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RESEARCH ARTICLE

PHYSICOCHEMICAL CHARACTERIZATION AND OPTIMIZATION OF ORGANIC FOOD WASTE COMPOST: PRACTICAL APPLICATION FOR SUSTAINABLE REGENERATIVE AGRICULTURE FARMING

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ABSTRACT

Extensive research has been conducted on creating compost from food waste by integrating various materials such as biochar and animal manure. Compost optimization often requires incorporating materials to enhance its effectiveness in promoting plant growth, rather than solely relying on food waste. However, there is a scarcity of studies assessing its effectiveness in practical applications until the compost is integrated with other materials. Hence, this study investigated the interaction between physicochemical characterization of organic food waste compost through its maturity and stability and aims to optimize the formulation of compost using food waste exclusively with its application effectiveness for sustainable approach of agriculture farming. In this work, a comprehensive investigation was conducted to explore the progression and characterization of this process. Compost produced from organic food waste was also evaluated for its maturity and stability using (i) structural characterization (scanning electron microscope (SEM) and Emmett and Teller (BET) surface area); (ii) spectroscopic analysis (Fourier transform infrared spectroscopy (FT-IR); (iii) thermogravimetric (TG) analysis; and (iv) DPPH scavenging activity. To assess the practical applicability of the compost, a model involving the utilization of the compost on mung bean plants was employed for assessment. Our results on SEM, BET, FT-IR, and TGA indicated that the finished compost was stable and proved maturity only when incorporated with eggshells. The compost exhibited favorable physicochemical and structural characteristics, leading to successful practical application.

KEYWORDS

Organic waste, compost, sustainable farming, waste management

1. INTRODUCTION

Organic compost waste can be described as any biodegradable material originating from plant or animal sources that can be utilized as a feedstock for composting. Fruit and vegetable scraps, coffee grounds, tea bags, eggshells, yard debris like grass and leaves, wood chips, livestock manure, and agricultural residues such as straw and crop residues are a few examples of organic compost waste. South Asia accounts for about 75% of open dumping of solid waste, followed by Sub-Saharan Africa, the Middle East, and North Africa. In countries with low or middle incomes, the amount of organic waste from human, agricultural, and industrial facilities is greater than 50%. There are several initiatives in place to address food waste, including Sustainable Development Goal 12.3 of the United Nations, which seeks to halve global per capita food waste and reduce food losses by 2030. For instance, France, which has implemented a law banning supermarkets from throwing away unsold food. The preferred technique for waste disposal in low-income countries still involves large quantities of global waste making its way to open dumping grounds and as a result, landfills emit toxic gases such as carbon dioxide and leachate which poses major risks to the environment and human health.

Although the investigation into organic compost fertilizer is not a recent pursuit, a critical consideration arises regarding the optimization of utilizing food waste independently, without the incorporation of supplementary materials. This focus on refining the standalone application of food waste is imperative for ensuring its effectiveness within the framework of regenerative farming. Rising awareness of the environmental and economic benefits of this approach has led to a surge in composting in recent years due to its high proportion of organic matter and nutrient-rich profile, which also lessens reliance on inorganic fertilizer, the agricultural application of organic waste is currently gaining awareness on a global scale. However, processing of these organic wastes is necessary before using them in agriculture (Srivastava et al., 2018). Composting has become a trend as it offers a simple and effective way for individuals, communities, and businesses to reduce waste, support soil health, and promote sustainability. It is a sustainable practice that eliminates waste, imitates the natural process of decomposition, and promotes the circular economy by recovering waste. Given the chances it creates for cooperation and education, composting can unite communities. Initiatives to increase community composting, public composting facilities, and composting workshops, can foster sociability and environmental awareness. Landfill is costly to operate and maintain, hence composting could assist by lowering expenses associated with waste management. Additionally, it lessens the need for soil supplements like artificial fertilizers, which can be expensive to buy.

Among the various waste management techniques, composting stands out as the most efficient approach for disposing of the organic fraction of solid waste. It is a natural process that transforms organic waste products like leaves, yard trimmings, and food scraps into a nutrient-rich soil

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supplement. Compost, which is the process' final byproduct, is a black, crumbly, and earthy-smelling substance that's frequently used as a soil amendment that can be utilized to boost crop yields, enhance soil quality in gardens, farms, and landscaping projects and thus, minimize the requirement for chemical fertilizers. Organic waste is a great supply of carbon, nitrogen, and other vital nutrients that microorganisms need to complete the composting process. Development of compost is generally understood as the biological oxidative decomposition of organic substances in wastes under controlled conditions that allow the development of aerobic micro-organisms converting biodegradable organic matter into a final product sufficiently stable for storage and application without adverse environmental effects.

