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Short communication

Biotransformation of rice husk into organic fertilizer through vermicomposting

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ABSTRACT

Rice husk (RH) is an abundant agricultural solid waste as a result of rice-milling process. The present study investigated the potential of converting RH amended with market refused fruit (market refused banana (B), honeydew (H) or papaya (P)) into vermicompost using *Eudrilus eugeniae*. RH was mixed with market refused fruit in an equal ratio to produce three different treatments (1B:1RH, 1H:1RH and 1P:1RH) for laboratory screening of solid wastes. Generally, the application of *E. eugeniae* permitted an increase in calcium (6.9–99.0%), potassium (15.0–121.4%), phosphorus (2.4–49.5%) and carbon (6.5–69.0%) in final vermicompost after 9 weeks of vermicomposting. However, decreases in magnesium (3.7–45.7%) and nitrogen (6.9–23.7%) were also observed in final vermicomposts. Among all the RH treatments, RH which was mixed with market refused papaya (1P:1RH) showed better quality vermicompost with higher nutritional status. It was also found that RH which was amended by market refused fruit (1B:1RH, 1H:1RH or 1P:1RH), especially market refused papaya, encouraged the growth of earthworm as compared to the treatment with RH alone. The present data reveal that vermicomposting is a feasible technology for bio-transforming RH into value-added material, namely vermicompost.

1. Introduction

Rice (*Oryza sativa* or *Oryza glaberrima*) is one of the major food crops in the world, especially in East and South Asia, Middle East, Latin America and West Indies. The inedible rice husk (RH) would always be removed during the rice-milling process and it is considered as waste by-product with little economic value because the efforts to utilize RH has been handicapped by its tough, woody, abrasive and resistance to degradation nature, low nutritive properties as well as high ash content (Sun and Gong, 2001). It is reported that for every ton of rice produced, about 0.23 tons of RH is formed (Chandrasekhar et al., 2003). The rigorous development of the rice milling industries in the world has resulted the generation of RH up to 120 million metric tons per year and the continuous generation of RH may present a major disposal problem in most of the rice production countries (Foo and Hameed, 2009).

Extensive research has been carried out to reuse RH but most of the research was conducted in laboratory scale and it is unknown to the researcher if the proposed method could be used to cater for the increasing quantity of RH. One of the methods that could be used to transform large quantity of RH into value added product is composting. However, the high lignin content of the RH can prolong the composting process. Leconte et al. (2009) found that the time required for the stability of RH with poultry manure in composting was about 180 days. Thus, other safe disposal and environmentally friendly management of RH, such as vermicomposting, was investigated in this study.

Vermicomposting is a microbial composting of organic wastes through earthworm activity (Domínguez et al., 2001). Microbes are responsible for the biochemical degradation of organic matters whilst earthworms are the important drivers to condition the substrate and alter the biological activity (Domínguez et al., 2002). In comparison with typical type of composting, vermicomposting results in bioconversion of solid wastes into two useful products: the earthworm biomass and the vermicompost that exhibits lower mass in lesser processing time and greater fertilizer value with high humus content and lesser phytotoxicity (Garg and Gupta, 2009; Sim and Wu, 2010).

To the best of our knowledge, limited study has been attempted to investigate the potential of reusing RH as feed stock in vermicomposting. Market refused fruits were used as amendments in this present study because the stock culture of *Eudrilus eugeniae* was grown using papaya as feedstock. Also, it was proven by Prabha et al. (2007) and Lim et al. (2011) that *E. eugeniae* can be cultured very well on fruit wastes. Thus, the appropriate combination of market refused fruit with RH might provide suitable condition for *E. eugeniae* to live in. Therefore, the aim of this study was to investigate the suitability of *E. eugeniae* in vermicomposting of RH

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together with market refused fruits, in which case the latter were found abundantly in local markets.

2. Materials and methods

2.1. Earthworm and collection of organic waste

E. eugeniae was obtained from ESI Agrotech, Malaysia. *E. eugeniae* was chosen in this study because *E. eugeniae* is a fast-growing earthworm that could convert organic waste rapidly (Domínguez et al., 2001). Stock earthworms were grown in the laboratory under ambient temperature on partially decomposed market refused papaya and ground RH in the ratio of 20:1.

The organic wastes used in this study were RH and market refused fruits, namely market refused banana (B), honeydew (H) and papaya (P). RH was obtained from Kilang BERNAS, Sekinchan while the fruits were collected from Selayang Wholesale Market, Kuala Lumpur, Malaysia. The market refused fruits were kept in refrigerator (at 4 °C) before they were used as feed stock in vermicomposting.

2.2. Experimental set up

The experiments were conducted in triplicate in rectangular plastic containers (17 cm × 14 cm × 12 cm), which were kept in dark laboratory. The temperature in the laboratory was maintained at around 25 ± 2 °C, which is the optimum temperature for *E. eugeniae* (Khwairakpam and Bhargava, 2009a). The containers were filled from bottom to top with pebbles (1 cm height), saw-dust (2 cm height) and soil (4 cm height). The lid and bottom of each container were punched several holes for aeration. Moisture content was maintained around 50% for all treatments by periodic sprinkling of distilled water.

RH and/or market refused fruits (market refused B, H or P) were ground and blended together with 50 mL distilled water in equal ratio to produce three different combinations of treatment, namely B:RH (1:1), H:RH (1:1) and P:RH (1:1). Four control treatments, consisting of individual wastes (RH, B, H and P) were also set up. The physico-chemical characteristics of all treatments are presented in Table 1. For vermicomposting experiments, 10 non-clitellate *E. eugeniae* (~0.70 g each) were selected from the stock culture and released into each experimental container. The worms were fed weekly up to 7 weeks with substrate material according to their weight at 0.75 g-substrate/g-worm/day (Ndegwa et al., 2000).

