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Optimizing Food Waste Decomposition through pH, Moisture Content, and Temperature Control: A Comprehensive Study

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ABSTRACT: Composting, a crucial process in sustainable waste management, transforms organic matter into nutrient-rich compost, which is an organic byproduct of the decomposition process known as composting. Compost serves as a sustainable means of recycling various organic materials into a nutrient-rich soil conditioner, finding applications in gardens, landscaping, horticulture, urban agriculture, and organic farming. This paper investigated the complex factors affecting the maturity of compost, focusing on parameters such as temperature, pH, and moisture content. The breakdown rates of eight carefully regulated combinations were compared to a sample that had not been altered. The analytic results showed the volume loss over time was a critical component in determining the maturity of compost. Combinations two (Temperature=High, Moisture Content=High, pH=Low), three (Temperature=High, Moisture Content=Low, pH=High), and four (Temperature=High, Moisture Content=Low, pH=Low) showed the most percentage volume loss by day 46, indicating faster maturation compared to the uncontrolled group. In this volume loss comparison, the circular truncated cone formula played a crucial role in revealing the ideal combinations for compost maturation. This comprehensive study not only contributed valuable insights into optimizing composting conditions but also highlighted the diverse applications of compost. By examining the complex interactions between pH, moisture content, and temperature, this study enhanced our knowledge of sustainable waste-to-resource operations and effective composting techniques.

KEYWORDS: Food decomposition; waste management; soil health; pH; nutrient recycling; sustainable agriculture.

1. Introduction

As food waste increasingly poses a significant challenge in waste management practices in Malaysia, this study aimed to explore composting as a viable alternative for food waste disposal. Composting holds promise for mitigating the negative environmental impacts associated with food waste, as it facilitates the breakdown of organic materials into nutrient-rich compost [1]. However, the inherent time-consuming nature of the natural composting process necessitates efforts towards optimization. The resulting compost serves as a versatile resource with various agricultural applications, including natural insecticide, fertilizer, and soil conditioner [2]. The primary objective of this research was to expedite the decomposition of food waste by investigating the intricate dynamics of composting, focusing on regulated variables such as pH, temperature, and moisture content.

Effective waste-to-resource operations are imperative in Malaysia, where daily food waste disposal amounts to 15,000 tons, including 3,000 tons of edible material [3]. This poses visual and logistical challenges, compounded by issues of storage and insect attraction. Consequently, the main aim of this study was to identify the optimal set of regulated factors to accelerate compost maturation and address Malaysia's urgent waste management issues. Determining the ideal pH, temperature, and moisture content for enhanced food waste decomposition was a key objective of this research. By examining these aspects, the study makes significant contributions to understanding sustainable waste-to-resource operations and efficient composting methods, with potential implications for broader waste management strategies.

The project involved collecting green waste from Universiti Teknologi Malaysia (UTM) and nearby markets, containing compost in flowerpots to regulate its growth, and subjecting four compost combinations to cold composting processes in a laboratory with controlled air conditioning. Through comprehensive analysis, this research seeks to advance our understanding of composting processes and provide practical solutions for the effective disposal and reuse of food waste [4].

2. Materials and Methods

2.1. Composting: selection of materials and preparation.

The purpose of this section is to clarify the controllable parameters that affect the compost-making processes. To improve cost and accessibility, food waste collected from UTM, and surrounding markets were utilized in the study. It is essential to guarantee consistency in the amount of nutrients present, which means that the study must be carried out in modest amounts and under strict time restrictions. Large-scale composting usually takes two to three months, and the method used was to layer soil, food waste, and brown sugar for nitrogen enrichment with carbon-rich material made from leaves. Irrigating each layer of soil as shown in Figure 1 involved using a solution of effective microorganisms mixed with regular water [5]. The compost was repeatedly layered and watered until it reached the appropriate height. At that point, it was covered with a canvas to retain the moisture and heat that were produced as the food waste breaks down [6]. The study emphasizes the need of both brown and green trash in composting simultaneously. Figure 2 (a, b) shows visual representation of green and brown waste. While brown garbage was carefully gathered near Universiti Teknologi Malaysia owing to its availability, green waste, which was acquired from Taman Universiti markets, prioritizes accessibility and cost effectiveness. Green garbage was chopped into smaller particles to hasten the breakdown process. The study also explored the function of alkalis and acids in parameter regulation. The laboratory-supplied hydrochloric acid and sodium hydroxide were carefully used to avoid extremes in acidity or alkalinity, protecting the composting process from possible failure [7].

