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Potential of Spent Mushroom Substrate in Vermicomposting

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ABSTRACT

The potential of spent mushroom substrate from saw dust in vermicomposting was investigated through the growth and reproduction of earthworms, including the nutrient elements of vermicompost produced at the end of vermicomposting. Five treatments in different ratios of cow dung: spent mushroom substrates were prepared as feed materials with four replicates for each treatment: 80: 20 (T_1), 60: 40 (T_2), 50: 50 (T_3), 40: 60 (T_4) and 20: 80 (T_5). After 3 weeks of pre-composting followed by 7 weeks of vermicomposting, T_4 showed the highest percentage of growth and reproduction where the mean number of earthworms increased (M = 295.00, SD = 17.32, n = 4) as did their weight (M = 28.86, SD = 5.97, n = 4). Furthermore, when a higher ratio of cow dung to spent mushroom was used in substrate T_1, the resulting vermicompost showed highest percentage of macronutrient elements: N (1.90%), P (0.57%), and K (2.74%) compared to other treatments. Overall, spent mushroom substrate can be decomposed through vermicomposting by using *Lumbricus rubellus* with an optimal ratio of cow dung.

Keywords: *Lumbricus rubellus*, macronutrient element, organic material, spent mushroom substrate, vermicompost
Abbreviations: df, degree of freedom; **F**, factorial

INTRODUCTION

Vermicomposting is a suitable alternate technology for conversion of different types of organic wastes (domestic as well as industrial) into value added material, vermicompost (Garg *et al*. 2006). Vermicomposting is the non-thermophilic biodegradation of organic material through the interaction between earthworms and microorganisms, whereby organic material residuals are fragmented rapidly into much finer particles by passing them through a grinding gizzard while maintaining nutrients (Sharma *et al*. 2005). The use of earthworms for waste management, organic matter stabilization, soil detoxification and vermicompost production has been well documented (Kaviraj and Sharma 2003; Loh *et al*. 2005; Suthar 2006).

Spent mushroom substrate is a nutrient-rich organic by product of the mushroom industry where the primary source in mushroom substrates is wood saw dust, cotton waste, straw or corn cobs. Wood saw dust is one of the most common sources which is routinely used for the cultivation of king oyster mushroom, *Pleurotus eryngii* and winter mushroom, *Flammulina velutipes* (Kwak *et al*. 2007).

According to Bae *et al*. (2006), chemical composition (absolute values) of spent mushroom substrates from saw dust was natural detergent fiber 78.2%, acid detergent fiber 60.4%, hemicellulose 17.8%, cellulose 40.4%, lignin 20.0%, non-fibrous carbohydrate 7.8%, crude protein 7.2%, true protein/crude protein 69.4%, non-protein nitrogen/crude protein 30.6%, acid detergent fiber-crude/crude protein 36.4%, ether extract 2.1%, crude ash 4.7%, and dry matter 40.8%.

Equally, from the production of 1 kg of mushroom, 5 kg of spent mushroom substrates will be generated (Semple *et al*. 2001), disposed either by direct open burning or sent to landfills. Due to the possibility of contamination these spent mushroom substrates cannot be reused in any manner and the disposal of different types of wastes has become a very important issue that needs to be addressed in order to maintain a healthy environment (Senapati and Julka 1993). Therefore, these nutrient-rich spent mushroom substrates need to be fully utilized before final disposal.

Accordingly, this study was conducted to assess the potential of spent mushroom substrates in vermicompsting using *L. rubellus* and the quality of vermicompost produced at the end of vermicomposting.

