Jurnal Kejuruteraan 33(3) 2021: 413-424
https://doi.org/10.17576/jkukm-2021-33(3)-04

Production of Food Waste Compost and Its Effect on the Growth of Dwarf Crape Jasmine

Nur Aqeela Syuhadah Aji, Abu Zahrim Yaser*, Junidah Lamaming, Mohd Al Mussa Ugak, Sariah Saalah & Mariani Rajin

Chemical Engineering Programme, Faculty of Engineering, Universiti Malaysia Sabah, Malaysia

**Corresponding author: zahrim@ums.edu.my*

Received 06 May 2021, Received in revised form 10 May 2021
Accepted 17 May 2021, Available online 30 August 2021

ABSTRACT

The main objective of this study is to investigate the physical, chemical and biological effects of compost made from food waste and unshredded dry leaves and to evaluate the performance of food waste compost on the growth of dwarf crape jasmine (dwarf Tabernaemontana divaricata). Food waste and dry leaves with a ratio of 3:1 have been added to the passive aeration-static bioreactor. The composting was carried out for 40 days. The physical, chemical, biological and morphological changes that occurred during the composting process were identified and evaluated. The plants were grown in media containing nine different proportions of compost and the plant growth was measured after 150 days. The results show that a maximum composting temperature of 47.8 °C and a decrease in the moisture content were achieved. The pH value increased while the electrical conductivity decreased during the composting process. The TOC decreased from 56% to 42%. The nutrient value of the composts was all within the recommended range. Among the treatments, the 5%-20% compost mixture shows the greatest growth development. Results in this study indicate that food waste composting with high EC compost value can be used to promote dwarf crape jasmine growth, provided that the mixture contains low compost dosage.

Keywords: Composting; dry leaves; passive aeration; plant growth; campus sustainability

INTRODUCTION

A campus community equipped with growth mind-set will not only necessitate the environmental sustainability measures, but will also benefit from the solutions. The society places a high value on the campus community capability through its knowledge, resources, and ideas nurtured. Therefore, the campus community should be at the frontline of sustainable evolution. More critical thinking and innovative solutions from the campus community are needed to achieve this stage and the solution should be practical and sustainable (Yaser 2020).

Composting is more environmentally friendly and cost-effective to landfilling and incineration. Composting is a biological process that converts organic waste into valuable products of compost, which can then be used to improve soil fertility.

Considering organic waste such as food waste is widely available and easy to collect in universities, it is best practice for waste management in universities. Managing food waste is a global issue as the generation of food waste increases, and food characteristics will have an impact on the environment if it is disposed of in landfill or incinerated.

Food waste composting might be challenging due to its inconsistence characteristics. Optimization is essential to accelerate the activity of microorganisms. There are several parameters that could affect composting effectiveness, such as temperature, aeration, moisture content and carbon to nitrogen ratio. The quality of the compost produced must be analyzed to ensure that it is safe for agricultural use. A survey has been conducted by He et al. (1995) and found that the electrical conductivity (EC) of municipal solid waste (MSW) compost was much higher

(3.7 – 7.5 mS/cm) than agricultural soils (0 – 4.0 mS/cm) and it could inhibit seed germination and plant growth.

It is important to use suitable plant medium to avoid disrupting the growth of the plant. Soil is the main planting medium for most types of crops (Wiranta 2010). Many gardeners use top soil as a part of their growing medium (Awang et al. 2009). However, the soil has low porosity, denser and poor in nutrients. Thus, it will disrupt the water infiltration into the soil, root penetration and nutrient uptake. Because of this condition, soil cannot be used as a single crop medium and must be mixed with other medium to increase porosity and nutrients. Compost is an excellent choice as a medium mixture as compost has a natural pH and is rich in micronutrients.

Other than that, several studies have been conducted to investigate the effect of food waste compost on a variety of crops, including cereal and legumes (Toundou et al. 2021; Chitravadivu et al. 2009; Jarboui et al. 2021), vegetables (Abu Samah et al. 2020; Haouas et al. 2021; Kumari et al. 2020; Lee et al. 2004), and ornamental and flowering plants (Shuhaimi et al. 2019; Abdullah et al. 2021). Most of these studies have shown that compost has a significant beneficial effect on the plant growth. Furthermore, using compost for landscaping around campus can reduce the dependence on chemical fertilizers while also reducing costs.

There has been no research on the effect of food waste compost on dwarf crape jasmine. Therefore, this study investigates and evaluates the performance of food waste composting and its effect on growth of dwarf crape jasmine.

METHODOLOGY

FEEDSTOCKS

Food waste and unshredded dry leaves are used as feedstocks in a 3:1 ratio (food waste: dry leaf) in the composting process. The ratio was chosen based on our preliminary study with different ratios of 0.7:1, 1.5:1 and 4:1 and found that mixtures with ratios of 1.5:1 and 4:1 have higher organic matter loss. Food waste was collected from nearby restaurants, and dry leaves were collected around Universiti Malaysia Sabah (UMS). Both food waste and unshredded dry leaves were segregated from not compostable materials such as plastic before feeding it into the composter. The characteristics of food waste, dry leaves and mixed waste are shown in Table 1. About 10 kg of compost seed was placed at the bottom of the reactor.

TABLE 1. Characteristics of food waste, dry leaves and mixed waste

Parameter	Food waste	Dry leaves	Food waste-Dry leaves
Moisture content (%)	66.4	7.8	54.6
pH	4.7	5.9	4.9
Electrical conductivity (mS/cm)	9.3	0.8	9.4
Nitrogen, N (%)	3.1	0.7	2.1
Phosphorus, P (%)	1.5	ND	ND
Potassium, K (%)	0.2	ND	ND
Carbon, C (%)	52.2	62.3	56.3
C/N ratio	17.1	95.9	27.2

ND – Not determined

EXPERIMENTAL SET-UP AND DESIGN

The composting process was carried out using the Active Zone-Yield composter (AZY) located at the Faculty of Engineering, UMS. Figure 1 illustrates the design of the front and back view of the AZY composter. The AZY composter consists of three-compartment, which are A, B and C. The volume of both compartments A and B is 0.9 m^3 and 1.5 m^3 for compartment C. Figure 1b shows the design of the back view of the composter. Each compartment has 15 holes in the back wall with a diameter of 2.6 cm and 10 cm length to maintain natural air convection. Two trials were run simultaneously. Trial 1 was conducted in compartment A, while Trial 2 was completed in compartment B. Compartment C, on the other hand, is the yield compartment, where the final compost is stored. Typically, composting requires mixing by turning. In most literature, the aim of mixing (or turning) is to gain substrates, nutrients, and moisture that are available to micro-organisms, homogeneously. However, in this study, no turning was performed during the composting process. The composting process lasted for 40 days.

