2026 Journal of Engineering, Technology and Social Sciences
Jurnal Kejuruteraan, Teknologi dan Sains Sosial
Volume 12 Special Issue: GTiMME
International Conference on Green Technology in Mechanical and Marine Engineering

DEVELOPMENT OF PRESSING PROCESS FOR COFFEE WASTE FIRE STARTER MACHINE

Jaslin Rasin[1*], Mohd Ashadi Mohd Yusop[2], Suhaimi Said[1], Lailatul Hamidah Md Hamdan[1], Andy Anak Buja[1], Sarah 'Atifah Saruchi[3]

[1]*Department of Mechanical Engineering, Politeknik Kuching Sarawak (PKS), KM 22, Jalan Matang, Petra Jaya, 93050 Kuching, Sarawak*
[2]*Department of Electric Engineering, Politeknik Kuching Sarawak (PKS), KM 22, Jalan Matang, Petra Jaya, 93050 Kuching, Sarawak*
[3]*Faculty of Manufacturing and Mechatronic Engineering Technology, Universiti Malaysia Pahang Al-Sultan Abdullah, 26600 Pekan, Pahang, Malaysia*
[*]*Corresponding author: Jaslin_len@poliku.edu.my*

ARTICLE INFO

Article history:
Received
14 July 2025
Received in revised form
18 September 2025
Accepted
03 October 2025
Published online
02 January 2026

***Keywords**:*

Coffee waste; Fire starter briquettes; Biomass energy; Pressing process; Combustion efficiency; Circular economy; Sustainable fuels

ABSTRACT

The global transition toward sustainable energy has strengthened the search for biofuels derived from agricultural waste, with coffee waste emerging as a promising biomass resource. This study presents the development of a pressing process for producing fire starter briquettes from coffee waste, focusing on the optimization of parameters that influence performance and combustion quality. A customized pneumatic pressing apparatus was designed to evaluate the effects of compression pressure, processing time, and cycle time on briquette properties. The briquettes were further characterized in terms of density, mechanical strength, moisture reduction, and final moisture content, as these factors directly impact durability and ignition efficiency. Comparative tests were conducted on two distinct briquette dimensions to assess geometric influence on burning behaviour and handling properties. Standardized performance evaluation included ignition and burn time, supported by graphical analysis of the relationship between moisture content after drying (%) and drying time (seconds) for different coffee waste samples. Results indicate that higher compression pressures and optimized cycle times significantly enhance density and mechanical strength while reducing residual moisture content, thereby improving combustion stability. Briquettes produced under these conditions exhibited consistent burning profiles, favourable cohesive qualities, and reduced emission levels compared to conventional biomass fire starters. The findings confirm that coffee waste briquettes processed through optimized pressing and drying protocols can provide energy outputs comparable to traditional fire starters while addressing waste management challenges. This work demonstrates the dual benefits of utilizing coffee waste as a carbon-neutral fuel and advancing scalable briquetting technology in agro-industrial communities.

1. Introduction

The rising global demand for sustainable and renewable energy sources has sparked interest in biomass-based technologies, especially those that use agricultural waste (Assaye, 2024). Agricultural residues are high in carbohydrates and low in sulfur which have great potential for producing biofuels (Attarde et al., 2025). Various conversion methods, such as biological processes like fermentation and anaerobic digestion, as well as thermochemical processes like pyrolysis and gasification, can turn agricultural waste into biogas, biofuels, and other useful products (Shahzad et al., 2024). Coffee invention generates significant waste, with approximately 90% of the coffee cherry discarded as by-products. Coffee waste can be recycled for various applications, such as heavy metal and dye removal, fuel production, composting, fuel production, and as a source of bioactive compounds (Iriondo-DeHond et al., 2020). The chemical composition of coffee waste is rich in polysaccharides, fiber, antioxidants,also enables its use in food, cosmetic industries, and pharmaceutical. Additionally, coffee waste serves as a promising material for green energy production and sustainable substitutes (Mirón-Mérida et al., 2021). Coffee waste stands out as a strong option due to its availability, organic nature, and good energy content. As a byproduct of the coffee industry, it is often thrown away or not fully used, which raises environmental issues and leads to wasted resources. Spent coffee grounds have also been explored as a component in firelighters, showing promising heat release properties (Bejenari et al., 2021). Another coffee waste product, coffee husk, can also be utilised to make fuel briquettes with advantageous properties like a high fixed carbon content and calorific value (Tesfaye et al., 2022).

