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The Influence of Different Ratio of Goat Dung and *Lontar* Shells (*Borassus Flabellifer* Linn) Charcoal on the Biochar Briquettes Properties

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ABSTRACT: Research goals was to determine the physico-chemical and burning propersties of biochar briquettes with different ratios between goat dung and *lontar* shell charcoal. Material used were goat dung, *lontar* shell, tapioca as binder and water. The equipment were kiln drum (pyrolysis drum), grinding machine, hydraulic pressor, briquette stove, infrared digital thermometer, digital hanging scales, digital sitting scales. Variables measured were density, moisture, ash, volatile matter, fixed carbon, calorific value, burning rate and burning resistance. Analysis of variance was applied to determine the influence of treatment on the variables measured. Result of analysis showed that treatment had a very significant ($P<.01$) on moisture, ash, volatile matter, fixed carbon, calorific value, burning rate and burning resistance, but no significant ($P>.05$) on density of biochar briquettes. More proportion of goat dung charcoal generated the biochar briquettes with properties more ash content, lower fixed carbon, higher volatile matter, reduced calorific value, faster burning rate, shorter burning resistance. It can be concluded that the physico-chemical and burning properties of the biochar briquettes generated in this study did not meet the standards according to SNI 01-6235-2000. In this case, however, the best ratio is 25% of goat dung charcoal and 75% of *lontar* shell charcoal.

KEYWORDS: briquettes properties, goat dung, *lontar* shell.

INTRODUCTION

Studies on the potential of alternative energy sources need to be continuously encouraged in order to provide environmentally friendly fuels with materials that are cheap and readily available around so that it can be adopted for use even on a small scale. One of the potential energy source is biomass. Aljarwi *et al*. (2020)[1] describe biomass as dry organic material from plants like wood, leaves, grass as well as agricultural, livestock, plantation and other wastes. Biomass material has potential as a renewable energy source because it contains adequate calories. According to Arni *et al* (2014) [2], the main components in biomass consist of cellulose and lignin which contain calories ranging from 3000 - 4500 cal/gram.

Goat dung is one of the animal waste products which in intensive farming always considered a source of environmental pollution. Goat dung has been widely used as manure that can increase soil and plant productivity. On the other hand, currently biochar technology is being developed with various sources of biomass involving waste from livestock dung (Lumbantobing *et al*., 2020) [3] As a biomass, report that goat dung contains a fairly high energy of 4071.72 calories/gram and contains a high percentage of volatile matter, namely 57.32%. (Dae Panie *et al*., 2022)[4]. Hence, goat dung also has the potential to be made into biochar briquettes.

Other potential biomass is waste from palm trees (*lontar/siwalan/ tuak*=*Borassus flabellifer* Linn) that is of *lontar* shells and *lontar* male fruit or often called ***mayang*** lontar. According to Dae Panie *et al*. (2022)[4]. these two wastes has long been used as direct fuel to substitute firewood. Both, *lontar* shell and *mayang lontar* contain high energy, 4470.08 and 3839.99 calories/gram, respectively, but the percentage of volatile matter is also high, that is 71.82 and 56.24%.

The calories in the two biomass material can be optimized through processing into other practical forms such as briquettes. Briquetting is also intended to concentrate carbon and release as much of the volatile matter contained in the biomass as possible, through the carbonization process. Aransiola *et al*. (2019)[5] stated that carbonizing the biomass before briquette making is another

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method of enhancing the properties of briquette. Carbonization is essentially the removal of volatile materials from the feedstock in the absence (or limited supply of) air.

The conversion of these biomass both goat dung and *lontar* waste, especially, into briquettes has not been applicated, even thought it can provide multiple impact to reduces pollution it also adding new benefits for human life. The question is what are the characteristics of biochar briquettes produced from a mixture of goat dung and *lontar* shell charcoal?

Based on the description above, it was necessary to examine the the influence of a mixture of goat dung and *lontar* shell (*Borassus flabellifer* Linn) on the physico-chemical and burning properties of biochar briquettes;

MATERIALS AND METHOD

Experiment was conducted in the Naimata Village, Maulafa District, Kupang City and Animal Feed and Nutrition Laboratory of the Kupang State Agricultural Polytechnic, in November 2021 to February 2022.

The materials used were goat dung, *lontar* shell and tapioca. Main equipment were a kiln drum (pyrolysis drum), grinding machine, hydraulic pressor, briquette stove, infrared thermometer, digital hanging scales with a capacity of 75 kg, digital sitting scales with a capacity of 5 kg and other supporting equipment.

