International Journal of Current Science Research and Review
ISSN: 2581-8341
Volume 07 Issue 02 February 2024
DOI: 10.47191/ijcsrr/V7-i2-30, Impact Factor: 7.943
IJCSRR @ 2024
www.ijcsrr.org

Physico-chemical Characteristics of Biochar Briquettes Blend of Goat Manure Charcoal, *Saboak* Shells and Rice Husk

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ABSTRACT: The study aimed to determine the effect of goat manure charcoal mixture, saboak shell and rice husk on the physico-chemical characteristics of biocharcoal briquettes. The completely randomized design with 4 treatments and 4 replicates was applied. Those treatments were P_1 = 25% goat manure + 75% *saboak* shell without rice husk, P_2 = 25% goat manure + 50% *saboak* shell + 25% rice husk, P_3 = 25% goat manure + 25% *saboak* shell + 50% rice husk, P_4 = 25% goat manure + 75% rice husk without *saboak* shell. Variables measured: yield, density, moisture content, ash content, volatile matter, fixed carbon and calorific value. The average data obtained were: yield 58.94%; density 0.65 g/cm^3; moisture 2.42%; ash 27.41%; volatile matter 26.58%; fixed carbon 43.59%. and calorific value 4086.7 cal/ g; Statistical analysis showed that treatment had a very significant effect ($P<0.01$) on ash content and fixed carbon; significant effect ($P<0.05$) on moisture content and calorific value; and not significant ($P>0.05$) on yield, density and volatile matter. It was concluded that increasing the proportion of rice husk charcoal in the mixture with goat manure and *saboak* shell produced biochar briquettes with characteristics decreased of moisture content, fixed carbon and calorific value, increased of ash content while yield, density and volatile matter tended to be the same.

KEYWORDS: briquettes, goat manure, physico-chemical, rice husk, *saboak* shells

INTRODUCTION

Along with the number of businesses in the livestock sector, the waste produced every day continues to grow. The Livestock Service Office of East Nusa Tenggara Province (BPS NTT Province, 2022) stated that the population of goats in Kupang City in 2022 was 8,768 heads. According to Noach and Handayani (2018), fresh PE goat faeces production is around 956.5 g/head/day or dry faeces 598.05 g/head/day. From this opinion, it can be estimated that the fresh goat faeces produced every day is 8,386.6 kg/day and 251,598 kg in a month. This potential if not utilised properly can have a negative impact on the environment including causing environmental pollution, a source of disease, and also as a contributor to greenhouse effect gas emissions.

Processing livestock waste is a must, in addition to minimising negative impacts on the environment and health, it is also intended to increase the added value of waste. Waste can be processed into fertiliser (compost and bokashi) and alternative fuel, namely charcoal briquettes. According to Afriani et al. (2017) briquettes are a solid fuel formed from mixing organic waste with adhesives and other substances so that they can be useful in combustion.

The processing of goat manure into briquette fuel has been carried out by several previous researchers, where goat manure charcoal is combined with charcoal from other biomass materials, such as *lontar* male fruit (Amalo et al, 2022), *lontar* shell (Noach et al, 2023). According to Amalo et al. (2022) goat manure has a low carbon content of 20.76%, high volatile matter of 57.32% and has a calorific value of 4070.72 cal/g.

The *saboak* shell comes from the palm/*lontar* or *siwalan* plant. The ripe *lontar* fruit can be processed into food in the form of pia/cake (Mahayasa et al., 2018), while the shell is used as a substitute for firewood without further processing. Dae Panie et al. (2022) reported that *saboak* shell has a carbon content of 22.08%, volatile matter of 71.82% and a calorific value of 4470.08 kal/g. Making of biocharcoal briquettes by combining goat manure and *saboak* shell has been reported by Rosinta et al. (2023) and Noach et al. (2023) where the combination level of goat manure 25% and saboak shell 75% produces the best briquette characteristics, although it does not fully meet the Indonesian National Standard (SNI) with the calorific value of 4454,06 cal/g.

On the other hand, there is also biomass waste such as rice husk as a by-product of rice milling, which according to Faizal et al. (2015) contains 37.21% carbon, 12.74% volatile matter and a calorific value of 4128 cal/g. The high carbon content of rice husk charcoal with lower volatile matter than *saboak* shell and goat manure, indicates that rice husk has the opportunity to be used as a

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mixture of biocharcoal briquettes which is expected to improve the quality of the briquettes. Based on this fact, a study was carried out to determine the physico-chemical characteristics of biochar briquettes made from a blend of goat manure charcoal, *saboak* shell and rice husk.