Fire starters are tools or devices designed to ignite fires efficiently and quickly. They come in various forms and utilize different ignition mechanisms to cause flames. Fire starters work by initiating the combustion process, which involves the rapid oxidation of fuel such as paper and wood in the presence of heat and oxygen. Each type of fire starter utilizes a different mechanism to create the initial spark or flame needed to ignite the tinder and fuel. Recent research explores new methods for making fire starters from waste materials. This addresses environmental issues and practical needs. Studies have looked into using biomass waste, such as pine cones, sawdust, and dry leaves, along with stearic acid as an adhesive (Juang et al., 2024). Previous researcher has also examined sawdust mixed with vegetable oils to shape it as a fire starter briquettes (Ezéchiel et al., 2023).

Briquetting is the process of turning low-density, otherwise useless materials into manageable, compact solid fuels that burn like charcoal or wood. Moisture content is a particularly crucial component impacting this process. In pelletised and briquetted materials, moisture serves as a natural binding agent that improves mechanical durability and affects the bulk density of the final product (Sołowiej et al., 2024). A suitable amount of moisture also acts as a lubricant in the pressing matrix, lessening frictional forces and, thus, the energy needed for compaction. Excessive or inadequate moisture can undermine both the structural integrity and combustion efficiency of briquettes, becoming moisture control a critical factor in enhancing briquette quality and production efficiency. The briquettes have better physical and combustion characteristics than the original waste. Commercial fire starters usually contain petrochemical ingredients that are both expensive and harmful to the environment and health. This creates a need for safer, cleaner, and more sustainable alternatives that can be produced locally from renewable materials. When properly processed, coffee waste has boundless potential as a raw material for fire starter briquettes that are cost-effective and eco-friendly.

The mixture of fire starter in this research are consists of sawdust, shredded paper, coffee waste and water to bind the dry ingredient. However, current briquetting methods in many research often do not address the unique properties of coffee waste, particularly when it comes to ensuring consistent quality in ignition time, structure, and combustion efficiency. Therefore, this research aims to develop and improve a pressing process specifically for coffee waste mixture. A custom pneumatic pressing machine was created to fit the physical properties of the material, with key process factors like pressure, moisture content, and binder composition carefully examined.

2. Methodology

The briquetting process begins with collection of wastes followed by size reduction, drying, and compaction by extruder or press. This project's methodology is centred on the methodical creation and assessment of a pressing process intended to turn coffee waste into fire starter briquettes. The pressing machine's design, construction, and assembly processes are described in detail in this part, along with the methods for material preparation and process optimisation. For reliable compression force and effective briquette production, the method combines pneumatic actuation and mechanical design. Characterising the material, especially controlling the moisture level, is essential to guaranteeing the end product's strength and quality. The process also includes the testing step, in which the machine's performance was evaluated using mechanical strength, briquette density, compression pressure, and cycle duration. The preparation of raw coffee waste to the final briquette testing shows that this methodical approach mentioned in every step of the process complies with regulations that support operational effectiveness and product dependability.

2.1 Material Selection and Component

a. Mild Steel

This mild steel plate is used to form a machine with a square- shaped for compression part.

Figure 1. Mild Steel.

b. Welding Rod

Welding rods, also known as electrodes, are the materials that are molten and infused

Figure 2. Welding Rod.

c. Pneumatic Mechanical 3/2 Way Button

Pneumatic mechanical 3/2-way button valve is a type of valve used in pneumatic systems to resistor airflow. It has three ports and two positions, and is activated by a mechanical force, such as a button where it can be pushed by hand.

