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ORIGINAL RESEARCH

Valorization of sawdust by co-composting with food waste using a small-scale composter

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Abstract

Purpose This study aimed to produce a value-added product by co-composting sawdust with food waste using a small-scale composter.

Method The composting experiment was carried out using 60L composting bins with a hole of 3 mm and 10 cm apart drilled on its side. Three experimental trials 1, 2 and 3 were adopted in this study with mixture of sawdust and food waste (Trial 1= 80% sawdust + 20% food waste, Trial 2 = 70% sawdust + 30% food waste, Trial 3 = 60% sawdust + 40% food waste). The composting process lasted for 90 days. Parameters examined throughout the composting process include temperature, moisture content, pH, electrical conductivity, organic matter content, and organic matter losses.

Results The results indicated that all the compost trials exhibit good development of composting process, with the highest solid organic degradation reached in a shorter period in compost trial 3. The temperature profile of the three trials are the same and above 60 ^{0}C after 30 days of composting. The compost samples had a pH ranging from 5.9 to 9.4. The electrical conductivity of the three composting trials was following the recommended value. The best compost trial that produces quality compost is compost trial 3.

Conclusion The results showed that all composts obtained were stable and matured. In brief, recycling sawdust through the composting process to obtain valuable end products is adequate but in the presence of nitrogen-rich waste, such as waste food materials.

Keywords Sawdust, Food waste, Composting techniques, Compost

Introduction

Nowadays, a huge amount of municipal solid wastes is being generated as a result of urbanization, rapid industrial development, a steady rise in the human population and, most importantly bad attitudes towards household waste disposal. The improper disposal of these wastes are continuously increasing and pose serious waste management challenges to humans, economies which in turn lead to the environmental burden. The accumulation of

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waste from households and manufacturing industries is the major source of pollution. Among these wastes, wastage of food is increasing daily. For instance, developing countries including Nigeria waste almost 21 million tons of food every year due to several reasons such as improper food chain supply poor storage system, economic crisis and delay in transportation (Yukesh et al 2020). In Nigeria and many other developing nations, many of these wastes are uncontrollably discharged in an open space forming a mammoth pile due to a poor collection system. Open dumping of wastes has been reported to have serious long-term effects on environmental factors (Yasin and Usman 2017). He (2019) reported that open discharge of waste can lead to air pollution causing a great health concern to humans.

Conventional methods of getting rid of these wastes have been a great challenge economically because of the requirement of huge financial resources. Open burning of waste is a common traditional practice in Nigeria, most especially in urban areas. This method of disposal through burning has many demerits such as the release of highly toxic pollutants which pose a serious threat to humans and the environment (Paritosh et al. 2017). Also, several other environmental and public health issues such as greenhouse gas (GHG) emissions, waste leachate, waterborne pollutants, soil and groundwater contamination along with odours and vector-borne diseases are occurring in the vicinity of disposal sites (Rahmani et al. 2015; Nizami et al. 2017). Ugya et al. (2018) reported that groundwater and surface water systems could also be contaminated through the infiltration of rainwater already contaminated with toxic materials from dumpsites and through runoff of contaminants from the dumpsites and mining area to the nearby stream.

Recently in Nigeria, there is an increase in demand for wood from timber for furniture and other construction purposes (Peter et al. 2017). As a result, a considerable amount of sawdust is generated from sawmills and this results in a mountain of sawdust being created at sawmill and dumpsite. Getting rid of this waste is a difficult challenge faced by saw millers. Many of the sawdust was dumped in nearby rivers and streams, many were used as landfills and many burnt regularly and it produces greenhouse gases and tons of harmful gases such as Nitrous oxide and carbon dioxide which are continuously released into the atmosphere and contribute to atmospheric warming (Peter et al. 2017). This gradual heating up of the environment could lead to climate change and global warming. It is, therefore, necessary to find a sustainable approach to recycle and recover this organic waste without causing an environmental hazard in the process. There are different techniques for converting waste into value-added products (Awasthi et al. 2016), among these available processes, composting is considered the best approach (Jara-Samaniego et al. 2017). According to Jarasamaniego et al. (2017), composting is encouraged because it is eco-friendly, cost-effective and conversion of waste to value-added products without causing an environmental hazard and the product can be used as organic fertilizer, soil stabilizer, and promoter of crops growth (Shi et al. 2016). Previously Yaser et al. (2007) have reported that sawdust can be co-composted with industrial sludge. During the composting process, microorganisms play an important role in converting organic material into stable material through the various biochemical processes, producing fiber-rich carbon-containing humus rich in organics such as nitrogen, phosphorus (Kishnet et al. 2020). These microorganisms perform well and operate vigorously in a balanced nutrients condition (Majeed et al. 2021). The development of these microorganisms during the composting process is particularly influenced by the C/N ratio which plays a crucial role because it represents the carbon and nitrogen sources necessary for their growth (Cristina and Ana 2020). These microbiomes involved in the composting process use carbon as a source of energy and nitrogen to build proteins (Kishnet et al. 2020). Due to the high carbon to nitrogen (C: N) ratio content of sawdust (Asadu et al. 2018), composting it alone would be difficult; it should be mixed with certain organic material with low C: N ratio content and high nitrogen content. Therefore, it is thus possible that, when sawdust is mixed with other organic materials rich in nitrogen, it will positively affect the efficiency and product quality. According to Li et al. (2013), food waste is organic materials with a low C: N ratio and high nitrogen content. Food waste has proved to be a convenient substrate for composting because of its easily degradable organic substances (Li et al. 2013). Therefore, understanding the effect of different proportions of both composting materials would contribute to the optimization of composting performance. Although different researchers have studied composting of food waste with different bulking agents (Yukesh et al. 2020, Gomez et al. 2020), the technology involved their management, and materials are costly and complex. The main objective of this work was to study the effects of composting different proportions of sawdust with food waste to obtain value-added products using a small-scale composter.

