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Evaluation of the physicochemical characteristics of composts produced from various local organic materials in Korhogo, Northern Côte d'Ivoire

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Abstract

The valorization of organic waste through composting can constitute a sustainable alternative for managing agricultural residues and improving soil fertility under different cropping systems. This study aimed to characterize and compare the physicochemical properties of three composts produced from different local organic materials in Korhogo, with a view to their use for improving soil fertility. Three compost types were prepared: peanut shells and cattle manure (C1), coffee grounds and sawdust (C2), and mango residues and cattle manure (C3). After 90 days of heap composting, the composts were analyzed for physicochemical characteristics (pH, electrical conductivity, organic matter, total carbon, moisture content, and C/N ratio), major nutrients (N, P, K, Ca, and Mg), and trace metal elements. Significant differences were observed among composts for all parameters studied. C1 had the highest total nitrogen content (1.52% DM) and an alkaline pH (8.5), whereas C2 had the highest moisture content (48.40% DM) and potassium content (62.94 mg kg^{-1} DM). C3 had the highest phosphorus (822.56 mg kg^{-1} DM), calcium (449.28 mg kg^{-1} DM), magnesium (39.16 mg kg^{-1} DM), and micronutrient contents. Trace metal concentrations remained low in all composts and were compatible with agricultural use. These results confirm that feedstock composition influences the agronomic quality of composts.

Keywords: Composting; Organic Waste; Agronomic Quality; Trace Metal Elements; Côte d'Ivoire

1. Introduction

The continuous increase in organic waste production, driven by population growth, urbanization, and agricultural development, is a major challenge for developing countries. When poorly managed, this waste causes soil and water pollution, greenhouse gas emissions, and pathogen proliferation. Organic waste valorization through composting can therefore provide a sustainable solution by reducing waste volumes while producing an organic amendment useful for agriculture (Huzir et al., 2026).

Composting is an aerobic biological process in which microorganisms transform biodegradable organic materials into a stable, sanitized product rich in plant nutrients. The resulting compost improves the physical, chemical, and biological properties of soils while supporting sustainable fertility management. In tropical farming systems, characterized by declining soil organic matter and low mineral nutrient availability, compost use can promote agricultural production while reducing dependence on mineral fertilizers (Hettiarachchi et al., 2020).

However, compost quality is strongly related to the nature of the raw materials and composting conditions. Significant differences may occur in pH, electrical conductivity, organic matter, carbon, nitrogen, phosphorus, and potassium contents. Compost maturity, often assessed through the carbon-to-nitrogen (C/N) ratio, also determines agronomic

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effectiveness. pH, electrical conductivity, and the C/N ratio are commonly used to evaluate the stability and quality of composts intended for agricultural use (Jiang et al., 2024).

The presence of trace metal elements requires particular attention because of potential risks to soils, crops, and the environment. Concentrations of lead (Pb), cadmium (Cd), copper (Cu), and zinc (Zn) are essential indicators of compost quality and safety before agricultural application (Gao et al., 2023; Ejileugha et al., 2024).

Analysis of compost physicochemical parameters is therefore an essential prerequisite for agricultural valorization, making it possible to assess fertilizing value, maturity, and compliance with environmental requirements. Although composting is increasingly recognized as a sustainable organic-waste management approach, information on compost quality from different waste formulations remains limited in many production contexts, particularly in sub-Saharan Africa (Huzir et al., 2026).

In Côte d'Ivoire, agricultural, livestock, and agro-food activities generate large quantities of cattle manure, peanut shells, mango residues, coffee grounds, and sawdust. These by-products remain underutilized despite their organic matter and nutrient potential. Their accumulation contributes to local environmental problems, but they also offer an important opportunity to produce composts for improving agricultural soil fertility. Because feedstock diversity can cause major variations in compost quality, rigorous evaluation is required before agronomic use.

The research question was therefore: do composts produced from various local organic materials in Korhogo exhibit satisfactory physicochemical, agronomic, and environmental characteristics?

