



Research Article

Assessment of Compost Stabilization during Short Term Composting of Fruits and Vegetable Wastes under North-Eastern Nigeria Conditions

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ABSTRACT

This study evaluated compost stabilization during short-term composting of fruit and vegetable wastes (FVW) under tropical conditions in North-East Nigeria. Temperature profiles followed a typical pattern, peaking at 52°C during the thermophilic phase (days 5–6) to ensure pathogen suppression, before stabilizing near ambient levels by day 31. Statistical analysis showed significant fluctuations ($p < 0.05$) in pH, while electrical conductivity (EC) at maturity (4.39 dS m⁻¹) remained within acceptable limits for soil application. Organic carbon and organic matter declined significantly ($p < 0.05$) from 18.03% and 31.10% to 9.83% and 16.93%, respectively, driven by microbial respiration. Nitrogen transformation shifted from initial ammonification (NH₄⁺-N: 38.03 mg kg⁻¹) to progressive nitrification, with NO₃⁻-N increasing from 74.03 mg kg⁻¹ to 142.43 mg kg⁻¹. This resulted in a low NH₄⁺/NO₃⁻ ratio, confirming maturity. Additionally, available phosphorus doubled, and exchangeable bases increased, resulting in a final effective cation exchange capacity (CEC) of 17.47 cmol⁺ kg⁻¹ and 98.47% base saturation. The results demonstrate that short term composting effectively transforms raw FVW into a stable, nutrient-enriched organic amendment. With enhanced nutrient availability, high CEC, and proven sanitization, the final product is highly suitable for improving soil fertility and microbial activity in tropical agricultural systems where organic matter is a limiting factor.

Keywords: Compost stabilization; Fruits and vegetable waste; Nitrogen transformation; North-Eastern Nigeria; Organic waste composting; Soil amendment; Waste management

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INTRODUCTION

The generation of fruits and vegetable wastes (FVW) has increased markedly with rapid urbanization and changing food consumption patterns, particularly in African developing countries (Ambuko *et al.*, 2025; Chisika & Yeom, 2025). In Nigeria, biodegradable market wastes are largely unmanaged and disposed of through open dumping due to limited waste segregation and treatment infrastructure (Omokaro *et al.*, 2025). This practice contributes to environmental degradation through odour emissions, leachate generation, greenhouse gas release, and the proliferation of disease vectors, posing risks to public

health and ecosystem sustainability (Abubakar *et al.*, 2022; Singh *et al.*, 2025; Zurbrügg *et al.*, 2012).

Fruits and vegetable wastes, however, represent a valuable organic resource because of their high biodegradability and nutrient content. Composting provides an environmentally sound waste management strategy that stabilizes organic residues through controlled microbial decomposition, reduces waste volume, and converts unstable organic matter into products suitable for agricultural use (Bernal *et al.*, 2009; Haug, 2018). In Africa, particularly in the Nigerian context where soil fertility decline is widespread and access to inorganic fertilizers is

constrained, composting of market derived FVW offers a dual benefit of waste reduction and soil fertility enhancement.

Application of organic compost has been shown to improve soil physical, chemical, and biological properties, including increased soil organic carbon, improved aggregation and water holding capacity, and enhanced microbial activity essential for nutrient cycling (Aytenew & Bore, 2020; Bashir *et al.*, 2021; Kelbesa, 2021; Sayara *et al.*, 2020). These benefits are particularly relevant for tropical soils in Nigeria, which are often characterized by low organic matter content and poor nutrient retention.

The agronomic value of compost depends strongly on its degree of maturity and stabilization (Cesaro *et al.*, 2019; Wichuk & McCartney, 2010). Immature compost may contain phytotoxic compounds, high ammonium concentrations, or unstable organic fractions, whereas mature compost is characterized by stabilized organic carbon, reduced ammonium levels, increased nitrate formation, and balanced nutrient availability (Siddiqui *et al.*, 2020). Fruits and vegetable wastes decompose rapidly, making short-term monitoring of compost maturity essential, especially for low-input, decentralized composting systems common in Nigerian markets and farming communities.

This study therefore evaluates the physical and chemical properties as well as the maturity dynamics of fruits and vegetable waste compost over a 31-day composting period under North-eastern Nigeria climate. Changes in organic carbon, nitrogen forms, and key physicochemical indicators were monitored to assess compost stabilization and its suitability for use as a soil amendment for improving soil fertility and supporting sustainable agriculture.

MATERIALS AND METHODS

Waste Collection and Compost Preparation

Fruits and vegetable wastes were collected from Kasuwan Gwari, Jimeta, Adamawa State Nigeria, a market where biodegradable materials from fruits and vegetables dominate the municipal solid waste in Jimeta metropolis. The waste collected consists mainly of fruit peels, vegetable residues, leafy materials, stems, and pulp remains. All visible non-biodegradable materials were manually removed prior to composting (Zurbrugg *et al.*, 2012). The wastes were shredded to sizes of approximately 2–5 cm to enhance microbial decomposition (Haug, 2018), and moisture content was adjusted to 55–65%, which is optimal for aerobic composting (Tang *et al.*, 2023).

Composting Design and Management

Composting was conducted using a dark plastic container under sheltered outdoor conditions to prevent direct exposure and eliminate nutrient losses through leaching while allowing natural aeration. The containers were measured 1.0 m in height and 0.5 m in diameter. Compost piles were manually turned every five days to maintain aerobic conditions and ensure uniform decomposition (Getahun *et al.*, 2012). Moisture content was maintained within the optimal range throughout the composting period.

