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Manufacture of hyacinth and coconut shell charcoal as a renewable fuel

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Abstract
The purpose of this study was to obtain briquettes with calorific value, compressive strength and combustion rate from briquettes made from a mixture of water hyacinth charcoal and coconut shell with starch adhesives. The making of briquettes using a mixture of water hyacinth and coconut shell charcoal is carried out by the pyrolysis process using a furnace, printing, and pressing briquettes using a briquette printer in the form of a box of a certain size. Determination of the quality of briquettes was carried out based on the proximate analysis method, namely by determining the water content, ash content, evaporating content, compressive strength test, and determination of calorific value. Briquette making mixes water hyacinth and coconut shell charcoal. In various variations, the comparison between the production of water hyacinth and coconut shell briquettes is made with variations of 1:1, 2:1, and 3:1. Proximate analysis data shows that the water content of a mixture of water hyacinth and coconut shell briquettes is 3.60-7.36%, ash content 5.05-7.28%, volatile substances 50.77-66.35%, compressive strength of briquettes 0.89-5.97 MPa and combustion heating value 4,922-6,237%.

Keywords: briquettes, water hyacinth, coconut shell, fuel

Introduction
Human needs continue to increase in the use of energy so we must anticipate by creating new alternative energy that can also be used as energy reserves, beyond our dependence on energy which has been supplied by the state. This alternative energy search will ease the burden of the country because it can reduce the amount of energy needed by the state. The depletion of fossil fuels that have been used as a producer of energy so far, are looking for alternative other equipment that can produce energy without using fossil fuels.

In addition, the impact of using fossil fuels that produce carbon monoxide (CO) gas, is not good for life, and the surrounding natural environment. In addition, with the increase in the price of petroleum in the global market, making the price of petroleum as the public consumption is the largest, rare, and expensive in the market. In addition, another problem faced by Indonesian society with increasing population is the increasing production of waste.

Human efforts to find resources for this source must be based on raw materials that are easy to obtain, are renewable and their products are easily used by all humans. The recent fuel crisis has shown that fuel consumption has reached a fairly high level (Arif, 2013) [1].

This increase in fuel use and depletion of oil reserves is one of the reasons that is serious about finding alternative energy sources that can be delivered. One way to overcome the problem of fuel consumption is to make alternative fuels in the form of charcoal briquettes by utilizing organic waste (coconut shell and water hyacinth). Coconut shell briquettes and water hyacinth can be an alternative fuel for various purposes. Shell briquettes are preferred because they have an energy of 7,340 calories and water hyacinth 3,207.90 calories have met SNI standards to produce higher heat than ordinary wood charcoal briquettes. Aside from being an alternative fuel, it turns out that coconut shell charcoal and water hyacinth also hold even higher economic value (Iriany *et al*. 2016) [3].

The coconut shell and water hyacinth used as charcoal can be increased in economic value by making charcoal briquettes. How to make activated charcoal from coconut shells and water hyacinth is also relatively easier and Indonesia is a country rich in coconut and water hyacinth plants. Coconut (Cocos nucifera L.) is one of the agricultural commodities as well as a very potential industrial crop and has a very important role both in terms of nutrition and economy for the Indonesian population, especially in North Sulawesi. Water hyacinth (Eichhornia Crassipes) is a plant that is easily found living in swamps or rivers/lakes in various regions in Indonesia, especially those in North Sulawesi on Lake Tondano.

In North Sulawesi, especially in Lake Tondano, it is overgrown with water hyacinth, which has become a threat to living things in the water. Decreasing the amount of light entering the waters causing a decrease in the level of solubility of oxygen in the water and can increase evapotranspiration (evaporation and loss of water through the leaves of plants), because of the wide leaves and rapid growth. The dead water hyacinth plant will descend into the bottom of the water so that it accelerates the silting process of the lake.

Research Methods
Manufacture of charcoal
The raw material of water hyacinth and coconut shell is dried first and then chopped into small pieces. Water hyacinth and coconut shell are included in the pyrolysis tool. The pyrolysis process is allowed to last for 6 hours. Then the charcoal is cooled

Manufacture of charcoal briquettes
Water hyacinth charcoal and coconut shell produced by

pyrolysis are crushed with mortar to be made as charcoal powder. The charcoal powder is sifted using a 40 mesh size sieve, Then the weight of water hyacinth and coconut shell are varied, namely 1: 1, 1: 2, 1: 3, 2: 1 and 3: 1. After being varied, water hyacinth and coconut shell are mixed with starch adhesive as much as 10% of the weight of the raw material. Then the mixture is printed using a briquette press with a compressive strength of 1 ton/cm^2. Printed briquettes are dried and analyzed for their characteristics.

