



## ANALYSIS OF BINDER MATERIAL AND CONCENTRATION ON THE COMBUSTION RATE OF ORGANIC WASTE BRIQUETTES IN BLITAR

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### ABSTRACT

Global energy crisis and the increasing amount of organic waste require innovative and environmentally friendly waste management solutions that can also provide alternative energy sources simultaneously. This study aims to analyze the effect of the type and concentration of binder on the burning rate of organic waste briquettes produced by the Blitar City Environmental Agency. The raw material used is dry leaves mixed with organic binders, namely dextrin and tapioca, with concentrations of 10%, 20%, and 30% respectively. The briquette production process includes drying, grinding, mixing with the binder, pressing, and testing through density measurement and burning rate analysis. The study results show that the type and concentration of the binder significantly affect the performance of the briquettes. An increase in tapioca binder concentration leads to a gradual increase in the burning rate, indicating its role as a combustible component. In contrast, higher dextrin concentration reduces the burning rate but extends the burning duration, with the lowest burning rate observed in sample A3. The optimal variation was achieved using tapioca binder at a concentration of 20% (sample B2), which produced a stable burning rate. These findings contribute to the development of more efficient biomass briquette technology by providing guidance on selecting the appropriate type and proportion of binder to enhance fuel performance.

**Keywords**—*Binder Concentration, Binder Type, Briquettes, Combustion Rate, Organic Waste.*

## I. INTRODUCTION

Waste management is a crucial environmental challenge in many Indonesian cities, including Blitar. The Dinas Lingkungan Hidup Kota Blitar reported that in 2023, household waste generation reached 70 tons per day (Alivia, 2023). This waste consists of both organic and inorganic materials. Poorly managed waste can cause water, soil, and air pollution. Innovative, effective, and sustainable solutions are needed for integrated waste reduction and handling.

Most of the waste in Blitar is dominated by organic matter, such as food scraps, leaves, and tree branches (IKPLHD, 2018). Thus far, the Dinas Lingkungan Hidup Kota Blitar has utilized organic waste primarily by processing it into compost or organic fertilizer. This program has contributed to reducing waste accumulation at the Landfill and producing value-added products for agriculture and landscaping. However, converting organic waste into fertilizer faces several obstacles, including: (1) the composting process requires a relatively long time, (2) it requires a significant land area, (3) the resulting fertilizer has a relatively low economic value, and (4) marketing is often limited to a local scale (Mawartiningsih et al., 2021).

Organic waste can be turned into briquettes, which offer greater economic and strategic value. Briquettes are solid fuels made from compressed biomass (Suhartoyo & Sriyanto, 2019). They have several advantages: competitive heating value, dense, uniform shape for easy storage, a faster pyrolysis or carbonization process than composting, and a broader market potential for households and small industries (Ramdhani, 2025).

In briquette production, the type and concentration of binder play a vital role. The adhesive functions to bind bio-char particles so they become dense, strong, and durable (Safitri, 2021). The type of binder (e.g., starch, tapioca, or clay) affects the physical, mechanical, and

thermal properties of the briquette (Borowski et al., 2017). Meanwhile, the concentration of the binder determines the optimal bond formed between particles (Rosadi et al., 2025). These two factors directly influence the combustion rate, which is a key performance parameter for users. A combustion rate that is too fast causes the briquette to be consumed quickly, while a rate that is too slow can reduce the efficiency of the heat generated (Suryaningsih & Pahleva, 2021). Therefore, finding the optimal formulation of binder type and concentration is essential to produce briquettes with ideal combustion characteristics.

The equations used to determine the combustion rate are as follows:

$$\text{Mass of burned briquette} = \text{initial briquette mass} - \text{residual briquette mass} \text{ (grams)} \dots (1)$$

$$\text{Combustion Rate} = \frac{\text{Mass of burned of briquette}}{\text{Combustion time}} = \frac{m}{t} \text{ (g/min)} \dots (2)$$

(Bello et al., 2023)

According to a study by (Harahap et al., 2024), in their study titled *The Influence of Raw Material Ratios and Binder Types on Charcoal Briquette Characteristics*, stated that variations in the ratio of sugarcane bagasse to wood sawdust, along with variations in binder types (molasses and tapioca flour), significantly influence the characteristics of the resulting charcoal briquettes, including moisture content, ash content, volatile matter, and calorific value. The study indicates that the optimum conditions were achieved using a 5% tapioca flour concentration with a sugarcane bagasse to wood sawdust ratio of 20:80. This composition produced briquettes with a moisture content of 3.4215%, ash content of 4.6505%, volatile matter of 9.7493%, and a calorific value of 5721.79 cal/g, all of which satisfy the SNI 01-6235-2000 standards for bio-charcoal briquettes.

Based on the background above, this study aims to analyze the performance differences of briquettes made from organic waste processed

at the aforementioned institution with variations in binder types and concentrations, specifically regarding their combustion rate and density. The results of this study are expected to provide technical recommendations for the Dinas Lingkungan Hidup Kota Blitar in developing efficient and economically valuable bio-char briquette technology as a complementary alternative to existing composting programs.

