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# Effects of C/N Ratio and Moisture Contents on Performance of Household Organic Waste Composting Using Passive Aeration Bin

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**Abstract.** The objectives of this study were to determine the effects of C/N ratio and initial moisture content on household organic waste composting using passive aeration bin. Four 200-L passive aeration plastic bins were prepared in this study. Food scraps and dry leaves were added to each bin once a day for 45 days. The 1st bin had the initial C/N ratio and moisture content of the waste mix at 35/1 and 60%, respectively. The 2nd bin was added by urea to the waste mix to adjust the C/N ratio to be 25/1. The 3rd and 4th bins were added by water to the waste mixture to have moisture contents of 65% and 70%, respectively. The waste mix and composts were analyzed for their characteristics. The temperature at the middle part of the waste layer in each bin was recorded daily. At the end of composting period, the composts were removed and weighed to determine the mass reduction and size distribution. It was found that the bin with urea addition (C/N ratio adjustment to 25/1) and the bin with initial moisture content at 70% enhanced the degradation of the organic matter. The mass reduction and the final volatile solids found in the composts from urea addition bin and 70% moisture content were 60.8%, 64.4% and 57.8%, 64.3%, respectively.

**Keywords:** composting, household organic waste, C/N ratio, moisture, passive-aeration bin

## 1. Introduction

At present, most organic waste in municipal solid wastes (OFMSW) generated in Thailand are disposed of in landfills. The decomposition of OFMSW under anaerobic conditions in landfill produces green house gases. Furthermore, dry leaves, the major component of garden waste are usually open-burned in the suburbs and rural areas and resulted in toxic compounds releasing. Composting can provide a viable alternative method for managing OFMSW. Home composting is one of the most environmentally beneficial activities that a typical homeowner can perform. Bin composting is a more suitable treatment option because it helps the compost pile retain heat and moisture, and also looks neater. Bins with passive aeration are usually used for home composting. It is usually suggested to stockpile organic materials for composting in order to create a hot compost pile [1]. However, keeping the household food scraps in the hot climate of a tropical country may generate an odor problem. Past research regarding bin or passive composting was conducted by filling or piling of wastes at once [2-6]. Karnchanawong and Suriyanon [7] revealed that the passive aeration bin with both lateral and vertical ventilations resulted on a higher rate of biological decomposition of organic wastes with daily batch-feeding. However, their study involved the high C/N ratio and fixed initial moisture content of the waste mix around 60%. The C/N ratio and moisture contents are the major factors for composting process control. The C/N ratio of the household organic waste is usually higher than the optimum value (25/1-30/1). In addition, it is usually advised to add water to the compost mix regularly during the composting period in order to control the moisture content. This task is rather troublesome. This study was therefore to determine the effects of C/N ratio adjustment and initial moisture contents on performance of household organic waste composting using passive aeration bin with daily batch-feeding and without moisture content control during composting process.

## 2. Materials and Methods

The study consisted of 2 experiments in order to determine the effects of C/N ratio and the initial moisture content on the composting performances.

Four 200-L passive aeration plastic bins were prepared in this study. Each bin had 16 lateral holes with size of 50 mm x100 mm and a vertical pipe installed at the middle part of the bin. Food scraps and dry leaves (1.6 kg total) with a ratio of 1:0.33 (wet weight) were added to each bin once a day for 45 days. All food scraps and dry leaves were reduced in size to less than 50 mm, and were mixed together thoroughly. In addition, the food scraps used in this study were collected from Chiang Mai University's canteen; they were comprised of 50% food scraps discarded during food preparation, and 50% leftover food. The food scraps discarded during food preparation were mainly vegetables. The leftover food used in this study consisted primarily of rice and noodles, and was prepared by draining off the liquid portion. The initial C/N ratio and moisture content of the waste mix were 35/1 and 60%, respectively. The 1$^{st}$ bin was used as a control bin without any C/N and moisture adjustments (also refer as MC60%). The 2$^{nd}$ bin was used to determine the effect of C/N ratio on composting performance by addition of urea to the waste mix to have C/N ratio of 25/1 (weight ratio of organic waste/urea: 1/0.00125). The 3$^{rd}$ and 4$^{th}$ bins were used to determine the effects of initial moisture content on composting performance by addition of water to the waste mixture to have moisture contents of 65% (MC65%) and 70% (MC70%). In addition, the mature compost produced from OFMSW was also daily added to the mixture of food scraps and dry leaves (5% by weight) in order to seed the microorganisms to accelerate waste decomposition. It should be remarked that there were no any addition of the water into the wastes during composting.