300 g samples were taken from 10 different points from the mixture and were mixed manually to make a

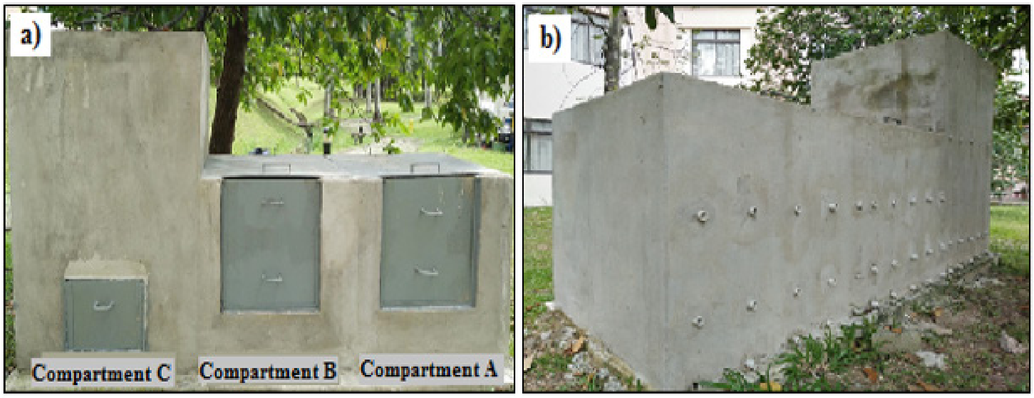

FIGURE 1. The a) front and, b) back view of Active Zone-Yield (AZY) composter

homogenized sample. The temperature was measured daily from five different points. The moisture content (MC) was determined by drying the sample at 103 °C in an incubator (Binder) for 24 h. The percentage of moisture content was calculated using equation (1). The total organic carbon (TOC) was determined by burning the oven-dry samples using a high-temperature furnace (Thermolyne 46100) at 550 °C for 4 h (Yaser et al. 2007). The ash was calculated using equation (2) (Zahrim et al. 2019), and the TOC was calculated using equation (3).

$$\text{MC (\%)} = \frac{\text{weight of wet sample} - \text{weight of dry sample}}{\text{weight of wet sample}} \quad (1)$$

$$\text{Ash (\%)} = \frac{W_{\text{crucible + sample (after burning)}} - W_{\text{crucible}}}{W_{\text{sample}}} \times 100 \quad (2)$$

$$\text{TOC (\%)} = \frac{100 - \text{ash}}{1.8} \quad (3)$$

For measuring the pH and conductivity of the compost, a 5 g sample of the compost was added to 50 mL of distilled water. The mixture was mixed using a magnetic stirrer for 20 min and left for 24 h. After the mixture was filtered, the pH and conductivity were measured using a pH/EC/TSD/°C portable meter (Hanna Hi 9811-5). For N, P and K tests, dried samples were used. Nitrogen (N) was measured using a protein analysis method by following Malaysian Standard (MS 417: Part 3: 1994). Phosphorus (P) and potassium (K) were determined using inductively coupled plasma – optical emission spectrometry (ICP-OES).

The fresh sample was used for identification and enumeration of *Salmonella* and *E. coli* in compost. *Salmonella* counts were estimated following the Australian Standard method (AS 1766.2.5 1991) and *E. coli* (AS 1766.2.3 1992). For *Salmonella*, the sample was plated into XLD agar and incubated for 24 h at 37 ℃ while for *E. coli*, plates were incubated at 44.0 – 44.5 ℃ for 48 h and counted using the MPN technique. For Fourier transform infrared spectroscopy (FTIR) analysis, a mixture of dry compost samples and potassium bromide (KBr) were pressed into pellet before scanned within a detection range of 4 000-400 cm^{-1} using FTIR Agilent Cary 630. The surface morphology of the compost samples was observed by a Hitachi scanning electron microscope (SEM). For N, P, K, and pathogen analysis, samples were sent to Chemsain Konsultant Sdn Bhd.

POT TRIAL

Dwarf crape jasmine was chosen for pot trial in this study because it is widely used for landscaping around the university. For plant growth development, dwarf crape jasmine (dwarf *Tabernaemontana divaricata*) seedling was transplanted to a pot containing 0%, 2.5%, 5%, 10%, 20%, 30%, 40%, 50% or 100% (by weight) compost. Each pot was filled with compost and top soil, and each potting mixture had three replicates. The plants were watered daily using tap water and no additional nutrients were added. The dry matter weight, plant height and width, leaf surface area and total number of leaves were all calculated after 150 days. The EC and water holding capacity (WHC) of the initial mixture were also measured. The WHC (g water/g dry material) was calculated as equation (4) (Ahn et al. 2008);

$$WHC = \frac{(W_s - W_i) + MC \times W_i}{(1 - MC) \times W_i} \quad (4)$$

Where: W_i is the initial weight of sample (g)
W_s is the final weight of sample (g)
M_C is the initial moisture content of sample (decimal).

RESULTS AND DISCUSSION

TEMPERATURE AND MOISTURE CONTENT

Figure 2 shows the changes in temperature of the compost pile and ambient during the composting process. The ambient temperature varied between 30.3 ℃ and 36.2 ℃.

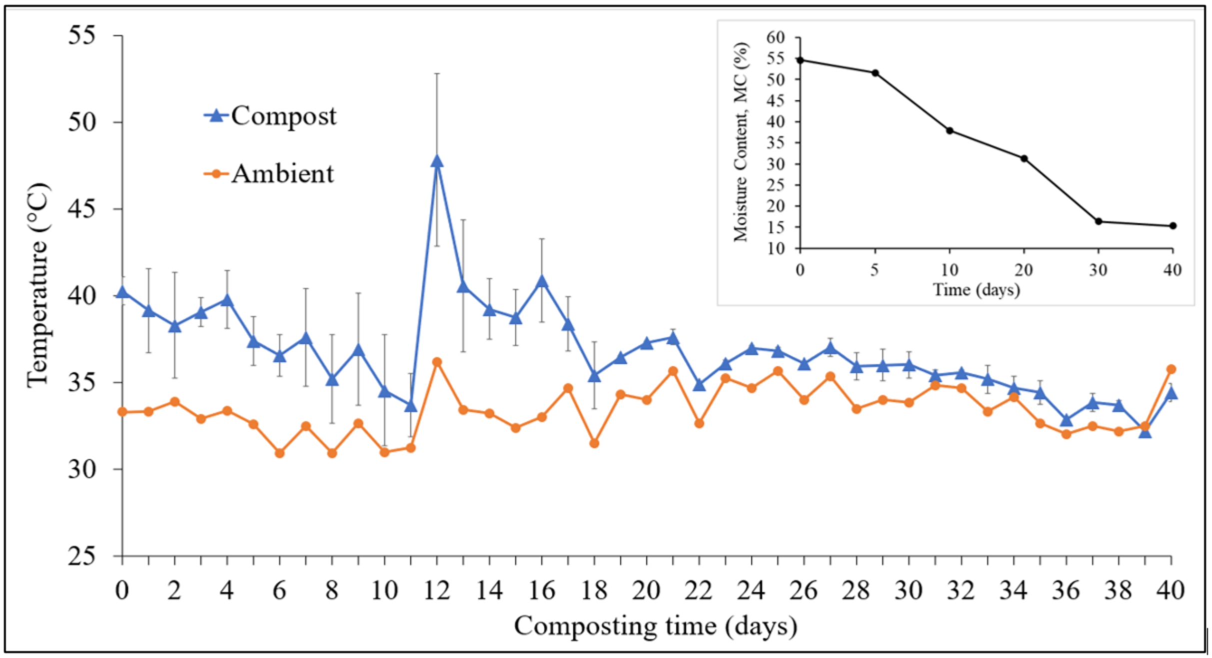

FIGURE 2. Temperature of the compost pile and ambient during the composting process; while the inset shows the profile of moisture content during the composting process

