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EFFECT OF RAW MATERIAL PROPORTIONS ON THE QUALITY OF COMPOST FROM CLOVE LEAF LITTER AND CATTLE MANURE

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Abstract
Agricultural and livestock wastes are widely available in clove-producing areas but remain underutilized as organic fertilizer inputs. This study aimed to evaluate the quality of compost produced from clove leaf litter, cattle manure, and agricultural residues based on physical and chemical characteristics. The experiment was arranged using a randomized block design with nine treatment combinations and three replications. Compost quality parameters analyzed included organic carbon content, total nitrogen, and C/N ratio. Data were subjected to analysis of variance followed by Duncan's Multiple Range Test at a 5% significance level. The results showed that variations in raw material proportions significantly affected all measured compost quality parameters. Compost formulations with balanced proportions of cattle manure, clove leaves, and agricultural residues resulted in lower C/N ratios, indicating improved compost maturity and stability compared to unbalanced material combinations. These findings demonstrate that locally available agricultural and livestock wastes can be effectively processed into high-quality compost, providing a practical approach to organic waste utilization and supporting environmentally friendly agricultural practices in clove-producing regions.

Keywords: agricultural residues, cattle manure, clove leaf litter, compost quality, organic fertilizer

Abstrak
Limbah pertanian dan peternakan banyak tersedia di wilayah penghasil cengkeh, namun belum dimanfaatkan secara optimal sebagai pupuk organik. Penelitian ini bertujuan untuk mengevaluasi mutu pupuk kompos yang dibuat dari daun cengkeh, kotoran sapi, dan limbah pertanian berdasarkan karakteristik fisik dan kimia. Penelitian disusun menggunakan Rancangan Acak Kelompok dengan sembilan perlakuan dan tiga ulangan. Parameter mutu kompos yang dianalisis meliputi C-organik, N-total, dan rasio C/N. Data dianalisis menggunakan analisis ragam yang dilanjutkan dengan Uji Jarak Berganda Duncan pada taraf nyata 5%. Hasil penelitian menunjukkan bahwa perbedaan proporsi bahan baku berpengaruh nyata terhadap seluruh parameter mutu kompos yang diamati. Kombinasi bahan kotoran sapi, daun cengkeh, dan limbah pertanian dalam proporsi seimbang menghasilkan kompos dengan rasio C/N yang lebih rendah dibandingkan kombinasi bahan yang tidak seimbang, yang mengindikasikan tingkat kematangan dan stabilitas kompos yang lebih baik. Hasil ini menunjukkan bahwa limbah pertanian dan peternakan lokal berpotensi diolah menjadi pupuk kompos berkualitas sebagai upaya pemanfaatan limbah secara berkelanjutan dan mendukung praktik pertanian ramah lingkungan di daerah penghasil cengkeh.

Kata kunci: daun cengkeh, kotoran sapi, limbah pertanian, mutu kompos, pupuk organik

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1. INTRODUCTION

Agricultural waste management remains a persistent challenge in many rural farming systems, particularly in plantation based agriculture where large quantities of organic residues are generated annually. In clove producing regions, fallen leaves constitute a substantial proportion of agricultural biomass that is often left unmanaged in the field. Similarly, livestock activities in rural areas generate significant amounts of cattle manure, which are frequently underutilized or improperly managed. Inadequate handling of these organic wastes may contribute to environmental degradation while overlooking their potential value as soil amendments and nutrient sources (Bernal *et al.*, 2017; Zhang *et al.*, 2020).

Composting is widely recognized as an effective and environmentally sound strategy for converting agricultural and livestock wastes into organic fertilizers. Numerous studies have shown that compost application can improve soil physical structure, enhance microbial activity, and increase nutrient availability, thereby supporting sustainable crop production systems (Agegnehu *et al.*, 2017; Ravindran *et al.*, 2018). However, the agronomic performance of compost is highly dependent on its quality, which is influenced by the composition of raw materials, composting conditions, and process management. Compost produced from poorly balanced materials may result in incomplete decomposition, leading to unfavorable nutrient dynamics and inconsistent field performance (Huang *et al.*, 2017).

