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Duration of Elevated Starting Temperature Influencing Food Waste Composting

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Abstract

This study aims to improve composting efficiency by elevating the starting temperature at mesophilic phase in order to accelerate microbial activities. The controlled starting temperature at 40°C was applied for 12 and 24 hours to a pile of synthetic food waste in the designed composting reactor compared with the conventional composting process. Composting parameters such as temperature, mesophilic and thermophilic bacterial quantities were investigated. It was found that the controlled starting temperature at 40°C for different duration showed significant enhancement for composting temperature profile, maximum temperature and bacterial quantity compared to the conventional condition. Moreover, the condition of 40°C elevated temperature for duration of 24 hours exhibited the higher maximum temperature and bacteria quantities compared to that of 12 hours. It is concluded that the composting efficiency could be improved by using the suitable duration of controlled starting temperature.

Keywords : food waste; composting; temperature control; elevated temperature; starting temperature

Introduction

In Thailand, about 27.40 million tons of municipal solid waste (MSW) were generated in 2017. However, only 20.22 million tons were properly disposed [1]. The remaining 7.17 million tons thus have caused serious pollution to the environment. More than 60% of MSW were organic [2] that can be transformed into useful products. One of a well known methods to convert organic waste into valuable materials is composting. Generally, composting can reduce organic waste volume by 40 to 50% [3]. Composting is the biological decomposition and stabilization process of organic substrates, under suitable conditions to produce a final product that is stable and free of pathogens [4].

Composting temperature is found to be a significant issue affecting composting efficiency. Temperature is effective factor in the composting process related to the bacteria activities and the composting progress [3]. It was reported that bacteria play a major role in the decomposition of organic matter in composting pile with their type dependence [5]. However, general conventional composting processes usually

proceed under environmental temperature which occasionally cause low microbial activity and thus affect to low degradation efficiency. The aim of this study is to improve composting efficiency by elevating starting temperature at mesophilic phase in order to accelerate microbial activity. The controlled starting temperature at 40°C was applied for 12 and 24 hours to a pile of synthetic food waste in the composting reactor compared with conventional composting process. Composting efficiency including temperature, mesophilic and thermophilic bacteria quantities were investigated and discussed.

Materials and Methods

Materials for composting

The main substrate in the composting material is synthetic food waste consisting of 20% vegetable scraps, 30% fruit scraps, 25% fish scraps, and 25% rice scraps. Dry leaves were mixed with the synthetic food waste to make the starting carbon to nitrogen ratio 36, as this ratio should be in the range 25-50 [6]. Moisture content of the composting material mixture was 60%, while the recommended range for it is 50-70% [5,7]. The synthetic food waste and dry leaves were crushed to 1-2 cm pieces prior to composting.

Composting reactor

A composting material batch of 7.32 kg was placed in a simple composting reactor and the lid made of stainless steel in cylindrical shape with 36 cm diameter and 36 cm height. The total volume of the reactor is 0.036 m^3 and the composting material was filled in the composting reactor with maintaining of 15% free volume. The reactor is surrounded by 3,000 watts of heating system. The air supply inlet is a perforated plate at the bottom of the reactor, using an air flow rotameter (DWYER, model: RMA–22SSV) to control the aeration rate at 0.5 L/min/kg that was calculated based on oxygen requirement for decomposition of organic matter [6]. The perforated plate at the bottom of the reactor distributes the air supplied by a compressor and the plate also filters the leachate. The reactor has 3 thermocouple probes located at top, middle, and bottom along the centerline, to monitoring the temperature profile in the composting pile. The average composting temperature of the 3 positions was then calculated. The initial composting temperature was the ambient temperature. A schematic diagram of the reactor is shown in Fig. 1. The composting was carried out until the pile had returned to ambient temperature, carbon to nitrogen ratio was below 20, and oxygen concentration had returned to ambient level. The composting was completed when all these mentioned parameters remained constant. Each run was performed in triplicate.

