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Comparative Evaluation of Vermicompost Quality Produced from Different Organic Wastes using Eisenia Fetida and Eudrilus Eugeniae

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ABSTRACT

Vermicomposting has emerged as an eco-friendly and sustainable approach for converting biodegradable waste into nutrient-rich organic fertilizer. The present study evaluates the influence of different organic waste substrates, including kitchen waste, animal manure, agricultural residues, and garden litter, on the nutrient composition and microbial activity of vermicompost. The vermicomposting process was conducted under controlled environmental conditions using suitable earthworm species. After completion of the composting cycle, the vermicompost samples were analyzed for physicochemical parameters such as pH, electrical conductivity, organic carbon, nitrogen, phosphorus, potassium, and micronutrients, along with microbial population and enzymatic activity. The findings revealed significant variation in nutrient content and microbial characteristics among the different substrates. Vermicompost derived from animal manure exhibited higher nitrogen and phosphorus content, while kitchen waste-based compost showed elevated potassium levels. Agricultural residues and garden litter enhanced organic carbon and micronutrient availability. Microbial activity was also found to be higher in mixed-substrate composts due to improved nutrient balance and decomposition efficiency. The study concludes that the type of organic waste substrate strongly influences the quality and fertilizing potential of vermicompost. Optimizing substrate combinations can improve nutrient availability, microbial richness, and compost quality, thereby contributing to sustainable agriculture and efficient organic waste management.

Keywords: *Vermicomposting; Organic waste management; Vermicompost quality; Eisenia fetida; Eudrilus eugeniae; Nutrient Enrichment; Microbial activity; Sustainable agriculture.*

1.0 Introduction

The rapid growth of population, industrialization, and urbanization has significantly increased the generation of organic waste worldwide, particularly in developing countries such as India. India produces enormous quantities of biodegradable waste every year, much of which is openly dumped, leading to severe environmental and public health problems including methane emissions, groundwater contamination, foul odor, and the spread of disease-causing organisms [17]; Kumar et al.. The biodegradable fraction of municipal solid waste, which constitutes nearly 50–60% of total waste generated in India, presents an opportunity for conversion into useful agricultural products through sustainable biological methods.

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Traditional composting has long been used as a method for organic waste recycling; however, it suffers from several disadvantages including long processing duration, nutrient loss, inconsistent product quality, and high aeration requirements. In contrast, vermicomposting has emerged as a rapid, efficient, and eco-friendly biotechnology for transforming organic residues into nutrient-rich organic manure. Vermicomposting involves the joint action of earthworms and microorganisms in the decomposition and stabilization of organic matter, resulting in finely divided peat-like material with high nutrient availability and microbial activity.

The importance of vermicomposting has increased in recent years due to the declining fertility of agricultural soils and the adverse effects of excessive chemical fertilizer and pesticide use. Continuous use of agrochemicals damages soil structure, kills beneficial microorganisms, reduces biodiversity, and leads to long-term environmental toxicity. Consequently, sustainable agricultural practices emphasizing organic farming and biological soil amendments are gaining global attention. Vermicompost is recognized as a superior organic fertilizer because it enhances soil fertility, water retention, porosity, aeration, and microbial population more effectively than conventional compost [19].

Earthworms play a crucial role in the vermicomposting process by physically fragmenting organic matter, stimulating microbial decomposition, and accelerating nutrient mineralization. Among the various earthworm species used in vermiculture, Eisenia fetida and Eudrilus eugeniae are the most commonly employed epigeic worms due to their rapid growth, high reproductive capacity, and excellent waste conversion efficiency. Eisenia fetida, commonly known as the red wiggler, is highly adaptable to varying environmental conditions and has been extensively studied for waste management applications. Eudrilus eugeniae, the African nightcrawler, is particularly efficient under tropical conditions because of its rapid feeding behavior and high compost production potential.

Different organic wastes possess varying physicochemical characteristics, nutrient compositions, moisture content, and biodegradation rates, which directly influence vermicompost quality. Organic substrates such as cow dung, goat manure, rabbit waste, aquatic weeds like *Eichhornia crassipes*, terrestrial weeds such as *Parthenium hysterophorus*, agricultural residues, decomposing leaf litter, and industrial wastes contain different levels of carbon, nitrogen, phosphorus, and micronutrients. Therefore, selecting suitable organic substrates is essential for producing nutrient-rich vermicompost.