Evaluation of compost quality is therefore essential to ensure its maturity and suitability for agricultural use. Indicators such as organic carbon content, total nitrogen, and C over N ratio are commonly used to assess compost stability and decomposition status (Bernal *et al.*, 2017). Although quality standards for compost have been established in many countries, including Indonesia, locally produced compost, particularly at the community or smallholder level, is often applied without systematic quality evaluation. This condition raises concerns regarding compost consistency and agronomic reliability (Yulnafatmawita *et al.*, 2019).

Clove (*Syzygium aromaticum*) is an important plantation commodity in Indonesia, particularly in Bali, where it plays a central role in rural livelihoods and spice production due to its essential oil components and economic value . Clove plantations generate large quantities of leaf litter throughout the production cycle, representing a locally abundant source of organic material. When combined with cattle manure, clove leaf waste has the potential to produce compost with improved nutrient balance and organic matter characteristics. Previous studies have demonstrated that combining plant residues with animal manure can enhance compost quality by optimizing the C over N ratio and accelerating organic matter decomposition (Awasthi *et al.*, 2016; Liu *et al.*, 2021). Nevertheless, scientific information regarding the quality characteristics of compost derived specifically from clove leaf waste and cattle manure remains limited.

Therefore, this study aims to evaluate the quality of compost produced from clove leaf litter, cattle manure, and agricultural residues based on selected physical and chemical characteristics. By assessing variations in compost quality resulting from different raw material proportions, this study seeks to provide scientific evidence supporting the effective utilization of locally available agricultural wastes for compost production. The findings are expected to contribute to improved organic waste management practices and support sustainable agricultural development in clove producing regions.

2. MATERIALS AND METHODS

2.1 Materials

The materials used in this study consisted of clove leaf litter collected from clove plantations in Mangening Village, Kubutambahan Sub-district, Buleleng Regency, Bali, Indonesia, and fresh cattle

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manure obtained from local livestock farmers. Additional agricultural residues included banana pseudostem, taro leaves, and grass residues sourced locally.

Agricultural lime (dolomite) was applied at a rate of 1% of the total compost material weight. Compost activators used were Trichoderma spp. and activated EM4 solution diluted at a ratio of 1:10. Water was used to maintain moisture content during composting. Chemical reagents were prepared for laboratory analysis of compost chemical properties.

The equipment used included basic agricultural tools (hoes, shovels, knives), buckets, chopping boards, compost thermometers, tarpaulins, 25 kg composting sacks, and laboratory instruments at the Laboratory of Soil Chemistry and Fertility, Faculty of Agriculture, Universitas Udayana.

2.2 Methods

2.2.1. Study Area and Experimental Design

This study was conducted from October to December 2024 in Mangening Village, Kubutambahan Sub-district, Buleleng Regency, Bali, Indonesia. Composting activities were performed under field conditions in the village, while laboratory analyses were conducted at the Laboratory of Soil Chemistry and Fertility, Faculty of Agriculture, Universitas Udayana.

The experiment was arranged using a randomized block design (RBD) consisting of nine treatments and three replications, resulting in 27 experimental units. Each experimental unit represented one composting sack. Blocking was applied to minimize environmental variability during the composting process (Syilfi. & Hidayat, 2024).

The treatments consisted of different proportions of cattle manure, clove leaves, and agricultural waste (banana pseudostem, taro leaves, and grass residues). The treatment compositions are presented in Table 1.

Table 1. Comparison of Compost Fertilizer Raw Materials

No	Fresh Cattle Manure (kg)	Clove Leaf Litter (kg)	Agricultural Residues (kg)
1	1	1	-
2	2	1	-
3	1	2	-
4	0.5	0.5	0.5
5	1	0.5	1
6	0.5	1	0.5
7	1	0.3	1
8	1.5	1	1
9	1	1.5	1

Note: The total number of experimental units was 27 units, obtained from 9 treatments x 3 replications.

2.2.2. Composting Procedure

Clove leaves and agricultural residues were chopped into approximately 2 cm pieces. Each experimental unit consisted of 3 kg of raw materials, mixed according to the assigned treatment proportions. A total of 27 composting sacks (25 kg capacity) were prepared.

