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# Manipulating Chicken Waste for Improved Vermicomposting Substrate

**Fatin Nabila Binti Abd Rashid[1], Nur Faezah Bt Omar[1], Najihah Farhan Sabri[1], Chuah Tse Seng[1], Noor Zuhairah Samsuddin[1*]**

*[1]Faculty of Plantation and Agrotechnology, Universiti Teknologi MARA Caw. Perlis Kampus Arau, 02600 Arau, Perlis, Malaysia.*

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**ABSTRACT.** Vermicomposting is a sustainable waste management and effective technique for using agricultural residue. Nowadays, poultry industries have overgrown around the world. The problem that arises from poultry industries due to the inappropriate disposal of chicken wastes is environmental pollution and groundwater contamination, which creates odours, promotes fly and rodent breeding, and releases greenhouse gases into the atmosphere. Proper chicken waste management was essential to reduce the effect and contamination on the environment and humans. Therefore, this study uses chicken waste to enhance its suitability as a vermicomposting substrate. Different approaches to manipulating chicken waste, including varying ratios of chicken dung and chicken feathers as a medium in vermicomposting, were investigated to determine their effects on the vermicomposting process and the quality of the resulting compost. The results showed T4 exhibited the highest biodegradability coefficient (51.59%), reflecting the most effective decomposition of organic matter. The pH values, ranging from 5.92 to 6.83, provided optimal conditions for earthworm activity, while the decrease in electrical conductivity (EC) indicated the production of non-toxic, low-salinity vermicompost. In contrast, T1, which used the highest proportion of chicken dung without chicken feathers, resulted in the greatest earthworm weight gain and cocoon production. By manipulating the composition of organic materials, particularly reducing the proportion of chicken feathers, the vermicomposting process can be made more effective, leading to better decomposition rates, improved earthworm growth, and the production of nutrient-rich compost suitable for agricultural use.

*Key words: chicken dung, chicken feather, vermicomposting, Eudrilus eugenia.*

## INTRODUCTION

Nowadays, the demand for chicken meat and chicken eggs has increased. According to Ahmad (2015), Malaysia is one of the countries with the highest consumption rates in the world for chicken at 35 kg and 280 eggs per person per year. Due to the rapid development of poultry or chicken industries in Malaysia, the yield of chicken waste has risen drastically yearly. The poultry industry proliferates worldwide and produces a huge amount of solid waste and wastewater in the environment. Thus, the main problems that come with this chicken production are chicken wastes such as feathers, offal, and manure that need to be taken care of as the non-appropriate disposal can cause pollution to the environment and humans when it becomes dumps and landfills (Muduli et al., 2019). Chicken wastes include manure, bedding materials, feathers, offal, and wasted feeds. Chicken dung contains high amounts of nitrogen due to the presence of high amounts of amino acids and protein. Because of this factor, chicken waste is known as one of the most valuable animal wastes that can be turned into organic fertilizer. Untreated chicken waste can create human and animal health problems, undesirable odours, and environmental pollution (Ahmad, 2015). Nonetheless, chicken

*Corresponding author: Tel.: +60 49882256; fax: +60 49882019.
*E-mail address*: *zuhairah445@uitm.edu.my* (Noor Zuhairah Samsuddin)

waste can be a useful commodity if used intelligently. Vermicomposting is a biodegradation process of composting organic matter in which earthworms break down organic waste into small particles (Muduli et al., 2019). After the vermicomposting process, the physiochemical properties of raw waste material will change completely known as vermicompost (Samal et al., 2019). Vermicomposting eliminates the bad smell of organic waste and reduces the many types of pathogenic organisms in the environment (Vihothini et al., 2016). Vermicompost is a finely divided mature peat-like material generated through the non-thermophilic method by earthworm and microorganism activities (Aira et al., 2007) that will cause the change in physical, biological, and chemical properties of soil (Kaur, 2020). Vermicompost has proven its suitability in managing organic waste in agriculture and turning it into valuable products (Muduli et al., 2019). Kaur (2020) stated that the vermicompost has significantly enhanced aeration, texture, and soil structure and prevents soil erosion. It arises about 50 µm of macropore space and increases the air-water relationship in the soil, consequently influencing crop growth. However, it is important to identify the best combination of chicken waste substrate required for effective decomposition by earthworms. Therefore, the experiment's objectives are to determine the effect of different ratios of chicken dung and chicken feathers as a medium substrate in vermicomposting through biodegradability coefficient, chemical properties, and earthworm growth and reproduction rate in all the chicken waste treatments.