Vermicomposting was conducted up to 63 days (9 weeks). The growth (and mortality, if any) of earthworm was observed weekly and the data of growth (in terms of quantity and biomass) was recorded for each experimental container. Earthworm biomass and quantity were measured according to Lim et al. (2011). About 100 g of homogenized wet substrates (free from earthworms, hatchlings and cocoons) were collected on the first and final day of vermicomposting for analysis. The samples were oven dried at 60 °C for 48 h, ground in a blender and stored in polythene bags (at 4 °C) before chemical analysis was conducted.

2.3. Vermicompost analysis

pH and electrical conductivity (EC) were measured using digital pH and conductivity meters in 1:10 (w/v, substrate:water extract) aqueous solution (Khwairakpam and Bhargava, 2009a). Total organic carbon (TOC) was determined using partially oxidation method (Walkley and Black, 1934). Total Kjeldahl nitrogen (TKN) was measured using Micro-Kjeldahl method (Shaw and Beadle, 1949). Total calcium, magnesium and potassium were measured by ignition method using atomic absorption spectrophotometer (Adi and Noor, 2009), while the total phosphorus was determined using colorimetric method (John, 1970).

2.4. Statistical analysis

One-way ANOVA was used to analyze the significant difference between treatments. Tukey's HSD test was also performed to identify the homogenous type of treatments for the various parameters. The probability levels used for statistical significance were $P < 0.05$ for the tests. The statistical analysis in this study was conducted using PASW® Statistics 18.

3. Results and discussion

3.1. Growth and reproduction of E. eugeniae in different treatments

Table 2 shows the maximum growth rate and individual weight of *E. eugeniae* in different feeding materials. It is clear that *E. eugeniae* fed with RH amended with any market refused fruits were generally higher than the other treatments done in the past. In this study, the earthworm showed significant difference in growth parameters, i.e. maximum growth rate (mg/worm/day) (ANOVA; $F = 4.955$, $P < 0.05$) and maximum individual weight (mg/worm) (ANOVA; $F = 7.138$, $P < 0.05$). As shown in Table 2, 1P:1RH treatment produced the highest growth rate (48.57 mg/worm/day) whilst RH treatment had the lowest growth rate (9.29 mg/worm/day). Statistically, the maximum growth rate only showed significant difference between 1P:1RH and RH treatments (ANOVA/Tukey's; $P < 0.05$). The maximum individual weight was the highest and lowest for treatment B and RH, respectively. There was significant difference between RH treatment with B, H, 1H:1RH and 1P:1RH treatments only.

Earthworm productivity is an important indicator in vermicomposting process and the difference in growth rate among different treatments seems to be closely related to feed quality (Suthar, 2010). Generally, feedstock with high polyphenolic and lignin contents (such as RH treatment in this study) is not favourable for most of the earthworm species (Ganesh et al., 2009). Also, high polyphenolic and lignin contents inhibit microbial activities and hence slow

Table 1
Initial physico-chemical characteristics of different treatments (mean ± SD, $n = 3$).

Treatment	pH	EC (μS/cm)	Calcium (g/kg)	Potassium (g/kg)	Magnesium (g/kg)	Phosphorous (g/kg)	TOC (g/kg)	TKN (g/kg)
B	7.51 ± 0.15^{a}	274.7 ± 48.4^{ab}	15.30 ± 0.75^{ab}	1.87 ± 0.21^{b}	1.47 ± 0.06^{a}	1.03 ± 0.25^{a}	265.77 ± 12.88^{a}	6.67 ± 0.06^{a}
H	7.46 ± 0.10^{a}	219.7 ± 28.0^{a}	14.33 ± 0.15^{ab}	1.60 ± 0.17^{ab}	1.37 ± 0.06^{a}	0.93 ± 0.06^{a}	232.47 ± 15.50^{a}	6.40 ± 0.10^{a}
P	7.45 ± 0.47^{a}	368.0 ± 83.2^{b}	14.60 ± 0.70^{ab}	1.60 ± 0.17^{ab}	1.30 ± 0.00^{a}	0.97 ± 0.12^{a}	253.77 ± 12.45^{a}	6.23 ± 0.15^{a}
RH	7.62 ± 0.24^{a}	230.3 ± 26.2^{a}	13.30 ± 0.26^{a}	1.40 ± 0.10^{a}	1.33 ± 0.06^{a}	0.83 ± 0.06^{a}	232.07 ± 6.76^{a}	7.60 ± 1.97^{a}
1B:1RH	7.76 ± 0.35^{a}	257.0 ± 15.1^{ab}	15.00 ± 1.05^{b}	1.53 ± 0.12^{ab}	1.53 ± 0.15^{a}	0.93 ± 0.00^{a}	247.57 ± 4.20^{a}	6.53 ± 0.12^{a}
1H:1RH	7.43 ± 0.09^{a}	264.0 ± 14.0^{ab}	14.03 ± 1.23^{ab}	1.53 ± 0.06^{ab}	1.33 ± 0.12^{a}	0.93 ± 0.06^{a}	250.50 ± 12.72^{a}	6.23 ± 0.06^{a}
1P:1RH	7.59 ± 0.22^{a}	253.0 ± 17.6^{a}	13.70 ± 0.28^{a}	1.65 ± 0.21^{ab}	1.40 ± 0.00^{a}	0.90 ± 0.14^{a}	270.45 ± 38.68^{a}	6.85 ± 0.21^{a}

Mean value followed by different letters is statistically different (ANOVA; Tukey's test, $P < 0.05$).