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Effect of Goat Dung, Saboak and Corn Cobs Charcoal Mixture on the Physicochemical Properties of Biochar Briquettes

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ABSTRACT: The experiment goals to investigate the physicochemical properties of biochar briquette mixed of goat dung, saboak shell and corn cob charcoal. Research used a completely randomized design with 4 different treatments were: P_1 = 25% of goat dung + 75% saboak shell charcoal; P_2 = 25% of goat dung + 50% saboak shell + 25% corn cob charcoal; P_3 = 25% of goat dung + 25% saboak shell + 50% corn cobs charcoal; P_4 =25% of goat dung + 75% corn cobs charcoal. Variables measured included yield, density, moisture, ash, calorific value, volatille matter and fixed carbon. Data were analyzed according to the statistic analysis procedure. The mean values obtained were yield 57.54%; density 0.62 g/cm3; moisture 4.67%; ash 16.93%; calorific value 5198.75 cal/g; volatile matter 25.18%; fixed carbon 53.23%. The results of variance analysis showed that the treatment had a very significant effect ($P<0.01$) on density and calorific value but not significant ($P>0.05$) on yield, moisture, ash, volatile matter and fixed carbon. It can be concluded that using of corn cobs as substitute of saboak shell ini briquettes making blend of goat manure can be improve the calorific value, with similar ini yield, moisture, ash, volatile matter and fixed carbon. The best characteristic of briquettes find out in mixing of 25% goat manure + 25% saboak shell + 50% corn cobs.

KEYWORDS: biochar briquettes, corn cobs, goat dung, physicochemical, saboak shells.

INTRODUCTION

Environmentally friendly and low-emission livestock farming practices actually add opportunities to increase production, for example, processing livestock manure into organic fertiliser or building simple digesters to produce biogas as an alternative energy source. In addition to biogas, livestock manure can also be made into briquettes through a charring or carbonisation process. It is known that livestock manure contains low bound carbon with high volatile matter. Livestock manure can be mixed with other materials sourced from biomass to improve its physical, chemical and combustion properties.

One of the easily available livestock wastes/dung is goat manure from intensive farms, with a potential fresh manure production of 956.5 g/head/day [1] which can have adverse effects on the environment such as pollution, sources of disease and pollutants [2]. [3] reported goat manure has a low carbon content of 20.76% and a calorific value of 4070.72 cal/g, with a high volatile matter of 57.32%). Several studies have combined goat dung with other biomass materials such as saboak shell [4], saboak shell and rice husk [5], lamtoro twigs [6], to improve the physicochemical and combustion properties of briquettes. In addition to these biomasses, corn cobs are one of the agricultural biomass wastes that are quite available post-harvest and have not been utilised as fuel, even though they have high carbon content and energy value. Based on Chemix Jogjakarta laboratory testing in 2023, it was revealed that corn cobs have a carbon content of 66.01%; volatile matter of 17.97% and a calorific value of 6204 cal/g.

Based on the above description, a study has been conducted to study the physico-chemical characteristics of biochar briquettes made from a mixture of goat dung charcoal, saboak shell and corn cob.

MATERIALS AND METHODS

The research was conducted in Naimata Village, Maulafa District, Kupang City for 4 months from April to July 2023. The materials used were goat dung charcoal, saboak shell, corn cob charcoal and tapioca. The equipment used were digital hanging scales of 75kg capacity with 20g sensitivity, pyrolysis drum, grinding machine with 20 mesh sieve, digital sitting scales of 5kg capacity with 1g sensitivity, briquette maker, porcelain cup, analytical balance, furnace, oven, bomb calorimeter and desiccator. The proximate results of the biomass materials used in this study are presented in Table 1.

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Table 1. Biomass Characteristics

Biomass	Moisture (%)	Ash (%)	Fix carbon (%)	Volatile Matter (%)	Calorific value (cal/g)
Goat dung[1]	9.38	12.54	20.76	57.32	4070
Saboak shell[1]	1.72	3.36	22.08	71.82	4470
Corn cobs[2]	5.70	10.33	66.01	17.96	6204[3]

Data source: [1]Rosinta et al. (2023); [2]Laboratory of Animal Nutrition and Feed of Kupang State Agricultural Polytechnic (2023); [3]Laboratory of Chem-Mix Pratama (2023).

