

# VERMICOMPOSTING DIFFERENT ORGANIC WASTES TO DETERMINE SUITABILITY FOR USE IN ORGANIC FARMING

Pornpailin Boonna<sup>1</sup>, \*Nipapun Kungskulniti<sup>1,2</sup>, Rochana Tangkoonboribun<sup>3</sup>, Naowarut Charoenca<sup>1,2</sup>

<sup>1</sup>Faculty of Public Health, Mahidol University, Thailand ; <sup>2</sup>Center of Excellence on Environmental Health and Toxicology, Thailand; <sup>3</sup>Thailand Institute of Scientific and Technological Research, Thailand

\*Corresponding Author, Received: 16 June 2019, Revised: 20 Nov. 2019, Accepted: 10 Feb. 2020

**ABSTRACT:** This research studied the quality of compost developed with three base organic wastes: water hyacinth scraps, food wastes, and corncobs using earthworms to enhance the process (vermicompost). One kilogram of local Thai earthworms, *Pheretima peguana*, were introduced into wastes of three different organic-based materials (either water hyacinth scraps, food wastes, or corncobs) in a vermibin chamber with a constant ratio of rice bran and cow dung. Each organic waste was tested at a high, medium or low ratio by weight with rice bran, and cow dung. These materials were vermicomposted for 45 days. Physico-chemical parameters and phytotoxicity assessed by germination index of the compost were analyzed on the final day of composting. Values of pH, electrical conductivity, moisture content, total nitrogen, phosphorus, potassium, organic carbon, and C/N ratio and germination index were determined. The vermicompost from all ratios of water hyacinth scraps and food wastes with rice bran and cow dung had acceptable nutrient levels (nitrogen, phosphorus, and potassium) as specified by the Thai agricultural standards, National Committee on Agricultural Commodity and Food Standards, Ministry of Agriculture and Cooperative. Results suggest that these organic wastes are suitable for large scale vermicomposting to produce a nutrient-rich fertilizer for organic farming.

*Keywords: Vermicompost, earthworms, Water hyacinths, Food wastes, Corncobs*

## 1. INTRODUCTION

Agricultural production in Thailand increasingly depends on fertilizer for high crop production. Although chemical fertilizers are increasing, the organic farming sector which is projected to increase to 0.6 million rai by 2021 looks to organic compost fertilizers more and more [1]. While there is a need for more organic compost as fertilizer, large quantities of organic wastes are available for compost but unused. For example, large volumes of water hyacinth wastes are cleared from canals where they generate a major disposal problem. In 2015, there was an estimated 4.52 million tons of water hyacinths in Thailand [2]. According to the FAO, these plants are suitable as a compost or inorganic fertilizer since large quantities of inorganic nitrogen and phosphorus accumulate in their roots [3]. Water hyacinths are free-floating aquatic macrophytes rich in organic micronutrients which must be harvested and disposed of since they block canal waterways. Corncobs are another abundant organic waste available after the harvest season. In 2013, the annual waste production from corncobs and stalks was approximately 9 million tons/year from the North and Northeast of Thailand [4]. Composting corncobs takes a longer time than leafy material like cornhusks. Food wastes are also an abundant source of organic material, but are often more difficult to collect, separate and transport from the waste stream.

Vermicomposting is a suitable biological process for disposing of organic wastes involving interactions between earthworms and microorganisms [5]. The role of earthworms is to convert different types of organic wastes into nutrient-rich manure [6]. Mutual action of earthworms and microorganisms change the biological, physical and chemical properties of waste materials and convert them into vermicompost. Research shows that use of earthworms can compost organic wastes faster than common composting. Hence, farmers can reduce the use of chemical fertilizer, which leads to environmental, and health hazards. Earthworms, *Pheretima peguana*, have unique capabilities to disintegrate organic wastes. They produce vermicompost with vermicast, homogeneous, odor-free, peat-like material containing significant quantities of nutrients with a low level of toxicants [7]. Vermicomposting is a suitable technique due to its simplicity, cost-effectiveness and can be used for all types of non-toxic biodegradable wastes. Municipal solid wastes are mostly composed of organic wastes with the highest ratio of around 64% for food wastes. Composting technology has gained interest for large-scale practice and disposal of a wide variety of organic wastes; hence, vermicomposting could be a useful means of handling and treating these organic wastes.