Figure 3. Pneumatic Mechanical 3/2 Way Button.

d. M4 Pneumatic T Joint

An M4 pneumatic T-joint is a suitable used in pneumatic (air pressure) systems to connect three sections of tubing or pipes together in a T-shape.

Figure 4. M4 Pneumatic T Joint.

e. Steel Bar

A steel bar is a long, solid rod made primarily of steel where often used in construction

2026 Journal of Engineering, Technology and Social Sciences
Jurnal Kejuruteraan, Teknologi dan Sains Sosial
Volume 12 Special Issue: GTiMME
International Conference on Green Technology in Mechanical and Marine Engineering

and manufacturing. It also known for their strength and durability, and are commonly used to reinforce concrete structures, making it more resistant to tension and bending forces.

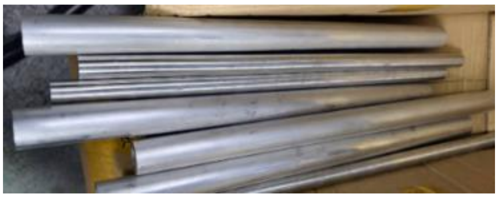

Figure 5. Steel Bar.

f. Pneumatic Double Acting Cylinder SC63 x 1800

This component allows an air pressure moves the piston in both directions (extend and retract).

Figure 6. Pneumatic Double Acting Cylinder SC63 x 1800.

g. M4 Connector

M4 connectors which are tiny with circular connectors with a 4mm threaded connection. Compact sensors, actuators, and proximity switches are commonly connected using it, particularly in settings with limited space.

Figure 7. M4 Connector.

2026 Journal of Engineering, Technology and Social Sciences
Jurnal Kejuruteraan, Teknologi dan Sains Sosial
Volume 12 Special Issue: GTiMME
International Conference on Green Technology in Mechanical and Marine Engineering

h. **Pneumatic Solenoid Valve Dual Direction 5/2 Way 24V Dc**
This component is a device used in pneumatic systems to control the flow of compressed air to and from a double-acting cylinder.

Figure 8. Pneumatic Solenoid Valve Dual Direction 5/2 Way 24V DC.

2.2 Fabrication and Assembly Steps

Several crucial steps are included in the Coffee Waste Fire Starter Machine's fabrication and assembly process, which combines structural construction with mechanical component integration to produce a working pressing system.

2.2.1 Materials Selection

The main frame and pressing components were invented using mild steel due to its durability and ease of machining. The pressing mold was made from stainless steel to prevent corrosion and ensure hygiene when handling coffee waste.

Figure 9. Pressing Mould.

2.2.2 Machine Frame Fabrication

The machine frame fabrication:

a. Mild steel hollow section (40x40 mm)
b. Cutting Process: Executed using a metal cutting bandsaw for precise dimensions.
c. Welding Process: MIG welding was employed to assemble the frame for higher strength and clean joints.
d. Finishing: The frame was coated with anti-rust paint to prevent corrosion.

Figure 10 Mild Steel Hollow Section.

2.2.3 Pressing Mechanism Fabrication

The pressing mechanism consists of:

a. Press Plate: Machined from a 10mm thick steel plate.
b. Guide Rods: Two 20mm diameter rods were connected to ensure linear movement of the compression plate.
c. Pneumatic Double Acting Cylinder SC63x1800 are installed vertically to offer pressing force. This cylinder allows bi-directional pressing and retraction appropriate for continuous operation.

Figure 11 Pressing Mechanism.

2.2.4 Mould Assembly

The mould was designed with a modular cavity to shape coffee waste into cylindrical fire starter briquettes. The mould includes:

a. Stainless steel cavity (Diameter: 50mm, Height: 100mm)
b. Detachable base plate for easy ejection.
c. Vents for excess moisture release during pressing.

