Reuse of powdered eggshells in vermicomposting of acidic waste

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Abstract

Vermicomposting is a process to biotransform organic solid waste into valuable product, namely vermicompost by using earthworms**.** Vermicomposting technology may provide a low input basis for sustainable management of organic fraction of solid waste. The present study was to investigate the suitability of orange skin to be reused as feedstock of *Eudrilus eugeniae* for 60 days. The maturity and quality of vermicompost are assessed through fertilizer parameters such as C/N ratio. All treatments expressed a significant decrease in C/N ratio (28.62- 45.40%) after 60 days of vermicomposting. Besides that, parameters such as moisture content, pH and electrical conductivity (EC) will also be discussed in this paper. Moisture content was in the range of 52 to 80% thought out the experiment. The vermicompost pH of orange skin was in the range of 8.7 to 9.0 after 60 days of vermicomposting. The decreased of EC in orange skin treatments (35.06- 39.97%) was also observed after 60days of vermicomposting. This study revealed the potential of biotransforming orange skin to high quality organic fertilizer by *E. eugeniae.*

1 Introduction

Huge amount of solid waste has been generated in the last few decades due to the rapid development of globalization and industrialization. In most of the countries, the sustainable management of solid wastes remains as a major challenge. According to Tuttobena et al. [1], agro- industrial waste more creates various environmental problems due to the high economic cost and heavy environmental repercussions of its disposal. For example, orange is planted widely and the discarded portion of orange is 30- 50%, which is relatively high when compared to other tropical fruits [2]. Studies haven been done on orange skin to determine its nutritive potential of orange skin as animal feed ingredient in order to reduce the usage of cereal grains [3]. Besides that, Tuttobena et al. [1] reported that orange waste can be reused as organic fertilizer after treatments. Thus, safe disposal and environmental friendly management of orange skin, such as vermicomposting, was investigated in this study.

Vermicomposting is a process of decomposition organic solid waste deposits by the aerobic activity of earthworms and microorganisms [4]. It can be regarded as a sustainable technology for managing non- toxic waste when space is a constraint [5]. It is an economical technique that produces humus like substrate known as vermicompost, which is a stabilized product contains high nutrients in the forms that are readily taken up by plants [6].

There is no significant study has been done to investigate the potential reuse of orange skin as feedstock in vermicomposting. The aim of this study was to investigate the suitability of *Eudrilus eugeniae* in vermicomposting of orange skin together with eggshell and soil.

2 Materials and Methods

2.1 Earthworms and Collection of Organic Wastes

E. eugeniae was obtained from ESI Agrotech, Malaysia. *E. eugeniae* was chosen in this study because *E. eugeniae* is a fast- growing and productive earthworm that is suited for rapid organic waste conversion[7, 8]. Orange skin was procured from a fruit juice stall in Sunway Pyramid, Malaysia. They were dried in direct sunlight for 1 week with periodic flipping. Eggshell was obtained from local market. The eggshells were cleaned and dried in an oven at 60°C for 1 day. Typical local available multipurpose organic soil (Peatgro) was obtained from ACE Hardware, Malaysia.

The characteristic of orange skin, eggshell and soil are presented in Table 1. The soil was sunbathed for 3 days to reduce pathogenic bacteria found in the soil. Orange skin, eggshell and soil were mixed in different proportions as shown in Table 2. Water was added to the prepared mixtures to achieve required moisture content. The dampened mixtures were left up to 3 days for stabilization purpose before *E. eugeniae* were introduced into the system to improve the palatability of the earthworms.

Table 1 Characteristics of orange skin, eggshell and soil.

Parameter	Orange skin	Eggshell	Soil
pH	4.37	10.03	4.87
Electrical conductivity (µS cm^{-1})	1779	80.7	218
TC (g kg^{-1})	295.73	160.11	643.20
TKN (g kg^{-1})	6.750	3.375	6.000
C/N ratio	43.81	47.44	107.20

2.2 Experimental set- up

The experiments were conducted in triplicate in cylindrical plastic containers of 500ml capacity, which were kept in dark laboratory. The temperature in the laboratory was maintained at 25±2°C which is the suitable temperature for *E. eugeniae*. Orange skin, eggshell and soil were grounded before they were mixed in different ratios to produce different combinations of treatment (Table 2). An optimal feeding rate of 0.75 g feed g^{-1} worm day^{-1} was used to determine the total weight feedstock mixtures in each treatment [7, 9]. After 3 days of stabilization of organic waste, 6 unclitellated *E. eugeniae* were introduced into each vermireactor unit. During the study, no additional feed was added. Periodic sprinkling of adequate quantity of distilled water was provided into the the vermireactor in order to maintain the moisture content of around 60-70%. The duration of the experiment was 60 days.

