

## The Effect of Adhesive Ratio on the Quality of Charcoal Briquettes

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### ABSTRACT

This study used cassava stem charcoal and charcoal from forest fires mixed with tapioca adhesive at different ratios, the aim was to analyze the effect of different adhesive ratios on the quality of charcoal briquettes. Charcoal briquettes are formed using a 40 bar press machine with a pressing time of 10 minutes. The mixture of charcoal briquette raw materials uses a tapioca adhesive ratio of 2%, 4%, 6%, 8% and 10%. Testing is carried out to determine the quality, then analyzed and compared with the SNI 01-6235-2000 standard. The effect of adhesive ratio on adhesive quality was analyzed using a Completely Randomized Design (CRD). The test results show the following values: density 0.54 g/cm<sup>3</sup>, moisture content 4.97%, compressive strength 28.43 kg/cm<sup>2</sup>, volatile matter content 36.02%, ash content 6.36%, fixed carbon content 56.45% and calorific value 6,195 cal/g obtained from a 10% adhesive ratio. The adhesive ratio has a very significant effect on the water content, compressive strength and calorific value; has a significant effect on the density value; and has no significant effect on the volatile matter value, ash content and bound carbon content. The results of charcoal briquette testing mostly meet the standards according to SNI (No. 01-6235-2000)

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## INTRODUCTION

The utilization of biomass energy derived from forestry, agriculture and plantation waste products that have been widely used is the use of firewood and charcoal (Patabang, D. 2012). More serious efforts are needed to increase the benefits of this waste, namely by making charcoal briquettes.

Research on charcoal briquettes from biomass (plants and their waste) has been widely conducted. However, there needs to be research that considers the use of tapioca adhesive ratios in making charcoal briquettes from a mixture of cassava stem charcoal and forest fire residue charcoal.

## LITERATURE REVIEW

Charcoal briquettes are wood charcoal whose shape, size and density have been changed by pressing a mixture of powder with an adhesive. Several methods of making charcoal briquettes (Wijayanti, D.S. 2009).

1. Pressing sawdust into charcoal briquettes is then followed by carbonization at medium pressure.
2. Simultaneous pressing and carbonization.
3. Pressing a mixture of charcoal and sawdust into charcoal briquettes followed by carbonization
4. Pressing a mixture of charcoal powder and adhesive into charcoal briquettes followed by drying and sometimes re-carbonization.

The chemical components of the adhesive type also determine the quality of charcoal briquettes. The following are the chemical components in tapioca.

Table 1. Content of Chemical Compounds in Tapioca (Triono, A. 2006)

Chemical compounds	(%)
Water	8 - 9
Protein	0.3 - 1
Fat	0.1 - 0.4
Ash	0.1 - 0.8
Coarse fiber	81 - 89

The chemical components of raw materials also play a role in making charcoal briquettes. The following are the chemical components of cassava stems.

Table 2. Content of Chemical Compounds in Cassava Stems (Sumada, K. 2011)

Chemical compounds	(%)
Cellulose(%)	56.82
Lignin (%)	21.72
Acid Detergent Fiber(%)	21.45

Chemical components in wood are important indicators in measuring the amount of energy produced from biomass. It is stated that the classification of Indonesian wood types is based on their chemical components (Pasaribu, G., et al. 2005), as follows.

Table 3.Types of Indonesian Wood Based on Chemical Components

Chemical Components	Classification		
	High	Medium	Low
Cellulose(%)	>45	40-45	>40
Lignin (%)	>33	18-33	>18
Pentocene(%)	>24	21-24	>21
Extractive (%)	>4	2-4	>2
Ash (%)	>6	0,2-6	>0,2

One of the factors that affect charcoal briquettes is the adhesive material. It is explained that the use of adhesive materials from plants such as molasses and starch has the advantage that the amount of material needed is less when compared to hydrocarbon adhesive materials, which will save the use of adhesives so that the cost of making charcoal briquettes is cheaper while the disadvantage is that it is less resistant to moisture (Januardi. 1989).

A quality reference is needed to determine whether the quality of charcoal briquettes is good or not, namely SNI 01-6235-2000 (Anonymous. 2000).

Table 4.Charcoal Briquette Quality Reference

Charcoal Briquette Quality Parameters	SNI 01-6235-2000
Density (g/cm <sup>3</sup> )	-
Moisture content (%)	≤ 8
compressive strength(kg/cm <sup>2</sup> )	-
volatile matter content(%)	≤ 15
Ash content (%)	≤ 8
Fixed carbon content (%)	-
Calorific value (cal/gr)	> 5.000

## METHODOLOGY

The materials used are cassava stems (*Manihot esculenta*) and charcoal from forest fires, tapioca, and water.