The aim of this study is to investigate the application of organic wastes such as food wastes,

corncoobs, and water hyacinth scraps as a base material for vermicomposting. The quality of vermicompost derived in this study was determined according to the Thai agricultural standard, National Committee on Agricultural Commodity and Food Standards, Ministry of Agriculture and Cooperative [8].

## 2. MATERIALS AND METHODS

### 2.1 Collection of Waste Materials and Earthworms

Food wastes were collected from the municipal landfill at Tandeaw subdistrict, Kaengkhoi district, Saraburi province. Water hyacinth scraps were collected from a local canal. Corncoobs were collected from local cornfields. Rice bran was collected from the local rice mill. Cow dung was collected from a dairy farm in Saraburi province. Earthworms, *Pheretima peguana*, were obtained from a local vendor in Mae-on, Chiangmai province using cow dung as culture medium.

### 2.2 Feedstock Materials Collection and Preparation

Water hyacinth scraps and corncoobs were chopped into small pieces before use. Nine sets of treatment were conducted with different ratios of three different organic base materials (water hyacinths or food wastes or corncoobs) on layers of rice bran and cow dung in a constant ratio as shown in Table 1. The base materials used in treatments T1-T3 was water hyacinths, T4-T6 food wastes, and T7-T9 corncoobs.

A cement vermibin with dimensions of 80 cm (diameter) and 40 cm (depth) was used for carrying out the process of vermicomposting. A piece of net fabric was used to cover the top of the vermibin to prevent animals and insects from entering the bin. In the vermibin, six separate layers of media were arranged using rice bran and cow dung mixed with soil as illustrated in Figure 1. One kilogram of local Thai earthworms, *Pheretima peguana*, were introduced on the top of Layer 6, then base material was placed on the top. Earthworms are endogenic species living and feeding on soil. All materials in the vermibin were the nutrients for earthworms as well. They make horizontal burrows through the soil. Mixing nitrogenous biomass such as rice bran is commonly used as bulking agent during base material composting. The process period of vermicomposting was 45 days with moisture content monitored periodically and maintained at 60-70% by sprinkling water manually.

Table 1 Combination of organic waste materials in vermicomposting

Treatment	Materials Ratio by Weight (OW:RB:CD)
T1	7:4:3
T2	6:4:3
T3	5:4:3
T4	7:4:3
T5	6:4:3
T6	5:4:3
T7	7:4:3
T8	6:4:3
T9	5:4:3

Note: OW = Organic waste base materials for earthworms; T1-T3 Water hyacinth scraps

T4-T6 Food wastes

T7-T9 Corncoobs

RB = Rice bran

CD = Cow dung

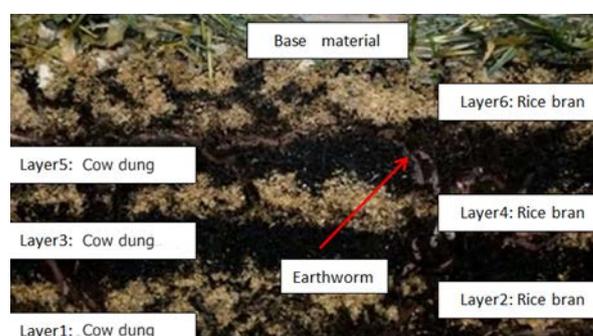


Fig. 1 Illustration of different material layers for vermicomposting in the vermibin