Table 2 Description of different treatments used in vermicomposting experiment

Treatment	Treatment description
S	Soil only (as experimental control)
1OS: 1ES: 1S	1 part of orange skin: 1 part of eggshell: 1 part of soil
1.5OS: 1.5ES: 1S	1.5 part of orange skin: 1.5 part of eggshell: 1 part of soil
2OS: 2ES: 1S	2 parts of orange skin: 2 parts of eggshell: 1 part of soil

2.3 Chemical analysis

The pH and EC were determined using a digital pH meter and conductivity meter respectively in 1:10 (w/v, substrate: water extract) aqueous solution [7, 8]. Total organic carbon was determined using a partial oxidation method [10] Total Kjeldahl nitrogen was measured using the micro- Kjeldahl method [11]. The moisture content were determined by drying 1gram of vermicompost sample in an oven at 105ºC for 24 hours.

3 Results and Discussion

3.1 Nutrient Quality of Vermicompost

After 60 days of vermicomposting process, the orange skin mixture was a stabilized and nutrients rich material. Interaction between earthworms microorganisms was the reason that enhanced the degradation of orgamic matter and release of nutrients matter [4]. In this current study, *E. eugeniae* successfully converted orange skin mixture into nutrient rich materials.

3.1.1 pH

According to Lim et al. [8], pH shift in vermicompost was substrate dependent. The pH of all amended vermireactors fell within 6.5 to 7.1 at day 0 (Fig. 1), which is an ideal condition for the earthworms. After 60 days of vermicomposting process, the vermicompost pH of orange skin ranged from 8.7 to 9.0. The increased of pH in acidic waste during vermicomposting process was also observed by Mainoo et al. [12] and Singh et al. [13]. The increase of pH could be due to the intense mineralization of nitrogen caused by vermicomposting of acidic wastes [4, 14, 15]. Sunberg et al. [16]reported that the pH of household wastes, which were acidic in nature, increased from 4.5-6 to 8-9 due to the degradation of organic acids by microorganisms [17]. No significant change in pH was observed for soil control treatment. This could be due to no amendment was introduced, thus it was difficult to regulate and maintain the pH of vermicompost at neutral level or above.

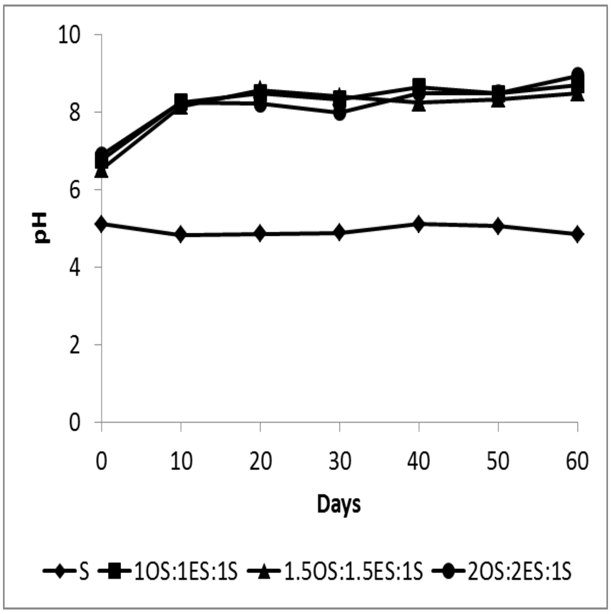

Fig. 1 pH in different treatments

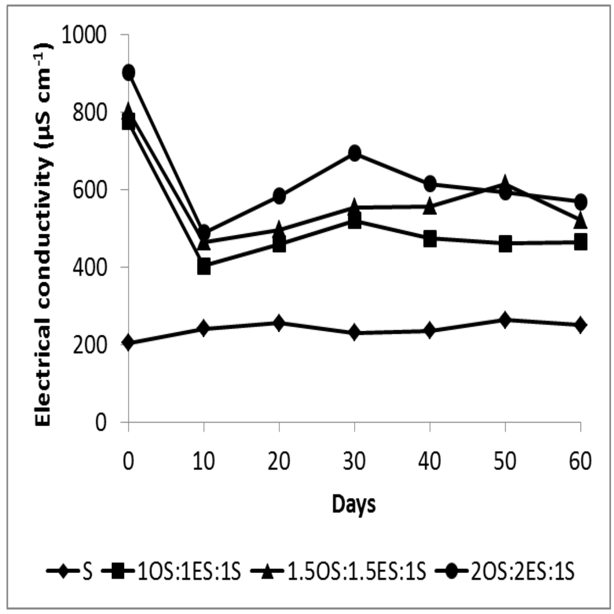

Fig. 2 Electrical conductivity in different treatments

3.1.2. Electrical conductivity

The electrical conductivity (EC) is a good indicator of the suitability of vermicompost to be used for agricultural purposes because it reflects the total amount of dissolved ions available in the water or the salinity of an organic amendments [18]. Vermireactors with amendments (1OS: 1ES: 1S, 1.5OS: 1.5ES: 1S and 2OS: 2ES: 1S) showed higher EC as compared to soil control (Fig. 2). This phenomenon indicates that amended treatments produced better quality vermicompost as the mixtures showed higher amount of nutrients available to plant developments. In Fig. 2, it shows a drastic decrease in EC during the first 10 days. This may due to the stabilization of the mixtures [19, 7]. There is a sharp increase of EC in treatment 2OR:2ES:1S after 10 days of vermicomposting (Fig. 2). This may be due to the release of soluble ions like ammonium and phosphate [20] or it could be contributed by the death of earthworms [21].

