International Journal of Agricultural Technology 2023 Vol. 19(4):1435-1446
Available online http://www.ijat-aatsea.com
ISSN 2630-0192 (Online)

# Comparison of the quality of animal manure compost conventional methods with vermicompost animal manure from *Lumbricus rubellus*

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Anandyawati, A., Muktamar, Z., Prameswari, W., Amrullah, A. H. K. and Anggoro, A. (2023). Comparison of the quality of animal manures compost conventional methods with vermicompost animal manures from *Lumbricus rubelus*. International Journal of Agricultural Technology 19(4):1435-1446.

**Abstract** The research revealed that vermicomposting alters animal manure's physical and chemical properties more rapidly than conventional composting and produces more optimal macronutrient values, C-Organic, pH, and C/N. According to panellist observations, this is indicated by changes in the physical properties of livestock manure, including odour, texture, and colour. Chemically, the decomposition process is aided by earthworms yields higher-quality organic fertiliser than conventional composting techniques. According to research findings, the varieties of livestock manure produced the highest levels of various nutrients. The manure vermicompost with the highest total nitrogen content was cow manure, followed by goat and chicken manure. On the other hand, chicken manure vermicompost contained the highest concentration of available P, followed by goat and cow manure vermicompost. The vermicompost made from goat manure contained the most available K, followed by chicken and cow manure. Goat manure vermicompost had the highest Organic C content, followed by cow and chicken manure vermicompost. Regarding pH, goat manure vermicompost was the most acidic, followed by cow and chicken manure vermicompost. In addition, the chicken, goat, and cow manure C/N ratio values were the closest to the soil C/N ratio.

**Keywords:** Chicken manure, Conventional composting, Cow manure, Goat manure, Vermicomposting

## Introduction

The expansion of the livestock industry to satisfy the requirement for domestic animal protein sources has another side effect, namely an increase in the number of faeces produced by livestock. The amount of solid livestock

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waste produced by each animal differs; for instance, chickens produce an average of 0.15 kg/day/head, goats produce an average of 1.13 kg/day/head, and cows produce an average of 8-10 kg/day/head (Ministry of Agriculture, 2015). This large livestock waste has the potential to yield advantages and disadvantages. The advantage is that livestock waste contains a high concentration of nutrients and organic matter, allowing it to be utilised in agricultural cultivation. On the other hand, the disadvantage is that livestock waste can contribute to environmental issues such as pollution if it is not appropriately managed.

Since livestock waste is still immature, it cannot be applied directly to the soil in agricultural cultivation; high levels of ammonia and sulphide gases can inhibit plant growth. Therefore, it is necessary to undergo the maturation process. The maturation process currently utilised by farming communities to reduce ammonia and sulphide gas levels in livestock waste has yet to prove effective. Since the process is lengthy, it emits anodour that contributes to air pollution, and the nutrient content tends to diminish. To address these issues, modifying and implementing appropriate innovations in the bioconversion of livestock waste using earthworms or vermicomposting is necessary.

Utilising the biological process of worms, the vermicomposting process will convert livestock waste into vermicompost, which has added value. In this process, earthworms were the primary biodegradation agent that completes the degradation of organic matter begun by microorganisms. Vermicomposting accelerates the decomposition and maturation of organic matter compared to conventional composting or the ripening process. Vermicomposting can also reduce the potential for odour pollution from livestock manure since it is accomplished through the simple activity of worms. In addition, vermicomposting can enhance livestock manure's macro- and micronutrient content and transform it into vermicompost.

This study aimed to determine the role of *Lumbricus rubellus* in enhancing the quality of various animal manures (chicken, goat, and cow manure) through vermicomposting.

## Materials and methods

The research was conducted at the Animal Husbandry Experimental Cage and Soil Science Laboratory, Faculty of Agriculture, Bengkulu University. This study was conducted from June to December 2019. Earthworms of the species *Lumbricus rubellus*, various livestock wastes in the form of fresh livestock manure (chicken, goat, and cattle), and materials for live worms were the primary ingredients of this study. The primary instruments utilised were the

*Lumbricus rubellus* worm cultivation tank, the Munsell Soil Colour Chart, various beakers, and laboratory analysis equipment.