Figure 12 Mould assembly.

2.2.5 Pneumatic System Integration

The pneumatic system includes:

a. Air Compressor: Supplies compressed air to the cylinder.
b. Solenoid Valve: Controls air flow path for pressing and retracting.
c. M4 Connectors: Used for protected and sealed pneumatic connections.
d. Pressure Regulator: Sustains optimal pressing force without destructive the briquette.

2.2.6 Assembly Process

a. Frame Assembly: The frame needs to fabricate to provide a stable structure.
b. Installation of Guide Rods and Press Plate: Ensured alignment for even the operation.
c. Mounting Pneumatic Cylinder: Fixed on the top frame, linked to the press plate.
d. Mold Placement: Positioned precisely below the press plate.
e. Pneumatic Connections: All tubes and connectors were connected and sealed.
f. Control Panel Setup: Included start/stop buttons and pressure control.

2.2.7 Testing and Calibration

Initial testing was conducted to:

a. Verify pressing force and stroke length.
b. Adjust the air pressure for optimal compression of coffee waste.
c. Ensure uniform briquette formation without structural defects.

2.3 Pre-Testing Procedure

The pre-testing of this project starts with steps below.

1) Inspection: Thoroughly inspect the machine to ensure that all parts are in good operating order.

2) Cleaning: Clean the equipment to get rid of any dirt or debris that gathered during storage or shipment.
3) Lubrication: Lubricate all moving parts to guarantee smooth operation and to prevent friction damage.
4) Connect the machine to a power supply and test it to ensure it is operational.
5) Check all safety features, press button, guards, to ensure they are operational.
6) Check the machine's operation by running it through a few cycles to confirm it is work as planned.
7) This setup is planned to test the effectiveness of this machine. The procedures for our post-testing are:
    a. Cleaning: Thoroughly clean the machine to eliminate any unwanted particle that may have accumulated during testing.
    b. Inspect the machine once again to ensure that there are no symptoms of damage or wear on the steel plate that may necessitate repair.
    c. Lubrication: To prevent wear and tear, lubricate all moving parts.
    d. Keeping Records: In the machine's logbook, record the testing findings, any issues or concerns, and any maintenance or repair requirements.
    e. Storage: Keep the machine in a safe and secure location to avoid damage or theft.

3. Results and Discussion

The main characteristics and processing parameters of the coffee waste fire starter briquettes made with the developed pressing machine are shown in Table 1. In addition to outlining important factors including compression pressure, processing time, cycle time, density, mechanical strength, moisture reduction features, and moisture content, the chart compares two distinct fire starter dimensions. In order to guarantee consistent briquette quality, sufficient mechanical strength for handling, and efficient moisture management during pressing, these factors are crucial for manufacturing process optimisation. Additionally, to increase production efficiency and product reliability, the data also shows how briquette size affects overall cycle time and compression performance.

Table 1. Properties of Fire Starter

Fire Starter Diameter (mm)	Fire Starter Height (mm)	Compression Pressure	Compression Time per Set (second)	Cycle Time (Including Loading/ Unloading mixture) (second)	Coffee waste Mixture prepation (second)	Moisture	Density	Mechanical Strength	Moisture Reduction
2	2	4 to 6 bar (adjustable via the pneumatic system)	20–30 per set briquette	60	300	Pre-dried to ~10-12% moisture for optimal compaction.	Estimated 0.8 to 1.2 g/cm³ (depending on moisture content and compression pressure)	Capable of withstanding moderate handling and transportation.	Vent holes in the mold help reduce excess moisture during pressing.
2	3		30–40 per set briquette	120	600				

For several coffee waste mixture samples, the graph in Figure 13 shows the correlation between the processing time (seconds) and the moisture percentage (%) after drying. Overall, it is clear that processing times for all studied materials reduce as the moisture content rises from 0% to 10%. The pressing period, which varies from 30 to 40 seconds depending on the sample, is much longer for samples with lower moisture contents, especially those below 2%. This implies that very low moisture content in coffee waste makes it tougher and more resistant to compression, which takes longer for the briquettes to form. On the other hand, the material softens with increasing moisture content, which shortens the pressing time (Krinski & Mariani, 2020). For all sample groups, the time needed drops to about 10 to 15 seconds at a moisture content of 8% to 10%.

