CAPACITIES OF WOOD CHARCOALS IN SOUTH KALIMANTAN IN PRODUCING ENERGY FOR HOUSEHOLDS

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ABSTRACT

At the end of the twentieth century, experts realized the impacts of the increasing use of pretrolium when its supply inevitably decreased. Cinnamon and other wood types such as alaban and candlenut are known as the wood types that are good enough to be used as the raw materials for charcoals. The objective of this study was to find out the quality of charcoals made from cinnamon wood, candlenut shell, alaban wood, and acacia wood in their capacities to produce energy primarily for domestic use. The method was to compare the capacity of 1 kg of charcoal with the capacity of 1 liter of kerosene poured into the Hock stove with 16 wicks to produce energy. The tests were carried out at the Laboratory of the Institute for Research and Standardization of Industry, Banjarbaru. The analysis of the respective physical and chemical properties of the charcoals indicated that the water contents of cinnamon wood, candlenut shell, alaban wood, and acacia wood charcoal were 0.66%, 1.15%, 0.69%, and 0.61%; ash 2.37%, 3.62%, 2.57%, and 0.48%; volatile matter 23.94%, 35.35%, 29.65%, and 42.61%; fixed carbon 73.69%, 61.03%, 70.48%, and 56.91%; and calorific value 7591.84 cal/g, 5649.70 cal/g, 7008.59 cal/g, and 6280.76 cal/g. After burned, the cinnamon wood charcoal gave the highest maximum temperature of 235°C with the burning duration of 50', alaban wood 216°C with the burning duration of 1 hour 10', acacia wood 195°C with the burning duration of 1 hour 8' and candlenut shell 175°C with the burning duration of 36'. The time required to boil 1 liter of water for cinnamon wood charcoal was 5', alaban wood 6'30", acacia wood 7'30", and the candlenut shell 8'59". When compared with the use of kerosene for Hock stove with 16 wicks, and converted into economic value, the 3 types of wood charcoals, namely cinnamon, alaban and acacia wood charcoals can be used as the alternative energy sources.

Keywords: Capacity, Wood Charcoal, Energy, Household

INTRODUCTION

Wood as a source of energy does not always get much attention although since the last few years the world has been shaken by energy issues. In the 19th century during the industrial revolution, the world began to use fossil fuels such as petroleum and coal that the charcoal consumption became declined. However, at the end of the twentieth century, experts realized the impacts of the increasing use of very large petroleum when its supply gradually decreased due to its non-renewable nature or in other words the sources of oil and coal would run out at some point. On the other hand, the natural resources in the forms of woods kept increasing.

Wood as fuel is still a significant source of energy in Indonesia at the present time and will be in the future because the supply is sufficient and can be renewed without being limited by time (Sudiyanto, 1978 in Kusasi, K, 1985). However, the development should be in line with the advancement of technology so that the use of wood as a fuel becomes more efficient. Because according Sudrad (1983), wood for fuel has properties that are less favorable, such

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as heterogeneous, having high water content, volominous, spending a lot of smoke, and having high ash content and calorific value.

Charcoal production in Indonesia in general and especially in South Kalimantan has a good prospect and is ideal to be developed, because raw materials in the form of logging waste, wood industrial waste and agricultural waste such as rice husk, straw and bagasse in this area are quite available. The purposes of the utilization of waste in the production of charcoals in Indonesia are to tackle the deficit in firewood production and to make it the source of foreign exchange through exports.

In South Kalimantan, where most of its forests are natural forests, the cinnamon and other wood species such as alaban and candlenut are able to grow well and known as the wood types that are good enough to be used as raw materials for making charcoals. In Souh Kalimantan, alaban wood is solely used as the building material. Cinnamon, in addition to its bark for spice ingredient and herbal remedy by local people, is used as firewood when the tree is no longer productive. The candlenut shell becomes waste after the content of the seed is taken out and used for various purposes, while acacia mangium growing everywhere can be fully utilized as the alternative energy.

Therefore, it is important to consider other beneficial uses of cinnamon wood, candlenut shell, and acacia mangium wood to make them more effective and able to improve people's living standards through small industries that can be carried out by the community. Unproductive cinnamon wood, acacia mangium wood and candlenut shell are processed into charcoals to meet the energy needs.

In this study, alaban wood charcoal was used because most people produced charcoals using alaban wood as the raw material. Alaban wood charcoal was also used as a comparison to the other three types of charcoals for the tests of their qualities and capacities to produce energy.