The world can employ this approach for the efficient treatment of solid waste because it is both cost-effective and sustainable in nature. The primary objective of composting is to generate solid organic wastes into nutrient-rich soil conditioners and organic fertilizers, which reduces odor, phytotoxic compounds, weed seeds, and infections. Microorganisms like bacteria, fungi, and insects convert organic elements into simpler compounds such as carbon dioxide, water, and humus during the composting process. This process enhances the soil by releasing nutrients and minerals that are essential to plant growth.

Parameters such as maturity and stability of compost are crucial as these two factors determine the quality of the end product. The degree of biodegradation accomplished throughout the composting process determines the relationship between stability and biological activity of the compost, whereas maturity is related to the final compost's absence of phytotoxins (Wang, 2004). Phytotoxins are chemicals made by plants that can stop other plants from growing or developing. These substances may have detrimental effects on plant development and may obstruct seed germination, root growth, or general plant health. The absence of phytotoxins indicates that the compost has undergone sufficient decomposition and stabilization, which is a sign of compost maturity. Several researchers have investigated maturity and stability of compost, by employing variables such as pH and moisture content to assess the stability of compost. In a study published in 2016, the maturity and stability of compost generated from food scraps and sawdust were evaluated using physical, chemical, and biological indicators (Bazrafshan et al., 2016). After 63 days of composting, the researchers discovered that the compost had matured and achieved a stable state with a balanced ratio of carbon to nitrogen, a high level of organic matter decomposition, and low amounts of volatile organic acids. Based on the findings, sawdust and food waste can serve as appropriate feedstock for creating stable and mature compost.

The stability and maturity of compost created from food waste using various ratios of food waste to woodchips were examined in another study by (Waqas et al., 2018). The researchers discovered that a food waste to woodchips ratio of 2:1 resulted in the most mature and stable compost, with a low level of volatile organic acids, a high amount of total nitrogen, and good moisture content. The research also discovered the compost created during the trial could potentially be used to enrich soil. Based on research in 2012, stability and maturity of compost produced by windrow composting from yard and food waste were assessed (Rui Guo et al., 2012). In accordance with the study, utilizing a windrow composting technique, food scraps and yard waste can be combined to create stable, mature compost. These studies show that food waste can be a useful feedstock for producing stable and mature compost, which can then be used for applications, provided that appropriate composting processes and proper markers of stability and maturity are applied. However, it is typically a labor and time-intensive process, making it undesirable for business opportunities. Development of composting technology, however, has led to a resurgence in interest recently. There is, however, no ideal approach for assessing the process of composting and there is still plenty of demand for research into effective composting analysis parameters and it requires further research to assess its applicability. A significant amount of research has been done on producing compost from food waste incorporating other materials. A study was conducted that involved the inclusion of tobacco and bamboo biochar in compost to enhance nitrogen conservation and improve overall compost quality (Dongyi Li, 2023). Similarly, another research was conducted incorporating montmorillonite into green waste composting, aiming to yield a stable and mature compost (Lu Zhang, 2023). Furthermore, another researchers investigated the promotion of humification and phosphorus activation during food waste composting through the addition of black soldier fly larvae (Ivã Guidini Lopes, 2023). However, limited studies have assessed the efficacy of these approaches throughout the value-added composting process, suggesting the necessity for improved compost formulation and further research. The focus of this study was to examine the relationship between the physicochemical properties of mature and stable organic food waste compost and its effectiveness when applied as a sustainable agricultural farming approach. To the best of our knowledge, the optimization of compost generally necessitates the inclusion of supplementary materials such as biochar and animal manure to maximize its impact on plant growth, rather than relying solely on food waste as a standalone source. Various methodologies have been employed to explore the characterization and progression of this process. The maturity and stability of compost derived from organic food waste were assessed using multiple approaches, including SEM and BET, FT-IR, TGA, DPPH scavenging activity, and finally practical application of the compost.

