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Effect of Goat Dung Charcoal Blend of Lontar Shell and Other Biomass on Physical and Chemical Properties of Biocharcoal Briquettes

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ABSTRACT: This study aims to determine the physicochemical properties of biocharcoal briquettes blend of goat dung charcoal, *lontar* shell charcoal and various biomasses. This study used a completely randomised design with 4 treatments and 4 replicates. The treatments were T_1: 50% goat dung charcoal + 40% *lontar* shell charcoal + 10% *lontar* male fruit charcoal, T_2: 50% goat dung charcoal + 40% *lontar* shell charcoal + 10% rice husk charcoal, T_3: 50% goat dung charcoal + 40% *lontar* shell charcoal + 10% corn cob charcoal, T_4: 50% goat dung charcoal + 40% *lontar* shell charcoal + 10% lamtoro twigs charcoal. The variables studied were briquette yield, density, moisture content, ash content, calorific value, volatile matter, and fixed carbon. The statistical analysis showed that the treatment had a very significant effect ($P<0.01$) on density, moisture, ash content, calorific value, volatile matter, and fixed carbon, but no significant effect ($P>0.05$) on yield. The average of yield 56.41%, density 0.68g/cm^3, moisture 5.39%, Ash 22.24%, fixed carbon 43.04%, volatile matter of 29.34% and calorific value 4555.67 cal/g. It was concluded that biocharcoal briquettes produced blend of goat dung charcoal, *lontar* shell, and various biomasses (*lontar* male fruit, rice husk, corn cob and lamtoro twigs) had varying physical and chemical properties, but in this study using *lontar* male fruit charcoal, rice husk and lamtoro twig, were better.

KEYWORDS*:* biocharcoal briquettes, biomass, goat dung, physicochemical, *lontar* shell.

INTRODUCTION

Before the introduction of fossil fuels, humans have used biomass as a source of energy and generally those that have low economic value or are waste after the primary product is taken. including agricultural waste, forest waste, faeces, and livestock manure. Livestock manure is one of the wastes from animal husbandry in the form of solid, liquid and gas. In intensive livestock business activities, solid waste is found in the form of manure/feces and feed residue. Indri et al. (2015) stated that the negative impact of livestock waste, if not handled and processed, can cause a pungent odour and become a source of great contamination to the surrounding environment.

Noach and Handayani (2018) reported the potential production of fresh faeces of Ettawa garade goat in intensive farming in Kupang Regency, East Nusa Tenggara, averaged 956.5 g/head/day or in a dry state of 598.05 g/head/day. Suding and Jamaludin (2015) stated that goat dung contains CH_4, CO_2, N_2 and CO compounds that have the potential to be utilised as fuel. Amalo et al. (2022) reported that goat dung has a calorific value of 4070.72 cal/g. In addition to livestock waste, forestry waste and agricultural waste such as *lontar* shells, *lontar* male fruit, rice husks and corn cobs also need to be studied for their utilisation. These materials are still very limited in processing and utilisation, especially as fuel, even though they have good calorific potential. The calorific value of *lontar* male fruit is 3839.99 (Amalo et al., 2022), *lontar* shells 4470.08 cal/g (Dae Panie et al., 2022), lamtoro twig charcoal 4197 cal/kg (Nur, 2017), rice husk 4303.82 cal/g (Saidah et al., 2023) while corn cob calorific value is 5653.99 cal/g (Sukowati et al., 2019).

Several previous studies have reported the utilisation of livestock waste (goat dung) combined with other waste as an environmentally friendly alternative fuel including goat dung mixed with *lontar* shells (Dae Panie et al., 2022; Rosinta et al., 2023), goat dung mixed with *lontar* male fruit (Amalo et al., 2022).