In addition to the comprehensive method of selecting and preparing composting materials described above, the study utilized several essential pieces of equipment and observational instruments. To achieve the ideal ratio of nitrogen-rich "greens" to carbon-rich "browns" during the composting process, various materials such as wood chips, straw, and dried leaves were utilized. Maintaining the optimal ratio of approximately 25 parts browns to 1 part greens by weight is crucial for effective composting, as excessive carbon may impede decomposition, while excess nitrogen can lead to unpleasant odors. Leaves, comprising the majority of yard waste [8], were intentionally reduced in size to facilitate decomposition, as larger leaves can be challenging to break down. Specialized equipment used in the experimental setup included a pH meter, thermometer, oven, and weight scale [9]. The pH meter measured the hydrogen-ion activity in the composting solution, aiding in determining its acidity or alkalinity levels. It comprised a reference electrode submerged in the solution and a glass pH-responsive electrode. Laboratory ovens were utilized to maintain consistent temperatures for various thermal convection applications, including annealing, curing, drying, and sterilizing. The LAB scale, a high-precision analytical balance capable of weighing up to 220 g [10], facilitated piece counting, percent weighing, and density calculations, among other functions. This array of equipment and instruments played a pivotal role in systematically monitoring and controlling composting parameters, ensuring a robust experimental design and precise data collection.

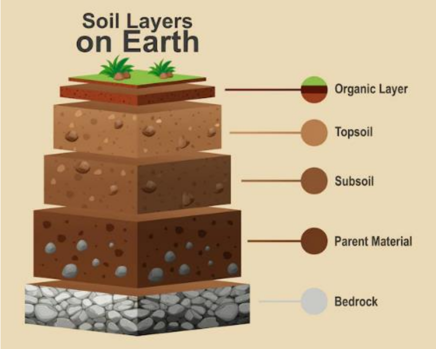

Figure 1: Different soil layers on Earth (Icon from Freepik).

(a) Green Waste (b) Brown Waste

Figure 2: Different categories of waste.

2.2. Influencing factors in the composting process.

Composting is a natural process that transforms raw organic materials into stable, nutrient-rich humic substances suitable for various soil and plant applications. At its core, composting involves controlled decomposition, wherein organic residues interact with soil to break down naturally [11]. Creating optimal conditions for microbial activity is crucial for successful composting. Key factors influencing effective composting include the chemical composition of raw materials (carbon and mineral content, pH), physical characteristics of feedstocks (size, shape, porosity of the pile), and the population of organisms involved (macrofauna, mesofauna, microorganisms such as bacteria, actinomycetes, and fungi).

Depending on how organic materials are mixed and piled, composting can occur aerobically or anaerobically. Aerobic composting, the most effective type, generates heat by converting organic waste to carbon dioxide through aerobic oxidation. Providing the compost pile with the right proportions of carbon, water, and air allows aerobic organisms to quickly break down the raw organic ingredients. Ideal parameters for fast aerobic composting include a carbon-nitrogen (C:N) ratio of 25:1 to 35:1, a moisture content of 45–60%, an oxygen concentration of over 5%, a feedstock particle size of no more than 1 inch, a bulk density of less than 1,000 pounds per cubic yard, and a pH of 5.5–8.5 [12].

