A study on physical characteristics of dried bio-slurry produced in tropical condition through treatment combination of drying and turning period

A M P Nuhriawangsa¹, D Ardika², L R Kartikasari¹ and B S Hertanto¹,*

¹Department of Animal Science, Faculty of Agriculture, Universitas Sebelas Maret, Jl. Ir. Sutami No. 36A Surakarta 57126, Indonesia
²Graduate Student of Animal Science Department, Faculty of Agriculture, Universitas Sebelas Maret, Jl. Ir. Sutami No. 36A Surakarta 57126, Indonesia

Corresponding author: bayusetya@staff.uns.ac.id

Abstract. The research aims to evaluate the physical characteristics of dried bio-slurry produced by treatment combination of drying and turning period in tropical conditions. Research material used fixed-dome digester model with a capacity of 12 m³ and cattle dung from Simmental crossbreed. Physical characteristics of bio-slurry were obtained by combining treatments between drying period (15 and 30 days) and turning period (each turning process in 7 and 10th day) as follows: T1 (15 days and 7th day), T2 (15 days and 10th day), T3 (30 days and 7th day), T4 (30 days and 10th day). The chemical compound of fresh bio-slurry was analyzed as initial information. The humidity, temperature, and color data were analyzed using analysis of variance and further analyzed using Tukey's test. Also, the chemical compound and pH used descriptive analysis. The study obtained that the chemical composition of fresh bio-slurry was moisture content (89.53%), C-organic (37.27%), nitrogen (48.92ppm), phosphor (1.71%), potassium (3.89%), and C/N ratio (7.454). Besides, the treatment showed a significant difference (P<0.01) in humidity and color. Temperature dan pH of dried bio-slurry remained constant at 29.10-29.27°C and 7 respectively. Therefore, treatment combinations can be applied to make dried bio-slurry as fertilizer in tropical conditions.

1. Introduction
Biogas is renewable energy and is obtained by converting livestock dung through a fermentation process in the digester. It can produce energy that helps people to be able to access power that is efficient, environmentally friendly, and clean. Besides, biogas processing will also produce high amounts of slurry that can be used as fertilizer. In general, bio-slurry is rich in ammonium compared to liquid and solid manure [1,2] because partly decomposing process of organic matter during the digestion process, so the nutrient compound of dry matter basis will be higher in the bio-slurry than that in the manure [3]. This condition leads to a positive effect to soil structure and plant growth as well. The anaerobic digestion of renewable raw materials in biogas plants also leads to an increase in farm fertilizers. Furthermore, sludge treatment and proper disposal are very important for the safety of the environment and living creatures.

Wet bio-slurry regularly produced from the digester is used as fertilizer in a specific time, i.e., growing period, so fertilizer needs to be stored. Some storages are commonly used, such as covered or
uncovered pond, tank or container [4]. In other situations, bio-slurry is transported from regions with large livestock to other regions with a lack of fertilizers. But economically, it is not feasible to carry wet bio-slurry over long distances because bio-slurry contains high water compared to nutrient content [5–10]. Wet slurry is very difficult in handling, so the way to handle slurry through proper treatments [11]. Therefore, the processing technology of bio-slurry is needed to reduce the mass, handle bio-slurry, and ensure the utilization in agricultural land [9]. Bio-slurry can be separated and stored into a liquid and a solid form. The solid slurry can be stored like compost or animal manure. Producing a dry bio-slurry can be efficient because of the larger volume in transportation. Also, the bio-slurry is easier in handling, more homogeneous, and more nutritious in composition [4]. Applying technology on bio-slurry, like drying and/or composting, can be separated both fractions into dry bio-slurry as solid fertilizer [8]. These technologies are often associated with the costly process, but those need to be applied in biogas digester because of lack of agricultural land for slurry application and limited storage in a biogas plant [12].

The drying process applied in sludges is very useful for many purposes because it can be applied as a natural fertilizer and land filling. The use of solar energy has an enormous amount of energy will reduce fuel energy consumption and improve the efficiency of the slurry drying system [11]. Slurry drying is conducted to decrease the moisture content of natural slurry [13]. Previous researchers expressed that slurry treatment using solar dryers, a relatively simple technology, has shown fairly good results related to the specific energy consumption [14–16]. Moreover, the solar drying of slurry looks to be a proper option to reduce the use of resources and decrease the negative impact on the environment compared to other slurry management systems [9]. Dried bio-slurry using solar drying can be applied in Indonesia because of climatic conditions. Indonesia has a tropical climate characterized by heavy rainfall, high humidity, high temperature, and low winds as well.