3.1.3 Ratio of carbon to nitrogen

C/N ratio is one of the most widely used indicator to determine the maturity and stabilization of organic matters because plants can only integrate nitrogen when C/N ratio is less than 20 [8, 22]. Generally, C/N ratio for all treatments decreased (Fig. 3) was due to the decrease of carbon content and increase in nitrogen content. This is because earthworm activity would decrease the organic carbon levels and accelerate the waste stabilization process, while the production of mucus and nitrogen excrements by earthworms would increase the nitrogen content [7, 8, 23, 24]. The final C/N ratios of vermicomposts were in the range of 24 (2OS: 2ES: 1S) to 59.32 (S). It is expected that the C/N ratio for all treatments would decrease if the process was continued after 60 days of vermicomposting.

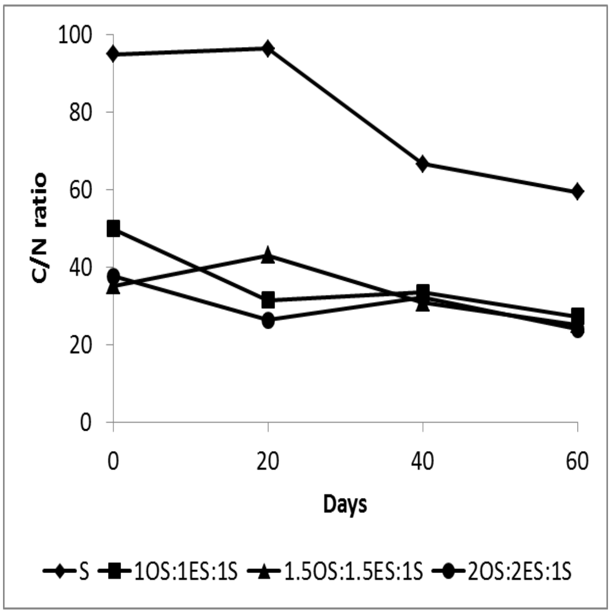

Fig. 3 C/N ratio in different treatments.

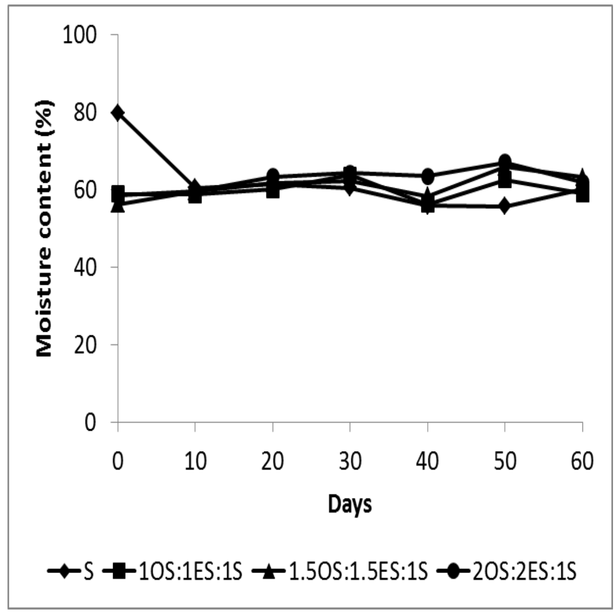

Fig. 4 Moisture content in different treatments.

3.1.4 Moisture content

Moisture content for this experiment was range in 52 to 80% (Fig. 4). Fig. 4 shows the moisture content of vermicomposting process in the duration of 90 days for all treatments. Generally, the optimum moisture content for vermicomposting is around 70-80% [25]. Domínguez and Edwards [26] also reported that the moisture content ranged from 60 to 70% was also suitable for earthworms to survive.

4 Conclusion

The present study showed that orange skin amended with eggshell and soil could be converted to organic fertilizer through vermicomposting process. Results suggested that the mixing of orange skin with eggshells and soil in an appropriate ratio (especially in the treatment of 2OS:2ES:1S) could decrease the C/N ratio to the desired level. However, it is suggested that vermicomposting of orange skin should be conducted more than 60 days so that better quality of vermicompost could be obtained. In conclusion, the study provides a basis to show that vermicomposting can be used as a sustainable technology to convert organic waste into nutrient rich materials, namely vermicomposts.

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