All materials were thoroughly mixed on a tarpaulin, amended with dolomite, and inoculated with compost activators. Water was added to achieve approximately 50% moisture content. Composting was conducted under aerobic conditions and allowed to ferment for four weeks.

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2.2.3. Observation of Composting Process

Observations were conducted to monitor compost maturation. Parameters observed included odor, color, temperature, and percentage of decomposition. Odor, color, and temperature were recorded weekly, while the percentage of decomposition was determined at the end of the composting period.

2.2.4. Compost Sampling and Chemical Analysis

At compost maturity, approximately 1 kg of compost sample was collected from each experimental unit. Samples were sieved, air-dried, and prepared for laboratory analysis. Chemical properties analyzed included organic carbon content using the Walkley–Black method, total nitrogen using the Kjeldahl method, C/N ratio calculated from organic carbon and total nitrogen values. All analyses were conducted at the Laboratory of Soil Chemistry and Fertility, Faculty of Agriculture, Universitas Udayana.

2.2.5. Statistical Analysis

Data were analyzed statistically using analysis of variance (ANOVA) based on the randomized block design to evaluate the effects of different raw material proportions on compost quality parameters. When significant differences among treatments were detected, Duncan's Multiple Range Test (DMRT) was applied at a 5% significance level to compare treatment means. Statistical analyses were performed using standard statistical software (Adnyana *et al.*, 2025).

3. RESULTS AND DISCUSSION

3.1 Physical Changes During the Composting Process

Observable physical changes occurred throughout the composting period, indicating progressive decomposition and stabilization of organic materials. Odor characteristics gradually changed from an initially unpleasant smell to an earthy odor at compost maturity. This transition reflects the reduction of volatile organic compounds, such as ammonia and low-molecular-weight organic acids, which are commonly produced during the early stages of composting and decrease as microbial metabolism stabilizes (Bernal *et al.*, 2017; Awasthi *et al.*, 2016).

Table 2. Changes in Compost Odor Over Time

No	Treatment	Beginning	1 WAC	2 WAC	3 WAC	4 WAC	5 WAC	6 WAC	7 WAC
1	Compost 1	4.00 ±0.00 a	3.00 ±0.00 b	3.00 ±0.00 b	3.00 ±0.00 a	2.67 ±0.58 bc	2.67 ±0.58 ab	2.67 ±0.58 c	2.67 ±0.58 a
2	Compost 2	4.00 ±0.00 a	3.00 ±0.00 b	3.00 ±0.00 b	3.00 ±0.00 a	2.33 ±0.58 bc	2.33 ±0.58 bc	2.00 ±0.00 b	2.00 ±0.00 b
3	Compost 3	4.00 ±0.00 a	4.00 ±0.00 a	4.00 ±0.00 a	4.00 ±0.00 a	3.00 ±0.00 b	3.00 ±0.00 a	3.00 ±0.00 c	3.00 ±0.00 a
4	Compost 4	4.00 ±0.00 a	4.00 ±0.00 a	3.67 ±0.58 a	2.67 ±0.58 a	2.67 ±0.58 bc	2.33 ±0.58 bc	2.00 ±0.00 b	1.00 ±0.00 c
5	Compost 5	4.00 ±0.00 a	3.33 ±0.58 b	3.00 ±0.00 b	2.67 ±1.15 a	2.00 ±0.00 c	2.00 ±0.00 c	2.00 ±0.00 b	1.00 ±0.00 c
6	Compost 6	4.00 ±0.00 a	4.00 ±0.00 a	4.00 ±0.00 a	3.33 ±1.15 a	4.00 ±0.00 a	3.00 ±0.00 a	3.00 ±0.00 a	2.67 ±0.58 a
7	Compost 7	4.00 ±0.00 a	3.00 ±0.00 b	2.00 ±0.00 c	2.67 ±1.15 a	2.00 ±0.00 c	2.00 ±0.00 c	1.00 ±0.00 c	1.00 ±0.00 c
8	Compost 8	4.00 ±0.00 a	4.00 ±0.00 a	4.00 ±0.00 a	4.00 ±0.00 a	3.67 ±0.58 a	3.00 ±0.00 a	3.00 ±0.00 a	2.00 ±0.00 b
9	Compost 9	4.00 ±0.00 a	4.00 ±0.00 a	4.00 ±0.00 a	4.00 ±0.00 a	4.00 ±0.00 a	3.00 ±0.00 a	3.00 ±0.00 a	3.00 ±0.00 a

