The Management of Organic Wastes Produced Vermicompost Using Earthworm *Eudrilus eugeniae* and Effects of Vermicompost on Growth of *Helianthus annuus*

Pitchya Tangsombatvichit, Sakuntep Chupong, Daojarus Ketrot and Kitti Boonlerthirun

***Abstract*—Vermicomposting is a tool for environmentally sound organic waste management. This biological organic waste decomposition process yields vermicompost, a biofertilizer. The use of earthworms in vermicompost processes is a good method for organic wastes reduction. Thus, the aim of this study was to investigate organic wastes (cow manure, sawdust, rice straws, eggshells, paper wastes, and mushroom spawns) mixed with fruit pomaces from fermented milk industry or fruit peels from fresh markets in vermicomposting. The thermo-tolerant earthworms, *Eudrilus eugeniae*, were used in this study. This is the first time, we used fruit pomaces from fermented milk industry for vermicomposting production. After the vermicompost process, the physio-chemical characteristics of vermicompost fertilizers from organic wastes mixed with fruit pomaces or fruit peels exhibited higher values of organic fertilizer quality including moisture, pH, electrical conductivity, germination index, total nitrogen, total potassium and total phosphorus than standard organic fertilizer. The vermicomposts supported sunflower plant growth better than commercial organic fertilizer or no added fertilizer. Therefore, organic wastes vermicompost can promote sustainable agriculture and a good method of waste management as biofertilizer.**

***Keywords*—biofertilizer, earthworm *Eudrilus eugeniae*, organic and industrial wastes, vermicomposting**

I. Introduction

At present, high organic solid wastes accumulation from households, markets and food industries has become a serious problem due to increasing population and industrialization. Some developing countries reduce organic waste decomposition in open dumping, which causes landfill gas pollution. The main greenhouse gases are methane and carbon dioxide. Also, the elimination of organic wastes causes water pollution or soil contamination. Industrial wastes remain highly untreated and cause environmental problems and pollution, so they have become an important topic for environmental protection. Thailand is an agricultural country with many agricultural wastes. The components of organic wastes are more than 40% [1]. Composting is one method for organic waste reduction. The final product is organic fertilizer for plant growth. Vermicomposting converts organic matter or industrial wastes by earthworms into vermicompost [2]. The organic matter nutrients are composed of more bioavailable forms. Vermicompost is also believed to contain plant nutrient elements, enzymes, hormones and stimulated microbial activities, which high essential elements of plant growth and reduce plant pathogens [3], [4]. The earthworm, *Eudrilus eugeniae*, is common in Thailand and is often referred to as an African night crawler because they originated from West Africa [5]. They live on the surface of moist soil (epigenic), especially cow dung and are also found in other organic matter. These large reddish-brown earthworms have a high reproductive rate, grow extremely rapidly and under optimum conditions and can also be used as animal feed for protein [5], [6]. In Thailand, tomato wastes, grasses or tomato wastes and grasses mixed with *Eudrilus eugeniae* have been used for vermicomposting. Higher N, P and K levels were observed than the control (no added *Eudrilus eugeniae*) and higher plant macronutrient levels were also observed than standard organic fertilizers [7]. In Vietnam, vermicomposting of water hyacinth mixed with pig manure was done by composting Vietnam's tropical earthworm *Perionyx excauvatus*. 25% of water hyacinth mixed with 75% of pig manure enhanced seed germination of *Oryza* sp. and increased N, P, K, Ca and Mg levels for plant growth [8].

In this experiment, we utilized vermicomposting technology for organic wastes reduction. The organic wastes such as cow dung, sawdust, rice straws, eggshells, paper wastes, mushroom spawns, fruit pomaces and fruit peels were converted to bioavailable forms in vermicompost production using *Eudrilus eugeniae*. After vermicomposting, the organic fertilizer was investigated using standard methods including percentage of moisture content, pH value, electrical conductivity (EC), germination index (GI), organic matter (OM), total nitrogen (N), total phosphorus (P) and total potassium (K). For each vermicomposting fertilizer, we tested sunflower *Helianthus annuus* growth rate compared with a commercial organic fertilizer and no fertilizer.

Manuscript received Oct. 5, 2016.