OBJECTIVE AND BENEFITS

The objective of this study was to determine the quality of cinnamon wood, candlenut shell, alaban wood, and acacia wood charcoals in their capacities to produce energy primarily for domestic use.

The results of this study are expected to be used as considerations in the development of wood charcoals for fuels, especially in their capacities to produce energy for domestic purposes with better quality. Therefore, the making of charcoals from cinnamon wood, candlenut shell, alaban wood, and acacia wood is one of the efforts to increase the utilization of woods that are no longer productive as sources of alternative energy for household purposes. The results are also expected to be able to stimulate / encourage people to use charcoals as the alternative energy amid fuel crisis, and to be a solution to the problems experienced by the society in general.

RESEARCH METHODOLOGY

Place and Time

The study was conducted in two locations. The raw materials for charcoals were collected in Loksado Village, Hulu Sungai Regency, while the processing and testing of some physical and chemical properties of charcoals were carried out at the Laboratory of the Institution for Research and Standardization of Industry, Banjarbaru, South Kalimantan. The burning of charcoal in generating energy was carried out at the Laboratory of Forest Product Technology, Banjarbaru. The study was conducted for one month including the stages of preparation, sample test and measurement, data processing, and result report.

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Materials and Equipment

Raw materials used in this study were cinnamon wood, candlenut shell, alaban wood and acacia wood collected from an area in South Kalimantan.

Equipment used in this study:

a. Charcoaling dome for carbonization process
b. Moister tester to measure water content
c. Bomb calorimeter to measure the calorific value
d. Oven/ furnace to measure volatile matter content
e. Stopwatch to measure time
f. Measuring cup
g. Furnace / Brazier (for charcoaling)
h. Kerosene stove Hock (for comparison)
i. Thermometer to measure the temperature of burning
f. Stationery

RESEARCH METHOD

1. Process of carbonization / Wood Charcoal Processing

a. Preparation of raw materials

Woods were burned inside the furnace dome with a diameter ranging from 10-25cm. The woods did not need to be dried because it would impede the course of the production process. The woods were inserted into the dome in a standing position and arranged as tightly as possible to prevent the wood from becoming ash. The wider the hollow space is, the greater the burning will be. Once all the woods were inserted, the hole of dome was sealed with bricks coated with clay.

b. Process of Charcoaling

All the holes in the furnace were left open first, except for the hole used to insert the woods. Small twigs were put into the burning hole to trigger the initial burning. Those twigs were inserted as deep as possible to accelerate the flame. The fire was allowed to spread into the entire furnace and burned all parts evenly. It was marked by the release of smoke from the furnace which took about 6 hours. After 6 hours, the initial burning hole was gradually closed using bricks until leaving a small hole that was about 6X6 cm. The next step was adjusting the air holes around the dome. When the flame was seen in the first air hole, it must be closed, followed by the other holes until the flame was seen up to the upper holes and all holes were completely closed. If the burning process goes well, after 48 hours the smoke was already thick and contained tar and wood vinegar. At that time, the condenser was installed. After 55 hours, the smoke thinned out indicating the burning process was finished and charcoal inside the dome was well-done. The last step was the process of furnace cooling.

c. Final Process in Charcoal Production

To stop the burning inside the furnace dome, the remaining air holes including chimney were covered. The furnace was then watered evenly to speed up the cooling process. The time needed to make charcoals in the dome cool was about 2 days because the charcoals in the furnace were a lot. In addition to the two day limit, to know the condition of the charcoal in the furnace was by touching the furnace and feeling the temperature inside the dome. If the temperature is normal, not hot anymore, the charcoals have cooled down and ready to be harvested. The ashes were removed from the furnace by opening the hole for inserting the wood that had previously been closed. Once opened, the charcoals were removed carefully so as not to break or to crush them because intact charcoals would be more favorable than broken or split charcoals.

Testing of Physical-Chemical Properties of Charcoal

The observation and measurement of physical-chemical properties of each type of charcoals included the determination of water, ash, volatile matter, fixed carbon, and calorific value content.

a. Determination of water content

The samples of charcoals were crushed and carefully weighed approximately 1 gram (X gram), dried in an oven at 103°C for about 2 hours, and then weighed (Y gram).

The percentage of water content was calculated by the formula:

$$\% \text{ Water} = X - Y / Y \times 100\%$$

X = weight of sample before drying (g)

Y = weight of sample after drying (g)

b. Determination of ash content

The samples of charcoals from the easily volatilized matter were weighed (A gram), made to become ash in the electric furnace at a constant temperature of 750°C for 6 hours, The ash was then cooled in an exicator and weighed (B gram).