Interestingly, Indonesia's dry season is longer than the wet season, with a mean annual temperature of about 25-27°C and average humidity of approximately 82% [17]. Therefore, solar drying combined with the mechanical process can be a promising step for slurry processing. The research goal is to evaluate the physical characteristics of dried bio-slurry produced by treatment combination of drying and turning period in tropical conditions.

2. Materials and methods

The study was conducted at a partner group of beef cattle in Bantul District, Yogyakarta, Indonesia. Research material used liquid slurry from fixed-dome digester model with a capacity of 12 m³ and source of cattle dung from beef cattle of Simmental crossbreed. The slurry was collected from an outlet digester and filtered using porous plastic to reduce the moisture. The slurry was then weighed with a weight of 1.5 kg per sample and followed by placing samples in treatment boxes with ambient temperature ranging from 27 to 31°C. There were 24 boxes representing 4 treatments with 3 replications in each treatment. The treatment of bio-slurry was done by combining treatments between the drying period (15 and 30 days) and turning period (each turning process in 7 and 10th day) as follows T1 (15 days and 7th day), T2 (15 days and 10th day), T3 (30 days and 7th day), T4 (30 days and 10th day).

The test of physical quality included pH, color, temperature, humidity. Also, the chemical compound of fresh bio-slurry was measured as initial information of matter used. The test of pH and humidity (%) was carried out in a row by adding 10 g of dried slurry and distilled water with a ratio of 1:2.5 in beaker glass. It then was mixed well and measured using the tester [18]. With modification, a digital thermometer was placed into slurry in the depth of 10 cm and let it show a constant scale to test the slurry temperature [19]. The color was determined using a color score with modification, as presented in Figure 1 [20].

The data of humidity, temperature, and color were analyzed using analysis of variance, and it will further be analyzed using Tukey's test. Also, the chemical compound and pH used descriptive analysis [21].
3. Result and discussion

The fertilizer obtained from this study was produced using the model, namely the integration of beef cattle farming with a biogas installation (Figure 2) [22]. Manure from beef cattle will be fermented using biogas digester, and the bio-slurry as a byproduct is dried to produce organic fertilizer used for growing horticultural crops. The model in this study is in accordance with the opinion that residual biogas from cattle farms (slurry) can be utilized for liquid organic fertilizer [23]. Likewise, the integration of slaughter farms and biogas produces liquid and solid organic fertilizers from bio-slurry [24]. Also, the model of cow dung utilization with biogas installation can produce good quality organic fertilizer due to plants' macro and microelements [25].

A: beef cattle cage, B: digester inlet, C: digester, D: outlet, E: slurry storage, F: compost utilization for horticulture

Figure 2. Model of integration of beef cattle with biogas digester to produce organic compost.

The chemical content of bio-slurry showed differences compared to other sources (Table 1). The type of organic material can cause the difference in chemical content of bio-slurry and the amount of water mixed [26]. Also, the other differences include type, sex, species, age and diet of livestock, geographical conditions and climates, and raw material composition [27].

Subsequently, the pH during the composting process for up to 30 days did not change with a pH value of 7. Bio-slurry is a product from a biogas digester that has undergone a fermentation process so that the pH has become constant. Thus, during storage, there will also be no change in pH value. A pH of 7 indicated that the compost was finished with the cessation of fermentation, and the pH was in the standard range of 6-8 [28]. The concentration of alkaline cations caused this pH balance (e.g., Ca, K)
produced at the end of a fermentation process that has a function as a buffer for the pH of the bio-slurry by releasing cations so that H ions will decrease and pH 7-8 is reached [29].

Table 1. Chemical content of the bio-slurry produced by the biogas digester in dry matter.

| Moisture (%) | C-organic (%) | N total (ppm) | P total (%) | K Total (%) | C/N Ratio | References |
|--------------|---------------|---------------|-------------|-------------|-----------|------------|
| 10.37        | 41.58         | 54.58         | 1.91        | 4.34        | 8.31      | *          |
| -            | 4.76          | 0.11          | 0.17        | 0.04        | -         | [23]       |
| -            | -             | 1.4-1.8       | 1.1-2       | 0.89-1.2    | -         | [25]       |
| 31.34        | 17.87         | 1.47          | 0.52        | 0.38        | 9.09      | [30]       |
| -            | 47.99         | 2.92          | 0.21        | 0.26        | 0.14-0.00 | [31]       |