### 2.3 Analysis of Vermicompost Characteristics

Various parameters measured as physico-chemical characteristics of the vermicompost included pH, electrical conductivity (EC), organic carbon (OC), organic matter (OM), C/N ratio, total nitrogen (TN), total potassium (K), total phosphorus (P), and Germination Index (%). A grab sample of 500 grams was collected by hand from 6 different points on the vermicompost surface for the analysis of all parameters [9]. The upper layer produced in the vermibin was analyzed for nutrient elements because the upper layer is changed to vermicast [10]. The pH was determined using a pH meter (AOAC973.04). EC was determined using a Conductivity Meter (BS EN 13038). Organic matter was determined by the Wet Oxidation method. Organic carbon was calculated by multiplying 1.72 to the value of organic matter per standard practice. The C/N ratio was obtained from dividing the value of organic carbon by total nitrogen. Total nitrogen was measured by the Kjeldahl method; and colorimetric measurement was done by spectrophotometer. Potassium was detected by

colorimetric method using ammonium molybdate in HCl. Phosphorus was determined by spectrophotometer. Germination index (GI) was tested using mung beans mixed with distilled water at the ratio of 1:10 (vermicompost to distilled water). The percentage germination index (GI) was calculated using the following formula:

$$GI = \frac{\% \text{ seed germination of compost} \times \% \text{ root growth of compost}}{\% \text{ seed germination of control} \times \% \text{ root growth of control}} \times 100$$

### 3. RESULTS

Characteristics of organic waste materials used for vermicomposting are shown in Table 2 and Table 3. These organic waste materials were found to have sufficient nutrients for producing vermicompost.

Table 2 The characteristics of base materials used for vermicomposting

Para meter	Mean value (Standard deviation)		
	WH	FW	CC
pH	7.70	5.80	7.30
Moisture content (%)	96.18 (0.45)	92.74 (0.2)	4.75 (0.52)
OC (%)	42.75 (0.33)	28.54 (0.1)	19.32 (0.34)
OM (%)	73.70 (0.5)	49.20 (0.95)	33.31 (0.17)
TN (%)	0.72 (0.09)	0.88 (0.17)	0.93 (0.00)
TP (%)	0.57 (0.04)	1.06 (0.23)	0.34 (0.17)
TK (%)	3.03 (0.07)	1.08 (0.33)	0.95 (0.01)
C/N ratio	59.40	32.43	20.77

Note: WH= Water hyacinths, FW= Food wastes, CC= Corncoobs

Table 4 presents parameters of vermicompost products in all nine treatments. The percentages of moisture content in T1-T3 (water hyacinths) ranged from 30.3 to 34.1; T4-T6 (food wastes) from 22.0 to 33.9; and T7-T9 (corncoobs) from 29.7-33.2. The moisture content of vermicompost products from the three base materials are close to the standard set by the Thai National Committee on Agricultural Commodity and Food Standards, 2005. The values of pH, conductivity, and organic content of the vermicompost products all met the standards set by the Thai National Bureau of Agricultural Commodity and Food Standards. The results of T2-T9 show that the value of C/N ratios were within the

standard ( $\leq 20:1$ ), except for T1 where the C/N ratio is slightly greater than the standard.

Table 3 The characteristics of media materials used for vermicomposting

Para meter	Mean value (Standard deviation)	
	CD	RB
pH	7.80	7.35
Moisture content (%)	10.91(0.02)	8.93(0.80)
OC (%)	45.25(0.90)	28.54(0.02)
OM (%)	78.01(0.33)	49.20(0.00)
TN (%)	1.32(0.95)	0.58(0.17)
TP (%)	0.65(0.55)	1.38(0.01)
TK (%)	2.73(0.00)	0.39(0.27)
C/N ratio	34.27	49.20