Four different treatments each using 1,000g of charcoal were tested in this study:
P1= 25% goat dung charcoal + 75% saboak shell without corn cob
P2= 25% goat dung charcoal + 50% saboak shell + 25% corn cob
P3= 25% goat dung charcoal + 25% saboak shell + 50% corn cob
P4 25% goat dung charcoal + 75% corn cob without saboak shells saboak shell

Research Variables

1. Yield; the yield of briquettes was calculated by formula according to the instructions of [7]:
   Yield (%) = (Dry Briquette Weight/Briquette Dough Weight) x 100 %
2. Density; the density of briquettes was calculated by formula according to the instructions of [7]:
   Density (g/cm3) = Mass/ Volume
3. Moisture; water content testing was carried out according to SNI 06-3730-1995 procedures using the formula:
   Moisture (%) = ((Initial Sample Weight - Final Sample Weight) / Initial Sample Weight)) x 100%
4. Ash Content; ash content tested by formula according to the procedures of SNI 06-3730-1995:
   Ash (%) = (Residual Burning Ash/Initial Mass of Briquettes) x 100%
5. Volatile Matter; volatile matter is tested by formula according to the procedure of SNI 1683:2021:
   VM (%) = ((initial weight of sample - weight of sample after heating) / initial weight of sample)) x 100%
6. Fixed Carbon; fixed carbon is calculated by formula according to the instructions of [4]:
   FC (%) = 100 - (volatile matter + moisture + ash content)
7. Calorific value; Calorific value tested by formula according to SNI 1683:2021 procedures:
   CV (cal/g) = ((Final Temperature - Initial Temperature) x Specific Calorific Value of Water)) / Mass of Water

Research Procedure

Goat manure, saboak shell and cob were sun dried and then carbonised. The saboak shell and corn cob were charred using a kiln drum (pyrolysis technique) while the goat manure was charred using a metal plate. All charcoal materials were ground to 20 mesh size using a grinding machine. The adhesive material used was tapioca as much as 10% of the charcoal material. Tapioca was dissolved in water (1:8) heated to form a gel, then mixed with charcoal powder and stirred evenly to form a dough. The dough is put in a cylindrical mould with a height of 12cm diameter of 4cm and then pressed using hydraulics power. The briquettes produced were cylindrical with a height of 5cm and a diameter of 4cm. The briquettes were dried and then laboratory tested. The data obtained were tabulated and analysed according to the variance procedure using Microsoft Excel software.

RESULTS AND DISCUSSION

Data on the physico-chemical characteristics of biochar briquettes mixed with goat dung charcoal, saboak shell and corn cob obtained in this study are presented in Table 2.

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Table 2: Physico-chemical Characteristics of Biochar Briquettes

Variables	Treatment				P-value	SNI
	P_1	P_2	P_3	P_4		
Yield (%)	58.75±0.19	57.92±0.84	56.16±1.66	57.31±1.76	0.08	-
Density (g/cm^3)	0.67±0.01^a	0.63±0.04^a	0.63±0.01^a	0.57±0.03^b	0.00	0.44
Moisture (%)	4.39±0.58	4.72±0.68	4.84±0.11	4.73±0.46	0.64	<8%
Ash (%)	17.31±0.51	17.04±0.29	16.60±0.40	16.76±0.15	0.07	<8%
Volatille Matter (%)	26.09±0.14	25.98±2.26	24.61±0.55	24.03±0.22	0.07	<15
Fixed Carbon (%)	52.21±0.35	52.27±2.54	53.96±0.63	54.48±0.42	0.07	78.5
Calorific value (cal/g)	5047.7±157.6^b	5088.9±117.7^b	5345.4±24.6^a	5312.7±94.3^a	0.00	>5000

Note: different superscripts on the same line indicate differences. P1 = 25% goat dung charcoal + 75% saboak shell without corn cob, P2 = 25% goat dung charcoal + 50% saboak shell + 25% corn cob, P3 = 25% goat dung charcoal + 25% saboak shell + 50% corn cob, P4 = 25% goat dung charcoal + 75% corn cob without saboak shell.

Yield

The yield of biochar briquettes mixed with goat dung charcoal, saboak shell and corn cob ranged from 56.16 - 58.75%, with an average of 57.54%. Statistical results showed that the treatment had no significant effect (P>0.05) on briquette yield. The increase in the proportion of corn cob charcoal along with the reduction of saboak shell charcoal did not affect the changes in the yield of biocharcoal briquettes produced. This same trend is caused by the same total biochar materials used with a uniform size of 20 mesh and relatively the same moisture content (4.39 - 4.84%). [8] stated that the finer the material used, the higher the yield produced.

The yield of biocharcoal briquettes obtained in this study is higher than the previous report [7] of 52.69% on briquettes of goat dung charcoal mixture and saboak shell, [6] at 55.2% on a mixture of goat dung, saboak shell and lamtoro twigs, but lower than [5] at 58.94% in a mixture of goat manure, saboak shell and rice husk. It cannot be concluded whether the briquette yield obtained has met the standard, because as far as the search has not found any information about the yield of biochar briquettes standardised according to the Indonesian National Standard.

