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Burning Characteristic of Biocharcoal Briquettes Blend of Goat Manure Charcoal, Saboak Shell and Corn Cob

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ABSTRACT: This study aims to determine the effect of a mixture of goat manure charcoal, saboak shell and corn cob on the combustion properties of biocharcoal briquettes. The method used in this study was a completely randomised design consisting of 4 treatments and 4 replications. The treatment consisted of P1: 25% goat manure charcoal + 75% saboak shell without corn cob, P2: 25% goat manure charcoal + 50% saboak shell + 25% corn cob, P3: 25% goat manure charcoal + 25% saboak shell + 50% corn cob, P4: 25% goat manure charcoal + 75% corn cob without saboak shell. The results of variance analysis showed that the treatments had a significant effect ($P<0.05$) on the combustion temperature, combustion resistance and the ability to boil water, but a very significant effect ($P<0.01$) on the combustion rate, and no significant effect ($P>0.05$) on the colour and smoke. The mean values obtained are: combustion temperature 333.3°C; combustion rate 2.308 g/min; combustion resistance 195 min; colour 3.5 smoke 3.96 and ability to boil water 12.94 min. It is concluded that increasing corn cob charcoal with different proportions results in increased briquette temperature, combustion rate and combustion resistance tend to decrease, colour and smoke burning tend to be the same and the ability to boil water quickly.

KEY WORDS: briquettes, corn cob and burning characteristic, goat manure, saboak shell.

INTRODUCTION

The world of animal husbandry is inseparable from the existence of waste. Livestock waste is all waste that includes all livestock faeces that are solid, liquid and gas. According to Indri et al. (2015), the negative impact if waste is not processed causes a pungent odour, polluted water sources, environmental cleanliness and disturbed comfort. Processing livestock waste is a must in overcoming negative impacts on the environment and health and is also intended to increase the added value of waste, one of which can be processed into alternative fuels.

According to Budiman et al. (2011), briquettes are one of the solid fuels composed of the remains of organic materials of natural origin. One of the livestock waste that can be processed into briquette fuel is goat manure in the research of Sulmiyati and Said (2017), it is stated that the bio charcoal briquettes produced from goat manure have a moisture content of 5.58%, ash content of 23.93%, fixed carbon 35.33%, volatile matter 35.16% and calorific value of 4,563 cal/g. The processing of goat manure into biocharcoal briquettes has been carried out by several previous researchers, where goat manure charcoal is combined with other biomass materials such as, mayang lontar Amalo et al. (2022) and lontar shell Noach et al. (2023). The combination of goat manure with biomass materials can increase the carbon content in briquettes, the more the carbon content increases, the better the calorific value. According to Dae panie et al. (2022), the content of goat manure mixed with other biomass produced a fixed carbon content of 20.76%, a calorific value of 4070.72%, a volatile matter of 57.32%.

Biomass is organic material derived from agricultural waste and can be used as raw material for briquetting Suryani et al. (2012). Agricultural waste that is potential enough to be processed into alternative fuels is corn cobs due to its abundant availability but has not been utilised properly. According to Lestari et al. (2010) corn cobs contain quite high crude fibre of 33%, cellulose content of about 44.9% and lignin content of about 33.3% which allows corn cobs to be used as raw material for making charcoal briquettes.

Saboak shell (as the people of Timor island call it) is a waste derived from palm trees. The utilisation of this waste has not been properly processed and is only used as a substitute for firewood. According to Dae Panie et al. (2022) saboak shell has a carbon content of 22.08%, volatile matter 71.28% and a calorific value of 4470 kcal/kg and the research obtained the best results in goat manure 25% and saboak shell 75%. Based on this description, research has been carried out to study how the combustion properties of biochar briquettes made using a mixture of goat manure charcoal, saboak shell and corn cob.

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MATERIALS AND METHODS

The research was conducted for 4 months from April to June 2023 in Naimata Village, Maulafa Sub-district, Kupang City, and consisted of collecting materials, making briquettes and testing the quality of the fuel.