The equipment to be used is a charcoal furnace, a pounder, 40 mesh and 60 mesh sieves, a digital scale, an oven, a charcoal briquette mold, a press, a heat balancer (desiccator), a vernier caliper, a Universal Testing Machine (UTM), ashing tool (thermolyne furnace), a calorific value measurement (peroxide bomb calorimeter), ashing cup, and cup clamp.

The process of making charcoal briquettes begins with the preparation of raw materials and ends with testing of charcoal briquettes (density, water content, compressive strength, volatile matter content, ash content, fixed carbon content, and calorific value). The following is the process flow (Figure 1).

The comparison between cassava stem charcoal and forest fire residue charcoal is 50:50, where tapioca adhesive will be added to the composition with a ratio of 1:10 to water, while the composition of tapioca adhesive used is 2%, 4%, 6%, 8% and 10% of the weight of the dry furnace charcoal powder.

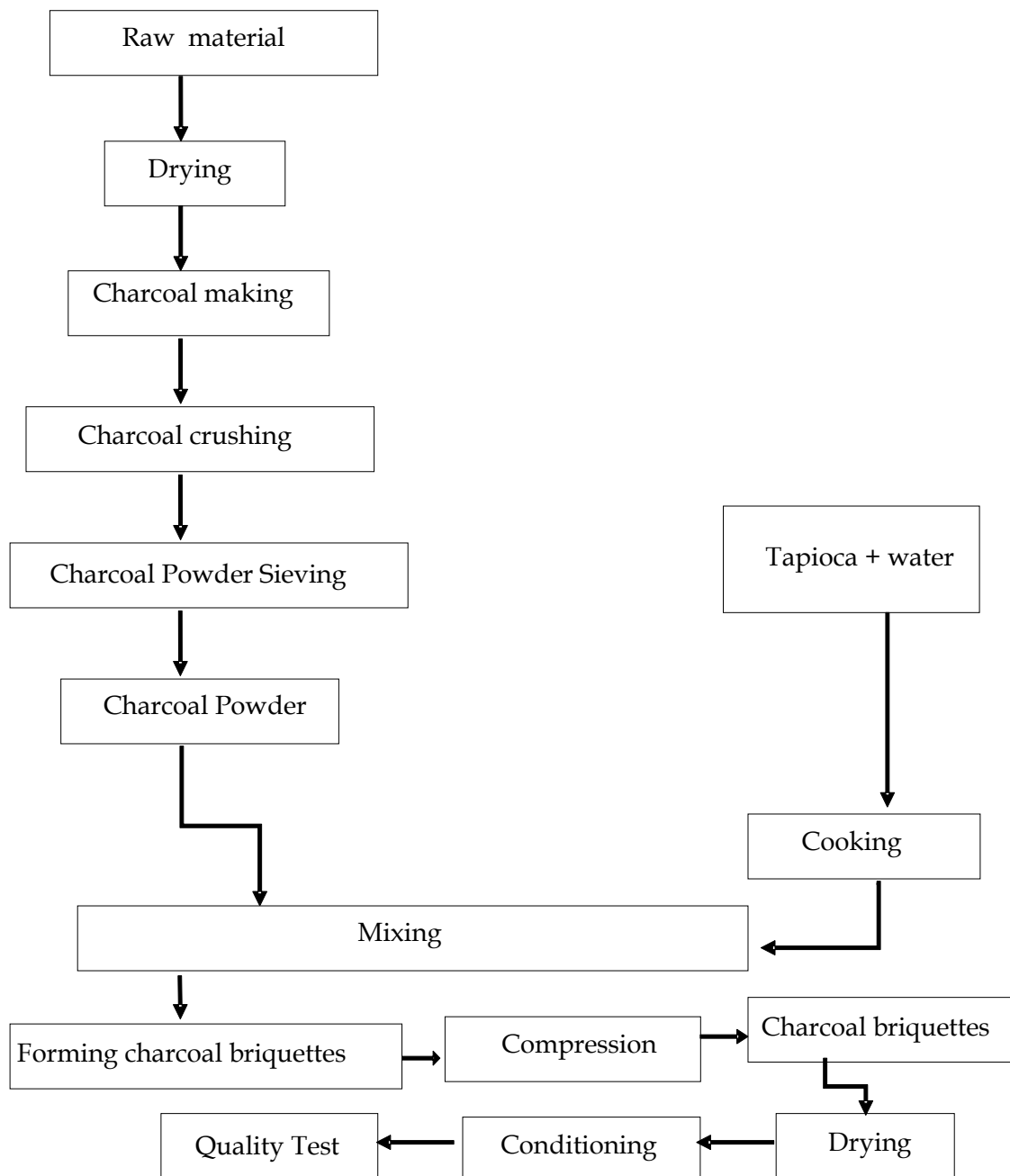


Figure 1. Charcoal Briquettes Making Process

Pressing to form charcoal briquettes using a press tool with a pressure of 40 bar for 10 minutes.

The data obtained from the research results were then processed using a Completely Randomized Design with 5 treatments and 5 replications for testing density, compressive strength, water content, volatile matter content, ash content and bound carbon content and for testing the calorific value, 5 treatments and 3 replications were carried out.

## RESULTS

Here are some results of charcoal briquettes quality testing.