Notes: 1 Odorless, 2 Not Strong, 3 Strong, and 4 Very Strong

Color changes from light brown to dark brown or black were consistently observed across treatments. Such changes are closely associated with humification processes and the formation of stable organic matter, and are widely recognized as reliable indicators of compost maturity (Huang *et al.*, 2017; Ravindran *et al.*, 2018). Temperature dynamics showed an initial increase followed by gradual stabilization toward ambient temperature, reflecting active microbial degradation during early composting and reduced biological activity at later stages. Similar temperature patterns have been reported in composting systems using mixed plant residues and animal manure (Zhang *et al.*, 2020).

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Table 3. Changes in Compost Color Over Time

No	Treatment	Beginning	1 WAC	2 WAC	3 WAC	4 WAC	5 WAC	6 WAC	7 WAC
1	Compost 1	4.00 ±0.00 a	3.33 ±0.58 ab	2.67 ±0.58 b	2.00 ±0.00 a	2.00 ±0.00 b	2.00 ±0.00 b	2.00 ±0.00 a	2.00 ±0.00 a
2	Compost 2	4.00 ±0.00 a	3.00 ±0.00 b	3.00 ±0.00 ab	2.00 ±0.00 a	2.00 ±0.00 b	2.00 ±0.00 b	2.00 ±0.00 a	2.00 ±0.00 a
3	Compost 3	4.00 ±0.00 a	3.67 ±0.58 a	3.33 ±0.58 a	3.00 ±0.00 a	2.67 ±0.58 a	2.67 ±0.58 a	2.00 ±0.00 a	2.00 ±0.00 a
4	Compost 4	4.00 ±0.00 a	3.00 ±0.00 b	3.00 ±0.00 ab	2.00 ±0.00 a	2.00 ±0.00 b	2.00 ±0.00 b	1.00 ±0.00 a	1.00 ±0.00 a
5	Compost 5	4.00 ±0.00 a	2.00 ±0.00 c	2.00 ±0.00 c	1.00 ±0.00 a	1.00 ±0.00 c	1.00 ±0.00 c	1.00 ±0.00 a	1.00 ±0.00 a
6	Compost 6	4.00 ±0.00 a	3.00 ±0.00 b	3.00 ±0.00 ab	2.00 ±0.00 a	2.00 ±0.00 b	2.00 ±0.00 b	2.00 ±0.00 a	2.00 ±0.00 a
7	Compost 7	4.00 ±0.00 a	2.00 ±0.00 c	2.00 ±0.00 c	1.00 ±0.00 a	2.00 ±0.00 c	1.00 ±0.00 c	1.00 ±0.00 a	1.00 ±0.00 a
8	Compost 8	4.00 ±0.00 a	3.00 ±0.00 b	3.00 ±0.00 ab	2.00 ±0.00 a	2.00 ±0.00 b	2.00 ±0.00 b	2.00 ±0.00 a	2.00 ±0.00 a
9	Compost 9	4.00 ±0.00 a	3.00 ±0.00 b	3.00 ±0.00 ab	3.00 ±0.00 a	2.00 ±0.00 b	2.00 ±0.00 b	2.00 ±0.00 a	2.00 ±0.00 a

Notes: 1 Very Dark. 2 Dark. 3 Bright. and 4 Very Bright

Differences in decomposition percentage among treatments indicate that raw material composition strongly influenced composting efficiency. Treatments with balanced proportions of cattle manure. clove leaves. and agricultural residues exhibited higher degradation rates. likely due to improved nutrient availability and microbial activity resulting from a more optimal C/N balance (Liu *et al.*. 2021).