Analysis Phase

Heating value

Calorific value testing will refer to the ASTM D240 standard, used Bomb Calorimeter equipment. The heat absorbed by water in the calorimeter bomb is calculated using the formula:

$$Q = m.Cp.\Delta T$$

Where:
Q: Heat absorbed (kJ)
m: Water mass in bomb calorimeter (gram)
Cp: Specific heat 4,186 kJ / kg^{o}C
T: Temperature difference (^{o}C)

Ash (Ash) (AOAC. 1970) The 1 gram sample mass is heated to a temperature of 750℃ with a heating rate of 3.3℃ / minute and a holding time of 120 minutes. The calculation formula according to ASTM D-3174-04 can be seen in the following equation:
Ash content = d / a x 100%

Information
a = sample mass after heating in grams
d = briquette mass (gram) after being heated at 750℃

Water content (AOAC. 1970)
The sample will be heated for 1 hour with a temperature of 107 ℃, the initial mass of sample (a) is heated in a drying oven until there is no change in mass (b), then moisture content (m) can be calculated using ASTM-D 3137-03:
moisture content = (a-b) / ax 100% information:

a = initial sample mass
b = final sample mass

Volatile substances

Volatile matter is one of the substances that comes out of a solid fuel that is burned in addition to water that becomes steam. The more volatile matter content in solid fuels, the more flammable and flammable, the faster the combustion rate. I gram of sample is heated to reach a temperature of 950 ℃ with a holding time of 10 minutes, the condition of the furnace without oxygen. The calculation formula uses ASTM D 3137:

$$\text{Volatile matter (\%)} = ((B-c) / B) \times 100$$

Where:
c = mass down in percent (%)
b = sample mass after heating

Compressive strength test (Ahmad, 2009) Measurement of mechanical compressive strength was carried out using a Force gauge tool. Compressive strength testing can be calculated by:

$$\tau = F / A$$

Where:
τ = compressive strength (N / mm2)
P = maximum / force load (N)
A = cross-sectional area (mm2)

Burn rate test (M. Alif, 2014). The briquette combustion rate is calculated by the weight of the briquettes that have been ignited divided by the time of combustion until the briquettes are burned or become ash
Burning rate of briquette = (briquette weight (g)) / (time until briquette is finished (s))

Results and Discussion

Pyrolysis of Water Hyacinth Charcoal

The manufacture of water hyacinth charcoal is done by pyrolysis using a pyrolysis furnace. The pyrolysis process of water hyacinth charcoal lasts for 6 hours. The pyrolysis temperature can be read at a maximum of 450 ℃. In the pyrolysis process, the gas / smoke produced through the condenser and the distillate is collected in the connecting container (connecting bottle).
Pyrolysis of 5 kg of water hyacinth produces liquid smoke as much as 0, 2 kg (2%) and besides that it also produces gas that cannot be captured which cannot be melted (non-condensable gas). Unrealized gas is estimated at 0.5 kg (5%). Water hyacinth charcoal produced in the pyrolysis process is shown in Figure 4.2 and subsequently for the process of making briquettes while liquid smoke is not used in this study.

Pyrolysis of Coconut Shell Charcoal

Coconut shell pyrolysis of 5 kg produces liquid smoke of 2.2 kg (22%), tar 0.9 kg (9%) and charcoal 5.4 kg (54%) and also produces gas that cannot be captured or cannot be liquidate at an estimated 1.5 kg (15%). Shell charcoal is cooled for 24 hours and removed from the pyrolysis device.

Smoothing and sifting the charcoal from pyrolysis

As much as 5 kg of charcoal from water hyacinth and coconut shell then pounded until smooth. Then sifted using a 40 mesh sieve. Sifted charcoal is put into a plastic bag and stored.

Charcoal Briquette Making

As much as 5 kg of each water hyacinth charcoal and coconut shell are ground until smooth. After that, water hyacinth and coconut shell charcoal are sifted using a 40 mesh sieve. Water hyacinth and coconut shell charcoal are mixed with starch adhesives. Starch adhesives are made by heating 20 grams of starch with 250 ml of water. At 70 ℃ until it forms a gel. The starch adhesive that has formed a gel is mixed with charcoal to form a flat mixture.