Result and Discussion

The average temperature profiles of food waste composting when starting temperature at 40°C was controlled for 12 and 24 hours compared with conventional composting condition are shown in Fig. 2. In the conventional composting condition, the temperature started to increase immediately after composting begun. The compost temperature is in the range of 29.1-51.2°C from day 1 to 30 with reaching the maximum temperature of 51.2°C within 72 hours. In case of using elevated temperature at duration of 12 hours, when reaching the setting starting temperature of 40°C, the composting pile temperature stayed constant at 40°C for 11 hours before rising to the maximum

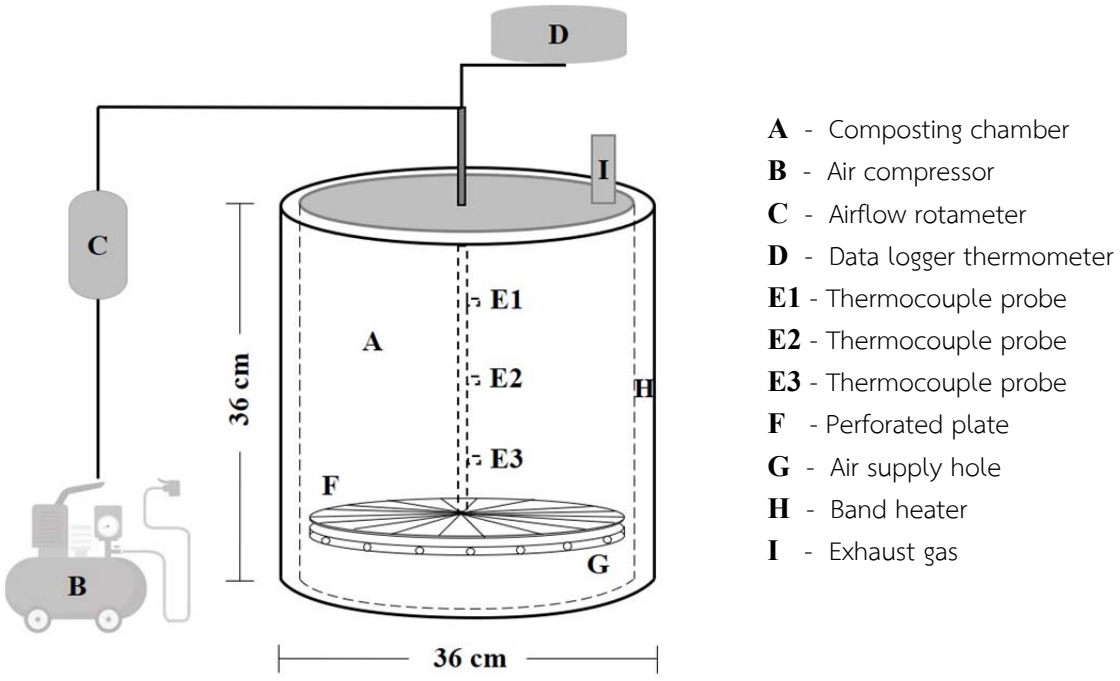

Fig. 1 Schematic diagram of the composting reactor

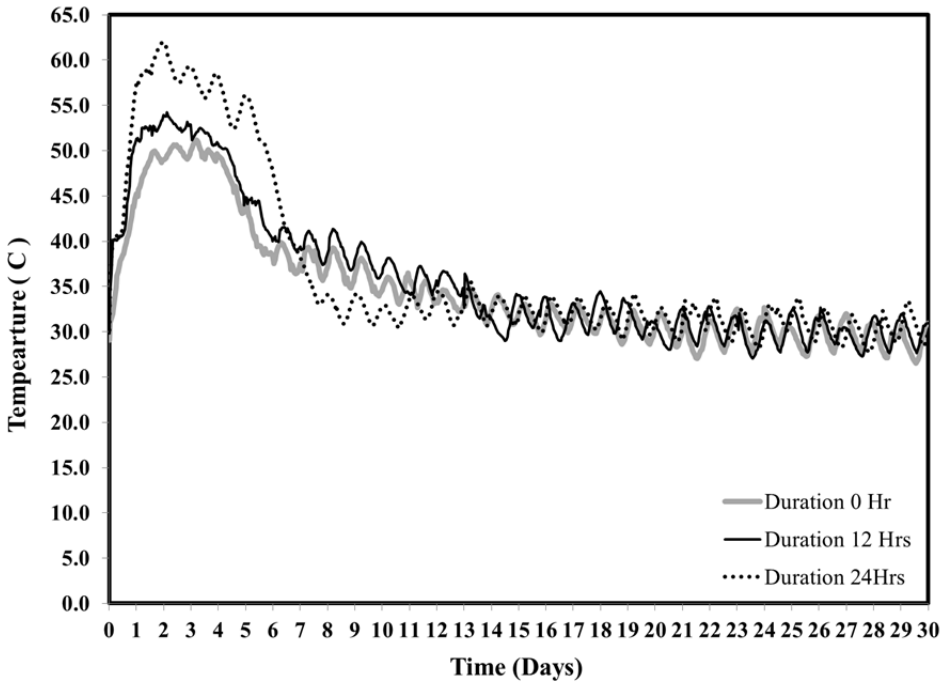

Fig. 2 Average temperature versus composting time

temperature of 54.2°C within 51 hours. The temperature was in the range of 30.8-54.2°C from day 1 to 30. In case of using elevated temperature at duration of 24 hours, after reaching the setting starting temperature of 40°C, the temperature of composting pile stayed unchanged for 9 hours and started to increase afterward**.** It is noticed that in this case the buffering time or lag time is decreased compared to a controlled starting temperature for 12 hours. This may be attributed to the duration of 24 hours is suitable condition without heat transfer to environment thus leads the microorganisms for a prompt switching from a low activity to a high activity [3]. The composting pile reached the maximum temperature of 62.0°C within 48 hours and the temperature was in the range of 30.2-62.0°C from day 1 to 30. It is seen that elevated temperature at duration of 24 hours exhibited the highest maximum temperature and the fastest decrease to the ambient temperature level.

The aerobic bacteria that involve in composting process have been measured and the quantities of mesophilic bacteria are shown in Fig. 3. It is found that there is significant difference of mesophilic bacteria quantity with varying elevated duration of starting temperature. In the conventional composting condition, the maximum quantity of mesophilic bacteria was 10.11 Log CFU/g. While, the maximum quantities of mesophilic bacteria were 9.98 and 9.96 Log CFU/g In case of using 12 and 24 hours, respectively. It is noticed that quantity of mesophilic bacteria is directly related to the composing pile temperature. That is when composting pile temperature is below than 45°C, the quantity of mesophilic bacteria is high which is due to a preference temperature of mesophilic bacteria is in the range of 20-45°C. However, the decreasing trend of mesophilic bacteria quantities is remarkably noticed when the composting pile temperature is higher than 50°C. This is because at the high temperature most of mesophilic bacteria is inactivated.