Chupong, S. is a student in Division of Plant Science, Faculty of Agricultural Technology and Agro-Industry Rajamangala University of Technology Suvarnabhumi, Pranakorn Si Ayutthaya 13000, THAILAND

Tangsombatvichit, P. is with the Division of Biology, Faculty of Science and Technology, Rajamangala University of Technology Suvarnabhumi, Pranakorn Si Ayutthaya 13000, THAILAND.

Ketrot, D. is with the Department of Soil Science, Faculty of Agriculture Kasetsart University, Bangkok 10900, THAILAND.

Boonlerthirun, K. is with Division of Plant Science, Faculty of Agricultural Technology and Agro-Industry Rajamangala University of Technology Suvarnabhumi, Pranakorn Si Ayutthaya 13000, THAILAND.

II. Materials and Methods

A. Bedding wastes and Earthworm

Earthworms (*Eudrilus eugeniae*) were provided by farmers in Ayutthaya province, Thailand (Fig. 1). The selected earthworms were similar in both size and maturity. The organic wastes in this experiment were fresh dairy cow dung (from Animal Science Division, RMUTSB, Thailand), sawdust, rice straws, eggshells (from a market in Ayutthaya province, Thailand), paper wastes, mushroom spawns, fruit pomaces (from fermented milk industry in Ayutthaya province, Thailand) and fruit peels including watermelon, papaya, mango and dragon fruit (from a market in Ayutthaya province, Thailand).

Fig. 1 *Eudrilus eugeniae* earthworms from farmers in Ayutthaya

B. Experimental design

Each vermicomposting experiment was performed in 24.8 cm x 33.3 cm x 14.8 cm (width x length x depth) plastic boxes. Ten small holes were drilled into the top and bottom of each box for draining and humidity control. Each container contained 2 kg of organic waste mixtures. After pre-composting, 100 g of earthworms (*Eudrilus eugeniae*) were cultured in each organic mixtures showed in Table 1. The humidity in each box was controlled at 50% using water, and avoiding sunlight and predators. All treatments were designed by Completely Random Design (CRD) with 3 replicates. The experiment was continued up to 6 weeks.

TABLE 1: THE BEDDING COMPOSITION OF DIFFERENT VERMICOMPOSTING TREATMENTS ARE GIVEN BELOW:

Treatment	Bedding composition ratio for vermicomposting
Treatment I	cow manure: sawdust: rice straws: eggshells: paper wastes: mushroom spawns: fruit pomaces (1: 1: 1: 1: 1: 1: 3)
Treatment II	cow manure: sawdust: rice straws: eggshells: paper wastes: mushroom spawns: fruit peels (1: 1: 1: 1: 1: 1: 3)

C. Physio-chemical analysis

After 6 weeks of vermicomposting, the earthworms were removed from the samples. Each vermicomposting box was homogenously mixed and then analyzed for moisture content using the hot air oven-drying method [9]. The pH value was determined using a pH meter. The electrical conductivity (EC) was measured using an EC meter. The germination index (GI) was observed with growth rate of mung bean seed with vermicompost suspension and compared with distilled water (control) for 72 hours [10]. The organic matter (OM) was determined using the sulfuric acid and chromic acid titration method [11]. Total nitrogen (N) was analyzed by the Kjeldahl method [12]. Total phosphorus (P) was analyzed by the Spectrophotometric molybdovanadophosphate method [12]. Total potassium (K) was analyzed by the Flame photometric method [12].

D. Vermicomposting quality test

The vermicompost quality was investigated with sunflower growth rate (*Helianthus annuus*). The experiment has 4 conditions: (1) no fertilizer (2) commercial organic fertilizer as the organic fertilizer qualify passed for standard organic fertilizer (3) vermicompost treatment I (4) vermicompost treatment II. The sunflower seeds were grown in 12 inch pots with soil. Each condition contained 50 grams per pot. All treatments were designed by Completely Random Design (CRD) with 3 replicates. Sunflower growth rate was measured by sunflower height (30 and 55 days) and number of leaves (30 and 55 days).