MATERIALS AND METHODS

Pre composting and vermicomposting experiments

The feed materials were obtained from different sources. Cow dung was obtained from a cow farm in Banting, Selangor. The spent mushroom substrates were obtained from local mushroom farmers. The earthworms for the experiments were produced by local earthworm breeder, MIF Sdn. Bhd., Petaling Jaya, Selangor. Five treatments in different ratios of cow dung: spent mushroom substrates were prepared as feed materials with four replicates for each treatment: 80: 20 (T_1), 60: 40 (T_2), 50: 50 (T_3), 40: 60 (T_4) and 20: 80 (T_5). The treatments were conducted in plastic bins of 45 cm × 30 cm × 30 cm in size which fulfill with 5 kg of feed materials.

The experiment started with 3 weeks of pre-composting; where all feed materials were mixed together with water to maintain the moisture content in the range of 60-70% and left it in order to avoid exposure of earthworms to high temperature during the initial thermophilic stage (Nair *et al*. 2006). The experiment *per se* was followed by 7 weeks of vermicomposting. 60 weighed matured earthworms, *Lumbricus rubellus* were introduced in each replicate as adapted from Kaviraj and Sharma (2003) and the moisture content of each replicate was maintained in a 60-70% range by spraying the surface with normal tap water.

After the 10^{th} week, the earthworms were sorted manually from the vermicompost produced. All earthworms were counted and weighed to determine their growth and reproduction rate through the differentiation between final and initial stage. The vermicompost produced at upper layer in the plastic bin was sampled (approximately 500 g) for analysis of nutrient elements before all the earthworms were taken out.

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Table 1 Multiplication of earthworms (weights and numbers) in different treatments.

Treatment	Plot	Weight of earthworms (g)		Earthworms weight gain (g)	Number of earthworms		Earthworms number gain/loss
		Initial	Final		Initial	Final	
T_1	A1	10.42	4.48	-5.94	60	21	-39
	A2	12.47	9.02	- 3.45	60	32	-28
	A3	9.11	21.52	12.41	60	75	15
	A4	9.05	2.48	-6.57	60	10	-50
T_2	B1	8.2	11.17	3.5	60	210	150
	B2	8.23	13.82	5.59	60	220	160
	B3	7.47	13.51	6.04	60	237	177
	B4	8.77	13.38	4.61	60	282	222
T_3	C1	5.50	21.03	15.53	60	400	340
	C2	5.00	40.33	35.33	60	352	292
	C3	6.69	28.77	22.08	60	255	195
	C4	5.51	34.38	28.87	60	299	239
T_4	D1	10.17	30.42	20.25	60	380	320
	D2	7.56	38.03	30.87	60	350	290
	D3	5.81	39.87	34.06	60	340	280
	D4	5.91	36.18	30.27	60	350	290
T_5	E1	4.99	8.77	3.78	60	53	-7
	E2	7.58	6.00	-1.58	60	45	-15
	E3	3.49	10.41	6.92	60	70	10
	E4	3.55	8.13	4.58	60	47	-13

T_1 - Cow dung : Spent mushroom substrate (80:20)
T_2 - Cow dung : Spent mushroom substrate (60:40)
T_3 - Cow dung : Spent mushroom substrate (50:50)
T_4 - Cow dung : Spent mushroom substrate (40:60)
T_5 - Cow dung : Spent mushroom substrate (20:80)

Statistical analysis

Statistical analysis was carried out using SPSS 11.0.1 (Standard Version) computer software package. One-way ANOVA was performed to analyze the significant difference of earthworms' weight and number between treatments during vermicomposting at P = 0.05. Significant differences between initial and final numbers and weights of earthworms in each treatment were determined by a paired sample *t*-test.

Nutrient elements analysis

Organic carbon in vermicompost produced was determined by the partial-oxidation method (Walkley and Black 1934). N was estimated by Kjeldahl digestion with concentrated H_2SO_4 (1:20, w/v) and followed by distillation (Bremner and Mulvaney 1982). P was detected by colorimetric method using ammonium molybdate in hydrochloric acid (John 1970). K was measured by the ignition method using atomic absorption spectrophotometry (Loh *et al.* 2005). Maturities of vermicompost were determined through the calculation of C/N ratio.

