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Composting of chicken manure for biofertiliser production: a case study in Kidal Village, Malang Regency

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Abstract. Kidal Village, located in Malang Regency, has around 106 traditional chicken poultries with hens chicken population of 1,463,720 chickens, producing of 85.8 tonnes chicken manure per day. Currently the chicken manure is remained untreated and left on the bottom of the chicken cage over one-year period. Such practice has resulted odour problems especially to those area nearby the chicken poultry. The aim of this study is to investigate the potential of valorizing chicken manure for biofertiliser, as well as the impact of co-composting of chicken manure (CiM) and cow manure (CoM) with *blotong* (B) on the compost physic-chemical quality. Randomized block design (RBD) was used in this study with factor of feedstock composition and C/N ratio. Composting was carried out under aerobic condition, with manual turning over, for 30 days period. The results demonstrated that CiM, CoM and *blotong* has high organic content, but lower C/N value. *Blotong* has higher moisture content (MC), which is suitable as co-composting feedstock to increase MC value of the mixture. This study also observed that all treatments combination have similar trends in terms of changes in temperature, pH and MC during composting process. The quality of resulted compost were well within the Indonesian standard value for organic compost (SNI 19-7030-2004), indicating that composting of chicken manure or cow manure with and without *blotong* may become potential alternative routes for tackling pollution problems from the untreated manure.

1. Introduction

Hens chicken manure has a great potential for further used. Chicken manure contains high in organic contents (i.e. volatile solids/VS of 62.47 % of total solids/TS) and high in macro-nutrients, such as itrogen (37.0 g/kg), phosphor (11.07 g/kg) and potassium (15.96 g/kg), respectively [1]. In addition, chicken manure also contains nutrients that essential for plant's growth, such as calcium, magnesium, sulphur, manganese, copper, zinc, iron, boron and molybdenum [2]. They found that the composition



of chicken manure if influenced several factors, for instance, by the type, age, and the diet. According to Yahya et al. [3], each hens chicken produces around 0.06 kg manure per day. In Kidal Village there were approximately 1.463.70 hens chicken, thus the potential of chicken manure was 85.8 tonnes per day. However, these hens chicken manure was not adequately treated and many poultry farmers left that manure under the chicken cage for over 6-month to 1-year period, before new chicken breeding season. Such practice and behavior have negatives impact to the nearby environment such as soil, water and air pollution. One of the evident effects currently occurred in Kidal Village is bad odor from hens' chicken manure. Therefore, introducing and implementing chicken manure treatment is urgently needed.

Composting is defined as a biochemical process of organic matter degradation, which can be carried out under aerobic or anaerobic condition [4]. Composting has been seen as a feasibly option to treat chicken manure as it can produce high-value product of biofertiliser or compost that still high in nutrients content [2]. Compost is an organic fertilizer that can be applied to agricultural land, as is able to improve the quality and the fertility of soil [5, 6]. They further added that composting is not a new technology, but it is remained as a suitable option due to its economic and environmental benefits. There are many operational parameters influenced composting, these include temperature, C/N ratio, moisture content, water content pH, nutrient balance, particle size, porosity, O₂ concentration, and aeration rate [7].

Various biomass substrates can be used for composting, such as chicken manure, cow slurry/manure and *blotong* (or known as filter cake from sugar industry) [8-10]. Furthermore, many studies have reported that co-composting may improve the decomposition process of organic matter as well as enhance the maturity and quality of the resulted composts [4, 11-14]. In this study, a laboratory scale experiments were carried out to investigate the potential of valorizing chicken manure for biofertiliser, as well as the impact of co-composting of chicken manure (CIM) and cow manure (COM) with *blotong* (B) on the compost physical quality. This study is hopefully can provide important data and information that can help the community in Kidal Village to tackle the problems of bad odour from untreated chicken manure.

2. Materials and Method

2.1. Composting feedstocks

Chicken manure (CIM) was collected from a chicken poultry farm in Kidal Village, Malang Regency, Indonesia. Cow manure (COM) was collected from Sumber Sekar Animal Husbandry Field Laboratory, Animal Husbandry Faculty, Universitas Brawijaya. Sugar filter cake waste (or *blotong*/B) was collected from Kebon Agung Sugar Factory in Malang Regency, Indonesia. There was no pre-treatment was subjected to all feedstock.