## METHODOLOGY

### Vermicomposting procedure.

Chicken dung (CD), chicken feathers (CF), banana trunk (BT), and mushroom medium residue (MMR) are used as composting medium substrates with African Night Crawler worms, *Eudrilus eugeniae*. There were five treatments with three replications, and the sums of fifteen experimental units were prepared in this study. All treatments in this study used the 6:3:1 ratio formulated by Ahmad et al. (2020), where 6 ratios were used for mushroom medium residues, 3 ratios were used for animal wastes, and 1 ratio was used for banana trunk. The ratio of the treatments was measured using the units of volume, which is Litre (L). The composition for all the treatments in this study was based on Table 1.

**Table 1**. Ratio of Medium in Each Treatment

| Treatments | Mushroom Medium Residue (MMR) | Chicken Dung (CD) | Chicken Feathers (CF) | Banana Trunk (BT) |
|---|---|---|---|---|
| Treatment 1 | 6 | 3 | - | 1 |
| Treatment 2 | 6 | - | 3 | 1 |
| Treatment 3 | 6 | 1.5 | 1.5 | 1 |
| Treatment 4 | 6 | 2 | 1 | 1 |
| Treatment 5 | 6 | 1 | 2 | 1 |

Note: 6 ratio = 1.8 L, 3 ratio = 0.9 L, 2 ratio = 0.6 L, 1.5 ratio = 0.45 L, and 1 ratio = 0.3 L.

The total composition for each treatment is 3 L conducted in a plastic basin with a volume of 5 L. All the medium substrates undergo the pre-composting process for 14 days (Ahmad et al., 2020). 28 g of African Night Crawler with a total of 30 worms were inoculated in each medium mixture treatment for the vermicomposting process. All basins were covered with a net and watered every day. The basins were then placed in a vermicompost house for 63 days.

**Vermicompost Biodegradability Coefficient (Kb)**

The organic matter content in all treatments was measured on day 1 (beginning) and day 63 (end) using a measuring cylinder to measure the organic matter conversion during vermicomposting. The vermicompost biodegradability coefficient will be calculated using Equation 1 (Manyuchi & Phiri, 2013):

K_b = ((OM_i-OM_f )×100)/(OM_i  (100-OM_f))×100 (1)

Where:

OM_f = Organic matter content at the end of the vermicomposting process

Om_i = Organic matter content at the beginning of the vermicomposting process.

**Chemical Properties Analysis of Vermicompost**

The data of pH values were collected every week from day 1 until day 63 using the Hanna Instrument HI9921 pH meter. Electrical conductivity (EC) for all treatments was taken every week from day 1 until day 63 using the Field Scout Direct Soil EC Meter, used directly at the experimental site.

**Growth and Reproduction of Earthworms**

The growth and reproduction rate were measured according to the total weight gain of earthworms (g) and cocoon production.

**Statistical Analysis**

The data were analyzed using SPSS (Statistical Package for Social Science) software. A paired T-test was used to analyze pH value and electrical conductivity (EC). One-way ANOVA was used to analyze the significant differences between all treatments. A Tukey test was performed to observe the mean at a 5% significant level between chicken waste treatment in chemical properties analysis and the growth and reproduction rate of earthworms.

## RESULTS AND DISCUSSION

### Vermicompost Biodegradability Coefficient (Kb)

The vermicompost biodegradability coefficient was used to measure the vermicompost quality. The highest Kb was found in T4, and significant differences compared to T2, T3 and T5 with 51.59%. Visual observations of Figures 1 to 5 showed that T1 and T4 exhibited complete degradation, whereas T2, T3, and T5 still had not completed their degradation processes. This is because the reduction in organic matter volume ranged from 39.99% to 51.59% compared to the initial volume of the vermicomposting medium (Table 2). These indicate the high composition of chicken dung compared to chicken feathers could increase the vermicomposting process and align with previous research by Pilli et al. (2019), which suggested that earthworms could consume organic matter and reduce its volume by 40% to 60% from the initial vermicompost medium volume. Furthermore, other factors influence the degradation rate due to the presence of moisture, oxygen, and microorganisms (Zhang et al., 2023).

