Jurnal Dinamis (*Scientific Journal of Mechanical Engineering*)
Journal homepage: https://talenta.usu.ac.id/dinamis/

Combustion Performance of Torrefied Coffee Parchment Briquettes: Effects of Particle Size and Briquetting Pressure

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ARTICLE INFO

Article history:
Received January 25th 2025
Revised May 27th 2025
Accepted June 29th 2025
Available online June 30th 2025

E-ISSN: 2809-3410

How to cite:
Juwaini, Adi Setiawan, , Muhammad, Azhar Syahputra, "Combustion Performance of Torrefied Coffee Parchment Briquettes: Effects of Particle Size and Briquetting Pressure", *Junal Dinamis (Scientific Journal of Mechanical Engineering)*, Vol. 13, No. 1, pp. 32-44, June 2025.

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http://doi.org/10.32734/dinamis.v13i1.19759

ABSTRACT

A substantial amount of coffee plantation waste is generated in Aceh highland, yet its utilization remains limited. Most of the wastes are dumped on the ground, while coffee parchment is often burned without further application. This study explores the conversion of coffee parchment into briquettes, focusing on their combustion characteristics. The parchment were subjected to torrefaction process at temperatures ranging from 240°C to 270°C and then ground to particle sizes of 40, 60, and 80 mesh. Briquettes were formed using 10% tapioca flour as a binder and compressed simultaneously for 20 pieces of briquettes at pressures of 300, 400, and 500 kg/cm². The resulting briquettes, with dimensions of 37×28×28 mm, exhibited a density of 0.63 g/cm³ and a combustion rate of 0.37 g/min, enabling a burn duration of up to 105 minutes and a peak temperature of 435°C. The best performance was achieved using a particle size of 60 mesh and a compaction pressure of 400 kg/cm². These findings demonstrate the potential of coffee parchment as a viable source of solid fuel for heating applications.

Keyword: *Coffee parchment, briquettes, density, rate of combustion.*

ABSTRAK

Limbah perkebunan kopi di Aceh Tengah sangat banyak, namun belum dimanfaatkan secara optimal. Limbah kopi sebagian besar hanya dimanfaatkan sebagai pupuk di kebun, sedangkan limbah kulit kopi (kulit ari) hanya dibakar dan tidak dimanfaatkan. Penelitian ini dilakukan untuk mengubah kulit ari kopi menjadi briket yang dapat digunakan untuk penghangat ruangan dengan memperhatikan karakteristik pembakaran briket tersebut. Penelitian ini mengubah kulit ari kopi menjadi briket menggunakan metode torifikasi pada suhu 240-270oC. Kulit ari hasil torifikasi dihaluskan pada ukuran mesh 40, 60, dan 80. Dengan menggunakan perekat tepung topioka 10%, pencetakan briket dilakukan pada tekanan 300 kg/cm², 400 kg/cm², dan 500 kg/cm². Menghasilkan briket berbentuk persegi panjang dengan dimensi 37x28x28 mm dengan kepadatan 0,63 g/cm² dengan laju pembakaran 0,37 g/menit sehingga briket ini mampu bertahan selama 105 menit pembakaran pada suhu tertinggi 435oC. Briket dengan hasil maksimal pada penelitian ini adalah briket dengan tekanan 400 kg/cm² dan ukuran partikel mesh 60.

Keyword: Coffee husk briquettes, coffee skin, combustion characteristics.

1. Introduction

Agricultural biomass, especially agricultural waste, is a raw material that has high economic value. Biomass is organic material produced through the process of photosynthesis, either in the form of products or waste. Agricultural waste, as a form of biomass, is an abundant alternative energy source with relatively high energy content. One of the promising sources of waste in Aceh is Gayo coffee waste, which remains largely unutilized.

Coffee plants grow well in lowlands up to around 1,000 meters above sea level, particularly in regions with average temperatures of approximately 20°C. Coffee plants can begin bearing fruit after 4–5 years, depending on local maintenance and climatic conditions. High yields are typically achieved starting at 8 years of age, and the plants remain productive for 15–18 years. With proper maintenance, coffee plants can remain productive for up to 30 years [1].

The coffee cherry consists of several layers: the outer skin (exocarp), the pulp (mesocarp), mucilage, the parchment or horn skin (endocarp), and the coffee bean (endosperm) [1]. Outer skin layer (excocarp) namely the layer that in young fruit is green and gradually changes to yellow green, yellow and finally red in ripe coffee fruit. The flesh of the fruit will be slimy when ripe and tastes a bit sweet. The inner skin, namely endocarp, quite hard and this skin is usually called horn skin [1]. There are two main methods for processing coffee beans: the wet method and the dry method. In dry processing, the beans are sun-dried directly. The wet method, on the other hand, involves several processing stages and generates various types of waste that can be used as solid fuel, such as coffee pulp and parchment (endocarp) [1].

The horn skin contains a high level of crude fiber, and its organic compounds have potential applications as compost or fertilizer. The calorific value of coffee parchment is 4600 kcal/kg, while coffee pulp with 5% moisture content has a calorific value of 3300 kcal/kg, making both potential fuel sources [2].

Various studies have explored the utilization of coffee waste, including the conversion of coffee pulp into ethanol fuel [3]. A study on the effect of combustion temperature on the quality of bioenergy derived from coffee waste found that the optimal pyrolysis temperature is 300°C, yielding a calorific value of 7,549 cal/g [4]. While pyrolysis requires significant energy input for thermal decomposition, torrefaction offers a more energy-efficient alternative. Torrefaction is a thermochemical process carried out at a temperature of 200-300°C with airless/low air conditions. The purpose of this process is to enhance the energy content of biomass prior to its densification into briquettes. The pressure of briquette formation greatly affects the results of water content, density and ignition time [5]. Higher compaction pressure reduces moisture content and increases ignition time. The higher the pressure, the greater the energy required and the stronger the pressing tool. Conversely, at lower pressures, the briquettes are more prone to breakage. Particle size also influences briquette strength. Larger mesh sizes tend to produce tougher briquettes due to better particle interlocking and reduced porosity, resulting in slower ignition. Smaller mesh sizes increase briquette porosity, making them more susceptible to moisture absorption, which affects combustion efficiency and storage stability. The purpose of this study was to study the combustion characteristics of briquettes produced from coffee parchment using the torrefaction and briquetting methods

2. Methods

2.1 Raw Material Preparation and Torrefaction

The feedstock was sourced from Coffee Factory located in Blang Rakal Village, Pintu Rime Gayo District, Bener Meriah Regency, Aceh Province. Initially, the feedstock was torrefied (mild pyrolysis) to reduce moisture content and improving the grindability of coffee parchment as well as increasing the caloric value. In addition, the torrefaction process can enhance the hydrophobicity of feedstock material. Torrefaction was performed at 250 °C using a drum-type retort kiln which was capable of processing 3 kg of raw material in two hours, yielding 63% product output [6]. Figure 1 illustrates the experimental steps of this study.