RESULTS AND DISCUSSION

The growth and reproduction of earthworms (number and weight) for five different types of treatments is presented in **Table 1**. Generally, all T_2, T_3 and T_4 treatments showed positive results with the increasing number and weight compared to T_1 and T_5. In T_1 and T_5 treatments, reduction of growth and reproduction of earthworm were recorded.

Statistically, the *F* value for the increasing of weight and number of earthworms (**Fig. 1**) are significant where F (df = 4, 15; $p < 0.05$) = 18.545 and F (df = 4, 15; $p < 0.05$) = 72.420. Through the mean of four replicates for all treatments, T_4 stated the highest gain in both, number (M = 295.00, SD = 17.32, n = 4) and weight (M = 28.86, SD = 5.97, n = 4) of earthworms.

In contrast to T_1 where it stated negative mean in both number (M = -25.50, SD = 28.45, n = 4) and weight (M = -0.8875, SD = 8.966, n = 4). The same situation was also recorded by Sangwan *et al.* (2008) after 8^{th} week of vermincomposting that might be due to the exhaustion of earthworm feed in vermicomposters. According to Neuhauser *et al.* (1980), when earthworm (*E. foetida*) received food below a maintenance level, it loose weight at a rate which depended on the quantity and nature of its ingestible substrates.

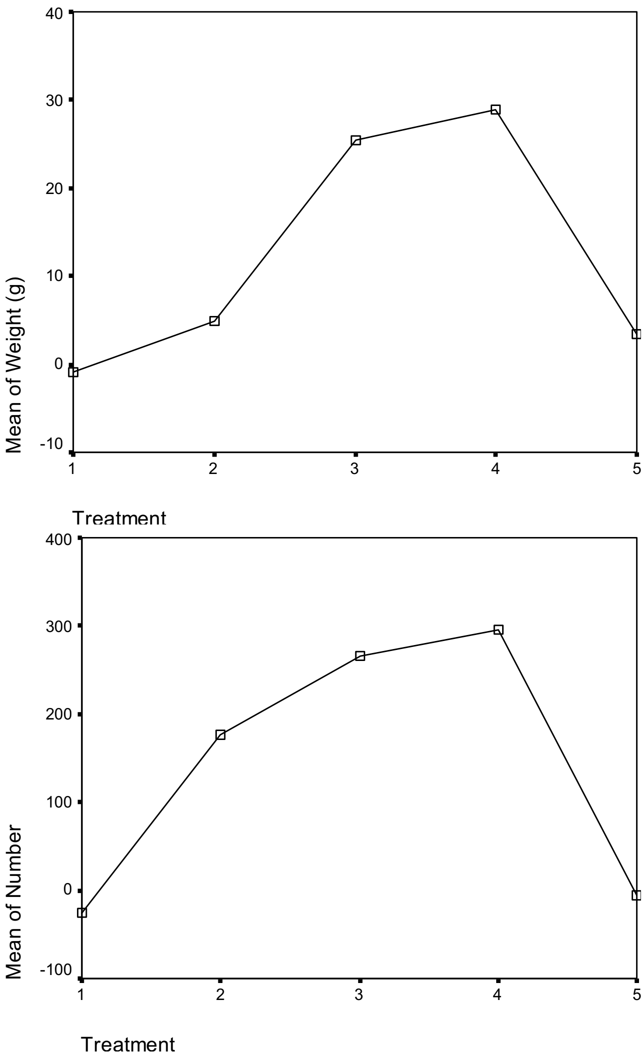

Fig. 1 Mean of earthworms' growth and reproduction (weight and number) in different treatments.

The growth and reproduction could be related to the

Table 2 Nutrient elements in vermicompost from five different types of treatments.