At the beginning of the composting process, the compost temperature was in the mesophilic temperature (< 40 °C). The temperature was rapidly increased to 47.8 °C on day 12 due to heat accumulation from microbial respiration. However, the compost temperature was maintained above 45 °C for only one day. After day 13, the compost temperature slowly reduced to ambient temperature. According to Wichuk & McCartney (2010), the compost is approaching a stable state when the compost temperature is equal to ambient temperature. Even though it is possible to carry out composting at mesophilic temperatures, it is more desirable and practical to remove pathogens at higher temperatures. Some previous studies also did not achieve more than 50 °C in composting (Karnchanawong & Nissaikla 2014; Sangamithirai et al. 2015; Young et al. 2016) while an average 6 °C temperature difference between compost and ambient temperature during the first 20 days of composting was observed by Guidoni et al. (2018). It is not that the composter did not work, but in this case, the ratio between dry leaves and food waste might contribute to the low temperature. In a previous study by our group with a different ratio, we managed to get 57 °C. Saalah et al. (2020) using a 1:1 ratio (food waste: dry leaves), while this study uses 3:1 (food waste: dry leaves).

The inset in Figure 2 shows the MC profile during the composting process. MC influences the composting process where higher or a lower value of MC from the optimum value may slow down the composting process. The initial MC in this study was 54.6%, which is in the optimum range for the composting process, which requires a minimum value of 50% for the microbial activity. The MC decreased to 15.4% on day 40. The decrease of MC during the composting process might be due to the evaporation of water from the compost mixture as well as due to the leaching process (Zahrim et al. 2018).

PH AND ELECTRICAL CONDUCTIVITY

The changes in pH and electrical conductivity (EC) during the composting process were shown in Figure 3. At the beginning of the composting, the pH was acidic (4.9) due to the organic acid formation. Other studies also report similar results where low pH value at the beginning of the composting process; pH value of 4.0 – 5.0 for composting kitchen waste and cornstalk (Yang et al. 2019), 5.0 – 5.5 for composting of food waste with various bulking agents (Margaritis et al. 2018) and 4.1 for composting of septage and organic waste (Thomas et al. 2020). The pH then increased due to the degradation of organic matter in which organic nitrogen was converted into ammonia. The pH value was maintained around 7.1 at the end of the composting and thus suitable for the seedling. Many studies recommended a pH range of 7.0 – 8.0 for final compost (Kalamdhad et al. 2009; Pandey et al. 2016).

EC is also one of the critical parameters in composting since it represents the salinity of the composting matrix. EC showed a contrary pattern compared to pH. The EC was slightly increasing at the beginning of the composting process and decreasing as the composting process progressed. The increase of EC at the initial stage was due to the decomposition of complex organic matter into

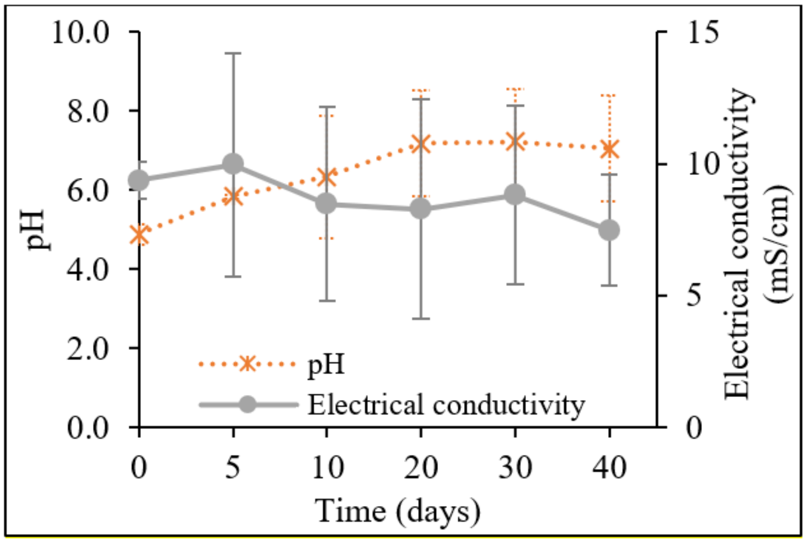

FIGURE 3. Changes of pH and electrical conductivity during the composting process

soluble components (Wang, Selvam et al. 2013). After day 5, the EC is continuously decreasing because of the generation of macro-molecular humus from the humification process (Yang et al. 2019).

The compost still has a high content of EC on day 40. The EC value must be below 4.0 mS/cm for safe use as a biofertilizer (Zhou et al. 2018). The usage of salt during cooking leads to the high salt content in feedstock and consequently has high EC value. Other studies also reported that food waste had high EC value. An EC value of 8.9 mS/cm of food waste was reported from (Shi et al. 2016), 7.8 mS/cm (Donahue et al. 1998), and 5.1 mS/cm (Agapios et al. 2020), respectively. However, there are several successful studies on food waste composting that produced compost with EC below 4.0 mS/cm (He et al. 2018; Waqas et al. 2018). Sangamithirai et al. (2015) suggested that final compost with high EC should be diluted 40 – 60% before using it as a soil amendment.

TOTAL ORGANIC CARBON

Figure 4 shows the total organic carbon (TOC) from this study and some previous studies during the composting period. The reduction of carbon during composting is mainly due to microorganisms' respiration and metabolism, as the microorganisms need organic carbon for their energy source (He et al. 2018; Pandey et al. 2016). Carbohydrates, proteins, lipids, and traces of inorganic compounds are the main content of food waste composition (Palaniveloo et al. 2020). The nitrogen in food waste was mainly organic nitrogen, which could be found in various molecular forms such as proteins, peptides, nucleic acids, amino acids, chitins, etc. The organic nitrogen was mineralized into ammonia in the water phase (Wang & Zeng 2018). Usually, carbohydrates, proteins, and lipids will break down to mono/disaccharides, amino acids, and fatty acids/glycerol, respectively (Dahiya et al. 2015), as shown below:

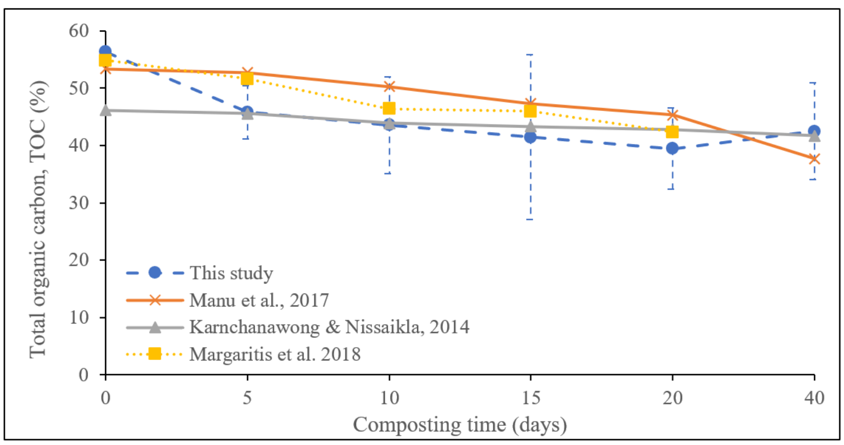

FIGURE 4. Comparison of the total organic carbon from this study and previous studies.