E. Statistical analysis

The growth rates of sunflower data were analyzed statistically by one-way ANOVA. Statistical analyses were performed using SPSS 23.0 by SPSS Inc. The level of significance was set to $P < 0.05$.

III. Results And Discussion

Physio-chemical analysis of vermicomposting

After 6 weeks of vermicomposting, the moisture content, pH, EC, GI, OM, total N, total P and total K of each vermicompost were investigated. The results indicated that the percentage of moisture of mixed organic wastes in treatment I and treatment II were 22.19 $\pm$ 4.05 and 26.39 $\pm$ 5.57, respectively (Table 2). Each of moisture of vermicompost is lower standard organic fertilizer, which was the standard organic fertilizer range (Table 2) [13]. The average pH of treatment I and treatment II were 7.9 $\pm$ 0.2 and 8.3 $\pm$ 0.0, respectively. The pH range of the conditions was 7.9-8.3, which was the standard organic fertilizer range for plant nutrients released in soil [7], [13], [14]. The result of the average EC of treatment I and treatment II were 1.80 $\pm$ 0.06 dS/m and 1.85 $\pm$ 0.04 dS/m, respectively which was the standard organic fertilizer range [13]. According to, Reference [15] presented the vermicompost of kitchen waste, agro-residues, or industrial wastes showed EC value similar to our results. EC measurement explains the salinity of the organic amendment. The ammonium and precipitation of dissolved salt can be production in chemical fertilizer but vermicomposts lead to less soluble salts and good cation exchange capacity [16]. Data revealed that the GI percentage of treatment I and treatment II were 97.42 $\pm$ 2.82 and 99.21 $\pm$ 5.33, respectively. The mung bean seed showed high quality grows on vermicomposting in both conditions. The high quality of seed growth may cause plant growth hormones or plant nutrients are present in vermicompost results (Table 2) [4]. For organic matter, the OM percentage of treatment I and treatment II were 23 $\pm$ 1.1 and 31 $\pm$ 1.1, respectively. All results showed values in the standard organic

fertilizer range in Table 2 [13].

TABLE 2 PHYSIO-CHEMICAL RESULTS OF THE FINAL MIXTURE AFTER 6 WEEKS OF VERMICOMPOSTING FOR DIFFERENT CONDITIONS (IN TRIPLICATE).

Physio-chemical characteristics	Vermicompost treatment I	Vermicompost treatment II	Standard*
Moisture (%)	22.19 ± 4.05	26.39 ± 5.57	≤ 30
Hydrogen ions (pH)	7.9 ± 0.2	8.3 ± 0.0	5.5-8.5
Electrical conductivity (EC dS/m)	1.80 ± 0.06	1.85 ± 0.04	≤ 10
Germination Index (% GI)	97.42 ± 2.82	99.21 ± 5.33	> 80
Organic matter (% OM)	23 ± 1.1	31 ± 1.1	≥ 20
Total Nitrogen (% N)	1.7 ± 0.1	1.6 ± 0.1	> 1.0
Total Phosphorus (% P)	1.7 ± 0.3	1.0 ± 0.0	> 0.5
Total Potassium (% K)	1.9 ± 0.2	2.2 ± 0.0	> 0.5

Mean ± standard deviation, n=9
*Standard Organic Fertilizer [13]

Interestingly, the major elements of plant such as nitrogen, phosphorus and potassium in treatment I and treatment II were higher than standard the organic fertilizer (Table 2). As results suggest, there was a similar trend in wastes mixtures in fruit pomaces and fruit peels vermicompost. Levels of N, P and K increased in vermicompost with fruit pomaces from fermented milk industry and fruit peels from fresh market. Similarly, the vermicomposts showed higher levels of N, P and K than the control (no added *Eudrilus eugeniae*) and gave higher macronutrients than the standard organic fertilizer [7], [15]. Vermicomposting of water hyacinth mixed with pig manure was done by composting Vietnam's tropical earthworm *Perionyx excauvatus*. 25% of water hyacinth mixed with 75% of pig manure enhanced seed germination of *Oryza* sp. and increased N, P, K, Ca and Mg levels for plant growth [8]. The compostable municipal waste solids spiked with cow dung was done using *Eisenia foetida*, and organic carbon, C:N ratio, total N, P, K and trace elements-Ca, Fe, Mn and Zn increased [17].