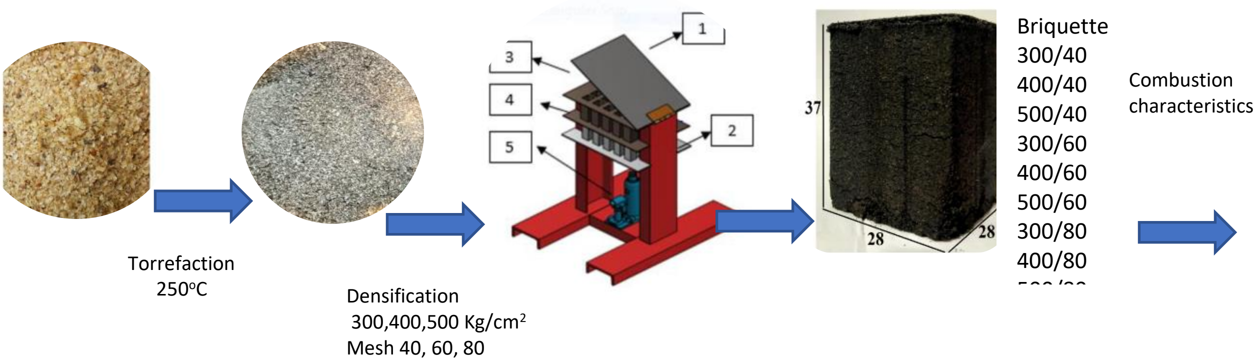


Figure 1 Research process

2.2 Densification

The torrefied material was ground using a grinding machine to obtain particle sizes of 40, 60, and 80 mesh, as these sizes produced well-formed and more cohesive briquettes [7]. Subsequently, the ground material was mixed with 10 wt.% binder. The binder was prepared from tapioca flour and water, mixed at a ratio of 1:25 and cooked for 15 minutes until thickened [8]. Briquettes were formed using a hydraulic jack equipped with a pressure gauge to ensure accurate compaction at 300, 400, and 500 kg/cm². A mold measuring 30×30×90 mm was used, producing rectangular briquettes as illustrated in Figure 2.

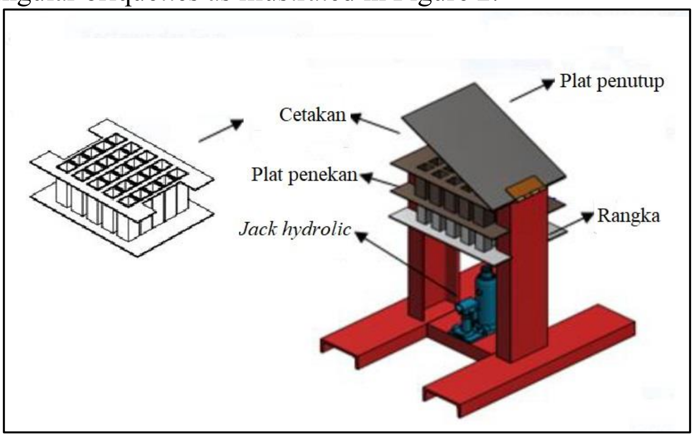


Figure 2 Briquette molding tool

2.3 Product Characterization

Biochar products were characterized by proximate analysis and bomb calorimeter analysis. Analysis of moisture, ash, fly matter, and fixed carbon content, proximate analysis was carried out following ASTM Standard D1762-84. Proximate analysis was initially carried out to determine the moisture content.

Approximately 1.0 g (W1) was weighed in a porcelain crucible and placed in an oven at 105 °C ± 5 °C for 2 h. The crucible containing the dried sample was then transferred to a desiccator and allowed to cool for 1 h, and then the sample was weighed (W2). The moisture content (M) was calculated using Equation 1.

$$\text{Moisture content (M) (\%)} = \frac{W1-W2}{W1} \times 100 \quad (1)$$

After determining the water content, the dry samples in the melting crucible were analyzed for volatile matter (VM) content by weighing 1–2 g of sample into the melting crucible (W1) and then was placed in a furnace at a temperature of 950 °C. Once the temperature was reached, the melting crucible was transferred to a desiccator for one hour, allowed to cool, and then weighed (W2). Volatile matter (VM) was calculated using Equation 2.

$$\text{Volatile Matter (VM) (\%)} = \frac{W1-W2}{W1} \times 100 \quad (2)$$

To determine the ash content, the sample was weighed as much as 2–3 g and placed in a crucible (W1) then placed in a furnace at a temperature of 750 °C for 6 hours. After all the samples became ash, the crucible was removed, placed in a desiccator, cooled, then weighed (W2). The ash content was calculated using Equation 3.