Note: RB= Rice bran, CD= Cow dung

Major nutrients analyzed in the vermicompost were total nitrogen, total phosphorus, and total potassium. Graphic illustration in Figure 2 shows the results of major nutrients after vermicomposting for 45 days with different treatments. Plants need nitrogen for leaf and stem growth; nitrogen also adds dark green color to the leaves. Phosphorus is important to enhance plants' maturity; it also helps seed and fruit formation. Potassium makes fruits juicier and sweeter, and enhances growth of fruit and root vegetables. The levels of nitrogen analyzed from all nine treatments meet the standard ( $\geq 1.0\%$ ) set by the Thai National Committee on Agricultural Commodity and Food Standards, 2005. The highest percentage of nitrogen (ranges: 2.8 to 3.0) was found in T4-T6 when food waste was used as base material. The second highest nitrogen levels (1.3% to 2.0%) were recovered from T1-T3 with water hyacinth used as base material. The least amount of nitrogen (1.2% to 1.4%) was found in T7 to T9 from corncoobs. The phosphorus standard of  $\geq 0.5\%$  was met by the results from T1 to T6, but not from T7 to T9. The highest levels of phosphorus (2.3% to 3.3%) were found in T4 -T6 where food waste was used as base material, followed by the levels of phosphorus in T1-T3 (0.5% to 2.6%) where the base material was water hyacinth. However, when corncoobs were used as base material (T7-T9), they yielded the least percentage of phosphorus (0.3-0.4) which did not meet the standard. The percentage of potassium found in T1 to T9 were all higher than or equal to the standard of 0.5%. The greatest values (1.6% to 2.1%) were found when water hyacinth was used as base material (T1-T3), followed by those in T4-T6 (0.9% to 1.1%) from food waste.

The least percentage of potassium (0.5) was found in T7-T9 for corncobs.

Considering the highest yields of major nutrients, the greatest value of nitrogen, 3.06%, was resulted from T6 (food waste: rice bran: cow dung = 5:4:3). Therefore, vermicompost using this ratio is suitable for growing green plants. For phosphorus, T4 (food waste: rice bran: cow dung = 7:4:3) yielded the highest percentage (3.39). This ratio of vermicompost is good for growing flowers and fruits. T1 (water hyacinth: rice bran: cow dung = 7:4:3) resulted in the highest value of potassium (2.14%). This ratio of vermicompost should be used for growing root vegetables and sweet fruits.

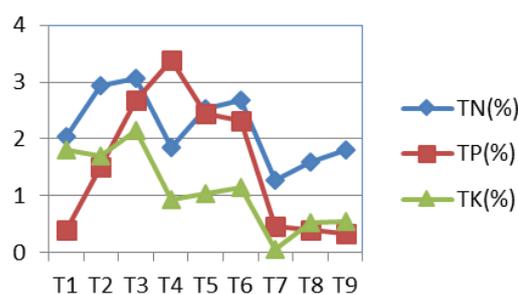


Fig. 2 Major nutrients derived from vermicompost after 45 days.

Table 4 Parameters of vermicompost products compared with the Thai Agricultural Commodity and Food Standards

