The Study Calorific Value of Organic Briquettes for Optimizing Healthy Food Drying as an Alternative to Rainy Weather

Joko Yunianto Prihatin[1(✉)], Ganang Wicaksono Pratama[1], Heri Kustanto[1], Slamet Pambudi[2], and Lujeng Widodo[3]

[1]Department of Mechanical Engineering, Sekolah Tinggi Teknologi Warga Surakarta, Surakarta, Indonesia
jokoyp.sttw@gmail.com
[2]Department of Electronica Engineering, Sekolah Tinggi Teknologi Warga Surakarta, Surakarta, Indonesia
[3]Department of Textile Chemistry, Sekolah Tinggi Teknologi Warga Surakarta, Surakarta, Indonesia

Abstract. Briquettes are a form of renewable energy that can replace the decline in oil and gas production as a necessity for human life. Briquettes made from coconut waste have a very positive potential in environmental sustainability compared to plastic and metal waste. Improper composition of raw materials and adhesives results in quality problems, the calorific value of the briquettes is not durable and smoky contaminates the air. The proper drying process in a small-medium rotary drying machine is to produce 70% dry quality, so the use of briquettes is required to be non-smoke and have a long lasting heat value according to SNi. This research is focused on the purpose of setting the composition of raw materials and adhesives so as to produce optimal calorific value. The method applied is an experiment of 2 factors and 2 levels to 1 response according to a statistical approach using 4 replicas of data collection. The results achieved in this study were the maximum calorific value of 7,158.9cal/g for the composition of the raw material used for coconut shell and the type of Styrofoam adhesive. So that it has a higher ability to meet the minimum standard of Sni 5,000 cal/g or an increase of 30.16%. The average drying quality percentage value of 22.5%, the optimal value for drying ability is in briquettes with composition II (coconut shell and Styrofoam) worth 20% or 1.6kg in 30 minutes.

Keywords: Coconut shell, Styrofoam, Dryer, Calor.

1 Introduction

Indonesia is an agricultural country consisting of various islands that are densely grown with coconut trees. Indonesia is one of the largest coconut producing countries in the world which is evenly grown in Java, Sumatra, Kalimantan, Sulawesi and Irian Jaya. The Directorate General of Plantation of the Ministry of Agriculture in 2015, the total area of coconut plantations in Indonesia is more than 3,585,599 hectares. Indonesia has

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become the largest coconut producing country in the World. The coconut fruit taken is the meat to get coconut milk and the solid waste, namely the coconut shell and coconut fiber. With a coconut production reaching 18.3 million tons, Indonesia has surpassed the Philippines's 15.4 million tons, and India's 11.9 million tons of coconut production [1].

Coconut shell waste produced is around 360 thousand tons per year. However, the utilization of coconut shell waste has not been carried out optimally. In general, coconut shells are only used for fuel purposes for households that still use firewood and also for water retention so that soil effectiveness increases. Coconut shell is generally used as a daily fuel to replace wood which has a negative impact on air pollution. One alternative solution is to form charcoal briquettes which are fuels made from certain combustible materials mixed with adhesive and then printed in the form of small solids. The briquette charcoal has a form that is easy to carry and use for household energy materials such as for furnaces, in the metal casting industry and others. The sample of coconut shell briquettes had better quality than compared with candlenut shell briquette samples [2].

Over the past 5 years, this type of briquette from coconut shell charcoal has become an alternative energy source that is in great demand by both the domestic and export markets [3]. Briquettes are said to be able to compete in the export market if they have stable quality and are able to meet the quality requirements of SNI 06-3730-95. The quality of the briquettes is quite significant based on the achieved calorific value reaching > 5000kcal/gr at SNI -1-6235-2000 as explained in Table 1.

Table 1. Briquette quality requirements according to SNI

Parameter		**Specification of SNI-1-6235-2000**
Water content (%)	:	≤ 8
Ash content (%)	:	≤ 8
Volatile Substance (%)	:	≤ 15
Heat Value (%)	:	$\geq 5{,}000$

The calorific value of the fuel is the maximum amount of heat energy released by the fuel through the mass or volume combustion reaction of the fuel. High ash content can affect the resulting calorific value. To achieve a denser pore quality in briquettes, a good amount of adhesive is also needed. Tapioca when used as an adhesive has a high adhesive power compared to other types of flour [4].

Today's food drying techniques really need development to maintain the stability of food quality. The risk of spoilage and a decrease in food nutrition can be prevented by determining the proper drying method and preservation techniques during the food manufacturing process [5].