2. MATERIALS AND METHODS

2.1 Directional Methods

This research was conducted at Chemistry Laboratory and Food Laboratory of Food Science and Technology, School of Applied Science and Mathematics, Universiti Teknologi Brunei, Brunei Darussalam and Department of Applied Chemistry, Graduate School of Engineering, Osaka University, Osaka, Japan.

2.2 Materials and reagents

The food waste was obtained from household waste and sawdust was bought from Rimba Garden Central, a local farmers' market in Brunei Darussalam. These materials were used as raw materials in this experiment. All the chemicals used in the experiment are of analytical reagent grades and were used as received. The reagents used in this experiment were 2,2,1-diphenyl-1-picrylhydrazyl DPPH, Bradford's dye reagent and methanol. The equipment used in this study were pH and EC meter (Horiba LAQUA F-74), muffle furnace, scanning electron microscope (Hitachi SU3500), UV-Vis spectrophotometer (BK-UV1900PC Biobase), Brunauer–Emmett–Teller (BET) (NOVA 4200e), thermal analyzer (Exstar TGDTA7200), fourier transform infrared (FT-IR) spectrometer (Thermo Fisher Scientific Nicolet iS5 FT-IR).

2.3 Collection and development of composting material

Composting process proposed in 2020 was carried out at laboratory level (Cristina Ghinea, 2020). Food waste such as banana peels, potato peels, watermelon rinds and eggshells were collected from household, shredded and weighed in the laboratory, and placed in plastic containers. The amount of sawdust added was adjusted based weight of food waste. In this experiment, a 2:1 ratio of food waste to sawdust was employed for mixing and preparation for composting. The plastic containers were modified by providing two layers of holes in order to facilitate natural air circulation. The composting process was monitored over 10 weeks. During the composting, the return and mixing of samples once at six days was carried out. After this period, compost was obtained which can be used as fertilizer for soil.

2.4 Physicochemical analyses of organic compost

2.4.1 Measurement of pH and electrical conductivity (EC)

Measurement of pH and EC was determined by suspension of compost in distilled water (ratio of 1:10 (c/w)), well mixed for 30 min, and then filtered through filter paper (Sasaki, 2003). Extracted samples were used to measure both pH and EC.

2.4.2 Determination of moisture content

10 g of compost was transferred to a weighed moisture tin and final weight was recorded. The moisture tin was dried overnight at 105°C. All samples were ground to powder for further analysis. The moisture content was obtained by the following calculation (Reeuwijk, 2002):

$$Moist\ (wt\%) = \frac{(A - B)}{(B - tare\ tin)} \times 100 \qquad (1)$$

As for the moisture correction factor (mcf) for sample to be weighed in analysis is:

$$Moisture\ Correction\ Factor\ (mcf) = \frac{(100 + \%moist)}{100} \qquad (2)$$

2.4.3 Determination of %Organic Matter Content

The method used for estimating the soil organic matter (SOM) was determined by ignition of the sample at high temperature at 550°C for 3 h. Loss-On-Ignition (LOI) based on (Schulte, 1996). An estimation of SOM percentage from the loss on-ignition method (SOMLOI) is calculated by the following equation:

$$SOM_{LOI} = \frac{(soil\ weight\ after\ combustion - oven - dry\ soil\ weight)}{oven - dry\ soil\ weight} \times 100 \tag{3}$$

2.4.4 Determination of organic carbon content

Total organic carbon content of compost was estimated by dry combustion method (Nelson, 1982). Result of SOM was recalculated applying a conversion factor of so-called Van Bemmelen 1.724. Final carbon content (%) was determined with the following equation:

$$\%\ SOC = \frac{SOM}{1.724} \tag{4}$$

2.4.5 Determination of nitrogen

Total nitrogen (N) content of compost was done by Bradford Protein Assay method. Bovine Serum Albumin (BSA) was used as the protein standard. The standard curve of protein concentration against absorbance was needed to calculate nitrogen content in compost. A standard series of protein dissolved in distilled water with different concentrations (0, 1, 2, 3, 4, 5, 6 mg/mL) was prepared and the absorbance of each concentration was measured at 595 nm. The results obtained for protein standard curve were plotted as protein concentration vs. absorbance at 595 nm. The correlation obtained by the linear regression for the protein standard curve is shown in Figure 1.

$$A_{595\ nm} = \ 0.0873 \times \ [BSA]_t - 0.0743 \tag{5}$$

where $[BSA]_t$ was expressed as mg/mL with $R^2 - 1$.