$$\text{ASH (\%)} = \frac{W1}{W2} \times 100 \quad (3)$$

Fixed carbon content was calculated by difference, as shown in Equation 4

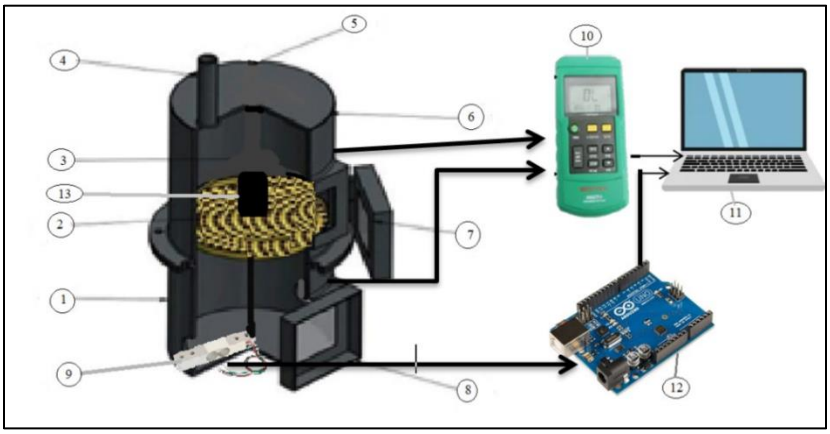
$$\text{Fixed carbon (FC) (\%)} = 100\text{-M-VM-ASH} \quad (4)$$

The calorific value of the samples was quantified using a bomb calorimeter (Koehler K88990 Bomb-type Calorimeter). The samples were placed in an alumina crucible with a capacity of about 10 mg and then heated from ambient temperature to 1000 °C. Density measurement (ρ) was carried-out by dividing the mass (m) by the volume of the briquette (v). Based on ASTM B-311-93, the density value can be obtained using the formula below [9]:

$$\rho = \frac{m}{v} \quad (5)$$

2.4 Combustion test

The combustion test consisted of several steps, including preparation of the test equipment, sensor calibration, and data acquisition setup using a computer, as illustrated in Figure 3. The briquette was weighed before being placed into the combustion chamber. After the setup was completed, the system was activated, and the briquette was ignited using a gas torch. Once ignition occurred, the torch was turned off, and combustion was sustained by air supplied from a blower. All data were recorded and automatically saved to the computer from the moment of ignition until the briquette was fully burned. The collected data were then analyzed to determine ignition time, flame duration, and combustion rate.



Information:
1. Bottom tube
2. Fuel
3. Combustion chamber
4. Tray
5. Chimney
6. Top tube
7. Top tube door
8. Bottom tube door
9. Load cell
10. Thermometer
11. Computer
12. Arduino
13. Test Specimen

Figure 3 Combustion Testing Tool Design

The schematic diagram of the combustion characteristic testing setup is shown in Figure 3. This testing apparatus is designed to evaluate combustion characteristics, including combustion rate, ignition time, combustion temperature, and adjustable airflow settings. It is equipped with a load cell to measure the weight of the test specimen, allowing for accurate calculation of the combustion rate. A thermometer is also integrated to monitor combustion temperature. Data acquisition and processing are handled by an Arduino system connected to a computer.

3. Results And Discussion

3.1 Torrefaction Experiment Results

The torrefaction process was conducted at temperatures below 280°C to prevent combustion of the coffee parchment. At higher temperatures, the carbon content tends to burn and turn into ash, which would result in the failure of the torrefaction process. the maximum temperature of burning coffee parchment is up to 1624°C [10]. A total of 3 kg of coffee parchment was torrefied over a period of 2 hours, yielding a product recovery rate of 63%. During the torrefaction process, the temperature was maintained below 280°C to prevent combustion within the drum retort kiln. Airflow was minimized by sealing all drum openings, while temperature monitoring was conducted using a Mastech thermometer connected to a computer for continuous data logging. Used oil served as the fuel source, with approximately 5 liters consumed to maintain heating for

128 minutes. In addition to improving the physical properties of the biomass, the torrefaction process also contributed to the reduction of harmful emissions, notably hydrocarbons (HC) and carbon monoxide (CO)—toxic compounds with a high affinity for binding to human blood [11].

3.2 Briquette Products

Briquettes were produced using torrefied coffee parchment that had been ground to mesh sizes of 40, 60, and 80. A 10% tapioca flour adhesive was used, prepared by cooking a mixture of tapioca flour and water in a 1:25 ratio. Proximate analysis of the tapioca flour revealed a moisture content of 9.84%, ash 0.36%, fat 1.5%, protein 2.21%, fiber 0.69%, and carbon content of 85.2%. The relatively high-water content in the adhesive mixture contributed to the overall moisture level of the briquettes [8]. Briquettes were formed using a hydraulic press at compaction pressures of 300, 400, and 500 kg/cm², then dried under direct sunlight for three days at an average ambient temperature of 38°C. The results of the briquette production are presented in Table 1.

Table 1 Weight and size of coffee parchment briquettes after drying

No	Briquette Code	Long (mm)	Wide (mm)	Massa (gram)
1	T500/80	37.58	28.54	19
2	T400/80	40.04	28.15	20
3	T300/80	43.15	28.00	20
4	T500/60	41.64	28.65	19
5	T400/60	43.18	28.15	20
6	T300/60	45.21	28.15	20
7	T500/40	43.78	28.73	19
8	T400/40	44.30	28.45	19
9	T300/40	45.43	29.22	19

The results in Table 1 include a briquette code that indicates the pressing pressure and particle size. The letter "T" refers to the pressing pressure, followed by a number representing the pressure value (in kg/cm²), and the number after the slash denotes the mesh size of the raw material. In the "length" column, significant variations can be observed. As the pressing pressure increases, the resulting briquette becomes shorter. The briquette shape also varies depending on the particle size. Briquettes made with 80-mesh size appear more uniform and compact, while those made with 40-mesh particle size have a rougher texture (Figure 4). The width of the briquettes remains relatively constant due to the fixed mold width. The weight of each briquette is nearly identical, as 25 grams of material were used per mold. The results of the pressing process are shown in Table 4.1, which presents the briquette weights. The observed weight reduction is attributed to moisture loss during compaction, as water is expelled from the raw material under pressure.

Visually, the best-quality briquettes in this study were those made with 80-mesh particles. These briquettes appeared neat, uniform, and structurally durable. Briquettes made with 60-mesh particles were slightly rougher and exhibited noticeable porosity. In contrast, briquettes produced with 40-mesh particles were the roughest, with larger pores and a higher tendency to break or crumble, especially when not fully dried. The visual differences in briquette appearance based on particle size are shown in Figure 4.