According to Gary A. Breintenbeck and David Schellinger [3], finished compost typically experiences a volume loss averaging 40.7%, with mass losses ranging from 11.5% to 31.4%. The substrate to be composted plays a crucial role in the process, as its chemical and physical properties significantly impact the efficiency of composting. In this bio-oxidative microbial degradation process, the molecular structure of the substrate determines the assimilation of nutrients by microorganisms. Composting generates a significant amount of energy during the exothermic process, with elevated temperatures and high pH values potentially leading to nitrogen loss through ammonia volatilization [13]. Adequate water levels, essential for microbial activity, should be maintained throughout the composting cycle. The ideal moisture content varies based on the size, physical condition, and type of composting system being utilized.

2.2.1. Compost on moisture content factor.

According to Leslie R. Cooperband [11], low moisture content hinders the composting process because microbes require water for their activity. Additionally, low moisture levels make compost piles more prone to spontaneous combustion, as moisture helps regulate temperature. Conversely, moisture content exceeding 60% results in pore spaces in the compost pile being filled with water rather than air (oxygen), leading to anaerobic conditions. To achieve the ideal moisture content, feedstocks with different moisture-holding capacities can be blended together. Carbonaceous materials like newspaper and wood by-products such as sawdust are commonly used as bulking (drying) agents to adjust moisture levels. Therefore, maintaining suitable moisture content is crucial for achieving the maximum rate of decomposition [14]. Low moisture content causes the compost to stack up and become hardened. Additionally, insufficient moisture content may result in blockages in the molding die, necessitating significant repair work such as electrical drilling to remove the blocked compost [9]. Moisture content is typically measured as the percentage of dried compost weight over the initial compost weight.

2.2.2. Compost on pH factor.

Since composting relies on microbial activity to decompose organic material, environmental factors such as pH value play a crucial role in the process [10]. It's commonly observed that the pH value of composting material decreases due to acid formation during the early stages of composting. This low pH value can sometimes hinder the progress of the composting reaction significantly. According to Kiyohiko Nakasaki et al. (1993) [14], controlling the pH value can prevent this retardation of the reaction and significantly increase the reaction rate in its early stages. This can effectively reduce the time required for high-rate composting and may help avoid odor problems caused by the slowing down of the composting reaction. Moreover, it has been demonstrated that nitrogen loss associated with pH control of composting material is minimal compared to the initial nitrogen content in the raw material. The primary challenge during the initial composting phase is inhibiting the adverse effects of organic acids, which involves controlling the pH. Various studies have investigated the use of alkaline materials such as NaOH, fly ash, and lime as pH control amendments in the initial stages of the composting reaction [6]. These efforts aim to prevent the pH from dropping too low during the initial activity period, thereby promoting a faster degradation rate of organic matter. However, it's worth noting that the use of alkaline amendments may have drawbacks, including the risk of increased ammonia emission [15].

2.2.3. Compost on temperature factor.

Biological activity is known to work efficiently in the elevated temperature range of 50-90 °C which can be reached in compost materials within a few months or even a few days [16]. According to Hongtao Liu et al, 2018 [5] composting is usually conducted in semi-open or outdoor areas because of the odorous gases generated and emitted during the process. However, in subtropical, temperate and sub-frigid zones, composting is significantly constrained by outside temperature, particularly during winter. Indeed, if the outside temperature is below zero or even relatively cold (e.g., 0 °C-10 °C), the composting process is usually inhibited, delayed, or fails. Therefore, environmental temperature is a critical factor that determines whether composting is successfully completed. Moreover, sufficiently high pile temperature is required for organic wastes stabilization and harmlessness. The effects of culture temperature at curing stage on the quality of the food waste compost were studied. After thermophilic degradation stage, compost was divided into three parts and cultivated at 15, 35, and 55°C. Curing at 55°C revealed the highest values in volatile solids reduction and carbon dioxide generation, while organic nitrogen was reduced most at 35°C [17].

