Influence of fermentation agents, duration, and water volume on liquid organic fertilizer derived from cow dung

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ABSTRACT This study evaluated the effects of fermentation agents (EM4 and yeast), fermentation duration (7, 14, and 21 days), and water volume (1 L and 2 L) on the physicochemical properties of liquid organic fertilizer (LOF) derived from cow dung. A Completely Randomized Design (CRD) with three replications was employed. Parameters analyzed included pH, carbon (C), nitrogen (N), hydrogen (H) concentrations, and C/N ratio. Results indicated that both fermentation agent and duration significantly influenced LOF properties. The yeast-based treatment with 7 days fermentation and 2 L water (Yeast + 7 days + 2 L) emerged as the most practical and efficient combination, achieving a near-neutral pH (6.53), balanced C/N ratio (9.98), and acceptable nitrogen content (0.40%) within the shortest time. In contrast, EM4 treatments, particularly EM4 + 21 days + 2 L, yielded higher nitrogen concentrations (0.52%) but required extended fermentation. A strong positive correlation ($r = 0.916$) was observed between carbon and nitrogen, indicating synchronized nutrient release during decomposition. The findings suggest that yeast serves as a rapid, resource-efficient, and sustainable fermentation agent for small-scale LOF production, offering a viable alternative to more complex microbial consortia such as EM4.

KEYWORDS: Liquid organic fertilizer; Cow dung fermentation; Yeast; Effective microorganisms (EM4); Fermentation duration.
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INTRODUCTION

The increasing global demand for sustainable agricultural practices has renewed interest in organic fertilizers derived from natural resources. Among these, cow dung is widely recognized as a nutrient-rich material containing essential macronutrients such as nitrogen, phosphorus, and potassium, along with beneficial microorganisms that enhance soil health and plant growth (Gupta *et al.*, 2016). Liquid organic fertilizer (LOF) produced from cow dung offers advantages in terms of nutrient availability and ease of application, thereby supporting regenerative farming systems (Suriani *et al.*, 2023).

Fermentation using microbial agents such as Effective Microorganisms-4 (EM4) and yeast (Saccharomyces cerevisiae) has been explored to enhance the efficiency of organic waste conversion. EM4 is a consortium of lactic acid bacteria and yeasts that accelerates decomposition and improves nutrient mineralization (Nasution & Rizka, 2022). Yeast, which is widely utilized in industrial fermentation processes, contributes to rapid substrate breakdown and stabilization of fermentation products (Maicas, 2020). The duration of fermentation is also a critical factor, as it influences microbial activity, nutrient release, and the stability of the final product (Hüdavi Ercoskun *et al.*, 2009).

Despite the documented benefits of these fermentation agents, comparative studies on their efficiency in cow dung fermentation, particularly under varying fermentation durations and water volumes, remain limited. Existing research has largely focused on single-agent applications or longer fermentation periods, leaving a gap in optimizing rapid and small-scale LOF production. While previous studies, such as Suriani *et al.* (2023), have demonstrated the effectiveness of EM4 in producing liquid organic fertilizer from cow dung, they primarily emphasize single-agent systems and extended fermentation durations. In contrast, limited attention has been given to the use of simpler and more accessible microbial alternatives such as yeast (Saccharomyces cerevisiae), particularly for rapid, small-scale production. Furthermore, comparative evaluations between yeast and established microbial consortia like EM4 under different fermentation durations and water volumes remain scarce. Therefore, this study addresses these gaps by evaluating the combined effects of fermentation agent, duration, and water volume on LOF quality, providing new insight into the potential of yeast as a faster, simpler, and effective alternative for LOF production. The objectives of this study were to compare the effectiveness of EM4 and yeast as fermentation agents in LOF production from cow dung and to determine the optimal fermentation duration and water volume for maximizing production efficiency.

METHODOLOGY

Experimental Design and Treatments

The study was conducted at the Faculty of Sustainable Agriculture, Universiti Malaysia Sabah. A Completely Randomized Design (CRD) with three replications was used. The experimental treatments were factorial combinations of two fermentation agents (EM4 and yeast), three fermentation durations (7, 14, and 21 days), and two water volumes (1 L and 2 L), resulting in 12 treatment combinations.

Substrate Preparation and Fermentation Process

For each replicate, 2000 g of fresh cow dung was mixed with 150 mL of molasses as a carbon source. The microbial agents were added as per treatment: 200 mL of EM4 solution or 100 g of commercial yeast ('Eagle' brand). Distilled water was added at the specified volume (1 L or 2 L). The mixtures were prepared in 4 L containers, stirred thoroughly for homogeneity, and allowed to ferment at ambient temperature (approximately 28-30°C). The containers were stirred manually once daily.