Figure 4. The images of briquette with particle size of (a) 80-mesh; (b) 60-mesh. c. 40-mesh

3.3 Physical Properties

Physical property testing is a crucial aspect of fuel research, as it provides data on moisture content, volatile matter, fixed carbon, and ash content. The test results are presented in Table 2. Among these properties, moisture content plays a significant role in influencing the combustion behavior of briquettes, particularly their ignition rate and flammability. Higher moisture content requires more heat to evaporate the water before combustion can proceed, resulting in slower ignition and reduced flammability. Consequently, moisture content is commonly used as an indicator for predicting combustion performance. The corresponding moisture content values are illustrated in Figure 5.

Table 2 Physical Test Results of Coffee Parchment Briquettes

Briquette code	Water content	Volatile matter	Fixed carbon	Ash
T500/80	8.25	60.0	28.65	3.1
T400/80	9.84	64.76	21.55	3.8
T300/80	11.05	67.15	15.04	6.76
T500/60	8.95	61.64	26.21	3.2
T400/60	9.94	65.52	19.75	4.79
T300/60	12.3	67.82	12.44	7.44
T500/40	9.24	64.04	23.41	3.31
T400/40	10.44	66.68	16.97	5.91
T300/40	13.63	69.63	8.19	8.55

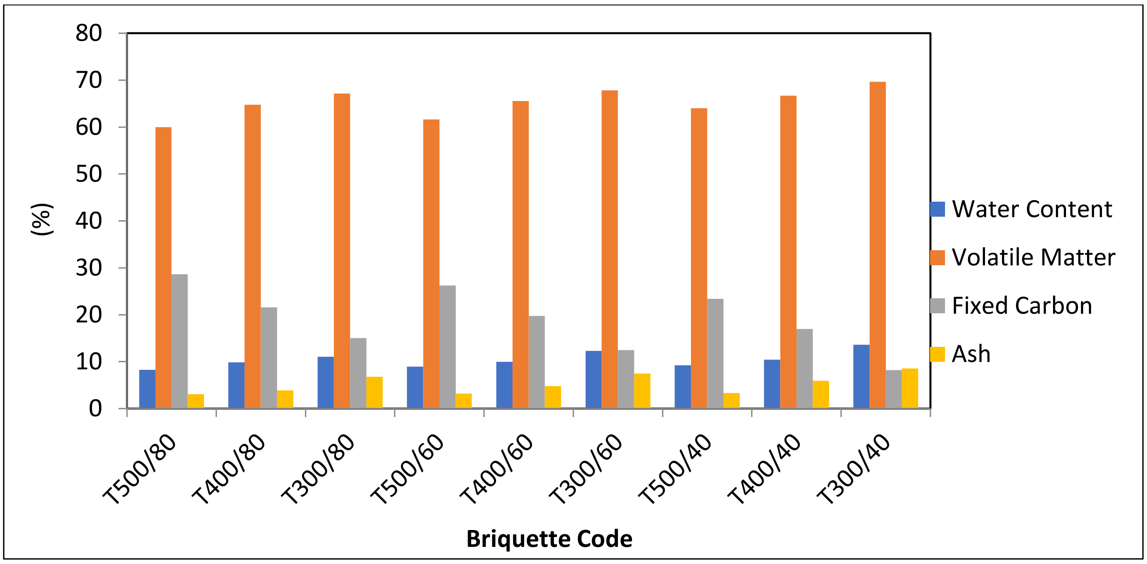


Figure 5 Proximate analysis results of briquettes

The graph summarizes the physical properties of the briquettes, including moisture content, volatile matter, fixed carbon, and ash. The highest water content is found in T300/40 briquettes with a value of 13.63% and the lowest value is 8.25% in T500/80 briquettes. In this study, a low moisture content preferably below 8% in accordance with Indonesian briquette standards was targeted for optimal performance [12]. The moisture content was influenced by the adhesive composition; higher adhesive ratios tended to increase the water content. Moisture levels were also higher in briquettes with a 40-mesh particle size. This was attributed to the larger pore structure, which allowed greater vapor retention during torrefaction.

Volatile substances are materials that evaporate easily. In biomass, volatile materials are methane, hydrocarbons, hydrogen, carbon monoxide and non-flammable gases such as carbon dioxide and nitrogen [14]. Volatile content reflects the extent of mass loss. Briquettes with high volatile content tend to produce more smoke; thus, lower concentrations are associated with higher quality [15]. The volatile matter content in raw coffee parchment was 72%, which decreased following the torrefaction process [16]. In this study, the highest volatile content was found in the T400/40 briquette (69.63%), which potentially leads to greater smoke emission during combustion, the lowest volatile substance value was found in the T500/60 briquette with a value of 61.64%.

Low ash content is also desirable, as excessive ash can hinder heat transfer and potentially damage chimneys and stoves due to dust accumulation. Among the samples, T500/80 exhibited the lowest ash content (3.10%), while T300/40 had the highest (8.55%). The ash content can also increase because the tapioca flour adhesive contains inorganic materials [17]. One of the elements that make up ash is silica. Monitoring ash content is crucial, as it directly influences the calorific value [13]. Carbon content is generally inversely proportional to moisture, volatile matter, and ash content levels. The greater the water content, volatile content and ash content, the lower the carbon content. T500/80 briquettes exhibited the highest fixed carbon content (28.65%), while T300/40 showed the lowest (8.19%). This result is attributed to the elevated levels of volatiles, moisture, and ash in T300/40 briquettes, which reduce the amount of combustible material.

Based on the physical testing results, T500/80 briquettes were deemed most suitable for room heating, with low moisture (8.25%), moderate volatile content (60%), and minimal ash (3.10%). These characteristics contribute to efficient combustion with minimal residue. Kpalo et al. reported that the ash content of briquettes affects the combustion rate because the ash content low ash content can prevent the formation of slagging, and also allows air to enter the furnace, thereby accelerating the combustion rate [18].