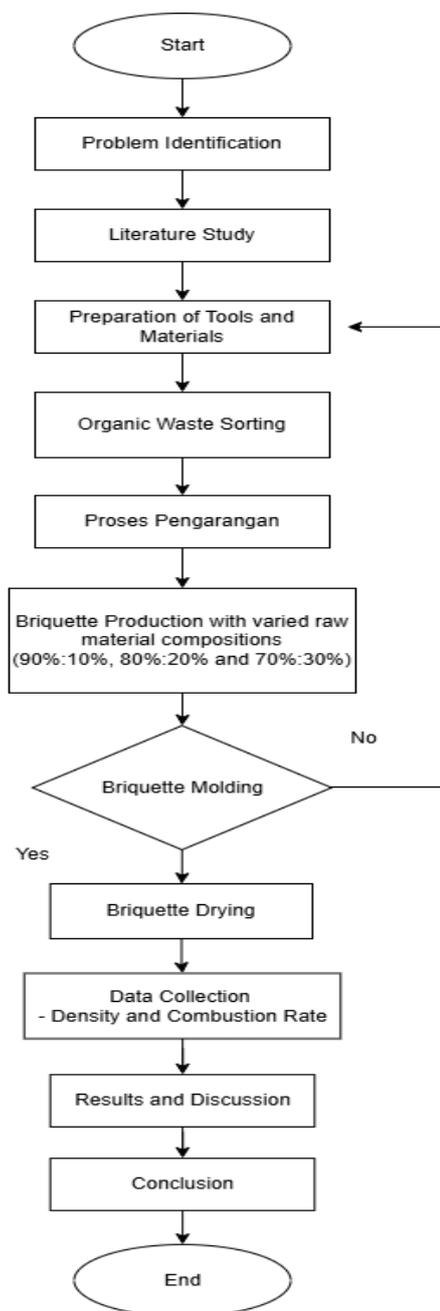
## II. METHOD

The method used in this research is an experimental method, testing the density and combustion rate of each briquette variation. The briquettes are 5x5 cm in size. The carbonization process is conducted through heating in an airtight chamber (oxygen-free environment). The material is then crushed and sieved. The equipment used in the production of these briquettes included a combustion furnace, a mortar and pestle, baking trays, a briquette mold, a mixing container, and digital scales. Meanwhile, the required materials consisted of organic waste, tapioca flour, dextrin, and water.

The binders used are starch and dextrin, and the briquettes were produced with several composition variations between charcoal and binder, as shown in the experimental design table (A1, A2, A3, etc.) are as follows:

**Table 1.** Briquette Variations

Binder Type	Sample	Blend Composition	
		Bio-char	Binder
Dextrin Binder	A1	90%	10%
		(45 g)	(5 g)
		80%	20%
Tapioca Binder	A2	(40 g)	(10 g)
		70%	30%
		(35 g)	(15 g)
Tapioca Binder	B1	90%	10%
		(45 g)	(5 g)
		80%	20%
Tapioca Binder	B2	(40 g)	(10 g)
		70%	30%
		(35 g)	(15 g)



**Figure 1** Flowchart of Briquette Production

Each briquette variation was produced and tested in triplicate (three replications) to improve data reliability. Density was determined by measuring the mass and volume of each briquette specimen. The combustion rate test was conducted by igniting the briquette and recording the mass reduction over time until the briquette was completely burned. The combustion rate was calculated using the ratio of mass loss to combustion time (g/min). Temperature and airflow conditions during combustion testing were kept as consistent as possible to reduce external variability.

### III. RESULT AND DISCUSSION

This test was conducted to determine the combustion rate of briquettes made from organic waste by examining the influence of binder types and concentrations. The data

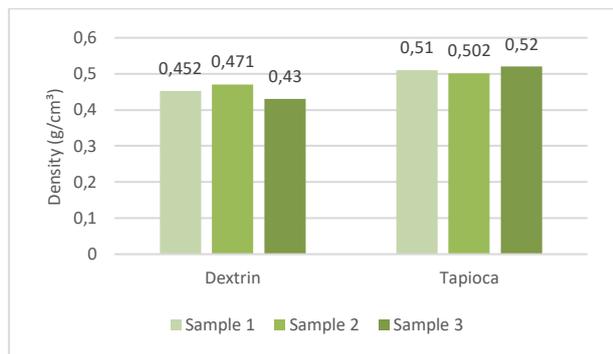
presented include the briquette density values and combustion rates obtained from the testing. The discussion will analyze how variations in the concentrations of both dextrin and tapioca binder affect the combustion rate parameters of the briquettes.

