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Participatory Conversion of Pineapple Waste into Bioenergy Briquettes to Support a Rural Circular Economy

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ABSTRACT

Pineapple peel, crown, leaf, and stem residues generated in the Tangkit Baru agrotourism area have not been optimally utilized and are commonly left around plantations. This community engagement program aimed to strengthen farmers' practical capacity to convert pineapple residues into bioenergy briquettes through participatory training. The program was conducted on 29 May 2025 at the Tangkit Baru Village Hall, Muaro Jambi Regency, involving 20 members of the Tangkit Pineapple Agrotourism Farmers' Group. Activities comprised preliminary coordination, interactive education, demonstration, group practice, discussion, process observation, and oral feedback. Participants were organized into five groups and practiced feedstock drying, six-hour carbonization, grinding, mixing 200 g of pineapple-waste charcoal with 40 g of tapioca flour and 100 mL of water, molding, and five-day sun drying. All groups completed the practice sequence and produced briquette samples that retained their form after demolding. Participants identified possible group-based uses of the product; however, fuel quality and economic feasibility were not tested. The program demonstrates the practicality of hands-on training for introducing simple waste-valorization technology to a farmer group. Follow-up assistance should include standardized testing of moisture, ash, volatile matter, fixed carbon, calorific value, mechanical durability, emissions, production costs, and market feasibility before commercial production.

Keywords: bioenergy briquettes, circular economy, community empowerment, participatory training; pineapple waste

INTRODUCTION

Pineapple (Ananas comosus (L.) Merr.) cultivation and processing generate substantial amounts of peel, crown, leaf, and stem residues. Reviews estimate that solid by-products may account for approximately half of the processed fruit mass, although the proportion varies by processing pathway (Chaudhary & Singh, 2024; Vieira et al., 2022). These residues contain lignocellulosic material and can be directed to food, biochemical, soil-amendment, or energy applications rather than being treated solely as waste (Paz-Arteaga et al., 2024; Rivera et al., 2023). Such valorization is consistent with a circular bioeconomy, in which agricultural residues are retained within productive value chains (Duque-Acevedo et al., 2022; Rao et al., 2024).

Tangkit Baru Village, Sungai Gelam District, Muaro Jambi Regency, is known locally for pineapple farming and agrotourism. The preliminary field survey and the farmers'

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account indicated that pineapple residues were commonly left along plantation margins with the expectation that they would decompose naturally. Unmanaged accumulation may create odor and visual nuisance and represents a missed opportunity to transform locally available biomass into a useful product. The local report estimated peak pineapple output at approximately 5,000 fruits per hectare; however, the program did not quantify the mass or seasonal flow of residues. This limitation makes a local waste inventory an important next step.

Briquetting densifies loose biomass into a more uniform solid fuel that is easier to handle, store, and transport. Product performance depends on feedstock characteristics, carbonization conditions, particle size, moisture, binder type and proportion, compaction pressure, and drying conditions (Ibitoye et al., 2021; Ngene et al., 2024; Obi et al., 2022; Pahnila et al., 2023). Studies have demonstrated that pineapple peel can be carbonized and incorporated into briquettes, while starch-based binders are widely used because they can improve cohesion and mechanical integrity (Ariani et al., 2023; Mibulo et al., 2023; Nonsawang et al., 2024). Nevertheless, producing a visually intact sample during training is not equivalent to demonstrating compliance with fuel-quality or safety standards.

The initial survey found no previous bioenergy-briquette training for the Tangkit Pineapple Agrotourism Farmers' Group. The service gap was therefore practical: farmers had access to residue biomass but limited exposure to a replicable conversion process and to the quality criteria required before marketing a fuel product. As stated in the activity report, the program was designed to pursue four linked objectives: (1) increase knowledge and practical skills concerning pineapple residues as briquette feedstock; (2) introduce the possibility of a productive community enterprise, including future production, financial-management, and marketing considerations; (3) strengthen awareness of the environmental implications of unmanaged residue accumulation; and (4) encourage community independence in using local resources, with longer-term potential for additional livelihoods. Because the program collected no scored learning, enterprise, environmental, or income indicators, achievement of these objectives was assessed only through implementation evidence and is interpreted cautiously.

METHOD

Community Engagement Design and Setting

The community engagement program used a participatory education and skills-demonstration design. It was conducted on Thursday, 29 May 2025, at the Tangkit Baru Village Hall, Jalan Gotong Royong RT 4, Tangkit Baru Village, Sungai Gelam District, Muaro Jambi Regency, Jambi Province. The activity was attended and supported by the Head of Tangkit Baru Village, Andi Baharu Alam.