3.4 Thermal Testing

Thermal testing was conducted to evaluate the quality of the briquettes based on their calorific value, ignition time, and flame duration. A higher calorific value indicates greater heat output, which reflects better fuel performance. Similarly, a longer flame duration suggests improved combustion efficiency and overall fuel quality. However, these characteristics are generally inversely related to ignition time of briquettes that burn longer often require more time to ignite. The calorific value of the briquettes was determined using a bomb calorimeter, and the results are presented in Figure 6.

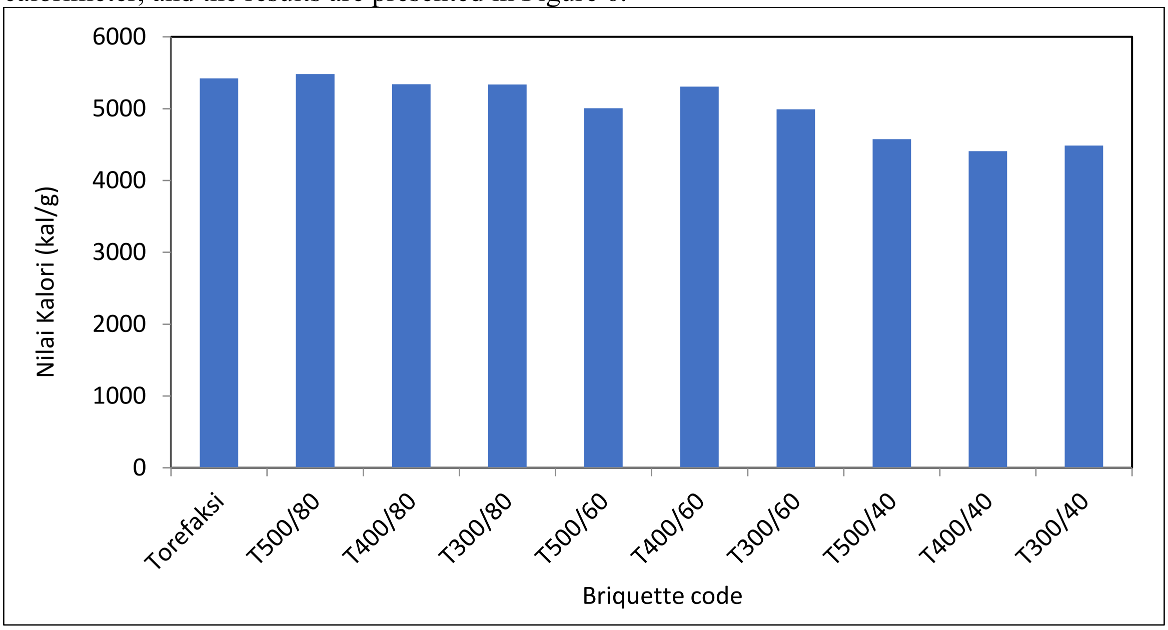


Figure 6 Calorie value graph

The graph shows that briquettes produced with 40-mesh particles exhibited the lowest calorific values, with only slight variations across different compaction pressures. The highest calorific value was observed in the T500/80 briquette, reaching 5,482.71 cal/g, which closely approximates the calorific value of the raw torrefied material. The calorific value of briquettes is influenced by the size of charcoal particles, density and charcoal raw materials [13]. Larger mesh sizes tend to yield higher calorific values. In this study, all 80-mesh briquettes exceeded 5,000 cal/g, meeting the Indonesian charcoal briquette standard [12]. Among the 60-mesh samples, the T300/60 briquette did not meet the standard, with a calorific value of 4,992.36 cal/g. All 40-mesh briquettes fell below the Indonesian briquette standard threshold. Silica, a key element affecting combustion performance, negatively impacts calorific value and overall briquette quality [19].

Ignition Time and Duration of Burning

In this study, ignition time was defined as the duration required for the briquettes to ignite and maintain a stable glowing combustion. For practical applications, it is desirable for briquettes to ignite easily and reach stable combustion quickly. During the experiment, ignition was performed using a gas torch without the aid of any auxiliary fuels. The ignition process is illustrated in Figure 7.

Figure 7 Briquettes after ignition using gas torch

After initial ignition, the briquettes were left to combust naturally, supported by airflow from a blower operating at 12.3 m/s. The combustion process continued until the briquettes were fully converted to ash. Throughout the process, temperature and weight loss were continuously monitored. The results of the study can be seen in Figure 8.