Bradford Protein Assay was used to initially evaluate the protein concentration in the compost to calculate its nitrogen content. Dye reagent was made by a ratio of 1: 4 (reagent:distilled water). 10 mL of dye reagent was diluted in 40 mL of distilled water. 100 µL of extracted liquid sample was mixed with 5 mL of dye reagent and incubated for 5 min. Samples were measured at 595 nm. Results obtained were calculated from the derived protein standard curve. After protein concentration was known, the nitrogen content was calculated using the equation as stated below (Mariotti et al., 2019).

$$W_p = 6.25 \times W_N \tag{6}$$

Where,

WP is the crude protein content, in grams per kilogram,

WN is the nitrogen content, in grams per kilogram.

2.4.6 Determination of C:N ratio

The carbon-to-nitrogen ratio was calculated using the equation below:

$$\frac{C}{N} = \frac{\%C}{\%N} \tag{7}$$

Where,

%C is the organic carbon content in %,

%N is the nitrogen content in %.

2.4.7 Scanning Electron Microscopy (SEM)

Scanning electron microscopy (SEM) of compost samples was conducted through a scanning electron microscope. Samples were grounded and sieved to 0.5 mm particle size. Double-sided adhesive was used to secure the powdered samples to the specimen holder. The mounts were coated with gold after being dried under a strong vacuum. Scrutiny of these specimens was made at 4000X magnifications.

2.4.8 Brunauer–Emmett–Teller (BET)

The surface areas of the grounded samples were measured via BET based on a method by (Su Lin Lim, 2015) using liquid nitrogen as the adsorbate at 50.0 K. The samples were de-gassed at 90°C for 2 h and then at 110°C for 22 h prior to the adsorption analysis. Results recorded were corroborated with the observation obtained from the SEM micrographs of all samples including control.

2.4.9 Thermogravimetric Analysis (TGA)

Thermogravimetric analysis was accomplished using a simultaneous thermal analyzer. Grounded samples (5-10 mg) were combusted from 30 to 700°C at a heating rate of 10°C/min using a platinum pan and pressure was sustained at 300 kPa (Díaz, 2021). The percentage of sample weight loss used to represent TG profiles. The first derivative of the TG profiles was employed to generate differential thermogravimetry (DTG) curves, demonstrating the rate of weight loss.

2.4.10 Fourier Transform Infrared (FT-IR)

The Fourier transform infrared (FT-IR) study was performed on a spectrometer. 2 mg of each sample was placed on the diamond crystal to collect the spectrum. The bands that were measured varied from 4000 cm^{-1} to 400 cm^{-1} with an interval of 2 cm^{-1}. For a uniform display and analysis, baseline corrections were made to spectra, and absorbance was standardized.

2.4.11 Determination of Antioxidant Activity by DPPH in compost

Antioxidant capacity of samples was determined by the methodology based on scavenging 2,2,1-diphenyl-1-picrylhydrazyl (DPPH) free radicals by inherent antioxidant in compost (Brand-Williams, 1995). A sample preparation was made by diluting 0.01 g of sample in 10 mL of distilled water to make a concentration of 1000 ug/mL. More concentrations (0, 10, 50, 100, 250, and 500 ug/mL) were created through a series of 1000 ug/mL dilutions. In preparation of DPPH, 1.5 mg of DPPH was dissolved in 30 mL of methanol to create methanolic DPPH, which was then covered to provide light protection. For all DPPH assays, 1.0 mL of methanolic DPPH was added in 1.0 mL of sample, mixed vigorously, and allowed to stand for thirty minutes at a dark environment for a subsequent reading in the spectrophotometer at 517 nm. The blank used in this assay was made up of methanolic DPPH. Decreased absorbance of DPPH solution is a measurement of radical scavenging activity (RSA) in percentage. The DPPH concentration against absorbance was needed to calculate remaining DPPH concentrations in the samples. Plotting DPPH concentration vs. absorbance at 517 nm represented the results for the %RSA.

The remaining DPPH percentages were calculated by:

$$\%DPPH = \left(\frac{A_{Control} - A_{Sample}}{A_{Sample}}\right) \times \ 100 \tag{8}$$

2.4.12 Application of compost

Matured compost was tested by planting five mung beans (*Vigna Radiata L.*) in a pot. Mung beans were cultivated under three conditions: with soil as a control, with compost alone, and soil mixed with compost for comparative analysis. This application was done in triplicate to obtain average data. The growth of the plants was observed every day for two weeks and the growth of the plants was recorded based on the height.