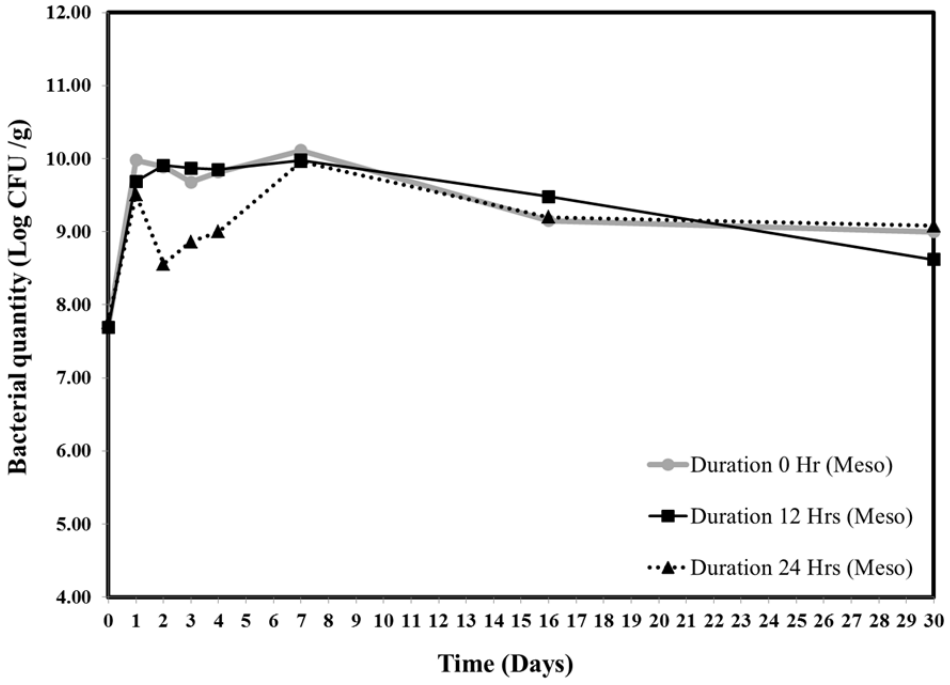

Fig. 3 Mesophilic bacteria quantity versus composting time

The quantity of thermophilic bacteria is also shown in Fig. 4. The increase of thermophilic bacteria quantity found to straightly correspond with the temperature raising in composting pile that was contribute from exothermic reaction via decomposition of organic matter. It was found that the condition in which exhibited a higher maximum temperature, a higher thermophilic bacteria quantity was found. Therefore, the highest maximum number of thermophilic bacteria (9.99Log CFU/g) is found in case of using elevated temperature at duration of 24 hours.

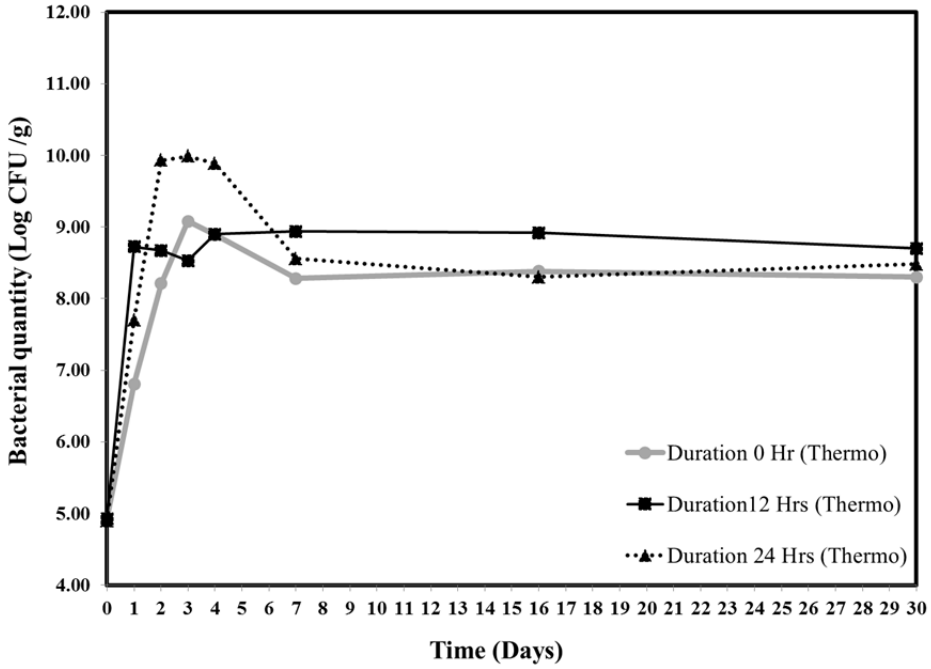

Fig. 4 Thermophilic bacteria quantity versus composting time

Conclusions

Controlled starting temperature at 40°C for different duration showed significant enhancement in composting temperature profile, maximum temperature and bacteria quantities compared to the conventional condition. Additionally, the condition of 40°C elevated temperature at duration of 24 hours exhibited the higher maximum temperature and bacterial quantities compared to that of 12 hours. Therefore, the composting efficiency can be improved by using suitable duration of controlled starting temperature.

Acknowledgement

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