IOSR Journal of Engineering (IOSRJEN) **www.iosrjen.org**
ISSN (e): 2250-3021, ISSN (p): 2278-8719
Vol. 11, Issue 10, October 2021, ||Series -I|| PP 01-14

Quality Improvement of Charcoal Briquette from Modified Coconut Shell as a Solid Fuel Source with the Starch Adhesive

Omar Ali Mohammed Ali[1], Luqman Buchori[2], Mohamad Djaeni[3]
[1] *Department of Chemical Engineering, Diponegoro University,*
[2] *, Department of Chemical Engineering, Diponegoro University*
[3] *, Department of Chemical Engineering, Diponegoro University*
Received 19 September 2021; Accepted 04 October 2021

Abstract:
Background: Indonesia is one of the biggest countries in the world that produce briquettes and coconut shell is the main source of these briquettes. This research purposed to observe the effect of adhesive variations, to obtain adsorption power of Cr ion, andanalyze the quality improvement of charcoal made of coconut shell with controllable convective drying . This paper used coconut shells as a source of briquettes because coconut shells have only been used as fuel for cooking or left as waste. To increase the added value of coconut products, it is necessary to make efforts to use coconut shell to be processed into charcoal, considering that the need for coconut shell charcoal tends to increase as a raw material for making activated charcoal. Sago or tapioca adhesive is used because in water with high temperatures, the amylum granules in sago and starch can swell. The starch granules can swell further as the temperature rises during the heating process.
Materials and Methods: . Thus, coconut shell is used as it is easily available in Indonesia where the research was done. For briquettes to endure, not easily be destroyed if subjected to collision or other physical occurrences, the adhesive is required throughout the manufacturing process. The physical characteristics of starch and sago are very similar. The amylum starch component has 17 % amylose and 83 % amylopectin, whereas the sago starch component contains 30 % amylose and 72 % amylopectin. This content demonstrates that starch and sago can be utilized as an adhesive in the production of briquettes while also being inexpensive. Chromium and its derivatives are hazardous metals that have been introduced into natural water as a result of various industrial wastes. (10)
Results: The leather tanning, textile dyeing, electroplating, and metal finishing industries are the primary suppliers, all of which have serious environmental and public health consequences. Many researchers have used agricultural and industrial waste products as activated carbon precursors in the removal of chromium. For Cr(VI) adsorption, many commercial activated carbons were employed both as received and after chemical modifications. In the presence of acidic solution and when the oxygen is sufficient, Cr (VI) direct interacts with activated carbon, and it is adsorbed on the surface by activated carbon.
Conclusion: This study made improve in this coconut shell as raw materials and enhanced charcoal made of coconut shell with controllable convective drying. Finally, the goal of the research was achieved by solving the problem involved in the previous studies that focused on charcoal in metallurgy is intimately linked to small blast furnaces, and the use of charcoal in coke making and iron making. This study made improve in this coconut shell as raw materials and enhanced charcoal made of coconut shell with controllable convective drying.
Key Word: quality improvement ; charcoal; coconut shell; chemical; convective drying.

I. Introduction

Charcoal is a major source of renewable energy with four primary uses: domestic, chemical, farming, and industrial. It is still used today as fuel for domestic use and in businesses such as pizzerias and steakhouses substance is a chemical that is used in the production of sulfides and carbon tetrachlorides, cyanides and so on, as high-absorbing carbon, used as chlorine, for the degassing, purification of water and wine, as activated carbon. It improves soil and water quality and is a major source of bioenergy and improves air quality within agriculture. In the industrial sector, carbon is used primarily as a fuel in boilers, cement, lime, pottery, thermal and civil engineering, and metal mining (Yatagai et al, 2016).

Source of activated charcoal Indonesia not only from coconut shell but still, a lot of other materials that can be used such as candlenut shell, sawet waste, ingredients mixing, timber or wood waste, peat, agricultural products, and livestock waste(Arsad and Hamdi, 2010). Activated carbon is said to be "material of the future" because can be said to be material with many functions because of its benefits perfect for any process cleansing / restoring/sanitizing materials including water (Sirichote et al., 2012), decreased caffeine levels in coffee (Marshand Rodriguez-Reinoso, 2016), screening color (Li et al., 2015), deodorizing or odor in the air (Sahu et al., 2010), drinking water treatment (Jeswani et al., 2015; Subha and Namasivayam, 2009), gas industry and air conditioning cleaning (Arena, et al., 2016). It's a carbon benefit active in water not only for purpose drinking water but keep it usable for water sanitization such as absorption easy metals (Pb, Fe, and Cu), and Nitriteand Phenol (Arsad and Hamdi, 2010).

Activated carbon is a porous solid containing 85-95% carbon compounds. In addition to fuel, carbon can be used as an absorbent. Activated carbon can be produced from several materials that contain a lot of carbon such as wood, sawdust, seed coats, rice husks, shells, peat, bagasse, coal, lignite,e and animal bones (Lempang, 2014). Activation increases the pore size of activated carbon and forms interlocking pores, with an increase in imicroporere volume and internal surface area (Zaid, 2013). The effectiveness of the absorption of activated carbon against heavy metals needs to be well known, so that coconut flour manufacturing plants can take advantage of the utilization of coconut shell charcoal to become activated carbon. The activated carbon produced can be used by coconut flour manufacturing plants in the management of factory wastewater containing heavy metals.

Earlier research by Rodriques and Juniors (2019) shows that coal is a source of renewable biomass and is a biothermal manufacturer of pig iron and steel of great industrial relevance. To increase the quality and yield of coal, investments must be made in improving kilns and controlling the process of carbonization. However, there is a lack of research that characterizes today's technologies in charcoal production to achieve the optimum balance, taking into account innovations and constraints. This balance is the basis for improving current carbonization furnaces and creating new proposals for furnaces. The key worldwide ovens for producing charcoal have been defined in this sense. A total of 21 carbonization kilns have been identified and the majority of them have been improved technologically. Even with carbonization ovens and technological progress, much of the world's production still uses low-tech conventional ovens, resulting in lower yields and efficiency. Several issues involving the manufacture of charcoal and the difficulty to consolidate ovens with better technology are therefore addressed.