2.3. Analytic parameters.

The first layer of the compost must consist of garden soil as a base for the compost then top it off with green waste [11]. The garden soil must be weighed first to standardize the thickness and its volume to make sure that all of the samples have the same properties. The green waste that has been collected must be chopped and diced into smaller size to increase the total surface area. Compile the green waste into one big bin to ease the distribution of green waste into eight samples. After that, keep piling the layer with brown waste and end the layer with compost soil mix with garden soil. Brown waste and mixed soil also must be weighted to make sure the thickness and volume is equally the same with all the sample. After the batch has completed, pour the water over the compost evenly to introduce the bacteria with active site of reaction. The batch will then be divided into eight samples to study and analyze according to each controlled parameter. The compost must be turned for every 3 days to get evenly decompose reaction. The batch will be divided into the following combination as shown in Table 1. Each of the sample that has been controlled with its parameters will be undergo a series of test to obtain the data and to be tabulated and graphed for further analysis and discussion.

Table 1. Combinations of the sample.

Parameter 1	**Parameter 2**	**Parameter 3**
Temperature = High	Moisture Content = High	pH = High
Temperature = High	Moisture Content = High	pH = Low
Temperature = High	Moisture Content = Low	pH = High
Temperature = High	Moisture Content = Low	pH = Low
Temperature = Low	Moisture Content = High	pH = High
Temperature = Low	Moisture Content = High	pH = Low
Temperature = Low	Moisture Content = Low	pH = High
Temperature = Low	Moisture Content = Low	pH = Low

2.4. Moisture content, pH, and temperature assessment in composting.

This study explores the thorough assessment of three critical composting process parameters: temperature, pH, and moisture content. Assessing moisture content is vital for evaluating compost quality, and employing a batch test technique is recommended for this purpose [18]. This involves weighing a sample, subjecting it to drying, and subsequently determining its moisture content. Similar to this parameter, compost's pH has a big impact on how suitable it is for different uses. To optimize composting conditions, a batch test is designed to measure the pH of the compost using distilled water. The study also highlights the need of temperature monitoring using a batch test, which is essential for understanding the dynamic breakdown process. Every three days, the temperature of the compost is recorded, paying particular attention to temperature fluctuations in the early phases [19]. The expected results of this study are to show that, in comparison to an undisturbed sample, compost maturation may be hastened under controlled conditions. Comparing food waste decomposition rates is made easier by applying a circular truncated cone volume calculation, which also reveals the best combination for accelerated compost maturity. The data analysis was conducted utilizing IBM SPSS Statistics 19, a widely used statistical software package renowned for its robust analytical capabilities. To determine the significance of the observed differences among various experimental conditions, the Duncan multiple range test was employed. This statistical test is recognized for its effectiveness in comparing means across multiple groups while controlling the family-wise error rate. Significance levels were set at $p < 0.05$, adhering to conventional thresholds for statistical significance. By employing rigorous statistical methods such as the Duncan multiple range test, the study ensured robustness in its analysis, enabling the identification of meaningful differences and insights into the experimental outcomes [20]. Hence, the information gathered from these evaluations advances our knowledge of how pH, moisture content, and temperature interact and helps develop more efficient composting methods.

3. Results and Discussion

3.1. Effects of composting on moisture content.

The batch test has been conducted to determine the moisture content in the compost and the parameters of the moisture content have been separated into two standardized amounts of water poured into the compost. For high moisture content parameters, the amount of water poured into the compost is one liter of tap water. Meanwhile for low moisture content parameters, the compost has been poured with only 500 milliliters of tap water. The data represented in Figure

3 reveals a lack of proportional increase or decrease in the numbers, indicating a challenge in controlling the moisture content of the compost. Despite the separation of the batches into two distinct groups, with one exposed to open surroundings and the other placed in an air-conditioned room with an average temperature of 20 °C, achieving consistent moisture levels has proven to be difficult. The group left in open surroundings is subject to weather conditions, particularly heavy rainfall during this season, making it extremely challenging to regulate and control the moisture content within the compost. The unpredictable nature of weather elements, especially precipitation, contributes to the observed variability in moisture levels between the two groups in Figure 3. The series 1-9 denotes nine distinct combinations observed over a span of 46 days. These combinations represent varied experimental conditions or treatments, each depicted in Figure 3. In total, there are nine unique combinations illustrated in the figure, each corresponding to specific parameters or interventions applied throughout the duration of the study.