Talking about new renewable energy, the potential and opportunity to utilise the various kind of biomass through a touch of practical technology is expected to provide important and useful information for humans and the environment. Biocharcoal briquettes made from biomass will be the hope of the future if supported by comprehensive studies related to its physical and chemical aspects (physicochemical) as an environmentally friendly fuel. Scientific studies by combining or mixing several biomass

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materials for making biocharcoal briquettes need to be the focus because each biomass material has advantages and disadvantages. It is realised that there is still limited information on the physiochemical characteristics of biocharcoal briquettes produced from a mixture of various biomass materials such as livestock, agricultural and forestry waste. Based on this fact, a study was conducted to study the properties of biocharcoal briquettes made from a mixture of goat dung and a variety of other biomasses such as *lontar* shells, *lontar* male fruit, rice husks corn cobs and lamtoro twigs

MATERIALS AND METHODS

This research was conducted in Naimata Village, Maulafa Subdistrict, Kupang City for 4 months from April to July 2023. The biomass materials used consisted of goat dung, *lontar* shells, *lontar* male fruit, lamtoro twigs, rice husks, corn cobs, and tapioca as an adhesive. The characteristics of the biomass materials used are presented in Table 1. The equipment used were pyrolysis drum, grinding machine with 20 mesh size, briquette mould, digital hanging scale of 75kg capacity with 20g sensitivity, digital sitting scale of 5kg capacity with 1g sensitivity, analytical balance, oven, furnace, desiccator, porcelain cup, and bomb calorimeter.

Table 1. Characteristics of biomass materials used in making biocharcoal briquettes

Biomass	Moisture (%)	Ash (%)	Volatile Mater (%)	Calor value (cal/g)	Fixed carbon (%)
Goat dung[2]	9,38	12,54	57,32	4070,72	20,76
Lontar shells[1]	1,72	3,36	71,82	4470,08	22,08
Lontar male fruit[2]	10,98	4,67	56,24	3839,99	28,11
Lamtor twigso[3]	1,56	5,36	42,34	6640,20	50,74
Rice husk[3]	2,39	42,42	21,76	3167,18	33,43
Corn cob [3]	5,7	10,33	17,96	6204,94	66,01

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).

The completely randomized design (CRD) was applied in this experiment consist of four different mixing ratios of charcoal goat dung and *lontar* shells and other biomass, as follows: T_1= 50% goat dung + 40% *lontar* shell + 10% *lontar* male fruit; T_2= 50% goat dung + 40% *lontar* shell + 10% rice husk; T_3= 50% of goat dung + 40% *lontar* shell + 10% corn cob; and T_4= 50% of goat dung + 40% *lontar* shell + 10% lamtoro twig. Each treatment was repeated four times so there are 16 experimental units. Each experimental unit uses 1 kg of biochar powder, with tapioca concentration 10% of the biochar (w/w)

Research procedure

The collected biomass materials, especially goat dung, *lontar shell*s and rice husks, were dried in the sun to facilitate the carbonisation process. *Lontar* shells, *lontar* male fruit, rice husk, lamtoro twigs and corn cob were carbonised using pyrolysis techniques, while goat dung was roasted. The hot charcoal after carbonating process is immediately cooled by sprinkling water and dried in the sun then all biochar materials are finely ground separately to obtain biochar powder of 20 mesh size. The three biochar materials were combined in the proportions according to the specified treatment, with a total mixture of 1000 grams. As an adhesive material was used tapioca as much as 10% of the charcoal material (w/w). Tapioca was dissolved in water then heated until it thickens to a clear colour. The adhesive is poured to the mixture of biochar materials and then 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. One press produces four briquettes with a height of 4.0cm. The dried briquettes obtained were not only sampled for laboratory testing, but also used in combustion testing. The data obtained were tabulated and analysed according to the analysis of variance procedure and further tested by Duncan's Multiple Range Test (DMRT) using SPSS v.29.

Variables measured

1. Yield; the yield of briquettes was calculated according to the instructions of Amalo et al. (2022) with the formula:

   Y (%) = (Dry Weight) / (Dough Weight) x 100 % …………………… (1)

2. Density (specific density), expressed as grams/cm3, calculated with the formula used by Noach et al (2023):

Density (g/cm3) = m/v ……………………………… (2))

where, m = mass of briquette; v = volume of briquettes calculated by the formula: $\pi.r^2.t$

3. Moisture content, expressed as a percent and calculated using ASTM D-3173-03 standard (Elfiano, 2014) with the formula:

Moisture content (%) = (a-b)/a x 100 ……………………… (3)

where, a = briquettes mass before heating (grams); b = briquettes mass after heating 107˚C

4. Ash content, expressed as a percent and calculated using ASTM D-3174-04 standard, with the equation:

Ash content (%) = d/a x 100 ……………………………………… (4)

where: d = briquettes mass after heating at 950oC (grams); a = briquettes mass before heating (grams)

5. Vollatile Matter; expressed as a percent and calculated with the formula used by Yuliah et al. (2017):

VM (%) = [$m3 – m4 ⁄ m2\ m1$] x 100 ……………………………………………….. (5)

where: m1 = empty bowl, m2 = empty bowl + sample, m3 = empty bowl + sample after heating, m4 = empty bowl + sample after cooling.