The completely randomized design (CRD) was applied in this experiment consist of four different mixing ratios of charcoal goat dung and *lontar* shells, as follows: $\mathbf{P_1}$= 25% goat dung + 75% *lontar* shell; $\mathbf{P_2}$= 50% goat dung + 50% *lontar* shell; $\mathbf{P_3}$= 75% of goat dung + 25% *lontar* shell; and $\mathbf{P_4}$= 100% of goat dung. Each treatment was repeated four times so there are 16 experimental units. Each experimental unit uses 1 kg of biochar powder, with tapioca concentration 6% of the biochar (w/w)

Variables measured in this studi, consist of: density, moisture, ash, volatile matter, fixed carbon, calorific value, burning rate and burn resistance.

The characteristic of the biochar briquettes studied include:

1. Density (specific density), expressed as grams/cm^3, calculated by equation:
   Density (g/cm3) = m/v ……………………………… (1)
   Where, m = mass of briquettes
   v = volume of briquettes calculated by the formula: $\pi.r^2.t$
2. Moisture content, expressed as a percent and calculated using ASTM D-3173-03 standard (Elfiano, 2014)[6] with the equation:
   Moisture content (%) = (a-b)/a x 100 ……………………….. (2)
   Where, a = briquettes mass before heating (grams)
   b = briquettes mass after heating 107˚C
3. Ash content, expressed as a percent and calculated using ASTM D-3174-04 standard, with the equation:
   Ash content (%) = d/a x 100 ……………………………………… (3)
   Where: d = briquettes mass after heating at 950ºC (grams)
   a = briquettes mass before heating (grams)
4. Vollatile Matter; expressed as a percent and calculated using ASTM D-3174-02 standard, with the equation:

VM content (%) = (b – c)/a x 100 …………………………………. (4)

5. Fixed Carbon; expressed as a percent and calculated using the equation:

Fixed carbon (%) = (100 – (volatile matter + moisture + Ash) ……… (5)

6. Calorific Value; expressed in calories/gram and calculated by bomb calorimeter.
7. Burning Rate is the mass of biochar briquettes burned in one unit of time and expressed in grams/minute.
8. Burning resistance (burn resistance) is time spent of the biochar briquette in burning process. It's calculated from the time the briquettes burn down to ashes and expressed in minutes.

Data analysis

Analysis of variance was applied to determine the influence of treatment on variables measured and continued by Duncan's multiple range test to find out difference between treatments, according to Gomez and Gomez (1995)[7].

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RESULT AND DISCUSSIONS

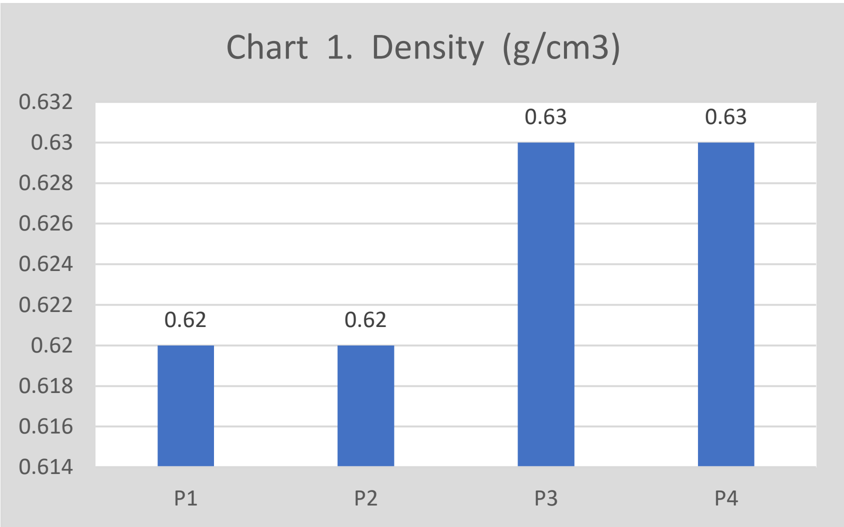
The properties of biochars produced a mixture of goat dung and *lontar* shell are shown in Figure 3