Materials and methods

Descriptions of bioreactor

60 L, low cost, and the non-biodegradable plastic container were used in this study (Fig.1). The plastic container is lightweight, easy to handle, control, and non-corrosive. The inner diameter of the container was 437 mm while the height was 565 mm. The filled line of 510 mm was marked from the bottom of the compost bin. Holes of 3 mm diameter 10 cm apart were drilled on the side and bottom of the container corresponding to 5% surface porosity; this was necessary to facilitate aeration and for the drainage of the leachate during the composting process. The reactor was placed on a styrofoam board to minimize heat transfer. The effective working volume of the bioreactors was 50 L, leaving the remaining 10 L as headspace.

Composting materials

The organic materials used were sawdust and food waste. The food wastes included cooked rice, vegetables, and fruits. Fresh sawdust from *Gmelina arborea* popularly known as Malaina tree was obtained from a local Sawmill, while the food wastes were collected from restaurants at the University of Ilorin campus. Sawdust was sieved using 5 cm mesh to obtain homogeneous materials. Bigger food particles were reduced manually to about 1.5 cm. The moisture contents of the sawdust and waste food were determined by oven-dried at 105 °C for 24 h. The basic characteristics of materials used shown in Table 1.

Table 1 Basic characteristics of materials used in the composting experiments

Parameter	**Food waste**	**Sawdust**
TN (%)	1.62 ± 0.16	1.54 ± 0.29
TOC (%)	30.34 ± 1.47	53.83 ± 0.20
C/N	9.48	34.95
pH	5.65 ± 0.11	5.36 ± 0.47
EC	57.63 ± 0.65	7.55 ± 0.47
Moisture content (%)	64.67 ± 1.12	35.74

Experimental setup and monitoring process

Composting experiment was carried out using the composting reactor of 60 L capacity (Fig. 1) and different proportions of composting materials. Three experimental trials 1, 2 and 3 were adopted in this study with mixture of sawdust and food waste (Trial 1= 80% sawdust + 20% food waste, Trial 2= 70% sawdust + 30% food waste, Trial 3 = 60% sawdust + 40% food waste) (Fig. 2). The moisture content of the material to be composted is one of the important factors affecting the composting process; the recommended range of the moisture is between 50 and 60% (Wang et al. 2021). Low moisture content would cause dehydration while too much moisture would lead to anaerobic and foul-smelling. Therefore, moisture contents were adjusted to the required range. After mixing the composting material, it was concluded to add water when the composting mixture is not intact when holding in the palm. 500 mL of water was sprayed into the compost and then mixed. This process was repeated until it remains intact when holding in the palm. Initial moisture contents were then determined by taking three replicate samples from the trials and oven-dried at 105 ºC for 24 h. The initial experimental compositions of each group are shown in Table 2.

Sampling and analysis Analytical methods

Each bin was turned manually weekly, making 12 times altogether, and watered at day 30 and 60. All relevant parameters like moisture content, pH, and EC were taken at an interval of seven days until the composts were stables. Temperature measurements of the composts were done thrice daily at 8 am, 12 pm, and 4 pm using a Reotemp compost thermometer starting from the first day until the last day. Temperatures were measured by inserting a temperature probe at the bottom, middle and upper levels of the compost through holes drilled on the side of the compost bins. All the experiments were performed under the same environmental conditions. Ambient temperatures were also taken daily throughout the experimental period 50 g of compost samples were taken from each bin at three different locations and were mixed thoroughly to make 0.15 kg samples on weeks 1, 2, 3, 4, and up to the last week. For pH and EC determinations, 50 g of compost were used. The pH and EC were measured by mechanical shaking the sample with distilled water at a ratio of 1: 10 (water to solid) for 1 h. The pH was measured with a pH meter (pH-3C, Shanghai, China) and EC was then measured using a conductivity meter (LeiCi, Shanghai, China).