MATERIALS AND METHODS

The research was conducted in Naimata Village, Maulafa District, Kupang City for 4 months from April to July 2023. The main materials used in this study were goat manure charcoal, *saboak* shell, rice husk, tapioca and water. The equipment used consist of pyrolysis drum, grinding machine with 20 mesh size, briquette pressor, digital hanging scale of 75kg capacity with 20g sensitivity, digital sitting scale of 5kg capacity with 1g sensitivity, analytical balance, furnace, porcelain cup, and bomb calorimeter. The characteristik of the three biomass materials used are presented in Table 1.

Table 1. Characteristik of goat manure, *saboak* shell and rice husk

Biomass	Moisture (%)	Ash (%)	Fixed carbon (%)	Volatile matter (%)	Calorific value (kal/g)
Goat manure [1]	9.38	12.54	20.76	57.32	4070.72
Saboak shell[1]	1.72	3.36	22.08	71.82	4470.08
Rice husk [2]	2,39	42,42	33,43	21,76	3167,2[3]

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).

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/cm^3) = 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 (%) = $[m_3 - m_4 / m_2\ m_1]$ x 100 ……………………………………………….. (5)
   where: m_1 = empty bowl, m_2 = empty bowl + sample, m_3 = empty bowl + sample after heating, m_4 = 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.

Research procedure

The collected biomass materials, especially goat manure, *saboak* shells and rice husks, were dried in the sun to facilitate the carbonisation process. *Saboak* shells and rice husks were carbonised using pyrolysis techniques, while goat manure 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%

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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.

RESULTS AND DISCUSSION

Physico-chemical characteritic of biochar briquettes mixed with goat manure, *saboak* shell and rice husk are presented in Table 2.

Table 2: Physicochemical characteritic of Biochar Briquettes

Variabel	Perlakuan				Nilai P
	P_1	P_2	P_3	P_4	
Yields (%)	58.75±0.19[a]	58.53±1.55[a]	59.38±0.55[a]	59.09±0.88[a]	0.60
Density (gr/cm³)	0.67±0.01[a]	0.65±0.03[a]	0.62±0.02[a]	0.64±0.01[a]	0.05
Moisture (%)	4.39±0.58[a]	2.04±1.46[b]	1.49±0.54[b]	1.75±0.54[b]	0.00
Ash (%)	17.31±0.51[a]	24.31±0.35[b]	31.68±0.58[c]	36.37±3.50[d]	0.00
Volatile matter (%)	26.09±0.14[a]	26.46±0.53[a]	26.73±0.54[a]	27.06±0.54[a]	0.07
Fixed carbon (%)	52.21±0.35[a]	47.2±2.22[b]	40.11±0.66[c]	34.83±4.44[d]	0.00
Calorific value (kal/g)	5047.7±157.6[a]	4056.6±106.7[b]	3725.2±343.1[b]	3517.2±305.8[b]	0.0

Note: different superscripts on the same line indicate significantly different ($P<0.05$); P_1=25% goat manure + 75% *saboak* shell, without rice husk; P_2=25% goat manure + 50% *saboak* shell + 25% rice husk; P_3=25% goat manure + 25% *saboak* shell + 50% rice husk; P_4=25% goat manure + 75% rice husk, without *saboak* shell

Yield

The yield of biochar briquettes ranging from 58.53% to 59.38% (Table 2) with the average of 58.94%. Statistically shown there is no significant effect ($P>0.05$) of the treatment on briquettes yield. It means that the mixture of the three biomass materials with different proportions have no changes the briquettes yield. This is because the biochar powder from the three biomass materials used has the same particle size of 20 mesh. According to Saranaung et al. (2018) the finer the size of the material, the higher the yield value and Komarayati et al. (2011) stated that the dense/compact structure of the material also affects the high yield ot the briquettes.

The yield of briquettes obtained in this study is higher than the previous study as reported by Rosinta et al. (2023) on biochar briquettes of a mixture of goat manure charcoal and *saboak* shells, was 52.69% and Amalo et al. (2022) on biochar briquettes of a mixture of goat manure charcoal and *lontar* male fruit, of 52.75%. So far, no standard has been established on the yield of biochar briquettes made from biomass.