The general objective was to characterize and compare the physicochemical properties, fertilizing value, and environmental quality of composts produced from different local organic materials in Korhogo for agricultural use. Specifically, the study aimed to: (i) characterize the physicochemical properties and fertilizing values of the composts through their major nutrient contents (N, P, and K); and (ii) assess environmental quality based on trace metal element concentrations.

2. Material and methods

2.1. Study Site

The study wasconducted at the Botanical Garden of Peleforo GON COULIBALY University in Korhogo, in the Poro Region of northern Côte d'Ivoire (Figure 1). Korhogo lies between longitudes 5°36′ and 5°54′ W and latitudes 9°24′ and 9°36′ N (N'Guessan et al., 2019). The climate is Sudanian tropical, with a rainy season from May to October and a dry season marked by the Harmattan (Kouassi et al., 2022). Annual rainfall ranges from 1,200 to 1,400 mm and mean annual temperature is approximately 27 °C (Coulibaly et al., 2024). The region has a water deficit exceeding 500 mm because of high potential evapotranspiration (Timité et al., 2022). Vegetation is dominated by Sudanian savanna, and soils are mainly tropical ferruginous soils with sandy-clay to sandy-loam textures, generally poor in organic matter, with average carbon and nitrogen contents of 0.44% and 0.039%, respectively (Siéné et al., 2020).

2.2. Materials

2.2.1. Organic Materials Used for Composting

The organic inputs used for composting were diverse and had complementary functions (Figure 2). Mango residues provided readily biodegradable material rich in water and soluble sugars. Peanut shells supplied a lignocellulosic fraction that contributed to compost structure and improved the C/N ratio. Cattle manure acted as a microbial inoculum and stimulated decomposition. Sawdust provided a stable carbon source and helped regulate moisture. Coffee grounds supplied additional organic matter and improved substrate texture and porosity. Wood ash, an alkaline mineral amendment rich in potassium and calcium, was used to improve mixture chemistry and help control certain pests.