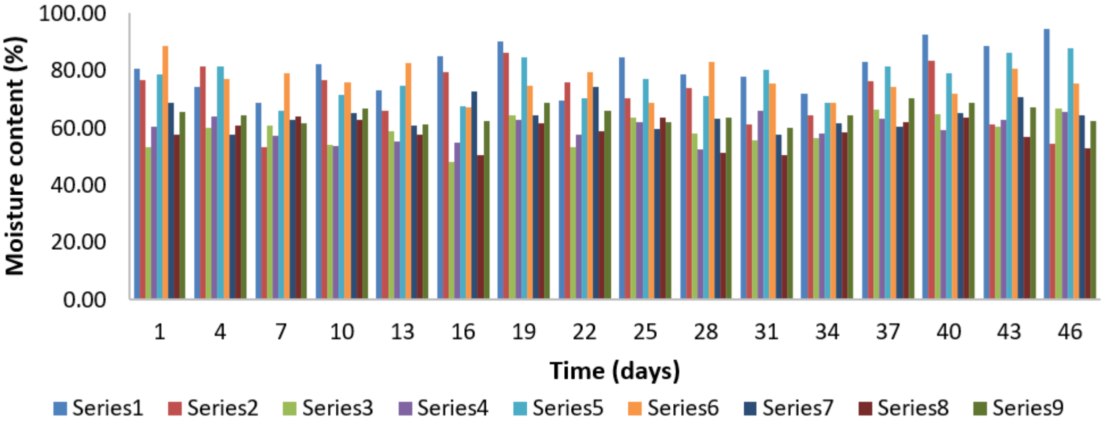

Figure 3. Moisture content versus time at different sample combinations. The set of series 1 to 9 stands for nine distinct pairings that were seen during 46-days span.

The research conducted a thorough analysis of the difficulties in managing moisture content during composting procedures, acknowledging its crucial function in guaranteeing ideal circumstances for microbiological activity. The study's conclusions are consistent with previous research, which emphasizes the need of keeping moisture levels within a particular range (usually 45–60%) to promote aerobic conditions and microbial multiplication. This research is supported by the work of academics such as Leslie R. Cooperband [11]. Cooperband's [11] research clarifies how low and high moisture content can hinder the composting process by limiting microbial activity or creating anaerobic conditions, which in turn affects the quality of the compost. The study's findings highlight the challenges of managing moisture, especially when dealing with changing weather circumstances. These findings are consistent with a larger conversation on customized methods of controlling moisture. Interestingly, even with the use of standard operating procedures, the batch test used to determine the moisture content found difficulties in maintaining uniformity. The challenge of controlling moisture levels was brought to light by dividing batches into high and low moisture groups and exposing them to various climatic settings, such as an air-conditioned room vs an open space [22]. Figure 3 also revealed an inability to respond proportionately to changes in water intake, pointing to potential problems with moisture regulation. The group that was exposed to open environments, in particular, saw more difficulties because of erratic weather, such periods of intense rain, which exacerbated the differences in moisture content between the two groups. This emphasizes the necessity for sophisticated techniques to efficiently control moisture in composting processes, taking into account the dynamic interactions between environmental influences and compost quality.