**Table 2**. Vermicompost biodegradability coefficient ($K_b$) of chicken waste vermicomposting at day 63.

| Treatment | $K_b$ (%) Day 63 |
|---|---|
| T1 (6MMR: 3CD: 1BT) | 49.47$^{ab}$ |
| T2 (6MMF: 3CF: 1BT) | 39.99$^{d}$ |
| T3 (6MMR: 1.5CD: 1.5CF: 1BT) | 45.97$^{bc}$ |
| T4 (6MMR: 2CD: 1CF: 1BT) | 51.59$^{a}$ |
| T5 (6MMR: 1CD: 2CF: 1BT) | 44.31$^{cd}$ |

Note: Mean value that followed by the different letter within column are significantly different at 5% level (P≤0.05) by using Tukey analysis.


**Figure 1**. Vermicompost biodegradability for T1

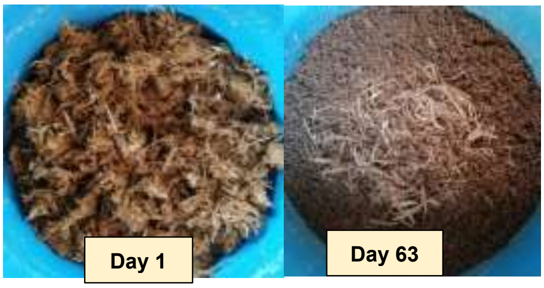


**Figure 2**. Vermicompost biodegradability for T2


**Figure 3**. Vermicompost biodegradability for T3


**Figure 4**. Vermicompost biodegradability for T4


**Figure 5**. Vermicompost biodegradability for T5

## pH Value of the Medium

The pH value is a critical factor in the efficiency and success of vermicomposting, ensuring favourable conditions for microorganisms and earthworms while optimizing plant nutrient availability. Based on Figure 6, the results indicated an initial alkaline pH on day 1 of the vermicomposting process, which gradually shifted towards acidity after 63 days. The pH measurements on day 42 of this study drop within the suitable pH range for vermicomposting, ranging from 7.42 to 7.59, which is considered neutral. However, the pH values recorded on day 63 varied. For T3, T1, and T4, the pH values were from pH 5 to 9, with 6.52, 6.74, and 6.83 values, respectively. In contrast, T5 and T2 exhibited pH values of 5.92 (moderately acidic) and 6.43 (slightly acidic). The pH of vermicompost has decreased over time, and earthworms can thrive in pH values ranging from 5 to 9. While microorganisms active in vermicomposting can function at even lower pH levels, the optimal range for vermicomposting typically falls between 6.5 and 7.5 (Kaur 2020). Furthermore, earthworms are highly sensitive to pH changes and prefer neutral conditions. When the pH drops below 6, earthworms may find it challenging to survive and may migrate or perish (Gajalakshmi and Abbasi 2004).