The main problem is that if the weather is often rainy every day, drying in the sun must be changed to drying using a dryer that uses briquette charcoal. The proper drying process in a karak rotary drying machine is to produce 70% dry quality, but only reach 50%. So that it has an impact on the smell and is not ready to be fried crispy and reduces the taste. The use of briquettes for fuel for food drying machines is required not to produce smoke and to have a long lasting heat value according to Sni.

The purpose of this study was to determine the composition of choosing the right type of coconut waste and the type of adhesive to produce the optimal calorific value. Furthermore, to determine the maximum calorific value that is able to meet the proper fuel requirements for combustion in a food drying machine.

2 Method

2.1 Variables and experimental design

The research method applied is experimental. The research was carried out at the Fluid Laboratory of the STT Warga Mechanical Engineering department and the tests were carried out at the UGM Yogyakarta Integrated Research and Testing Laboratory in early 2022. The equipment used consists of main equipment, supports and measuring instruments. Styrofoam, starch, coconut fiber, coconut shell, distilled water, 6 liter pot, mixing spoon, drying tray, pounder, carbonization drum, stirrer, briquette printer, digital scale, measuring cup 600gr, caliper, stop watch, thermometer.

The independent variable consists of 2 types of raw materials weighing 220 grams and 2 types of adhesives weighing 80 grams. While the dependent variable used is the physical test of the response to the heat calorific value. The data from the test results taken were 4 times the sample for each composition. In detail the composition of the level factors used are as described in Table 2.

Table 2. Factor level of coconut waste briquettes experimental design

Factor		Level 1	Level 2	Total of specimen
A.	Raw material type	Coconut Shell	Coconut Fiber	220gr
B.	Adhesive type	Starch	Styrofoam	80gr

2.2 The process of making specimen briquettes

Coconut shell and coconut fiber raw materials are cleaned using running water and a plastic brush. Furthermore, it is chopped or cut into small sizes to facilitate the carbonization process. Drying is carried out using hot sunlight for a minimum of 4 hours to reach a dryness value of 70%. The carbonization step was carried out in a closed drum equipped with a flame from an LPG gas stove for 6 hours. This process is done by closing the drum during combustion, so that evaporation is well controlled. The Fig. 1 describes the drying process in an open environment.

Next the Styrofoam adhesive material is dissolved before melting using thinner and mixed with mother-in-law's tongue water which has been blended which aims to reduce toxic levels. Starch raw material is enough to add water to dissolve it. Furthermore, raw materials and adhesives along with water are determined by weight measurements using digital scales.

Based on the experimental design for each composition, it is mixed in 1 container and mixed until evenly distributed. The comparison of the sizes applied is as described in Table 3.

Fig. 1. Specimen production: coconut waste drying process as raw material for briquettes and carbonizing at 6 hours

Table 3. Composition of coconut waste briquette test specimens

Composition/Caloric Value	Coconut Shell (gr)	Coconut Fiber (gr)	Starch (gr)	Styrofoam (gr)	Water (aquades) ml
A1, B1 = I	220		80		150
A1, B2 = II	220			80	150
A2, B1 = III		220	80		150
A2, B2 = IV		220		80	150

Based on the composition of the factors and levels specified in the experimental design, briquettes were printed. And proceed with cutting according to size 5 x5 x 5cm and dried in the hot sun for 2 days x 4 hours.

The process of testing the calorific value was carried out using the ASTM D5142-02 standard using a pyrolysis type manufacturing technique. The calorific value is the amount of heat produced by the complete combustion of a unit quantity of fuel [6].

Determination of the calorific value by measuring the energy generated in the combustion of one gram of the test sample [7]. Weigh one gram of the test sample, then place it in a silica cup, then put it in the combustion bomb calorimeter. Combustion begins when the water temperature is fixed. Measurements are carried out until the temperature reaches a maximum, so that the calorific value is obtained based on the ASTM approach to the formula below, was calculated using Equation (1).

$$CV = T2 - T1 - 0.05xmx0.24 \quad (1)$$

Note :
Cv = calorific value of charcoal briquettes
T1 = initial water temperature (°C)
T2 = water temperature after burning (°C)
0.05 = temperature due to heat increase in wire
m = calorimeter specific gravity = 73529.6 (kJ/kg)
0.24 = constant 1 J = 0.24 kal

The next step is to test it on a character drying machine based on an initial mass of 2 kg x 4 rotary trays or a total of 8 kg for 30 minutes. The mass of the food particles before drying was measured and compared with the mass after drying. At the Fig. 2 we have explanation.