### 1. Density ( $\text{g}/\text{cm}^3$ )

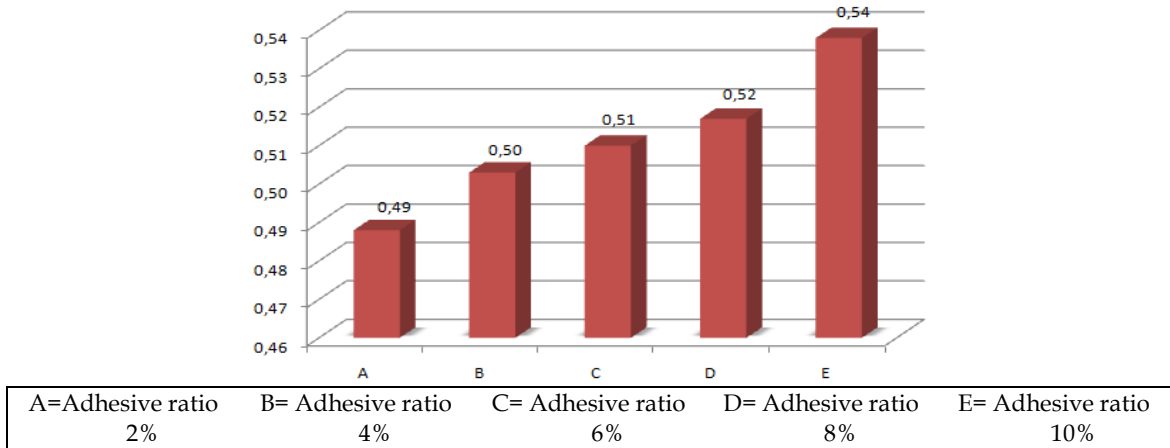


Figure 2. Density of Charcoal Briquettes at Different Adhesive Ratios

### 2. Moisture Content (%)

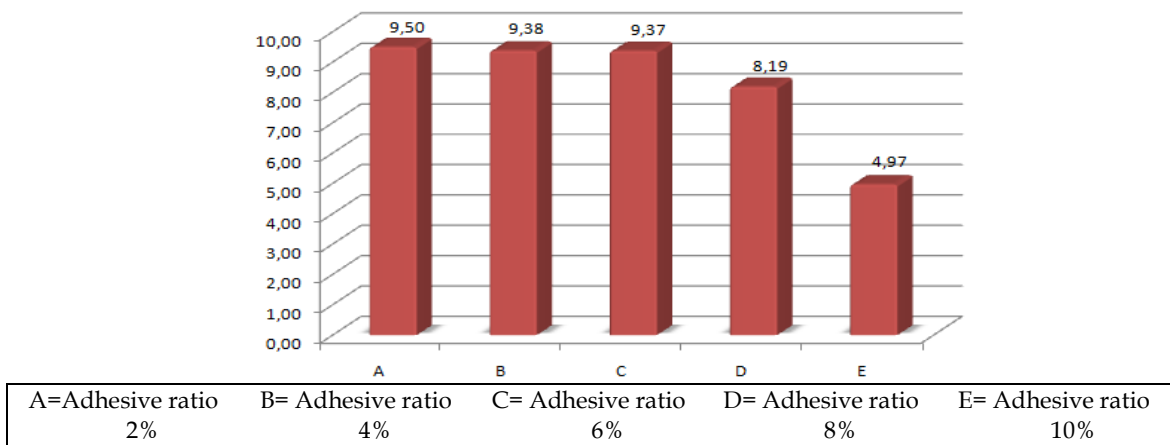


Figure 3. Moisture Content of Charcoal Briquettes at Different Adhesive Ratios