The percentage of ash was calculated by the formula:

$$\% \text{ Ash} = B / A \times 100\%$$

c. Determination of volatile matter content (V.M)

Charcoal powder from the determination of charcoal water content was weighed approximately 1 gram (M gram) and put into a closed nickel cup. It was heated into electric furnace 950°C for 6 minutes, cooled in an exicator and weighed (N gram).

$$\% \text{ V.M.} = M - N / M \times 100\%$$

d. Determination of fixed carbon content

Fixed carbon is the fraction of carbon (C) contained in charcoal. The percentage of carbon is expressed by the formula:

$$\% \text{ C} = 100 - \% \text{ V.M.} - \% \text{ Ash}$$

e. Determination of calorific value

The calorific value is the amount of heat generated by the 1.00 grams of charcoal. The calorific value was calculated based on the amount of heat absorbed in a unit of cal/gram. The sample of charcoal briquette was weighed as much as 1.00 grams, and put in a Bomb Calorimeter. The calorific value read on the tool was then corrected in order to obtain the final calorific value:

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$$\text{Calorific value} = A - B$$

Description:

A = Calorific value read on the tool (cal/gram)

B = Correction of heat on the iron wire (1 cm = 2.3 cal)

Charcoal Combustion

Charcoals from each type were weighed as much as 1 kg, while kerosene as a comparator was weighed as much as 1 liter, poured into the stove and then lit. The burning of charcoal in a brazier was started by burning some slabs in it.

2. Observations and Measurements

The observations and measurements were made on 1 kg of each charcoal that was burned, compared with 1 liter of kerosene which was poured into the stove. The parameters observed and measured were:

i. The duration of burning

ii. Maximum temperature

iii. Time to boil 1 liter of water

iv. The amount of water that is boiled for 1 kg of charcoal burning.

RESULTS AND DISCUSSION

Results of Laboratory Analysis

Observations and measurements were carried out at the laboratory. The recapitulation of the test results of water, ash, volatile matter, fixed carbon, and calorific value content of charcoal is presented in Table 1.

Table 1. Test results of water, ash, volatile matter, fixed carbon and calorific value contents in cinnamon wood, candlenut shell, alaban wood and acacia wood charcoals

Test Parameter	Charcoal			
	Cinnamon Wood	Candlenut Shell	Alaban Wood	Acacia Wood
Water content (%)	0.66	1.15	0.69	0.61
Ash content (%)	2.37	3.62	2.57	0.48
Volatile Matter (%)	23.94	35.35	26.95	42.81
Fixed carbon (%)	73.69	61.03	70.48	56.91
Calorific Value (Cal/gr)	7591.84	5649.70	7008.59	6280.76

Source: Results of Test at the Laboratory of Baristand Banjarbaru, 2012.

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It is known from table 1 that the water content of cinnamon wood, candlenut shell, alaban wood, and acacia wood charcoals was 0.66%, 1.15%, 0.69%, and 0.61%, respectively. It showed that the lowest water content was 0.66% in cinnamon charcoal and the highest was 1.15% in candlenut shell charcoal. The maximum water content of charcoals in this study was very low in percentage, and it indicated that the charcoal had better quality because according to Anonim (1983) better charcoals as fuel are charcoals with small water content. The average percentage of water content of charcoals in this study did not differ much because the four types of wood charcoals in the making were determined by the carbonization process, namely the amount of air, temperature and duration of drying (Griffioen, 1950 in Anonymous, 1983). Furthermore, the water content of charcoal is also influenced by the water content of wood before being carbonized, because the raw materials used in this research, cinnamon, candlenut shell, alaban wood, and acacia wood had already dry-aired that the charcoal produced had not much different water content percentage, but when compared to the SNI-01-6235-2000 standard, where the maximum water content is 8%, the four types of charcoals met the standard of a good quality charcoal.

The ash content of cinnamon wood, candlenut shell, alaban wood, and acacia wood charcoal was 2.37%, 3.62%, 2.57% and 0.48%, respectively. The minimum ash content was in acacia wood charcoal and the maximum was in candlenut shell charcoal, 3.62%. If viewed from wood specific gravity, it can be concluded that the specific gravity influenced ash content. If the wood has a high specific gravity, it will contain low ash content. The specific gravity of acacia wood was 0.42 to 0.57 and the specific gravity of candlenut shell was 0.35. When compared with the SNI-01-6235-2000 standard that the maximum ash content is 8%, the charcoal in this study met the standard of a good quality charcoal as an alternative fuel.