Babich and Fernandex (2010) also stated that the use of charcoal is today closely related to Brazil's small explosion furnaces. Given the challenge of mitigating CO2, there is increasing interest in the use of charcoal as a source of renewable energy. The use of charcoal in coking and iron making was examined in the context of Europe's efforts to reduce carbon dioxide emissions in the stainless steel industry in the post-Kyoto period. In this paper, the findings of an experimental study carried out at the Ferrous Metallurgy Department on the behavior of carbon under the blast-furnace simulation conditions, RWTH University of Aachen and National Metallurgy Research Centre, Madrid. Thermo-analytic, laboratory, and pilot systems were used to simulate conditions in the track and the furnace shaft. Two pyrolysis furnaces of the different wood specimens under different carbonization conditions provided charcoal samples. In addition, technical and ecological evaluation of the blast oven process was conducted with a mathematical model injecting various forms of charcoal. All tests and measurements were carried out with reference injection mineral coals. Conversion performance is greater or equivalent with coals for all the tested charcoals. Changing the coke temperature, furnace productivity and additional operational parameters for the replacement of sprayed coal with coal depends on the content and composition of the charcoal ash.

Based on the description above, so this research is purposed to analyze the effect of particle size on burning time, and heat value of charcoal, and evaluate the effect of drying temperature and air flow on drying time and the quality of coconut coal, also to prepare the charcoal with low carbon monoxide emission. with the quantities methods which are the quantities and variability of products that must be dried overtime when the drier is designed, the average ambient temperature and relative humidity for Ilorin, initial product fresh humidity, and final dried product humidity levels have been considered for this purpose.

II. Material And Methods

According to Tahir (2013), there are four main functional systems, a combustion chamber, an exchanger, a suction unit, and a drying chamber linked with a 50 mm circular pipeline (see Fig. 3.1). A conical carbon container that produces heat and keeps the heated air in the combustion chamber before being moved into the dryers. The heated air absorbs a 0,50 hp axial ventilator, which is dispersed through the drying chamber through a heat exchanger in the combustion chamber. The drying chamber consists of three drawers for the drying procedure. The cupboard is isolated. The desiccation case is 62 cm long, 71 cm wide and 66 cm long (outer dimension 6 66 cm x 75 centimeters x 66 centimetres). The drying chamber has a double wall and a fiberglass 2 cm thick. The solid fuel is fired at the operating combustion chamber, the heated air is then transported via the heat exchanger/consumer and filtered with the aid of the suction unit. The heat and mass are dried and the rest/exhaust air is passed through the chimney while the hot air moves through the products in the drying tank. The dyer is made from local building materials using a 240 V DC battery-driven suction fan with USD 320.

Adsorption is the most widely used method compared to other methods because this method is safe, does not provide side effects that endanger health, does not require complicated and expensive equipment, and is easy to use. Coconut coir contains lignin and cellulose which can be used as activated charcoal which serves to adsorb heavy metals. One of the characteristics that are considered the advantages of an adsorbent is its regenerating properties or can be regenerated using a desorption agent (Munawar, 2010). However, this also has a negative impact. The adsorbent that has been used to adsorb heavy metals is usually only discharged into the environment and becomes waste. This adsorbent waste under certain conditions will cause the metal in the adsorbent waste to be released again. This will cause environmental pollution again. Therefore, it is necessary to treat the adsorbent waste that has been used. The binding of the coconut fiber activated charcoal adsorbent that has adsorbed heavy metals is expected to reduce the heavy metals that will be released again.

The quantities and variability of products that must be dried overtime when the drierise dis esigned, the average ambient temperature and relative humidity for Ilorin, initial product fresh humidity, and final dried product humidity levels have been considered for this purpose. Other considerations included fast loading and removal of dried products from the fresh product drying chamber; heat generation system and heat transfer method; and heat storage during drying. Structural stability was also considered, a fan with sufficient force to overcome the backpressure of the tray containing the goods during the drying process. It was also taken into consideration that the air flow speed through the tanks should not be too high to allow the products to blow off the drying tanks.

Due to the relationship between, the mass of moisture to be taken out of products Ichsani and Dyah (2002):

$$Mw = \frac{\mathrm{mi}\ (\mathrm{M0} - \mathrm{Mf})}{(100 - \mathrm{Mf})} \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (1)$$

Where; mw and mi are the sum of humidity to be removed and, where appropriate, the original product weight in kg; (wet basis).

$$\mathrm{ma\ Cpa\ (Tb - Tc) = mwL} \ldots\ldots\ldots\ldots\ldots (2)$$

Cpa, where ma is dry air per kg; CPA - Continuous air-heat potential in J kg-1 0C; TB and TC are both the initial and final air-drying temperatures in J kg-1 (see above). The heat from free water evaporation from the commodity is latent at J kg-1. Ichsani and Dyah (2002) are the air mass required for moisture drying:

$$\mathrm{ma} = \frac{\mathrm{mw}}{(\Delta\ \mathrm{WCB\ x\ n})} \ldots\ldots\ldots\ldots\ldots\ldots (3)$$

Where ma is the air mass required to extract moisture from the substance, and where; mw is the moisture to be removed; In addition, there is a shift in the WCB in the moisture ratio that may be eliminated by heated air; n is the pickup part. After measurement of the volumetric flow rate of dry air was determined following Axtell (2002):

$$\mathrm{mv = ma\ x\ vs} \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (4)$$

The drying rate of volumetric air is at m3/s where;mv and the drying volume of air are at m3 kg-1. The required heat energy is calculated by Axtell to determine the amount of charcoal needed for the dryer (2002):

$$\mathrm{Q = maf\ (h2 - h1)} \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (5)$$

Where; Q is the amount of heat power in kJ s-1; maf is a kg s-1 air flow rate; h1 is a specific air enthalpy in kJ kg-1 air; and h2 is a specific air enthalpy at a temperature of drying air in kJ/kg. A means of deciding how much coal in the combustion chamber should be burned:

$$\mathrm{QC} = \frac{Q}{\mathrm{CC}} \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (6)$$

Where; Qc is kj for drying thermal energy and Cc is kJ/kg for charcoal calorification. Qc is kJ/kg of charcoal for combustion in kg. The drying rate is the rate of moisture changes during drying. This has been done to assess Ichsani and Dyah (2002):

$$R = \frac{(dM)}{dt} = \frac{mi - mf}{t} \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots(7)$$

The rates in g/h where; r; dM is the mass shift in g; dt is the change of time in h; The initial and final masses of the substance are in g and mf. The conditions for quality determinations were humidity, ash, raw fat, and crude proteins, crude fiber and dried fish sample carbohydrates.