The materials used in this study were 4kg goat manure charcoal, 6kg corn cob, 6kg saboak shell and 1.6kg tapioca. The equipment used were digital scales with a capacity of 75kg with a sensitivity of 20g, digital sitting scales with a capacity of 5kg with a sensitivity of 1g, pyrolysis drum, grinding machine with a 20 mesh size sieve, briquette stove, briquette mould, infrared thermometer and stopwatch. The characteristics of the charcoal materials used are presented in Table 1.

Table 1. Charcoal material characteristics

Biomass	Moisture (%)	Ash (%)	Fixed carbon (%)	*Volatile matter* (%)	Calori kal/g
Goat manure[1]	9.38	12.54	20.76	57.31	4040.72
Saboak shells[1]	1.72	3.36	22.8	71.85	4470.08
Corn cob[2]	5.70	10.33	43.42	68.80	4500.32

notes: [1] Rosinta et al. (2023); [2]Amin et al.. (2016)

This study used a completely randomised design (CRD) consisting of 4 treatments and 4 replicates. The four combinations tried were:

P1: 25% goat manure charcoal + 75% saboak shell + no corn cob.
P2: 25% goat manure charcoal + 50% saboak shell + 25% corn cob
P3: 25% goat manure charcoal + 25% saboak shell + 50% a corn cob
P4: 25% goat manure charcoal + no saboak shell + 75% corn cob

Variables measured

1. Burning temperature, is defined as the heat generated from the combustion process of biocharcoal briquettes. The measurement of combustion temperature is carried out in a span of 20 minutes using an infrared thermometer during the combustion process and is expressed in units (°C) (Dae Panie et al., 2023).
2. Burning rate, is the speed of the mass of biochar briquettes burning in unity of time and is expressed in g/minute. the combustion rate can be calculated according to the instructions of Aljarwi et al. (2020):
   Burning rate = t/m
   Description:
   m = mass of burnt briquettes (initial briquette mass - residual briquette mass (grams)
   t = burning time (minutes)
3. Burning resistance, is the length of time required in the combustion process of biocharcoal briquettes. Measurement of burning resistance is carried out using a stopwatch and is expressed in minutes referring to the procedure of Taklal et al. (2022).
4. Combustion colour and smoke, the colour of combustion is the colour and smoke produced by burning briquettes and smoke is the condition that arises during combustion. Observations of colour and smoke were made by panelists based on the indicators as presented in Table 2.

Table 2. Scoring list of colour and combustion smoke

Score	Flame colour	Smoke
1	Yellow	a little bit of smoke
2	Reddish-yellow	a little bit of smoke
3	Red	not emitting smoke
4	Bluish-red	not emitting smoke
5	Blue	not emitting smoke

Source: Dae Panie (2023)

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5. Water boiling ability, the ability to boil water (minutes) is the time required to boil 1 litre of water and is expressed in minutes. The calculation of time starts from the time the pot is placed on the briquette stove until the water boils. Testing the ability to boil water is done to assess the effectiveness of burning bio charcoal briquettes. The procedure for testing the ability to boil water was carried out using a glass-lidded stainless pot, 0.08 mm thick, 15 in diameter, with a capacity of 2 litres.

Research Procedure

Goat manure, saboak shells and corn cobs that have been obtained are collected and dried in the sun to facilitate the charring process. Charring goat manure by roasting on a zinc plate while saboak shell with corn cobs using pyrolysis. The three materials are sprinkled then dried in the sun and ground to get charcoal powder. Tapioca used in making the adhesive as much as 10% of the charcoal material 1000g. then dissolved in water 880ml of water and then heated until thick. The weighed charcoal material is then mixed with tapioca until it becomes dough. Four moulds were used, cylindrical in shape with a height of 12 cm and a diameter of 4 cm. The dough was moulded using a 3ton hydraulic press to produce the same briquettes with a height of 4 cm and a diameter of 4 cm.The briquettes that have been printed are then dried in the sun until dry (field moisture content ≤8%) to reduce the moisture in the briquettes and facilitate the briquettes in the combustion test process.