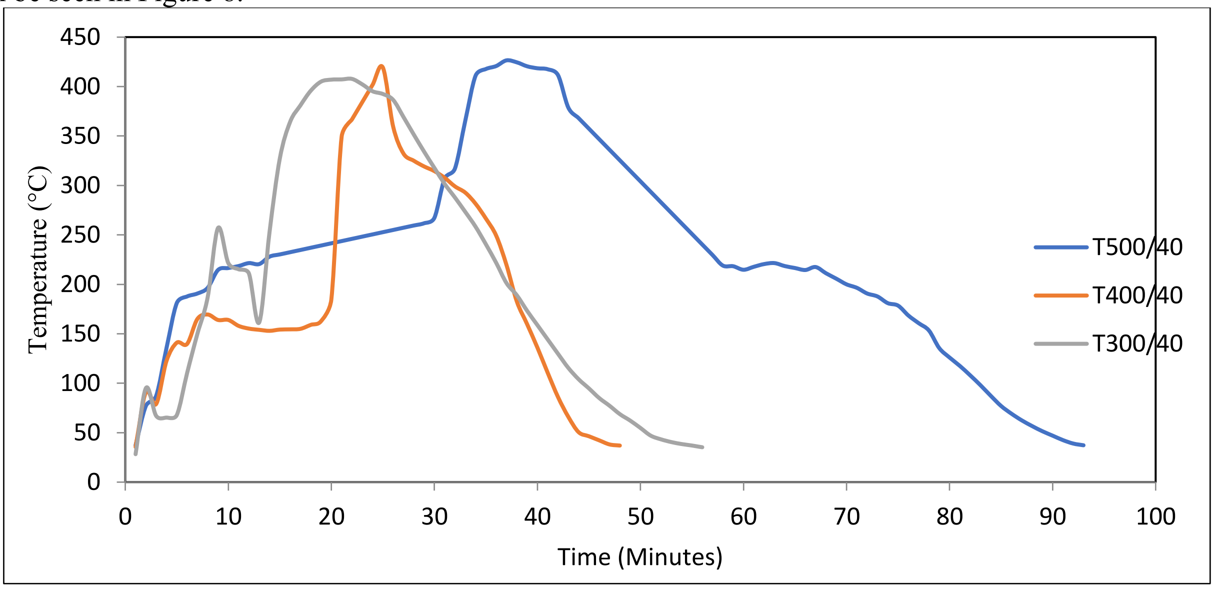


Figure 8 Combustion temperature versus time of briquette of 40-mesh particle

As shown in Figure 8, the combustion temperature initially dropped once the gas torch was turned off. At that point, the briquettes glowed red and were ready to sustain combustion with airflow assistance from the 12.3 m/s blower. Among all samples, the T300/40 briquette had the longest ignition time, requiring about 4 minutes. The flame extinguished quickly once the torch was removed, indicating poor ignition performance. In contrast, the T500/40 briquette ignited within approximately 2 minutes. The ignition time is also influenced by the density of the briquette. Less dense briquettes tended to ignite faster but also burned out more quickly due to their porous structure. Briquettes with T500/40 pressure have a higher temperature of 426°C and a burning time of up to 93 minutes. The particles that make up the briquette also affect the density of the briquette. The results of testing briquettes with mesh 60 can be seen in Figure 9.

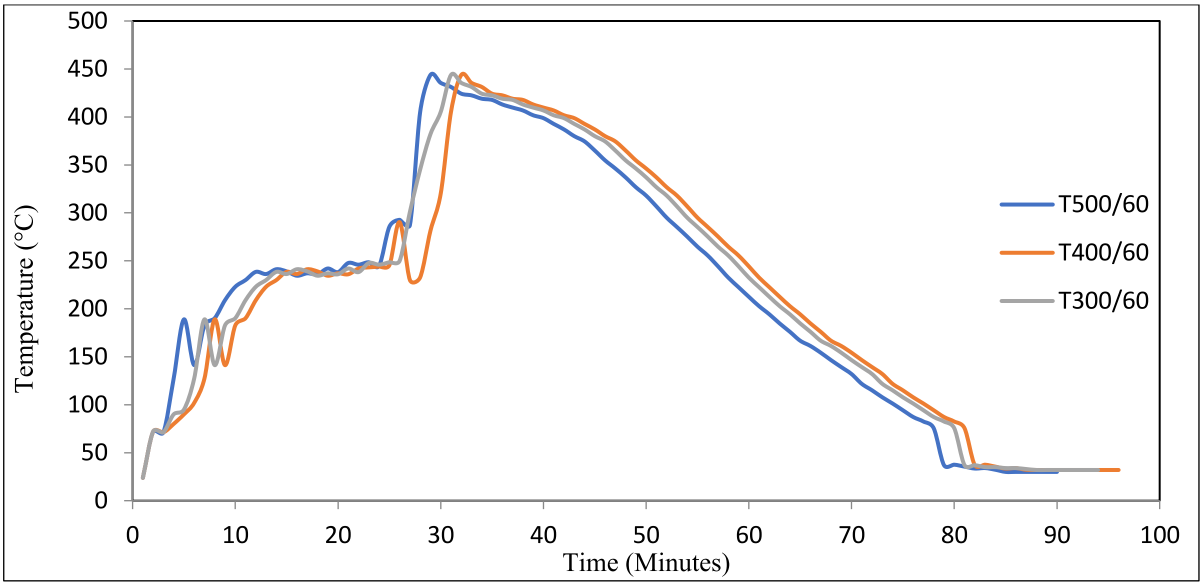


Figure 9 Combustion temperature versus time of briquette of 60-mesh particle

As shown in Figure 9, combustion profiles for mesh 60 briquettes exhibited consistent ignition times of approximately 2 minutes across all pressure levels, with total burn durations reaching up to 96 minutes. Briquettes made with 60-mesh particles reached peak temperatures of 443°C faster than those with 40-mesh, and exhibited longer combustion durations—particularly the T400/60 sample. Among the 80-mesh samples, the T400/80 briquette ignited the fastest, achieving ignition in 3 minutes at 155°C. It reached a peak combustion temperature of 418°C as show in figure 10.