(a) (b)

Fig. 2. The process of drying karak rice food uses briquettes as fuel: (a) food drying machine, (b) measurement of the mass of the drying product

Data analysis applies a statistical system of tables and graphs approaches that are adapted to the related research results approach. The discussion focuses on the comparison of literature on the development of coconut waste briquettes in the last 10 years. So that with consideration of data analysis and discussion of the literature review it can be concluded.

3 Result and Discussion

3.1 Result of research data

Determination of the calorific value of fuel in this study used a bomb calorimeter with a weight of about 1 gram of material used. Meanwhile, the calorific value of fuel is calculated based on the amount of calories expended equal to calories absorbed. The test results based on factor composition and level are in accordance with Table 4.

Table 4. Results of testing the calorific value of coconut waste briquettes

Composition/ Caloric Value	Sample 1 (kal/gr)	Sample 2 (kal/gr)	Sample 3 (kal/gr)	Sample 4 (kal/gr)
A1, B1 = I	6894	6,825.06	6,204.60	6,687.18
A1, B2 = II	7516	7,215.36	6,839.56	7,065.04
A2, B1 = III	5953	5,893.47	5,357.70	5,774.41
A2, B2 = IV	7420	7,123.20	6,752.20	6,974.80

The results of testing the briquette's ability to dry quality in a drying machine are the initial mass values and the final mass values of raw karak food products. In order to obtain the difference in the effectiveness of the drying ability. Specifically as described in Table 5.

Table 5. Comparison of the mass of karak products resulting from drying of coconut waste briquette-fired machines

Composition	Wet mass (kg)	Dry mass (kg) I	II	III	IV	Mean	difference (kg)	diff. dry mass (%)
A1, B1 = I	8	6.6	6.7	6.9	6.6	6.7	1.3	16.25
A1, B2 = II	8	6.4	6.4	6.3	6.5	6.4	1.6	20
A2, B1 = III	8	5.9	5.6	5.8	5.9	5.8	2.2	27.5
A2, B2 = IV	8	5.7	5.8	6.2	5.9	5.9	2.1	26.25
Average							1.8	22.5

3.2 Analysis and Discussion

The graph Fig 3. is obtained from the adjustment of the table data for the calorific value of testing coconut waste briquettes. Based on these graphs it can be shown that the calorific value is high enough to reach 7,000cal/gr achieved in the 2nd composition A1,B2 and the 4th composition A2,B2. It means that the use of liquid Styrofoam adhesive can bind the raw material carbon well and have good density quality.

Styrofoam has less chemical resistance than polypropylene. Polystyrene dissolves in ether, hydrocarbons. Polstyrene has a low water absorption below 0.25%. at moment its low recycling rate, polystyrene has polluted environment, causing serious threat to both wildlife and human health [8].

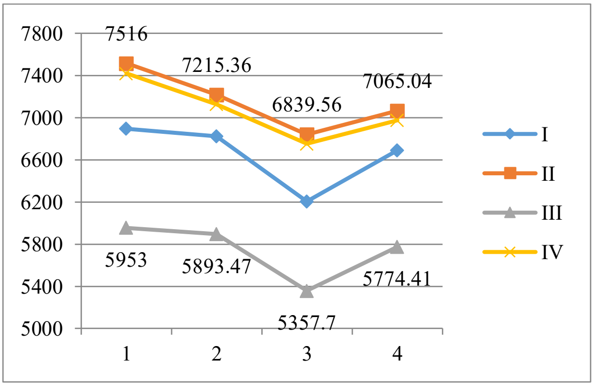

Fig. 3. Graph the 4-specimen calorific value test results of coconut waste briquettes

The graph of the test results above is then analyzed for the average value of the ability to produce heat. And by considering the value of the SNI standard, it can be seen the percentage of difference in comparison that has a better value or is not feasible. The measurable explanation is as described in Table 6.

Table 6. Comparison of the average calorific value of the test results of coconut waste briquettes against SNI.