Data Analysis

Non-parametric variable data including combustion and smoke colour scores were obtained first using root transformation, namely: $Y = \sqrt{x} + 0.5$ where y = transformed data, and x score data. Data were tabulated followed by variance analysis to determine the effect of treatment on the variables studied while Duncan's Multiple Range Test was used to see differences between treatments using Microsoft excel.

RESULTS AND DISCUSSION

The burning characteristics of biocharcoal briquettes blend of goat manure charcoal, saboak shell and corn cob obtained in this study are presented in Table 3.

Table 3. Characteristics of combustion quality of bio charcoal briquettes

Variables	Treatment				P Value
	P1	P2	P3	P4	
Burning temperature (°C)	307.8 ± 16.4^{a}	321.6 ± 18.7^{ab}	357.7 ± 24.4^{bc}	346.1 ± 26.4^{c}	0.02
Burning rate (g/minute)	2.57 ± 0.21^{a}	2.25 ± 0.08^{b}	2.24 ± 0.08^{b}	2.17 ± 0.06^{b}	0.00
Burning resistance (minute)	220 ± 16.3^{a}	195 ± 19.1^{b}	185 ± 10.0^{b}	185 ± 10.0^{b}	0.01
Flame colour	4 ± 0^{a}	3.5 ± 0.6^{a}	3.2 ± 0.5^{a}	3.2 ± 0.5^{a}	0.11
Smoke emitted	4 ± 0^{a}	4 ± 0^{a}	3.9 ± 0.12^{a}	$3{,}9 \pm 0{,}10^{a}$	0.24
Water boiling ability (menit)	14.1 ± 1.11^{a}	12.6 ± 0.63^{b}	12.1 ± 0.48^{b}	13 ± 0.91^{b}	0.02

Notes: Different superscript on the same row indicate differences. P1= 25% goat manure + 75% saboak shell without corn cob; P2= 25% goat manure + 50% saboak shell + 25% corn cob; P3 25% goat manure + 25 saboak shell + 50% corn cob; P4= 25% goat manure + no saboak shell + 75% corn cob.

Burning temperature

Table 3 shows that the average combustion temperature of briquettes ranged from 307.8-357.7 ^{0}C. The results of variance analysis showed that the treatment had a significant effect on combustion temperature ($P<0.05$). This means that the mixture of goat manure charcoal, saboak shell and corn cob with different proportions produces biocharcoal briquettes with different temperatures. The results of the Duncan test conducted showed that the pairs that were significantly different ($P<0.05$) were P3-P1, P4-P1 and P4-P2. The higher the proportion of corn cob charcoal used, the greater the temperature produced than without corn cob, this is thought to be because the combustion temperature is related to the calorific value. The higher the calorific value, the more the combustion temperature will increase, this is in line with the opinion of Ristianingsih et al. (2015) that calorific value greatly affects the high and low combustion temperature, where the higher the calorific value, the more the combustion temperature increases. Table 3 shows that the lowest temperature value is obtained from the treatment of a mixture of goat manure charcoal 25% saboak shell 75%, without corn cobs, which is 307.8^{0}C, while the highest temperature is obtained from the treatment of a mixture of goat manure charcoal 25%, saboak shell 25% and corn cobs 50%.

The temperature obtained in the study is still higher than the results of previous research by Dae Panie et al. (2022) of 264.60^{0}C. In the briquette mixture of goat manure charcoal and saboak shell and Dhawi (2017) of 261.27^{0}C in the briquette mixture of goat manure charcoal and hazelnut shell charcoal. This difference is due to the different treatment and diversity of biomass used.