### 3. Compressive Strength ( $\text{kg}/\text{cm}^2$ )

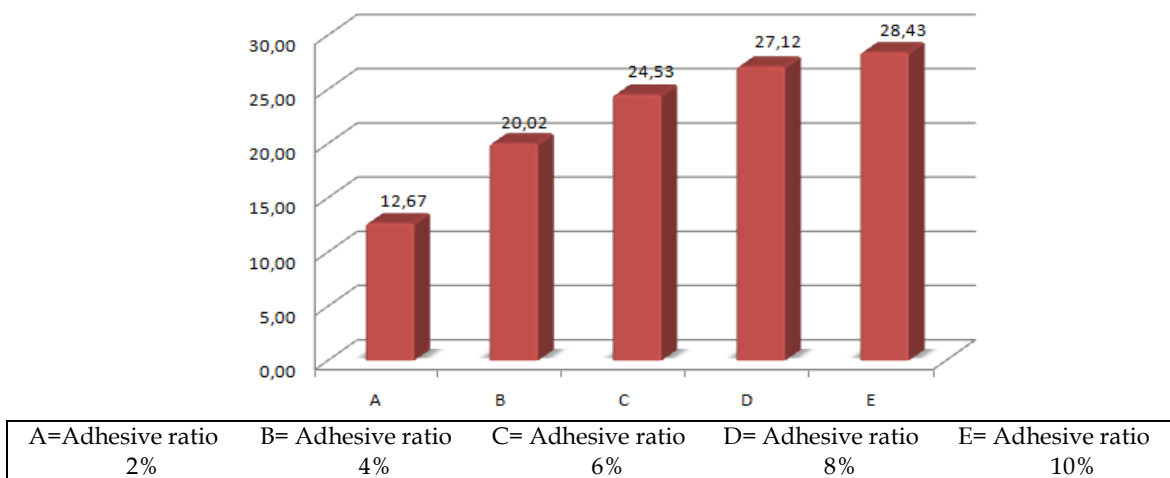
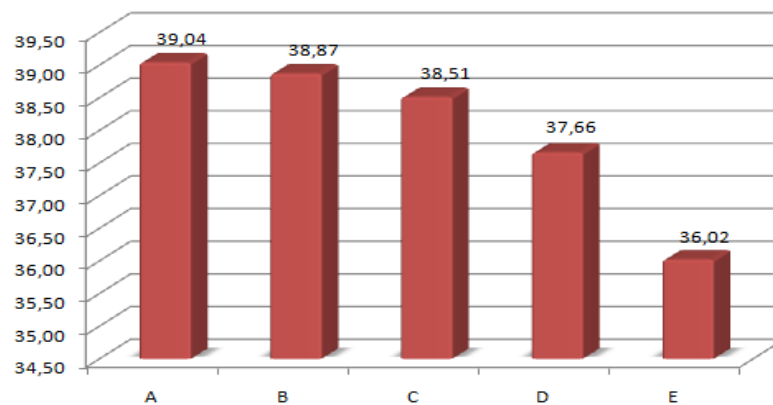


Figure 4. Compressive Strength of Charcoal Briquettes at Different Adhesive Ratios

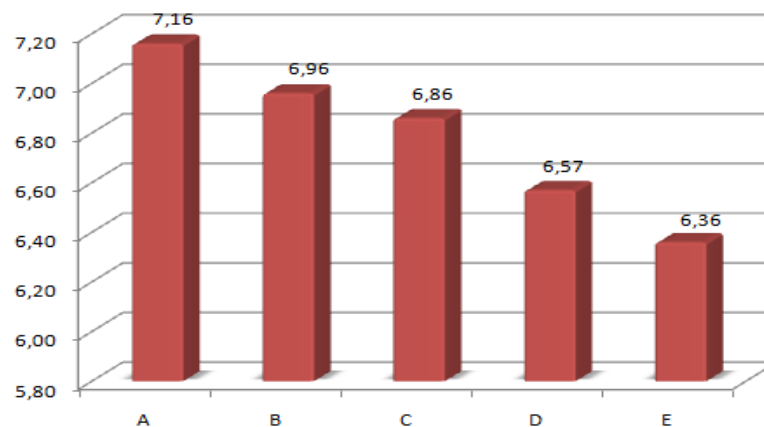
#### 4. Volatile Matter Content (%)