Vermicomposting quality test for economic plant

After 30 days of cultivation, the sunflower growth rate, in terms of the number of leaves and plant height, in commercial organic fertilizer, treatment I and treatment II vermicomposting was significantly higher than no fertilizer (Table 3, 4). The quality of vermicompost treatment II and treatment I showed that sunflower grew better than commercial organic fertilizer. According to earthworm's gut was identified microbial varieties enhance plant nutrient activated in soil [18]. The stem color and flower of each sunflower was the same in all conditions. However after 55 days of cultivation, the sunflower growth rate in treatment II (fruit peels) vermicomposting was significantly higher than treatment I (Table 3, 4). Causing the result showed the OM value of vermicompost II was higher than vermicompost I (Table 2). Perhap the microbial numbers and their extracellular enzymes were more abundant in vermicompost produced from fruit peels, vegetable wastes and cow dung than the compost which activated plant growth [19]. While, commercial organic fertilizer, treatment I and treatment II vermicomposting also showed significantly higher growth rate than no fertilizer (Table 3, 4). Also, interference from diseases were not found. Soil supplemented with vermicompost revealed better plant growth compared with soil composed with inorganic fertilizers [20]. The vermicompost fertilizer can be used with many plants such as rice, legume, tomato, strawberry, Chinese cabbage and zinnia [7], [21-24].

TABLE 3 AVERAGE NUMBER OF LEAVES OF SUNFLOWERS (*HELIANTHUS ANNUUS*) AFTER DIFFERENT VERMICOMPOSTING TREATMENTS AT 30 AND 55 DAYS OF CULTIVATION.

Treatment	Number of leaves (n = 9)	
	30 days	55 days
No fertilizer	15.9 ± 1.4[a]	25.8 ± 1.3[a]
Commercial organic fertilizer	18.6 ± 1.1[b]	30.3 ± 0.7[b]
Vermicompost Tm1	18.0 ± 0.3[b]	31.1 ± 1.5[b]
Vermicompost Tm2	20.3 ± 2.2[c]	32.6 ± 1.0[c]

TABLE 4 AVERAGE OF HEIGHT OF SUNFLOWERS (*HELIANTHUS ANNUUS*) AFTER DIFFERENT VERMICOMPOSTING TREATMENTS AT 30 AND 55 DAYS OF CULTIVATION.

Treatment	Height (cm.) (n = 9)	
	30 days	55 days
No fertilizer	56.7 ± 7.6[a]	123.0 ± 6.8[a]
Commercial organic fertilizer	69.9 ± 1.4[b]	138.4 ± 1.0[b]
Vermicompost Tm1	62.6 ± 3.9[a]	135.8 ± 7.0[b]
Vermicompost Tm2	71.3 ± 5.6[b]	147.6 ± 1.6[c]

IV. Conclusion

Our vermicompost analysis of organic and industrial wastes mixed using earthworm *Eudrilus eugeniae* for produced vermicomposting provides the better quality of vermicompost compared with standard organic fertilizer. This is the first time, we used fruit pomaces from fermented milk industry produced vermicomposting. Here, we found that the our vermicompost can utilize for sunflower *Helianthus annuus* growth Thus, our perspective in this knowledge will be bring to management of fruit pomaces and fruit peel wastes mixed for potentially useful raw material in vermicompost production as biofertilizer use for large scale of organic plants.

Acknowledgment

We would like to thanks Assoc.Prof. Dr. K. Rattanakhanokchai for funding, advice and support. We also thanks P. Ketbot for kind support, and S. Noknark for her invaluable suggestions about vermiculture. Also, we special thanks are extended to Faculty of Science and Technology and Faculty of Agricultural Technology and Agro-Industry, Rajamangala University of Technology Suvarnabhumi for laboratory testing equipment support.

