomass feedstocks.

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Parameters that can be directly compared include moisture content and physical characteristics, while parameters such as calorific value, ash content, density, fixed carbon content, compressive strength, and combustion characteristics were not tested in this study. These limitations must be taken into account to ensure that the comparison does not lead to overly broad conclusions.

The moisture content of patchouli briquettes, at 10.53%, is still higher than that reported in some other studies on biomass briquettes. This difference may be attributed to the characteristics of the raw material, binder composition, amount of water used, particle size, molding pressure, as well as the drying method and duration. Setiani *et al*. (2019) demonstrated that moisture content is related to the combustion quality of briquettes, while a study on a mixture of corn cobs and coconut shells indicated that briquette characteristics can be influenced by material composition and process conditions. Rudiyanto *et al*. (2023) also reported that the use of different raw materials and binders results in varying moisture content and other quality parameters.

Thus, the patchouli briquettes in this study cannot yet be declared superior or inferior overall compared to other biomass briquettes. The primary advantage demonstrated by this study lies in the utilization of patchouli distillation waste as a raw material that had not previously been optimally utilized. Meanwhile, to comprehensively determine energy quality, it is necessary to test calorific value, ash content, fixed carbon content, density, compressive strength, ignition time, and burning duration using standardized testing methods.

Overall, the research results show that 8 kg of patchouli waste can be utilized through a carbonization and compaction process to produce 748 grams of dry briquettes, yielding a 9.35% conversion rate. The resulting product is cube-shaped, blackish in color, has a fairly dense texture, and does not crumble easily upon physical examination. The moisture content, based on a weight change from 19 grams to 17 grams, is 10.53%. These results indicate the potential for utilizing patchouli waste as a raw material for biomass briquettes, although further testing is still needed to comprehensively assess its energy quality and economic viability.

These findings suggest that patchouli distillation waste can be channeled into one of the derivative products within the patchouli agribusiness system. Processing the waste into briquettes not only has the potential to reduce residues from distillation activities but also creates added value through alternative energy products. Future development should focus on optimizing the binder composition, carbonization conditions, and drying methods, as well as improving yield, testing energy quality, and conducting a business feasibility analysis. With this approach, the utilization of patchouli waste can be developed from a mere waste treatment

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activity into an innovation that supports resource efficiency, product diversification, and the development of a more sustainable agribusiness.

CONCLUSION

The study shows that patchouli distillation waste can be utilized as raw material for briquettes through the stages of drying, carbonization, grinding, mixing with tapioca flour as a binder, molding, and final drying. The resulting briquettes are solid, blackish in color, fairly hard in texture, and not easily crumbled. Test results show a moisture content of 10.53% and a yield of 9.35%. Utilizing patchouli waste to produce briquettes has the potential to reduce the accumulation of distillation waste while simultaneously producing an alternative energy product with added value. However, further testing is needed to determine the energy quality and feasibility of its utilization more comprehensively.

The utilization of patchouli waste needs to be developed at the farmer and community levels through the application of simple, easy-to-implement technologies. The government can support this development through training, extension services, and the provision of appropriate biomass-based technologies. Future research is recommended to test calorific value, ash content, density, compressive strength, burning time, and energy efficiency. Additionally, an economic analysis covering production costs, cost of goods sold, profits, and business development opportunities is needed so that the potential of patchouli waste briquettes as a sustainable agribusiness product can be assessed more comprehensively.

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