6. Fixed carbon; the fixed carbon content of the briquettes expressed as a percent and calculated with the formula used by Noach et al (2023):

Fixed carbon (%) = 100% - (% volatile matter + % moisture + % ash)……………(6)

7. Calorific Value; expressed in calories/gram and calculated by bomb calorimeter.

RESULTS AND DISCUSSION

Data on the physicochemical properties of biochar briquettes blend of goat dung charcoal, *lontar shell* charcoal, *lontar* male fruit, rice husk, corn cob and lamtoro twigs obtained in this study are presented in Table 2.

Table 2: Physico-chemical characteristics of biocharcoal briquettes

Variables	Treatment				P value	SNI
	T_1	T_2	T_3	T_4		
Yield (%)	56,62±0,83	56,45±2,12	56,00±1,07	56,55±1,64	0,93	-
Density (g/cm^3)	0,70±0,02^b	0,62±0,01^a	0,68±0,01^b	0,70±0,02^b	0,00	0,44
Moisture (%)	6,06±0,21^{bc}	3,55±0,21^a	5,49±0,60^b	6,47±0,51^c	0,00	<8
Ash (%)	20,15±0,37^a	22,58±0,92^b	25,84±0,56^c	20,38±0,22^a	0,00	<8
Volatile matter (%)	30,56±0,35^c	27,67±0,39^a	28,63±0,65^b	30,50±0,31^c	0,00	<15
Fixed carbon (%)	43,25±0,48^b	46,20±0,42^c	40,04±0,48^a	42,65±0,49^b	0,00	78,35
Calor value (cal/g)	4614,00±51,8^b	4598,24±85,8^b	4242,14±183,5^a	4768,29±59,9^b	0,00	>5000

Note: different superscripts on the same line indicate significantly different ($P<0.05$). T_1: 50% goat dung charcoal + 40% *lontar* shells + 10% *lontar* male fruit, T_2: 50% goat dung charcoal + 40% *lontar* shells + 10% rice husk, T_3: 50% ,goat dung charcoal + 40% *lontar* shells + 10% corn cob, T_4: 50% goat dung charcoal + 40% *lontar* shells + 10% lamtoro twigs.

Yield

Table 2, shows the yield of biocharcoal briquettes obtained ranged from 56.00 -56.62%, with an average of 56.41%. The results of variance analysis showed that the treatment had no significant effect ($P>0.05$) on the yield. This shows that the use of different biomass charcoal in a mixture of goat dung charcoal and lontar shells produces no change in the rendement of the resulting biochar briquettes.

The yield of biocharcoal briquettes in this study was higher than the previous report (Amalo et al., 2022) on biocharcoal briquettes mixed with goat dung charcoal and *lontar* male fruit charcoal with 6% adhesive produced a yield of 52.75%. This difference is thought to be due to the higher amount of adhesive used in this study. This is supported by Mulyadi et al, (2013) which states that the addition of tapioca adhesive percentage has a very significant effect on the yield of briquettes produced. As far as the

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search has not found any information about the yield of biochar briquettes standardised according to the Indonesian National Standard.

Density

Table 2, shows the density of biocharcoal briquettes obtained ranged from 0.62 -0.70g/cm^3 with an average of 0.68g/cm^3. the highest was in T1 which was 0.70 g/cm^3 and the lowest was T2 which was 0.62 g/cm^3. The results of variance showed that the treatment had a significant effect (P <0.05) on the yield of biocharcoal briquettes. The Duncan test results showed that the treatment pairs T_2:T_3, T_2:T_4 and T_2:T_1 were different (P<0.05). The best treatment is T_1 and T_4 because it has the highest density value. This shows that different biomass material mixtures produce biocharcoal briquettes with densities that tend to be different.

The density of biocharcoal briquettes produced in this study is higher than previous research conducted by Rosinta et al (2023) on biocharcoal briquettes mixed with goat dung charcoal and lontar shell charcoal with 6% adhesive producing a density of 0.63 g/cm^3. The difference in density is thought to be because the amount of adhesive used in this study is higher than the previous study. This is supported by previous research by Arifah (2017) that the higher the level of adhesive in making biochar briquettes, the higher the density. This is because the adhesive has the property of binding particles so that the resulting biocharcoal briquettes are more compact. The density of biocharcoal briquettes produced in this study has fulfilled SNI 01-6235-2000 of 0.44 g/cm^3.