**Table 2.** Density Data of Briquettes using Dextrin Binder

Sample	Briquette Mass (g)	Volume (cm <sup>3</sup> )	Density (g/cm <sup>3</sup> )
A1	41,2	91,125	0,452
A2	42,9	91,125	0,471
A3	39,2	91,125	0,43

**Table 3.** Density Data of Briquettes using Tapioca Binder

Sample	Briquette Mass (g)	Volume (cm <sup>3</sup> )	Density (g/cm <sup>3</sup> )
B1	46,5	91,125	0,51
B2	45,7	91,125	0,502
B3	47,4	91,125	0,52



**Figure 2.** Effect of Tapioca Starch and Dextrin Binders on Briquette Density

Briquettes using dextrin binder showed density values ranging from 0.43 to 0.471 g/cm<sup>3</sup>. Among these samples, A2 (80% charcoal : 20% dextrin) produced the highest density, while A3 (70% charcoal : 30% dextrin) showed the lowest density. This indicates that increasing the binder proportion beyond a certain level did not necessarily improve compactness, and excessive dextrin may have reduced the structural solidity of the briquettes.

In contrast, briquettes made with tapioca starch binder exhibited higher overall density values, ranging from 0.502 to 0.52 g/cm<sup>3</sup>. Sample B3 showed the highest density,

indicating that tapioca starch provided better particle bonding and compaction compared to dextrin. The more uniform and higher density values also suggest that tapioca created a stronger internal structure within the briquettes.

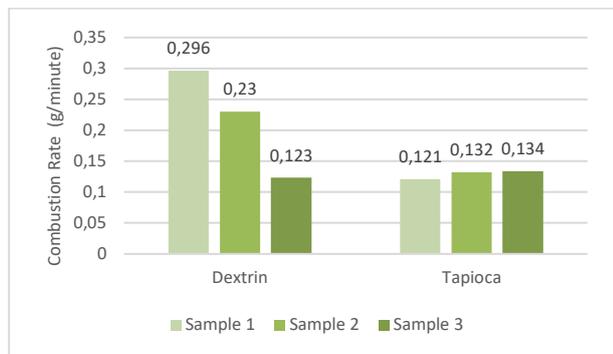
Comparatively, tapioca binder produced denser briquettes than dextrin binder for all composition variations. Higher density generally indicates better mechanical strength, longer burning duration, and slower combustion rate (Bartlett et al., 2019). Therefore, based on density characteristics alone, tapioca starch is more effective as a binder in the production of organic waste briquettes in this study.

**Table 4.** Combustion Rate Data of Briquettes with Dextrin Binder

Sample	Initial Mass (g)	Final Mass (g)	Burning Time (menit)	Combustion Rate (g/menit)
A1	41,2	12,1	98	0,296
A2	42,9	12	134	0,230
A3	39,2	13,2	235	0,123

**Table 5.** Combustion Rate Data of Briquettes with Tapioca Binder

Sample	Initial Mass (g)	Final Mass (g)	Burning Time (menit)	Combustion Rate (g/menit)
B1	46,5	24,2	184	0,121
B2	45,7	18,7	203	0,132
B3	47,4	17,2	224	0,134



**Figure 3.** Effect of Tapioca Starch and Dextrin Binders on the Combustion Rate of Briquettes

Regarding combustion performance, briquettes with dextrin binder burned faster, with combustion rates ranging from 0.143 to 0.296 g/min, while tapioca-bound briquettes exhibited slower combustion rates of 0.121 to 0.134 g/min. The slower burning rate of tapioca briquettes is consistent with their higher density, which limited oxygen diffusion and prolonged burning duration. Among all samples, A1 (dextrin) showed the fastest combustion, whereas B1–B3 (tapioca) demonstrated more stable and longer-lasting burning behavior. The slower burning rate of tapioca briquettes is consistent with their higher density, which restricts oxygen diffusion into the briquette pores and slows down the oxidation of fixed carbon. Conversely, the lower density of dextrin briquettes increases porosity, allowing more air penetration and accelerating the combustion process.

When compared to previous studies, these results show a similar trend but with a higher density range. According to a study by (Dalimuthe et al., 2023) on briquettes made from a mixture of groundnut shells and coconut shells with fixed starch adhesive, the resulting briquette densities ranged from 0.170–0.292 g/cm<sup>3</sup>. This value is lower than the density

achieved in this study, which reached above 0.5 g/cm<sup>3</sup> in the tapioca variations. This discrepancy may be attributed to differences in biomass type, and the binder composition used. This indicates that the combination of raw materials and binder types in this research produces a more compact briquette structure. A study conducted by (Carnaje et al., 2018) states that density influences combustion efficiency and the durability of briquettes.

The findings of this study are also consistent with the findings of (Alfian et al., 2025) briquettes using tapioca binder produced denser and more durable briquettes with slower combustion rates, making them more suitable for applications requiring longer burning time. Meanwhile, dextrin binder resulted in briquettes that ignited and burned more quickly, which may be advantageous for applications requiring rapid heat release.

Therefore, the selection of binder should be adjusted according to the intended briquette application: tapioca for longer, steadier combustion, and dextrin for faster burning performance.

#### IV. CONCLUSION

The combustion rate of briquettes with dextrin binder is higher than those with tapioca flour binder at compositions of 90% and 80%. For tapioca binder, a higher adhesive concentration leads to a higher combustion rate. Conversely, for dextrin, a higher adhesive concentration results in a lower combustion rate. The mixture composition of organic waste powder and adhesive that produced briquettes with optimal characteristics is sample B2, consisting of 80% organic waste and 20% tapioca binder.

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