2.2. Experimental design and set-up

Completely randomised design (CRD) was used in this study, with factor of different feedstock composition (i.e. CIM: B and COM: B) and different C/N ratio (i.e. 25 and 30). It is assumed in this study, that the composting process need be carried out under ideal moisture content of 60% [15]. Effective microorganism (EM4) solution was added with concentration of 4% of the total mixture weight. Details of experimental design with the amount of feedstock added are shown in Table 1.

Table 1. Experimental design and mixture composition

Feedstock composition	C/N ratio	CiM (kg)	CoM (kg)	B (kg)	EM4 solution (mL)	Total weight (kg)
P1 (CiM:B)	25	1.13	0	2	55	3.13
P2 (CiM:B)	30	1.34	0	2	75	3.34
P3 (CoM:B)	25	0	2.58	2	248	4.58
P4 (CoM:B)	30	0	2.34	2	267	4.34

The calculation of how much composting feedstock added based on selected C/N ratio was based on the equation below, as described in Dougherty [16]:

$$R = \frac{(R_1 \times Q_1) + (R_2 \times Q_2)}{(Q_1 + Q_2)} \quad (1)$$

Where, R represents the ideal C/N ratio for composting feedstock mixture, R_n is the C/N ratio of material n, and Q_n is mass of material n (“as is”, or “wet weight”) (in kg).

The calculation of the amount of water added was based on the following equation [16]:

$$G = \frac{(M_1 \times Q_1) + (M_2 \times Q_2)}{(Q_1 + Q_2)} \quad (2)$$

Where, G represents the ideal moisture content for composting (in %), M_n is moisture content of material n (in %), and Q_n is mass of material n (“as is”, or “wet weight”) (in kg).

2.3. Composting procedures

The procedure for composting experiment was based on Siburian [17] with modification as follows: first, prepared EM4 solution by adding molasses and water with ratio of 100:100:1800 (EM4: molasses: water). Next, all composting feedstocks were weight according to the value as stated in Table 1, then added with the EM solution and mixed thoroughly according to the treatment set-up. The mixture of composting feedstock was placed in the composting box, made of wood with the dimension of 25 cm (L) x 25 cm (W) x 30 cm (H). The composting box was remained open to create aerobic condition. The composting was carried out for duration of 30 days. The compost pile was turned over with spading fork every 6 days to provide aeration to the entire mixture. The temperature was measured on a daily basis, while pH and moisture content/MC was analysed on the cycle of 3- and 6-day period, respectively. The resulted compost was analysed for the following parameters of C-organic, total nitrogen, phosphor and potassium.

2.4. Analysis

Temperature and pH was analysed based on the standard method [18]. MC was measured using gravimetric method [18], C-organic content was based on Walkey-Black method [18], nitrogen (N) content using total Kjeldahl nitrogen method [18]. Phosphorous (P) and potassium (K) content was measured using spectrophotometric and atomic absorption spectrometry (AAS) method [19]. The C/N ratio was calculated by dividing the concentration of C-organic with total nitrogen.

3. Results and Discussion

3.1. Characteristics of composting feedstock

The characteristics of feedstock material used in study are seen in Table 2. The results showed that chicken manure has low C/N ratio, due to high nitrogen content. Cow manure and *blotong* have much higher C/N ratio. All tested samples were still much lower than ideal C/N ratio for composting of 30-35 [20]. Furthermore, *blotong* has the highest MC value (71%), in which combining chicken manure or cow manure with *blotong* may increase the MC content of the mixture. Therefore, mixing these feedstocks are advisable and can boost the value of C/N ratio and MC to ideal range for composting.