Carbohydrates → Mono/disaccharides

Proteins → Amino acids

Lipids → Fatty acids/glycerol

The degradation was rapid at the beginning of the composting and followed by slow degradation. This is attributed to a higher amount of biodegradable carbon sources in the initial feedstock and leads to a higher reduction of organic carbon compared to the end of composting (Yaser et al. 2007).

Changes in the C/N ratio indicate organic matter decomposition (Iqbal et al. 2010; Neugebauer & Sołowiej 2017; Onwosi et al. 2017). The initial C/N ratio depends on the type and ratio of feedstock used, and it should be between 20 – 30 to ensure rapid biodegradation of OM (Wang & Zeng 2018). If the initial C/N ratio is high, a lack of N source for microorganism growth will slow down the biodegradation (Chen et al. 2020).

The initial C/N ratio of feedstock was 23.3 (Manu et al. 2017), 50.9 (Karnchanawong & Nissaikla 2014), and 32.0 (Margaritis et al. 2018). The composting time becomes longer if the initial C/N ratio is higher (Azim et al. 2018). Kumar et al. (2010) reported that the total volatile solid reduction is related to moisture content and C/N ratio. The total volatile solid reduction is at its maximum when low MC and high C/N ratio or higher MC and low C/N ratio. From Figure 4, faster degradation in this study may occur due to high organic content (54.6% TOC) while low TOC composting (~46% TOC) by Karnchanawong & Nissaikla (2014) shows the slowest degradation attributed to high MC (74.8%).

NUTRIENTS CONTENT

Compost can be used in agriculture because it may contribute to a rise in soil organic matter levels and eventually improve the supply of nutrients to a crop. N, P, and K are essential for plant growth. Nitrogen is used to synthesize nucleic acids, amino acids, amides, proteins, nucleotides, co-enzymes, etc., making it the most restrictive plant growth factor. Phosphorus is essential for root growth and plays a vital function in plant metabolism. For proper plant growth and reproduction, potassium is necessary for large amounts because it is critical for photosynthesis (Garg et al. 2008).

The nutrient content of the compost is shown in Table 2. In this study, the N, P and K values on day 40 were 2.6%, 1.1% and 0.8%, respectively. A similar result was obtained by Bhave & Kulkarni (2019), where the final K value of passive aerated food waste composting was 0.7%. Based on the N, P and K values of the final compost, all the parameters were within the recommended range. It may help farmers minimize dependency on inorganic fertilizer and improve the soil quality simultaneously.

C/N ratio was one of the parameters to determine the maturity and stability of the compost (Lim et al. 2011; Pandey et al. 2016). The C/N ratio in this study decreased from 27.2 to 12.9. The decrease in the C/N ratio is possibly due to the mineralization of organic carbon (Wang & Zeng 2018).

PATHOGEN

The presence of a pathogen in compost must be considered because applying compost containing pathogen to the crop soil will impact the environment and then pose a threat to humans. Pathogens present in compost are bacteria, protozoa, viruses or helminths (Sunar et al. 2014). Many studies have used *Salmonella spp*. and *E. Coli* as an indicator to detect the presence of a pathogen in compost. At the end of the composting process in this study, *Salmonella spp*. was not detected in 25 g of a sample while *E. Coli* was detected in the compost at 51 MPN/g. A study by Cekmecelioglu et al. (2005) also reported the pathogen was not entirely inactivated due to the low temperatures during composting of food waste, manure, and bulking agent for 12 days. A similar finding was also found in other studies by Van Fan et al. (2018), where 7.5 MPN/g of *E. Coli* was found in the final compost of food waste, rice bran, and dry leaves with the maximum temperature of 46 °C. The absence of *Salmonella spp*. may be due to the

TABLE 2. Nutrient content of the final compost

	This study	Malaysia SIRIM MS 1517:2012 Standard (Keng et al. 2020)	Recommended range (Van Fan et al. 2016)
Nitrogen, N (%)	2.6 ± 0.3	> 1.5	> 1.0
Phosphorus, P (%)	1.1 ± 0.6	NA	0.6 – 1.7
Potassium, K (%)	0.8 ± 0.2	NA	0.4 – 1.1
C/N ratio	12.2 ± 1.2	< 25.0	≤ 25.0

complete removal during the composting process, or there is no presence of *Salmonella spp*. in the food waste mixtures at all. Meanwhile, the presence of *E. Coli* could be due to insufficient temperature for pathogen inactivation.

According to the EPA (2003), aerated static pile composting requires a temperature of 55 °C or higher for at least 3 days to attain adequate elimination of the pathogen in the composting process. This study did not meet that requirement. However, Wichuk & McCartney (2007) mentioned that compost with a temperature of more than 55 °C for three days cannot ensure it is pathogen-free. So, the pathogen inactivation cannot be measured by the time-temperature parameter only (Singh et al. 2011). Besides, segregated food waste and landscape waste were from medium and low-risk pathogen materials, respectively (Van Fan et al. 2016). With this type of waste, a pathogen-free compost can be yielded even without achieving the sanitation temperature (Van Fan et al. 2018). Table 3 shows the microbial standard for some countries. Based on the results of this study, it fulfilled the standard in all of the countries. Thus, the compost produced is safe to be used.

Most probable number (MPN); the possible concentration value that is close to its maximum value in a liquid medium, colony-forming unit (CFU); the number of distinguishable colonies of bacteria which form on a culture plate. The MPN estimates are highly variable compared to CFU (Gronewold & Wolpert 2008).

FUNCTIONAL GROUPS AND MORPHOLOGICAL STUDIES

The Fourier transform infrared (FTIR) spectroscopy is used to identify the chemical structure and functional groups of a matter based in the changes of relative absorbance intensity. The presence and absence of these functional groups indicate a process of degradation and stabilization (Lim & Wu 2016; Srivastava et al. 2020). The FTIR spectra of the initial and final composting process are shown in Figure 5.