This study consisted of three phases: the maturation of various animal manures using conventional methods, the maturation of various animal wastes using *Lumbricus rubellus* worms (vermicomposting), and the analysis and assessment of changes in the quality of various animal wastes.

***The maturation of various animal manures using conventional methods***

The maturation of various animal wastes without using *Lumbricus rubellus* worms or conventional methods was accomplished by placing chicken, goat, and cow manure in a plastic container of up to 1,040 grammes, observing changes in physical properties every 10 days for forty days, and analysing chemical properties in a laboratory after forty days.

***The maturation of various animal wastes using Lumbricus rubellus worms (vermicomposting)***

*Lumbricus rubellus* (vermicomposting) worms were used to mature chicken, goat, and cow manure by keeping the worms in nest media comprised of manure from these animals. Animal manure was air-dried and sieved through a 2-millimetre sieve. The mixture was subsequently combined with soil (0–15 cm), dried, and sieved through a 2-millimetre sieve. The soil and animal manure were homogenised at a ratio of 3:1. The nesting media was tailored to the worms at a temperature of 17-25 $^{\circ}$C, humidity of 50-60% and pH of 6-7. The nesting media was placed in a 10 cm plastic container height, and the acclimatisation test was conducted. In order to conduct the acclimatisation test, ten worms were placed in the nesting media. If the worms did not depart the nesting media within 48 hours, the media was ready for use.

The worms' weight to the nesting media weight was 1:8. The care of worms entails regulating temperature, humidity, oxygen levels, disturbances from other animals, and their dietary requirements. For forty days, worms were fed a 1:1 ratio of raw animal manure (chicken, goat, and cow) to their weight. The vermicompost generated was harvested by separating it from the worm biomass. Vermicompost was dried, sieved through a 2-millimetre sieve, and subsequently analysed.

***The Analysis and Assessment and analysis of changes in quality of various animal wastes***

The physical and chemical parameters of animal manure were observed to assess changes in its quality without and with worms (vermicompost). The parameters of odour, texture, and colour were observed regarding physical properties. Organoleptic evaluated odour parameters and texture with the participation of 25 panellists. For forty days, samples for organoleptic testing were collected every ten days. The panellists' assessments were recorded on an organoleptic test form using a score range of 1 to 4 and the following criteria.

Panellists recorded their evaluations on the organoleptic test form with Vermicompost Organoleptic criteria under Decree of the Minister of Agriculture No. 261/KPTS/SR.310/M/4/2019 concerning Minimum Technical Requirements for Organic Fertilisers, Biological Fertilisers, and Soil Improvers.

On the test form, panellists recorded their assessments using the Vermicompost Organoleptic criteria outlined in the Decree of the Minister of Agriculture No. 261/KPTS/SR.310/M/4/2019 concerning Minimum Technical Requirements for Organic Fertilisers, Biological Fertilisers, and Soil Improvers (Ministry of Agriculture, 2019). The organoleptic criteria for vermicompost comprise two elements: texture criteria and odour criteria. Each criterion was assigned a score ranging from 1 to 4. 1) Rough; 2) Quite Crumb; 3) Crumb; and 4) Highly Crumb were the texture criterion. The smell criteria are: 1) Highly Smelly; 2) Smelly; 3) Moderate; and 4) Smells like soil.

The Munsell soil colour chart was used to observe colour parameters; thus, there was a standard for the assessment. The chemical variables analysis included pH $H_2O$, Organic C, the C/N ratio, total N, available P, and available K.

## Results

### *Changes in physical properties*

Observations of physical property changes, including odour, texture, and colour, were conducted every ten days for forty days (Table 1). According to Decree Number 261/KPTS/SR.310/M/4/2019 issued by the Minister of Agriculture, the compost's organoleptic score was used to assess its odour and texture. The rate at which chicken manure compost's odour, texture, and colour changed was slower than that of vermicompost chicken manure. After forty days of observation, the average value of the chicken manure compost odour parameter was 2; on the other hand, the average value of the chicken manure vermicompost was 2.96. According to the panellist's assessment, the odour of chicken manure compost and vermicompost remained smelly criteria. However, the value of chicken manure vermicompost approached the moderate criteria.