Table 1. Materials used for construction of the dryer and their specifications

Materials	Specification	Quantity
Galvanized steel sheet	Thickness 1 MM	1 standard size
Galvanized mesh	2.4. m x 1.2 m	1
Mild steel sheet	Thickness 1 mm	2 standard size
Pipe	60 mm	½ standard length
Pair of hinges	75 mm size	1
Blower	Centrifugal fan with prime mover	1
Bolts and nut	M18	20
Mild steel rod	12 mm	½ standard size
Lagging material	Wool fibre	Lump
Square pipe	25 mm x 25 mm mild steel	½ standard size
Angle iron	42 mm x 42 mm mild steel	½ standard size
Angle iron	25 mm x 25 mm mild steel	½ standard size
Painting	Finishing pints	Lump
Mild steel rod	8 mm	½ standard size

Based on the figure, it is known that the elevator support height is 260 mm, the tube height is 660 mm and the funnel height is 150 mm, while the dryer has a width and height of 260 x 350 mm.

3.1. Variables

1. Dependent variable: Quality improvement
   A product resulting from the carbonization process of materials which contains carbon, especially wood biomass
2. Independent variable: Adhesive type and concentration
   Starch adhesive and sago adhesive are the two types of adhesives that were used to form the briquettes of coconut shell charcoal.

3. Independent variable: carbonization temperature and time
   Heated at a low heating rate, with a longer vapor residence, and a small temperature

Equipment and Materials

Equipment: heat exchanger, chimney, drying chamber, frame, combustion chamber, suction, adjustable stand, and tray.

Materials: coco shell, starch, sago starch, MO indicator, Na_2CO_3 0.07N, 10% NaOH solution (Dissolve 10 g NaOH in 100 ml of distilled water, Oxygen with a purity of more than 99.5%, a certified standard benzoic acid (calorific value of 6318 cal / g).

Procedures

a.Raw Materials Drying

The cocoa cup has first been washed out of fibers and then secured and then divided into smaller pieces, making it easy to set up and generate more coal mass during carbonization.

b. Carbonization with (Pyrolysis)

Coconuts were burnt by drum kilns. When the raw material is being filled, the bamboo is 10 cm in diameter and 1 m long and intended to be used as an air hole during the carbonization process. After the drum kiln is out, branches, paper, or kerosene have been combusted. The burning was also finished.

During the combustion process,s the stove drum was shut down and closed troughs in the underside of the stoveDrummmm were initiated. The fire hadn't disappeared. The first hole was closed and the opening of the top of the hole began, before the combustion came to an end. Therefore, the burn diluted on the ground. To avoid further fire, all holes are shut for 5–7 hours until the smoke is diluted.

c. Filtering and Milling

The effects of milled charcoal are then tamed with a 60 mesh, with the use of a frying machine.Sieving is the most important solid particle size measurement for particles above 0.04 mm in size

d. Mixing of Adhesives for Tapioca

The tapioca adhesive is heated to 24 g of starch in 150 mL of water until the gel develops. For Sago adhesive, the same medication was also used. If the mixture weighs 300 grams, powder and adhesive in the cocoon shell are taken into consideration. The adhesive weight of Tapioca is 8%. While the weight of the sago adhesive was different, 1%, 2%, 5% , and 6%, were different, 7% and 8%. 3% and 4%. Mixing the cocoa powder with the adhesive after measuring the comparison.

Sago or tapioca adhesive is heated and stirred until thickened during the mixing with water. Then it was combined with charcoal powder in a predetermined ratio until homogeneous. As the adhesive is combined with the powder, the adhesion and cohesion forces cause the powder particles to attract each other. The adhesion force is responsible for the attraction among particles that are not identical, whereas cohesive force is the one that is responsible for the attraction between identical particlesTo create a thin layer on the particles' surfaces and to improve the contact area between them, water molecules (H_2O) were used as a solvent for the adhesive. The resulted blend was designed to achieve a consistent shape, improve the sales price, and make packaging and use easier. Compression was used to raise the density among particles, which has an impact on the chemical and physical properties of the briquettes produced. The briquettes were dried in the oven for 24 hours in order to water content as much as possible. Briquettes that had not been dried weighed more or less than 13 grams; after drying, they were more or less than 9 grams in weight. (Sudding and Jamaluddin, 2016)

e. Compression and Moulding

Results of briquettes of dough moulded and compressedmoldedbination of coconut shell charcoal powder with starch or sago).

f. Drying Ultimately

The wood briquettes were leaves around 12 hours after printing "room temperature" then dried between 24 hours : 36 hours start fom 45°C every to hours make it more 20°C. So it's 45°C,65°C and keep it on 80°C . Then the briquettes were in "room temperature for 6 hours" then claught in a plastic sac and sealed dry.

g. Density of Coconut Shell Charcoal

Density measurement was carried out by measuring the briquettes and determining both the diameter and the height in a dry state. The density of the charcoal can be established with the formula Ichsani and Dyah (2002):

$$K = \frac{w}{¼\pi\ D2.T} \quad \ldots\ldots\ldots\ldots\ldots\ldots(8)$$

Whereas:
W = Briquette weight (g)
K = Density
D = Briquette diameter (cm)
T = Briquette height

h. Ash Content of Coconut Shell Charcoal
A drying rate of 30 minutes in a 105 ° C cooker was used to test the ash content. Then the cup was cooled for 30 minutes in an exicator and its empty weight measures were taken. The empty rate was then fed a sample of 1 gram. The plates with these samples were put into the house 4 hours before the sample was transformed into ashes at a temperature of 850°C. The rate was also removed from the oven and then weighed and cooled up in the exicator. Ash material decision is made three times over (triplo).
The ash content can be calculated using the following formula Ichsani and Dyah (2002):

$$\text{Ash content } (\%) = \frac{A}{B} X \ 100\% \ldots\ldots\ldots\ldots\ldots(10)$$

Where:
A = weight of ash (gram)
B = weight of sample (gram)

i. Combustion period for Briquette Coconut Shell Charcoal
The determination of combustion duration is made by burning briquettes above Bunsen. The porcelain cup has been added to the briquettes as the briquettes began to burn. Once the briquettes start to burn, switch on and turn off the stopwatch until it burns to ash. The time of combustion is measured three times over and repeated.
j. Calor of Coconut Shell Combustion of Charcoal Briquette Result
The aim of this study is to measure the fuel calorific value by a bomb calourimeter of about 1 gram with the weight of the materials used.
The calorification value of the fuel is calculated using the following equation according to the amount of heat released and the heat consumed Ichsani and Dyah (2002):

$$\text{Calor value} = \frac{(T2-T1) \text{ x w}}{\text{m}} \ldots\ldots\ldots\ldots\ldots\ldots(11)$$

Whereas:
W = coefficient of calorimeter bomb (kal/°C)
T2 = temperature after combustion (°C)
T1 = initial temperature (°C)
m = burnt sample weight (g).