Density

The density of biochar briquettes mixed with goat dung charcoal, saboak shell and corn cob ranged from 0.57 - 0.67 g/cm^3 with an average of 0.63 ± 0.02 g/cm^3. Statistical results showed that the treatment had a very significant effect (P < 0.01) on the density of briquettes. Duncan's further test showed that the treatment pairs P_4-P_3, P_4-P_2 and P_4-P_1 were significantly different (P<0.05), while P_3-P_2, P_3-P_1 and P_2-P_1 were not significantly different (P>0.05). This means that biomass with varying proportions produces biochar briquettes with different densities.

The increasing proportion of corn cob charcoal used along with the decreasing proportion of saboak shell charcoal showed a decreasing briquette density. This is thought to be because the density value of corn cob is lower than the density value of saboak shell so that more corn cob causes a reduction in density. [9] reported that raw materials with high density tend to produce briquettes with high density. The density of saboak tian shell is 0.84 g/cm^3 [10] while the density of corn cob is 0.29 g/cm^3 [11].

Table 2 shows that the highest average density was obtained from P1 using 25% goat manure and 75% saboak shell without corn cob at 0.67 g/cm^3 and continued to decrease to the lowest at P4 using 25% goat manure and 75% corn cob without saboak shell at 0.57 g/cm^3. The density of bio charcoal briquettes obtained in this study (0.63 g/cm^3), is higher than the previous study of 0.50 g/cm^3 on briquettes of goat dung charcoal mixture and palm kernel with 6% adhesive [3]. This is thought to be because the level of adhesive used is different and in this study used 10% adhesive, this is in accordance with research conducted by [12] that higher levels of adhesive in the manufacture of biochar briquettes produce higher densities. The density of biocharcoal briquettes in this study has met the SNI, which is 0.44 g/cm^3 (SNI 01-6235-2000).

Moisture Content

The moisture content of biochar briquettes mixed with goat dung charcoal, saboak shell and corn cob ranged from 4.39 - 4.84% with an average of 4.67 ± 0.46%. Statistical results showed that the treatment had no significant effect (P>0.05) on the moisture content of the briquettes. The increase in the proportion of corn cob charcoal along with the reduction of saboak shell charcoal did not affect the changes in the moisture content of the biocharcoal briquettes produced. This same trend is thought to be influenced by the uniform level of adhesive used (10%) and the same particle size (20 mesh) in all treatments. [13] stated that the higher the level of adhesive used, the higher the moisture content produced. According to [14] finer particles absorb more water than coarser particles.

The moisture content of biocharcoal briquettes obtained in this study (4.67%) is not much different from the previous report of 4.52% briquette mixture of goat dung charcoal and saboak shell with 6% adhesive level [7]. Generally, the moisture content of biochar briquettes from this study has met the SNI, which is <8% (SNI 01-6235-2000).

Ash Content

The ash content of biochar briquettes mixed with goat dung charcoal, saboak shell and corn cob ranged from 16.60 - 17.31% with an average of 16.93 ± 0.34. Statistical results showed that the treatments had no significant effect (P>0.05) on the ash content of the briquettes. The increase in the proportion of corn cob charcoal along with the reduction of saboak shell charcoal did not affect the changes in the ash content of the biochar briquettes produced. This same trend is thought to be due to the uniform proportion of adhesive materials used so that it does not have an impact on significant differences in briquette ash content. [15] stated that the higher the adhesive level, the higher the ash content. According to [12] ash is the remaining part of the combustion process that no longer has the element carbon. The ash content of charcoal briquettes is influenced by the silica ash content of the powder raw material and the level of adhesive used. One of the main constituents of ash is silica and its effect is not good on the calorific value of the resulting charcoal briquettes. The higher the ash content, the lower the quality of the briquettes because high ash content can reduce the calorific value of charcoal briquettes.

The ash content of biochar briquettes obtained in this study (16.93%) is lower than that reported by [7] of 29.61% in briquettes of goat dung charcoal mixture and saboak shell, and [16] in briquettes made from goat dung of 38.62%. This shows that the use of corn cob can reduce the ash content of the briquettes produced, however, this result still does not meet the SNI which is <8% (SNI 01-6235-2000).

Volatile Matter

Volatile matter content of biochar briquettes mixed with goat dung charcoal, saboak shell and corn cob ranged from 24.03 - 26.09% with an average of 25.18 ± 0.79%. Statistical results showed that the treatment had no significant effect (P>0.05) on the volatile matter content of the briquettes. The increase in the proportion of corn cob charcoal along with the reduction of saboak shell charcoal did not affect the change in volatile matter content of the resulting biocharcoal briquettes. One of the factors causing this uniformity is that the carbonisation temperature used through the pyrolysis process is the same, namely 450^{o}C for saboak shell and corn cob.

The results obtained from this study are not much different from those reported previously, namely 25.04% in the briquette mixture of goat dung charcoal and palm shell [4]; 26.58% for a mixture of goat dung, saboak shell and rice husk [5], 25.54% for a mixture of goat dung, saboak shell and lamtoro twigs [6].