Sampling Procedure

The experiment followed a time series design, with compost samples collected at 2, 4, 6, 8, 10, 12, 17, 24, and 31 days after composting commenced. At each sampling time, composite samples were obtained by mixing subsamples collected from the top, middle, and bottom of each pile. Each sample was air-dried, ground down into a fine powder and analysed for electrical conductivity (EC), pH, total nitrogen, carbon, phosphorus potassium, ammonium and nitrate. Daily temperature of the surroundings and the compost were recorded and all analyses were conducted in triplicate.

Physicochemical Analyses and Maturity Assessment

Compost pH and electrical conductivity (EC) were determined in a 1:5 (w/v) compost weight to volume of distilled water. Organic carbon (OC) was determined using the Walkley Black method (Mylavarapu *et al.*, 2014), and organic matter (OM) was estimated as $OC \times 1.724$ (Nelson & Sommers, 1996). Ammonium (NH_4^+-N) and nitrate ($NO_3^- -N$) were extracted using 2 M KCl and determined calorimetrically (Bremner, 1996). Compost maturity was assessed using temporal changes in pH, EC, organic carbon, ammonium and nitrate concentrations, and the NH_4^+/NO_3^- ratio as an indicator of nitrogen transformation and stabilization (Bazrafshan *et al.*, 2016; Bernal *et al.*, 2009).

Data Analysis

The data obtained were analysed using one-way analysis of variance (ANOVA) to assess the effect of composting duration on measured parameters. Mean separations were performed using Tukey's honest significant difference (HSD) test at $P < 0.05$, and results are presented in timeline series graphs as means \pm standard deviation.

RESULTS AND DISCUSSION

Temperature Dynamics During Composting

The atmospheric and compost pile temperature are shown in Fig 1. The results showed that during the

early composting, the temperature of the compost increased rapidly from 37 °C on day 1 to a maximum of 52 °C during days 5 - 6, while the atmospheric temperature remained relatively stable around 30 - 31 °C. This rapid rise in compost temperature indicates microbial activity associated with the decomposition of organic materials particularly the easily degradable materials present in the fruit and vegetable wastes. Temperatures above 50 °C suggests the attainment of a thermophilic phase,

which is essential for producing compost intended for soil fertility improvement (Papale *et al.*, 2021; Saypariya *et al.*, 2024). In addition to the breakdown of organic substrates higher compost temperature eliminates plant pathogens, weed seeds, and harmful microorganisms (Ayilara *et al.*, 2020; Lim *et al.*, 2013; Musa *et al.*, 2020). Therefore, this process enhances the hygienic quality of the compost and ensures that the final product can be safely applied to agricultural soils without introducing biological contaminants.

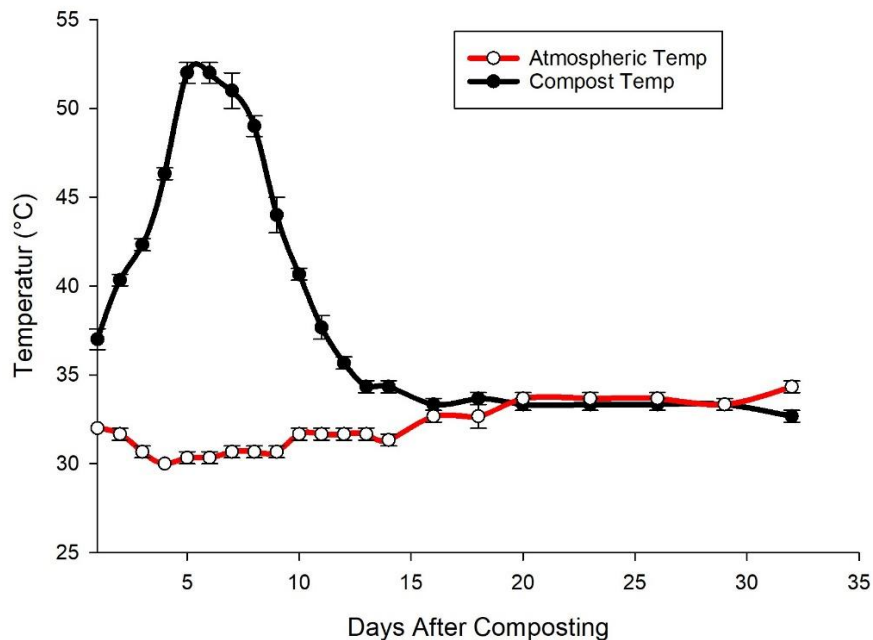


Fig. 1: Change in Temperature During 31 Days Composting

As composting continued, the temperature gradually declined from the highest to 44 °C by day 9, and then rapidly dropped to 37 °C by day 11. This reduction may be associated with the depletion of readily available organic substrates and the transition from the thermophilic stage to the cooling phase of composting. During this period, microbial activity shifts from thermophilic organisms to mesophilic microorganisms that continue the decomposition of more complex organic compounds such as cellulose and lignin (Saypariya *et al.*, 2024). Therefore, this stage is critical for the gradual stabilization of organic matter, which will lead to the formation of humified materials that contribute to soil organic carbon when applied as a soil amendment. From day 12 onward, the compost temperature remained relatively stable between 33 °C and 35 °C, closely approaching the atmospheric temperature. This stabilization indicates that the compost had entered a curing phase which is also termed as the maturity stage. During this phase,

microbial activity decreases and organic matter becomes more chemically stable. The convergence of compost temperature with ambient temperature toward the end of the composting period (day 31) is a key indicator of compost maturity. Matured compost is characterized by stable organic compounds, reduced microbial respiration, and improved nutrient availability (Xie *et al.*, 2025).