III. Result

Starch adhesive and sago adhesive are the two types of adhesives that were used to form the briquettes of coconut shell charcoal. Tapioca adhesives were used at 8 % concentration. In addition, adhesive variations of range from 1% - 8% were performed while on the sago adhesives. Table 2 shows the quality testing findings on the coconut shell charcoal briquettes that were manufactured. This analysis is based on an average of three repetition in each treatment.Coconut shell that will be used is cleaned first from its fiber and dirt attached to it, then dried under the sun so that during the process of charring or carbonization smoke produced is not too much and simplify the process of carbonization.(Sudding and Jamaluddin, 2016).

Table 2. The Briquette of Coconut Shell Charcoal Quality Testing Results.

Adhesive Type	(%)Tapioca	Calorific Value (kcal)	Adhesive Type	(%)Sago	Calorific Value(kcal)
Sago	1	6673,041	Tapioca	1	6744,259
	2	6802,766		2	6807,621
	3	6665,643		3	6789,764
	4	6458,846		4	6679,827
	5	6384,256		5	6652,912
	6	6507,179		6	6627,029
	7	6345,775		7	6483,523
	8	6349,685		8	6402,275

One molar (1M) of HCl able was used in for an activation with the activated charcoal coconut shell. Table 3 shows the power of adsorption measurements of the activation resulted.When the adhesive is mixed with the powder, then the powder particles will attract each other due to the force of adhesion and cohesion. Adhesion force is the force of attraction between the particles which are not similar while the cohesive force is the force of attraction between similar particles. Molecules of water (H2O) are used as a solvent for adhesive and to form a thin layer on the surface of the particles that will increase the contact surface between the particles.(Sudding and Jamaluddin, 2016).

Table 3. Power of Adsorption in Activated Charcoal Coconut Shell Against Cr Ion (VI)

	%Adhesive	Ion Cr (VI) in (ppm)	Adsorption capacity average (W) (mg /g)	Cr (VI) absorbed on average (ppm)	The rest of the Cr (VI) Average(ppm) (Ce)	(%)Power adsorption average
1	A (4%)	50	0,365	7,314	42,686	14,630
2	B (8%)	50	0,414	8,290	41,701	16,590
3	C (12%)	50	0,456	9,130	40,870	18,260
4	D (16%)	50	0,549	11,007	38,993	22,150

Briquette of Coconut Shell

Because of the high content of cellulose and lignin in coconut shells, its thermal diffusion characteristic is high, making it suitable for be used as a fuel. Coconut shell is made into briquettes for use as an alternative fuel, which increases its economic value and makes it easier to be used. The materials used to make briquettes originate from an old coconut shell that is dark brown when viewed from the slit side. The carbon content of the old shell is higher, while the water content is lower. The coconut shell was washed first to remove any fibers or dirt, then dried in the sun to reduce the amount of smoke emitted during the charring or carbonization process and make easier the carbonization process (Sudding and Jamalujddin, 2016).

The process of carbonization in this research was carried out in a kiln drum in the existence of a small air supply to ensure that the produced charcoal did not undergo further combustion, resulting in a high yield of charcoal with little ash. The total weight of coconut shells burned was 125 kg, which was split into five separate burns. The coconut shell that was burned for each burning weighed 25 kg and took 3-6 hours to be burned. Pyrolysis of 125 kg coconut shell yielded 30 kg of charcoal with a 24 % yield. The charcoal obtained from the process of carbonization was then ground to a smaller scale. To achieve the identical size, sieving with 60 mesh size was used. Besides that, as the adhesive was sieved, charcoal was combined with sago flour and starch in proportions of 1% till 8%. Pyrolysis process for 6 hours then cooled with water to get shell charcoal and activated carbon.(Sudding and Jamaluddin, 2016).

Seventeen percent of amylose and 83 %amylopectin make up the amylose component in starch. Meanwhile, sago contains72% amylopectin and 28 % amylose and, which comes from the tapioca component. These elements implied that starch and sago can be used as an adhesive. In water with high temperatures, the amylum granules in sago and starch can swell. The starch granules can swell further as the temperature rises during the heating process. Starch granules can swell reversibly (it can return to their original state), however swelling of the starch granules is permanent after a certain temperature is surpassed (it cannot be returned to its original state). Gelatinization is the irreversible starch reaction that takes place at 85°C. The viscosity or consistency of the solution will increase as the swelling of the starches granulate increases (Sudding and Jamaluddin, 2016).

Sago or tapioca adhesive is heated and stirred until thickened during the mixing with water. Then it was combined with charcoal powder in a predetermined ratio until homogeneous. As the adhesive is combined with the powder, the adhesion and cohesion forces cause the powder particles to attract each other. The adhesion force is responsible for the attraction among particles that are not identical, whereas cohesive force is the one that is responsible for the attraction between identical particles. To create a thin layer on the particles' surfaces and to improve the contact area between them, water molecules (H2O) were used as a solvent for the adhesive. The resulted blend was designed to achieve a consistent shape, improve the sales price, and make packaging and use easier. Compression was used to raise the density among particles, which has an impact on the chemical and physical properties of the briquettes produced. The briquettes were dried in the oven for 24 hours to reduce the water content as much as possible. Briquettes that had not been dried weighed more or less than 13 grams; after drying, they were more or less than 9 grams in weight. (Sudding and Jamaluddin, 2016).

a. Density

The density of briquettes is calculated by comparing their mass and volume, and it influences briquette quality. Table 4 shows the effects of density measurements of coconut shell briquettes with different compositions of adhesives. The effect of adding adhesive has a tendency to increase the coconut shell charcoal briquettes density. The addition of adhesive components led to rise the density of the briquettes(Priyanto, E., & Putri, S. L., 2017).