The FTIR spectra exhibited similar areas of absorbance peaks with only changes in intensities. A broad peak at 3000 – 3600 cm^{-1} may be attributed to H bonded O-H stretching, which most likely come from carbohydrates (Hagemann et al. 2018). A peak at 2924 cm^{-1} signifies the presence of the C – H aliphatic asymmetric methylene

TABLE 3. The microbial standard for the pathogen of *Salmonella* spp and *Escherichia coli*

	Salmonella spp	*Escherichia coli`*
This study	Absent in 25 g	51 MPN/g
US EPA 503 (Gurtler et al. 2018)	< 4 MPN/3 g	NA
UK Composting Standard (Sunar et al. 2014)	Absent	< 1000 CFU/g
European standard (Brinton 2000)	Absent in 25 g	< 1000 MPN/g

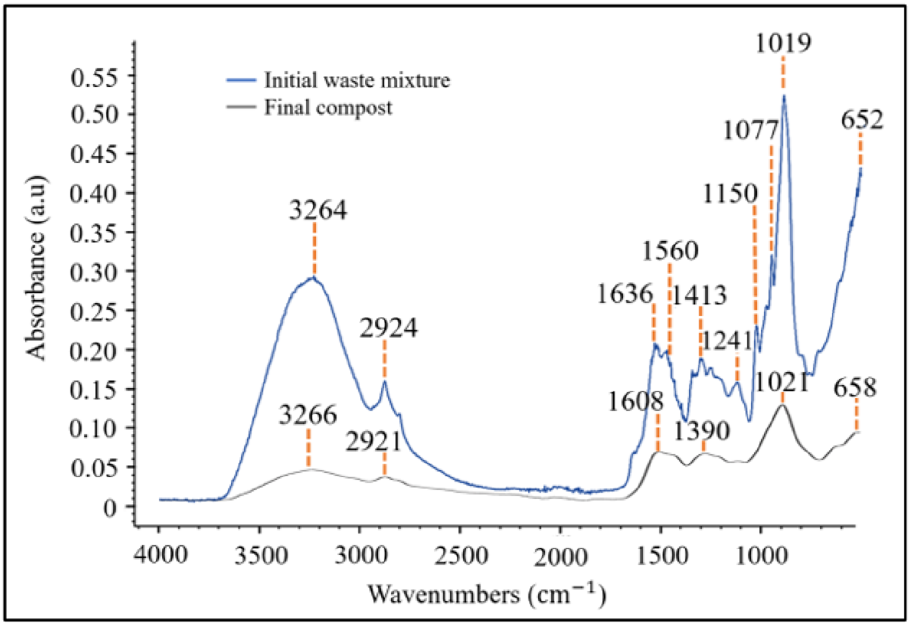

FIGURE 5. FTIR spectra during initial and final of the composting process

group (Voběrková et al. 2020). Peaks at 1636 cm^{-1} can be assigned to C=C in aromatic structure (Ait Baddi et al. 2004). A C=C of amide can contribute to a hardly visible peak around 1560 cm^{-1} (Voběrková et al. 2020). A peak between 1410 – 1450 cm^{-1} represents the COO- groups (Wang, Li et al. 2013). A broad but small peak at 1241 cm^{-1} can be attributed to C – O stretch vibrations of carboxylic acids (Tandy et al. 2010). A peak around 1020 – 1100 cm^{-1} indicates the C – O stretch of polysaccharides (Jindo et al. 2016).

Following the composting process, the height of the peak at 3000 cm^{-1} – 3600 cm^{-1} decreased. The decrease in intensity could be caused by the decomposition of carbohydrates, which results in a reduction in the atomic groups and structure of OH and CH_2 (Lim & Wu 2015, 2016). Similarly, a reduction of the band intensity at 2917-2925 cm^{-1} indicates the decomposition of aliphatic compound and stabilization or decomposition of feedstock. The absence of several functional groups such as polysaccharides and aromatic structure and the reduction in band height of carbohydrates and aliphatic from the initial compost mixture illustrate the compost stability and maturity (Srivastava et al. 2020).

The SEM images revealed several changes in the surface morphology of the compost samples. The scanning electron micrograph for the initial and final compost is shown in Figure 6. From the images obtained by the SEM-EDS analysis, it is observed that in the initial feedstock mixture, the structure was relatively compacted, more robust, and larger-sized particles. With the increase in time and degradation process, the size of particles was converted into a smaller-sized solid particle, a more fragmented and granular structure with an increase of voids on the surface indicating matured compost formation. The final compost structure was more uniform due to the complete degradation process (Ishak et al. 2014).

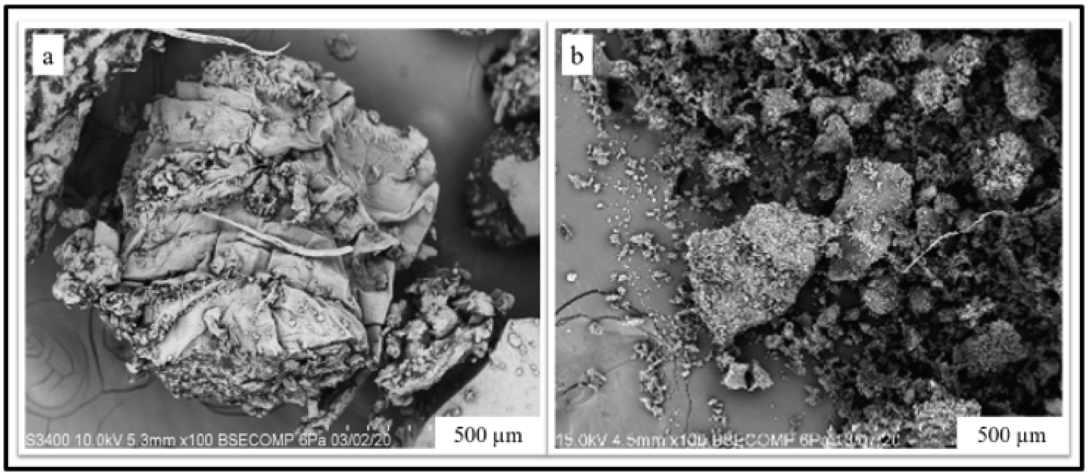

FIGURE 6. Scanning electron image during the initial (a) and final (b) of composting (magnification factor = 100)

POT TRIAL

Direct application of compost with a high EC value might be phytotoxic and is detrimental to the growth of plant seedlings. Phytotoxicity of the compost can be determined using a plant growth test, which is a relatively simple and direct process (Brinton 2000). Table 4 shows the EC and WHC of the mixture during the initial pot trial and the growth of dwarf *Tabernaemontana divaricata* after 150 days. As shown in Table 4, the WHC and EC were increased with an increasing proportion of compost. All mixtures have an optimum EC value (< 4.00 mS/cm) except mixture with 100% compost. Figure 7 shows the effect of compost proportion on plant growth. The maximum plant growth was observed in 5% - 20% of compost medium. After 150 days, the height of plants ranges from 0 to 21.5 cm while the plant width ranges from 0 to 24.3 cm. The media with 20% of compost has the highest value of dry weight (5.2 ± 0.5 g), leaf area (4.7 ± 1.0 cm2) and number of leaves (184.3 ± 20.4). Plant with 10% and 5% compost has the highest plant height (21.5 ± 1.7 cm), and plant width (24.3 ± 6.4 cm), respectively. Poor growth of dwarf crape jasmine in 100% compost media, likely due to high salinity (Bugbee 2002; Garcia-Gomez et al. 2002). A study by Morales et al. (2016) also reported that media with high EC value (5.6 mS/cm) produced lower melon fresh weight compared to media with low EC. The plant growth in 5% - 20% compost media was better than in 0% compost, which is similar to the findings by Shuhaimi et al. (2019) where Roselle in food waste compost and topsoil media showed greater growth in terms of number of the leaves, the number of fruits, total leaf area and dry weight compared to topsoil only. This might be due to food waste compost providing extra macronutrients to the plants (Shuhaimi et al. 2019).