The average texture parameter values for chicken manure compost and vermicompost chicken manure were 3.48 and 3.76, respectively. This indicated that the texture of chicken manure vermicompost derived from chicken manure compost had been classified as crumb criteria. Regarding the colour parameters for vermicompost, chicken manure vermicompost was marginally darker than chicken manure compost. Chicken manure compost was a dark olive-grey colour; on the other hand, chicken manure vermicompost was a very dark olive-grey colour.

**Table 1.** The average odour, texture, and colour variations between chicken manure compost and vermicompost

| Observation Parameters | Chicken Manure Compost | | | | Chicken Manure Vermicompost | | | |
|---|---|---|---|---|---|---|---|---|
| | day 10 | day 20 | day 30 | day 40 | day 10 | day 20 | day 30 | day 40 |
| Smell | 1.00 | 1.08 | 1.76 | 2.00 | 1.00 | 1.40 | 2.12 | 2.96 |
| Texture | 2.96 | 2.96 | 3.12 | 3.48 | 3.08 | 3.16 | 3.62 | 3.76 |
| Color | 5/6 5 Y Olive | 5/6 5 Y Olive | 4/4 5 Y Olive | 3/2 5 Y dark olive gray | 5/6 5 Y Olive | 4/4 5 Y Olive | 3/2 5 Y dark olive gray | 3/1 5 YR very dark olive gray |

**Table 2.** The average odour, texture, and colour variations between goat manure compost and goat manure vermicompost

| Observation Parameters | Goat Manure Compost | | | | Goat Manure Vermicompost | | | |
|---|---|---|---|---|---|---|---|---|
| | day 10 | day 20 | day 30 | day 40 | day 10 | day 20 | day 30 | day 40 |
| Smell | 1.16 | 1.48 | 2.12 | 2.68 | 1.68 | 1.84 | 2.80 | 3.20 |
| Texture | 1.4 | 2.24 | 2.72 | 3.04 | 2.08 | 3.68 | 3.76 | 3.88 |
| Color | 4/1 5 G dark greenish gray | 4/1 5 G dark greenish gray | 3/1 5 G dark greenish gray | 3/1 5 G dark greenish gray | 4/1 5 G dark greenish gray | 3/1 5 G dark greenish gray | 2.5/1 5 G greenish black | 2.5/1 5 G greenish black |

Goat manure compost undergoes delayed odour, texture, and colour changes than vermicompost manure (Table 2). At the end of forty days of observation, the average parameter value for the odour of goat manure compost was 2.68; on the other hand, the average parameter value for the vermicompost of goat manure was 3.20. Goat manure compost had an odour according to smelly criteria; on the other hand, goat manure vermicompost had a moderate odour. The average value for texture was 3.04 for goat manure compost and 3.88 for vermicompost made from goat manure. This indicated that goat manure and goat manure vermicompost satisfy the crumb criteria; however, the average value was closer to the highly crumb criteria. Regarding colour, goat manure compost was lighter than vermicompost goat manure, which was greenish-black in appearance.

**Table 3.** The average variations in odour, texture, and colour of cow manure compost and cow manure vermicompost

| Observation Parameters | Cow Manure Compost | | | | Cow Manure Vermicompost | | | |
|---|---|---|---|---|---|---|---|---|
| | day 10 | day 20 | day 30 | day 40 | day 10 | day 20 | day 30 | day 40 |
| Smell | 1.28 | 1.52 | 2.16 | 2.92 | 1.24 | 2.04 | 3.24 | 3.36 |
| Texture | 1.72 | 2.52 | 2.84 | 3.12 | 2.24 | 3.80 | 3.96 | 4.00 |
| Color | 4/1 5 G dark greenish gray | 4/1 5 G dark greenish gray | 3/1 5 G dark greenish gray | 3/1 5 G dark greenish gray | 4/1 5 G dark greenish gray | 3/1 5 G dark greenish gray | 2.5/1 5 G greenish black | 2.5/1 5 G greenish black |

During forty days of observation, the physical properties of cow manure compost changed more slowly than those of vermicompost made from cow manure. The average smell of cow manurewas 2.92; on the other hand, the average smell of cow manure vermicompost was 3.36. According to the panellist's assessment, the smell of cow manure compost on the criteria for smelly and vermicompost was near the moderate criteria. The average value for the texture parameter was 3.12 for cow manure compost and 4.00 for cow manure vermicompost. This indicated that the texture of cow excrement, according to the criteria, was relatively crumbly and that the texture of cow manure vermicompost was also Highly crumbly. Regarding colour, cow manure compost had a milder dark greenish-grey colour than cow manure vermicompost, which was greenish-black (Table 3).