3.2. Effects of composting on pH.

The pH test has been conducted to test the acidity and alkalinity of the compost; the pH of the compost was controlled to achieve the objectives of this study. The acid and alkalis that has been used is hydrochloric acid and sodium hydroxide solution. Figure 4 illustrates the variation in pH levels within the compost over time across different sample combinations. The x-axis represents time, spanning the duration of the experiment, while the y-axis denotes the pH values measured within the compost. Each line on the graph represents a distinct sample combination, numbered from 1 to 9. The graph provides a visual depiction of how pH levels fluctuate over the course of the observation period for each sample combination, offering insights into the dynamic nature of pH regulation within the composting process. Figure 4 also illustrates a fluctuating pattern characterized by alternating increases and decreases. The alkalinity and acidity levels observed in the compost are intricately linked to the amounts of acid and alkalis introduced into the composting system. Compost, functioning as a miniature ecosystem, tends to naturally balance its alkalinity and acidity over time [6]. This equilibrium is evident in the graph, where both pH values exhibit efforts to reach a balanced pH state. Notably, the undisturbed sample maintains a consistent pH level, persistently endeavoring to achieve this equilibrium. The dynamic interplay of acid and alkali within the compost ecosystem is reflected in the fluctuating pH levels, emphasizing the self-regulating nature of composting processes in maintaining a harmonious pH balance [14,22].

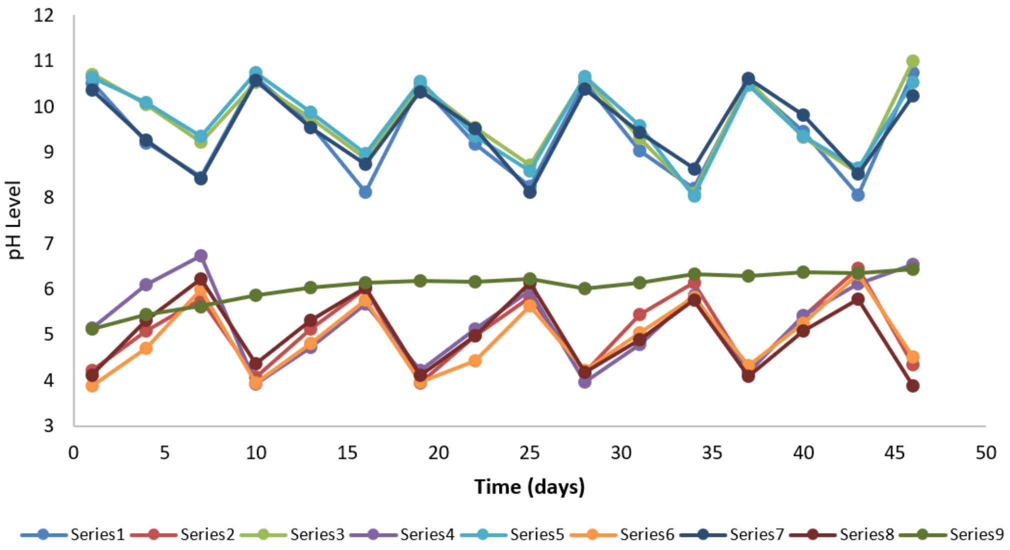

Figure 4. pH in the compost versus time at different sample combinations. The set of series 1 to 9 stands for nine distinct pairings that were seen during 46-days span.

The results pertaining to variations in pH in the compost are consistent with other research that examined the dynamic character of pH control in composting systems. Studies in the past [15,21] have shown the intricate interaction between acidic and alkaline components added to compost, which is comparable to the alternating increases and drops in pH levels shown in this investigation. Research has demonstrated how organic acids generated during the decomposition process and the buffering ability of compost materials play a part in regulating pH levels [6]. Additionally, studies on the dynamics of composting have highlighted the self-regulating processes that are intrinsic to compost ecosystems, wherein the gradual stabilization of pH is facilitated by microbial activity and the breakdown of organic waste [21]. The undisturbed sample's constant pH level emphasizes how resilient compost systems are in their pursuit of balance. The aforementioned discoveries enhance the comprehension of composting procedures by highlighting the significance of pH regulation in maximizing microbial activity and nutrient accessibility. Furthermore, they emphasize the necessity of additional investigation to clarify the precise mechanisms behind pH variations and their consequences on the stability and quality of compost [22].