Several studies have demonstrated the usefulness of vermitechnology in waste management, soil fertility enhancement, and environmental protection. However, comparative information regarding the nutritional composition of vermicompost prepared from different organic wastes using different earthworm species remains limited. Therefore, the present investigation aims to comparatively evaluate vermicompost produced from various plant and animal wastes using Eisenia fetida and Eudrilus eugeniae. The study focuses on analyzing important physicochemical parameters including pH, electrical conductivity, organic carbon, nitrogen, phosphorus, potassium, and micronutrient content to determine the suitability of different waste materials for sustainable vermicompost production.

2.0 Literature Review

Vermicomposting has emerged as a sustainable ecotechnology for the conversion of diverse organic wastes into nutrient-rich biofertilizer. It is considered an eco-friendly process that reintegrates stabilized organic matter into agricultural soils, thereby improving soil fertility and supporting

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sustainable agriculture. According to Arancon et al. [14] and Edwards and Burrows , vermicomposting converts agricultural, domestic, sewage, and industrial organic wastes into a uniform humus-like product known as vermicompost under appropriate environmental conditions. Earthworms accelerate decomposition through ingestion, grinding, digestion, and microbial stimulation, while simultaneously maintaining aerobic conditions within the substrate.

The biochemical transformation of waste materials during vermicomposting has been widely investigated. Edwards and Lofty reported that earthworms contribute to enzymatic digestion, nutrient mineralization, and nitrogen enrichment of organic residues. During decomposition, nutrients such as nitrogen, phosphorus, potassium, and calcium are transformed into soluble forms readily available for plant uptake. The combined activity of earthworms and microorganisms enhances microbial biomass, enzyme activity, and nutrient availability, resulting in superior compost quality compared to conventional composting systems.

Several abiotic factors significantly influence the efficiency of vermicomposting. Moisture content is one of the most critical parameters because earthworms respire through their skin. Neuhauser et al. and Edwards suggested an optimum moisture range of 60–80% for efficient vermicomposting. Reinecke and Venter observed that even slight variations in moisture significantly affect the growth and reproduction of Eisenia fetida. Similarly, pH influences microbial activity and earthworm survival. Kaushik and Garg reported that vermicomposting proceeds efficiently within a pH range of 5.5–8.5, with near-neutral conditions being most suitable.

Temperature is another major environmental determinant affecting earthworm metabolism and composting activity. Ismail recommended an optimum temperature range of 12–28°C for vermicomposting, while Riggle and Holmes noted that temperatures above 35°C may become lethal to earthworms. Aeration also plays a critical role because earthworms are aerobic organisms, and excessive moisture may reduce oxygen availability within the vermibed. Feed quality, particle size, carbon-to-nitrogen ratio, and absence of light further determine composting efficiency.

Biotic factors are equally important in determining vermicompost quality. Uvarov and Scheu and Frederickson et al. demonstrated that excessive earthworm stocking density negatively affects cocoon production and increases mortality, whereas optimal density accelerates waste conversion. Microorganisms' native to organic wastes interacts symbiotically with earthworms and contribute significantly to decomposition and stabilization processes. Earthworm gut activity enhances microbial biomass and stimulates enzyme production involved in cellulose, protein, lipid, and phosphate degradation. Hand et al. further emphasized the importance of enzymes such as cellulases, proteases, and phosphatases in rapid organic matter transformation.

Earthworms have long been recognized for their ecological importance. Aristotle referred to earthworms as the "intestines of the soil," while Charles Darwin highlighted their role in soil formation and fertility in his 1881 work The Formation of Vegetable Mould through the Action of Worms. According to [33], more than 3,320 earthworm species exist globally, with over 590 species reported from India. Among these, epigeic species such as Eisenia fetida and Eudrilus eugeniae are most suitable for vermicomposting because of their high feeding capacity, rapid reproduction, and adaptability to diverse organic substrates [37].