To further explore the biodegradation of the compost mixtures, organic matter contents were also determined weekly by heating it in a furnace at 550 ºC for 6 h (USCC 2002). The organic matter contents were then fitted to a first-order kinetic model equation (1) by a non-linear least-square method to determine the rate of organic matter loss using OriginPro (Origin Lab Corp., Northampton, MA, USA)

$$OM_{min} = A\left(1 - e^{kt}\right) \tag{1}$$

where OM_{min} is the mineralized OM (%) at the composting time t (day), A is the potentially mineralizable OM (%) and k is the corresponding rate constant (day^{-1}). The loss of organic matter from the compost material was calculated from the initial and final organic matter contents, according to equation 2 (Qasim et al. 2019):

Loss of organic matter =

$$\frac{\left[OM_i(\%) - OM_f(\%)\right]\times 100}{OM_i(\%)\times\left[100 - OM_f(\%)\right]} \tag{2}$$

where OM_i is the organic matter content at the beginning of the process, and OM_f is the organic matter content at the end of the process.

Table 2 Composition of experimental trials

Composting mixture			
Trials	**Sawdust (%w/w)**	**Waste food (%w/w)**	**Initial moisture Content (%)**
1	80	20	60
2	70	30	60
3	60	40	60

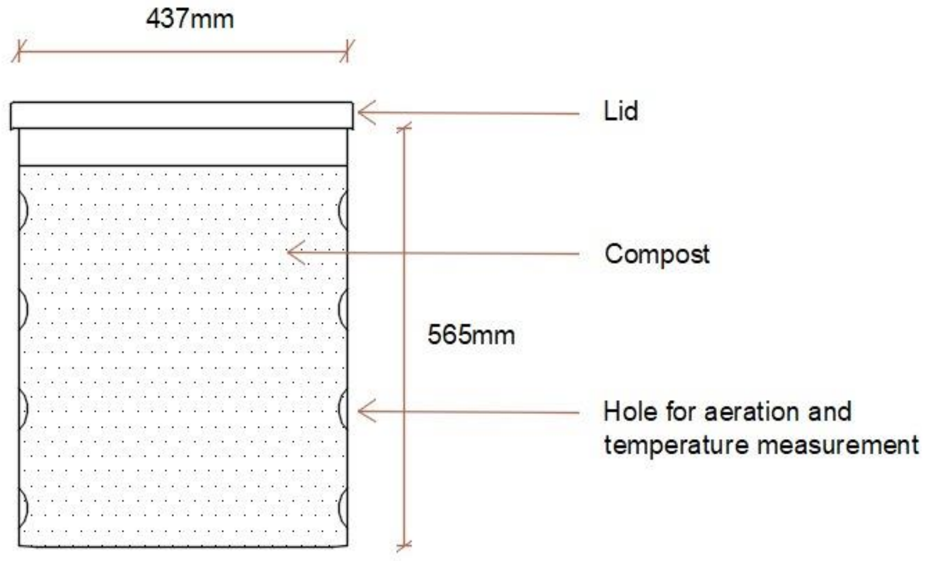

Fig. 1 Schematic diagram of composting system

Characterization of the final compost

Compost obtained from the composting trials was analyzed for its various physical and chemical properties. Various method of characterizing final compost exists in literature, namely physical, chemical, and biological method (Wang et al. 2021), in this study, therefore, all three methods were used. The chemical properties of the final compost assessed include; EC, pH, CEC, C/N ratio, Phosphorus, and Nitrogen contents, while the physical assessment was based on the colour of the final compost. The compost phytotoxicity evaluation was carried out using the Germination index (Carl et al. 2019). Extracts were prepared from the compost by mixing 10 g of air-dried compost in distilled water in the ratio of 1:10 (w/v). The mixture was shaken for 30 min then filtered using Whatman No 4 filter paper to generate compost extract which was then used in seed germination tests. Tomatoes (*Solanum lycoperiscum*) and Spinach (*spinacia oleracea L.*) were bought from IITA Ibadan (Viability as tested = 90%) for germination test. Whatman No 4 filter paper moistened with compost extract was placed in a Petri dish after which Ten (10) viable seeds of tomatoes and spinach were placed on it. A control experiment was also set up using distilled water. The experiments which were in triplicate were set up in the laboratory at room temperature. After 7 days of incubation, germinated seeds were counted and root length measured (Tibu et al. 2019). The germination index (GI) of the treatment was evaluated based on the following formula

GI (%) =

$$\frac{\%\, Seed\ germination \times root\ lenght\ of\ treatment}{\%\, Seed\ germination \times root\ lenght\ of\ control} \times 100 \tag{3}$$