Generally, the temperature pattern observed in this study suggests that the composting process was effective in producing a stable and mature organic amendment. The thermophilic phase ensured sanitation and rapid organic matter decomposition, while the subsequent cooling and maturation phases promoted the formation of stabilized organic matter. When applied to soil, such compost can enhance soil structure, water holding capacity, microbial activity, and nutrient supply, particularly in tropical soils that often have low organic matter content. Therefore, the recorded temperature profile confirms that the

fruit and vegetable compost produced under these conditions is suitable for improving soil fertility and supporting sustainable crop production.

Changes in pH and Electrical Conductivity (EC)

Compost pH varied significantly ($p < 0.05$) across the 31-day composting period. The pH values ranged from 6.05 to about 6.48 (Fig 2). The initial pH, which is near neutral at day 2 (6.29) decreased slightly during the early active decomposition phase (day 6 - 8), likely due to organic acid production from rapid microbial breakdown of readily decomposable organic materials. This corroborates findings that a drop in pH is a classic sign of microbial fermentation, as bacteria rapidly utilize easily digestible sugars and fats and release organic acids as by-products, which

naturally increase the acidity of the environment (Atasoy *et al.*, 2024; Lund *et al.*, 2020). The subsequent increase observed at day 12 (pH 6.48) reflects ammonification and buffering effects associated with organic matter mineralization, a trend commonly reported during compost stabilization. As the material matures, it typically undergoes alkalisation before finally stabilizing (Lalremruati & Devi, 2023). Overall, the pH values remained within a range considered suitable for soil application indicating minimal risk of soil acidity upon compost use (Ho *et al.*, 2022). This pH range is in the optimum range for growing media as mentioned by (Bunt, 1988) who stated that the optimal range is from 5.2 to 7.3.

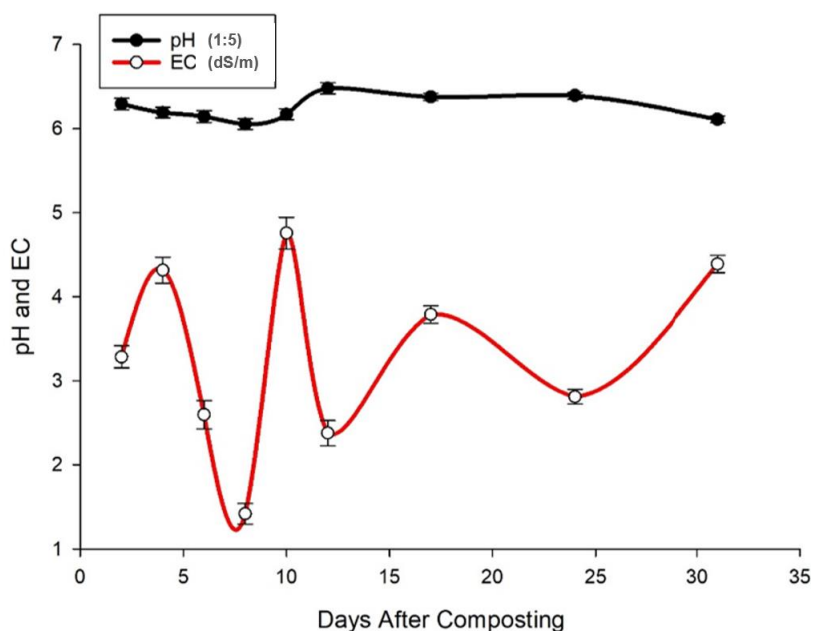


Fig 2. Changes in pH and Electrical Conductivity (EC) During Composting

The electrical conductivity (EC) showed a significant ($p < 0.05$) temporal variation over the observed period of composting (Fig 2). The value of EC increased rapidly at day 4 and 10, followed by intermittent declines. Higher EC values during the active composting (day 4 and 10) reflect the release of soluble salts from the decomposing FVW materials. The highest EC at day 10 (4.76 dS m^{-1}) suggests intensive mineralization, while the relatively lower EC at later stages indicates partial stabilization. An increase in EC during the early stages typically signifies the rapid decomposition of organic matter (Saypariya *et al.*, 2024) particularly during the active thermophilic phase. Despite fluctuations, EC levels at maturity (Day 31) remained within tolerable limits for organic soil amendments, particularly for tropical soils with low inherent fertility like the North-Eastern

Nigeria. This corroborate with the findings of (Dadi *et al.*, 2019; Shemekite *et al.*, 2014) for fruit and vegetable composting. However, (Dadi *et al.*, 2019; Kassegn *et al.*, 2015) reported a decline trait of lower EC as composting progresses to maturity and was associated to ammonia volatilization, mineral salts precipitation and leaching. While a spike in EC confirms high microbial activity, it is also critical to monitor, as excessively high salinity can sometimes inhibit microbial growth and affect the final compost quality for sensitive plants (Finore *et al.*, 2023). In general, the EC values of matured compost types were within the usual range for most composts, consistent with (Teshome, 2022) finding who reported that matured compost samples had EC values ranging from 2.5 to 5.5 mS/cm.