During the waste loading period, sample of the well-mixed organic wastes were taken twice a week to determine their characteristics-: pH, electrical conductivity (EC), C, N, moisture content (MC) and volatile solids (VS). The temperature at the middle part of the waste layer in each bin was recorded daily. Compost from each bin was taken randomly from the waste layer, for analysis of pH, conductivity, C, N, VS, and GI once a week. After 120 days, the composts were removed and weighed to determine the mass reduction and size distribution. The final compost was mixed thoroughly and a composite sample was taken to determine pH, conductivity, C, cation-exchange capacity (CEC), N, P and K values. All analyses of each sample were done in triplicate. Temperatures were recorded using a glass thermometer. The pH and EC were determined by measuring slurry of a 1:10 ratio of compost to water using a Horiba F-21 pH meter. C and N contents were determined using methods based on Walkley and Black [8] and a modified micro Kjeldahl procedure [9]. MC and VS were determined using a gravimetric method. CEC was measured using a displacement method and distillation for adsorbed ammonium. Phosphorus and potassium were analyzed using digestion with $HNO_3$-$HClO_4$ followed by a colorimetric method using Barton's solution and a flame photometer, respectively [9]. GI was carried out on water extracts by mechanically shaking the fresh samples for 1 h at a ratio of solid to distilled water of 1:10 (w/v). Three mL of each extract was pipetted into a sterilized Petri dish lined with Whatman#1 filter paper. Ten flowering white cabbage seeds (*Brassica chinensis var. parachinensis*) were distributed on the filter paper and incubated at 20-25°C in the dark for 48 h. Four replicates were analyzed. The responses were calculated by the following formula [10]:-

$$\text{Germination index, \%} = \frac{\text{Seed germination, \%} \times \text{root length of treatment, cm}}{\text{Seed germination, \%} \times \text{root length of control, cm}} \times 100\%$$

# 3. Results and Discussions

## 3.1. Waste Characteristics

The average characteristics of the fresh wastes daily fed in all bins during 45 days were shown in Table 1. The average pHs of the wastes loaded were slightly acid and were in the range of 5.14 to 5.28, due to the organic acid generated. The average EC of the wastes loaded in the control (also MC60%) and urea added bins were around 2.5 dS/m while in the MC65% and MC70% showed lower EC values due to the higher moisture contents. The VS of the wastes in all bins were around 83%. The C/N ratios of the wastes in the control (also MC60%), urea added bins, MC65% and MC70% were 35.3, 25.6, 35.0 and 35.0, respectively.

## 3.2. Compost Characteristics' Variation

### 3.2.1. Effects of C/N adjustment on compost performance

The compost characteristics during the waste addition and composting period are presented in Figure 1. It was found that the maximum temperature during the waste addition period were in the range of 52.9–55.9

Table 1: Average Characteristics of the Fresh Wastes (avg ± sd, n=14)

| Bin | pH | EC (dS/m) | MC (%) | VS (%) | C (%) | N (%) | C/N ratio |
|---|---|---|---|---|---|---|---|
| 1. Control bin (MC 60%) | 5.22±0.44 | 2.57±0.49 | 60.6±1.31 | 82.6±2.6 | 46.3±1.58 | 1.32±0.06 | 35.3±2.5 |
| 2. Urea added bin | 5.14±0.31 | 2.47±0.51 | 60.8±0.68 | 83.8±3.6 | 43.3±1.8 | 1.69±0.1 | 25.6±0.85 |
| 3. MC 65% | 5.15±0.37 | 2.26±0.38 | 65.7±1.37 | 82.0±2.02 | 46.4±1.36 | 1.34±0.13 | 35.01±3.4 |
| 4. MC 70% | 5.28±0.32 | 1.94±0.35 | 70.5±0.84 | 82.6±2.32 | 46.4±1.44 | 1.33±0.12 | 35.04±3.3 |