The volatile matter content of charcoal briquettes obtained in this study, shows a number that is still quite high and has not met the standards set according to the Indonesian National Standard (SNI 01-6235-2000) which is <15%. The high volatile matter obtained in this study is thought to be due to the suboptimal carbonisation process and should be studied more specifically. According to [17] the higher the temperature and time of carbonisation, the more volatile matter content is wasted so that the resulting volatile matter content is low. The same thing was also stated by [15] that the high and low levels of volatile matter are influenced by the temperature and length of carbonisation process. [18] reported a decrease in volatile matter content as the temperature and carbonisation time of rice straw increased, where the volatile matter content decreased significantly at 650oC compared to 450oC.

Fixed Carbon

The fixed carbon content of biochar briquettes mixed with goat dung charcoal, saboak shell and corn cob ranged from 52.21 - 54.48% with an average of 53.23 ± 0.99%. Statistical results showed the treatment had no significant effect (P>0.05) on the fixed carbon content. This means that the increase in the proportion of corn cob charcoal as the proportion of saboak shell charcoal decreases does not give significant changes to the fixed carbon content of the resulting biocharcoal briquettes. This condition is caused by the determinants of fixed carbon content in briquettes such as moisture content, ash and volatile matter which in this study also showed insignificant results due to the increasing proportion of corn cob charcoal.

[19] stated that fixed carbon is the fraction of carbon (C) that is bound in charcoal in addition to the water fraction, fly matter content, and ash content. The presence of fixed carbon in charcoal briquettes is influenced by the value of ash content and fly content. The content of fixed carbon will be high if the ash and fly content of charcoal. According to [20], the content of fixed carbon is highly dependent on the volatile matter content of the briquette, briquettes with high volatile matter content have lower fixed carbon content, while briquettes with low volatile matter content have higher bound carbon content. This is also thought to be influenced by the water content and ash content in this study which tend to be the same where the higher the water content and ash content, the lower the fixed carbon content, this is in line with the opinion of [21] that the higher the water content and ash content in briquettes will reduce the fixed carbon content.

The fixed carbon content of biochar briquettes obtained from the study (53.23%), is higher than the previous report, which was 40.84% in briquettes of goat dung charcoal mixture and palm shell [4]. This difference is due to the fact that corn cob charcoal has a higher carbon content than saboak shell (Table 1), thus increasing the proportion of corn cob charcoal causes the fixed carbon content to increase. Nevertheless, the results obtained from this study have not been able to meet the standard according to SNI, which is 78.5% (SNI 01-6235-2000).

Calorific Value

The calorific value of biochar briquettes mixed with goat dung charcoal, saboak shell and corn cob ranged from 5047.74 - 5345.48 cal/g with an average of 5198.68 cal/g. Statistical results showed that the treatment had a very significant effect ($P<0.01$) on the calorific value of briquettes. This means that the mixture of the three biomass materials with an increasing proportion of corn cob charcoal as the saboak shell charcoal decreases, produces biochar briquettes with different calorific values. Duncan's further test showed that the treatment pairs P4-P2, P4-P1, P3-P2, P3-P1 were significantly different ($P<0.05$).

Increasing the proportion of corn cob charcoal as the proportion of saboak shell charcoal decreases produces briquettes with increased calorific value. Table 2 shows the highest calorific value in the briquette mixture of 25% goat dung, 25% saboak shell and 50% corn cob at 5345.48 cal/g (P3) and the lowest in the mixture of 25% goat dung and 75% saboak shell without corn cob at 5047.74 cal/g. This is due to differences in the calorific value content of corn cob and saboak shell. [17] stated that the calorific value of briquettes depends on the composition of the raw materials used. [22] reported a calorific value of corn cob of 4500.32 cal/g, while the results of [7] showed a calorific value of saboak shell of 4470.08 cal/g and goat dung of 4070.72 cal/g.

The calorific value of biochar briquettes obtained in this study was 5198.75 cal/g, this result is higher than the previous study by [4] is 4454.06 cal/g on briquettes of goat dung charcoal mixture and palm shell, but not different from the other report on briquettes of goat dung mixture, saboak shell and lamtoro twigs, amounting to 5195.05 cal/g [6]. The calorific value of biochar briquettes in this study met the SNI, which is >5000 cal/g (SNI 01-6235-2000).

CONCLUSION

The use of corn cob as a substitute for saboak shell in making briquettes mixed with goat manure can increase the calorific value of briquettes, but the yield, moisture content, ash content, volatile matter and fixed carbon content tend to be the same. The best physico-chemical characteristics of briquettes were obtained from a mixture of 25% goat manure charcoal, 25% saboak shell and 50% corn cobs.

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