Density

The density of biochar briquettes ranging from 0.62 to 0.67g/cm³ (Table 2), with the average of 0.65g/cm³. Statistically shown there is no significant effect ($P>0.05$) of the treatment on briquette density. It means that the mixture of the three biomass materials with different proportions produces biochar briquette densities that tend to be the same.

This same density is due to in addition to the uniform charcoal powder particle size of 20 mesh, the compressive strength at the time of pressing is also the same. this argument is supported by the statement of Priyanto et al. (2018) that particle size and homogeneity of the constituent materials affect the size of the density of the briquette. According to Pambudi et al. (2018) the greater the pressure applied, the greater the density produced.

The density average of biochar briquettes in this study is higher than the research of Noach et al. (2023) of 0.62 g/cm³ mixture of goat manure charcoal and *saboak* shell and research of Amalo et al. (2022) of 0.50g/cm3 mixture of goat manure charcoal and *lontar* male fruit. The density of briquettes obtained in this study has met the Indonesian National Standard of at least 0.44 g/cm3 (SNI 01-6235-2000. Another factor causing this difference is the level of adhesive material. in this study 10% adhesive was used from the biochar material, while previous studies Amalo et al. (2022); Rosinta et al. (2023) and Noach et al. (2023) used an adhesive of 6% of the biochar material. according to Arifah. (2017) that the more adhesive used in making biochar briquettes, the higher the density produced.

Moisture

The moisture content of biochar briquettes ranging from 1.49% to 4.39% (Table 2) with the average of 2.42%. Statistically shown the treatment had significant effect (($P<0.05$) on the moisture content of the biochar briquettes. DMRT shows that the treatment pairs P_1:P_2, P_1:P_3 dan P_1:P_4 are significant different ($P<0.05$). This means that mixtures of the three biomas with different proportions produce biochar briquettes with different moisture contents. Based on the table, it seems that the using of rice husk as material mix in briquettes making can reduced the moisture content of biochar briquettes. This is to related to characteristics of rice husk. According to Listiana et al. (2021) rice husk charcoal has low water absorption properties. In addition, the place of storage can also affect the moisture content of briquettes. Regarding the statement, Nurmalasari and Afifah (2017) stated that briquettes have hygroscopic properties so that if left in the open air, the briquettes will absorb water from the air.

The moisture of the briquettes produced from this study is better than the previous study of 4.52% on biochar briquettes mixture of goat manure and *saboak* shell (Noach et al. 2023) and Amalo et al. (2022) on biiochar briquettes mixture of goat manure and *lontar* male fruit of 4.39%. Overall, the moisture of biochar briquettes of this study has met the maximum Indonesian National Standard (SNI 01-6235-2000) of 8%.

Ash content

The ash content of biochar briquettes ranging from 17.31% to 36.37% (Table 2) with the average of 27.42%. Statistically shown the treatment had a very significant effect ($P<0.01$) on the ash content of the biochar briquettes. DMRT shows that all the treatment pairs are significant different ($P<0.05$). This means that mixtures of the three biomas with different proportions produce biochar briquettes with different ash contents. Based on the table, it seems that the using of rice husk as material mix in briquettes making can increase the ash content of biochar briquettes. This is thought to be related to the characteristics of rice husk, which has high ash content. Proximate analysis of Animal Nutrition and Feed Laboratory of Kupang State Agricultural Polytechnic 2023, shows that ash content of rice husk 42.42% higher than *saboak* shell and goat manure. Rosinta et al. (2023) stated that ash content of *saboak* shell 3.36% and goat manure 12.54%

The ash content of the briquettes of this study was higher than that reported by Amalo et al. (2022) of 25.66% on biochar briquettes of goat manure and *lontar* male fruit mix and lower than that reported by Noach et al. (2023) with an ash content of 29.7% of biochar briquettes of goat manure and *lontar* shell mix. The ash content of this study does not meet the Indonesian National Standard for ash content of biochar briquettes <8% (SNI 01-6235-2000).