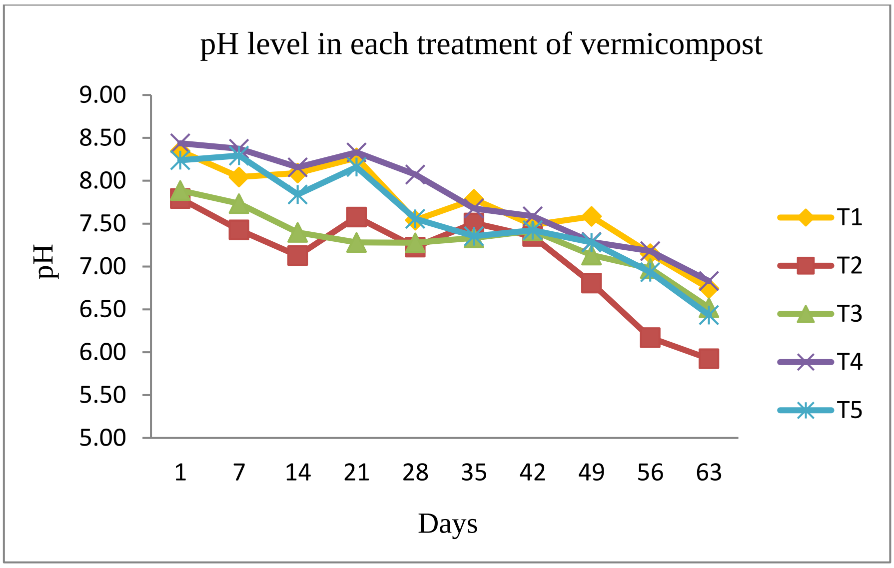


**Figure 6**. Mean pH value in each treatment of vermicompost over 63 days

**EC Value of the Medium**

Electrical conductivity (EC) is used to assess the maturity of compost. Based on Figure 7, the initial EC value was higher than the final value after 63 days of the vermicomposting process. The EC range on day 1 was initially high and reached between 2.54 and 3.58. After 42 days, the EC value tends to drop between the range of 2.02 and 2.47. These EC values at day 63 were reduced and ranged from 1.16 to 1.43. This trend is due to the decomposition of organic matter, which reduces the concentration of soluble salts and ions in the compost. Lower EC values indicate that the compost is approaching a stable and mature state. Thus, the decrease in EC value is also caused by the loss of organic matter weight and the release of mineral salts via the activity of earthworms and the raw materials used in vermicomposting (Ramnarain et al. 2019). Therefore, lower EC values in vermicompost result from exchangeable calcium, magnesium, and potassium (Natarajan and Devi 2014). This reduction in EC signifies that the vermicompost end product is non-toxic and has low salinity, which does not negatively impact most crops or microbial activity (Majlessi et al. 2012).

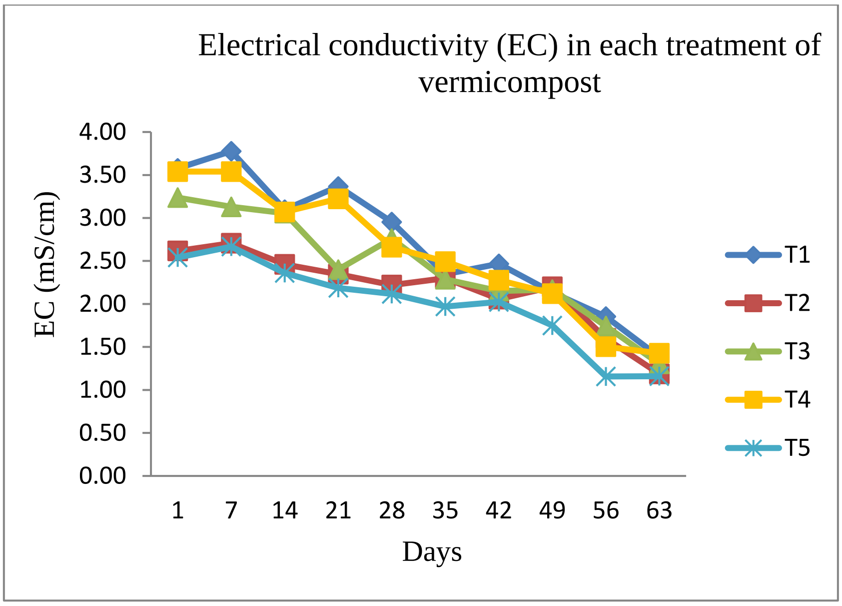


**Figure 7**. Mean EC in each treatment of Vermicompost over 63 days.

## Growth and Reproduction of Earthworms

### *Total Weight Gain of Earthworms (g)*

Based on Table 3, there was a significant difference in total weight gain of earthworms at ($P \leq 0.05$) between T1 and T2 at day 63. T1 substrate media proved to be the most favorable medium for earthworm growth, resulting in adult and juvenile earthworms achieving the highest weight gain at day 63. In contrast, T2 demonstrated the lowest earthworm growth. This suggests that the absence of nutrient-rich materials like chicken dung (CD) or the presence of chicken feathers (CF) inhibits earthworm growth.

T3, T4, and T5, which included various combinations of CD, and CF, showed intermediate results. While they did not perform as well as T1, they still supported considerable earthworm growth compared to T2. The high total weight of juvenile earthworms in T1 on day 63 suggests that this treatment created conditions conducive to earthworm reproduction and population expansion.