Note: * The results of the analysis from the Department of Soil, Faculty of Agriculture, UGM

The results showed that there was no significant difference in temperature during the composting process (Table 2). Bio-slurry temperature is influenced by microbial activity. This treatment used bio-slurry for organic composting came from decomposition in a biogas digester so that there was no microbial activity. The temperature of the bio-slurry in this research would decrease gradually with the end of the decomposition process. The high temperature of the bio-slurry is due to microbial activity [32]. The higher the microbial population with the availability of decomposed materials, the higher the temperature of the bio-slurry. The ambient temperature of the storage also affects the organic N transformation system, so it will also affect the temperature of the bio-slurry [33]. Similarly, the treatments of this study were not significantly different because bio-slurry is produced from a biogas digester with uniform ambient temperature.

Table 2. The results of the analysis of variance in the physical quality of compost with different drying and turning period.

| Variables             | T1              | T2              | T3              | T4              | P       |
|-----------------------|-----------------|-----------------|-----------------|-----------------|---------|
| Temperature (°C)      | 29.27±0.24      | 29.21±0.21      | 29.20±0.27      | 29.10±0.23      | 0.631   |
| Humidity (%)          | 30.83±2.93a     | 31.67±2.79a     | 31.48±1.66b     | 21.67±1.56b     | 0.001   |
| Color score           | 5.33±0.51bc     | 5.00±0.63c      | 6.00±0.63ab     | 6.67±0.51a      | 0.001   |

a,bDifferent superscripts on the same line show very significant differences (P<0.01)

Other results showed a significant difference in humidity (P<0.01) with different drying times and frequency of turning. The humidity in the drying time for 15 days is higher than that of 30 days. This is in accordance with previous research [34] that the humidity of organic fertilizers is related to storage time. The longer the storage time, the humidity decreases. The decrease in humidity is due to the evaporation of water from the bio-slurry. This is in line with previous research that the water will evaporate during cow dung storage [35].

Also, the result of the color measurement showed a difference (P<0.01) between the combination of drying and turning period. The color of compost with a turning frequency of ten days and a drying period of 30 days has a better color (dark brownish-green with a dominant green color) than the drying time of 15 days and a turning of 7 or 10 days. Solid bio-slurry is light brown or green and tends to be dark. Other research showed that the color of the cow dung bio-slurry added by molasses changes during fermentation to brownish-yellow [28]. This change is possible because of the role of oxygen that fills the pore space in the bio-slurry [36].

4. Conclusion

The model of integration of beef cattle with a biogas digester to produce bio-slurry can be used as organic fertilizer with good chemical content. The dried bio-slurry from the research treatment with a drying time of 30 days and a turning time of 10 days has the best quality, and it can be applied for farmers in tropical conditions.
Acknowledgment
The authors express our gratitude to Universitas Sebelas Maret for funding our project, with contract number: 624/UN27.21/PP/2017.