Moisture

Table 2, shows that the moisture content of biocharcoal briquettes obtained ranged from 3.55 -6.47%, with an average of 5.39%. the highest was in T_4 which was 6.47% and the lowest moisture content was in T_2 which was 3.55%. The results of variance showed that the treatment had a very significant effect (P <0.01) on the moisture content of biocharcoal briquettes. The Duncan test results showed that the treatment pairs T_2:T_3, T_2:T_1, T_2:T_4 and T_3:T_4, were different (P<0.05). This shows that different biomass material mixtures produce biocharcoal briquettes with water content that tends to be different.

The water content produced by T_2 is lower than the previous study but in T_1, T_3 and T_4 it is higher than the previous study conducted by Rosinta et al. (2023) biocharcoal mixture of goat dung and lontar shell produced biocharcoal briquettes with a water content of 4.52%. This is because the density produced in this study is different from previous studies so that the resulting water content tends to be different.

The high and low water content is influenced by the density produced by a briquette. It is seen from the existing data that T_2 which has a low moisture content also has a low density value as well. This agrees with Amalo et al. (2022) the higher the density of the briquette causes less water to be freed during drying as a result the moisture content is higher. However, the briquettes produced from each treatment in this study have met SNI 01-6235-2000 of <8%.

Ash Content

Table 2 shows that the ash content of biocharcoal briquettes obtained ranged from 20.15 - 25.84%, with an average of 22.24%. The highest ash content of biocharcoal briquettes produced was in T_3, 25.84%, and the lowest was in T_1, 20.15%. The results of the variance analysis showed that the treatments had a very significant effect (P<0.01) on the ash content of biocharcoal briquettes. The Duncan test results showed that the treatment pairs T_1:T_2, T_1:T_3, T_4:T_2, T_4:T_3 and T_2:T_3 were different (P<0.05). This shows that different biomass material mixtures produce biocharcoal briquettes with different ash content.

The high and low ash content produced from each treatment in this study is due to the different mixture of biomass materials used in each treatment. It is proven that T_1 has the lowest ash content because according to the analysis results of the Laboratory of Animal Nutrition and Feed of Kupang State Agricultural Polytechnic, the charcoal powder of lamtoro twigs itself has a fairly low ash content of 5.36%. Meanwhile, T_3 had the highest ash content because the corn cob charcoal used in this treatment had a high ash content of 10.33%.

The ash content obtained in this study was lower than the results of research by Rosinta et al. (2023) on briquettes made from a mixture of goat dung charcoal and lontar shell charcoal which produced an average ash content of 29.61%. The lower ash content is due to the different doses and compositions that make up the biochar briquettes. The ash content of the briquettes produced in this study did not fulfil SNI 01-6235-2000 of <8%.

The high ash content in this study is thought to be due to the high proportion of goat dung used. This is in line with the opinion of Rosinta et al. (2023) The increasing level of goat dung from the briquettes, the ash content produced by biocharcoal briquettes is also getting higher. According to Amalo et al. (2022) goat dung has a fairly high ash content value of 12.54%. Nahas

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et al. (2019) stated that the silica content contained in livestock manure is high and the effect of silica content on the calorific value of briquettes is not good.

Volatile Matter

Table 2 shows that the volatile matter content of biocharcoal briquettes obtained ranged from 25.03 - 26.09%, with an average of 25.54%. The highest biocharcoal briquettes produced were in T_1 which was 30.56% and the lowest was T_2 which was 27.67%. The results of variance showed that the treatment had a very significant effect (P <0.01) on the volatile matter of biocharcoal briquettes. The Duncan test results showed that the treatment pair T_2:T_1, T_2:T_3, T_2:T_4, T_3:T_1 and T_3:T_4 were different at (P<0.05). This shows that different biomass material mixtures produce biochar briquettes with volatile matter levels that tend to be different.

The high volatile matter of biocharcoal briquettes produced from each treatment is strongly influenced by the type of raw material used. Because each biomass material has a different level of particle density. This agrees with (Faizal et al., 2015) the lower the density of the raw material, the faster the decrease in fly substance levels, because particles exposed to heat will be released from their bonds faster. This can be seen in T_2 which has low volatile matter content because the corn cob biomass material used has a low level of density between particles.