Although samples from Series 3 (Samples 1-3A, 2-3B, and 3-3C) initially exhibit longer pressing times than samples from Series 2 because of the height of the fire starter is more, the trend is constant throughout both sets of samples (Series 2 and Series 3). As the moisture content gets closer to 10%, though, this disparity narrows. These findings suggest that for the coffee waste pressing process, a moisture level of 8% to 10% is optimal. Briquettes may be made faster without sacrificing structural integrity thanks to this range, which maximises the trade-off between material workability and processing efficiency (Okpala et al., 2025). However, excessive drying of the material can lead to increased processing time, increased energy consumption, and damage on the pressing mechanism.

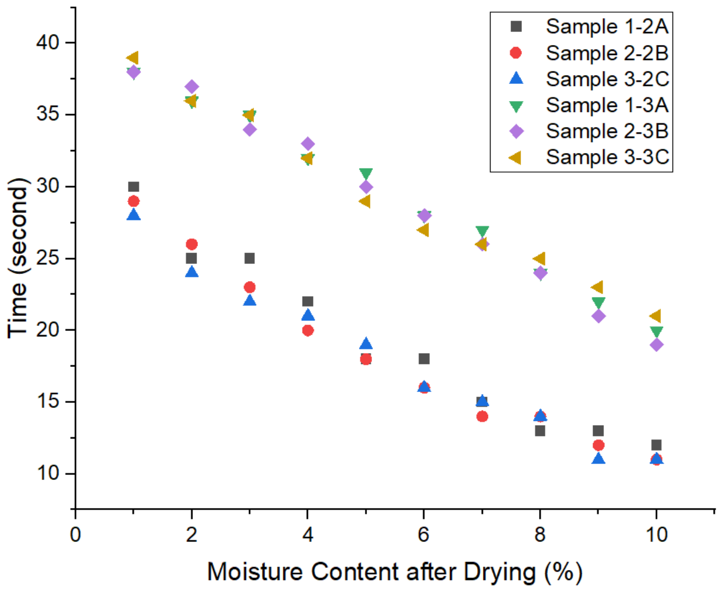

Figure 13. Relationship between Moisture Content after Drying (%) and Time (seconds) for Different Coffee Waste Samples

4. Conclusion

An efficient technique for turning coffee waste into fire starter briquettes through regulated pressing process has been effectively proven by the creation of the coffee waste fire starter pressing machine. Briquettes of different sizes and mechanical characteristics could be produced thanks to the incorporation of a pneumatic double-acting cylinder, which offered a steady and modifiable compression force. It was found that the ideal moisture content for coffee waste was between 8% and 12%, which greatly shortened the pressing time while maintaining the briquettes' adequate density and structural integrity. The manufactured machine's adjustable compression pressure and vented mould made it possible to effectively reduce moisture during pressing, enhancing the briquette's handling strength and longevity. The findings indicated that whereas larger briquettes required longer processing times, the 2mm diameter by 2mm height briquettes attained a faster cycle time of 60 seconds. All things considered, the machine increased output while guaranteeing that the fire starters fulfilled the technical requirements for moderate handling and transit. By turning coffee waste mixture into useful and energy-efficient fire starters, this project not only promotes sustainable waste utilisation but also advances environmentally acceptable fuel options. Additional improvements can include experimental material mixture optimisation for better combustion performance and automation for increased production rates.