Table 4. Density Testing Results for Briquettes Coconut Shell Charcoal

Adhesive	(%)Tapioca	Density (g/cm^3)	Adhesive	(%) Sago	Density (g/cm3)
Sago	1	0,642	Tapioca	1	0,651
	2	0,643		2	0,648
	3	0,654		3	0,652
	4	0,774		4	0,761
	5	0,742		5	0,749
	6	0,809		6	0,790
	7	0,815		7	0,829
	8	0,856		8	0,854

Table 5 displays the outcomes of statistical analysis data for briquette density measurement which were made with different quantities of the two adhesives. In adhesive sago, the highest tapioca value is 8% with a density of 0.856, while in adhesive tapioca, the highest sago value is 8% with a density of 0.854.It was appeared that that both data (briquette density, sago concentration, and tapioca concentration) were distributed normally (Priyanto, E., & Putri, S. L., 2017).

Table 5. Tapioca and Sago Concentration as Adhesives Statistical Analysis Results of Measurements Briquette Density

Adhesive	Aspects	Value	Results	Aspect	Value
Sago	N Test:Sago concentration Sig	1,00	Normal	Pearson correlation	0,950
	Density Sig	0,823	Normal	Sig	0,00
	R Square	0,902		tCal Sig	26,293 0,00
Tapioca	N Test: Tapioca concentration Sig	1,00	Normal	Pearson correlation	0,95
	Density Sig	0.766	Normal	Sig	0.00
	R Square	0.922		tCal Sig	30,60 0,00

Table 5 shows the correlation coefficient between briquette density and sago compositions is 0.95, its significance is 0.00 and with 0.902 value of r square. This indicates that increasing the composition of sago as an adhesive influences the briquettes density by 90.2%, in addition to other factors affecting the density by less than 10%. Thus, these findings are confirmed with value of t-count that is 26.293 with 0.00 significance value.These statistic results showed that the correlation between the two data that are the concentration levels of starch with briquettes density are very strong. The increase in density of briquettes are influenced by the increased of briquettes concentration of 92.2%. So the influence of other factors is less than 8%(Sudding and Jamaluddin, 2016).

Similarly, the correlation coefficient between briquette density and tapioca compositions is 0.950, its significance is 0.00 and with 0.922 value of r square. Hence, these findings are confirmed by a t-count value of 30.60 with 0.00 significance value.

These statistics revealed that there is a clear association between the two data sets of starch composition values and briquette density. As the density of briquette is increased, it affected by the 92.2 % increases in briquette concentration. As a result, there were an effect with less than 8% caused by other variables.

b. Ash content

After a fuel has been burned, ash is unburned items that no longer contain carbon. Ash is made up of minerals or elements found in the substance, which is burned, in our experiment the material used to make briquettes, which can be made from the briquette adhesive or coconut shell charcoal (Priyanto, E., & Putri, S. L., 2017).

Table 6 shows the effects of ash content measurements on briquettes of coconut shell charcoal.

Table 6. Coconut Shell Charcoal Briquette Ash Content Test Results

Adhesive	(%) Tapioca	Ash Content	Adhesive	(%)Sago	Ash Content
Tapioca	1	1,54	Sago	1	1,17
	2	1,48		2	1,32
	3	1,56		3	1,50
	4	1,60		4	1,51
	5	1,71		5	1,55
	6	1,54		6	1,58
	7	1,82		7	1,67
	8	1,77		8	1,87

Table 7 displays the outcomes of statistical analysis data for briquette ash content measurement which were made with different quantities of the two adhesives. In adhesive sago, the highest tapioca value is 8% with a ash content of 1.77, while in adhesive tapioca, the highest sago value is 8% with a ash content of 1.87. It was appeared that that both data (briquette ash content, sago concentration, and tapioca concentration) were distributed normally.

Table 7 shows the correlation coefficient between briquette density and sago compositions is 0.96, its significance is 0.00 and with 0.915 value of r square. This indicates that increasing the composition of sago as an adhesive influences the ash content of briquettes by 95.6%, with other factors affecting the density by less than 5%. Thus, these findings are confirmed by the value of t-count that is22.156 with 0.00 significance value.

Similarly, the correlation coefficient between briquette ash content and tapioca compositions is 0.794, its significance is 0.09 and with 0.631 value of r square. Hence, these findings are confirmed by a t-count value of 22.939 with 0.00 significance value as shown in Table 7.

Table 7. Statistical Analysis Results of Ash Content for Tapioca and Sago Concentration as Adhesives in Briquette

Adhesive	Aspects	Value	Results	Aspect	Value
Sago	N Test:Sago concentration Sig.	1,00	Normal	Pearson correlation	0,96
	Ash content Sig.	0,872	Normal	Sig.	0,00
	R Square	0,915		tCal. Sig.	22.16 0,00
Tapioca	N Test: Tapioca concentration Sig.	1,00	Normal	Pearson correlation	0,794
	Ash content Sig.	0.860	Normal	Sig.	0.09
	R Square	0.631		tCal. Sig.	22.939 0,00

The amount of ash in a product continues to rise in conjunction with the amount of adhesive used. This might be because of the presence of ashes in the adhesive. Where the levels of adhesive are higher, the ash content generated is also higher. The quality of inorganic materials in briquettes made from adhesive and coconut shells affected the high levels of ash. The number of inorganic materials, especially calcium, iron, and phosphorus, in the sago and tapioca adhesive. While both adhesives own the number of inorganic materials, inorganic substances concentration on starch adhesive is likely to be greater (Priyanto, E., & Putri, S. L., 2017).

c. Combustion Duration

The time it takes for fuel to burn out is known as the period of combustion. One of the most critical aspects of fuel efficiency is the time of combustion. The higher the energy generated and therefore the higher the fuel quality, the longer it takes for a fuel to burn. Turning on the stopwatch when the briquettes begin to burn and turning it off when the briquettes were burned to ashes. The determination of combustion time is performed three times of repetitions.(Musabbikhah, Saptoadi, H., Subarmono, & Wibisono, M. A., 2016)

Table 8 shows the results of testing the time of combustion for the coconut shell charcoal briquettes made up with different adhesive levels.

Table 8. Coconut Shell Charcoal Briquette Combustion Duration Test Results

Adhesive	(%)Tapioca	Combustion Duration (S)	Adhesive	(%)Sago	Combustion Duration(s)
Tapioca	1	1414.8	Sago	1	1888
	2	1633.8		2	1745
	3	1687.8		3	1705
	4	1689.6		4	1687
	5	1525.8		5	1840
	6	1830.6		6	1750
	7	1781.4		7	1600
	8	1973.4		8	1675

The effect of the levels, as well as the types of adhesives on the period of combustion, is shown in Table 8.In adhesive sago, the highest tapioca value is 8% with a combustion duration of 1973,5, while in adhesive tapioca, the highest sago value is 8% with a combustion duration of 1675. The higher the adhesive content, the longer the time it takes for the adhesive to burn.