### *Changes in chemical properties*

Comparing the chemical properties of compost waste and vermicompost made from livestock waste was also used to assess their quality. Analysed chemical property parameters include pH $H_2O$, Organic C, C/N ratio, total N, available P, and available K.

Bioconversion of chicken manure through the vermicomposting process demonstrated a higher observational parameter value than traditional chicken manure composting (Table 4). Total N, available P, available K, Organic C, and pH increased significantly. The C/N ratio decreased to 17.93, and Organic C and total N levels increased. The highest nutrient content in chicken manure vermicompost was available P (2.90%), available K (2.70%), and Total N (1.49%). The quality of chicken manure vermicompost satisfied the quality standards outlined in Decree 261/KPTS/SR.310/M/4/2019 of the Minister of Agriculture.

**Table 4**. Chemical properties of chicken manure compost and chicken manure vermicompost

| **Variable Observation** | **Chicken Manure compost** | **Chicken Manure Vermicompost** | **Standard*** |
|---|---|---|---|
| Total N (%) | 0.70 | 1.49 | total macronutrient |
| Available P (%) | 1.30 | 2.90 | min $\geq$ 2 |
| Available K(%) | 0.80 | 2.70 | |
| Organic C (%) | 20.00 | 26.77 | $\geq$ 15 |
| C/N ratio | 28.57 | 17.93 | $\leq$ 25 |
| pH | 6.33 | 7.29 | 4 – 9 |

Information: * Decree of the Minister of Agriculture Number 261/KPTS/SR.310/M/4/2019 concerning Minimum Technical Requirements for Organic Fertilizers, Biological Fertilizers, and Soil Improvements

The traditional strategy of goat manure composting results in reduced parameter values compared to vermicompost (Table 5). Total N, available K, available P, Organic C, and pH levels were higher in vermicompost. An increase followed the decrease in the C/N ratio to 18.22 in the vermicompost's total N- and Organic C levels. The highest nutrient content values for goat manure vermicompost were available K (3.05%), Total N (1.90%), and available P (0.90%), respectively. The purity of goat manure vermicompost satisfied the quality standards outlined in Decree 261/KPTS/SR.310/M/4/2019 of the Minister of Agriculture.

**Table 5.** Chemical properties of goat manure compost and goat manure vermicompost

| **Variable Observation** | **Goat Manure compost** | **Goat Manure Vermicompost** | **Standard*** |
|---|---|---|---|
| Total N (%) | 0.70 | 1.90 | total macronutrient |
| Available P (%) | 0.40 | 0.90 | min $\geq$ 2 |
| Available K(%) | 0.30 | 3.05 | |
| Organic C (%) | 22.1 | 34.65 | $\geq$ 15 |
| C/N ratio | 31.57 | 18.22 | $\leq$ 25 |
| pH | 5.50 | 8.27 | 4 – 9 |

Information: * Decree of the Minister of Agriculture Number 261/KPTS/SR.310/M/4/2019 concerning Minimum Technical Requirements for Organic Fertilizers, Biological Fertilizers, and Soil Improvements

The traditional method of composting cow manure results in lower parameter values than vermicompost (Table 6). The total N, available P, available K, Organic C, and pH levels were higher in vermicompost. Following the decrease in the C/N ratio to 18.78, the total N and Organic C levels increased. The highest nutrient values for cow manure vermicompost were available K (3.03%), Total N (1.98%), and available P (0.70%). The quality of cow manure vermicompost satisfies the 2019 Ministry of Agriculture Number 26 quality standards.