Organic Carbon and Organic Matter Dynamics

Organic carbon (OC) and organic matter (OM) contents declined progressively and significantly ($p < 0.05$) throughout the composting period. Organic carbon decreased from 18.03% at day 02 to 9.83% at day 31, leading to a difference of about 8.85, approximately 45%. This decline reflects microbial respiration losses as carbon dioxide during organic matter decomposition (Getahun *et al.*, 2012). According to (Guo *et al.*, 2019) and (Dadi *et al.*, 2019), the organic carbon content of all compost types decreases with time due to limited carbon sources and the synthesis of additional complex and formed

organic molecules during the maturation period. (Kassegn *et al.*, 2015) also indicated that the organic carbon content of compost samples decreased during composting, reporting a % OC of 55.12 at the initial stage and 15.69 at the final phase. This may be due to the loss of carbon as CO₂ during decomposition, as indicated by (Getahun *et al.*, 2012) who found a decrease in carbon from approximately 44% at the beginning to 17% during the maturing phase. This process of composting FVW produces stable end-products that serve as slow-release fertilizer for agricultural purposes.

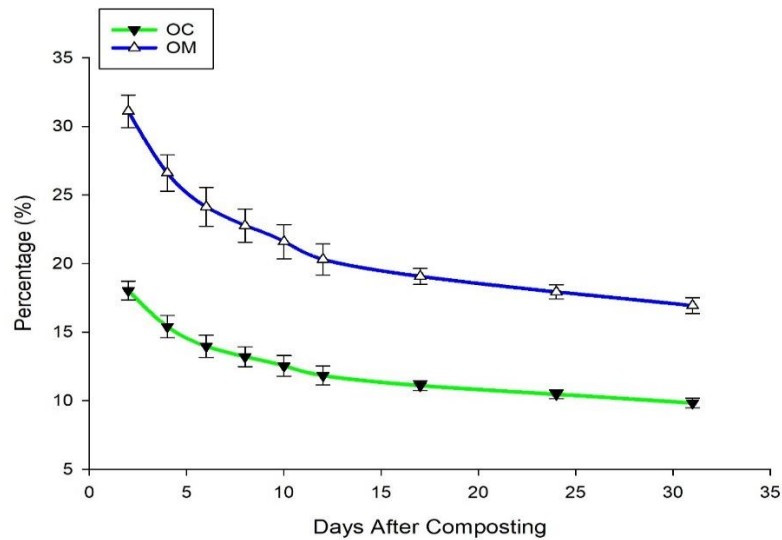


Fig 3: Temporal Variation of OC and OM

A similar trend was observed for OM, which decreased from 31.10% to 16.93% over the same period (Fig. 3). The continuous reduction in OC and OM further justifies the active decomposition and stabilization of the composted fruit and vegetable wastes. Such declines are characteristic of compost maturation, where labile carbon fractions are progressively transformed into more stable humified forms. The stabilized OC levels observed at later stages (day 24–31) suggest improved compost maturity and suitability for soil amendment applications. The current study is in line with the findings of (Getahun *et al.*, 2012) who reported a decline in OC from 44% to 17% over the period of FVW composting in Addis Ababa, Ethiopia.

Nitrogen Transformation and Compost Maturity

The variation in ammonium (NH₄⁺-N) and nitrate (NO₃⁻-N) concentrations during the composting period are significantly different ($p < 0.05$) during the composting period and are presented in Fig 4. The results show contrasting patterns between the two inorganic nitrogen forms, indicating the progression of nitrogen transformation processes during compost

decomposition. Ammonium concentration was relatively high at the beginning of the composting process (38.03 mg kg⁻¹ at day 2), reflecting intense ammonification associated with the rapid breakdown of organic matter. During this stage, microbial activity decomposes nitrogen containing organic compounds, particularly the readily degradable nitrogen containing organic materials, releasing ammonium as an intermediate product. As composting progresses, the NH₄⁺-N concentration decreased suddenly between day 4 and day 6, followed by minor fluctuations between days 8 and 12. Thereafter, a gradual decline was observed toward the end of the composting period, reaching its lowest value (13.57 mg kg⁻¹) at day 31. The early decline between day 2 and 6 can be attributed to ammonia volatilization as temperature increases from 40 to 52 °C which is termed as thermophilic conditions (Fig. 1) and the onset of nitrification, while the reduction in concentration of the ammonium over the observed period suggests its progressive conversion into nitrate through microbial nitrification, as well as possible nitrogen losses through ammonia volatilization.

In contrast, NO_3^- -N showed an overall increasing trend throughout the composting process. During the initial composting period, an initial decrease from 74.03 mg kg^{-1} to 31.23 mg kg^{-1} was observed from day 2 to 4 respectively followed by a substantial increase to 99.00 mg kg^{-1} at day 6, suggesting intermittent nitrification activity. Despite the observed fluctuations, NO_3^- -N concentrations increased significantly ($p < 0.05$) during the later period of composting, reaching a maximum value of $142.43 \text{ mg kg}^{-1}$ at day 31. This sudden nitrification signal at later stages indicates increased compost stabilization and aerobic microbial activity. This observation is consistent with the findings of (Sánchez-Monedero *et al.*, 2001a), who reported that high ammonification during the initial stages of composting is due to the abundance of readily decomposable nitrogen rich substrates. Similarly, studies by (Chamoli *et al.*, 2024) argued that sudden increase in nitrate concentration at the maturation stage indicates the establishment of favourable aerobic conditions that promote the activity of nitrifying microorganisms responsible for oxidizing ammonium to nitrate. Though transformation and potential losses of nitrogen during composting are largely influenced by the nature of the composting materials and the pH of the composting mixture (Chang *et al.*, 2019; De Guardia *et al.*, 2010; Kucbel *et al.*, 2019; Zhao *et al.*, 2025), as the composting process progresses, temperature declines, oxygen availability improves, which results to increase nitrification. Hence, the observed decline in NH_4^+ -N accompanied by a marked increase in NO_3^- -N as a result of continues nitrification processes can serve as a reliable indicator of compost maturity and stabilization.