TABLE 4. Electrical conductivity and water holding capacity during initial of pot trial and plant growth after 150 days

Compost in media (% by weight)	WHC (g water/g dry sample)	EC (mS/cm)	Dry weight (g)	Plant height(cm)	Plant width(cm)	Leaf area(cm^2)	Number of leaves
0	0.4 ± 0.0	0.1 ± 0.0	3.2 ± 0.5	16.3 ± 1.2	16.6 ± 2.4	3.8 ± 0.5	80.3 ± 13.5
2.5	0.4 ± 0.0	0.1 ± 0.0	2.5 ± 0.6	19.0 ± 1.2	19.3 ± 1.4	4.4 ± 0.3	135.7 ± 17.8
5	0.2 ± 0.0	0.2 ± 0.0	3.3 ± 1.1	19.5 ± 0.6	24.3 ± 6.4	4.1 ± 0.9	159.0 ± 39.2
10	0.3 ± 0.0	0.3 ± 0.1	4.5 ± 1.7	21.5 ± 1.7	23.4 ± 2.8	4.4 ± 1.1	140.3 ± 53.5
20	0.5 ± 0.1	0.3 ± 0.1	5.2 ± 0.5	20.5 ± 3.1	23.9 ± 0.2	4.7 ± 1.0	184.3 ± 20.4
30	0.5 ± 0.1	0.9 ± 0.3	4.1 ± 1.4	19.5 ± 3.1	20.6 ± 2.0	4.0 ± 0.1	147.3 ± 53.4
40	0.7 ± 0.1	1.3 ± 0.5	4.3 ± 1.8	18.4 ± 2.9	21.5 ± 1.0	4.3 ± 1.0	139.3 ± 44.5
50	0.8 ± 0.1	1.1 ± 0.6	0.5 ± 0.4	5.9 ± 10.3	3.9 ± 6.8	0.6 ± 1.0	0.00
100	2.1 ± 0.1	4.8 ± 1.2	0.3 ± 0.0	0.00	0.00	0.00	0.00

FIGURE 7. Effect of compost proportion in media on growth dwarf crape jasmine after 150 days

CONCLUSION

In this study, the maximum temperature was achieved at 47.8 °C on day 12. The moisture content was recorded at 15.4%, while pH and EC values were 7.1 and 7.5 mS/cm on day 40, respectively. The organic carbon shows a rapid loss in the beginning and slowly degrades after day 30. The N, P and K values of the compost were within the recommended range. The pathogen results met the limit. These results show that food waste composting with high EC compost value can be used to promote dwarf crape jasmine growth, provided that the mixture contains low compost dosage.

ACKNOWLEDGEMENT

The authors acknowledge University Malaysia Sabah for the financial aid (SDN0042-2019 & SDG03-2020) and postdoctoral awarded to Dr. Junidah Lamaming. The authors like to thank Patricia Bennedette Anak Danggau and Mohammad Fahim Inteser Alam for their assistance.

DECLARATION OF COMPETING INTEREST

None

REFERENCES

Abdullah, R., Osman, N., Yusoff, S., Yusof, H., Halim, N.S. & Rosli, N.S. 2021. Effects of palm kernel biochar and food waste compost on the growth of palm lily (*cordyline fruticosa*), coleus (*coleus sp.*), and boat lily (*rhoeo discolor*). *Applied Ecology and Environmental Research* 19: 205-218.

Abu Samah, M.A., Abdul Halim, M.I., Ibrahim, M.Z., Ahmad, M.N., Mohd Jan, N.H. & Kamarudin, M.K.A. 2020. Effects of iium food waste compost and inorganic fertilizer on growth performance of brassica juncea (mustard). *International Journal of Advanced Science and Technology* 29 (9s): 1600 - 1611.

Agapios, A., Andreas, V., Marinos, S., Katerina, M. & Antonis, Z.A. 2020. Waste aroma profile in the framework of food waste management through household composting. *Journal of Cleaner Production* 257: 120340.

Ahn, H.K., Richard, T.L. & Glanville, T.D. 2008. Laboratory determination of compost physical parameters for modeling of airflow characteristics. *Waste Management* 28 (3): 660-670.

Ait Baddi, G., Hafidi, M., Cegarra, J., Alburquerque, J.A., Gonzálvez, J., Gilard, V. & Revel, J.-C. 2004. Characterization of fulvic acids by elemental and spectroscopic (FTIR and ^{13}C-NMR) analyses during composting of olive mill wastes plus straw. *Bioresource Technology* 93 (3): 285-290.

Awang, Y., Shaharom, A.S., Mohamad, R.B. & Selamat, A. 2009. Chemical and physical characteristics of cocopeat-based media mixtures and their effects on the growth and development of c*elosia cristata*. *American journal of agricultural and biological sciences* 4 (1): 63-71.

Azim, K., Soudi, B., Boukhari, S., Perissol, C., Roussos, S. & Thami Alami, I. 2018. Composting parameters and compost quality: A literature review. *Organic Agriculture* 8 (2): 141-158.

Bhave, P.P. & Kulkarni, B.N. 2019. Effect of active and passive aeration on composting of household biodegradable wastes: A decentralized approach. *International Journal of Recycling of Organic Waste in Agriculture*.

Brinton, W.F. 2000. *Compost Quality Standards and Guidelines.*

Bugbee, G.J. 2002. Growth of ornamental plants in container media amended with biosolids compost. *Compost Science & Utilization* 10 (2): 92-98.

Cekmecelioglu, D., Demirci, A. & Graves, R.E. 2005. Feedstock optimization of in-vessel food waste composting systems for inactivation of pathogenic microorganisms. *Journal of Food Protection* 68 (3): 589-596.

Chen, T., Zhang, S. & Yuan, Z. 2020. Adoption of solid organic waste composting products: A critical review. *Journal of Cleaner Production* 272: 122712.

Chitravadivu, C., Balakrishnan, V., Manikandan, J., Elavazhagan, T. & Jayakumar, S. 2009. Application of food waste compost on soil microbial population in groundnut cultivated soil, india. *Middle-East Journal of Scientific Research* 4 (2): 90-93.

Dahiya, S., Sarkar, O., Swamy, Y.V. & Venkata Mohan, S. 2015. Acidogenic fermentation of food waste for volatile fatty acid production with co-generation of biohydrogen. *Bioresource Technology* 182: 103-113.

Dexin, S., Evanylo, G. & Goatley, J.M. 2012. Effects of compost sources and seeding treatments on germination and emergence of four turfgrass species. *Compost Science & Utilization* 20 (3): 165-170.

Donahue, D.W., Chalmers, J.A. & Storey, J.A. 1998. Evaluation of in-vessel composting of university postconsumer food wastes. *Compost Science & Utilization* 6 (2): 75-81.

Garcia-Gomez, A., Bernal, M.P. & Roig, A. 2002. Growth of ornamental plants in two composts prepared from agroindustrial wastes. *Bioresource Technology* 83 (2): 81-87.

Garg, V.K., Gupta, R. & Yadav, A. 2008. Potential of vermicomposting technology in solid waste management. In *Current Developments in Solid-State Fermentation*, edited by Ashok Pandey, Carlos Ricardo Soccol and Christian Larroche, 468-511. New York, NY: Springer New York.

Gronewold, A.D. & Wolpert, R.L. 2008. Modeling the relationship between most probable number (MPN) and colony-forming unit (CFU) estimates of fecal coliform concentration. *Water Research* 42(13): 3327-3334.