Para Meters	Treatments									Std.*
	Mean value (Standard deviation)									
	T1	T2	T3	T4	T5	T6	T7	T8	T9	
Moisture content (%)	30.3 (0.90)	32.7 (0.10)	34.1 (0.33)	28.6 (0.45)	22.0 (0.21)	33.9 (0.30)	29.7 (0.00)	32.2 (0.03)	33.2 (0.55)	≤ 30
pH	7.9	7.6	7.3	6.7	6.3	6.7	7.1	7.2	7.4	5.5-8.5
EC (ds/m)	1.53 (0.19)	2.37 (0.06)	2.26 (0.08)	1.56 (1.08)	1.26 (0.32)	1.45 (0.94)	2.07 (1.08)	2.54 (2.08)	1.97 (0.58)	≤ 10
Organic carbon (%)	41.75 (0.70)	38.90 (1.04)	33.01 (1.25)	38.25 (1.25)	31.01 (1.43)	24.01 (2.25)	23.41 (0.95)	21.36 (1.7)	19.36 (1.75)	-
Organic matter (%)	71.98 (1.20)	67.06 (1.79)	56.89 (2.15)	65.94 (0.3)	53.46 (1.33)	41.39 (1.05)	40.36 (1.05)	36.82 (1.6)	33.37 (0.05)	≥ 20
C/N ratio	30.25 (0.97)	19.45 (0.18)	17.90 (0.32)	13.23 (1.95)	10.23 (2.11)	7.84 (1.32)	16.25 (0.97)	16.43 (1.6)	15.24 (0.55)	≤ 20:1
TN (%)	1.38 (0.05)	2.0 (0.88)	1.84 (0.14)	2.89 (0.00)	3.03 (0.95)	3.06 (0.00)	1.44 (0.71)	1.3 (0.02)	1.27 (0.01)	≥ 1.0
TP (%)	0.59 (0.08)	1.50 (0.05)	2.67 (0.06)	3.39 (1.26)	2.45 (1.50)	2.31 (1.85)	0.45 (1.06)	0.39 (1.08)	0.33 (0.55)	≥ 0.5
TK (%)	2.14 (0.88)	1.69 (0.88)	1.80 (0.94)	1.14 (1.58)	1.04 (0.38)	0.94 (1.97)	0.54 (0.11)	0.52 (1.48)	0.49 (0.52)	≥ 0.5
Germination index (%)	88.50 (1.94)	85.71 (0.54)	82.95 (1.30)	95.21 (0.9)	92.71 (1.7)	89.72 (1.1)	82.50 (1.45)	81.50 (0.0)	80.50 (2.06)	≥ 80

Note: \* from Thai agricultural standard, National Committee on Agricultural Commodity and Food Standards, Ministry of Agriculture and Cooperative, 2005.

### 3.1 Germination Index (GI)

Germination index (GI) is the most commonly used parameter to evaluate the phytotoxicity of the final compost and the effect on seed germination [11]. The germination index (GI) test results of vermicompost at 45 days is shown in Table 3. The germination index for T1-T9 ranged from 80.50% to 95.21% which corresponds to the findings in the study by Ponsa [12] reporting that the germination index in all treatments met the standard. Additionally, Tiquia and Tam [13] reported that the germination index values in their study were more than 80%, phytotoxic-free and were considered to have complete maturity. Therefore, the germination index in this study similarly showed non-phytotoxicity to plant growth.

### 4. DISCUSSION

In this study, both the ratio of organic material and the type of material that produces the best nutrient value were considered. Results showed the ratios of organic waste mixed in the compost met the Thai standard. However, the three types of material vermicomposted had different nutrient results for nitrogen, phosphorus and potassium. While food wastes scored highest in nitrogen and phosphorus levels, water hyacinth waste was highest for potassium and second to food wastes in nitrogen and phosphorus. Corncoobs lagged behind in nutrient level in the compost time of this experiment. High rate composting methods might improve results for corncoobs; however, when water hyacinth wastes were used in combined high rate composting and vermicomposting, this system was found feasible for the rapid production of compost fertilizer [14].

In short, though food waste produced very good results, the collection, separation and transport of these wastes is not presently feasible in Thailand. Additional investigation of how food wastes could be collected from the waste stream for the production of nutrient-rich compost is needed. Water hyacinth waste results show that these wastes can be feasibly incorporated into a composting system to produce organic fertilizer useful in Thailand. Compost production operations from hyacinth wastes on a large-scale need development so the commercial rewards of using hyacinth wastes as compost material can be further demonstrated and expanded.

### 5. CONCLUSION

Results show that both food wastes and water hyacinth wastes have the greatest potential for use in producing compost using earthworms. While all of the organic materials tested in this research have

potential, corncoobs have the least potential for timely compost production. Food wastes have limited feasibility in Thailand since they are presently not collected to be recycled. Water hyacinth wastes are abundant, can be separated and collected and have the potential for more rapid, high rate compost production. Our findings suggest that further use of water hyacinth wastes is indicated through vermicomposting as an important element to reduce water hyacinth disposal costs and to produce organic fertilizer for farming.

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