The inverse relationship between NH_4^+ -N and NO_3^- -N observed in this study reflects the typical pattern of nitrogen dynamics during composting. Early composting stages are dominated by ammonification due to the decomposition of nitrogen-rich organic substrates, while nitrification becomes more pronounced during the curing phase when temperature decreases and oxygen availability improves. Similar trends were reported by (Sánchez-

Monedero *et al.*, 2001b), who noted that ammonium accumulation occurs during the early thermophilic phase, whereas nitrate formation increases as compost stabilizes. Furthermore, the decreasing NH_4^+ -N together with the strong accumulation of NO_3^- -N toward the end of the composting period indicates progressive compost stabilization and maturity. The resulting low $\text{NH}_4^+/\text{NO}_3^-$ ratio at day 31 suggests that the compost had reached a mature stage that is suitable for agricultural application. Mature compost characterized by higher nitrate and lower ammonium concentrations is generally considered more stable, less phytotoxic, and more beneficial for soil fertility improvement.

Nutrient Availability and Exchange Properties

Available phosphorus (AvP) increased significantly ($p < 0.05$) with composting time, rising from 35.67 mg kg^{-1} at day 2 to a maximum of 71.30 mg kg^{-1} at day 31 (Fig. 5). At the initial stage (day 2), AvP was relatively low (35.67 mg kg^{-1}). However, as composting progressed to day 4 - 6, AvP increased rapidly from 42.20 to 58.03 mg kg^{-1} and temporary declined from 38.73 to 31.33 mg kg^{-1} on day 8 and 12 respectively. After day 16, AvP gradually increased again and remained relatively stable before its rapid increase toward the end of composting. By day 31, AvP reached its maximum value of 71.30 mg kg^{-1} , indicating substantial mineralization of organic phosphorus and reduced fixation as the compost matured.

The relatively low available phosphorus (AvP) at the initial stage (day 2) indicates that most phosphorus in fresh organic residues exists in organic or insoluble forms. As composting progressed, microbial decomposition and mineralization of organic phosphorus compounds increased AvP from 58.03 mg kg^{-1} on day 6 to 63.93 mg kg^{-1} on day 10. This phase aligns with intense microbial activity, when enzymes such as phosphatases break down organic materials and release phosphorus in plant-available forms (Wei *et al.*, 2015). However, a temporary decline around days 10 - 12 may result from microbial immobilization of phosphorus or its fixation with metal ions like iron and aluminum during active decomposition.

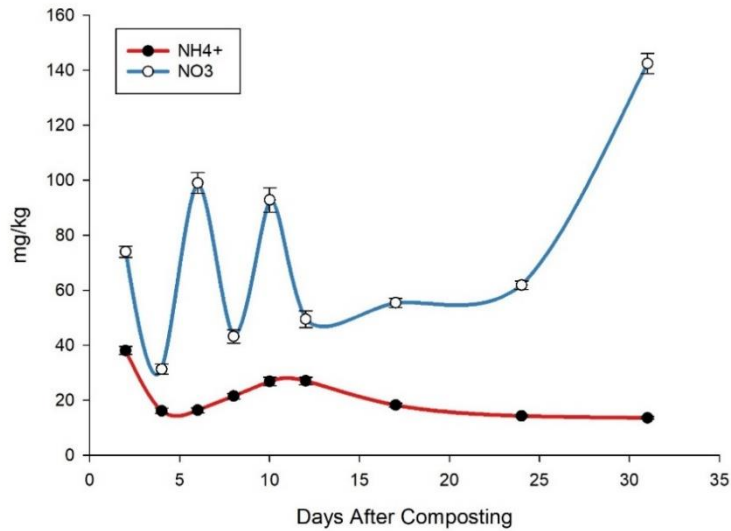


Fig 4: Concentrations of Ammonium (NH₄⁺-N) and nitrate (NO₃⁻-N)

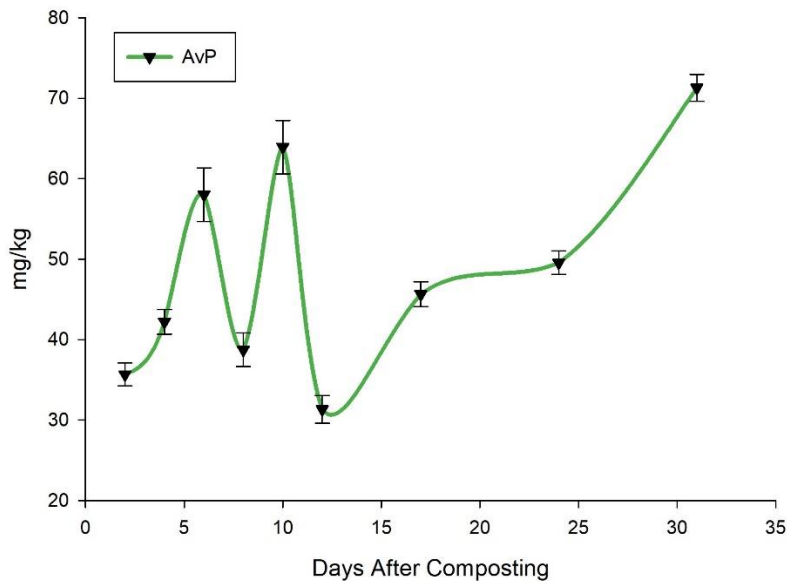


Fig 5: Variation of Available Phosphorous During Composting

After day 16, the gradual increase in the AvP and the subsequent stabilization before the rapid increase to its maximum indicates substantial mineralization of organic phosphorus and reduced fixation as the compost matures. The increase during the maturation stage suggests improved nutrient stabilization and accumulation of soluble phosphorus forms. This trend demonstrates that the mature compost possesses higher phosphorus availability, making it more suitable as a soil fertility amendment for crop production. The final high AvP level indicates

that composting effectively enhances the phosphorus content and agronomic value of fruit and vegetable waste compost. The stabilization of AvP and its rapid increase toward the end of composting is a result of mineralization of organic phosphorus and reduced fixation (Naher *et al.*, 2018).