References
[1] Möller K, Stinner W, Deuker A and Leithold G 2008 Nutr. Cycl. Agroecosyst. 82 209–32
[2] Tambone F, Scaglia B, Imporzano D G, Schievano A, Orzi V, Salati S and Adani F 2010 Chemosphere 81 577–83
[3] Möller K and Müller T 2012 Eng. Life Sci. 12 242–57
[4] Bonten L T C, Zwart K B, Rietra R P J J, Postma R and de Haas M J G 2014 Is bio slurry from household digesters a better fertilizer than manure? (Wageningen: Alterra)
[5] Sensel K and Wragge V 2008 Pflanzenbauliche Verwertung von Gärrückständen aus Biogasanlagen unter besonderer Berücksichtigung des Inputsubstrats Energiepflanzen (Berlin: Institut für Agrar- und Stadtökokologische Projekte an der Humboldt-Universität).
[6] Döhler H and Verfahren S P 2006 und Wirtschaftlichkeit der Gärraupenbereitung Verwertung von Wirtschafts- und Sekundärrohstoffdüngern in der Landwirtschaft–Nutzen und Risiken (Darmstadt: KTBL) p 199–212
[7] Döhler H and Wulf S 2009 In Gülzower Fachgespräche Gärraupenbereitung Für Eine Pflanzenbauliche Nutz-Stand (Lauenburg: Fachagentur Nachwachsende Rohstoffe) p 15–28
[8] Drosg B, Fuchs W, Al Seadi T, Madsen M and Linke B 2015 Nutrient Recovery by Biogas Digestate Processing (Paris: International Energy Agency IEA Bioenergy).
[9] Rehl T and Müller J 2011 Resour. Conserv. Recycl. 56 92–104
[10] Vázquez-Rowe I, Golkowska K, Lebuf V, Vaneechaute C, Michels E, Meers E, Benetto E and Koster D 2015 Waste Manag. 43 442–59
[11] Yuna G, Hongb L, Xua L, Tang W and Wanga Z 2014 Energy Procedia 70 626–33
[12] Maurer C and Müller J 2019 Energies 12 1294
[13] Kumar S and Prakash O 2019 Biogas Plant Slurry Dewatering and Drying Using Hybrid System: A Review (Singapore: Springer Nature Pte. Ltd.) p 117–25
[14] Baumann R 2009 Entwässerung und solare Trocknung von flüssigem Klärschlamm (Stuttgart: University of Hohenheim).
[15] Krawczyk P 2016 Procedia Eng 157 230–37
[16] Bux M and Starcevic N 2005 Stand der Technik solarer und solarunterstützter Trocknungsverfahren für Klärschlamm (Deutschland: GWF Wasser Abwasser) p 504–09.
[17] Nation Encyclopedia 2021 Indonesia-Climate https://www.nationsencyclopedia.com/Asia-and-Oceania/Indonesia-CLIMATE.html#ixzz71YxjPtax
[18] AOAC 1990 Official Methods of Analysis (Washington: Association of Official Analytical Chemist).
[19] Suhartana I P G, Setiyo Y and Widia I W 2017 J. Biosistem dan Teknik Pertanian 5 51–60
[20] Warnars L and Oppennoorth H 2014 Bio-Slurry: A Supreme Fertilizer. A Study on BioSlurry Result and Uses (Den Haag: Delthahage)
[21] Steel R G D and Torrie J H 1997 Principles and procedures of statistics: A biometrical approach (New York: McGraw-Hill)
[22] Nuhriawanaga A M P, Kartikasari L R, Hertanto B S and Ardika D 2017 Seminar Nasional Program Studi Peternakan Berkelanjutan 2: Peningkatan Produktivitas Ternak Lokal Terpadu Berkelanjutan dalam Mendukung Ketersediaan Pangan Hewani (Surakarta: Program Studi Peternakan FP UNS) p 160–62
[23] Fadilah H F, Kusuma M N and Afrinisa R D 2019 Seminar Nasional Sains dan Teknologi Terapan VII (Surabaya: Institut Teknologi Adhi Tama) p 513–18
[24] Irfan M, Sukorini H, Erni D W, Zali M and Heryadi A Y 2018 J. Dedikasi 15 107–13
[25] Kumar S, Malav L C, Malav M K and Khan S A 2015 Int. J. Ext. Res. 2 42–6
[26] Zawani K, Suheri H, Kusmarwiyah R and Parwata I G M A 2015 Agroteklos 25 151–57
[27] Risberg K, Cederlund H, Pell M and Schnürer V A A 2017 Waste Management 61 529–38
[28] Novitamala C B, Suwerda B and Werdiningsih I 2015 J. Kesehatan Lingkungan 7 51–8
[29] Zwart K and Postma R 2014 Bio-slurry as fertilizer (Wageningen: Alterra)
[30] Singgih B and Yusmiati 2018 J. Kelitbangan 06 139–48
[31] Farihah T 2020 J. Aplikasi Ilmu-ilmu Agama 20 47–62
[32] Al-Amin M, Rahman M M, Islam S M A, Dhakal H, Khan M R I, Amin M R and Kabir A K M A 2020 Bang. J. Anim. Sci. 49 142–50
[33] Shekhar G G and Sreeja V 2018 The 4th Proceedings of International Conference on Energy Efficient Technologies for Sustainability-ICEETS’18 (Tamil Nadu: St. Xavier’s Catholic College of Engineering) p 1–5
[34] Priyadi D and Ermayati TM 2014 Prosiding Seminar Nasional Hasil Penelitian Unggulan Bidang Pangan Nabati: Bioresources untuk Pembangunan Ekonomi Hijau (Bogor: Pusat Penelitian Bioteknologi Lembaga Ilmu Pengetahuan Indonesia) p 169–78
[35] Perta E S, Mautone A, Oliva M, Cervelli E and Pinodzzi S 2020 Sustainability 12 1–11
[36] Mudiarta I M, Setiyo Y and Widia I W 2018 J. Il. Tek. Pertanian Agrotechno 3 276–84