Table 4. Changes in Compost Temperature Over Time

No	Treatment	Beginning	1 WAC	2 WAC	3 WAC	4 WAC	5 WAC	6 WAC	7 WAC
1	Compost 1	47.80 ±1.25 ab	37.67 ±0.21 bc	36.37 ±1.98 a	38.83 ±0.64 ab	32.03 ±0.85 b	31.40 ±1.41 bc	34.00 ±1.31 abc	35.07 ±1.60 ab
2	Compost 2	49.83 ±1.70 a	38.63 ±1.96 bc	35.27 ±2.10 a	41.87 ±3.27 a	35.13 ±1.70 a	32.57 ±1.79 abc	34.33 ±1.29 abc	34.90 ±1.64 ab
3	Compost 3	48.80 ±0.66 ab	38.23 ±1.97 bc	37.03 ±1.11 a	36.87 ±1.91 b	36.50 ±1.51 a	33.57 ±0.93 ab	35.90 ±1.65 ab	36.17 ±1.63 ab
4	Compost 4	42.37 ±2.66 d	39.23 ±0.55 ab	36.10 ±0.69 a	38.80 ±2.10 ab	34.27 ±0.55 ab	30.93 ±1.10 c	32.87 ±1.17 c	34.50 ±0.66 b
5	Compost 5	42.87 ±2.40 cd	40.50 ±0.26 ab	38.30 ±0.72 a	39.27 ±0.81 ab	36.73 ±0.12 a	34.30 ±0.44 a	36.73 ±2.14 a	37.70 ±1.93 a
6	Compost 6	45.90 ±1.82 bc	37.60 ±1.25 bc	36.43 ±2.23 a	38.77 ±1.42 ab	35.10 ±0.95 a	33.00 ±0.36 abc	35.30 ±1.91 abc	35.60 ±1.14 ab
7	Compost 7	42.73 ±2.29 cd	41.93 ±1.26 a	36.70 ±1.23 a	39.00 ±0.85 ab	35.57 ±2.00 a	30.67 ±0.76 c	33.37 ±0.98 bc	34.87 ±1.46 ab
8	Compost 8	49.10 ±0.79 ab	39.33 ±2.82 ab	36.13 ±2.11 a	40.63 ±2.47 ab	36.83 ±2.03 a	32.43 ±1.89 abc	35.07 ±0.87 abc	35.70 ±1.55 ab
9	Compost 9	45.80 ±1.67 bc	36.03 ±2.25 c	36.87 ±2.41 a	39.30 ±2.60 ab	36.70 ±1.01 a	32.67 ±1.36 abc	34.20 ±1.31 abc	34.20 ±1.57 b

3.2 Chemical Quality of Compost

3.2.1 Organic Carbon Content

Organic carbon content differed significantly among treatments, as confirmed by analysis of variance followed by Duncan's Multiple Range Test at the 5% significance level (Figure 1). Compost 1 exhibited the highest organic carbon content and was statistically different from composts with lower carbon values, such as Compost 8 and Compost 9. Treatments containing higher proportions of clove leaf material tended to maintain higher organic carbon levels, reflecting the relatively slow decomposition of lignocellulosic components compared to manure based substrates (Awasthi *et al.*, 2016).
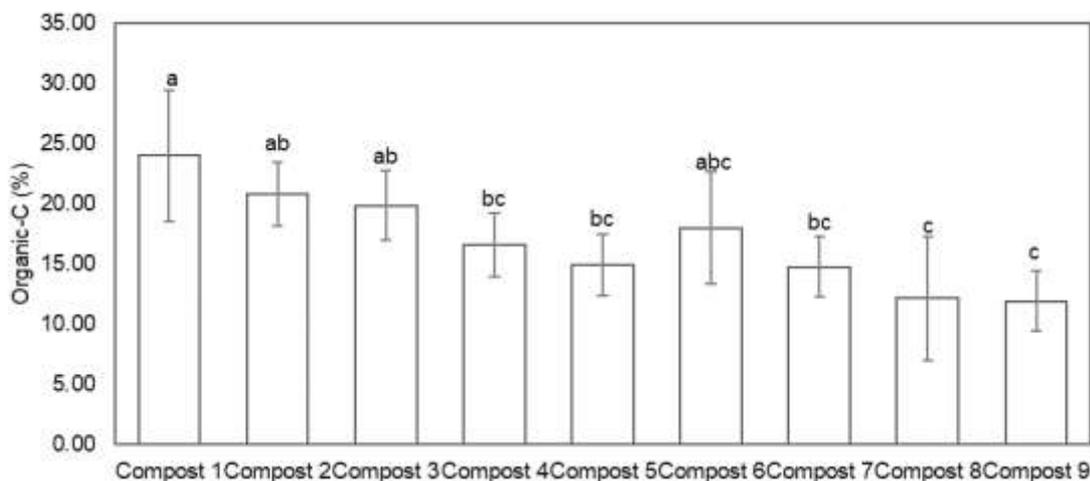