References

[1] T. Chinda, N. Leewattana, and N. Leeamnuayjaroen, "The study of landfill situations in Thaland" *1st Mae Fah Luang University International Conference*, pp. 1-8, Thailand, 2012

[2] A. Yadav, and V.K. Garg, "Industrial wastes and sludges management by vermicomposting," *Rev. Environ. Sci. Biotechnol*, vol. 10, pp. 243-276, Sept. 2011. https://doi.org/10.1007/s11157-011-9242-y

[3] S. Gajalakshmi, and S.A. Abbasi, "Earthworms and vermicomposting," *Indian J. of Biotechnology*, vol.3, pp. 486-494, Oct. 2004.

[4] J. Pathma, and N. Sakthivel, "Microbial diversity of vermicompost bacteria that exhibit useful agricultural traits and waste management potential," *SpringerPlus*, vol. 26, pp. 1-19, Oct. 2012. https://doi.org/10.1186/2193-1801-1-26

[5] J. Dominguez, C.A. Edwards, and J. Ashby, "The biology and ecology of *Eudrilus eugeniae* (Kinberg) (Oligochaeta) bred in cattle wastes," *Pedobiologia*, vol. 45, pp. 341-353, Jan. 2001. https://doi.org/10.1078/0031-4056-00091

[6] B. Sivasankari, S. Indumathi, and M. Anandharaj, "A study on life cycle of earth worm *Eudrilus eugeniae*," *Inter. J. Res. Pharm. Life Sci*, vol 1, pp. 64-67, 2014.

[7] S. Klongkongsub, and P. Sohsalam, "Vermicompost production by using tomato residues and yard waste," *J. Med. Bioengineering*, vol. 2, pp. 270-273, Dec. 2013. https://doi.org/10.12720/jomb.2.4.270-273

[8] L. Zirbes, Q. Renard, J. Dufey, P.K. Tu, H.N. Duyet, P. Lebailly, F. Francis, and E. Haubruge, "Valorisation of a water hyacinth in vermicomposting using an epigenic earthworm Perionyx excavates in central Vietnam," *Biotechnol. Agron. Soc. Environ*., vol. 15, pp. 85-93, Aug. 2011.

[9] *International Fertilizer Industry Association (IFA)*, Determination of moisture of fertilizers. France 2014.

[10] S. Meunchang, S. Panichsakpatana, and R.W. Weaver, "Co-composting of filter cake and bagasse; by-products from a sugar mill," *Bioresour. Technol*., vol. 96 pp. 437-442, Mar 2005. https://doi.org/10.1016/j.biortech.2004.05.024

[11] A. Walkley, and I.A. Black, "An examination of the Degtjareff method for determining soil organic matter, and a proposed modification of the chromic acid titration method," *Soil Sci*., vol. 37, pp. 29-38, Jan. 1934. https://doi.org/10.1097/00010694-193401000-00003

[12] *Food and Agricultural Materials Inspection Center (FAMIC)*, Testing methods for fertilizers. Incorporated Administrative Agency, Japan 2013.

[13] J. Prasitket, N. Chuvorrivate, M. Ruengnab, T. Padung, P. Choulvanapong, and S. Reanjareang, "*Organic fertilizer: Production, utilization and quality*," Department of Agriculture, 2005, pp.87.

[14] N.O.K Mainoo, S. Barrington, J.K. Whalen, and L. Sampedro, "Pilot-scale vermicomposting of pineapple wastes with earthworms native to Accra, Ghana," *Bioresour. Technol*., vol. 100, pp. 5872-5875, Dec. 2009. https://doi.org/10.1016/j.biortech.2009.06.058

[15] P. Garg, A. Gupta, and S. Satya, "Vermicomposting of different types of waste using Eisenia foetida: A comparative study," *Bioresour. Technol*., vol. 97, pp. 391-395, Feb. 2006. https://doi.org/10.1016/j.biortech.2005.03.009

[16] E. Albanell, J. Plaixats, and T. Cabrero, "Chemical changes during vermicomposting (Eisenia foetida) of sheep manure mixed with cotton industrial wastes," *Biology Fertilizer Soils*, vol. 6, pp. 266-269, May 1988. https://doi.org/10.1007/BF00260823

[17] S. Suthar, K. Kumar, and P.K. Mutiyar, "Nutrient recovery from compostable fractions of municipal solid wastes using vermitechnology,". *J. Mater. Cycles. Waste Manage*. 17: 174-184, Jan. 2015. https://doi.org/10.1007/s10163-014-0238-x