Where

GI is germination index

Results and discussion

Composting temperature evolution

Composting temperature is one of the key parameters that indicate the stability and maturity of the compost (Mayur et al. 2018, Waqas et al. 2017) and also plays an important role in the sanitization of the final product (Wang et al. 2017) . According to Waqas et al. (2017), the disintegration of complex compost organic matrix to a simpler component is enhanced by temperature. In all the experimental trials, typical composting temperature evolution follows the order of sequence: mesophilic < 45 ºC, thermophilic > 45 ºC, and cooling phase < 45 ºC (Mayur et al. 2018) but the duration of each temperature phase differ among the composting trials, this is mainly because of the different experimental condition among the trials. The observed temperature ranged between 22.65 ºC and 65.45 ºC throughout the experimental period. Fig. 3 shows the temperature profile of trial 1, 2, and trial 3. It was observed that the temperature of the three trials changes rapidly from day 1 immediately after the compost mixtures were stacked into the compost bins. This shows that the biodegradation of compost matrix through the activities of microbes has started. On day 1, the temperature of the compost trial 1, 2, and 3 reached 22.65 ºC, 23.56 ºC and 27.76 ºC, respectively, which indicate the rapid activities of the microorganism. This was in agreement with other findings (Waqas et al. 2017). Waqas et al. (2017) used a high-density polyethylene reactor of different shapes to compost sawdust with poultry manure and recorded an initial temperature of 25 ºC. Several studies have confirmed that the thermophilic temperature phase can be achieved within a shorter day of establishing the compost using a plastic composter. Temperatures of the trials continue to rise fastest in trial 3 than in trials 1 and 2 and compost trial 3 had a longer thermophilic phase than trials 1 and 2. The thermophilic phase in trial 3 lasted for 35 days, which is good enough to sanitize the compost of pathogen and weed. Onwosi et al. (2017) reported that if the thermophilic temperature is maintained above 55 ºC for three days, the material will be free of pathogens and weeds. The temperature rise and longest thermophilic stage of trial 3 can be attributed to the high availability of nitrogen supplied by food waste (40%), which provides favourable conditions for the growth of microorganisms in the mixture (Waqas et al. 2017). This shows that food waste at 40% is capable of supplying enough nitrogen for the microorganism.

According to the results of this study, trials 1 and 2 attained their thermophilic temperature phase after day 25 of setting up the composting experiment and lasted for 20 days in trial 1 and 26 days in trial 2. After day 54 of composting, temperatures start to decrease immediately after the thermophilic phase; possibly because of a reduction in microbial activity due to loss of substrate of organic compost (Waqas et al. 2017; Chang et al. 2019). However, the temperature of the three composting trials started to decrease gradually and finally reached ambient temperature. The decrease in temperature was fastest in compost trial 1 and enters the maturation phase on day 65, followed by trial 2 on day 69 and lastly trial 3 on day 75. This could be a result of a decrease in the activities of microorganisms and heat loss from the compost by convection. However, throughout the composting period, trial 1 recorded the lowest temperature than other trials; this could be attributed to the lowest activities of microorganism as a result of limited availability of nitrogen from food waste (20%) and a high percentage of sawdust which inhibit microbial activities as a result of high carbon to nitrogen ratio. This showed that nitrogen is one of the important nutrients needed by microorganisms involved in composting. The best mixing ratio as regards temperature in this study was trial 3. This is simply because 40% of food waste is capable of providing enough nitrogen for the microorganism's growth and activities; therefore, heat generated is higher than the other two remaining experimental trials in this study. Stable compost in all the trials was obtained at 90 days.

Fig. 2 Experimental setup overview of the reactor used in this study

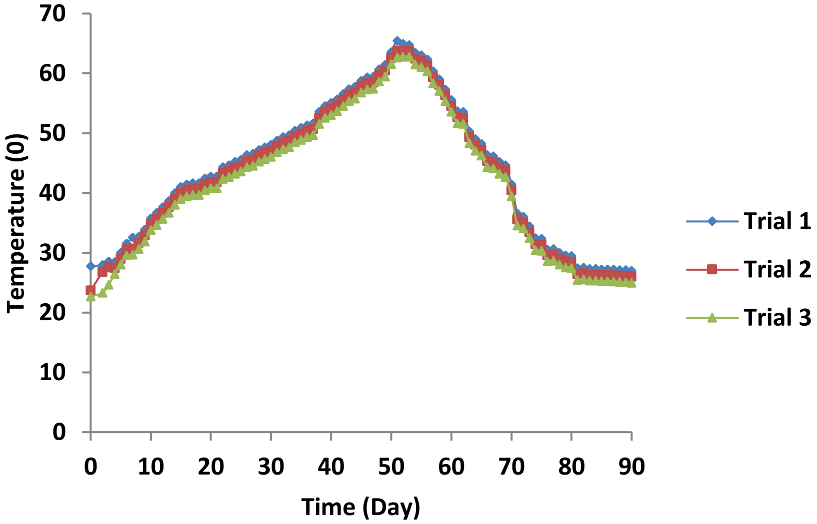

Fig. 3 Variation of the temperature of the three trials during composting

Moisture content

Estimation of moisture requirement is important for optimum productivity of composting process and it is one of the major factors that need to be considered in the composting system design (Hemidate et al. 2018). The availability of adequate moisture in compost enables a proper supply of oxygen for the growth of microorganisms, viable microbial activities and also controls the temperature of the compost. When the moisture content is lower than the required minimum (40%), it would lower the activities of microorganisms and consequently lower the biodegradation process. Also, if the moisture content is too high, composting material will rot (Lee et al. 2020). It is therefore important to adjust the moisture content to the required range to provide a suitable condition for microorganisms. According to (Angelica et al. (2020), the optimum moisture content required for composting is between 50 and 60%. Furthermore, the moisture content of the matured compost should be less than 55% (Lee et al. 2020).