Figure 1. *Organic C Content of Compost at the End of the Study*

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The statistically significant differences indicated by DMRT grouping demonstrate that variation in raw material composition directly influenced carbon dynamics during composting. Although high organic carbon content contributes positively to soil organic matter. excessively high values may indicate incomplete decomposition if not accompanied by sufficient nitrogen availability. Similar findings were reported by Bernal *et al*. (2017). who emphasized the importance of balanced substrate composition to achieve mature compost.

3.2.2 Total Nitrogen Content

Total nitrogen content was significantly affected by treatment composition. with composts containing higher proportions of cattle manure exhibiting significantly higher nitrogen levels according to DMRT analysis. This result highlights the role of animal manure as a primary nitrogen source during composting. contributing to enhanced nutrient value of the final compost product (Liu *et al*.. 2021; Ravindran *et al*.. 2018).
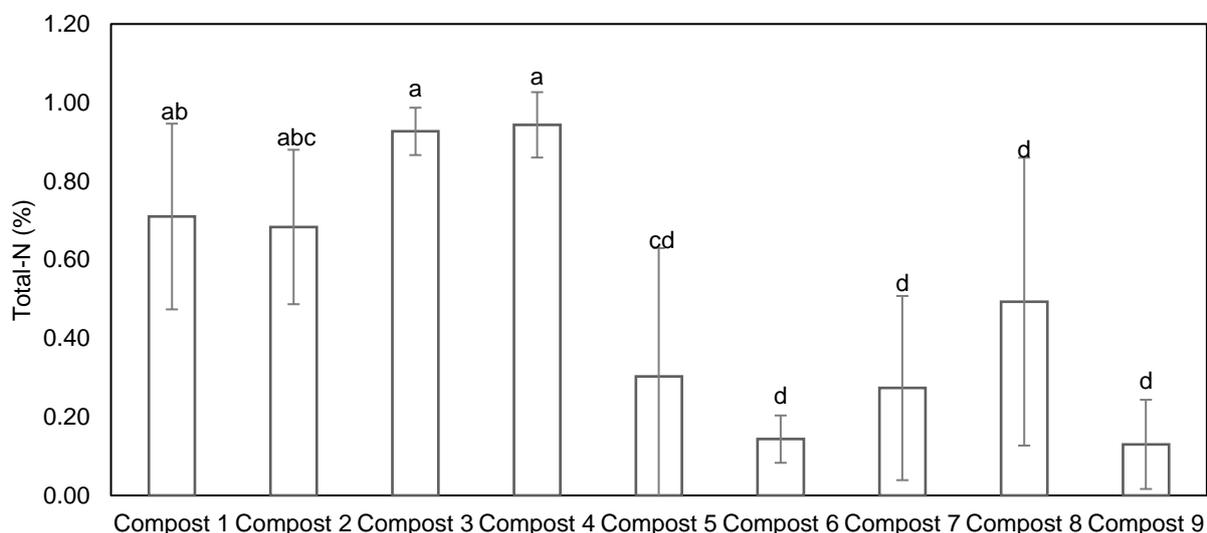

Figure 2. *Total-N of Compost at the End of the Study*

Adequate nitrogen availability during composting promotes microbial growth and accelerates organic matter decomposition. However. nitrogen losses through volatilization may occur if composting conditions are poorly managed. The statistically significant variation among treatments underscores the need for optimized material ratios to improve nitrogen retention and compost quality (Zhang *et al.*, 2020).