Burning rate

Table 3 shows that the average burning rate ranged from 2.57-2.17 grams/minute. The results of variance analysis showed that the treatment had a very significant effect ($P<0.01$) on the burning rate of briquettes. This means that mixing the three ingredients with different proportions produces briquettes with different burning rates. The results of the Duncan test conducted showed that the pairs that were significantly different ($P<0.05$) were P1-P2, P1-P3, and P1-P4. The higher the proportion of corn cob charcoal used, the lower the burning rate. This is thought to be due to the particle size of a material the smaller the size, the higher the density, this is in line with the opinion of (Sudiro and Suroto, 2014) which states that the smaller the grain size of the material, the denser the briquettes so that it is more difficult for oxygen to enter which causes the combustion time to be longer. From table 3, it can be seen that the lowest combustion rate value was obtained from the P4 treatment with a mixture of 25% goat manure charcoal and 75% corn cob at 2.17 g/min while the highest rate value was obtained in P1 with a mixture of 25% goat manure charcoal and 75% saboak shell at 2.57 g/min. This is because the treatment has a high density so as to produce a long burning rate. This is in accordance with the opinion of Hendra (2007), which states that briquettes with high density produce charcoal briquettes with high density, while briquettes with low density will produce low briquettes and the burning rate process is shorter than briquettes that have high density.

The burning rate obtained in this study is still higher than the results of previous research by Dae Panie et al. (2022) of 2.28 grams/minute on briquettes of goat manure charcoal and saboak shell and Nahas et al. (2019) with a burning rate of 0.29 minutes on a mixture of cow dung and tapioca flour. This difference is thought to be the use of different levels of diversity and treatments used.

Burning resistance

Table 3 shows that the combustion resistance ranges from 220-185 minutes. The results of variance showed that the treatment had a significant effect ($P <0.05$) on the combustion resistance of briquettes. This means that the mixture of the three ingredients with different proportions produces briquettes with different combustion resistance. The results of the Duncan test show that the treatment has a significant effect on the briquette combustion temperature ($P < 0.05$). The treatment pairs that were significantly different ($P<0.05$) were P1-P2, P1-P3 and P1-P4. The higher the proportion of corn cob charcoal used, the lower the combustion resistance. This is thought to be because fuel resistance is interconnected with density, the higher the density, the longer the fuel resistance will be in line with the opinion of Satmoko et al. (2013) which states that the higher the density, the higher the density.

From Table 3, it can be seen that the lowest combustion resistance value is obtained in a mixture of 25% goat manure charcoal and 75% corn cob at 185.0 minutes, the highest in a mixture of 25% goat manure charcoal and 75% saboak shell, this difference is due to the specific gravity of the material and in the treatment it obtains a high density and produces a long enough combustion resistance. According to Hendra (2007), which states that raw materials that have a high density will produce charcoal briquettes with a high density so as to produce a long enough combustion resistance.

The combustion resistance obtained in this study is still higher than the results of previous research by Dae Panie et al. (2022) of 175.00 minutes on a mixture of goat manure charcoal and saboak shell, Jamilatun (2012) without using livestock manure of 103.57 minutes on coconut shell. This difference is due to the different levels of use and diversity of biomass used.

Flame colour

Table 3 shows that the combustion colour ranges from 4.00-3.25. The results of variance analysis showed that the treatment had no significant effect on the colour of burning briquettes ($P>0.05$). This means that the mixture of goat manure charcoal, saboak shell and corn cob with different proportions produces the same burning colour, this is thought to be influenced by the carbon content of the briquettes. The high carbon content of briquettes greatly affects the colour of the fire produced by Toufik (2015). Table 3 shows that the colour of combustion obtained in this research tends to be red. The results of the briquette combustion colour obtained from this study are higher than the results of research by Dae Pannie et al. (2022) of 2.75 on a mixture of goat manure charcoal and saboak shell. Research conducted by Dhawi (2007) obtained a high combustion colour score of 3.55 on a mixture of goat manure charcoal and shell This difference is due to the different treatments used and in this study using three mixtures of biomass materials.