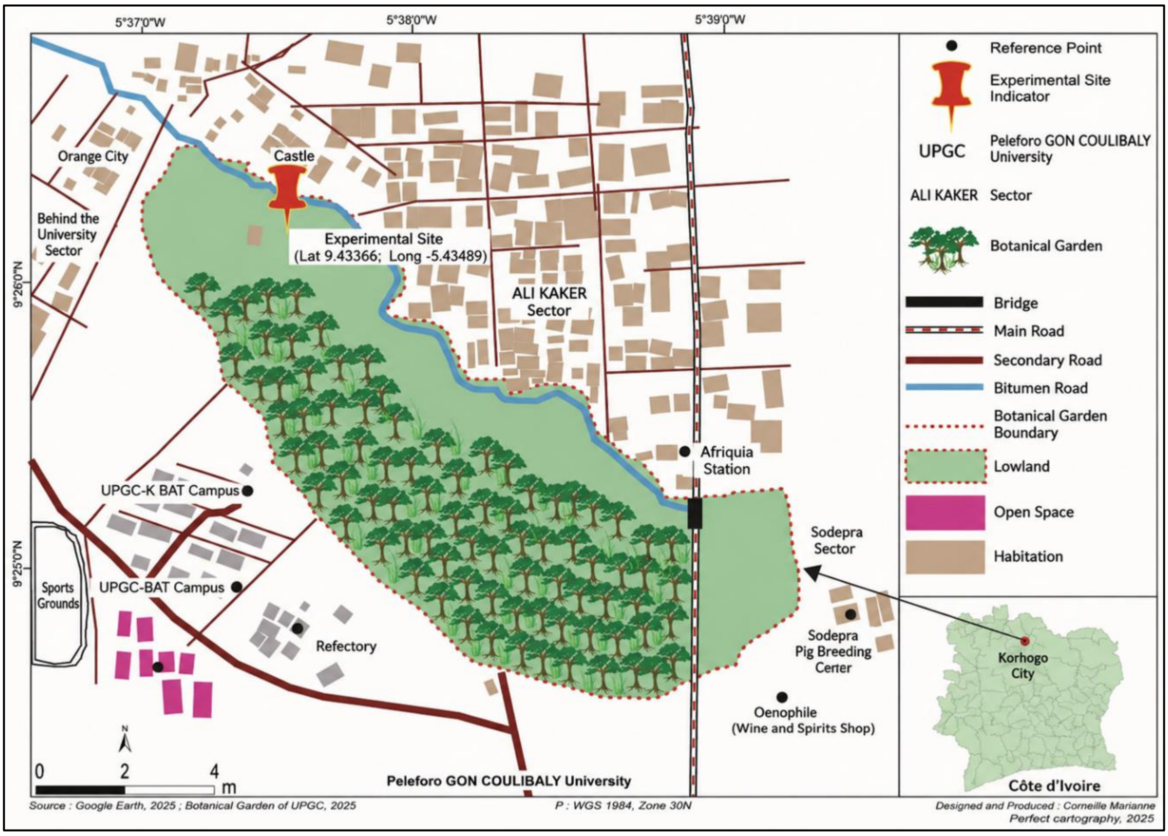

Figure 1 Location of the study site. Source: Condé (2026)

Figure 2 Organic materials used for composting.

2.2.2. Technical and Laboratory Equipment

Technical equipment included a scale for weighing inputs; plastic sheets for covering heaps; a Soil Tester S-1 for measuring pH and temperature during composting; an auger for sampling; field tools (machete, hoe, shovel, and watering can); and plastic buckets for germination tests. Laboratory equipment included a precision balance; volumetric flasks, beakers, crucibles, and tubes for digestion, dilution, and ignition; an oven for drying at 105 °C; a muffle furnace for ignition at 550 °C; a desiccator for cooling treated samples; and a pH meter.

2.3. Methods

2.3.1. Composting Procedure

Collection of Organic Materials

Organic waste was collected methodically from local sources. Mango residues came from processing units, sawdust from sawmills coffee grounds from retail outlets, cattle manure from cattle sheds, and ash from households. Substrates were selected for their abundance and complementarity, allowing a carbon- and nitrogen-balanced mixture favorable to composting and microbial activity.

Grinding of Organic Materials

Grinding reduces particle size, increases the surface area accessible to microorganisms, improves mixture homogeneity, and accelerates organic matter decomposition (Sebgo, 2015). Peanut shells were ground using a mechanical mill commonly used for cereals until a finer, more homogeneous particle size was obtained.

Establishment of the Compost Heaps

The experiment was established in a semi-shaded area to limit direct solar radiation. The plot was cleared and marked out over 2 m × 1.5 m per heap. A thin ash layer was placed on the soil to reduce pests, particularly termites.

Each heap consisted of four alternating organic layers. For C1, each layer contained 10 kg peanut shells and 5 kg cattle manure; for C2, 9.75 kg coffee grounds and 3.25 kg sawdust; and for C3, 17.5 kg mango residues and 7.5 kg cattle manure. Organic layers were separated by approximately 1 kg of ash to limit nutrient losses, improve aeration, and promote microbial activity. Water was applied after each layer to adjust moisture.

After construction, heaps were covered with black plastic sheets to limit moisture loss, retain heat, and create favorable thermal conditions for decomposition.

2.3.2. Monitoring of Physicochemical Parameters during Composting

Temperature and pH Monitoring

The process was monitored through watering and regular temperature and pH measurements using a portable multipara meter probe. Measurements were taken in situ at the upper, middle, and lower sections of each heap. PH was measured at the same insertion points directly in moist compost. Measurements were taken between 8:00 and 10:00 a.m. to limit daily thermal variation.