Participants and Implementation Team

Participants were 20 members of the Tangkit Pineapple Agrotourism Farmers' Group. The implementation team consisted of lecturers and students from the Biology Education Program, Faculty of Tarbiyah and Teacher Training, UIN Sulthan Thaha Saifuddin Jambi, under the coordination of the community-service team. Village officials and farmer-group representatives supported local coordination.

Educational Intervention

The educational component introduced the local abundance of pineapple residues, potential environmental concerns associated with unmanaged accumulation, biomass valorization, renewable-energy principles, and the basic concept of briquetting. Content was delivered through an interactive presentation, discussion, and question-and-answer session. A practical demonstration followed so that the information could be directly connected with each production step.

Implementation Stages

Implementation comprised planning, delivery, and evaluation. During planning, the team appointed the organizing committee and resource persons, conducted an initial site survey, and coordinated with village officials and farmer representatives. Delivery began with opening remarks from the village head and the service-team representative, followed by the educational session and practical demonstration. The 20 participants were divided into five working groups, with lecturers and students assisting each group. The activity concluded with group discussion, oral feedback, evaluation, and closing remarks.

Tools and Materials

The equipment recorded in the activity documents included metal cans, cooking pots, a wood-fired stove and firewood, matches, knives, spoons, manual pounders, mixing basins, and three-inch polyvinyl chloride molds. Materials consisted of pineapple peel, crown, leaf, and stem residues; tapioca flour; water; and cooking oil used as a mold-release agent.

Briquette Production Procedure

The feedstock was collected and sun-dried before carbonization. The dried material was carbonized over embers for approximately six hours until charcoal was formed without complete conversion to ash. The charcoal was manually pounded into smaller particles. Tapioca flour was mixed with heated water to form a paste, after which 200 g of pineapple-waste charcoal was combined with 40 g of tapioca flour and 100 mL of water. The mixture was stirred until homogeneous, placed into lightly oiled molds, manually compacted, demolded, and sun-dried for five days.

Training and Evaluation Method

The 20 participants were divided into five groups and accompanied by lecturers and students during practice. Evaluation focused on implementation and immediate outputs because the source report contained no scored pretest, post-test, written satisfaction questionnaire, or laboratory fuel test. The team documented attendance, completion of production steps by each group, observable shape retention after demolding, participant questions, oral feedback, and requests for follow-up. Results were summarized descriptively, and no inferential analysis was performed. Terms such as “quality,” “effective fuel,” or “economic feasibility” were therefore not assigned on the basis of appearance alone.

Table 1. Training-scale pineapple-waste briquette procedure

No.	Stage	Training procedure	Immediate check
1	Drying	Sun-dry collected pineapple residues before carbonization.	Material visibly dry
2	Carbonization	Heat dried residues in a limited-oxygen container for approximately 6 h.	Char formed without complete conversion to ash
3	Grinding	Manually pound carbonized material to reduce particle size.	Material sufficiently fine for mixing
4	Binder preparation	Heat water and tapioca flour to form a starch paste.	Homogeneous paste
5	Mixing	Combine 200 g charcoal, 40 g tapioca	Uniform moldable mixture

		flour, and 100 mL water.	
6	Molding	Place mixture into an oiled 3-inch mold and compact manually.	Sample retains shape after demolding
7	Final drying	Sun-dry molded samples for approximately 5 days.	Dry-to-touch sample for later testing

RESULTS AND DISCUSSION

The Education and Question-and-Answer Session

The educational session addressed the common practice of leaving pineapple crowns, peels, leaves, and stems around plantation margins, where they were expected to decompose. Facilitators explained the possibility of converting these residues into an alternative fuel product. Participants actively asked questions after the presentation. This interaction showed engagement with the topic, although the absence of a scored knowledge assessment means that knowledge improvement cannot be quantified.

Hands-on Practice and Discussion

All 20 farmer-group participants were organized into five working groups. Each group completed the demonstrated sequence from handling carbonized material to binder preparation, mixing, molding, and demolding. The small-group arrangement allowed lecturers and students to provide direct assistance while participants practiced. All five groups produced molded pineapple-waste briquette samples. Participants were described in the activity report as enthusiastic during practice. These observations document participation and task completion, but they do not constitute a quantified change in competency.