Nutrient elements	Vermicompost				
	T_1	T_2	T_3	T_4	T_5
Organic carbon (%)	16.88	23.51	23.96	19.66	32.14
Nitrogen (as N, in %)	1.90	1.46	1.75	0.94	0.87
Phosphorus (as P, in %)	0.57	0.38	0.46	0.24	0.23
Potassium (as K, in %)	2.74	1.43	1.39	0.67	0.40
C/N ratio	8.9	16.1	13.7	20.9	36.9

T_1 - Cow dung : Spent mushroom substrate (80:20)
T_2 - Cow dung : Spent mushroom substrate (60:40)
T_3 - Cow dung : Spent mushroom substrate (50:50)
T_4 - Cow dung : Spent mushroom substrate (40:60)
T_5 - Cow dung : Spent mushroom substrate (20:80)

biochemical quality of feed materials (Flack and Hartenstein 1984) along with microbial biomass and decomposition activities (Suthar 2006). Supported by Edwards (1988), who stated that, feeds which provide earthworms with sufficient amount of easily metabolizable organic matter and non-assimilated carbohydrates favor the growth and reproduction of the earthworms. The high N content in cow dung directly increases earthworm biomass and reproduction performance (Loh *et al*. 2005). Besides that, it increases the rate of decomposition which leads the vermicomposting to stop at early week. Scarcity of feed materials, cease the earthworms to be alive which directly decreased the number and weight of earthworms.

The differences between initial and final numbers and weights of earthworms (*L. rubellus*) are significant ($p < 0.05$) in T_2, T_3 and T_4.

The nutrient elements in vermicompost from five different types of treatments are presented in **Table 2**. The higher ratio of cow dung compared to spent mushroom substrate in T_1, resulted a better quality of vermicompost compared to other treatments.

According to Hand *et al*. (1998), the use of cow dung increases the nitrate-nitrogen content in vermicompost and initial N present in feed materials directly influence the N content in vermicompost (Loh *et al*. 2005; Suthar 2006). In addition, the extents of N fixed by free living nitrogen-fixing bacteria also contribute significant influence to the N content in vermicompost (Kale *et al*. 1982).

With low percentage of organic carbon compared to high percentage of N, leads to lower C/N ratio in vermincompost of T_1. Therefore, T_1 produced an acceptable maturity compared to other treatments. For T_4 and T_5, vermicompost produced from other treatments is also preferable when their maturity degree of compost are below than 20 (Morais and Queda 2003). According to Pramanik *et al*. (2007), the increase in the earthworms' population leads to rapid decrease in C, CO_2 and water loss through evaporation during mineralization due to enhanced oxidation of the organic matter. This contradicts with T_1 where result showed that with the decrease of earthworms' population, resulted low percentage of organic carbon compared to other treatments. This could be contributed by the extent of decomposition through composting accelerated by microorganisms which are high in the cow dung itself (Gaur and Singh 1995).

For P and K, T_1 stated the highest percentage compared among to other treatments. According to Garg *et al*. (2006), P and K increased significantly in all substrates with earthworm inoculated waste than in control; treatments without earthworms. In addition, the increase of P and K also contributed by bacterial and faecal phosphate activity of earthworms which probably lead towards mineralization and mobilization of phosphorous (Edwards and Lofty 1972).

CONCLUSION

Spent mushroom substrate can be decomposed through vermicomposting by using *Lumbricus rubellus*. Growth and reproduction of earthworms were optimum at 40: 60 ratio of cow dung: spent mushroom substrate (T_4).

On the other hand, T_1 produced a better quality of vermicompost when it showed highest percentage of macronutrient elements; N (1.90%), P (0.57%), and K (2.74%) compared to other treatments.

The results demonstrated the suitability of saw dust based spent mushroom substrate from sawdust based to be used for vermicomposting. When used in certain ratio, spent mushrooms have shown to accelerate the mineralization of nutrients and have also proved to be a better feed material for vermiculture. Thus, the generation of organic waste from the agriculture sector indirectly can be reduced or eliminated especially in mushroom cultivation sectors.

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