Smoke emitted

Table 3 shows that the combustion smoke ranges from 4.00-3.95. The results of variance analysis showed that the treatment had no significant effect on the combustion smoke of the briquettes (P>0.05). This means that the mixture of goat manure charcoal, saboak shell and corn cob with different proportions produces combustion smoke that tends to be the same. The absence of smoke in each treatment is influenced by the adhesive, the type of adhesive used in this research is tapioca flour because it has good viscosity and the smoke produced is small according to Saleh (2013) the use of tapioca adhesive produces relatively little smoke compared to other adhesives. The incomplete charring process also affects the presence of smoke because there are still remnants of raw materials. Biomass material that is included in the pyrolysis derum must be completely dry material so as to facilitate the time of charring.

From Table 3, it can be seen that the lowest combustion smoke value was obtained in a mixture of 25% goat manure charcoal, 25% saboak shell and 50% corn cob at 3.25 while the highest combustion smoke value was obtained in a mixture of 25% goat manure charcoal and 75% saboak shell at 4.0. The combustion smoke score obtained from this study is still higher than the results of previous research by Dhawi (2017) of 3.33 (slightly smoky) on a mixture of goat manure charcoal and hazelnut shell, while research conducted by Elfiano et al. (2014) obtained the highest smoke content of 35.52% with a strong pressure of 3.15 MPa on a mixture of wood charcoal with tapioca adhesive.This difference is due to the different treatments used and in this study using three mixtures of biomass materials.

Water boiling ability

From Table 3, it can be seen that the ability to boil water ranges from 12.1-14.1, minutes the results of variance showed that the treatment had a significant effect on the ability to boil water briquettes (P <0.05). This means that the mixture of goat manure charcoal, saboak shell and corn cob with different proportions produces different boiling ability. The results of the Duncan test conducted showed that the pairs that were significantly different (P < 0.05) were P1-P2, P1-P3, and P1-P4.

The ability to boil water is related to the calorific value, the higher the calorific value, the temperature will increase according to Ristianingsih et al. (2015) the calorific value is very influential on the high and low combustion temperature, where the higher the calorific value, the higher the combustion temperature. High calorific value will accelerate the ability to boil water, this is in line with the opinion of Samsinar (2014) that the greater the calorific value of briquettes, the faster the time needed to boil one litre of water.

From Table 3, it can be seen that the lowest value of the ability to boil water was obtained in a mixture of 25% goat manure charcoal, 25% saboak shell and 75% corn cob at 12.1 minutes while the ability to boil the highest water was obtained in a mixture of 25% goat manure charcoal, 50% saboak shell and 25% corn cob at 14.1 minutes, this difference is due to the fact that P3 obtained a high calorific value so as to produce the ability to boil water quickly. The ability to boil water obtained in this study is still lower than the results of previous research by Dae Panie et al. (2022) of 14.75 minutes on a mixture of goat manure charcoal and saboak shell, while research conducted by Nurrohim et al. (2018) obtained the results of the ability to boil water 13.07 minutes on nipah fruit charcoal briquettes, and in other studies conducted by Jamilatun (2012) obtained results of 7.19 minutes on coconut shell charcoal. This difference is due to the different treatments used and the use of a diversity of biomass materials. In addition to the ability to boil water, the briquettes made can be used in cooking processes such as cooking vegetables, frying tempeh, grilling fish, cooking rice, and boiling eggs.

CONCLUSION

Based on the results and discussion, it can be concluded that the mixture of goat manure charcoal, saboak shell and corn cob with different proportions produces briquette combustion temperature tends to increase, combustion rate and combustion resistance tends to decrease, combustion colour tends to be the same, has no smoke and the ability to boil water quickly. The best burning quality of briquettes is found in the mixture of goat manure charcoal 25% + saboak shell 25% + corn cob 50%.

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