Table 2. Physico-chemical characteristics of composting feedstocks

Feedstock ID	Parameters					
	MC (%)	C-organic (%)	Nitrogen (%)	Phosphorous as P ₂ O ₅ (%)	Potassium as K ₂ O (%)	C/N ratio
Chicken manure (CiM)	21.66	34.66	3.89	8.91	3.74	8.91
Cow manure (CoM)	9.33	39.31	2.19	17.95	0.69	17.95
<i>Blotong</i> (B)	71.00	46.02	2.90	15.85	3.74	15.87

Many studies have reported that chicken manure, cow manure, and *blotong* can be used composting materials, as previously described. However, Vanecastele et al. [21] suggested that co-composting of chicken manure with addition of other feedstock materials (i.e. wheat straw, grass clippings, grass hay, Poplar bark, wood chips) has produced the highest quality of compost than composting the chicken manure alone. Another study by Alavi et al. [22] also found that co-composting of cow manure with vinnase, bagasse and natural zeolite has provided a much better quality of compost. Ismaya et al. [8] reported that addition of *blotong* to composting of sugar cane bagasse has positive influence on improving the compost quality.

3.2. Changes in temperature, pH and MC during composting

Figure 1 shows the trends for temperature, pH and MC during composting of CiM with *blotong*, CoM with *blotong* and CoM alone. The results showed that all treatments have similar behaviours over 30-day composting period. As shown in Figure 1a, at the start of composting process, the mixture of composting materials has temperature in the range of 30-32 °C, almost similar to the ambient temperature of Malang City. Up to day 6, the temperature was continuously increased to 41-42 °C for all co-composting treatments, which indicated the degradation of organic matter and aerobic metabolism of microbial activities [22, 23]. After that, a gradual decrease in the temperature was observed in all treatments. At the end of composting period (day 30), the temperature of compost was in the range of 28 – 30 °C, which reported to be due to a reduction on the organic matter content and activity of microorganism [22, 23].

Figure 1b shows a clear decrease in pH after 3-day of composting from 6.8 to 5.4-5.7, possibly due to rapid degradation of organic matter and accumulation of organic acid [23]. Similarly, a study by Yang et al. [24] has also reported a decrease in pH values in the early stage of composting. This study reveals that starting from day 3, there was a slightly consistent and continuous increase in pH to almost neutral value in the range of 6.5-6.8 in day 15. The pH was then remained stable reaching the value of 6.8 in day 30 for all treatment. pH is one of the factor that can influence the metabolism and activity of microorganism in composting [20]. Previous study has highlighted that an increase in pH during composting period is correlated to higher microbial activity [25].

As can be observed from Figure 1c, moisture content during composting process was gradually decreased from around 60 % to 42.86 – 45.33%, respectively. This result is supported by previous study which indicated the similar trends [26]. Guo et al. [27] stated that a temperature increase due to microbial heat generation during composting process have caused evaporation, thus decreasing the MC value of compost pile. Nikaeen et al. [26] added that MC is one of the important factors for supporting the microbial activity and the transport of nutrients needed by the microorganisms.