Volatile Matter

The volatile matter of biochar briquettes in this study, ranging from 26.09 - 27.07% (Table 2), with the average of 26.58%. Statistically shown there is no significant effect ($P>0.05$) of the treatment on the volatile matter content. It means that the mixture of the three biomass materials with different proportions have no changes the volatile matter content of the biochar briquettes. This same trend is related to the characteristics of the biochar particles used, which have the same size of 20 mesh. According to Dewi et al. (2020) The size of charcoal powder also affects the height of volatile matter, where the smaller the particle size of charcoal powder, the lower the volatile matter produced.

The volatile matter content of biochar briquettes produced in this study is higher than previous study that reported by Noach et al (2023) on bio charcoal briquettes mixed with goat manure and *saboak* shell of 25.04%, also on charcoal briquettes mixed with rice husks and coconut shells reported by Yuliah et al (2017) of 25.61%. The difference in volatile matter results is thought to be caused by the different treatments applied, as well as the carbonating process and the partikel size. Maryono et al. (2013) stated that the length of carbonating and temperature in the carbonization process greatly affect the high and low volatile matter produced. The volatile matter content obtained in this study has not met the Indonesian National Standard where the maximum volatile matter content in charcoal briquettes is 15% (SNI 01-6235-2000).

Fixed carbon

Presents the average carbon content of biochar briquettes from a mixture of goat manure charcoal, saboak shell, and rice husk ranging from 34.83 - 52.21% (Table 2), with the average of 43.59%. Statistical showed that the treatment had a very significant effect ($P<0.01$) on the fixed carbon content. DMRT shows that all the treatment pairs are significant different ($P<0.05$). This means that mixtures of the three biomas with different proportions produce biochar briquettes with different fixed carbon contents. On the basis of the table above, it seems that the using of rice husk as material mix in briquettes making can decrease the fixed carbon content of biochar briquettes.

The carbon content of the briquettes produced decreased with the increase in the proportion of rice husk. The decrease in fixed carbon is associated with the increase in volatile matter content of the biochar briquettes. This is supported by the statement of Junary et al. (2015) that the higher the carbon content of biochar briquettes, the less volatile matter is produced and the high volatile matter content will reduce the level of fixed carbon produced.

The carbon content of biochar briquettes in this study is higher than previous study that reported by Noach et al (2023) on bio charcoal briquettes blend of goat manure and *saboak* shell of 40.48%. The carbon content of the briquettes in this study did not meet the minimum of 78.5% as the Indonesian National (SNI 01-6235-2000).

Calorific Value

The calorific value of biochar briquettes from a mixture of goat manure charcoal, *saboak* shell, and rice husk ranging from 3517.2 - 5047.7 cal/g (Table 2) with the average of 4086.68cal/g. The results of variance analysis showed that the treatment had a significant effect ($P<0.05$) on the calorific value of briquettes. DMRT shows that the treatment pairs P_1:P_2, P_1:P_3 dan P_1:P_4 are significant different ($P<0.05$). This means that mixtures of the three biomas with different proportions produce biochar briquettes with different moisture contents. Based on the table, it seems that the using of rice husk as material mix in briquettes making can reduced the calorific value of biochar briquettes. Higher proportion of rice husk produced biochar briquettes with lower calorofic value. Noach et al (2023) stated that the reducing in the calorific value of briquettes is related to ash content and volatile matter.

In the study, it is clear that increasing the proportion of rice husk in the mixture of biochar materials, produces briquettes with increased ash content and decreased fixed carbon. this is the reason why the calorific value of the resulting biocharcoal briquettes has decreased. Referring to the calorific value of charcoal briquettes in the Indonesian National Standard (SNI 01-6235-2000) of at least 5000 cal/g, the results obtained in this study show that the blend of goat manure and palm shells without rice husks has met the standard (5047.7 cal/g), but overall the briquettes produced have not met the standard (4086.68cal/g).

CONCLUSION

It was concluded that increasing the proportion of rice husk charcoal in the mixture with goat manure and saboak shell produced biochar briquettes with characteristics of moisture content, fixed carbon and calorific value decreased, ash content increased while yield, density and volatile matter tended to be the same. The physicochemical characteristics of biochar briquettes produced in this study have not entirely fulfilled the requirements standardised in SNI 01-6235-2000.

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Cite this Article: Thomas A.B. Wator, Yakob R. Noach, Upik Sy. Rosnah, Twen O. Dami Dato (2024). Physico-chemical Characteristics of Biochar Briquettes Blend of Goat Manure Charcoal, Saboak Shells and Rice Husk. International Journal of Current Science Research and Review, 7(2), 1136-1141