Concentrations of Exchangeable Basis

The concentrations of calcium (Ca), magnesium (Mg), sodium (Na), and potassium (K) showed significant ($p < 0.05$) variations throughout the composting period (Fig 6). Generally, Ca and Mg concentrations

increased during the composting period with slight fluctuations observed at day 8-12. The results showed that Ca increase from 7.80 cmol (+) Kg⁻¹ at day 2 to a maximum of 10.83 cmol (+) Kg⁻¹ at day 31, while magnesium increased from 2.90 to 4.17 cmol (+) Kg⁻¹ over the same period. These increases can be attributed to the mineralization of organic matter and the concentration effect resulting from the loss of carbon as CO₂ during microbial decomposition. As

fruit and vegetable residues decompose, structural components of plant tissues release Ca and Mg into more readily available forms, leading to their gradual accumulation in the compost matrix. The temporary fluctuation observed at some stages may be associated with variations in microbial activity, moisture content, and the heterogeneity of the composting materials.

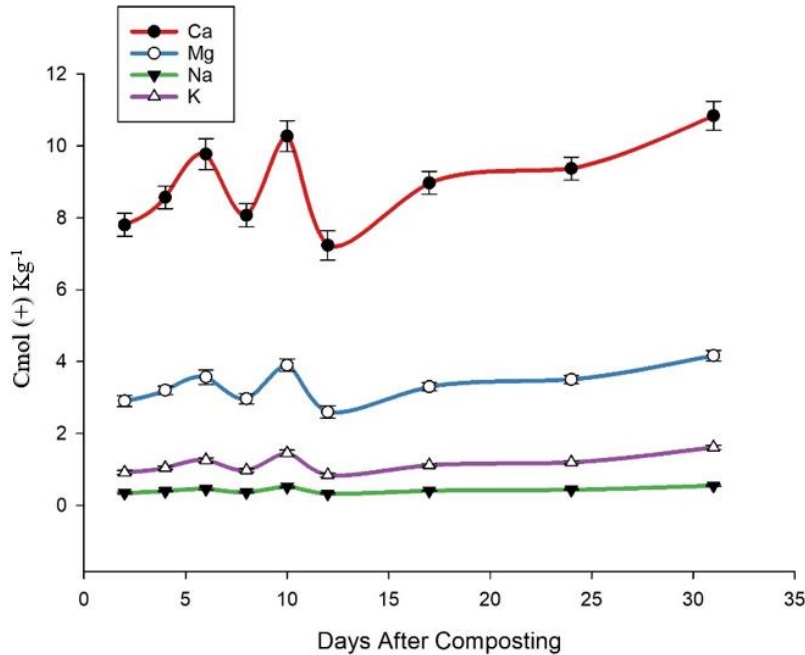


Fig 6: Concentrations of Exchangeable Basis (Ca, Mg, Na, and K) during 31-day Fruit and Vegetable Waste Composting

Comparatively, Na and K also showed an overall increasing trend during the composting process. Although with minor fluctuations, Na increased from 0.35 cmol (+) Kg⁻¹ to 0.55 cmol (+) Kg⁻¹ at day 2 and 31 respectively, while K increase from 0.92 to 1.62 cmol (+) Kg⁻¹ over the same observed period. The gradual increase in these nutrient elements is largely attributed to the release of soluble mineral salts during the decomposition of organic residues and the reduction in compost mass. Potassium, in particular, is highly soluble and can readily be released from plant tissues, especially in fruit and vegetable wastes that are naturally rich in element. Therefore, the increase in K during compost stabilization reflects enhanced nutrient availability and contributes

significantly to the fertilizer value of the final compost. Meanwhile, the relatively low sodium levels suggest that the compost would not pose salinity risks when applied to soil, making it suitable for soil fertility improvement. The overall increasing trend of Ca, Mg, Na and K toward the later stages, which when summed together referred to as total exchangeable basis (TEB) indicates progressive compost stabilization and improved nutrient enrichment of the compost. The current study is in line with (Gao *et al.*, 2023) who reported similar increase in Ca, Mg, Na and K as a results of enhanced mineralization coupled with reduced leaching losses in maturing compost as organic acids initially chelate divalent cations before their stabilization.