Assessment and Regulation of Moisture

Moisture was assessed before watering using the hand-squeeze test (Michel and Fuchs, 2020). A representative handful of compost was squeezed firmly. Material that immediately crumbled indicated insufficient moisture and led to the addition of 20 L of water per heap. Water flowing between the fingers indicated excess moisture. Slight cohesion without water release indicated optimal moisture.

Progress Indicators and Maturity Criteria

Maturity was assessed using temperature decline and pH stabilization. A progressive decrease in temperature to near ambient values indicated reduced microbial activity and entry into maturation. Stabilization of pH between 6 and 8 was used as a criterion of chemical stability. Simultaneous achievement of both conditions indicated maturity.

Germination Test for Maturity and Phytotoxicity

Four treatments were evaluated: C1 (peanut shells + cattle manure), C2 (coffee grounds + sawdust), C3 (mango residues + cattle manure), and a sand control. Each treatment was replicated three times in pots containing 4 kg substrate. Ten maize seeds were sown per pot, totaling 30 seeds per treatment. Pots were maintained under identical conditions and watered regularly.

After 10 days, germinated seeds were counted and radicle length was measured. The germination index (GI) was calculated according to Zucconi et al. (1981) and Kong et al. (2023). GI combines germination percentage and root growth. GI < 80% indicates phytotoxicity, whereas GI ≥ 80% indicates mature compost suitable for agronomic use (Kong et al., 2023).

2.3.3. Determination of Compost Fertilizing Value

Sample Preparation

After 90 days, 100-g composite samples were prepared from five 20-g subsamples collected from the top, base, center, left side, and right side of each heap using a cross-sampling design. Samples were air-dried, sieved to 0.5 mm, packed in airtight bags, and transported to the laboratory of the Institut National Polytechnique Félix Houphouët-Boigny in Yamoussoukro.

pH Determination

Compost pH was determined potentiometrically using a HANNA pH meter in accordance with ISO 10390:2021. Five grams of each sample were suspended in 100 ml distilled water at a 1:5 solid-to-liquid ratio and shaken for 24 h. After settling and filtration, pH was measured in the filtrates using a calibrated glass electrode.

Moisture, Dry Matter, and Organic Matter

Dry matter (DM) and moisture contents were determined according to AFNOR. (2025). Samples were dried at 105 °C for 24 h to constant mass. Organic matter was determined by loss on ignition according to AFNOR *NF EN 15935* (2021), with dried samples ignited at 600 °C for 4 h.

Total Carbon, Total Nitrogen, and C/N Ratio

Total carbon was determined by dry combustion using a CHN elemental analyzer (NDIR) according to Nelson and Sommers (1996). Total nitrogen was determined by the modified Kjeldahl method (Bremner, 1996) after acid digestion, distillation, and titration. The C/N ratio was calculated from total C and N contents.

Major Nutrients

Total phosphorus was determined colorimetrically using the ascorbic-acid-reduced molybdenum blue method after acid extraction with absorbance measured at 880 nm. K, Ca, and Mg were determined by ICP-OES after acid digestion according to EPA 3051A (USEPA, 2007) and analysis according to EPA 6010D (USEPA, 2018).

Trace Metal Elements

Fe, Mn, Cu, Zn, and Pb were determined by ICP-OES. Portions of 0.5 g dry matter were acid-digested according to EPA 3051A using 10 mL concentrated HNO_3. After cooling, digests were filtered when necessary and made up to 50 mL with ultrapure water. Concentrations were determined according to EPA 6010D. Accuracy and precision were checked using certified reference materials, a procedural blank and standard addition. Results were expressed as mg kg^{-1} DM.

2.4. Statistical Analyses

Data were subjected to one-way analysis of variance (ANOVA) to evaluate the effect of compost constituents on physicochemical parameters, major nutrients, micronutrients, and trace metal elements. When significant differences occurred ($p < 0.05$), means were compared using Tukey's test at the 5% significance level. Results were expressed as mean ± standard deviation. Analyses were performed using SPSS version 26.