Immediate Product Output

The immediate physical output was a set of molded briquette samples from all five groups. The samples retained their cylindrical form after removal from the molds, showing that the mixture could be shaped under the training conditions. Shape retention is a useful process observation, but it does not establish fuel quality. Moisture content, ash, volatile matter, fixed carbon, calorific value, density, compressive strength, shatter resistance, ignition time, burning rate, thermal efficiency, and gaseous emissions were not measured. Research on pineapple-peel and other agricultural-residue briquettes shows that these parameters vary substantially with carbonization, formulation, pressure, and drying (Ariani et al., 2023; Mibulo et al., 2023; Nonsawang et al., 2024; Saeed et al., 2021). Accordingly, the program output is best interpreted as a training prototype.

Binder Formulation and Technical Interpretation

The use of tapioca flour was appropriate for a low-complexity demonstration because starch binders are accessible and commonly used in biomass briquetting. However, the training formulation contained binder at 20% of the charcoal mass, and no comparison formulation was tested. Binder proportion may improve cohesion while also affecting ash, moisture, ignition, and heating characteristics; the optimum cannot be inferred without controlled testing (Obi et al., 2022). Future trials should compare several binder proportions and apply consistent particle size, compaction pressure, and drying conditions.

Implementation Challenges

Three practical bottlenecks were recorded. First, fresh pineapple residues contain substantial moisture and therefore require extended drying, particularly during cloudy or rainy weather; the team recommended maximizing direct sun exposure and planning production during drier periods. Second, the six-hour carbonization process requires continuous supervision so that the material carbonizes without burning completely into ash; participants were guided in controlling the fire and air supply. Third, manual grinding requires considerable physical effort; a hammer mill was identified as a possible future option if production scale increases. These constraints are consistent with the broader briquetting literature, which emphasizes feedstock preparation, process control, particle size, and product standardization (Ibitoye et al., 2021; Ngene et al., 2024).

Evaluation, Participant Feedback, and Sustainability

The activity connected an existing local problem with a tangible production exercise. Oral feedback documented in the report indicated that participants were pleased with the activity and expected similar follow-up programs. The report also recorded interest in developing the briquettes through a micro-, small-, or medium-enterprise pathway, with households and local food vendors identified as possible future users, and a request for a separate future activity on soap making. These were expressions of interest rather than evidence of market demand or business feasibility.

The proposed circular-economy contribution therefore remains prospective rather than demonstrated. The program did not measure the quantity of waste diverted, displacement of conventional fuels, avoided emissions, production costs, consumer demand, or income. A staged continuation should quantify seasonal residue supply; establish a safe, repeatable protocol; test proximate, mechanical, combustion, and emission properties; and calculate unit cost, labor requirement, break-even volume, packaging needs, and target markets. Only after these steps should a farmer-group enterprise, village-owned enterprise, or microenterprise model be considered (Duque-Acevedo et al., 2022; Rao et al., 2024).

Table 2. Documented implementation data and immediate outputs

Indicator	Documented value	Interpretation boundary
Date and setting	29 May 2025; Tangkit Baru Village Hall, Muaro Jambi	Single community-engagement event
Participants	20 farmer-group members	No demographic profile was collected
Practice organization	5 working groups	Four participants per group based on the recorded totals
Training formulation	200 g charcoal + 40 g tapioca flour + 100 mL water	One formulation; no comparator
Processing time	Approximately 6 h carbonization and 5 d sun drying	Temperature and final moisture were not measured
Immediate output	All 5 groups produced molded briquette samples	Fuel quality and safety were not tested
Evaluation source	Observation, discussion, and oral participant feedback	No scored pretest, post-test, or questionnaire

Figure 1. Documented stages of the community engagement program

(a) Interactive education

(b) Facilitated group practice

(c) Participant and facilitator group

Source: Community engagement activity report, 29 May 2025.

Limitation

The program was a single-day training with 20 members of one farmer group. The evaluation relied on attendance records, facilitator observation, product documentation, and oral feedback. Because no validated pretest–posttest instrument, written satisfaction survey, delayed follow-up assessment, laboratory analysis, emission test, or economic assessment was available, the program cannot establish knowledge gain, sustained adoption, product compliance, environmental benefit, or income creation. These outcomes should be measured in a follow-up implementation study.

CONCLUSION

Participatory training enabled 20 members of the Tangkit Pineapple Agrotourism Farmers' Group to complete a simple sequence for converting carbonized pineapple residues into molded briquette samples. The activity established proof of participation and process completion and helped participants recognize a possible productive use for locally available residues. It did not yet demonstrate fuel quality, environmental impact, or commercial feasibility. Program sustainability should therefore focus on standardized production, laboratory and safety testing, a seasonal residue inventory, quantified learning evaluation, and a market and cost assessment before the briquettes are promoted as household fuel or developed as a village enterprise.\

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