The statistical results analysis which is in Table 9 yielded a value of r square that is 0,972, indicating that the adhesive concentration size determines 97.2 % of the increase in the period of briquette combustion, with less than 3% of other issues affecting. The value of the correlation coefficient is 0.980, and its significance is 0.00, which is an ideal number, indicating that the adhesive composition and combustion time have a very good relationship.

The strength of the relationship between starch adhesive compositions and the time of combustion of coconut shell charcoal briquettes formed can be seen in Table 9.. The value of r square is0,972, this implies the increase in the composition of starch adhesive affected the combustion time period of briquettes by 97.2 %, which indicates the rise in the composition of starch adhesive influenced the combustion time duration of briquettes by 97.2 %.

The same manner would go for the effect of sago adhesive composition on the time of briquette combustion, as shown in Table 9. Both the sago concentration data and the duration of combustion data are normally distributed (where the values of sago concentration significance are 0.00 and it is 0.997for combustion duration), and both are greater than 0.05, as shown in the table. With a correlation of 0.980 and a significance of 0.00, this correlation is very good and appropriate. The determination coefficient value (r Square = 0.953) indicates that briquette concentration is responsible for 95.3 % of the rise in combustion time, while other variables account for less than 5%.

Table 9. Tapioca and Sago Concentration as Adhesives Statistical Analysis Results of Measurements Briquette Combustion Duration

Adhesive	Aspects	Value	Results	Aspect	Value
Sago	N Test:Sago concentration Sig.	1.00	Normal	Pearson correlation	0.980
	Duration time Sig.	0.997	Normal	Sig.	0,00
	R Square	0.953		tCal. Sig.	16.61 0.00
Tapioca	N Test: Tapioca concentration Sig.	1.00	Normal	Pearson correlation	0.98
	Duration time Sig.	0.995	Normal	Sig.	0.09
	R Square	0.972		tCal. Sig.	48.80 0.00

d. Calorific Value

Table 10. Coconut Shell Charcoal Briquette Calorific Value Test Results

Adhesive	(%)Tapioca	Calorific value (kcal)	Adhesive	(%)Sago	Calorific Value (kcal)
Tapioca	1	6,744	Sago	1	6,673
	2	6,808		2	6,803
	3	6,790		3	6,666
	4	6,680		4	6,459
	5	6,653		5	6,384
	6	6,627		6	6,507
	7	6,484		7	6,346
	8	6,402		8	6,350

In adhesive sago, the highest tapioca value is 8% with a caloric value of 6.402 while in adhesive tapioca, the highest sago value is 8% with a caloric value of 6.350. The amount of heat energy generated by a solid fuel at any weight unit when it burns perfectly is known as its calorific value. Fuel calorific value is determined by its composition. Solid fuels can burn for longer periods of time, releasing more steam, and vice versa. Even though the weights are the same, the combustion time for coconut fiber and coconut shell would be vastly different.

Even if the mass is the same, fiber is easier to be burnt and can burn fully in a much shorter time than the coconut shell. As a result, the quantity of energy released by the coconut shell combustion can be much greater than that released by the fiber. Therefore, most people who want to iron with charcoal prefer coconut shell charcoal rather than fiber charcoal of coconut or other light materials like the charcoal of mango tree (Hasan, E. S., Jahiding, M., Mashuni, Ilmawati, W. O. S., Wati, W., & Sudiana, I. N., 2017).

Analytical statistics Tables 4.10 show the results of connection among the adhesive materials (sago and starch) and the caloric formed by briquettes. The strength of the relationship between starch adhesive compositions and calorific value of coconut shell charcoal briquettes formed could be noticed in Table 2.0. The value of r square is 0,850, this implies the increase in composition of starch adhesive affected the period of combustion caloric of briquettes by 85 %, which indicates the rise in the composition of starch adhesive influenced the caloric of briquettes combustion of briquettes by 85%. The values oft-count and significance which are 147.297 and 0.00 respectively prove the results of the test. The higher the levels pf adhesive, the lower the heat produced

The same manner would go for the effect of sago adhesive composition on the caloric of briquette combustion, as shown in Table 2.0.Both the sago concentration data and the caloric data are normally distributed (where the values of sago concentration significance are 1 and it is 0.973for the caloric data), and both are greater than 0.5, as shown in Table 2.0.With a correlation of 0.866 and a significance of 0.00, this correlation is very appropriate. The determination coefficient value (r Square = 0.750) indicates that briquette concentration is responsible for 75%of the rise in the combustion of briquettes.

Table 11. Tapioca and Sago Concentration as Adhesives Statistical Analysis Results of Measurements Briquette Calor Produced (kcal)

Adhesive	Aspects	Value	Results	Aspect	Value
Sago	N Test:Sago concentration Sig.	1.00	Normal	Pearson Cor.	0.980
	Calorific Sig.	0.997	Normal	Sig.	0,00
	R Square	0.953		tCal. Sig.	16.61 0.00
Tapioca	N Test: Tapioca concentration Sig.	1.00	Normal	Pearson Cor.	0.922
	Calorific Sig.	0.933	Normal	Sig.	0.00
	R Square	0.850		tCal. Sig.	147.29 0.00

Results of Measurements BriquetteCalor Produced (kcal)

In addition, the data indicated by Table 11. that in the production of briquettes there is no distinction between sago and starch as an adhesive in terms of the properties of briquettes. Those properties such as density, duration of combustion, ash content, and the caloric created by briquettes, where the value of t-test significance is 0.00, and the value of r square for starch is 0.850 and the value is 0.750 for sago, not a large difference.

The effect of the adhesive and the form of adhesive on the calorific value can be seen in Figure 4.9. Briquettes with a sago adhesive content of 1% - 2% noticed an increase. Briquettes calorific value made with sago adhesives represents 6673.0505 cal/gram, while the briquettes calorific value made with sago adhesives represents 6802.7761 cal/gram. Furthermore, the briquettes calorific value made with sago adhesives represents 2%, which is the highest of any calorific value. Sago adhesive, on the other hand, has a lower calorific value than starch adhesive. The amount of ash in the briquettes affects it as well. The presence of ash in briquettes will lower their calorific value. Sago adhesive has a greater ash content compared to starch adhesive. As a result, the calorific value of such briquettes is varied too.The higher the gluten content, then the higher density and the time of burning briquettes

IV. Discussion

Coconut shell charcoal was activated with a 1 M HCl solution, then it was neutralized by NaOH and aqueduct to produce activated carbon. As HCl is a strong acid solution and has a minimal composition (in this case 1 M), it can widen the charcoal pores, allowing the particles in the mixture to be absorbed effectively. After being neutralized and purified, the powder of charcoal was baked for two hours at 110°C to eliminate any remaining water, resulting in powdered activated carbon (powder). (Hasan, E. S., Jahiding, M., Mashuni, Ilmawati, W. O. S., Wati, W., & Sudiana, I. N., 2017).