Briquette Printing

Water hyacinth and coconut shell charcoal mixed with amylum adhesive are placed in a cuboid mold with a height of 4 cm and a width of 4 cm, then compacted with hand power.

Drying of Briquettes

The printed briquettes are then dried under the sun for 7 days. After drying for 7 days, the dried briquettes are then removed from the briquette mold.

Briquette Quality Analysis

Testing the water content of mixed briquettes from water hyacinth charcoal with coconut shell based on ASTM D-3137-03. Based on the results of analysis and calculations, the water content of the mixture of water hyacinth and coconut shell charcoal is shown in Table 4.1.

Table 1: Water content of charcoal briquettes mixed with water hyacinth and coconut shell charcoal

Mixed Briquettes EG:TK	Water content (%)	Mixed Briquettes Tk :eg	Water content (%)
A (1:1)	4.02	D (1:1)	4.02
B (2:1)	7.36	E (2:1)	6.57
C (3:1)	3.60	F (3:1)	6.09

Based on the water content data in table 4.1 shows that the water content of briquettes A, B and C, which is a mixture of water hyacinth with coconut shell ranges from 3.60-7.36%. The lowest water content with a value of 3.60%. Obtained from C briquette, which is a mixture of water hyacinth and coconut shell charcoal briquettes (3: 1) while the highest water content with a value of 7.36% is obtained from briquette B, which is a mixture of water hyacinth charcoal with coconut shell charcoal (2: 1)

The water content of D, E and F briquettes, namely the mixture of coconut shell and water hyacinth briquettes ranges from 4.02-6.57%. The lowest water content with a value of 4.02% is obtained from coconut shell mixed briquettes with water hyacinth charcoal (1: 1). While the highest water content with a value of 6.57% is obtained from E briquettes, which are coconut shell charcoal briquettes with water hyacinth charcoal (2: 1).

The difference in water content of each briquette can be caused by the composition of mixed briquettes from water hyacinth charcoal and coconut shells which are not the same. The higher the composition of the mixture of water hyacinth charcoal the water content of briquettes A, B, C increases. Similarly, the water content of the briquettes D, E, F increases when the amount of coconut shell charcoal composition is higher. The high and low water content of each briquette can be caused by the surface area of the water hyacinth coconut shell which is not the same. Large surface area allows evaporation of water more quickly than charcoal with a smaller surface area.

Water content in briquettes greatly affects the heat value produced. The high water content will cause a decrease in calorific value. This is because the heat stored in briquettes is first used to remove the water before producing heat which can be used as burning heat (Hendra, 2000). The expected water content is as low as possible so that it can produce a high calorific value and will produce flammable briquettes.

Testing the ash content of mixed briquettes from water hyacinth charcoal with coconut shell based on ASTM D-3174-04.

The results of the analysis and calculations carried out that the ash content of the mixture of water hyacinth charcoal and coconut shell charcoal is shown in Table 4.2

Table 2: The level of briquette ash mixed with water hyacinth and coconut shell

Mixed Briquettes EG:TK	Ash Content (%)	Mixed Briquettes TK :EG	Ash Content (%)
A (1:1)	6.15	D (1:1)	6.15
B (2:1)	7.28	E (2:1)	8.1
C (3:1)	5.05	F (3:1)	7.2

Based on the ash content data in table 4.2, it shows that ash content A, B, C is a mixture of water hyacinth briquettes with coconut shell ranging from 5.05-7.28%. the lowest ash content with a value of 5.05% is obtained from C briquettes, namely water hyacinth charcoal briquettes with coconut shell charcoal (3: 1). While the highest ash content with a value of 7.28% was obtained from briquette B, which is a mixture of water hyacinth briquettes with coconut shell (2: 1). D, E, F ash content of briquettes, which is a mixture of coconut shell and water hyacinth, ranges from 6.15 to 8.1%. The lowest ash content with a value of 6.15% is obtained from D briquettes, which are coconut briquettes and coconut water hyacinth mixture briquettes (1: 1), while the highest ash content is 8, 1% is obtained from E briquettes, namely coconut shell charcoal and charcoal briquettes water hyacinth (2: 1). The difference in the ash content of each briquette can be caused by the composition of mixed briquettes from water hyacinth charcoal with coconut shell charcoal that is not the same. Data shows that the ash content of briquettes A, B and C is higher if the amount of water hyacinth charcoal is increasing, but conversely if the amount of coconut shell charcoal is higher then the ash content of the briquettes D, E and F is getting smaller. In general, the high and low ash content of briquettes depends on the purity of charcoal or the quality of coconut shell charcoal and the quality of water hyacinth charcoal. Besides that, the greater the ash content of food briquettes fuel can be predicted the amount of silica content in charcoal is quite a lot or vice versa.