3. Results

3.1. Temperature and pH During Composting

Compost temperature increased rapidly during the first days. C1 reached 65 °C on day 21 (D21), followed by C2 at 60 °C, whereas C3 reached a lower peak of 45 °C. Temperatures then progressively declined to values close to ambient temperature during maturation.

Initial pH values were 6.5 for C1, 6.3 for C2, and 5.8 for C3. PH increased until D21, reaching 8.5, 8.2, and 6.8, respectively. It then decreased slightly between D21 and D60 before stabilizing. At D90, pH values were 8.0 for C1, 7.7 for C2, and 6.0 for C3.

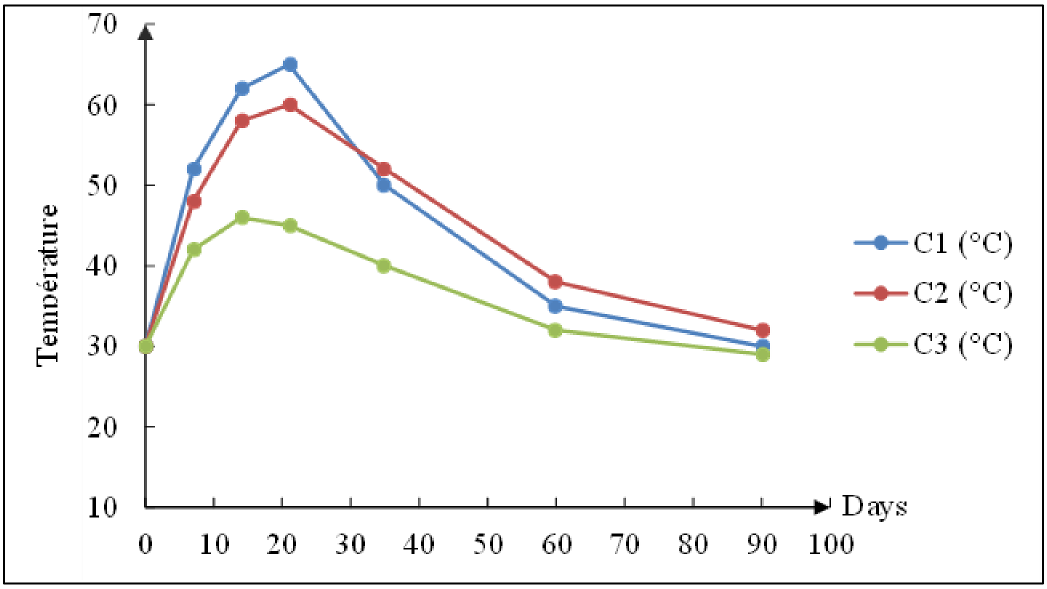

Figure 3 Evolution of the temperature of the different composts during composting