**Table 6.** Chemical properties of cow manure compost and cow manure vermicompost

| Variable Observation | Cow Manure compost | Cow Manure Vermicompost | Standard* |
|---|---|---|---|
| Total N (%) | 0.60 | 1.98 | total macronutrient |
| Available P (%) | 0.20 | 0.70 | min ≥ 2 |
| Available K(%) | 0.15 | 3.03 | |
| Organic C (%) | 16.40 | 31.22 | ≥ 15 |
| C/N ratio | 27.33 | 18.78 | ≤ 25 |
| pH | 6.00 | 7.83 | 4 – 9 |

Information: * Decree of the Minister of Agriculture Number 261/KPTS/SR.310/M/4/2019 concerning Minimum Technical Requirements for Organic Fertilizers, Biological Fertilizers, and Soil Improvements

It demonstrated that the *Lumbricus rubellus*-assisted composting process could enhance the chemical properties of animal manure. Cow manure vermicompost had the highest total N value (1.98%), followed by goat manure vermicompost (1.90%) and chicken manure vermicompost (1.49%) as seen in Tables 4, 5, and 6. Meanwhile, chicken manure vermicompost had the maximum available P (2.90%), followed by goat manure vermicompost (0.90%) and cow manure vermicompost (0.70%). The goat manure vermicompost had the highest available K (3.05%), followed by chicken manure vermicompost (3.03%) and cow manure vermicompost (2.70%). Goat manure vermicompost (34.65%), cow manure vermicompost (31.22%), and chicken manure vermicompost (26.77%) had the most excellent Organic C values. In terms of pH, goat manure vermicompost had the highest pH (8.27), followed by cow manure vermicompost (7.83) and poultry manure vermicompost (7.29). For the most excellent C/N ratio, the chicken manure vermicompost (17.93), goat manure vermicompost (18.22), and cow manure vermicompost (18.78) values were closest to the soil C/N ratio, respectively.

## Discussion

Vermicomposting is one of the most feasible and environmentally favourable methods for the bioconversion of industrial waste or sludge into valuable and high-quality vermicompost (Bhat *et al.*, 2016). Vermicomposting is a straight forward biotechnological process with a faster waste disposal rate than conventional composting that yields vermicompost of superior quality. The benefits are due to the decomposition of organic matter within earthworms' digestive systems. This study was conducted to compare the physical and chemical properties of solid waste (manure) from livestock that was composted in the traditional manner and with the assistance of Lumbicusrubelus worm because vermicomposting can be considered green biotechnology because earthworms are used to process biodegradable solid waste (Wu *et al*., 2014).

The physical properties of vermicompost change more rapidly than those of traditional compost. This is because earthworms aid in the decomposition process by consuming organic matter, and some microorganisms aid in the acceleration of decomposition during earthworm digestion (Husamah *et al.*, 2017). Vermicompost contains the humus that earthworms excrete, distinguishing it from other organic fertilisers. It takes several years for soil or organic matter to decompose and form humus, whereas earthworm faeces contain humus (Sinha *et al*., 2010). The physical properties of vermicompost made from cow manure changed quickly, followed by goat and chicken manure. These parameters include odour, texture, and colour, which are used to determine solid compost's maturation level. According to Karthikeyan *et al.*, (2007), excellent vermicompost is dark in colour, odourless, and has a smooth texture. It is said that vermicompost has attained maturity when its colour becomes blackish brown. The pigment change in all treatments towards a blackish-brown hue was accompanied by a change in the texture of the medium, which became smoother and crumblier (Afriyansyah, 2010).

In addition to worm activity, the type and size of forage also influence the rate at which worms decompose livestock manure. In this investigation, goat and cow manure tended to be smoother than chicken manure, which contained small gravel-like lumps. The finer the size of feed ingredients, the easier it is for earthworms to consume them, whereas fibrous ingredients can hinder their ability to do so (Yuliarti, 2009). The rate of vermicompost maturation is also affected by the bacteria present in earthworm digestion, which will help increase the compounds required for plant or other organism growth (Reanida *et al.,* 2012).