Table 1. Physico-chemical characteristics of biochar briquettes

Variables	Treatments			
	P_1	P_2	P_3	P_4
Density (g/cm^3)	.62	.62	.63	.63
Water content (%)	3.34^d	4.41^c	5.01^{bc}	5.31^a
Ash content (%)	21.34^d	29.74^c	31.87^{bc}	35.95^a
Volatile matter (%)	$19,57^d$	23.91^{bc}	26.30^b	30.37^a
Fix carbon (%)	55.76^a	41.93^b	36.81^c	28.82^d
Burning rate (g/minute)	1.89^d	2.24^c	2.27^b	2.74^a
Burning resist (minute)	180^a	180^a	160^b	120^c
Calor value (cal/g)	4454.06^a	3842.02^b	3466.02^d	3732.66^c

Different of superscipt ^{a,b} on the same row shown significant difference (P<.01)

1. Density



The average density of biochar briquettes ranges from 0.62 to 0.63 g/cm^3. The results of the variance analysis showed that the treatment had no significant effect (P>0.05) on the density of briquettes. The lowest density was found at P_1 and P_2 and the highest at P_3 and P_4. Chart 1 showed that the reduced level of lontar shell charcoal or increased goat dung charcoal used result in high density biochar briquettes. This increase in density has to do with the mass of briquettes and the volume of briquettes produced during briquetting. The reduced level of the lontar shell will cause a decrease in the volume of briquettes produced. This agrees with Hendra and Darmawan (2000)[8] which states that if the density produced is large, the volume will be smaller. The density of briquettes obtained in this study was still lower than previous studies of 1g/cm^3 (Sumangat and Broto, 2009)[9] on jatropha seed cake briquettes. On the other hand, higher than SNI 01-6235-2000 of 0.44 g/cm3 but lower than the Japanese standard (1.0-1.2 g/cm3) and USA (1.0 g/cm3).

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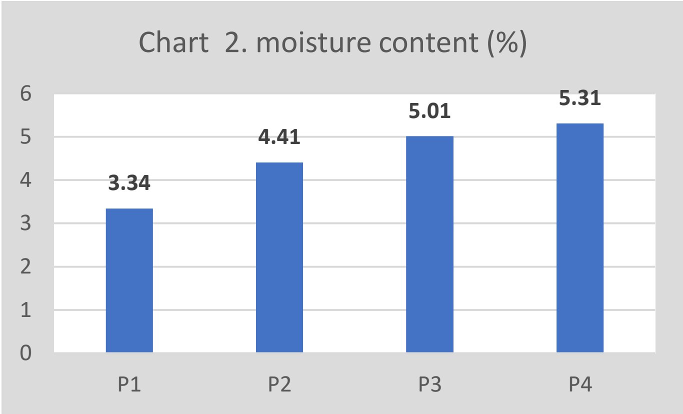
2. Moisture content

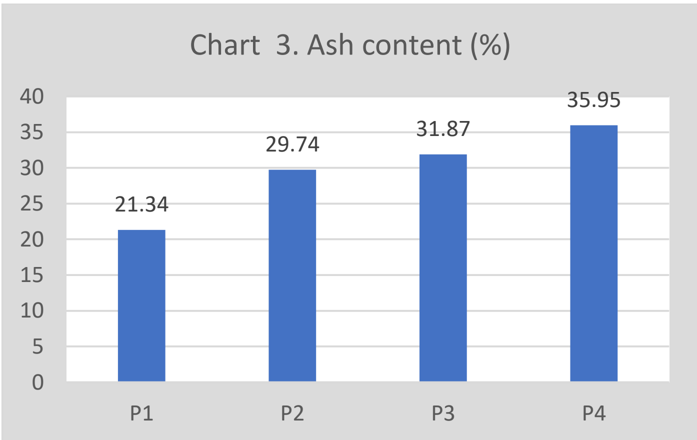


The average moisture content of biochar briquettes ranges from 3.3 to 5.3%. Analysis of variance showed that the treatment had a very significant effect (P<0.01) on moisture content. The ratio of 25% goat dung charcoal and 75% *lontar* shell produced biochar briquettes with the lowest moisture content of 3.34% meanwhile the highest (5.31%) in 100% goat dung. Chart 2 showed that the less portion of *lontar* shell in the mixture produces biochar briquettes with increased moisture content.