3.3. Effects of Composting on temperature.

The batch test for the temperature parameter begins with the initial temperature, which is the same as the ambient temperature at the time the compost is formed, the temperature dynamics in the composting process are closely monitored as shown in Figure 5. Figure 5 depicts the temperature variations within the compost over time across nine different sample combinations. We can see a notable increase in temperature, which is mainly ascribed to microbial activity in the compost. The breakdown process is sparked by the addition of green waste, which provides bacteria with a source of nitrogen [24]. A few days later, the soil becomes less aerated and compacted because of moisture content and external influences, which lowers the temperature. Flipping the compost over initiates a new phase that results in a temperature rise fueled by bacterial activity. As the observation comes to an end, the temperatures are not as high as they were previously, which suggests that there is less food in the compost. Notably, temperature decreases for combinations five through eight indicate the occurrence of a cold-composting process in those cases.

The batch test's temperature dynamics are consistent with earlier research on the thermal profiles of composting processes. The addition of green waste causes a noticeable temperature increase, which is indicative of the beginning of microbial activity—a phenomena that has been extensively studied in the literature on composting [5]. The availability of materials high in nitrogen fuels microbial activity, which in turn starts the decomposition of organic waste and raises the temperature inside the compost pile. Later temperature swings, such the drop ascribed to reduced aeration and compaction, highlight the complex interaction between microbial activity and environmental variables in controlling compost temperature [16]. The temperature spike that was seen after turning the compost emphasizes how physical manipulation may promote microbial metabolism and heat production [17]. Prior research on compost rotating as a way to improve oxygen diffusion and quicken decomposition rates has observed this phenomenon. Additionally, the decrease in temperature towards the conclusion of the observation period points to a reduction in the amount of organic matter that is accessible, which is consistent with the idea that the availability of substrate in mature compost diminishes with time [25]. The discovery of cold-composting processes in certain combinations highlights the dynamics of composting that are variable due to initial substrate composition and management approaches, among other aspects [23]. These results add to the body of information already available on composting thermodynamics by illuminating the intricate relationships that shape temperature profiles during the composting process between microbial activity, substrate properties, and external factors.

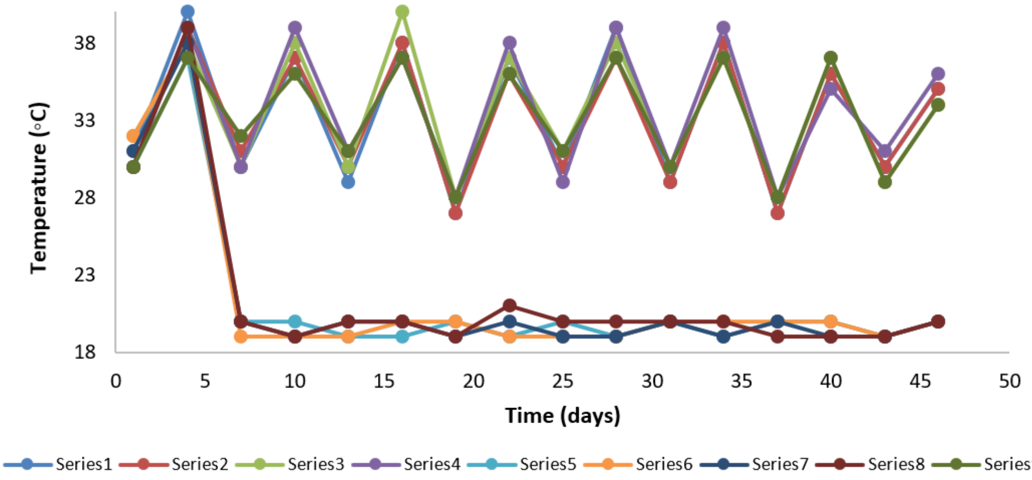

Figure 5: Temperatures in the compost versus time at different sample combinations. The set of series 1 to 9 stands for nine distinct pairings that were seen during 46-days span.