In addition, the results demonstrated that vermicompost's chemical properties were superior to conventionally produced compost. Wu *et al.* (2014) reported that vermicomposting produces organic fertilisers with greater nutrient availability than conventional composting. This is because conventional composting tends to produce compost with a higher ammonium content. In contrast, vermicomposting contains more available N in the form of nitrate, which promotes plant growth. According this research, the macronutrients and

Organic C levels in vermicompost animal manure are higher than in conventional compost. According to Harizena (2012), the activity of microorganisms that affect the levels of organic C will result in a decrease in organic compounds and an increase in inorganic compounds, as well as the release of carbon dioxide during the composting process. The C/N ratio can predict the mineralisation and stabilisation of organic waste during vermicomposting (Suthar and Singh, 2008). A high C/N ratio indicates that plants have limited access to nutrients. In contrast, an average C/N ratio indicates adequate plant nutrient availability and represents the vermicomposting process's maturation or degree of completion (Jamaludin and Mahmood, 2010).

Each vermicompost of animal manure increased pH, indicating that the worms adjust the pH conditions to match those of their natural habitat. The optimal pH range for the life cycle of the *Lumbricus rubellus* worm is 5 to 9 (Edwards and Arancon, 2011). In this investigation, goat manure had the highest pH, followed by cow and chicken manure. This is comparable to a study conducted by Suroningrum (2022), which discovered that goat manure vermicompost had a higher pH than other manure.

The cow manure vermicompost had the maximum total nitrogen content (1.98%), followed by goat manure vermicompost (1.90%) and chicken manure vermicompost (1.49%). Contrary to the findings of Riwandi *et al.* (2021), the maximum total N content was found in vermicompost made from goat manure, while the lowest was found in cow manure. The total amount of nitrogen in vermicompost made from chicken manure is 2.41%. Mineralisation microorganisms in the soil perform the nitrification process, transforming organic nitrogen into inorganic nitrogen. In the digestion of earthworms, microorganisms cause N mineralisation, which consists of demonisation (protein to $R\text{-}NH_2$), ammonification ($R\text{-}NH_2$ to $NH_4^+$), and nitrification of $NH_4^+$ to $NO^-$ (Benbi and Richter, 2022).

Meanwhile, chicken manure vermicompost had the maximum available P-value (2.90%), followed by goat manure vermicompost (0.90%) and cow manure vermicompost (0.70%). In his study, Suroningrum (2022) concluded that the available P content in chicken manure vermicompost was greater than in goat and cow manure vermicompost. This is because the food ingredients consumed by worms, specifically chicken manure, contain more phosphorus than other manures. In addition, according to Pattnaik and Reddy (2010), the activity of phosphatase enzymes during worm metabolism converts organic matter into dissolved P forms, which are then released in vermicompost with the assistance of microorganisms.

Even though the physical and chemical parameters of animal manure vermicompost are superior to those of conventional composting, the vermicomposts produced have met the solid organic fertiliser standards according to Ministry of Agriculture Decree No. 261 of 2019 regarding Minimum Technical Requirements for Organic Fertilisers, Biological Fertilisers, and Soil Improvements. Animal manure vermicomposting requires additional investigation on the appropriate method, composition, and feed to produce vermicompost that meets these standards.

This study concludes that the decomposition process aided by worms is more efficient than the conventional method. Changes in the physical properties of livestock manure, including odour, texture, and colour, indicate this. Chemically, the decomposition process, with the aid of earthworms, produces higher-quality organic fertiliser than conventional composting techniques. The study's findings indicated that the types of livestock manure produced the highest levels of various nutrients.

The manure vermicompost with the highest total nitrogen content was cow manure, followed by goat and chicken manure. In contrast, chicken manure vermicompost contained the highest concentration of available P, followed by goat and cow manure vermicompost. The vermicompost made from goat manure contained the most available K, followed by chicken and cow manure. Goat manure vermicompost had the highest Organic C content, followed by cow and chicken manure vermicompost. Regarding pH, goat manure vermicompost was the most acidic, followed by cow and chicken manure vermicompost. In addition, the chicken, goat, and cow manure C/N ratio values were the closest to the soil C/N ratio. It is necessary to conduct additional research with more potent organic materials and worm species to obtain vermicompost of higher quality. In addition, it is necessary conducted research on the effect of vermicompost on crop yield and production.

## Acknowledgements

The author would like to offer particular thanks to University of Bengkulu, Ministry of Education, Culture, Research and Technology, The Republic of Indonesia, for providing a research grant with the Penelitian Pembinaan scheme in 2019.

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(Received: 10 September 2022, accepted: 3 July 2023)