The high moisture content of the biochar briquettes produced is influenced by the incomplete drying of the raw materials which results in the large amount of moisture contained in the briquettes. The high and low of moisture content will affect the quality of the briquettes produced (Usman, 2007)[10]. Nahas *et al.* (2019) [11], stated that higher the moisture content produced from a biochar briquette will cause a decrease in the calorific value of the briquette According to Gandhi (2010) [12]. the high moisture content of briquettes can also be influenced by the concentration of starch adhesive used

The moisture content of the briquettes obtained in this study was still lower than the previous study of 39.05% in cow dung briquettes, 36.12% in goat dung briquettes and 38.65% in chicken dung briquettes (Nahas *et al*., 2019) [11], and in the research of Tumbel and Makalalak (2019) [13] found 2.72% on tapioca-adhesive coconut shell charcoal briquettes, 2.94% on clay-adhesive coconut shell charcoal briquettes and 2.855 on bentonite-adhesive coconut shell charcoal briquettes. This result, overall, meet the maximum standart of 8% according to SNI 01-6235-2000

3. Ash content



The average ash content of biochar briquettes ranges from 21.3 to 35.5%. Analysis of variance showed that treatment had a very significant effect (P<0.01) on the ash content. The ratio of 25% goat dung and 75% *lontar* shell produced biocahr briquettes with lowest ash content (21.3%) and the highest in 100% of goat dung (35.95%). Chart 3 showed that more proportion of goat dung generated the higher the ash content of the biochar briquettes. According to Ristianingsih *et al* (2015) [14] the high ash content can

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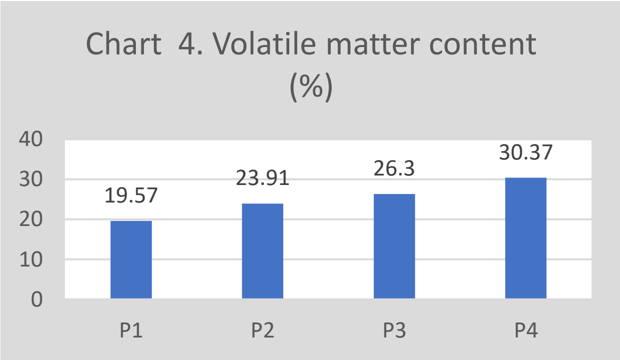
also be influenced by several impurities contained in the raw materials for making briquettes so that the amount of mineral content in charcoal and the combustion process leaves a lot of ash as a residue of combustion. Impurities contained in the raw materials are in the form of minerals that cannot be burned such as SiO_2, Al_2O_3, Fe_2O_3, CaO and alkali. Nahas *et al*. (2019) [11], stated that the silica content in goat dung has a bad influence on the calorific value of a briquette.

The ash content obtained in this study was lower than previous studies of 36.62% in goat dung briquettes, 41.52% in cow dung briquettes and 42.14% in chicken dung briquettes (Nahas *et al*., 2019) [11], while higher than result by Fretes *et al*. (2013) [15] with ash content of 20.7% in sago pulp briquettes with 10% adhesive and 14.4% in sago pulp briquettes without adhesive. Result of this study have not fulfilled the maximum of 8% according to Indonesia standard (SNI 01-6235-2000), Japanese standard 3-6%, USA standard 8.3% and British standard 5.9%.

4. Volatile Matter



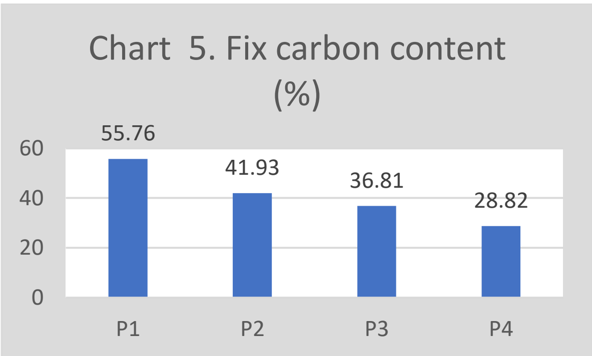
The volatile matter average of biochar briquettes ranges from 19.57 – 30.37%. Analysis of variance showed that the treatment had a very significant effect ($P<0.01$) on the volatile matter. The ratio of 25% goat dung and 75% *lontar* shell generated biochar briquettes with the lowest VM content (19.57%) and the highest in 100% of goat dung (30.37%). Chart 4 shows an increase in volatile matter levels where an increase the portion of goat dung causes an increase in the volatile matter content in biochar briquettes.

The high of volatile matter content in biochar briquettes is related to the volatile matter content in the raw material and the incomplete carbonization process. Acording to Yemita *et al* (2016) [16] which stated that the carbonization process is required for produce calorific value and carbon content high and will reduce the water content and levels of volatile substances in the material raw.