Composition	Average calorific value (cal/gr)	The difference from SNI is 5,000 (cal/gr)	Percentage (%)
A1, B1 = I	6,652.71	1,652.71	24.84
A1, B2 = II	7,158.99	2,158.99	30.16
A2, B1 = III	5,744.65	744.65	12.96
A2, B2 = IV	7,067.55	2,067.55	29.25

The average value of the maximum calorific value that can be achieved is in composition 2, equal = (7516 + 7,215.36 + 6,839.56 + 7,065.04)/4 = 7,158.99cal/gr. Based on the safe calorific value according to SNI standards of 5,000cal/gr, a higher difference of 2,158.99 = 7,158.99 – 5,000cal/gr is obtained. If the difference is ascertained in percentage, it becomes 30.16% . The calorific value of briquettes made from raw and raw coconut coir was found to be the highest at 1460 kcal/kg followed by rice straw at 1070 kcal/kg, peanut shell at 530 kcal/kg and bagasse at 384 cal/kg [9].

The technique of making briquettes using the briquette agglomeration process produces perfect burnt quality. in its composition by adding biomass, it can minimize the bottom ash produced from burning the briquettes [4]. The low calorific value of the briquettes can be affected by the value of the ash composition, this is because the ash content has an element of silica which has an unfavorable effect on the briquette ignition process. So that the higher the ash content value will cause the lower calorific value. The calorific value of tapioca flour adhesive has a higher value than molasses type adhesive, because briquettes with tapioca briquette adhesive have high values of density, compressive strength, ash content and volatile matter [10].

Briquettes with the best composition are briquettes with tapioca flour adhesive and the addition of coconut shell charcoal at a dose of 30%, which is close to the standard briquette criteria, namely the highest calorific value, lowest water content, highest burning rate and highest burning temperature. The calorific value depends on the characteristic of the fuel. Solid fuel will burn longer, so the energy released by it self will be greater, and vice versa. Fiber is more flammable, and will burn completely in a very short time compared to coconut shells even though they have the same mass. The amount of energy produced from burning coconut shells is much higher than the energy produced from the fiber. That's why if you want to iron using charcoal, people generally use coconut shell charcoal, and not coconut fiber charcoal or other soft materials like mango tree charcoal [6].

The method used in the manufacture of briquettes is the blending method which can produce a quality organic briquette calorific value of 3.673-5.876 calories/gram which meets the quality briquette fuel standards according to the Indonesian National Standard (SNI) [11]. Making briquettes with a mixture of young coconut shell waste and starch of 10% and drying in the sun for 2 days only produces a very low calorific value of 6.21cal/gr [12].

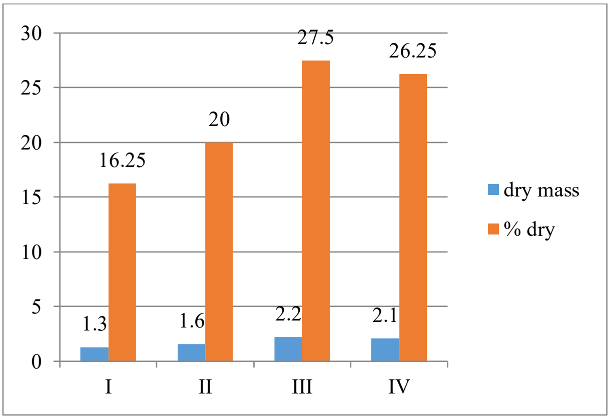

Fig. 4. Graph of the dry mass value of the product and the percentage of drying ability in drying karak rice machine fueled by coconut waste

From Fig 4., the IIIrd composition shows the best results of the drying process of karak food. The use of coconut fiber raw materials and starch adhesive produces briquette quality which is able to dry to 2.2 kg in 30 minutes, or is able to dry by 27.5%. The average drying quality percentage value of 22.5%, the optimal value for drying ability is in briquettes with composition II (coconut shell and sterofoam) worth 20% or 1.6kg in 30 minutes. The application of the rotating drum drying method has the most optimal energy efficiency, at 60-90% dry [5].

Drying using solar energy is more economical than using LPG gas, but the drying time is longer than LPG. Drying using a dryer is of better quality and hygienic than direct drying. A system which minimizes exposure to light, oxidation and heat, (i.e. high heat 70oC and shorter time duration) may help conserve critical bioactive compounds. This new drying technologies and pretreatment methods must base upon drying efficiency, quality preservation, and cost effectiveness. So it is safe for the environment. [13].

4 Conclusion

Selection of the A1 B2 composition or the use of the type of coconut shell coconut waste and the right type of Styrofoam adhesive results in an optimal calorific value. The maximum calorific value capable of meeting the proper fuel requirements for combustion in a food drying machine is 7,158.9 cal/gr. This value is higher than the SNI standard of 5,000 cal/gr, or a difference of 2,158.9 cal/gr or 30.16%. Optimal drying ability value 20% < average 22.5%.

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