[18] R.K. Sinha, S. Agarwal, K. Chauhan, and D. Valani, "The wonders of earthworms and its vermicompost in farm production: Charles Darwin's 'friends of farmers', with potential to replace destructive chemical fertilizers from agriculture," *Agricultural Sciences*, vol. 1, pp. 76-94, Aug. 2010. https://doi.org/10.4236/as.2010.12011

[19] S.H. Devi, K. Vijayalakshmi, K.P. Jyotsna, S.K. Shaheen, K. Jyothi, and M.S. Rani, "Comparative assessment in enzyme activities and microbial populations during normal and vermicomposting," *J. Environ. Biol.*, vol. 30, pp. 1013-1017, Nov. 2009.

[20] S. Subler, C.A. Edwards, and P.J. Metzger, "Comparing vermicomposts and composts. *Biocycle*, vol. 39, pp. 63-66, 1998.

[21] R. Bejbaruah, R.C. Sharma, and P. Banik, "Split application of vermicompost to rice (*Oryza sativa* L.): its effect on productivity, yield components, and N dynamics," *Organic Agri*., vol. 3, pp. 123-128, June 2013. https://doi.org/10.1007/s13165-013-0049-8

[22] F.A. Gutierrez-Miceli, L. Santiago-Borraz, J.A.M. Molina, C. Nafate, M. Abud-Archila, M.A.O. Llaven, R. Rincon-Rosales, and L. Dendooven, "Vermicompost as a soil supplement to improve growth, yield and fruit quality of tomato (*Lycopersicum esculentum*)," *Bioresour. Technol*., vol. 98, pp. 2781-2786, Nov. 2007. https://doi.org/10.1016/j.biortech.2006.02.032

[23] A. Jeyabal, and G. Kuppuswamy, "Recyling of organic wastes for the production of vermicompost and its response in rice-legume cropping system and soil fertility," *European J. Agron*., vol. 15, pp. 153-170, Nov. 2001. https://doi.org/10.1016/S1161-0301(00)00100-3

[24] R. Singh, R.R. Sharma, S. Kumar, R.K. Gupta, and R.T. Patil, "Vermicompost substitution influences growth, physiological disorders, fruit yield and quality of strawberry (Fragaria x ananassa Duch.)," *Bioresour. Technol*., vol. 99, pp. 8507-8511, Nov. 2008. https://doi.org/10.1016/j.biortech.2008.03.034

Sakuntep Chupong is a undergraduate student at Division of Plant Science, Faculty of Science and Technology, Faculty of Agricultural Technology and Agro-Industry, Rajamangala University of Technology Suvarnabhumi, Phranakorn Sri Ayutthaya. His current interests include management of organic, agricultural and industry wastes via vermicomposting technology, plant and agro biotechnology.

Kitti Boonlertnirun received the B.Sc. (1988), M.Sc. (1992) in Horticulture and Ph.D. (2013) in Plant Breeding from Kasetsart University.

He is an Associate Professor at Division of Plant Science, Faculty of Agricultural Technology and Agro-industry, Rajamangala University of Technology Suvarnabhumi, Phranakorn Sri Ayutthaya. His current interests include vegetables production technology and plant breeding, especially waxy corn breeding.

Pitchya Tangsombatvichit received the B.S. (2006) in Agricultural Science (Second Class Honours) from Kasetsart University, M.S. (2008) in Applied Radiation and Isotopes from Kasetsart University and Ph.D. (2014) in Biochemical Technology from King Mongkut's University of Technology Thonburi (KMUTT).

She is now a Lecturer at Division of Biology, Faculty of Science and Technology, Rajamangala University of Technology Suvarnabhumi. Her current interests include management of organic, agricultural and industry wastes via vermicomposting technology, yeast and molecular technology, alternative energy technology, and applied radiation technology.

Daojarus Ketrot received the B.S. (2007) in Agricultural Chemistry (First Class Honours) and Ph.D. (2013) in Soil Science from Kasetsart University.

She is now a Lecturer at Department of Soil Science, Faculty of Agriculture, Kasetsart University. Her current interests include soil pollution, soil chemistry, and soil and plant analysis.