Concerning compost trials 1, 2, and 3 of this study, the initial moisture contents were adjusted to the maximum required range of 60% (Lee et al. 2020). Fig 4 shows the moisture contents variation of the three trials during composting experiments. It can be seen that the moisture content of the three compost trials decreased gradually during the composting process in the first 30 days with the compost trial 3 with the highest percentage of water loss (Fig. 4). The highest percentage moisture loss in trial 3 can be attributed to vigorous consumption of moisture by active microbial for biological activities (Lee et al. 2020, Jae-Han et al. 2020) with the release of water vapour (Ermolaev et al. 2015) and due to turning frequency of the compost (Zhou 2017, Waqas et al. 2017) and also because of heat formation in the compost (Waqas et al. 2017) which evaporates moisture from the compost. At the start of the composting process, trials 1 and 2 recorded the smallest moisture variations from the initial moisture contents; therefore, these trials recorded the lowest temperatures. In trial 3 experiments, moisture content at days 30 and 60 was 35.60% and 43.65%, in trial 2, 39.43% and 45.65%, while in trial 1, was 42.65 and 47.54%. Therefore, moisture was added to the compost for viable microbial activities. The reduction in moisture content in compost trials 1 and 2 may also be due to frequent turning of the compost (Zhou 2017). The final moisture content of each trial at the end of experiments was 52.20% in trial 1, 48.40% in trial 2 and 43.50% in trial 3 (Fig. 4).

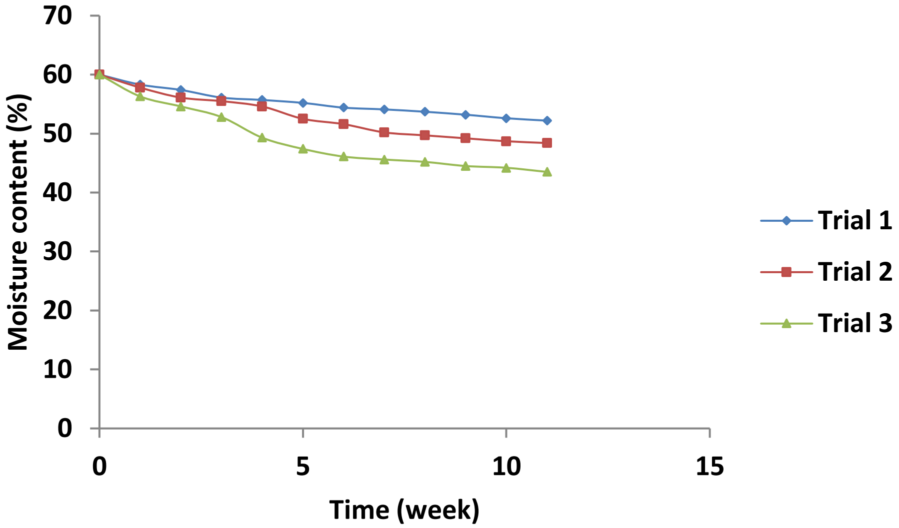

Fig. 4 Variation of moisture content of the three trials during composting

Evaluation of pH and electrical conductivity (EC)

pH

The pH range is one of the most important factors in the composting experiment. Waqas et al. (2017) explained that variation in pH level tends to occur during composting due to changes in the chemical composition of the organic substrates, a decline in the early stage of the composting, rise during the active stage, and almost neutral in the later stage of the composting. Many researchers have reported that the initial pH value after setting up the composting experiments could range from about 6.0 to 6.5 (Chang and Li 2019; Varelas 2019). Fig. 5 shows the evaluation of the pH of the composts trials in this study. The initial pH values of the compost trials after mixing in this study were slightly alkaline (7.9 – 8.7). This was in agreement with the finding of Abdul-Halim et al. (2019) who recorded the same range of initial pH values.

However, after the first week of the composting, pH increased sharply in all three trials due to the degradation of organic matter by microorganisms which lead to volatilization and consumption of organic acids under high temperature and the production and accumulation of $NH+^4$ (He 2019). The increase in pH was also recorded by Wang et al. (2021) in the composting of mixed deer manure and straw. Trials 2 and 3 recorded the highest pH values at this stage. This may be as a result of the percentage of waste food in these trials. He et al. (2020) reported that the pH tends to increase in the first 2 to 3 weeks of composting as ammonia gas is produced from the decomposition of nitrogen but decrease later due to the decomposition of organic acid to organic matter.