The amounts of EM4 (200 mL) and commercial yeast (100 g) were chosen based on common practice in small-scale organic fertilizer preparation and the recommendations provided by the product manufacturers, to keep the fermentation process practical and effective. Since EM4 and yeast come in different forms, they were not matched based on exact microbial equivalence but were used according to typical usage rates. The mixtures were stirred by hand once a day to keep them well mixed and maintain fairly consistent fermentation conditions throughout the process.

Parameter Analysis

After the respective fermentation period, the LOF was filtered. The pH was measured using a calibrated pH meter. The concentrations of Carbon (C), Nitrogen (N), and Hydrogen (H) were determined using a CHNS Analyzer (Fadeeva *et al.*, 2008). The C/N ratio was calculated from the obtained values.

Statistical Analysis

Data was analyzed using Minitab-16 software. Treatment means were compared using Tukey's Honest Significant Difference (HSD) test at a 5% significance level ($p \leq 0.05$) to identify specific differences between treatment combinations. Correlation analysis was conducted to examine relationships between the measured physicochemical parameters.

RESULT AND DISCUSSION

The physicochemical properties of the LOF were significantly influenced by the type of fermentation agent and the duration of fermentation. The pH values ranged from 5.25 to 6.53, indicating conditions from slightly acidic to near neutral. Yeast-based treatments consistently produced higher pH values compared to EM4 treatments. The highest pH (6.53) was observed in the Yeast + 14 days + 2 L treatment, whereas EM4 treatments generally resulted in lower pH values, particularly at shorter fermentation durations (Figure 1). These differences may be associated with variations in microbial activity and decomposition processes between the fermentation agents (Zeng *et al*., 2025). A near-neutral pH is considered favorable for agricultural applications, as it reduces the risk of soil acidification and improves nutrient availability for plants.

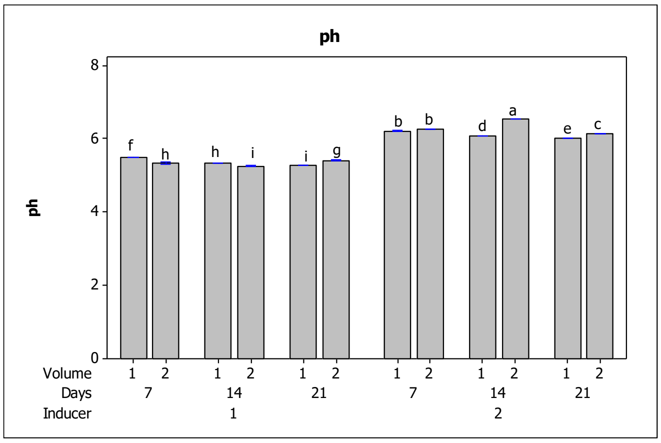

Figure 1. pH of liquid organic fertilizer is influenced by fermentation agent, duration, and water volume. Different letters above bars indicate significant differences ($p \leq 0.05$). Fermentation agent 1 = EM4, Fermentation agent 2 = Yeast.

Carbon concentration remained relatively stable across all treatments ranging from 5.99% to 6.80%, with no statistically significant differences observed (Figure 2). This suggests that the total carbon content in the substrate was not drastically mineralized or lost as CO2 under the tested conditions, regardless of the agent or duration.

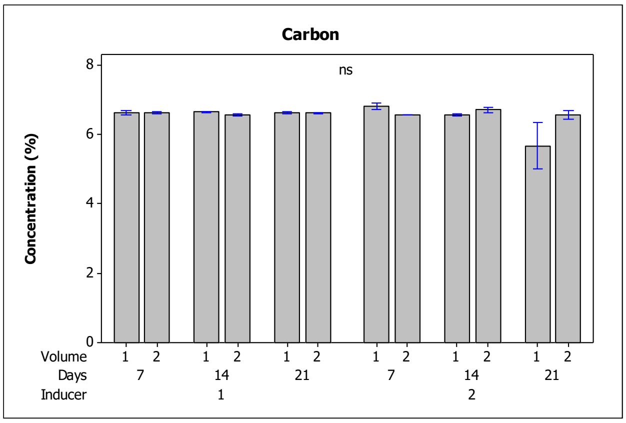

Figure 2. Carbon concentration (%) of liquid organic fertilizer across treatments. "ns" indicates no significant difference.

Nitrogen content, which is a critical indicator of fertilizer quality, varied between 0.40% and 0.52%. The highest nitrogen concentration (0.52%) was achieved with the EM4 + 21 days + 2 L treatment (Figure 3). This aligns with the understanding that EM4, containing specialized decomposer bacteria, facilitates more complete breakdown of complex organic nitrogen compounds over extended periods (Kurniawan *et al*., 2022). Notably, the Yeast + 7 days + 2 L treatment produced a satisfactory nitrogen content of 0.40%.