The volatile matter content of cinnamon wood, candlenut shell, alaban wood, and acacia wood charcoal was 23.94%, 35.35% 26.95% and 42.61%, respectively. Sudrad (1983) stated that a good charcoal as a heat source was charcoal that had volatile matter content of less than 15%. It is even supported by the SNI-01-6235-2000 standard that a good charcoal as fuel is the charcoal that had a maximum volatile matter content of 15%. This is due to differences in the elements contained in the waste of wood charcoal. This is similar to the opinion of Sjostrom (1995), that the difference in the number of elements in the wood such as H_2O, CO_2, CH_4, CO, and H_2, which easily volatilize when the wood is heated, will increase the volatile matter content. The volatile matter content of charcoals in this study was higher than the maximum volatile matter content stated in the SNI-01-6235-2000 standard, which is 15%. Therefore, it did not meet the standard of good quality charcoal because it contained volatile matter content more than 15%, which ranged from 23.94% - 42.61%. Volatile matter content is influenced by the physical properties of the raw material used to make charcoal, and the raw materials in this study have low specific gravity.

The fixed carbon content of cinnamon wood, candlenut shell, alaban wood, and acacia wood charcoal was 73.69%, 61.03%, 70.48% and 56.91%, respectively. According to Sudrad (1982), the fixed carbon content was not influenced by the type of raw material but by the maximum temperature of processing and the duration of charcoaling reaching a certain condition. If the temperature of charcoaling was low, the fixed carbon content would also low. Conversely, if the temperature of charcoaling was high, it would produce high fixed carbon content as well. The temperature of charcoaling will affect the outcome of fixed carbon content. If the temperature of charcoaling ranges from 300 to 400°C, it will produce a fixed carbon content of 80%, but if the temperature at 400 - 500°C, the fixed carbon content will reach up to 85%, and if above 500°C, it will reach 90%.

Calorific value charcoal cinnamon 7591.84 cal / g, pecan shell charcoal 5649.70 cal / g, charcoal alaban 7008.59 cal / g and acacia wood charcoal 6280.76 cal / g, nurhayati (1974) in Rosidah RM (1987) said Banwa calorific value is affected by moisture content and ash content, moisture content and high ash content which would otherwise reduce the calorific value of the material if the water content and low ash content, calorific value of the fuel will be high. Charcoal in this study support the statement, because the four types of wood charcoal contains moisture content and low ash content and relatively high calorific value. Similar to the statement Hendriawan in Adi (2005), that the high moisture content can degrade the quality of the charcoal charcoal because it can lead into a low calorific value. The higher heating value of charcoal produced, the better to be used as fuel. The calorific value of charcoal in this study ranged between 5649.70 cal / g - 7591.84 cal / g, compared with SNI-01-6235-2000 minimum calorific value charcoal 5000 cal / g, has met the requirements as a good fuel. This is due to the higher value of the heat produced is also getting bigger so it can be used as an alternative to kerosene and firewood.

B. Burning Charcoal

To determine the capacity of charcoal to produce energy in the household is done by comparing the capacity of charcoal to convert the fuel / energy to produce kerosene fuel with a specific ratio within the stove included. Observations on charcoal burning cinnamon, candlenut shell charcoal, charcoal wood charcoal alaban and acacia wood and the capacity to 1 liter of boiling water in the kerosene can be seen in Table 2 below.

Table 2. Observation data of burning of cinnamon wood, candle shell, alaban wood, and acacia wood charcoals compared with kerosene

Parameter Measured	Kerosene	Cinnamon Charcoal	Candlenut Shell Charcoal	Alaban Charcoal	Acacia Mangium Charcoal
Burning Duration	4 hours 30’	50’	36’	1 hour 08’	1 hour 10’
∑ boiled water (liter) /1 kg of charcoal	45 liters	10 liters	4,23 liters	10,8 liters	9,58 liters
Maximum temperature (˚C) of burning	308˚C	235˚C	175˚C	216˚C	195˚C
Average time to boil 1 liter of water	6’ 00”	5’00”	8’ 53”	6’ 30”	7’ 30”

Source: Observations at the Laboratory of Forest Product Technology, Forestry Faculty, Lambung Mangkurat University, 2012

Data in Table 2 above shows that 1 kg of cinnamon charcoal with calorific value of 7,591.84 cal/g could burn for 50 minutes, and was able to boil water by 10 liters. The average time to boil water was 5 minutes 00 second with a maximum burning temperature of 235°C.