A=Adhesive ratio 2%	B= Adhesive ratio 4%	C= Adhesive ratio 6%	D= Adhesive ratio 8%	E= Adhesive ratio 10%
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Figure 5. Volatile Matter Content of Charcoal Briquettes at Different Adhesive Ratios

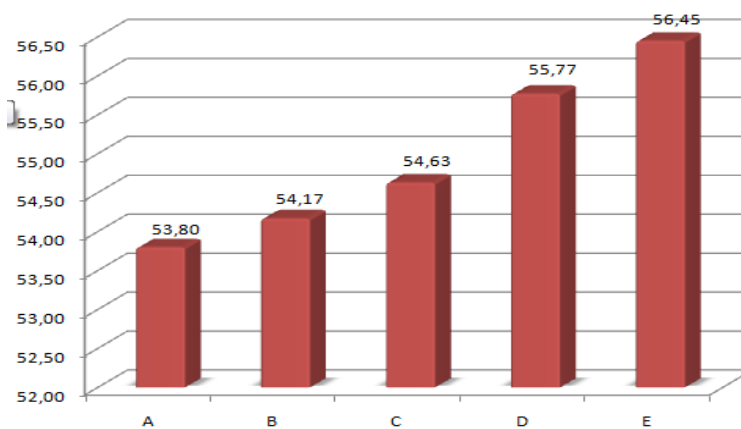
#### 5. Ash Content (%)



A=Adhesive ratio 2%	B= Adhesive ratio 4%	C= Adhesive ratio 6%	D= Adhesive ratio 8%	E= Adhesive ratio 10%
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Figure 6. Ash content of Charcoal Briquettes at Different Adhesive Ratios

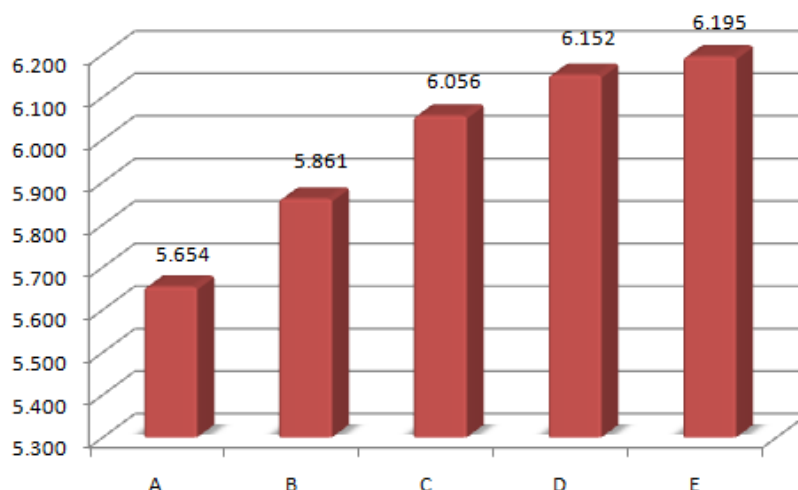
#### 6. Fixed Carbon Content (%)



A=Adhesive ratio 2%	B= Adhesive ratio 4%	C= Adhesive ratio 6%	D= Adhesive ratio 8%	E= Adhesive ratio 10%
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Figure 7. Fixed carbon content of Charcoal Briquettes at Different Adhesive Ratios

7. Calorific Value (%)



A=Adhesive ratio 2%    B= Adhesive ratio 4%    C= Adhesive ratio 6%    D= Adhesive ratio 8%    E= Adhesive ratio 10%

Figure 8. Calorific Value of Charcoal Briquettes at Different Adhesive Ratios

**DISCUSSION**

Based on the analysis of variance (ANOVA) in Table 5, it shows the effect of adhesive ratio treatment on the quality parameters (test values) of charcoal briquettes as follows (at 95% and 99% confidence levels).

Table 5. Significance of the Influence of Treatment on the Quality Testing of Charcoal Briquettes.

Quality Parameters	Effect of Adhesive Ratio Treatment		
	Very Significant	Significant	Not Significant
Density (g/cm <sup>3</sup> )	**		
Moisture content (%)	**		
Compressive strength (kg/cm <sup>2</sup> )	**		
Volatile matter content(%)			ns
Ash content (%)	**		
Fixed carboncontent (%)			ns
Calorific value (cal/gr)	**		

\*Confidence levels: 95% (2.87); 99% (4.43)

The treatment of different levels of adhesive ratio has a very significant effect on the results of density, water content, compressive strength, ash content, and calorific value tests of charcoal briquettes. The adhesive ratio with increased levels (2%, 4%, 6%, 8%, and 10%) is able to increase the value of the test results very significantly.