Acknowledgements

This research was funded by a TVET Applied Research Grant Scheme (T-ARGS) from Ministry of Higher Education of Malaysia thru Jabatan Pendidikan Politeknik dan Kolej Komuniti (JPPKK). Thanks to Department of Mechanical Engineering, Politeknik Kuching Sarawak (PKS) for providing the laboratory facilities.

References

Assaye, Y. (2024). Agricultural Waste for Energy Storage, Conversion and Agricultural Applications. *American Journal of Modern Energy*, *10*(3), 38–41. https://doi.org/10.11648/j.ajme.20241003.11

Attarde, C., Shetty, R., & Shah, T. (2025). Review on Biofuel Production from Agricultural Waste in a Sustainable Way: Pathways, Processes and Technological Advances. *The Bombay Technologist*, 269–281. https://doi.org/10.36664/bt/2024/v71i1/173226

Bejenari, V., Marcu, A., Ipate, A.-M., Rusu, D., Tudorachi, N., Anghel, I., Şofran, I.-E., & Lisa, G. (2021). Physicochemical characterization and energy recovery of spent coffee grounds. *Journal of Materials Research and Technology*, *15*, 4437–4451. https://doi.org/10.1016/j.jmrt.2021.10.064

Ezéchiel, K., Joel, T. K., Souloukngа, M. H., & Roger, D. D. (2023). Production and characterization of ecological fire starter from sawdust and vegetable oil. *Heliyon*, *9*(8), e18253. https://doi.org/10.1016/j.heliyon.2023.e18253

Iriondo-DeHond, A., Iriondo-DeHond, M., & del Castillo, M. D. (2020). Applications of Compounds from Coffee Processing By-Products. *Biomolecules*, *10*(9), 1219. https://doi.org/10.3390/biom10091219

Juang, D., Zulfa Arifah, D., Alfaroh, B., Sabila Rasyad, A., & Agustina, A. (2024). Utilization of Biomass Waste with Stearic Acid as Fire Starter. *BIOLINK (JurnalBiologi Lingkungan Industri Kesehatan), 11*(1), 78–89 https://doi.org/10.31289/biolink.v11i1.12408

Krinski, I., & Mariani, V. (2020). Briquettes Production From Lignocellulosic Waste For Energy Purposes As An Alternative Fuel. *Procceedings of the 18th Brazilian Congress of Thermal Sciences and Engineering*. https://doi.org/10.26678/ABCM.ENCIT2020.CIT20-0450

Mirón-Mérida, V. A., Barragán-Huerta, B. E., & Gutiérrez-Macías, P. (2021). Coffee waste: a source of valuable technologies for sustainable development. In *Valorization of Agri-Food Wastes and By-Products* (pp. 173–198). Elsevier. https://doi.org/10.1016/B978-0-12-824044-1.00009-X

Okpala, I. F., Onyenanu, I. U., Ezechukwu, V. C., & Ilochonwu, C. E. (2025). Performance Optimization of a Locally Developed Charcoal Briquette Machine Using Response Surface Methodology. *Scientific Journal of Engineering, and Technology*, *2*(1), 55 66. https://doi.org/10.69739/sjet.v2i1.486

Shahzad, H. M. A., Asim, Z., Khan, S. J., Almomani, F., Mahmoud, K. A., Mustafa, M. R. U., & Rasool, K. (2024). Thermochemical and biochemical conversion of agricultural waste for bioenergy production: an updated review. *Discover Environment*, *2*(1), 134. https://doi.org/10.1007/s44274-024-00171-w

Sołowiej, P., Neugebauer, M., & Esmer, O. (2024). Coffee Grounds as an Additive to Wood Pellets. *Energies*, *17*(18), 4595. https://doi.org/10.3390/en17184595

Tesfaye, A., Workie, F., & Kumar, V. S. (2022). Production and Characterization of Coffee Husk Fuel Briquettes as an Alternative Energy Source. *Advances in Materials Science and Engineering*, *2022*, 1–13. https://doi.org/10.1155/2022/9139766