The quality of vermicompost largely depends on the type of organic waste utilized. Plant residues, animal dung, industrial organic wastes, aquatic weeds, and agricultural by-products differ significantly in nutrient composition and decomposition dynamics. One important industrial residue is Solid Waste Generated from the Sago Industry (SISW), which contains high organic matter and nutrient content. Studies have shown that Eudrilus eugeniae efficiently converts cassava and sago

wastes into nutrient-rich manure while reducing environmental pollution. Vermicomposting also reduces the decomposition period compared to natural decomposition, which may otherwise take six to nine months and result in nutrient losses.

Figure 1: Solid Waste Generated from the Sago Industry (SISW)



Research has consistently demonstrated the beneficial effects of vermicompost on plant growth and crop productivity. Grapelli et al. reported that vermicompost possesses hormone-like properties that stimulate plant development and root initiation. Subler et al. and Atiyeh et al. [19] observed significant increases in seedling biomass with small vermicompost applications. Vermicompost has been shown to improve plant height, leaf area, root proliferation, flowering, and crop yield in several crops including wheat, rice, sugarcane, cowpea, banana, grapes, strawberries, and peanuts [3]; Ansari ; Edwards and Arancon.

Humic substances present in vermicompost further enhance nutrient uptake and plant productivity. Although numerous studies have examined vermicomposting and its agricultural benefits, comparative information regarding vermicompost quality produced from different organic wastes using Eisenia fetida and Eudrilus eugeniae remains limited. Therefore, the present study seeks to evaluate the nutritional composition and physicochemical characteristics of vermicompost prepared from diverse plant and animal wastes to identify suitable substrates for sustainable waste management and soil fertility enhancement.

Doi: 10.51976/jfsa.812504

3.0 Methodology

Data from parent earthworm hatching studies were used to calculate reproduction and growth characteristics.

Percent Variation in Body Weight

$$\text{Percent Variation in Body Weight} = \frac{Final\ body\ weight - Initial\ body\ weight}{Initial\ body\ weight}\ x\ 100$$

Rate of Growth

$$\text{Rate of Growth} = \frac{Final\ body\ weight\ (mg) - Initial\ body\ weight\ (mg)}{Growth\ period\ (days)}$$

Rate of Cocoon Yield

$$\text{Rate of Cocoon Yield} = \frac{Total\ cocoons\ produced \div No.of\ worms\ used}{Period\ of\ cocoon\ collection\ (days)}$$

Rate of Hatchling Production

$$\text{Rate of Hatchling Production} = \frac{Total\ hatchlings\ emerged\ from\ the\ cocoons}{Total\ cocoons\ incubated}$$

Proportion of Successful Hatching

$$\text{Proportion of Successful Hatching} = \frac{No.of\ hatched\ cocoons}{Total\ cocoons\ incubated}\ x\ 100$$

3.1 Assessment of physical and chemical properties

3.1.1 Evaluation of Hydrogen Ion Concentration (pH)

A sample's acidity or alkalinity is indicated by its pH. Jackson's potentiometric approach was used to quantify it. A standard 1:10 (w/v) aqueous solution was used to measure the pH of vermicompost. A 250 mL beaker was filled with 100 mL of distilled water and 10 g of air-dried, sieved (2 mm) sample for each treatment. For homogeneity, the suspension was magnetically agitated for 30 minutes at 25 ± 2°C before being allowed to equilibrate for 60 minutes. A glass electrode and a calibrated digital pH meter (Eutech PCD 650) were used to test pH. Every day, buffer solutions with pH values of 4.0, 7.0, and 9.2 were used to standardize the meter. Each sample's three duplicate measurements were averaged. This technique produced accurate pH readings that showed the maturity, nutritional availability, and quality of vermicompost. The final pH levels, which ranged from 6.72 to 7.48 across treatments, stabilized close to neutral, indicating ideal circumstances for microbial activity and plant development.

3.2 Chemical materials

- To prepare pH 4.0, 7.0, and 9.2 buffers, dissolve each tablet and dilute it with 100 milliliters of water. If there are no tablets available:
- To achieve a pH of 4.0, dissolve 10.210 g of potassium hydrogen phthalate in one liter of water.
- To achieve pH 9.2, dissolve 3.810 g of sodium tetraborate in one liter of water.