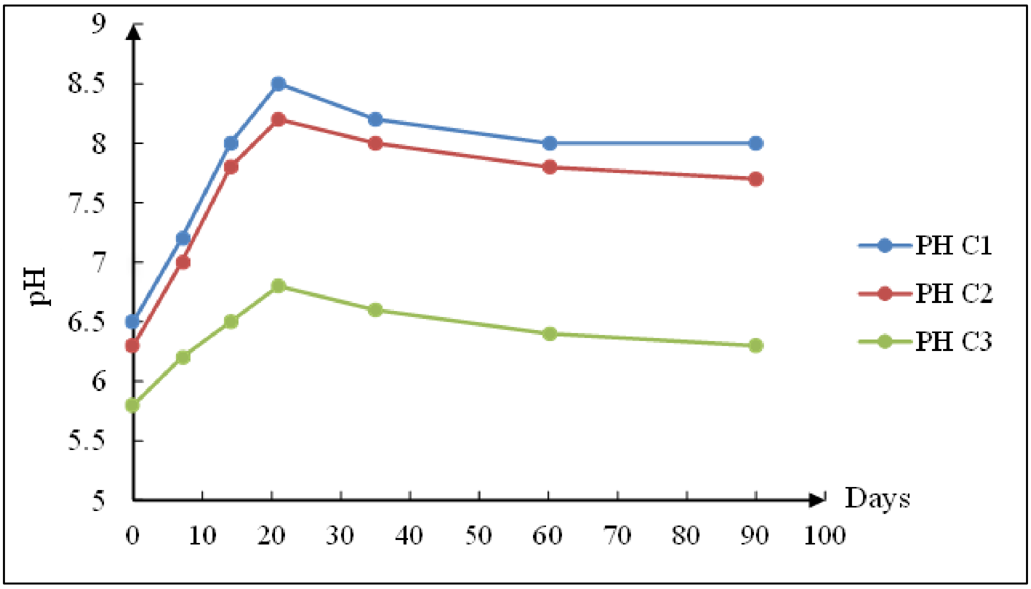

Figure 4 Evolution of the pH of the different composts during composting

- C1: Compost produced from peanut shells and cattle manure
- C2: Compost produced from coffee grounds and sawdust
- C3: Compost produced from mango residues and cattle manure

3.2. Major Mineral Elements

Significant differences ($p < 0.05$) were observed for all major nutrients. Total nitrogen ranged from 0.57 to 1.52% DM, with C1 highest, followed by C3 and C2. Phosphorus ranged from 117.56 to 822.56 mg kg^{-1} DM, with C3 highest. C2 had the highest potassium content. C3 also had the highest calcium and magnesium contents.

Table 1 Major mineral element composition of the three composts

Parameters	C1	C2	C3
N (% DM)	1.52 ± 0.00c	0.57 ± 0.00a	1.13 ± 0.01b
P (mg/kg DM)	327.37 ± 0.41b	117.56 ± 0.29a	822.56 ± 0.02c
K (mg/kg DM)	50.92 ± 0.04a	62.94 ± 0.04b	51.29 ± 0.32a
Ca (mg/kg DM)	150.68 ± 0.56b	125.66 ± 0.28a	449.28 ± 0.47c
Mg (mg/kg DM)	13.13 ± 0.00b	4.61 ± 0.00a	39.16 ± 0.00c

Means followed by different letters within the same row are significantly different at the 5% significance level ($p < 0.05$). C1 = peanut shell compost; C2 = coffee grounds compost; C3 = mango waste compost. Ca = calcium; Fe = iron; P = phosphorus; Mg = magnesium; N = nitrogen; K = potassium. % DM = percentage of dry matter; mg/kg DM = milligrams per kilogram of dry matter

3.3. Germination Index

All treatments recorded GI values above 80%. C1 had the highest germination index (95.6%), followed by C3 (91.0%) and C2 (88.8%), whereas the T0 control had the lowest value (81.1%).

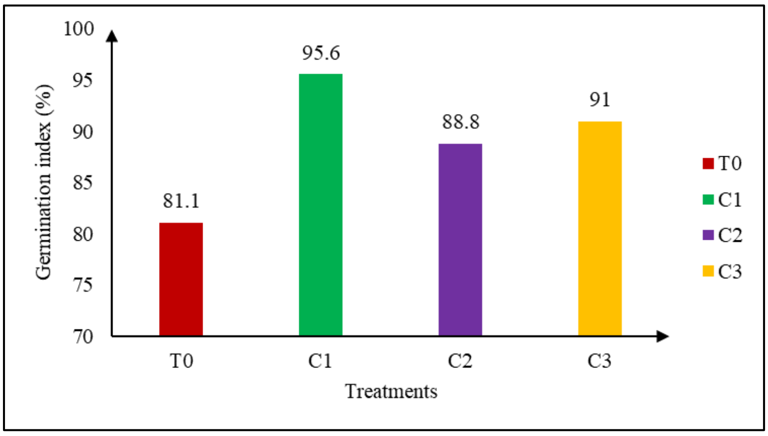

Figure 5 Germination index of the different composts evaluated

- C1: Compost produced from peanut shells and cattle manure
- C2: Compost produced from coffee grounds and sawdust
- C3: Compost produced from mango residues and cattle manure
- T0: Control treatment without compost application

3.4. Micronutrients

Significant differences were observed for all micronutrients. C3 had the highest Fe (559.75 ± 0.07 mg kg^{-1} DM), Mn (9.06 mg kg^{-1} DM), Zn (2.57 ± 0.00 mg kg^{-1} DM), and Cu (0.32 ± 0.01 mg kg^{-1} DM) contents.