3.2.3 C/N Ratio

The C over N ratio is a key indicator of compost decomposition and stability. In this study, C over N ratios varied significantly among treatments based on DMRT results (Figure 3). Compost 3 and Compost 4 exhibited the lowest C over N ratios and were statistically different from treatments with higher ratios, indicating more advanced organic matter decomposition. In contrast, Compost 5, Compost 6, and Compost 9 showed significantly higher C over N ratios, suggesting slower decomposition rates likely associated with excess carbon relative to nitrogen availability.
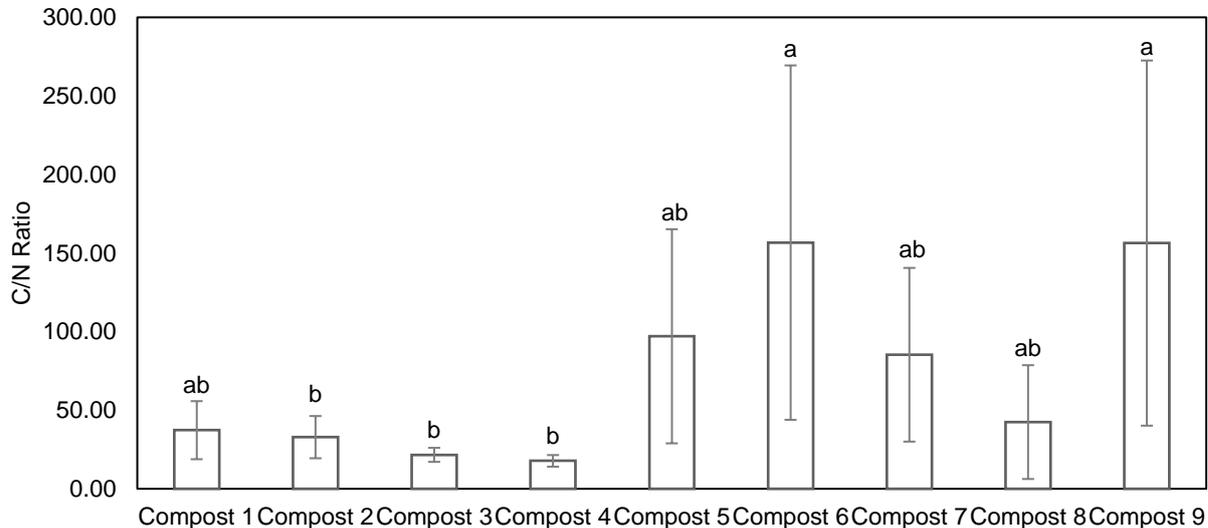
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Figure 3. *C/N Ratio of Compost at the End of the Study*

Lower C/N ratios are generally associated with improved compost maturity and reduced risk of nitrogen immobilization when applied to soil. Similar patterns have been reported in composting studies involving mixed organic residues, where substrate imbalance resulted in elevated C/N ratios and delayed stabilization (Bernal *et al.*, 2017; Zhang *et al.*, 2020).

4. CONCLUSION

This study evaluated the quality of compost produced from clove leaf litter, cattle manure, and agricultural residues based on selected physical and chemical characteristics. The results showed that differences in raw material proportions significantly affected compost quality, particularly organic carbon content, total nitrogen, and C/N ratio, as confirmed by analysis of variance followed by Duncan's Multiple Range Test at the 5 percent significance level.

Among the treatments tested, Compost 3 (1 part cattle manure : 2 parts clove leaf litter) and Compost 4 (0.5 part cattle manure : 0.5 part clove leaf litter : 0.5 part agricultural residues) were identified as the best treatments. These treatments produced compost with the lowest C/N ratios, indicating a higher degree of organic matter decomposition, improved compost maturity, and greater stability compared to other formulations.

Overall, the study confirms that clove leaf litter, cattle manure, and agricultural residues can be effectively utilized to produce high-quality compost when combined in appropriate proportions. The identification of Compost 3 and Compost 4 as optimal formulations directly addresses the research objective and provides a practical reference for sustainable organic waste utilization and the development of environmentally friendly fertilizer inputs in clove-producing areas.

5. ACKNOWLEDGEMENTS

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