Guidoni, L.L.C., Marques, R.V., Moncks, R.B., Botelho, F.T., da Paz, M.F., Corrêa, L.B. & Corrêa, É.K. 2018. Home composting using different ratios of bulking agent to food waste. *Journal of Environmental Management* 207: 141-150.

Gurtler, J. B., Doyle, M.P., Erickson, M.C., Jiang, X., Millner, P. & Sharma, M. 2018. Composting to inactivate foodborne pathogens for crop soil application: A review. *Journal of Food Protection* 81 (11): 1821-1837.

Hagemann, N., Subdiaga, E., Orsetti, S., de la Rosa, J.M., Knicker, H., Schmidt, H.-P., Kappler, A. & Behrens, S. 2018. Effect of biochar amendment on compost organic matter composition following aerobic composting of manure. *Science of The Total Environment* 613-614: 20-29.

Haouas, A., El Modafar, C., Douira, A., Ibnsouda-Koraichi, S., Filali-Maltouf, A., Moukhli, A. & Amir, S. 2021. Evaluation of the nutrients cycle, humification process, and agronomic efficiency of organic wastes composting enriched with phosphate sludge. *Journal of Cleaner Production* 302: 127051.

Hashemimajd, K., Kalbasi, M., Golchin, A. & Shariatmadari, H. 2004. Comparison of vermicompost and composts as potting media for growth of tomatoes. *Journal of Plant Nutrition* 27(6): 1107-1123.

He, X.-T., Logan, T.J. & Traina, S.J. 1995. Physical and chemical characteristics of selected US Municipal solid waste composts. *Journal of Environmental Quality* 24 (3): 543-552.

He, Z., Lin, H., Hao, J., Kong, X., Tian, K., Bei, Z. & Tian, X. 2018. Impact of vermiculite on ammonia emissions and organic matter decomposition of food waste during composting. *Bioresource Technology* 263: 548-554.

Iqbal, M.K., Shafiq, T., Hussain, A. & Ahmed, K. 2010. Effect of enrichment on chemical properties of MSW compost. *Bioresource Technology* 101(15): 5969-5977.

Ishak, N.F., Ahmad, A.L. & Ismail, S. 2014. Feasibility of anaerobic co-composting empty fruit bunch with activated sludge from palm oil mill wastes for soil conditioner. *Journal of Physical Science* 25(1): 77.

Jarboui, R., Dhouib, B. & Ammar, E. 2021. Effect of food waste compost (FWC) and its non-aerated fermented extract (NFCE) on seeds germination and plant growth. *Open Journal of Soil Science* 11(2): 17.

Jindo, K., Sonoki, T., Matsumoto, K., Canellas, L., Roig, A. & Sanchez-Monedero, M.A. 2016. Influence of biochar addition on the humic substances of composting manures. *Waste Management* 49: 545-552.

Kalamdhad, A.S., Singh, Y.K., Ali, M., Khwairakpam, M. & Kazmi, A.A. 2009. Rotary drum composting of vegetable waste and tree leaves. *Bioresource Technology* 100 (24): 6442-6450.

Karnchanawong, S. & Nissaikla, S. 2014. Effects of microbial inoculation on composting of household organic waste using passive aeration bin. *International Journal of Recycling of Organic Waste in Agriculture* 3 (4): 113-119.

Keng, Z.X., Chong, S., Ng, C.G., Ridzuan, N.I., Hanson, S., Pan, G.-T., Lau, P.L., Supramaniam, C.V., Singh, A., Chin, C.F. & Lam, H.L. 2020. Community-scale composting for food waste: A life-cycle assessment-supported case study. *Journal of Cleaner Production* 261: 121220.

Kumar, M., Ou, Y.-L. & Lin, J.-G. 2010. Co-composting of green waste and food waste at low C/N ratio. *Waste Management* 30(4): 602-609.

Kumari, N., Sharma, A., Devi, M., Zargar, A., Kumar, S., Thakur, U., Bhatia, A., Badhan, K., Chandel, S., Devi, A., Sharma, K., Kumari, S., Choudhary, M. & Giri, A. 2020. Compost from the food waste for organic production of cabbage, cauliflower, and radish under sub-tropical conditions. *International Journal of Recycling Organic Waste in Agriculture* 9 (4): 367-383.

Lee, J.-J., Park, R.-D., Kim, Y.-W., Shim, J.-H., Chae, D.-H., Rim, Y.-S., Sohn, B.-K., Kim, T.-H. & Kim, K.-Y. 2004. Effect of food waste compost on microbial population, soil enzyme activity and lettuce growth. *Bioresource Technology* 93(1): 21-28.

Lim, P.N., Wu, T.Y., Shyang Sim, E.Y. & Lim, S.L. 2011. The potential reuse of soybean husk as feedstock of *eudrilus* *eugeniae* in vermicomposting. *Journal of the Science of Food and Agriculture* 91 (14): 2637-2642.

Lim, S.L. & Wu, T.Y. 2015. Determination of maturity in the vermicompost produced from palm oil mill effluent using spectroscopy, structural characterization and thermogravimetric analysis. *Ecological Engineering* 84: 515-519.

Lim, S.L. & Wu, T.Y. 2016. Characterization of matured vermicompost derived from valorization of palm oil mill byproduct. *Journal of Agricultural and Food Chemistry* 64(8): 1761-1769.

Manu, M.K., Kumar, R. & Garg, A. 2017. Performance assessment of improved composting system for food waste with varying aeration and use of microbial inoculum. *Bioresource Technology* 234: 167-177.

Margaritis, M., Psarras, K., Panaretou, V., Thanos, A.G., Malamis, D. & Sotiropoulos, A. 2018. Improvement of home composting process of food waste using different minerals. *Waste Management* 73: 87-100.

Morales, A.B., Bustamante, M.A., Marhuenda-Egea, F.C., Moral, R., Ros, M. & Pascual, J.A. 2016. Agri-food sludge management using different co-composting strategies: Study of the added value of the composts obtained. *Journal of Cleaner Production* 121: 186-197.

Neugebauer, M. & Sołowiej, P. 2017. The use of green waste to overcome the difficulty in small-scale composting of organic household waste. *Journal of Cleaner Production* 156: 865-875.

Onwosi, C.O., Igbokwe, V.C., Odimba, J.N., Eke, I.E., Nwankwoala, M.O., Iroh, I.N. & Ezeogu, L.I. 2017. Composting technology in waste stabilization: On the methods, challenges and future prospects. *Journal of Environmental Management* 190: 140-157.

Palaniveloo, K., Amran, M.A., Norhashim, N.A., Mohamad-Fauzi, N., Peng-Hui, F., Hui-Wen, L., Kai-Lin, Y., Jiale, L., Chian-Yee, M.G. & Jing-Yi, L. 2020. Food waste composting and microbial community structure profiling. *Processes* 8(6): 723.

Pandey, P.K., Cao, W., Biswas, S. & Vaddella, V. 2016. A new closed loop heating system for composting of green and food wastes. *Journal of Cleaner Production* 133: 1252-1259.