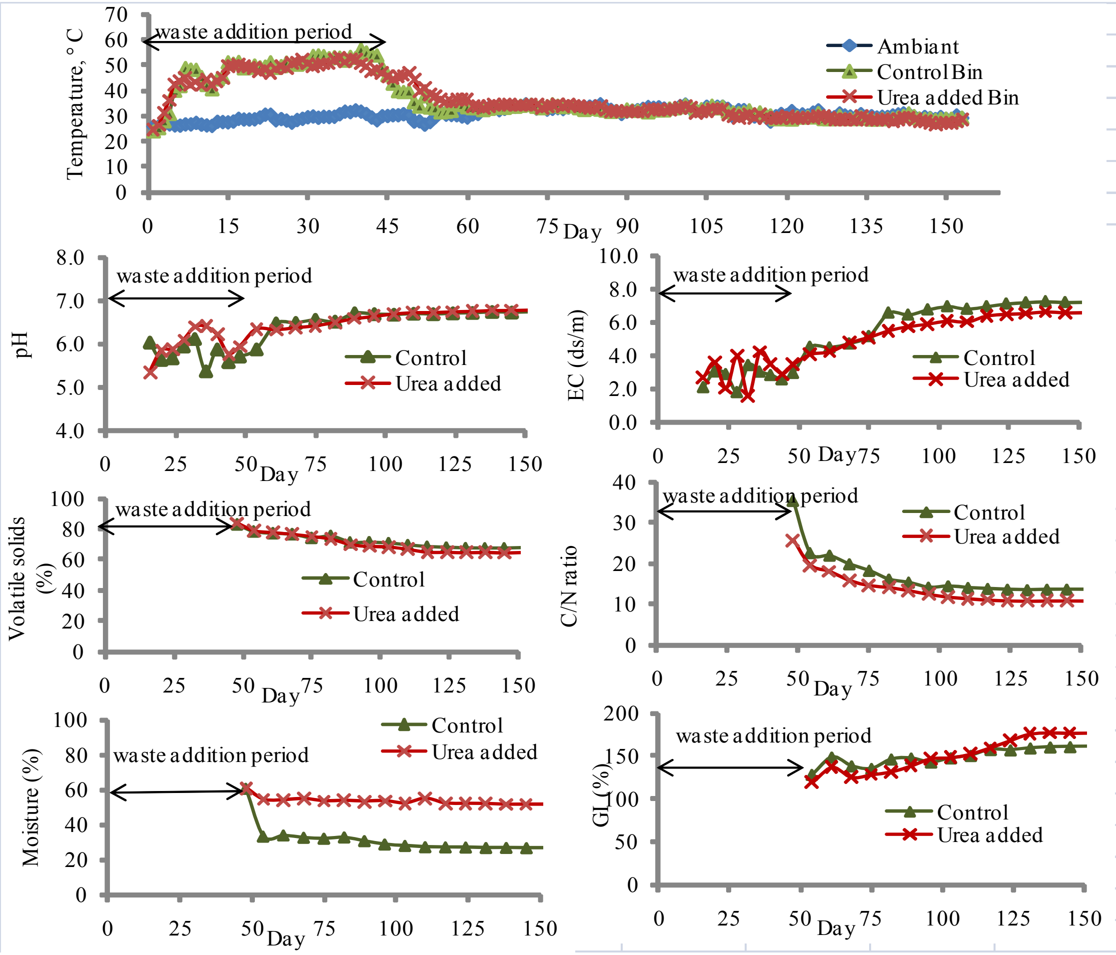


Fig. 1: Compost characteristics' variation in the study of the effect of C/N ratio.

°C. The average and maximum temperatures found in the control bin and urea added bin were 46.1°C and 55.9°C; 46.1°C and 52.9°C, respectively. After waste loading period, the average and maximum temperatures found in the control and urea added bins were found to be 31.6°C and 40.9°C; 31.2°C and 37.4°C, respectively. The temperatures found in both bins were not significantly different. pHs of the compost mixes in both bins during waste loading period were in the range of 5.34-6.4, and gradually increased to be slightly acid in the range of 6.73-6.78 at the end of the composting period. There were no any significant differences among the average values of pH in these two bins. During the waste loading period, the EC of the composts show fluctuation values in the range of 1.56–3.96 dS/m. After waste loading period until the end of the experiment, the EC increased to be in the range of 6.57-7.18 dS/m. The compost in the urea added bin showed the higher values of EC value due to mineralization of urea added.