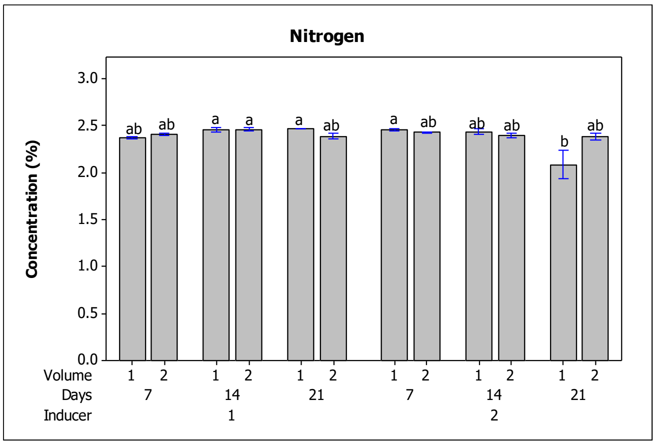

Figure 3. Nitrogen concentration (%) of liquid organic fertilizer. Different letters indicate significant differences ($p \leq 0.05$).

The C/N ratio, a key parameter for fertilizer maturity and nitrogen availability, ranged from 9.98 to 11.20. The Yeast + 7 days + 2 L treatment achieved a balanced C/N ratio of 9.98 (Figure 4). Ratios below 20:1 are considered ideal for mature compost, indicating that nitrogen is readily available for plant uptake and will not be immobilized by soil microbes (Zhang *et al.*, 2019). The strong positive correlation ($r = 0.916$, $p \leq 0.01$) between carbon and nitrogen (Table 1) indicates synchronized decomposition, where microbes utilize carbon for energy while conserving and transforming nitrogen efficiently, minimizing losses (Paul *et al.*, 2019).

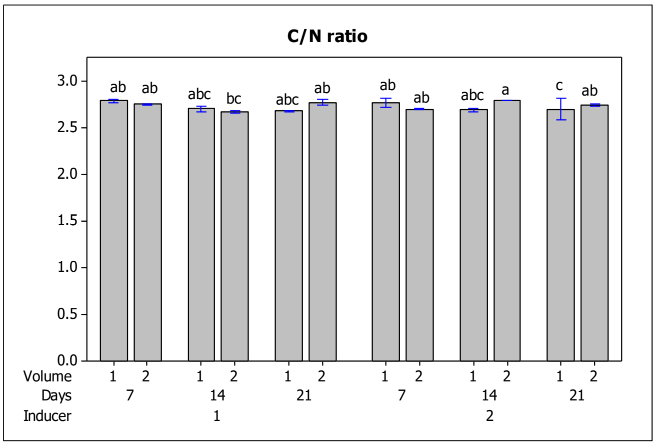

Figure 4. C/N ratio of liquid organic fertilizer. Different letters indicate significant differences ($p \leq 0.05$).

Table 1. Correlation matrix for physicochemical properties of liquid organic fertilizer.

Parameters	pH	Carbon	Hydrogen	Nitrogen
Carbon	-0.058			
Hydrogen	-0.232	0.170		
Nitrogen	-0.171	0.916 ***	-0.092	
C/N ratio	0.176	0.651	0.576 ***	0.293

The better performance seen in treatments with 2 L of water may be due to improved dilution of the substrate and smoother movement of materials during fermentation. The higher water content likely helps microbes work more effectively by spreading nutrients more evenly and preventing the buildup of unwanted by-products. However, these processes were not directly measured in this study and should be explored further in future research. It should be noted here that microbiological characterization was beyond the scope of this study and is recommended for future work to validate microbial contributions.

CONCLUSION

This study demonstrates that both the fermentation agent and duration significantly influence the quality of liquid organic fertilizer (LOF) derived from cow dung. EM4 proves effective for maximizing nitrogen content but requires an extended fermentation period of 21 days. In contrast, yeast provides a faster and more resource-efficient pathway, producing a stable and agronomically sound fertilizer within just 7 days. The treatment combining yeast, a 7-day fermentation period, and 2 L of water is (Yeast + 7 days + 2 L) recommended as the optimal protocol for small-scale, sustainable LOF production, as it offers a practical balance between production efficiency, nutrient quality, and operational feasibility. However, a limitation of the present study is the focus on primary decomposition indicators (C and N) and physicochemical properties without quantifying phosphorus (P) and potassium (K) levels, which are essential for fully validating the LOF as a complete fertilizer. Future research should include a comprehensive NPK analysis and focus on field trials to validate the agronomic performance of this yeast-based LOF. Furthermore, economic analyses are necessary to solidify their advantage over conventional inputs and confirm its viability for broader agricultural application.

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