Rosazlin, A., Fauziah, C., Wan Rasidah, K., Rosenani, A. & Kala, D. 2011. Assessment on the quality of recycled paper mill sludge mixed with oil palm empty fruit bunch compost. *Malaysian Journal of Soil Science* 15: 49-62.

Saalah, S., Rajin, M., Yaser, A.Z., Azmi, N.A.S. & Mohammad, A.F.F. 2020. Food waste composting at Faculty of Engineering, Universiti Malaysia Sabah. In *Green Engineering for Campus Sustainability*, edited by Abu Zahrim Yaser, 173-191. Singapore: Springer Singapore.

Sangamithirai, K.M., Jayapriya, J., Hema, J. & Manoj, R. 2015. Evaluation of in-vessel co-composting of yard waste and development of kinetic models for co-composting. *International Journal of Recycling of Organic Waste in Agriculture* 4(3): 157-165.

Shi, S., Zou, D., Wang, Q., Xia, X., Zheng, T., Wu, C. & Gao, M. 2016. Responses of ammonia-oxidizing bacteria community composition to temporal changes in physicochemical parameters during food waste composting. *RSC Advances* 6(12): 9541-9548.

Shuhaimi, S.A.-D.N., Kanakaraju, D. & Nori, H. 2019. Growth performance of roselle (*hibiscus sabdariffa*) under application of food waste compost and Fe_3O_4 nanoparticle treatment. *International Journal of Recycling of Organic Waste in Agriculture* 8(1): 299-309.

Singh, R., Kim, J., Shepherd, M.W., Luo, F. & Jiang, X. 2011. Determining thermal inactivation of *escherichia coli* O157:H7 in fresh compost by simulating early phases of the composting process. *Applied and Environmental Microbiology* 77(12): 4126-4135.

Srivastava, V., Goel, G., Thakur, V.K., Singh, R.P., Ferreira de Araujo, A.S. & Singh, P. 2020. Analysis and advanced characterization of municipal solid waste vermicompost maturity for a green environment. *Journal of Environmental Management* 255: 109914.

Sunar, N., Stentiford, E., Stewart, D. & Fletcher, L. 2014. The process and pathogen behavior in composting: A review. UMT-MSD 2009 Post Graduate Seminar 2009.

Tandy, S., Healey, J.R., Nason, M.A., Williamson, J.C., Jones, D.L. & Thain, S.C. 2010. FT-IR as an alternative method for measuring chemical properties during composting. *Bioresource Technology* 101(14): 5431-5436.

Thomas, A.R., Arulraj, P.R., Kranert, M. & Philip, L. 2020. Investigation on greenhouse gas emissions and compost dynamics during in-vessel co-composting of septage and mixed organic wastes. *International Journal of Environmental Science and Technology* 17(3): 1675-1690.

Toundou, O., Pallier, V., Feuillade-Cathalifaud, G. & Tozo, K. 2021. Impact of agronomic and organic characteristics of waste composts from togo on *zea mays L*. Nutrients contents under water stress. *Journal of Environmental Management* 285: 112158.

Van Fan, Y., Lee, C. T., Klemeš, J. J., Bong, C. P. C. & Ho, W.S. 2016. Economic assessment system towards sustainable composting quality in the developing countries. *Clean Technologies and Environmental Policy* 18 (8): 2479-2491.

Van Fan, Y., Lee, C.T., Klemeš, J.J., Chua, L.S., Sarmidi, M.R. & Leow, C.W. 2018. Evaluation of effective microorganisms on home scale organic waste composting. *Journal of Environmental Management* 216: 41-48.

Voběrková, S., Maxianová, A., Schlosserová, N., Adamcová, D., Vršanská, M., Richtera, L., Gagić, M., Zloch, J. & Vaverková, M.D. 2020. Food waste composting - is it really so simple as stated in scientific literature? – a case study. *Science of The Total Environment* 723: 138202.

Wang, K., Li, W., Gong, X., Li, Y., Wu, C. & Ren, N. 2013. Spectral study of dissolved organic matter in biosolid during the composting process using inorganic bulking agent: UV–vis, GPC, FTIR and EEM. *International Biodeterioration & Biodegradation* 85: 617-623.

Wang, S. & Zeng, Y. 2018. Ammonia emission mitigation in food waste composting: A review. *Bioresource Technology* 248: 13-19.

Wang, X., Selvam, A., Chan, M. & Wong, J.W.C. 2013. Nitrogen conservation and acidity control during food wastes composting through struvite formation. *Bioresource Technology* 147: 17-22.

Waqas, M., Nizami, A.S., Aburiazaiza, A.S., Barakat, M.A., Ismail, I.M.I. & Rashid, M.I. 2018. Optimization of food waste compost with the use of biochar. *Journal of Environmental Management* 216: 70-81.

Wichuk, K. & McCartney, D. 2007. A review of the effectiveness of current time-temperature regulations on pathogen inactivation during composting. *Journal of Environmental Engineering and Science* 6: 573-586.

Wichuk, K.M. & McCartney, D. 2010. Compost stability and maturity evaluation — A literature review. *Canadian Journal of Civil Engineering* 37(11): 1505-1523.
Wilson, S.B., Stoffella, P.J. & Graetz, D.A. 2002. Development of compost-based media for containerized perennials. *Scientia Horticulturae* 93(3): 311-320.
Wiranta, B.T.W. 2010. *Baja Kompos Untuk Tanaman Hias*. Kuala Lumpur: Synergy Media.
Yang, F., Li, Y., Han, Y., Qian, W., Li, G. & Luo, W. 2019. Performance of mature compost to control gaseous emissions in kitchen waste composting. *Science of The Total Environment* 657: 262-269.
Yaser, A.Z. 2020. Introduction. In *Green Engineering for Campus Sustainability*, edited by Abu Zahrim Yaser, 1-3. Singapore: Springer Singapore.
Yaser, A.Z., Rahman, R.A. & Kalil, M.S. 2007. Co-composting of palm oil mill sludge-sawdust. *Pakistan Journal of Biological Sciences* 10 (24): 4473-4478.
Young, B.J., Rizzo, P.F., Riera, N.I., Torre, V.D., López, V.A., Molina, C.D., Fernández, F.E., Crespo, D.C., Barrena, R., Komilis, D. & Sánchez, A. 2016. Development of phytotoxicity indexes and their correlation with ecotoxicological, stability and physicochemical parameters during passive composting of poultry manure. *Waste Management* 54: 101-109.
Zahrim, A., Sariah, S., Mariani, R., Azreen, I., Zulkiflee, Y. & Fazlin, A. 2019. Passive aerated composting of leaves and predigested office papers. In *Research Methods and Applications in Chemical and Biological Engineering*, edited by Ali Pourhashemi, Sankar Chandra Deka and A. K. Haghi, 217. Apple Academic Press Inc.
Zahrim, A., Yee, I., Thian, E., Heng, S., Janaun, J., Chong, K., Haywood, S., Tan, V., Asis, T. & Al-Mizi, T. 2018. Effect of pre-treatment and inoculant during composting of palm oil empty fruit bunches. *ASEAN Journal of Chemical Engineering* 2: 1-16.
Zhou, Y., Selvam, A. & Wong, J.W.C. 2018. Chinese medicinal herbal residues as a bulking agent for food waste composting. *Bioresource Technology* 249: 182-188.