The best pH for the growth and reproduction of microorganisms is approximately 7.0 (Wang et al. 2021). This was confirmed in experimental trial 3 in which the initial pH level was 7.3 and the highest temperatures were recorded in this trial due to vigorous activities of microorganisms. This pH range (7.3) provided a conducive condition for microbial growth. In trial 3, a considerable amount of organic matter was degraded, CO_2 gas was evolved, also ammonifying bacteria decomposed the proteins in the organic raw materials (Zhao et al. 2020; Xu et al. 2015) , and nitrogen in the form of ammonium salts or volatilizes in the form of ammonia (Huang et al. 2016) also exited. Turning frequent (once in a week) and ventilation (3 mm diameter hole) affect the removal of these gases from the compost, and the presence of ammonium salt increased the pH (Cai et al. 2016). After the fifth week, the pH then decreased to reach pH 5.5 and rise again to 8.1 in the later stage of the composting. The decrease in pH could be due to the low production of CO_2 during organic matter degradation, while the increase in pH level at the later stage of the process could be probably due to the degradation of organic acid compounds (Wang et al. 2021). Very low pH value can pose a great challenge during composting, but adding phosphoric acid to raw materials can improve the problem of low pH (Zhang et al. 2018). At the end of the composting experiments, the pH level in each trial was above 7.0 and slightly higher than the initial values. The pH levels of this study were within the range of 5.4 and 9.3 in trial 1, 5.0 and 9.4 in trial 2 and within the range of 5.3 and 9.4 in trial 3.

The electrical conductivity of the composting trials

Fig. 6 shows the variation of the electrical conductivity of the three composting trials. The electrical conductivity shows the salt concentration which reflects the ionic concentration of both organic and inorganic salts in the composting materials. The concentrations of the ionic salts reflect the salinity and suitability of the compost to use as a soil additive for crop production. The high concentration of salts in the raw materials poses a serious challenge because after composting, the salts present would be released into the final compost and if it is used as fertilizer could lead to too much salt in the soil which could inhibit the absorption of other salts in the soil (Lee et al. 2020), this could lead to water stress in crop and reduces the rate of photosynthesis in a plant (Lee et al.

2020). It can be said theoretically that electrical conductivity is directly proportional to the amount of raw materials used. At the beginning of the composting process, compost trial 3 had the highest EC (Fig. 6). This observation might be as a result of the production and accumulation of soluble salts which is assumed to be as a result of food salinity or the presence of mineral salts such as phosphates and ammonium ions through the breakdown of compost materials (He et al. 2020). Early in the third week, compost trials 1 and 2 had almost similar EC, except trial 3 that still maintained higher EC than trials 1 and 2. After the 7th week, the EC of the three trials declined but trial 3 still maintained the highest EC than trials 1 and 2. In trial 1, the food waste was the smallest (20%) so it had the smallest EC (4.3 ms/cm), followed by trial 2 with 30% food waste and smaller EC (4.6 ms/cm) and lastly, trial 3 with the highest food waste percentage (40%) so it had the highest EC. The decline in EC of the composting trials after the 7th week may be due to the humification of organic materials that caused dissolved salt and macro-molecular organic acids to turn into macro-molecular humus (Nour et al. 2020). After the 9th week, the final EC in all trials was below 4 mS/cm which is good for plant production (He et al. 2020) (Fig. 6).