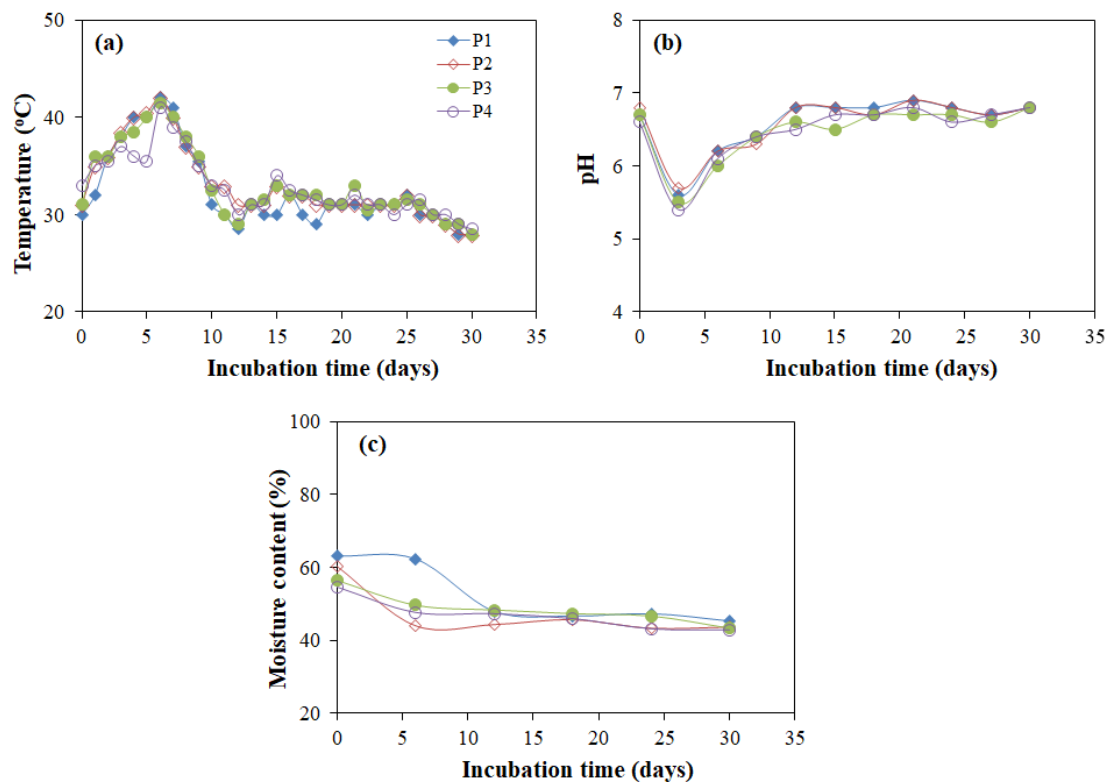


Figure 1. Trends in temperature, pH and MC over 30 days composting period

3.3. Changes in C-organic, N, P, K and C/N ratio during composting

Figure 2 illustrates the changes value in terms of C-organic, N, P, K and C/N ratio at the beginning (initial) and the end (final) of composting. All treatment samples for parameters of C-organic and C/N ratio indicated similar trends, where a reduction value was evident after 30 days composting period (figure 2a and 2e). Similar patterns were also reported in other studies by Jeong et al. [20] and Tripetchkul et al. [28]. A reduction in C-organic and C/N ratio was due to decomposition and mineralisation of organic matter, which causing a maximum carbon loss and an increase in nitrogen concentration [20, 28].

Figure 2b and 2c also showed that for treatment of co-composting of chicken manure with *blotong* (i.e. P1 and P2), there was a decrease in nitrogen and phosphorous content, but reverse patterns was found in treatment of co-composting of cow manure with *blotong* (i.e. P3 and P4). However, the final value of both parameters analysed was still well within the standard value for organic compost. Figure 2d illustrates that, at the beginning of composting process for treatment P1 and P4, potassium content was 1.46 % and 1.72% and the value increased to 1.95 % and 2.30 % at end of composting. While for treatment P2 and P3, there was a slight decrease in potassium content from 2.06 % to 1.97% and from 1.72% to 1.56%, respectively. A study by Alavi et al. [22] reported that an increase of potassium content throughout composting period maybe due to conversion of insoluble potassium into soluble form, triggered by acid production during decomposition of organic matter by microorganisms.