3. RESULTS AND DISCUSSION

3.1 Changes in physicochemical properties

This study examined the effect of maturity and stability of organic food waste compost and its application effectiveness. Changes in physicochemical properties contributed to the final quality of compost and the result showed significant changes. The changes in physicochemical properties of initial and final compost are shown in Table 1. As compared to the initial substrate, the final compost in this study was more stable and had a richer nutritional profile. It was discovered that the physical and chemical characteristics of the final compost varied greatly from its initial material. Through the evolution of the composting process, the pH of the substrate declined significantly, and it was 6.29 in the finished compost as opposed to 7.25 in the initial compost. The electrical conductivity (EC) rose substantially from 1.49 to 2.00 mS in the initial compost and final compost, respectively. The pH dropped from 7.29 to 6.25, it will continually drop during the start of the aerobic degradation process and eventually, rise again with the decomposition of organic matter by microorganisms (Cecilia Sundberg, 2013). The pH decline may be attributed to the bioconversion process' production of carbon dioxide (CO_2), ammonia (NH_3), nitrates (NH_{3}-), orthophosphates ($PO_4{}^{-3}$), and organic acids (Sharma, 2019). The decomposition of organic matter and increased amounts of soluble mineral salts in forms that are usable during composting were responsible for the rise in EC. In accordance with

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(Network, 2019), compost must meet certain minimal quality criteria such as pH 4 and 9 and EC 190 mS/m. The optimal pH levels recommended by (WRAP, 2018) could vary from 6 to 8, with a maximum of 9.

Table 1: Physicochemical properties of compost

Sample	pH	EC	MC (%)	LOI (%)	TOC (%)	TN (%)	C/N Ratio
Initial Compost	7.25±0.12	1.49±0.02	31.83±1.49	41.89±0.76	24.30±0.01	2.15±0.02	11±0.13
Final Compost	6.29±0.49	2.0±0.04	16.58±0.06	42.88±1.67	23.86±0.97	2.52±0.07	9±0.15

- Note: The reported values are the mean ± SD.
- MC, moisture content; LOI, loss on ignition (%); TOC, total organic carbon; TN, total nitrogen; C/N; carbon to nitrogen ratio

The moisture content (MC) was monitored during the entire process and showed a noticeable decline. Initial compost had 31.83% of moisture while the final compost had 16.58% which is below the optimal range of 40-70% for waste biodegradation (Benbelkacem, 2010).

Compared to initial compost, total organic carbon (TOC) dropped from 24.3% to 23.86% in the final compost. The pattern of TOC loss can be attributed to the mineralization and degradation of organic materials. Likewise, a reduction in organic carbon was caused by respiratory activity and the microbial population assimilating carbon. The final compost had a low TOC level and was rich in humic acid, indicating that the product had been stabilized.

Nitrogen content (TN) was discovered to be higher during the composting process, rising from 2.15 to 2.52% in the initial substrate and final compost, respectively. The stability and maturity of compost are indicated by the C/N ratio. Comparing the finished compost to the initial compost in the study, the C/N ratio drastically dropped to 9 from 11. The final compost had a lower C/N ratio due to the mineralization and degradation of organic matter, as well as carbon loss via respiration and N enrichment as the composting process progressed. The decomposition of complex compounds such as lignin, cellulose, and hemicellulose as well as a rise in humification rate reduced the C/N ratio. Initial C/N ratios of 25 to 30 are typically thought to be appropriate for composting (Rui Guo et al., 2012). However, recent studies have successfully conducted composting at lower C/N ratios; as a result, the compost generated in the current study has the potential to be regarded as mature and stable.

3.2 SEM and BET analysis during composting process

SEM can effectively monitor the microstructures and has been used to study the particle size, maturity and stability of compost (Arora, 2019). SEM of the initial compost, final compost and control are shown in Figure. 1. The final compost had a more porous, fractured, and granular structure than the initial waste and control, which had a comparatively compacted and flock-like structure. Several researchers used SEM to investigate changes in the surface structure of initial compost and final compost reported similar results (Su Lin Lim, 2014; Srivastava et al., 2020). Additionally, BET analysis of compost and control revealed that the compost has the largest surface area. BET surface areas for compost and control were 1.805 m^2/g and 0.550 m^2/g, respectively. The BET surface area appeared to correlate with the observation gathered from the SEM micrographs of the compost and control.