Table 2 Micronutrient contents of the produced composts

Parameters	C1	C2	C3
Fe (mg/kg DM)	197.39 ± 0.40b	119.54 ± 0.77a	559.75 ± 0.07c
Mn (mg/kg DM)	2.43 ± 0.00b	1.09 ± 0.00a	9.06 ± 0.00c
Zn (mg/kg DM)	0.59 ± 0.00b	0.28 ± 0.00a	2.57 ± 0.00c
Cu (mg/kg DM)	0.09 ± 0.00a	0.11 ± 0.00b	0.32 ± 0.01c

Means followed by different letters within the same row are significantly different at the 5% significance level ($p < 0.05$). C1 = peanut shell compost; C2 = coffee grounds compost; C3 = mango waste compost. Fe = iron; Mn = manganese; Zn = zinc; Cu = copper. % DM = percentage of dry matter; mg/kg DM = milligrams per kilogram of dry matter.

3.5. Trace Metal Elements

Pb was highest in C3, whereas Hg was highest in C1. As was not detected in any compost. Cd was detected in C1 and C3 but not in C2. Cr and Ni were also highest in C3. Overall, concentrations remained very low.

Table 3 Trace metal element concentrations in the produced composts

Parameters	C1	C2	C3
Pb (mg/kg DM)	0.076 ± 0.000b	0.040 ± 0.000a	0.116 ± 0.000c
Hg (mg/kg DM)	0.082 ± 0.000c	0.046 ± 0.000b	0.018 ± 0.000a
As (mg/kg DM)	ND	ND	ND
Cd (mg/kg DM)	0.003 ± 0.000b	ND	0.005 ± 0.000c
Cr (mg/kg DM)	0.257 ± 0.000b	0.195 ± 0.000a	0.909 ± 0.000c
Ni (mg/kg DM)	0.015 ± 0.000b	0.002 ± 0.000a	0.050 ± 0.000c

Means followed by different letters within the same row are significantly different at the 5% significance level ($p < 0.05$). C1 = peanut shell compost; C2 = coffee grounds compost; C3 = mango waste compost. Pb = lead; Hg = mercury; As = arsenic; Cd = cadmium; Cr = chromium; Ni = nickel. % DM = percentage of dry matter; mg/kg DM = milligrams per kilogram of dry matter; ND = not detected.

3.6. Physicochemical Quality

Significant differences occurred for most physicochemical parameters. pH ranged from 6.8 in C3 to 8.5 in C1. Electrical conductivity decreased from C1 to C3. Organic matter and total organic carbon were higher in C1 and C2. The C/N ratio was highest in C2 (34.55), followed by C3 (13.00) and C1 (12.86). Moisture was highest in C2 (48.40%).

Table 4 Physicochemical characteristics of the three experimental composts

Parameters	C1	C2	C3
pH	8.5 ± 0.02c	7.7 ± 0.01b	6.8 ± 0.05a
EC (µS/cm)	26.85 ± 0.18c	14.06 ± 0.06b	8.50 ± 0.10a
OM (% DM)	33.80 ± 0.76b	34.23 ± 0.28b	25.00 ± 0.50a
TOC (% DM)	19.59 ± 0.44b	19.84 ± 0.16b	12.50 ± 0.30a
C/N	12.86 ± 0.36b	34.55 ± 0.36c	13.00 ± 0.40a
Moisture (% DM)	38.59 ± 0.26b	48.40 ± 0.56c	20.00 ± 0.40a

Means followed by different letters within the same row are significantly different at the 5% significance level ($p < 0.05$). C1 = peanut shell compost; C2 = coffee grounds compost; C3 = mango waste compost. pH = hydrogen potential; EC = electrical conductivity; OM = organic matter; TOC = total organic carbon; C = carbon; C/N = carbon-to-nitrogen ratio; Moisture = moisture content. µS/cm = microsiemens per centimeter; % DM = percentage of dry matter.