Candlenut shell charcoal with a calorific value of 5,649.70 cal/g could burn for 26 minutes, and boil water as much as 4.23 liters. The average time to boil water was 8 minutes 53 seconds, with a maximum burning temperature of 175°C.

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Alaban wood charcoal with a calorific value of 7008.59 cal/g could burn for 1 hour 08 minutes, and boil water as much as 10.08 liters. The average time to boil water was 6 minutes 30 seconds with a maximum burning temperature of 216°C.

Acacia wood charcoal with 7,008.59 cal/g could burn for 1 hour 10 minutes, and boil water by 9.58 liter. The average time to boil water was 7 minutes 30 seconds, with a maximum burning temperature of 195°C.

One liter of kerosene as a comparison with a calorific value of 10.081 cal/lt using a stove Hock with 16 axis could burn for 4 hours 30 minutes, and boil water as much as 45 liters. The average time to boil water was 6 minutes, with a maximum burning temperature of 308°C.

The combustion of four types of charcoals in this study showed that cinnamon charcoal had the best quality as fuel, followed by alaban, acacia wood and candlenut shell charcoal. The physical and chemical properties of cinnamon and alaban wood charcoals were not much different, but at the time of burning the cinnamon charcoal run out faster than alaban and acacia wood charcoal. However, the capacity of cinnamon charcoal to boil 1 liter of water was cinnamon relatively fast, 5 minutes, with the highest maximum temperature of 235°C, and the maximum water of 10 liters in 50 minutes.

There was no difficulty at the time of the first ignition of cinnamon, alaban and acacia wood charcoal, but the ignition of the candlenut shell charcoal the researchers found a little trouble in terms of firing because the structure of candlenut shell charcoal was too small. Candlenut shell charcoal showed the lowest values for all parameters. It can be said that the charcoal from candlenut shell had a low quality as fuel for domestic use.

When compared with the capacity of kerosene fuel to boil 1 liter of water for 6 minutes, it was not much different from the capacity of the wood charcoals in this study. The cinnamon, alaban and acacia wood charcoal contained low ash and water contents, and high calorific value. Similarly, if converted into economic value (Rp), the price of kerosene was nearly Rp 10,000/liter, while the price of 1 kg of charcoal was about Rp 3,500/kg. The duration of burning 1 liter of kerosene was equivalent to 3 kg of charcoals. Also, if considered from the capacity of the charcoals to boil 1 liter of water and the maximum amount they could boil, the three types of charcoals in this study can be used as the alternative fuel/energy for domestic purposes.

CONCLUSIONS AND SUGGESTIONS

Conclusions

1. Charcoals in this study contained water, ash, volatile matter, fixed carbon, and calorific value content ranging from 0.66% - 1.15%, 0.48% - 3.62%, 26.92% - 42.61%, 56, 91% - 73.69%, and 5,649.70 cal / gram – 7,591.84 cal / gram, respectively.

2. The results of physical and chemical analysis of charcoals compared with the quality standard of charcoal in SNI-01-6235-2000 indicated that the parameters of water, ash, and calorific value content met the requirements of charcoal quality standard as good fuel, but volatile matter content did not meet the charcoal-quality standard requirements because according to SNI-01-6235-2000 the maximum volatile matter content was 15%.

3. After the burning, the cinnamon charcoal was at the maximum temperature which was followed by alaban, acacia and candlenut shell charcoal at a temperature of 235°C 216°C, 195°C, and 175°C in burning duration of 50 minutes, 1 hour 10 minutes, 1 hour 8 minutes and 36 minutes, respectively.

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4. The time required to boil 1 liter of water for cinnamon, alaban, acacia wood charcoal was 5', 6' 30", 7' 30", while the shell charcoal 8' 59 ".

5. Compared with the use of kerosene for stove Hock with 16 wicks and when converted into economic value, the 3 types of wood charcoals, namely cinnamon, alaban and acacia charcoal can be used as the alternative energy since petroleum currently is hard to obtain and the price is relatively expensive whereas the candlenut shell charcoal did not meet the quality requirement as the alternative energy because its structure was too small that it was difficult to get burned (taking a long time to get burned).

SUGGESTIONS

1. Alaban charcoal has long been processed and used as fuel for general people. Making charcoal from cinnamon and acacia woods can be developed as the alternative energy in times where people are in petroleum crisis.

2. Candlenut shell charcoal has a very small structure. In order to utilize it as an alternative fuel, it should be used in the form of charcoal briquettes or activated charcoal.

3. It is necessary to consider how to use charcoals to supply the energy needs in households.

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