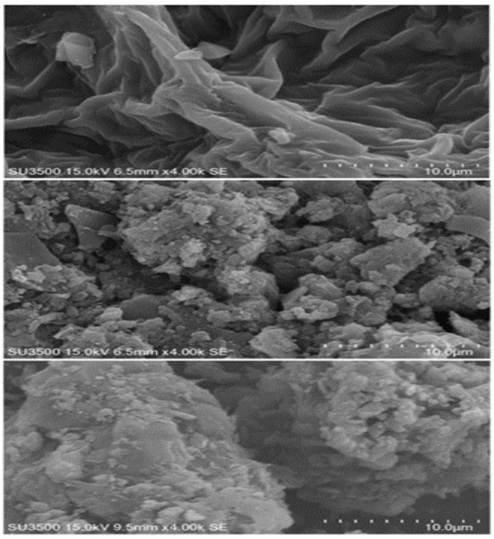

Figure 1: Scanning electron images of (a) initial compost, (b) final compost and (c) control.

3.3 Thermogravimetric Analysis (TGA) analysis of compost

TGA is a thermal method to evaluate how the mass of a sample varies as the temperature and heating rate are constantly increased. The measurement of the substrate material at two-time intervals during composting demonstrated thermal stability of samples, which was explained by mass loss due to oxidation, degradation, and dehydration. The percentage of sample weight loss used to represent TGA. The rate of weight loss was shown using differential thermogravimetry (DTG) curves that were created from the first derivative of TGA profiles. Figure 2 presents the initial and finished compost's TG and DTG curves. Under heating conditions, the mass of both samples gradually decreased.

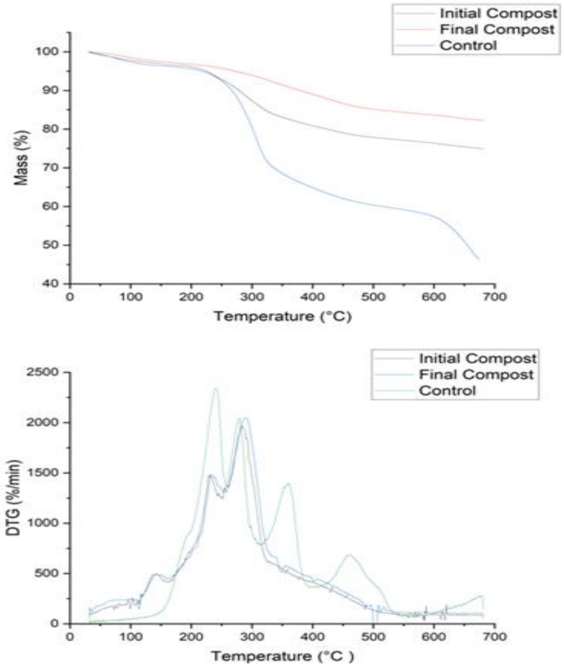

Figure 2: (a) Mass loss and (b) derivative thermogravimetry (DTG) curves analysis of control, initial and final compost

Under atmospheric conditions, the total mass losses at the end temperature of 800°C were 38, 38, and 93% for initial compost, final compost and control, respectively (Figure 2a). TGA curve of the final compost had a higher weight percentage (or lower mass loss) as compared to the initial wastes (Figure 2a). The differences in mass % of TGA result could be attributed to the increased volatile materials in the initial waste which equivalent to the volatile solid contents of the samples derived from combustion in muffle furnace at 550°C reported by (Lim et al., 2014). As a result of the increased molar complexity of carbohydrates and the extent of aromaticity, the final compost was comparably more stable since it contained a greater number of heat resistant chemicals (Khatua et al., 2018). Therefore, final compost was relatively more stable as higher temperature was required to achieve the same mass losses as compared to the initial compost.