One element of ash content is silica and the effect is not good on the calorific value that will be produced. The lower the ash content, the better the quality of the briquettes that will be produced. According to Jamilatun (2011), the ash contained in solid fuels is minerals that cannot be burned and left behind after the combustion process and the accompanying reaction. The ash content produced is also very close to the type of the briquette constituent and how to make it.

Based on the results of table 4.2, it shows that the briquette ash content of mixtures A, B, C, D and F is smaller or equal to 8%, meaning that the briquettes can meet briquette quality standards based on SNI No.1 / 6235/2000. The level

of E briquette ash is greater than 8% so the briquette does not meet the briquette quality standards that are allowed.
The smaller the ash content of the briquettes produced the better the quality of the briquettes. Briquettes with high ash content are very unfavorable because they will form a crust. The higher the ash content, the more difficult the flame from briquettes and high ash levels can reduce the heating value of the briquettes.

Testing the levels of volatile substances of mixed briquettes from water hyacinth charcoal with coconut shell based on ASTM D-3175-02.

The results of the analysis and calculations carried out that the levels of volatile substances from mixed briquettes of water hyacinth and coconut shell charcoal are shown in Table 3

Table 3: Levels of volatile substances, mixture of water hyacinth and coconut shell charcoal

Mixed Briquettes EG:TK	Content of volatile substances (%)	Mixed Briquettes TK :EG	Content of volatile substances (%)
A (1:1)	66.35	D (1:1)	80.96
B (2:1)	50/88	E (2:1)	89.65
C (3:1)	50/77	F (3:1)	87.04

Based on data table 4.3. shows that the highest level of volatile substances is E briquette which is 89, 65%, while the lowest volatile substance of 50.77% briquette is C. briquette The level of volatility will be smaller if a high temperature pyrolysis process is carried out. According to Hendra (2000), high levels of volatility will reduce the quality of briquettes because with so many volatile substances, the carbon content gets smaller so that the resulting heat value is lower and will cause a lot of smoke produced from combustion.
The level of volatile substances produced by D, E and F briquettes is between 80.96-89.65%. The highest level of volatile substances is E briquette which is 89.65%, while the smallest level of volatile substances is D briquette which is 80.96%. The high volatile content in briquettes will cause more smoke when the briquettes are turned on. The higher the volatile substance, the easier it will burn and the faster the rate of combustion (Wahyu, 2012). Based on the results of the research, the levels of volatile substances from each briquette have met the quality standards of briquettes based on Permen ESDM No.47 / 2006 in accordance with the raw materials.

Testing of compressive strength of mixed briquettes from water hyacinth charcoal with coconut shell.

The results of the analysis and calculations carried out that the compressive power of the mixture of water hyacinth charcoal and coconut shell charcoal is shown in Table 4.

Table 4: Compressive strength testing of water hyacinth and coconut shell briquettes

Briquettes	Power Press (MPa)
1:1	5.97
2:1 (ET)	0.89
3:1 (ET)	5.18
2:1 (TE)	1.03
3:1 (TE)	1.88

Briquette compressive strength is the ability of briquettes to provide the durability of briquettes against the breakage or destruction of briquettes if given a load on these objects. The higher the compressive value of charcoal briquettes means the better resistance to rupture (Triono, 2006). Determination of briquette compressive strength aims to determine the durability for packaging and facilitate the transportation of charcoal briquettes.
The lowest compressive strength is found in the composition 2 : 1 (water hyacinth and kalapa shell) which is 0.89 MPa while the highest compressive strength value is in the composition 1: 1, which is 5.97 MPa. From table 4.4 it can be seen that the briquettes for the composition of water hyacinth have a low compressive value compared to the coconut shell. In the compressive strength test for all composition of water hyacinth and coconut shell charcoal briquettes.