The average volatile matter content of this study is higher than the previous study which was 19.57% in the mixture ratio of 25% goat dung and 75% lontar shell (Noach et al., 2023). The higher volatile matter content of this study is thought to be due to the use of higher goat dung charcoal. where goat dung charcoal itself has a volatile matter content of 57.32%. Volatile matter content is also strongly influenced by the moisture content of biocharcoal briquettes. This can be seen in Table 2 where the higher the water content, the higher the volatile matter content. According to Ristianingsih et al. (2015) high water content will produce high volatile matter as well. The volatile matter content of this study has not fulfilled the minimum SNI 01-6235-2000 of 15%.

Fixed Carbon

Table 2 shows that the fixed carbon content of biocharcoal briquettes obtained ranged from 40.04 - 46.2%, with an average of 43.04%. The highest in this study was in T_2 which was 46.20% and the lowest was T_3 which was 40.04%. The results of variance showed that the treatment had a very significant effect (P <0.01) on the fixed carbon of biocharcoal briquettes. The Duncan test results showed that the treatment pairs T_3:T_4, T_3:T_1, T_2:T_3, T_2:T_4, and T_1:T_2 were different at (P<0.05). This shows that different biomass material mixtures produce biochar briquettes with different levels of fixed carbon.

The high and low levels of fixed carbon in the resulting briquettes are influenced by varying moisture content, ash content and volatile matter. This can be seen from T_2 which has a high fixed carbon content has a low water content and volatile matter while T_3 which has a low fixed carbon content has a high water content, ash content and volatile matter. fixed carbon levels contained in biochar briquettes produced from this study have not met SNI 01-6235-20000 of >78.35%.

The average fixed carbon content contained in the briquettes from this study was lower than the previous study of 55.76% in briquettes with a mixture ratio of 25% goat dung and 75% *lontar* shell (Noach et al., 2023). The lower fixed carbon content of biochar briquettes from this study when compared to previous studies is thought to be due to the higher portion of goat dung used in this study and the smaller portion of *lontar* shell. Because each biomass has different cellulose and hemicellulose where fixed carbon levels are the result of cellulose and hemicellulose reactions during combustion (Budiawan et al., 2014).

Calorific Value

Table 2, shows the calorific value of biocharcoal briquettes obtained ranged from 5047.65 - 5367.97 cal/g with an average of 5195.05 cal/g. The highest biocharcoal briquettes produced were in T_4 which was 4768.29 cal/g and the lowest was T_3 which was 4242.12 cal/g. The results of variance showed that the treatment had a significant effect (P <0.01) on the calorific value of biocharcoal briquettes. The Duncan test results showed that the treatment pairs T_3:T_2, T_3:T_1 and T_3:T_4 were different (P<0.05). This indicated that different biomass material mixtures produce biocharcoal briquettes with different calorific values.

The calorific value obtained in this study is higher than the previous study conducted by Rosinta et al. (2023) where biocharcoal briquettes mixed with goat dung charcoal and lontar shell produced an average calorific value of 3874.93 cal/g. This higher calorific value is thought to be due to the different portion of raw materials used and also the briquettes produced have lower moisture content and ash content so that they have a calorific value that tends to be better than previous studies.

The high calorific value of biochar briquettes produced in this study is inversely proportional to the ash content produced, the higher the ash content produced, the calorific value will decrease. This is in line with Nahas et al. (2019) ash content, moisture

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content and carbon content contained in briquettes greatly affect their calorific value. This can be seen from T3 which has the lowest calorific value has a high ash content while T4 which has a high calorific value has a low ash content. However, the calorific value produced from each treatment in this study has not fulfilled SNI 01-6235-2000 of 5000 cal/g.

CONCLUSION

It was concluded that bio charcoal briquettes produced from a mixture of goat dung charcoal, saboak shell, and various biomasses (*lontar* male fruit, rice husk, corn cob and lamtoro twigs) had varying physical and chemical properties, but in this study using *lontar* male fruit charcoal, rice husk and lamtoro twig, were better. Overall, the physicochemical properties of biocharcoal briquettes produced in this study have not entirely fulfilled the requirements standardised in SNI 01-6235-2000.

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