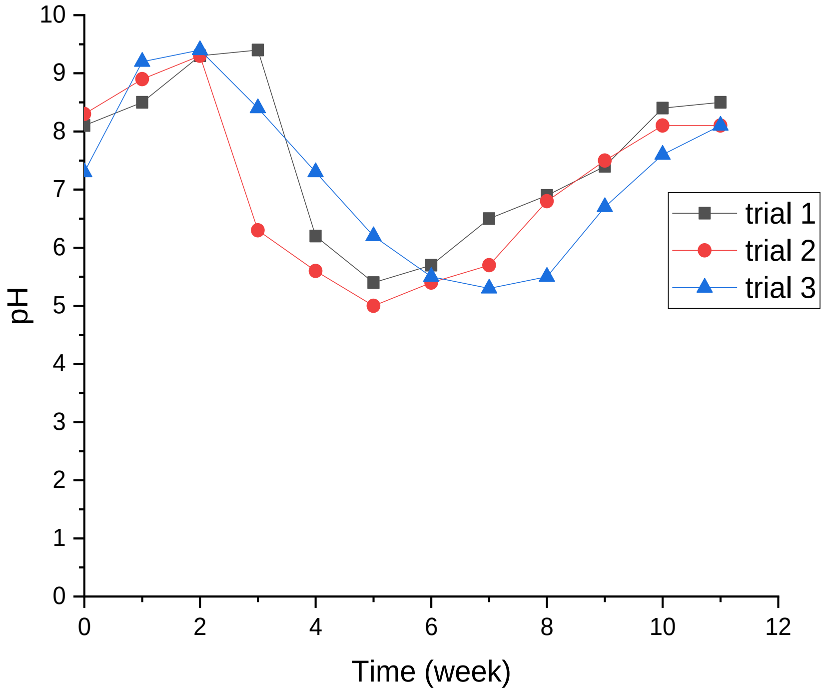

Fig. 5 pH of the composting trials

Organic matter degradation of the composting trials

The variation of organic matter degradation of compost trials 1, 2, and 3 are displayed in Fig. 7. The organic content in all the three composting trials showed a declining trend throughout the composting process from the initial value of 88.40% in all the trials. The highest values of A were observed in trial 3 with the highest percentage of food waste (40%). Similar patterns were observed in trials 1 and 2, according to their temperature profile during composting. Qasim et al. (2019) reported similar values during the composting of poultry manure with sawdust using different reactor shapes. The decrease in organic matter values was a result of microbial activity on compost matrixes (Qasim et al. 2019). The highest organic matter degradation in this study was observed in compost trial 3 which had the highest proportion of food waste (40%). This was possible because food waste provided adequate nitrogen which could be used by microorganisms as food and enhanced maximum microbial activity during the composting process. The difference in organic matter degradation showed by the composting trials may be due to differences in food waste proportion in the composting trials. The organic matter losses during composting in the three experimental trials followed a first-order kinetic equation (1), where all the parameters of the equation have been previously defined. Fig. 7 shows the fitted curves while the results of the curve fitting experimental data are shown in Table 3. The rate of organic matter losses is defined by the product of parameters A k in equation 1. This value shows that the rate of organic matter losses was faster in compost trial 3 (0.147% OM/day) than compost trial 2 (0.143% OM/day) and trial 1 (0.139% OM/day). The organic matter losses were correlated with an increase in the temperature of compost trials. In compost trial 3, the highest amount losses in organic matter was in line with the higher temperature recorded in this trial, which suggested that more microbial degradation took place in this trial, while the lower temperature observed in compost trials 1 and 2 suggested that fewer microbial activities took place in this trials.