The DTG curves (Figure 2b) showed three distinct peaks, that was three stages of mass loss. The first peak occurred in the temperature range of 50-150°C for all samples. At temperatures between 160 and 265°C, a steady decline in mass % was seen after dehydration. The mass loss formed in third peak was recorded at higher temperature range of 300–350°C. Mass loss seen in first peak of DTG result (Figure 2b) was caused by the dehydration of the remaining fluid in the samples. Similar results were noted by other researchers (Huayong Wu et al., 2011; Nuhaa Soobhany et al., 2017). Second peak which was between temperatures of 160°C to 265°C was attributed to the heat degradation of carbonaceous biomass, such as aliphatic molecules, carbohydrates, and carboxylic groups, as well as the decarboxylation processes of easily degradable materials (Soobhany et al., 2017; Khatua et al., 2018). This peak may have formed as a result of cellulose, hemicellulose, and microbial cell wall breakdown. It was confirmed by the FT-IR measurement (Figure 3) that the intensity had decreased. Third peak occurred at a higher temperature range between 300–350°C was caused by thermal dissociation and breakdown of extra stable and complex aromatic compounds such as lignin (Baffi et al., 2007; Khatua et al., 2018).

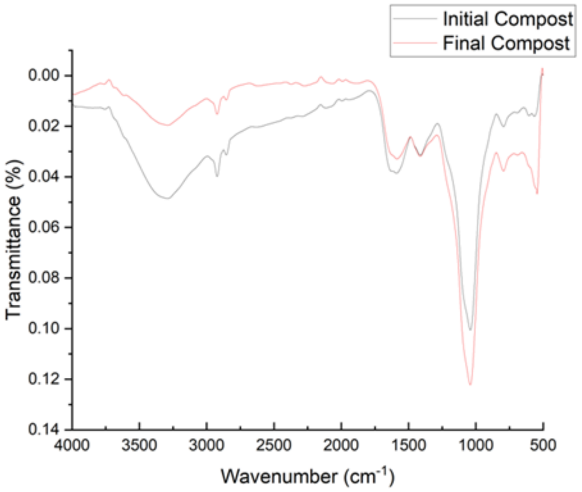

Figure 3: FT-IR spectra of initial and final compost

3.4 Changes in Fourier Transform Infrared (FT-IR) analysis during composting

Changes in the intensity of the absorbance can be utilized for assessing the stability of compost by using FT-IR spectroscopy to determine the substance's chemical functional groups. The FT-IR spectra of the initial and final compost are illustrated in Fig. 3. FT-IR spectra of initial and final compost, and control samples showed substantial differences. The main absorbance bands in the FT-IR spectra of 3 samples were 3500-3200 cm^{-1} (O-H, Hydrogen groups), 3000-2850 cm^{-1} (C-H, Alkane) 1630-1475 cm^{-1} (C=C, Alkene, Aromatic). The FT-IR spectra of final compost showed a significant reduction in the peak intensity at 3374 cm^{-1} when compared to the initial compost showing the breakdown of phenols and carbohydrates due to a decrease in hydroxide (OH^-) and methylene (CH_2) structures. Researcher observed identical outcomes while evaluating the maturation of organic compost (Cascant, 2016). The FTIR spectra of the compost in this study exhibited properties which, according to principle, were in line with the findings of compost literatures (Hussain, 2015; Srivastava, 2020). In contrast to initial compost, there was an apparent increase in the band intensity at 1646.4 cm^{-1} in the final compost. The rise in aromatic groups during composting may have caused this alteration. In 2009 researchers discovered an increase in band intensity around 1650-1640 cm^{-1} caused by aromatic C=C stretching in compost made from olive mill waste (Zainab Droussi et al., 2009). Another group of researchers noted a similar outcome during the investigation of the maturity of organic waste composts (Héla Makni et al., 2010). Due to increased concentrations of aromatic ethers and polysaccharides, the peak intensity rose at 1026 cm^{-1}. A significant peak bandwidth at 1070–1030 cm^{-1} due to aromatic ethers and carbohydrates in compost were reported by (Droussi et al., 2009). Alkyl halides and polysulfide groups can both be responsible for the peaks between 793.5 and 547.6 cm^{-1} with small differences in the final compost which corresponds with findings by (Reusch, 2013). The results of the FT-IR study indicated that the initial compost mixture's polysaccharides and carbohydrates disappeared, but the compost had developed aromatic compounds, nitro groups, and humic structures that showed stability and maturity.