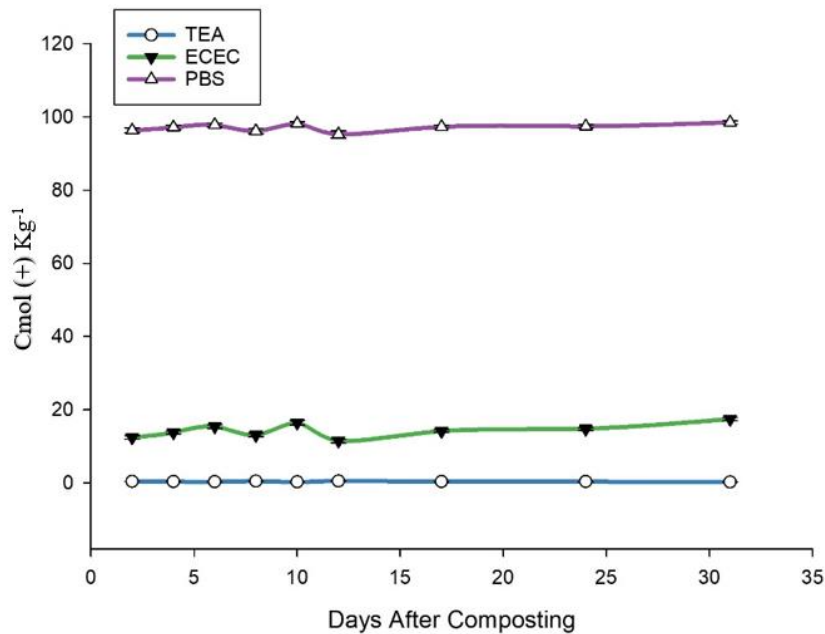


Fig 7: Variation of Total Exchangeable Acidity (TEA), Effective Cation Exchange Capacity (ECEC) and Percent Base Saturation (PBS) During Composting

Effective cation exchange capacity (ECEC) followed increasing trend with significantly ($p < 0.05$) difference with compost maturity. The highest ECEC value recorded at day 31 ($17.47 \text{ cmol (+) kg}^{-1}$) indicates enhanced nutrient retention capacity of the compost, one which is critical for improving soil fertility in low ECEC tropical soils (Musa *et al.*, 2025). Percent base saturation (PBS) also increased progressively, reaching 98.47% at day 31, suggesting dominance of basic cations and favourable conditions for crop nutrient uptake. The higher PBS at 31 day suggests that despite the slightly acidic pH (6.11), the compost is very rich in available minerals and does not have toxic levels of exchangeable acidity. This is typical for food-based composts because fruits and vegetables are naturally high in potassium and magnesium (Fruit and Vegetable Processing - Ch02 General Properties of Fruit and Vegetables; Chemical Composition and Nutritional Aspects; Structural Features (Cont.), n.d.; Wilton, 2023). It is therefore necessary to characterise the fruit and vegetable materials to know which account for the higher potassium and magnesium.

Implications for Waste Management and Soil Fertility Improvement

The observed physicochemical changes demonstrate that fruit and vegetable waste undergo rapid decomposition and stabilization within a relatively short composting period (31 days). By day 24–31, the compost exhibited key maturity indicators, including

stabilized pH, reduced organic carbon, low ammonium concentration, high nitrate accumulation, and improved nutrient availability. These characteristics confirm the suitability of the compost for use as a soil amendment. These results underscore the suitability of fruit and vegetable waste for rapid composting under controlled conditions, offering a sustainable strategy for organic waste management while producing a nutrient-rich soil conditioner.

From a waste management perspective, the results highlight the potential of short-term composting as an effective strategy for managing market-derived fruit and vegetable dumps in Nigeria. Agronomically, the mature compost produced at later stages offers substantial benefits for soil fertility improvement, particularly in tropical soils with low organic matter and nutrient reserves. The integration of such compost into soil management practices can therefore contribute to sustainable agriculture while simultaneously addressing organic waste disposal challenges.

Conclusions

The composting of fruit and vegetable waste over 31 days effectively transformed raw organic residues into a stable, nutrient-rich soil amendment. The temperature profile indicated distinct thermophilic, cooling, and maturation phases, ensuring sanitation by eliminating pathogens. Reductions in organic carbon and shifts from ammonification to nitrification

confirmed organic matter stabilization. Key indicators of compost maturity, including reduced ammonium levels, increased nitrate concentration, stabilized pH, and convergence of compost temperature with ambient conditions, were clearly achieved by the end of the composting period. Additionally, increases in available phosphorus and cation exchange capacity highlighted nutrient enrichment. The final compost's pH and electrical conductivity were suitable for sensitive crops, indicating that the process produced a high-quality product beneficial for improving soil fertility, especially in organic matter-deficient tropical soils.

Fruit and vegetable waste composting be widely adopted as an environmentally sustainable strategy for organic waste management and soil fertility enhancement. Encourage farmers and agricultural practitioners to incorporate the matured compost into their soil management practices to enhance soil structure, nutrient availability, and microbial activity. However, proper monitoring of composting conditions, particularly temperature, moisture, and aeration is essential to ensure efficient decomposition and high-quality compost. There is a need to further studies with larger containers to validate the compost physical and chemical properties particularly the temperature, pH, ECEC and PBS. Further studies should be conducted to account for the types and number of microorganisms that are actively present during and after composting. Additionally, further studies should be conducted to evaluate the field performance of the produced compost under different cropping systems and soil types. Investigations into optimizing composting duration, improving nutrient retention, especially nitrogen, and minimizing losses through volatilization and leaching are also recommended. Integrating this compost with other soil fertility management practices, such as inorganic fertilizers or biofertilizers, could also further enhance its effectiveness and contribute to sustainable agricultural production systems.

Declaration of competing interest

The authors declare no conflict of interest associated with this publication.