Rate Testing Combustion of mixed briquettes from water hyacinth charcoal with coconut shell.

The results of analysis and calculations carried out that the combustion rate of a mixture of water hyacinth and coconut shell charcoal briquettes is shown in Table 5.

Table 5: The rate of combustion of water hyacinth and coconut shell briquettes

Mixed Briquettes EG:TK	Value of combustion rate	Mixed Briquettes TK:EG	Value of combustion rate
1:1	0.0035	1:1	0.0039
2:1	0.0030	2:1	0.0037
3:1	0.0032	3:1	0.0035

Based on table 4.5. It can be seen that the lowest combustion rate in the ratio of water hyacinth and coconut shell 2 : 1 is 0.0030 while the highest combustion rate is obtained at comparison 1 : 1 which is 0.0039 This is due to the resulting density value so that the briquettes last longer.
The combustion rate is influenced by the density of a briquette, where the more tightly a briquette is, the burning rate is longer or longer when burned, because the more tightly a briquette is, the air cavity becomes less or more difficult through oxygen in the combustion process.

The results of this study also show that the more coconut shells in the briquettes, the longer the combustion time so that the burning rate is smaller. This is because the coconut shell has a higher heating value and greater density than water hyacinth, where the higher the calorific value the longer the combustion time.

Calorific Value Test of mixed briquettes from water hyacinth charcoal with coconut shell Parr Adiabatic Bomb Calorimeter method

Based on the results of the calorimeter bomb analysis, it was conducted that the heating value of mixed briquettes from water hyacinth and coconut shell charcoal is shown in Table 6.

Table 6: Heat value of briquettes mixed with water hyacinth and coconut shell charcoal

Mixed Briquettes EG:TK	Heating value (kal/gr)	Mixed Briquettes EG:TK	Heating value (kal/gr)
A (1:1)	5.248	A (1:1)	5.248
B (2:1)	4.922	B (2:1)	5.840
C (3:1)	5.303	C (3:1)	6.237

Based on table 4.6 data, it shows that the heating value of water hyacinth mixture briquettes with coconut shell charcoal A, B and C which ranges from 4,922-5,303 Cal / gr. The calorific value of 4,922 kal / gr is obtained from B briquettes, namely the mixture of water hyacinth briquettes and coconut shell (2 : 1). The decrease in the value of mixed briquettes may be due to the high ash content of briquettes. The high ash content can affect flame and decrease the calorific value. The heating values of D, E and F briquettes, which are mixed coconut shell and water hyacinth briquettes, range from 5.175-6.237 kal / gr. The decreasing calorific value of the mixed briquettes, besides being caused by the high ash content of briquettes, may also be caused by the low purity of charcoal, which still contains many organic impurities such as tar. The low purity of carbon can affect the quality of briquettes, namely reducing the heating value of combustion. Sometimes ash in solid fuels that cannot burn minerals are left behind after the combustion process and accompanying reactions. The ash content produced is also very closely related to the type of briquette constituent and how to make it (Jamilatun, 2011). The calorific value needs to be known in the manufacture of briquettes, because to know the heating value of combustion that can be produced by briquettes as fuel. The higher the calorific value produced by briquette fuel, the better the quality. The addition of water hyacinth charcoal composition on briquettes A, B and C or the addition of coconut shell charcoal composition to the briquettes D, E and F causes a decrease in the heating value of the briquettes. But the heating value of combustion of each briquette is high enough so that only briquette B which has a briquette combustion heating value from the SNI briquette quality standard is 5000 cal / gr.

Conclusion

From the results of research on making briquettes from a mixture of water hyacinth and coconut shell charcoal, it can be concluded that:

1. Charcoal from water hyacinth and coconut shell can be made briquettes using a mixture of starch adhesives.
2. The temperature of pyrolysis and the amount of adhesive affect the heating value of briquettes.
3. The results of the analysis of the quality of the mixture of water hyacinth and coconut shell briquettes turns out that briquettes A, B, C, D, E, F are quality briquettes because they have met briquette quality standards recommended by SNI.
4. The heating value of a mixture of water hyacinth and coconut shell briquettes is 4,922-5,303 Kal / gr while the mixture of charcoal briquettes at coconut shells and water hyacinth is 5,175 - 6,237 kal / gr.
5. The biggest compressive strength of briquettes is briquette A, which is a ratio of 1: 1 (5.97 MPa).

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