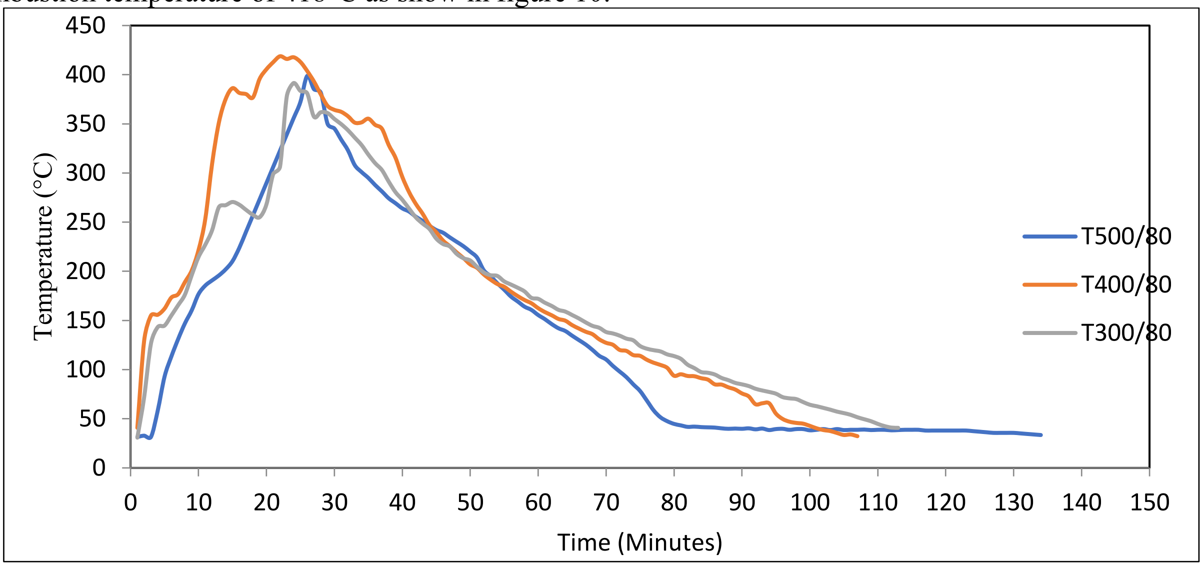


Figure 10 Combustion temperature versus time of briquette of 80-mesh particle

T500/80 had the longest ignition time—6 minutes at 113.25°C—likely due to its high compression pressure and fine particle size, which reduced its porosity and hindered combustion [20]. T300/80 briquettes exhibited the longest burn duration, sustaining combustion for 112 minutes, with a final temperature of 40.75°C. Conversely, T400/40 had the shortest burn duration of 48 minutes, ending at 36.98°C. Based on the data in Figures 7 through 9, T400/60 briquettes demonstrated the best overall performance, with rapid ignition (2 minutes), a peak temperature of 435.5°C, and a total burn duration of 96 minutes.

Burning Rate

The burning rate is the speed of the briquette mass (grams) that burns per unit of time (minutes) [13]. Density is a physical property which is the ratio between the mass of the briquette and its volume. Briquette density is influenced by the particle size and uniformity of the constituent charcoal. Higher-density briquettes tend to exhibit slower burning rates, as combustion progresses more gradually due to reduced porosity [19]. Combustion rate test results are presented in Figure 11.

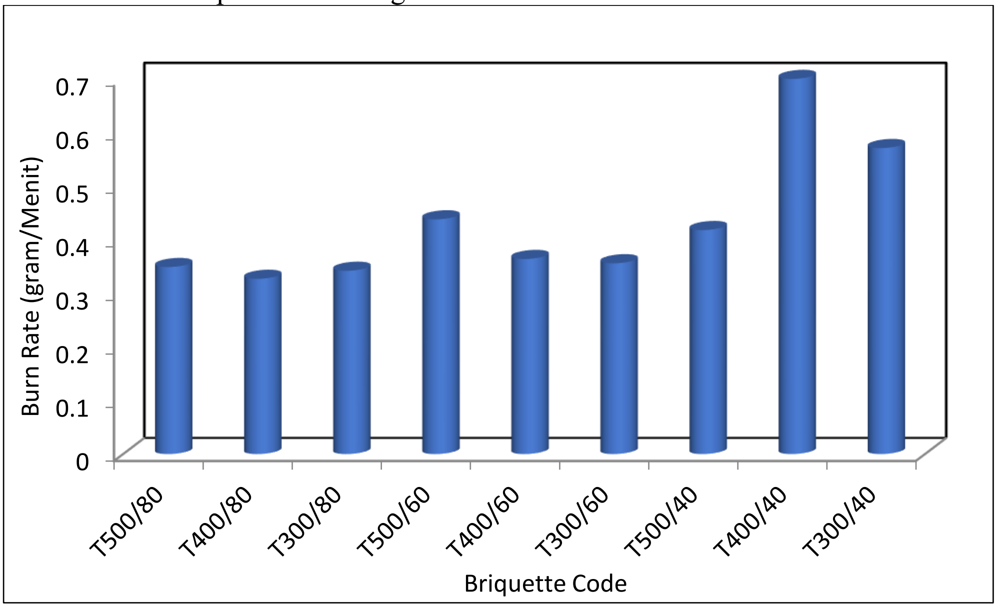


Figure 11 Burn rate graph

According to the graph, T400/40 briquettes exhibited the highest burning rate (0.7 g/min), indicating the fastest consumption among all samples. T400/80 had the lowest burning rate, measured at 0.327 g/min. Briquettes with a 40-mesh particle size burned faster than those with 60 or 80 mesh, likely due to their lower density and higher porosity. Physical property testing revealed that finer particle sizes 80 mesh generally led to higher flame temperatures and longer combustion durations, although ignition behavior varied depending on density and pressure. Additionally, increased compaction pressure tended to enhance flame temperature and prolong both ignition and burn durations [21].

3.5 Mechanical Properties

Mechanical testing was conducted to evaluate density, drop resistance, compressive strength, and porosity, key indicators for assessing briquette quality prior to commercialization. Density testing was performed to determine the mass-to-volume ratio of the briquettes. The drop test was used to assess the briquettes' ability to withstand impact from a height of 1.8 meters. Compressive strength was measured to evaluate the briquettes' resistance under stacking pressure. Porosity testing was conducted to determine the briquettes' capacity to absorb moisture.

Density

Density is the ratio between weight and volume of briquettes. Density has a big influence on how long the briquettes burn. The size of the density is influenced by the size and homogeneity of the briquette constituents. Smaller particle sizes can expand the bond area between powders, thereby increasing the density of the briquettes. To calculate the mass density of briquettes, you can use equation (5) and obtain the results that can be seen in Figure 12 below:

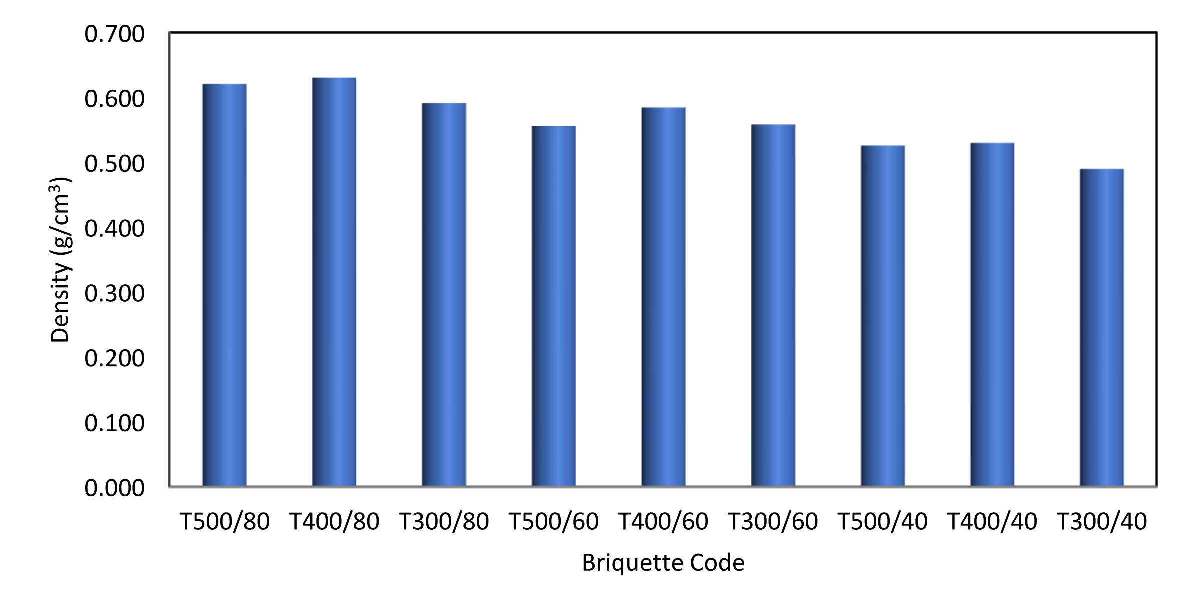


Figure 12 The density of resulting briquettes

Density tests revealed that the T300/40 briquette had the lowest value at 0.490 g/cm³, while T400/80 showed the highest density at 0.630 g/cm, the results showed a direct correlation between increased mesh size and higher briquette density. In general, the finer the particles sizes 80 mesh, the greater the resulting briquette density [22]. According to Masturin, a finer particle size can enlarge the bonding area between powders, thereby increasing the density of the briquettes. The density value affects the compressive strength and combustion rate. As stated by Iskandinata et al. [17], higher density improves compressive strength but may hinder ignition due to reduced air cavities. Conversely, low-density briquettes are more combustible due to larger air gaps, which facilitate oxygen flow during combustion. Briquettes with low density will run out faster because there are too many air cavities [23].

Drop test

The drop test assesses friability by measuring the percentage of material lost after dropping briquettes from a height of 1.8 meters. According to briquette quality standards, friability should not exceed 1%; higher values indicate insufficient mechanical durability. The results of the Coffee Parchment briquette test can be seen in Table 13 below:

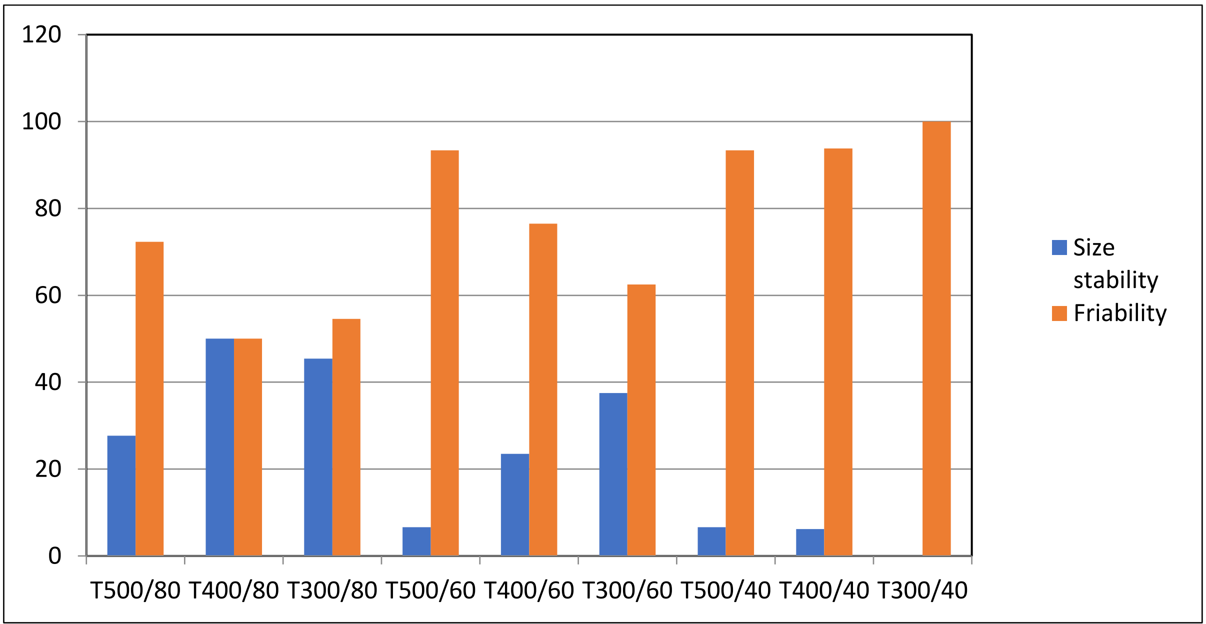


Figure 13 Drop test results

According to the drop test results, none of the briquettes met the ASTM standard for mechanical durability, T400/80 briquettes exhibited the best performance among samples, retaining 50% of their original form. In contrast, T300/40 briquettes completely disintegrated, with 100% friability indicating poor impact resistance.

The results of the mechanical testing of the best briquettes are those with high pressure and mesh size. The best briquettes in the mechanical testing are T400/80 briquettes with a size stability value of 50% and a density value of 0.630 g/cm3.

4. Conclusion

Study examined the effects of briquetting pressure and particle size on the combustion behavior of coffee parchment briquettes. Higher compaction pressure improved density, reduced moisture content, and extended burning time, but made ignition more difficult. Finer particles (mesh 80) increased calorific value but reduced porosity and ease of ignition, while coarser particles (mesh 40) ignited more easily but had lower structural quality. The optimal briquette was produced at 400 kg/cm² with 60-mesh particles (T400/60), meeting Indonesian briquette standards with 21.55% carbon, 3.85% ash, a 2-minute ignition time, and a 96-minute burn duration. As recommendation, T400/60 briquettes are best suited for applications requiring high combustion efficiency. For uses prioritizing easy ignition, lower pressure (300 kg/cm²) and coarser mesh (40) are more appropriate, despite shorter burn times.

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