The volatile matter produced from a briquette greatly affects the quality of the briquettes produced. According to Nahas *et al*. (2019) [11], the ash content, water content and carbon content in briquettes greatly affect the calorific value

Overall, the volatile matter content of the biochar briquettes in this study does not meet the maximum of 15% according to Indonesian standard (SNI 01-6235-2000)

5. Fixed Carbon



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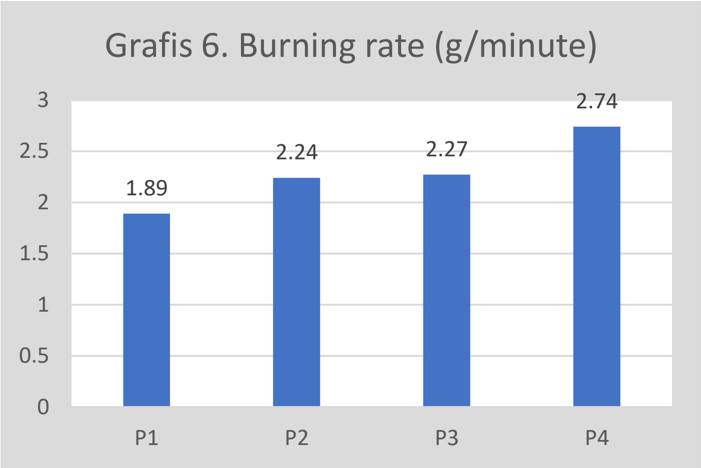
The fixed carbon average of biochar briquettes ranges from 28.82 to 55.76%. Analysis of variance showed that the treatment had a very significant effect (P<0.01) on the fixed carbon. Ratio of 25% goat dung and 75% *lontar* shell generated biochar briquettes with the highest fixed carbon (55.76%) and the lowest in 100% of goat dung (28.82%).

Chart 5 shows an decrease in fixed carbon levels due to increase in the portion of goat dung. The larger portion of *lontar* shells or smaller of the goat dung, generated the biochar briquettes with highest fixed carbon content. This result is associated to the fixed carbon content of the material uses in briquettes, where the goat dung contain less of fixed carbon (20.78%) than *lontar* shells (22.08%), hence, more portion of goat dung can be reduced fixed carbon. Overall, the result of this research not different from the previous study that was reprorted by Sulmiyati and Said (2017) [17] at 35.33% but did not meet the minimum standard of 77% according to Indonesian standar (SNI 01-6235-2000), Japanese standard of 60-80%, USA standard of 60% and British standard of 75,3%.

6. Burning Rate



The average burning rate of biochar briquettes mixed with goat dung and lontar shells ranging from 1.89 to 2.74 g/minute. The results of the variance analysis showed that the treatment had a very significant effect (P<.01) on the burning rate. The slowest burning rate (1,98 g/minute) was found in a mixture of 25% goat dung and 75% *lontar* shell charcoal (P_2), while the fastest was in a mixture of 100% goat dung without *lontar* shell charcoal (P4).

Chart 6 indicated that more proportion of goat dung produced biochar briquettes with faster burning rate. The burning rate of briquettes is related to the density and volatile matter content, where the lower of density and higher volatile matter content, causes faster of burning rate. This was accordance with Sarjono and Hendriyanto (2017) [18] which stated that the high volatile matter content and density affect the rate of briquette burning. The high volatile matter content causes the biochar briquettes to burn easily so that the burning rate is faster. On the other hand, briquettes with low compression pressure have a smaller density, causing the fuel to burn faster and the burning rate to be higher.

The burning rate of briquettes is one indicator in determining the quality of briquettes which is closely related to the fire resistance or burn resistance of briquettes. The faster the burning rate, the shorter the fire resistance. Result of this study was not different to previous study by Aljarwi *et al* (2020) [1] with ranging from 2.221 to 2.436 g/min on rice husk wafer briquettes with different pressures.