It is due to chicken dung containing fewer complex compounds than chicken feathers, which may affect earthworms' interest in feeding the waste during the vermicomposting process. Earthworms prefer organic matters that consist of low-complex compounds such as lignin and cellulose. Coulibaly et al. (2011) also reported that chicken dung substrate is more conducive to promoting the growth and development of worms than cow, sheep, and pig manure.

**Table 3**. Total weight gain of earthworms during the vermicomposting process at day 63.

| | **Total Weight Gain of Earthworms (g)** | |
|---|---|---|
| **Treatment** | **Day 63 (Adult)** | **Day 63 (Juvenile)** |
| T1 (6MMR: 3CD: 1BT) | 18.43[a] | 7.16[a] |
| T2 (6MMR: 3CF: 1BT) | 9.56[b] | 4.61[b] |
| T3 (6MMR: 1.5CD: 1.5CF: 1BT) | 12.36[ab] | 5.42[ab] |
| T4 (6MMR: 2CD: 1CF: 1BT) | 14.91[ab] | 7.02[a] |
| T5 (6MMR: 1CD: 2CF: 1BT) | 15.77[ab] | 6.54[a] |

Note: Means value within a column followed by different letter are significantly different at 5% level ($P \leq 0.05$) by using Tukey's analysis.

### *Cocoon Production*

A cocoon is a translucent, small, spherical protective capsule in which earthworms lay their eggs. Table 4 presents the cocoon production of earthworms harvested on day 63 of the vermicomposting process. T1 produced the highest cocoon production with 1740 cocoons and a significant difference ($P \leq 0.05$) compared to T2. This indicates that the higher concentration of chicken dung in T1, which contains high levels of nitrogen and organic carbon, influences the population of earthworms, thus providing more conducive conditions for cocoon production. Corresponding to Coulibaly & Zoro Bi (2010) found that earthworms in chicken waste vermicompost produce about 40.87% cocoons higher than cow and sheep manure.

**Table 4**. Cocoon production of earthworms over the vermicomposting period in all treatments of chicken wastes

| | **Cocoons Production** |
|---|---|
| **Treatment** | **Day 63** |
| T1 (6MMR: 3CD: 1BT) | 1740[a] |
| T2 (6MMR: 3CF: 1BT) | 1247[b] |
| T3 (6MMR: 1.5CD: 1.5CF: 1BT) | 1495[ab] |
| T4 (6MMR: 2CD: 1CF: 1BT) | 1610[a] |
| T5 (6MMR: 1CD: 2CF: 1BT) | 1529[a] |

Note: Mean value that followed by the different letter within a column are significantly different at 5% level ($P \geq 0.05$) by using Tukey analysis.

## CONCLUSION

In conclusion, the vermicomposting process successfully transformed different combinations of chicken waste treatments into nutrient-rich vermicompost. T4 showed the highest biodegradability coefficient (51.59%), indicating the most efficient organic matter breakdown compared to T2, T3, and T5. Chicken dung enhanced decomposition, while treatments with higher chicken feather content slowed the process. The pH values within the range of 5.92 to 6.83 indicated a moderately to slightly acidic environment, which was generally conducive to earthworm activity.

Furthermore, the reduction in electrical conductivity (EC) values across all treatments indicated that the vermicompost produced was non-toxic and had low salinity, favorable for microbial activity and earthworm growth. The treatment with the highest chicken dung ratio, T1, resulted in the highest earthworm weight gain and cocoon production. In contrast, T2, with the highest chicken feather component, resulted in significantly lower performance, highlighting that chicken dung is likely a more favourable medium for growth and reproduction in earthworms during vermicomposting. The findings suggest that optimizing chicken dung and other organic materials improves vermicomposting efficiency and earthworm development, offering practical insights for sustainable waste management and compost production.

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## AUTHOR CONTRIBUTIONS

Fatin Nabila conducted the research and drafted the manuscript, while Noor Zuhairah Samsuddin reviewed and edited it with Chuah Tse Seng, Nur Faezah Omar, Najihah Farhan Sabri.

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## COMPETING INTEREST

The authors declare that there are no competing interests.

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