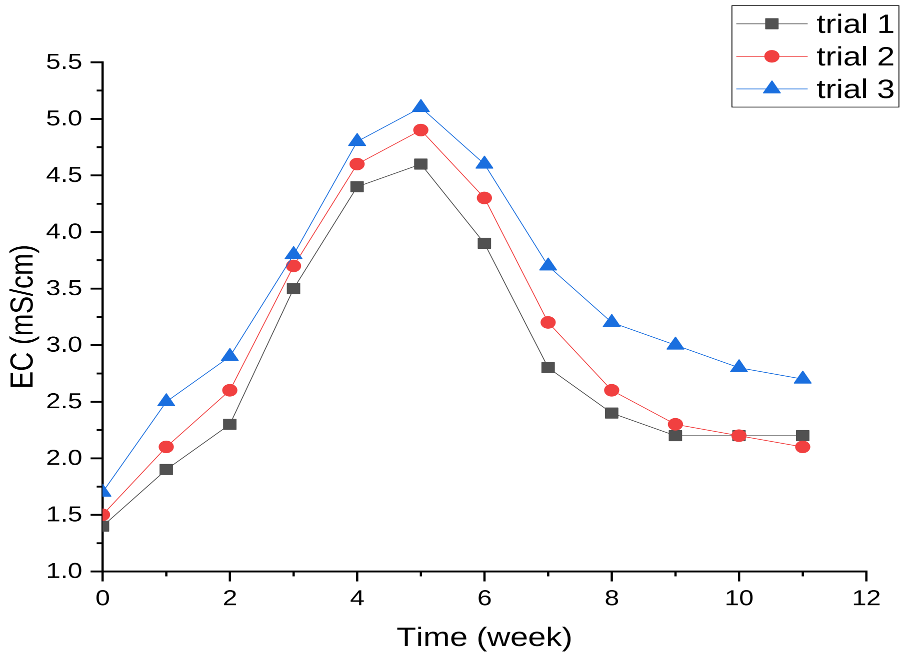

Fig. 6 Electrical conductivity of the composting trials

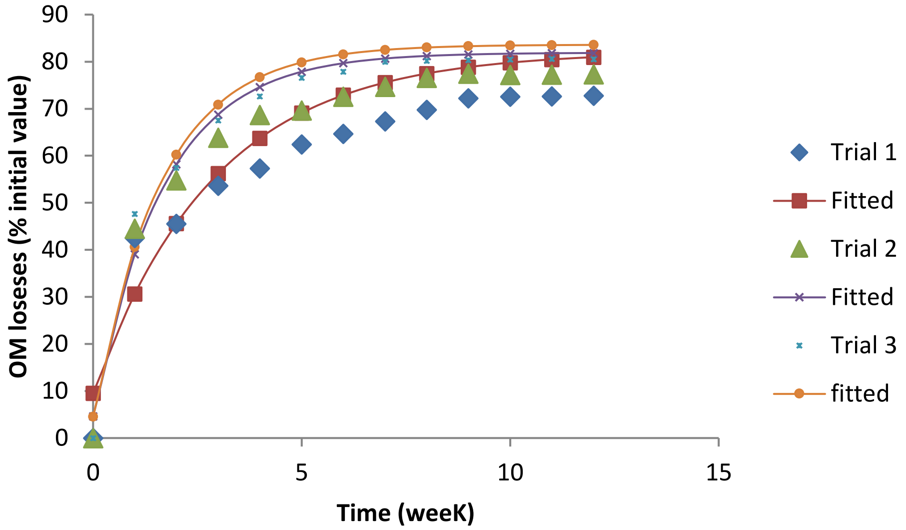

Fig. 7 Organic matter losses during composting. Lines represent curve-fitting

Table 3 Parameters of first-order kinetic equations for organic matter loss during composting

Compost trials	A (%)	K (d^{-1})	SE	Adj R^2
Trial 1	62.93 ± 2.61	0.139	0.139	0.877
Trial 2	65.08 ± 2.99	0.143	0.143	0.857
Trial 3	70.09 ± 3.53	0.147	0.147	0.840

Evaluation of the quality of the final compost

The quality of the final products is deeply associated with the feasibility of the composting method used. The purpose of composting is to convert waste into valuable products which must meet the standard. The characteristics of the final compost obtained in this study are shown in Table 4. At the end of the composting period which lasted for 90 days, the temperature of all the composting trials was stable and compost looked much darker in colouration (Zahrim et al. 2016); earthy smell, fine texture and showed homogeneity of materials. The composting experiments were all stopped and samples were taken for final compost analysis. Each of the compost shows different compost quality in terms of their physical and chemical characteristics (Table 4).

The quality of each of the compost trials varied significantly in terms of their physical and chemical characteristics. In general, the final pH of all composts was revealed to be alkaline (6.40 – 9.40) with low electrical conductivity (2.01 – 3.41), low nitrogen (1.13 – 1.87), slightly high C/N ratio (12.32 – 17.82), low CEC (12.68 – 25.42), total nitrogen (1.13 – 1.85), and extractable p (7.51 – 10.84). The slightly high C/N ratios were observed in compost trial 1 which indicates the presence of unutilized complex nitrogen and carbon while the complete breakdown of these materials is indicated by low C: N ratios (Karanja et al. 2019). The final compost can therefore be used as a soil improver.

Table 4 Chemical properties of the final compost

Composting Trials	C:N	pH	EC	CEC (Cmol/Kg)	Phosphorus (Cmol/Kg)	Nitrogen (%)	Moisture content (%)
Trial 1	17.59 ± 0.25	7.0 ± 2.01	3.13 ± 0.24	12.76 ± 0.08	9.29 ± 1.52	1.14 ± 0.02	52.20
Trial 2	15.85 ± 0.10	7.33 ± 2.21	3.0 ± 0.22	21.52 ± 0.48	10.08 ± 0.81	1.85 ± 0.01	48.40
Trial 3	12.56 ± 0.20	6.4 ± 1.05	3.15 ± 0.16	25.17 ± 0.22	9.15 ± 1.44	1.68 ± 0.01	43.50

Phytotoxicity of the final compost

Germination index (GI) is one of the important indexes used to access the toxicity and maturity of the final compost. Tomatoes recorded 100% germination in all the compost trials, while spinach seed recorded 90% germination in compost trials 1 and 2 and 100% germination in compost trials 3. The control experiments recorded 90% germination for both seeds. 100% GI recorded by tomatoes indicated no adverse effects of the compost on the germination of the plant's seeds. The difference in GI observed in the two seeds used could be attributed to seed sensitivity (Tibu et al. 2019). Theoretically, when GI exceeds 80%, the compost is said to be phytotoxin-free (Wang et al. 2021). In this study all compost trials showed GI values higher than this limit and, therefore, they can be considered phytotoxin-free.

Conclusion

In this study, the effects of different proportions of food waste on composting sawdust were investigated in a perforated composter. Based on the results presented above, composting of sawdust with food waste in the ratio of 60: 40 was able to convert the sawdust waste into matured compost. The organic matter degradation can be fitted into the first-order kinetic model. Of the three composting trials, compost trial 3 exhibited higher organic matter degradation and higher temperature. The results showed that all compost obtained were stable and matured. In brief, recycling sawdust through the composting process to obtain valuable end products is adequate but in the presence of nitrogen-rich material.

Compliance with ethical standards

Conflict of interest The authors declare that there are no conflicts of interest associated with this study.

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