The adsorption of Cr (VI) to activated carbon was measured by adding up 2 % to 8% of activated carbon into 50 ml Cr (VI) 50 ppm solution and it was shaken for about 90 minutes. After that, the solution was centrifuged at 6000 rpm. Then the filtrate solution from centrifugation products was extracted using activated carbon, which settled in centrifuge tubes bottom, and it was then analyzed by an Atomic Absorption Spectrophotometer (AAS) at 357.9 nm.(Hasan, E. S., Jahiding, M., Mashuni, Ilmawati, W. O. S., Wati, W., & Sudiana, I. N., 2017).

Table 3 shows the measurement results of activated charcoal coconut shell adsorption against Cr (VI) ion mixture with different adhesive compositions. As shown in Table 3., the highest adsorption capacity of coconut shell activated carbon to Cr (Vi) was 0.549 mg/g at an adhesive 16 percent concentration, with a Cr(Vi) absorbed concentration of 11.007 ppm and a percentage adsorption power of 22.150 %. The lowest capacity of adsorption was 0,365 mg/g, which corresponds to a 4 % adhesive concentration, a 7.314 ppm ion Cr (Vi) adsorbed concentration, and 14.630 % adsorption power. The addition of adhesive at higher concentrations reduces calorific value instead. This is because an increase in the volume of adhesive causes the decline of fixed carbon. Thus, it is necessary to determine the optimum composition of the adhesive to obtain the maximum calorific value (Hasan, E. S., Jahiding, M., Mashuni, Ilmawati, W. O. S., Wati, W., & Sudiana, I. N., 2017).

Previous studies done by Babich and Fernandex, (2010) and Allwar, (2015), make analysis that focused on the charcoal in metallurgy is intimately linked to small blast furnaces, and the use of charcoal in coke-making and ironmaking has been investigated. But they did not make any improvement in the coconut shell as raw materials in improving the charcoal drying process and quality of coconut coal.

So this study solves the problems. Based on the analysis above, there are improvements in this coconut shell as raw materials and enhanced charcoal made of coconut shell with controllable convective drying. The characterization of the briquettes according to the sorption capacity of Cr io.

V. Conclusion

The goal of the research was achieved by solving the problem involved in the previous studies are the gluten (starch starcharch) concentration has an important effect on the rise in density, ash cont,ent and burning of briquettes of the coconut shell. The higher the gluten content, the more density, the amount of as,h, and the time burned. The heat produced by burning the cocoa shell charcoal briquette has considerably affected the adhesive levels. The higher the adhesive level, the lower the heat. As an adhesive briquet, there is no significant difference between NetWorm and maize starch on the properties of the Briquettes. coconut shell (density, ash content, the time of burning, and the produced of calories). Cr is quite efficient in adsorbing active coconut shell charcoal, which activates with 1 M HCl (Vi).

References

[1]. Alleman, B. (2013).Remediation option for metal-contaminated sites. Boca Raton, FL: Lewis.

[2]. Allwar, A. (2015). Production of Activated Carbon from Coffee Grounds Using Chemical and Physical Activation Method. Journal of Physical Science 19, 93.

[3]. Anem,J.(2014). Utilization of Coconut Shell Waste into Coconut Shell. Journal of Development, No. 1, Vol 3.

[4]. Arsad and Hamdi, (2010). Technology For The Processing And Utilization Of Active Carbon For Industry. Journal of Forest Products Industry Research, Vol. 2 No 2.

[5]. Arena, Noemi , Lee, Jacquetta, dan Clift, Roland. (2016). Life Cycle Assessment of activated carbon production from coconut shells. Journal of Cleaner Production.

[6]. Arni et al. (2014). Comparing fire-history interpretations based on area, number, and estimated volume of macroscopic charcoal in lake sediments. QuaternaryResearch, 72, 462–468.

[7]. Arsad, E., & Hamdi, S. (2010). Technology for processing and utilizing activated carbon for the industry. Journal of Forest Industry Research.

[8]. Axtell, B. (2002). Drying food for profit: A guide for small business. (Ed.). London: Intermediate Technology Development Group Publishing Ltd. P.85-103.

[9]. Babich, Alexander, Dieter Senk, Miguel Fernandez. (2010). Charcoal Behaviour by Its Injection into the Modern Blast Furnace. https://www.jstage.jst.go.jp/article/isijinternational/50/1/50_1_81/_article

[10]. Barlina,R., & Install, PM. (2009). Processing and Storage of Dried Coconut (Dry Grated Coconut). Retrieved from http://balitka.litbang.pertanian.go.id/ monograph-post-harvest-coconut-35-processing-and-storingandesiccated-coconut-kelapa-parutkering /

[11]. Buck, et. al. (2018). The value of forests to world food security. Human Ecol, 25:91-120.

[12]. Chen, et al. (2018).Ecosystem carbon stock of a tropical mangrove forest in North Sulawesi, Indonesia.

[13]. Gafur, Abdul. (2017). The effect of two stage gasifying agent on biomass downdraft gasification to the gasifier performance. AIP Conference Proceedings.

[14]. Hadi, R.(2011). Socialization techniques coconut shell activated charcoal combustion air supply system controlled. Bulletin of Agricultural Engineering, vol 16 no 2.