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Appendix I: Chemical Properties of Compost Over the Period of Observation

DAC	pH	EC	OC	OM	NH	NO	AvP	Ca	Mg	Na	K	TEB	TEA	ECEC	PBS	
Day02	6.29 ^{ab} c	3.28 ^c d	18.03 ^a	31.10 ^a	38.03 ^a	74.03 ^c	35.67 ^e f	7.80 ^{de}	2.90 ^{cd}	0.35 ^{cd}	0.92 ^{de}	12.03 ^{de}	0.45 ^{abc}	12.47 ^{de}	96.30 ^a b	
Day04	6.19 ^{ab} c	4.32 ^a b	15.40 ^{ab}	26.60 ^{ab}	16.13 ^d	31.23 ^f	42.20 ^d e	8.57 ^{bcd} e	3.20 ^{bc} d	0.40 ^{bcd}	1.05 ^{cd} e	13.37 ^{cd} e	0.40 ^{bcd}	13.80 ^{cd} e	97.10 ^a b	
Day06	6.14 ^{bc}	2.60 ^e	13.97 ^{bc}	24.13 ^{bc}	16.37 ^c d	99.00 ^b	58.03 ^b c	9.77 ^{abc}	3.57 ^{ab} c	0.46 ^{abc}	1.26 ^{bc} c	15.07 ^{ab} c	0.35 ^{cde}	15.47 ^{ab} c	97.77 ^a b	
Day08	6.05 ^c	1.42 ^f	13.20 ^{bcd}	22.77 ^{bcd}	21.50 ^c	43.17 ^{ef}	38.73 ^e f	8.07 ^{cde}	2.97 ^{cd}	0.37 ^{cd}	0.98 ^{de}	12.57 ^{cd} e	0.50 ^{ab}	13.10 ^{cd} e	96.10 ^a b	
Day10	6.17 ^{bc}	4.76 ^a	12.53 ^{bcd} e	21.60 ^{bcd} e	26.83 ^b	92.87 ^b 49.43 ^d	63.93 ^a b	10.27 ^a b	3.90 ^{ab}	0.52 ^{ab}	1.45 ^{ab}	16.13 ^{ab}	0.30 ^{de}	16.47 ^{ab}	98.10 ^a b	
Day12	6.48 ^a	2.38 ^e	11.83 ^{cde}	20.30 ^{cde}	27.03 ^b	18.20 ^c	55.43 ^d e	45.63 ^d e	8.97 ^{bcd} d	3.30 ^{bc} d	0.33 ^d	0.84 ^e	11.00 ^e	0.55 ^a	11.53 ^e	95.20 ^b
Day17	6.38 ^{ab}	3.79 ^b c	11.10 ^{cde}	19.07 ^{cde}	18.20 ^c d	55.43 ^d e	45.63 ^d e	8.97 ^{bcd} e	3.30 ^{bc} d	0.41 ^{bcd} e	1.12 ^{cd} e	13.77 ^{bc} d	0.40 ^{bcd} d	14.20 ^{bc} d	97.27 ^a b	
Day24	6.39 ^{ab}	2.81 ^d e	10.47 ^{de}	17.93 ^{de}	14.30 ^d	61.83 ^{cd}	49.57 ^c d	9.37 ^{abc} d	3.50 ^{ab} c	0.44 ^{abc} d	1.20 ^{bc} d	14.40 ^{bc} d	0.38 ^{bcd} e	14.80 ^{bc} d	97.40 ^a b	
Day31	6.11 ^{bc}	4.39 ^a b	9.83 ^e	16.93 ^e	13.57 ^d	142.43 a	71.30 ^a	10.83 ^a	4.17 ^a	0.55 ^a	1.62 ^a	17.13 ^a	0.26 ^e	17.47 ^a	98.47 ^a	
Standard Error for Comparison	0.08	0.20	0.91	1.52	1.50	4.06	3.02	0.52	0.21	0.03	0.08	0.76	0.04	0.70	0.88	
Critical Value for Comparison	0.29	0.69	3.18	5.33	5.26	14.24	10.58	1.82	0.75	0.12	0.28	2.68	0.14	2.46	3.07	

**Appendix II: Summary of ANOVA
Completely Randomized AOV for pH**

Source	DF	SS	MS	F	P
DAC	8	0.51253	0.06407	6.21	0.0006
Error	18	0.18573	0.01032		
Total	26	0.69827			

Grand Mean 6.2456 CV 1.63

Homogeneity of Variances			F	P
Levene's Test	0.53	0.8208		
O'Brien's Test	0.23	0.9789		
Brown and Forsythe Test	0.17	0.9921		

Welch's Test for Mean Differences

Source	DF	F	P
DAC	8.0	4.65	0.0251
Error	7.5		
Component of variance for between groups		0.01792	
Effective cell size	3.0		

DAC Mean

Day10	6.1700
Day12	6.4800
Day17	6.3767
Day2	6.2933
Day24	6.3933
Day31	6.1100
Day4	6.1900
Day6	6.1433
Day8	6.0533

Observations per Mean 3
Standard Error of a Mean 0.0586
Std Error (Diff of 2 Means) 0.0829

Tukey HSD All-Pairwise Comparisons Test of pH by DAC

DAC	Mean	Homogeneous Groups
Day12	6.4800	A
Day24	6.3933	AB
Day17	6.3767	AB
Day2	6.2933	ABC
Day4	6.1900	ABC
Day10	6.1700	BC
Day6	6.1433	BC
Day31	6.1100	BC
Day8	6.0533	C

Alpha 0.05 Standard Error for Comparison 0.0829
Critical Q Value 4.955 Critical Value for Comparison 0.2906
There are 3 groups (A, B, etc.) in which the means are not significantly different from one another.