4. Discussion

The results showed that raw material type strongly influenced composting and the agronomic characteristics of the resulting composts. Differences among treatments reflected the effect of substrate composition on microbial activity, mineralization, and stabilization.

Temperature was a major indicator of biological activity. C1 and C2 exceeded 55 °C, the thermophilic threshold, indicating intense decomposer activity. Maintaining temperatures above 55 °C promotes rapid organic matter degradation and compost sanitization through pathogen elimination (Oueld Lhaj et al., 2026).

The pH variations also indicated proper process development. The initial increase resulted from organic nitrogen mineralization and ammonia production. Final stabilization reflected declining microbial activity and improved biochemical stability, consistent with Li et al. (2023).

All germination indices exceeded 80%, indicating that the composts were sufficiently mature for agricultural use. C1 had the highest GI (95.6%), followed by C3 (91.0%) and C2 (88.8%). These high values may reflect greater biological stability and fewer phytotoxic compounds, in agreement with Kong et al. (2023).

Differences in mineral composition reflected the influence of the initial feedstocks. Compost C1 exhibited the highest nitrogen content, which may be attributed to better nitrogen conservation during composting. Bernal et al. (2009) reported that the quality of feedstocks strongly influences nitrogen losses and the final availability of this element in compost. In contrast, compost C3 contained higher concentrations of phosphorus, calcium, and magnesium, probably because of the naturally high mineral content of mango residues. Bamogo et al. (2025) reported that mango residues are an important source of calcium and magnesium, while Ballo et al. (2026) suggested that the progressive degradation of organic matter in mango residues promotes mineral enrichment during composting. The higher potassium concentration observed in compost C2 may be associated with the high organic matter content of coffee grounds.

C3 had the highest Fe, Mn, Zn, and Cu concentrations. This accumulation may result from initial substrate composition and progressive organic matter mineralization. Compost micronutrient contents depend mainly on feedstock type and transformation during decomposition (Gao et al., 2023).

Trace metal concentrations were very low, and arsenic was undetectable. These results indicate good raw-material quality and a low risk of soil and crop contamination. Properly sorted organic waste generally produces composts with heavy-metal concentrations below regulatory limits (Sharma et al., 2019).

The pH range was generally compatible with mature compost. Relatively low electrical conductivity indicated limited salinization risk. Higher organic matter and total organic carbon in C1 and C2 suggest greater potential to improve soil structure and fertility.

The C/N ratio was particularly informative. C1 had a ratio of 12.86, compatible with mature compost according to Bernal et al. (2009). In contrast, the high C/N ratio of C2 (34.55) indicated incomplete decomposition and possible temporary nitrogen immobilization after soil incorporation.

Overall, composting local organic waste can provide a sustainable source of quality organic amendments capable of improving soil fertility and agricultural production.

5. Conclusion

The study conducted in Korhogo showed that raw material type significantly influenced the agronomic quality of the produced composts. Peanut-shell compost (C1) was distinguished by good maturity, stability, high nitrogen content, and low trace metal contamination. Coffee-ground compost (C2) showed promising agronomic potential but would require further maturation, whereas mango-residue compost (C3) was characterized by high mineral contents. Composting local organic waste can therefore constitute a sustainable alternative for producing quality organic amendments and improving soil fertility and agricultural production in northern Côte d'Ivoire. Field agronomic trials are needed to confirm effectiveness and optimize use.

Compliance with ethical standards

Disclosure of conflict of interest

No conflict of interest to be disclosed.

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