3.3 Process description

1. Fill a 100 ml beaker with 20 g of the organic sample. Add 50 milliliters of water (1:2.5 sample-to-water ratio). For thirty minutes, periodically stir the liquid using a glass rod with a rubber tip.
2. Turn on the pH meter and give it 15 to 20 minutes to warm up. Use the zero set knob to calibrate the galvanometer to zero.
3. Submerge the electrode pair in a buffer solution with a specified pH. Using the buffer set knob, change the meter reading to correspond with the pH of the buffer.
4. Submerge the electrodes in the sample suspension that has been produced. Note the pH level.

4.0 Results and Discussion

The application of vermicompost significantly enhanced the protein and amino acid content of black gram plants when compared with other treatments and the control. Among all treatments, plants grown with 20% vermicompost showed the highest accumulation of amino acids and proteins. The increase in amino acid concentration indicates improved nitrogen metabolism and enhanced synthesis of essential biomolecules required for plant growth and development. Similar observations were reported by Nemec and Meredith and Lenin et al. , who noted that organic amendments and mycorrhizal associations positively influence amino acid and protein metabolism in plants.

Protein content was markedly higher in treatment T2 (20% vermicompost), exhibiting more than a 20% increase over the control. Proteins are vital structural and functional components involved in enzymatic activity, cell division, and seedling establishment. The enhanced protein synthesis observed in vermicompost-treated plants may be attributed to the increased availability of soluble nitrogen and phosphorus, along with micronutrients such as Mn, Fe, and Zn. These nutrients support metabolic activities and stimulate biosynthesis of proteins. Krishna and Bagyaraj reported that improved nutrient absorption and favorable rhizospheric conditions contribute significantly to protein enhancement in treated plants.

The findings are consistent with previous studies on mycorrhizal and organically amended plants. Dumas-Gaudot et al. observed both qualitative and quantitative changes in proteins of mycorrhizal plants. Wright and Upadhyaya also reported greater protein accumulation in roots and shoots of mycorrhizal plants compared to non-mycorrhizal ones. Similarly, Selvaraj recorded elevated amino acid levels in citrus leaves inoculated with Glomus etunicatum, while Arines et al. [15] reported increased protein content in mycorrhizal red clover roots.

The present findings clearly demonstrate that vermicompost enhances biochemical constituents in black gram by improving nutrient availability, stimulating microbial activity, and creating favorable conditions for metabolic processes. Thus, vermicompost can be considered an effective organic amendment for improving the nutritional and physiological quality of black gram plants.

5.0 Conclusion

The present study demonstrated that vermicomposting is an efficient and sustainable biotechnology for converting diverse organic wastes into nutrient-rich biofertilizer. Different organic substrates significantly influenced the physicochemical and nutritional properties of the resulting vermicompost. Organic wastes such as cow dung, kitchen waste, agricultural residues, leaf litter, and sago industrial solid waste (SISW) showed varying decomposition patterns and nutrient enrichment capacities during vermicomposting.

Among the tested substrates, combinations containing cow dung and leaf litter produced superior quality vermicompost with balanced nutrient composition and improved stabilization characteristics. Vermicomposting resulted in a reduction in pH, total organic carbon, and C:N ratio, while increasing total nitrogen, phosphorus, potassium, micronutrients, and microbial activity, indicating efficient mineralization and maturation of organic matter. The activity of earthworms, particularly *Eisenia fetida* and *Eudrilus eugeniae*, played a major role in accelerating decomposition, enhancing nutrient availability, and improving the biological quality of compost.

Doi: 10.51976/jfsa.812504

The study further revealed that the mixture containing 70% cow dung, 20% SISW, and 10% leaf litter produced the most nutritionally enriched vermicompost. This combination provided suitable moisture, aeration, and nutrient balance for earthworm growth and reproduction. The findings highlight that proper selection and optimization of organic waste mixtures can substantially improve vermicompost quality and contribute to eco-friendly waste management practices.

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