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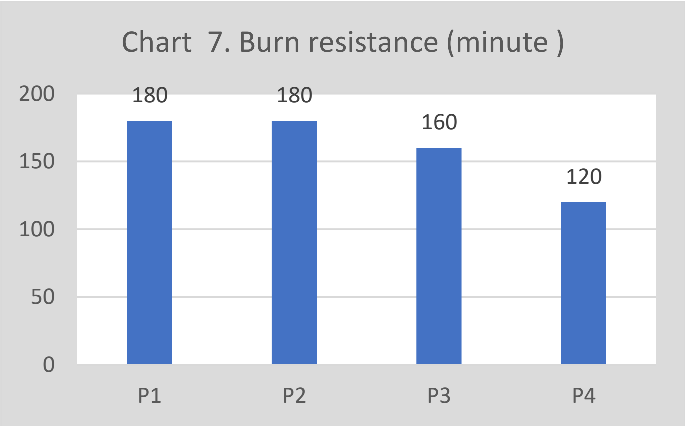
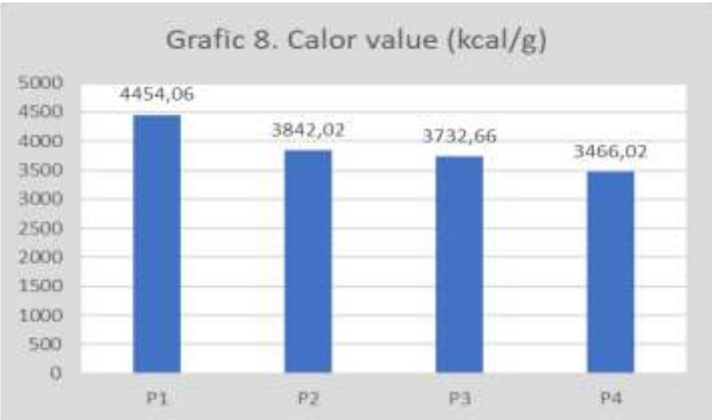
7. Burn resistance



The burn resistance of biochar briquettes mixed of goat dung and lontar shells ranging from 120 to 180 minutes. The results of the variance analysis showed that the treatment had a very significant effect ($P<.01$) on burn resistance. The using of goat dung 25% (P_1) and 50% (P_2) generated the longest of burn resistance was 180 minutes and the shortest at 120 minutes was found in 100% of goat dung (P_4). Chart 7. showed an reduced in burn resistance due to increase in the portion of goat dung. This result is associated to fixed carbon and volatile matter content as described previously, where the larger portion of the goat dung, can reducing fixed carbon and adding volatile matter content.

This results is not different to the previous studies by Dhawi (2017) [19] which reported burn resistance of biochar briquette processed by mix of goat dung and other biomass sucs as, coconut shell, hazelnut shell, *kesambi* charcoal with ranges 120,75 to 180 minutes

Calorific Value



The average calorific value of biochar briquettes in this research ranges from 3466.02 to 4454.06 cal/g. Analysis of variance showed that the treatment had a very significant effect ($P<.01$) on the calorific value. Ratio of 25% goat dung and 75% *lontar* shell generated biochar briquettes with the highest energy value (4454,06 cal/g) and the lowest in 100% of goat dung (3466,02 cal/g). Overall, this result did not fulfilled the minimum standard of 5000, according to Indonesian standard (SNI 01-6235-2000), Japanese standard is 6000-7000 cal/g, USA standard is 6230 cal/g and British standard is 7289 cal/g.

Chart 8 shows a decrease in energy value as the portion of goat dung increase. Reducing of energy value due to increase of goat dung portion, is associated to volatile matter and fixed carbon conten. These two components are the main indicator and determine the quality of briquettes. According to Nahas *et al.* (2019) [10], the ash content, water content and carbon content in briquettes greatly affect the calorific value.

Result of this study were not different from previous study reported by Sulmiyati and Said (2017) [17] on briquettes mixed with goat dung and hazelnut shells of 4563 cal/g, higher than Nahas *et al*, (2019) [11] which reported of 3525 cal/g on goat dung briquettes, 3193 cal/g on cow dung briquettes and 2991 cal/g on chicken dung briquettes. Almu *et al*. (2014) [20] obtained a calorific value of 5722.69 cal/g in nyamplung fruit briquettes and 4792.40 cal/g in briquettes mixed with nyamplung seeds and rice husk ash.

CONCLUSIONS

It can be concluded that: 1) More proportion of goat dung in the mixture generated briquettes with more ash content, lower fixed carbon, higher volatile matter, reduced calorific value, faster burning rate, shorter burning resistance;.2) Uses of goat dung in briquette making with mix to lontar shell charcoal up to 50% still is producing fairly good briquettes. In this case, however, the best mix rastio is 25% of goat dung and 75% of *lontar* shell charcoal; 3) The physico-chemical and burning properties of the briquettes produced in this study did not meet the standards according toIndonesian standard (SNI 01-6235-2000).

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A. Stages of Briquettes making

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B. Testing the moisture, ash and calorific value









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