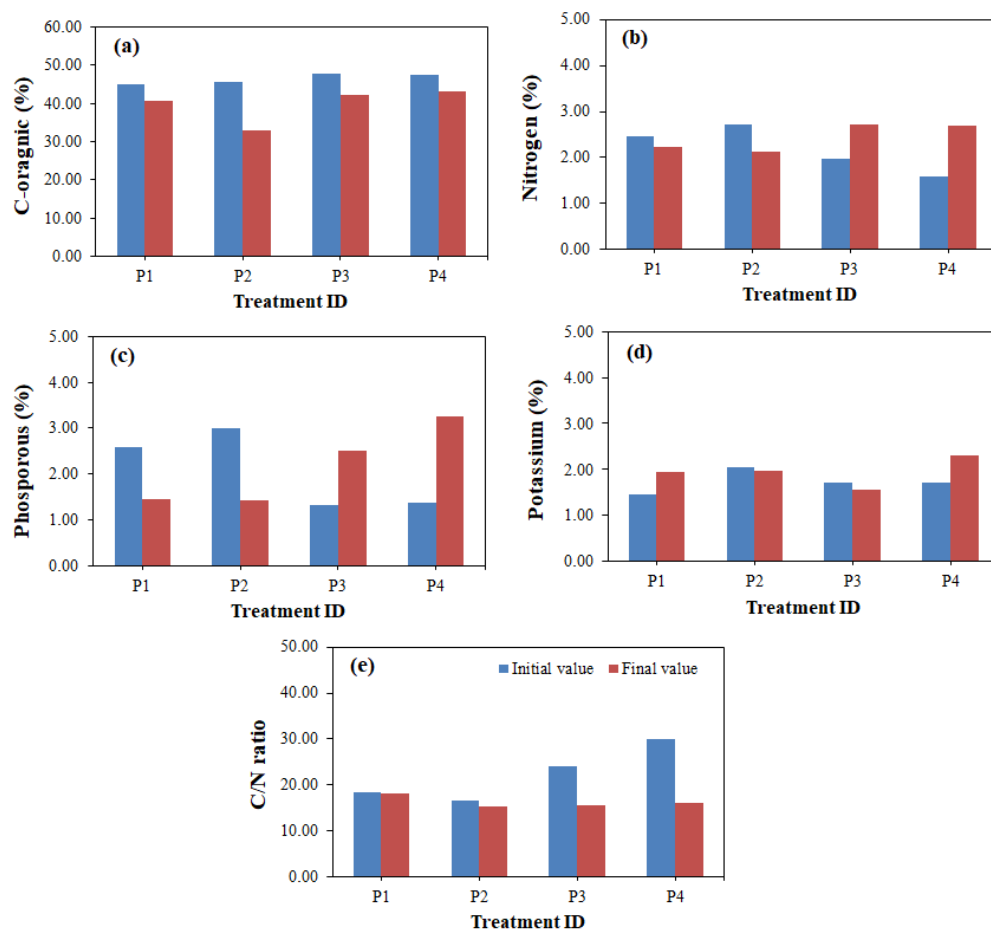


Figure 2. Changes in C-organic, N, P, K and C/N ratio at the beginning and the end of composting

3.4. Compost quality

The characteristics of compost from this study in comparison with SNI of organic compost (SNI 19-7030-2004) and compost from composting of chicken manure are shown in Table 3. The results suggested that all parameters tested were meeting the standard value criteria for organic compost, except that of C-organic content. A high C-organic content in the results compost was possibly due to incomplete degradation of carbon during composting process. However, based on other parameter values, this study indicates that the resulted compost is potential to be used as organic compost or biofertiliser. Furthermore, this study also suggest that co-composting of chicken manure or cow manure with blotong can enhance the quality of the compost, and may be opted as one of the feasible routes for valorising the manure. In term of composting chicken manure alone with addition of EM4 and molasses, our previous study also suggest similar results, but with slightly lower quality compared to the compost from co-composting process. This is indicated by lower MC value, C-organic and C/N ratio, which still below that of the standard value. Other studies have emphasised that co-composting strategy was able to improve the quality of compost [4, 11-14]; thus it can be further used for agricultural purposes as biofertiliser or soil conditioner.

Table 3. Quality of compost in comparison with SNI of organic compost

Parameters	CiM only*	This study				SNI 19-7030-2004
		P1	P2	P3	P4	
pH	6.9	6.8	6.8	6.8	6.8	6.8-7.49
MC (%)	20	45.33	43.67	43.33	42.86	< 50
C-organic (%)	7.5	43.03	42.14	32.84	40.64	9.8-32
N (%)	1.04	2.68	2.72	2.13	2.23	>0.40
P (%)	1.29	3.26	2.5	1.44	1.46	>0.10
K	0.95	2.3	1.56	1.97	1.95	>0.20
C/N ratio	7	16.06	15.49	15.42	18.22	10-20

Note: *data resulted from previous study (unpublished)

4. Conclusions

The findings in this study confirmed that, based on the physic-chemical characteristics, chicken manure or cow manure can be valorised using composting technology either as single- or co-composting feedstock. All treatments indicated similar patterns of changes in temperature, pH and MC during composting. The results showed that compost resulted from co-composting process was meeting the criteria in the Indonesian standard value for organic compost (SNI 19-7030-2004), indicating that the compost is useful as biofertiliser or soil conditioner. It is concluded that In-depth investigation, however, is still necessary to identify potential of other biomass feedstock to be added in composting of chicken manure and/or cow manure.

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