3.5 Determination of Antioxidant Activity by DPPH

The compost's antioxidant capacity (AC) is determined by DPPH scavenging activity, which is proportional to AC. The percentage of radical scavenging activity (%RSA) is used to represent the antioxidant capacity results from the compost. AC of all sample concentrations was analyzed and presented in Table 2. Each concentration has a strong antioxidant content.

Table 2: DPPH radical scavenging activity (%RSA) of compost

	DPPH radical scavenging activity (%RSA)						
Compost	Conc. (ug/mL)	10	50	100	250	500	1000
	%RSA	71.1	71.4	72.0	73.3	74.7	78.6

3.6 Practical application of food waste compost

Over a period of 14 days, the growth of Mung beans was meticulously monitored, and the resulting height of the plant shoot was diligently recorded, considering the dynamic developmental changes observed throughout the experimental duration. Remarkably, it was observed that approximately 81.6% of the initially planted seeds displayed robust growth, with their shoots attaining lengths ranging from 5 to 8 cm, a promising testament to the potential benefits of the growth-promoting properties of the experimental conditions. The seeds sown in soil alone exhibited a moderate success rate in terms of mung bean growth however, their growth rate was notably slower compared to those planted with compost. This observation underscores the capacity of compost to augment growth by providing essential nutrients, fostering maturity, and enhancing stability.

Extensive scientific research and agricultural experiences consistently reveal the favorable effects of compost application on plant growth, yield, and overall soil health. Organic farmers, gardeners, and land managers widely acknowledge compost as a valuable and potent soil amendment. Composting with food waste alone can yield minimal effective results, but its overall quality in terms of nutrient content, pH balance, and other key attributes can be enhanced through the addition of specific materials. Incorporating supplementary components such as yard waste, eggshells, straw, or other carbon-rich and nitrogen-rich materials contributes to achieving a well-balanced and nutrient-enriched compost. In this research, eggshells were incorporated into the compost to distinguish the effectiveness of compost derived solely from food waste from that of compost enriched with eggshells. Eggshells have the potential to enhance food waste compost in several ways. They serve as a natural source of calcium, enriching the compost's mineral content. Additionally, they contribute to pH regulation, mitigating acidity within the compost. Furthermore, eggshells aid in promoting proper aeration and drainage, enhancing compost structure. Nevertheless, it is crucial to recognize that the effectiveness of compost can be influenced by a multitude of factors.

One of the potential causes of unsuccessful application is that some part of compost has turned anaerobic, meaning it has lost its ability to absorb oxygen. Excessively moist compost inhibits oxygen from circulating and creates anaerobic conditions, which is not the best environment for seedlings since it promotes hypoxia (oxygen deprivation) in roots. Secondly, anaerobic breakdown can release organic acids and substances similar to ammonia that could be harmful to seedlings. Compost must be kept moist but not saturated to prevent slow germination and rotting seedlings (Anthony, 2023). Additionally, lower moisture content could also lead to slower decomposition process of compost (Sherman., 1999; Diaz., 2007). Insufficient nitrogen could be another factor. The remaining components in the compost are broken down by bacteria using nitrogen, which deprives the seedlings of nutrients and turns them into a source of food for the microbes (Anthony, 2023). Compost can be enhanced with micronutrients and bacteria that are good for plants to increase organic benefits. This makes the compost biologically active, which increases the benefits it provides to agriculture and the environment by combining organic and biofertilizers (Neugart et al., 2018). The beneficial bacteria for plants are very active in converting the inaccessible forms of nutrients (such as N, P, Zn, etc.) and promote root and shoot growth by creating phytohormones. Bacteria both in the product and in the rhizosphere benefit from the presence of organic matter. The effectiveness of the finished product will increase with the bacteria's ability to survive in the compost (Siddiq et al., 2018). To the best of our knowledge, a significant amount of research has been done on producing compost from food waste alone. However, no study has reported its efficacy in the application up until the compost is value added, implying the formulation of compost needs to be improved and needs further research.

4. CONCLUSION

In this study, the potential for creating high-quality compost from organic food waste was examined in the lab to assess the effects of both stability and maturity of compost. The findings of this study indicated that the final compost was stable and matured enough, hence suitable for application. The application of compost proved effective when incorporated with organic material such as eggshells. The correlations of stability and maturity can be leveraged further to enhance the composting process. Application of bioactive compost and enhanced organic fertilizers to barren agricultural lands may have significant positive effects on the environment and the economy.

CONFLICT OF INTEREST

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