After the waste loading period to the end of the experiment, the VS and C/N ratio of the composts in the control and urea added bins continually decreased to be 67.7%, 64.4% and 13.9, 10.9, respectively. The moisture content of the compost in the control bin decreased sharply to be less than 30% after waste loading period. The higher moisture content of the compost investigated in the urea added bin might be because of the high hygroscopic property of urea especially in the high humidity ambient [11]. The higher decreasing of VS and C/N in the urea added bin were investigated. These results clearly illustrated that the C/N ratio adjustment to 25/1 using urea resulted in the higher biodegradation activities, compared with the control bin. All composts had shown the GI using flowering white cabbage seeds greater than 80% after waste loading period. It means that the composts produced were free form phytotoxicity.

### 3.2.2. Effects of initial moisture content on compost performance

The compost characteristics during the waste addition and composting period are presented in Figure 2. It was found that the maximum temperature during the waste loading period were in the range of 50–65 °C. The average and maximum temperatures found in MC60% (control bin), MC65% and MC70% bins were found to be 46.1, 46.1, 44.8°C and 55.9, 53.3, 53.1°C respectively. After waste loading period, the average and maximum temperatures in MC60% (control bin), MC65% and MC70% bins were found to be 31.2, 32.5, 33.9°C and 37.4,43.1,43.9°C, respectively. The low temperatures were observed in the bin with the lower moisture content. The lower biodegradation activities resulted from the lower moisture content might be the cause of this investigation.