[15]. Hartanto, S. (2010). Making Activated Carbon from Oil Palm Shell with Chemical Activation Method. Indonesian Journal of Materials Science.
[16]. Hartanto, Feri Puji and Fathul Alim. (2010). Optimization of Husk Pyrolysis Conditions Rice To Produce Bioarang Briquette Fuel As Material Alternative Burn. Department of Chemical Engineering. Faculty of Engineering. Diponegoro University.
[17]. Hasan, E. S., Jahiding, M., Mashuni, Ilmawati, W. O. S., Wati, W., & Sudiana, I. N. (2017). Proximate and the Calorific Value Analysis of Brown Coal for High-Calorie Hybrid Briquette Application. Journal of Physics: Conference Series, 846(1).
[18]. Hendra, D. (2007). The manufacture of activated charcoal from the waste of central wood logging using semi-pilot scale production technology. Journal of Forest Products Research 25 (2).
[19]. Ichsani, D., Dyah, W.A. (2002). Design and experimental testing of a solar dryer combined with the kerosene stoves to dry fish. American Society of Agricultural and Biological Engineering, 1-3.
[20]. Jamilatun. (2008). Ignition and Combustion Properties of Biomass Briquettes, Coal Briquettes, and Wood Charcoal. Process engineering journal. https://doi.org/10.22146/jrekpros.554
[21]. Jeswani, Harish & Burkinshaw, Richard & Azapagic, Adisa. (2015). Environmental sustainability issues in the food–energy-water nexus: Breakfast cereals and snacks. Sustainable Production and Consumption. 2. 10.1016/j.spc.2015.08.001.
[22]. Lempang, M. (2014). Production and Use of Activated Charcoal. EBONI Technical Info. volume 11 No. 2. December 2014. Pages : 66 and 71.
[23]. Li, Y., Shao, J. Wang, X., Deng, Y, , Yang., H, Chen H. (2015). CHaracterizataion of modified blochars derived brom bamboo purolusis and their utilization for target component abstoprtion. EnergyFuels. 28 (8), 5119-5127
[24]. Marsh, Harry. and Francisco Rodríguez Reinoso. (2016). Activated Carbon, Elsevier Science.
[25]. Maryono, Sudding and Rahmawati. (2013). Briquette Manufacturing and Quality Analysis Coconut Shell Charcoal in View of Kanji content. Makassar. Department of Chemistry FMIPA, State University of Makassar.
[26]. Musabbikhah, Saptoadi, H., Subarmono, & Wibisono, M. A. (2016). Optimization of temperature and time for drying and carbonization to increase calorific value of coconut shell using Taguchi method. AIP Conference Proceedings, 1717.
[27]. Ndraha, Taliziduhu, (2010). Introduction to the theory of Human Resource Development, Rineka Cipta, Jakarta
[28]. Palungkun, (1999). Successful Breeding of Lumbricus rubellus Earthworms. Jakarta: Self-Help Spreader.
[29]. Pari, Djeni Hendra and Ridwan, A Pasaribu. (2012). Forest Products Research and Development Center). Increasing the Qualities of Activated Charcoal from Mangium Bark. Journal of Forest Products Research
[30]. Priyanto, E., & Putri, S. L. (2017). Bio-briquettes Innovation Co-FES (Coconut Fiber and Egg Shell) as the Eco-Friendly Fuel with Pressure Giving Methods for Indonesian Energy Fuels Challenge, 403–410.
[31]. Qin, Linbo & Han, Jun & Ye, Wei & Zhang, Shun & Yan, Qiangu & Yu, Fei. (2014). Characteristics of Coal and Pine Sawdust Co-carbonization. Energy & Fuels. 28. 848–857. 10.1021/ef401942a.
[32]. Riyanto, & Ramadhan, B & Wiyanti, Defi. (2018). Treatment of Waste Lubricating Oil by Chemical and Adsorption Process Using Butanol and Kaolin. IOP Conference Series: Materials Science and Engineering. 349. 012054. 10.1088/1757-899X/349/1/012054.
[33]. Robert Dürr, Andreas Bück. (2020) Influence of moisture control on activity in continuous fluidized bed drying of baker’s yeast pellets. Drying Technology 0:0, pages 1-6.
[34]. Rodrigues, T. and Aldo Braghini Junior. (2019). Charcoal: A discussion on carbonization kilns. Journal of Analytical and Applied Pyrolysis 143 (2019) 104670.
[35]. Sahu, Jaya & Acharya, Jyotikusum & Meikap, B. (2010). Optimization of production conditions for activated carbons from Tamarind wood by zinc chloride using response surface methodology. Bioresource technology. 101. 1974-82. 10.1016/j.biortech.2009.10.031.
[36]. Sudrajat and Pari, (2011). Active charcoal and its future. Forestry research and development service.
[37]. Siregar, (2010). Effect Of Charcoal Application On The Early Growth Stage Of Acacia mangium and Michelia montana. Indonesia Journal of Forestry Research. DOI: 10.20886/ijfr.2007.4.1.19-30
[38]. Subha, R. & Namasivayam, C.. (2009). Zinc chloride activated coir pith carbon as low cost adsorbent for removal of 2,4-dichlorophenol: Equilibrium and kinetic studies. Indian Journal of Chemical Technology. 16. 471-479.

[39]. Sudding and Jamaluddin. 2016. The Processing Of Coconut Shell Based On Pyrolysis Technology To Produce Reneweable Energy Sources. Proceedings of ICMSTEA 2016 : International Conference on Mathematics, Science, Technology, Education, and their Applications, Makassar, Indonesia, 3rd – 4th October 2016

[40]. Tahir, Moh. 2013. DESIGN AND TEST OF DRYING SYSTEM AND DRYING CHARACTERIZATION OF LEADING COMMODITIES OF GORONTALO REGION. RESEARCH REPORT

[41]. Utomo, 2013).Efforts to Increase Productivity and Rendement of Sugarcane in Pg Bone, Camming and Takalar Based on Waste Utilization.

[42]. Wijayanti (2009). Sugarcane Dregs Activated Charcoal As Adsorbent In Purification Used cooking oil. Bogor: Faculty of Mathematics and Science Natural. Bogor Agricultural Institute.

[43]. Yatagai et al, (2016). Cesium adsorption from aqueous solutions onto Japanese oak charcoal I: effects of the presence of group 1 and 2 metal ions. Journal of Wood Science. 60. 473-479. 10.1007/s10086-014-1431-1.

[44]. Yokoyama and Matsumura.(2008).Asian biomass handbook. Journal of the Japan Energy Institute, Tokyo, Japan.

[45]. Zaid, K.C., et al. (2013). Activated Carbon: Water Quality Improvement Solutions. American Water Works Association. Pages : 3..

Omar Ali Mohammed Ali, et. al. "Quality Improvement of Charcoal Briquette from Modified Coconut Shell as a Solid Fuel Source with the Starch Adhesive." *IOSR Journal of Engineering (IOSRJEN)*, 11(10), 2021, pp. 01-14.