Meanwhile, the addition of the adhesive ratio level has no significant effect on volatile matter content and fixed carbon content in charcoal briquettes.

Table 6. Compliance with Charcoal Briquette Quality Standard References

Quality Parameters	SNI 01-6235-2000	Samples	Remark
Density (g/cm <sup>3</sup> )	-	0.49-0.54	-
Moisture content (%)	≤ 8	4.97-9.50	√
Compressive strength (kg/cm <sup>2</sup> )	-	12.67-28.43	-
Volatile matter content(%)	≤ 15	36.02-39.04	x
Ash content (%)	≤ 8	6.36-7.16	√
Fixed carbon (%)	-	53.80-56.45	-
Calorific value (cal/gr)	> 5.000	5,654-6,195	√

### 1. Density

The adhesive ratio treatment has a very significant effect on the density of charcoal briquettes. This is because the large adhesive ratio increases the amount of adhesive material in the composition of charcoal briquettes. A larger weight than the volume of charcoal briquettes will increase the density of charcoal briquettes.

SNI 01-6235-2000 does not require density in the charcoal briquette quality standards.

### 2. Moisture Content

The adhesive ratio treatment has a very significant effect on the moisture content of charcoal briquettes. The greater amount of adhesive has increased the compactness of the bond between the charcoal powder. This good bond makes it difficult for water vapor to enter the charcoal briquettes.

The range of moisture content for charcoal briquettes is still acceptable/meets SNI 01-6235-2000 standards.

### 3. Compressive Strength

The higher density of charcoal briquettes at a 10% adhesive ratio results in high strength and compactness of charcoal briquettes, indicated by high compressive strength values. This is because the greater amount of adhesive is able to bind between charcoal powder better so that it can withstand greater loads.

SNI 01-6235-2000 does not require compressive strength in the charcoal briquette quality standards.

### 4. Volatile Matter Content

The volatile matter content is more influenced by the carbonization process, namely the length of time and temperature of carbonization. Fast carbonization time and low carbonization temperature will increase the volatile matter content and vice versa.

The volatile matter content of the tested charcoal briquettes did not meet the SNI 01-6235-2000 standards.

#### 5. Ash Content

The ash content value is influenced by the density value, chemical components of raw materials, mineral content and pressing pressure. The lower the ash content quality value, the better the quality of the charcoal briquettes (Sari, M.K. 2010).

The ash content of the charcoal briquettes tested met the SNI 01-6235-2000 standards.

#### 6. Fixed Carbon Content

The fixed carbon content is greatly influenced by the density level of charcoal briquettes. High density represents the amount of charcoal powder which is a representation of the carbon contained in charcoal briquettes. The fixed carbon content will follow the density value of the raw material (Cao, Z., et.al. 2019). Other factors are the volatile matter content and ash content, if both are at a low level will increase the fixed carbon content in charcoal briquettes.

SNI 01-6235-2000 does not require fixed carbon content in the charcoal briquette quality standards.

#### 7. Calorific Value

The high amount of adhesive due to the increased adhesive ratio has increased the density of charcoal briquettes. The high density of charcoal briquettes along with the increasing level of fixed carbon will increase the calorific value of charcoal briquettes. Tapioca adhesive also has sufficient carbon content to increase the calorific value of charcoal briquettes. The density of raw materials also plays a role in increasing the calorific value of charcoal briquettes (Sirajuddin, Z. 2021)

The addition of charcoal from forest fire residue also increases the calorific value of charcoal briquettes because wood has a fairly high calorific value of around 4,400 cal/g and will increase if it has been carbonized (Tajalli, A. 2015).

The calorific value of the charcoal briquettes tested met the SNI 01-6235-2000 standards.

### **CONCLUSIONS AND RECOMMENDATIONS**

Increasing the adhesive ratio has successfully improved and increased the quality of charcoal briquettes, especially the calorific value of charcoal briquettes which has exceeded the requirements of the SNI 01-6235-2000 standard.

### **FURTHER STUDY**

Further research needs to be developed into the use of various types of natural adhesives such as wheat flour, sago flour and corn flour as alternative adhesives in making charcoal briquettes.

### **ACKNOWLEDGMENT**

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