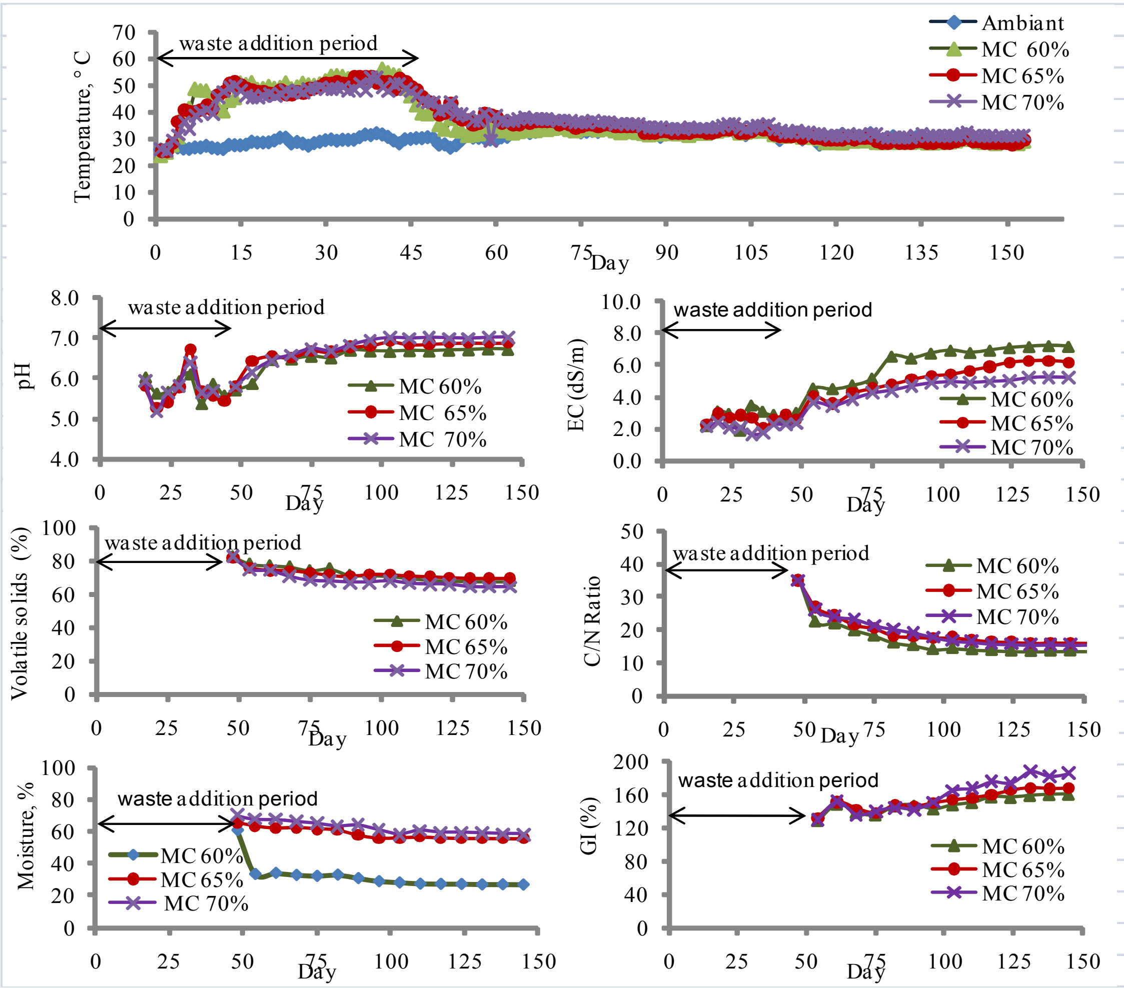


Fig. 2: Compost characteristics' variation in the study of the effect of initial moisture content.

The pHs of the compost mixes in MC60%, MC65% and MC70% bins during waste loading period were in the range of 5.15-5.28, and gradually increased to be slightly acid to neutral in the range of 6.72-7.01 at the end of the composting period. It was found that the higher value of the moisture content of the waste gave the higher value of the pH of the compost product. During the waste loading period, the EC of the composts show fluctuation values in the range of 1.65–3.44 dS/m. After waste loading period until the end of the experiment, the EC increased to be in the range of 5.21-7.16 dS/m. The compost in the MC70% bin showed the lowest values of EC value, followed by MC65% and MC60% bins, respectively. These results were corresponding to the dilution of mineral substances by water present in the higher moisture content bins. All composts had shown GI greater than 80% after waste loading period. At the end of the composting period, the moisture contents in the final composts of MC60%, MC65% and MC70% were 26.5%, 55.6% and 58.4%, respectively. After the waste loading period to the end of the experiment, the VS and C/N ratio of the composts in MC60%, MC65% and MC70% bins continually decreased to be 67.8%, 69.4%, 64.32% and 13.5, 16.1 and 15.5, respectively.

## 3.3. Mass Reduction, Size Proportion and Final Compost Characteristics

### 3.3.1. Effects of C/N adjustment on compost performance

The mass reduction found in the control bin and urea added bins were 41.5% and 60.8%, respectively. The value obtained from the urea added bin was quite high, compared with normal range (35-40%) observed in the composting of organic wastes [12]. The proportion of the size smaller than 12.5 mm of the compost from the control and urea added bins were 71.6% and 70.9%, respectively, which illustrated no significant difference. The final composts from the control and urea added bins had the following characteristics; pH 6.8 and 6.9; EC 8.0 and 7.2 dS/m; MC 25.5% and 32.5%; C/N ratio 11.2 and 9.7; CEC 98.5 and 94.6 cmol/kg; $N:P_2O_5:K_2O$ 2.6%:0.6%:1.9% and 3.1%:0.4%:2.1%; GI 175.3 and 179.8, respectively. The higher mass reduction and nitrogen content were found in the compost produced from urea added bin.

### 3.3.2. Effects of initial moisture content on compost performance

The mass reduction found in MC60%, MC65% and MC70% bins were 41.5%, 52.2% and 55.8% respectively. The proportion of the size smaller than 12.5 mm of the compost from MC60%, MC65% and MC70% were 71.6%, 76.7% and 86.5%, respectively. These results clearly show that MC70% had higher biodegradation activity. The final composts from MC60%, MC65% and MC70% bins had the following characteristics; pH 6.8, 7.0, 7.4; EC 8.0, 6.7,5.9 dS/m; MC 25.5%, 31.5%, 39.1%; C/N ratio 11.2, 12.2, 13.9; CEC 98.5, 107.8, 107.5 cmol/kg; $N:P_2O_5:K_2O$ 2.6%:0.6%:1.9%, 2.4%:0.6%:2.3%; 2.3:0.5:2.3 GI 175.3, 189, 197.8, respectively. Highest pH and GI values, mass reduction and proportion of the compost with smaller size were obtained in MC70% bin.

# 4. Conclusions

It can be concluded that the bin with C/N ratio adjustment using urea and the bin with initial moisture content at 70% can enhance the biodegradation process. The mass reduction and the final VS found in the composts from urea added bin and MC70% were 60.8%, 64.4% and 57.8%, 64.3%, respectively. All composts' characteristics met the Thai compost standards.

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