3.4. Comparative volume analysis from composting.

Using the circular truncated cone method, a thorough analysis of the volume loss at day 46 in Table 2 provides insightful information about the effectiveness of different composting configurations. The data illustrates the reduced height in centimeters of the compost over the observation period and provides insights into the volume change across different Day/Combination settings. The most notable finding is that, according to the statistics, combinations two, three, and four exhibit noticeably greater percentage volume decreases than their counterparts. This considerable reduction in volume indicates that these combinations are maturing more quickly, indicating a higher level of compost breakdown and transformation efficiency. This phenomenon most likely results from a number of variables. First off, it is conceivable that combinations two, three, and four have a better balance of organic matter, which allows for quicker rates of decomposition [5]. These mixes may have an equal number of nitrogen- and carbon-rich components, which would encourage microbial activity and create the perfect conditions for breakdown. Variations in moisture content and aeration in various combinations may also be quite important. Sufficient aeration is necessary to provide aerobic conditions that support effective composting, and the right amount of moisture encourages microbial activity and nutrient breakdown [25]. It's possible that combinations two, three, and four preserved more ideal conditions for the composting process, which boosted microbial activity and thus reduced volume. Furthermore, by increasing porosity and boosting nutrient availability, the addition of bulking agents or additives to certain combinations may help to expedite maturation rates. On the other hand, combination nine, which was the undisturbed control sample, may have undergone a slower rate of disintegration because of unfavorable organic material composition or subpar circumstances [3]. Overall, the stark differences in volume reduction amongst combinations highlight the complex interactions between diverse elements affecting the effectiveness of composting. Through the analysis of these subtleties, researchers may get important knowledge on how to best optimize composting procedures for increased resource efficiency and sustainability.

Table 2. Data of reduced height in cm of the compost.

Day/Combination	1	4	7	10	13	16	19	22	25	28	31	34	37	40	43	46
1	0	0.7	1.2	1.7	2.2	2.7	3.3	3.8	4.3	4.7	5.4	6	6.4	7	7.5	8.0
2	0	0.8	1.4	2	2.5	3	3.7	4.3	4.8	5.5	6	6.6	7.2	7.8	8.4	9.0
3	0	0.8	1.4	2	2.5	3	3.7	4.3	4.8	5.5	6	6.6	7.2	7.8	8.4	9.0
4	0	0.8	1.4	2	2.5	3	3.7	4.3	4.8	5.5	6	6.6	7.2	7.8	8.4	9.0
5	0	0.6	1.1	1.5	2	2.5	2.9	3.4	3.9	4.3	4.8	5.3	5.7	6.2	6.7	7.2
6	0	0.5	1	1.4	1.9	2.3	2.7	3.2	3.6	4	4.5	4.9	5.3	5.8	6.2	6.7
7	0	0.6	1.1	1.5	2	2.5	3	3.5	3.9	4.4	4.9	5.4	5.8	6.3	6.8	7.3
8	0	0.5	1	1.4	1.9	2.4	2.8	3.3	3.7	4.1	4.7	5.2	5.6	6.1	6.6	7.0
9	0	0.7	1.2	1.7	2.2	2.7	3.3	3.8	4.3	4.7	5.4	6	6.4	7	7.5	8.0

Day/Combination	Original Volume (cm^3)	Volume Obtained (cm^3)	Percentage Loss (%)
1	8393	5036	40.00
2	8393	3837	56.67
3	8393	3837	56.67
4	8393	3637	56.67
5	8393	4668	44.38
6	8393	5582	33.49
7	8393	4858	42.12
8	8393	5211	37.91
9	8393	5036	40.00

Best Combinations = 2,3,4
Highghest Pecentage Loss (%) = 56.67%

4. Conclusions

The goals of the study and the thorough observations made throughout the whole research process directly inform the results that are offered here. Several important findings have been made in the quest to improve food waste decomposition by carefully regulating pH, moisture content, and temperature. The study's goal of identifying the ideal blend of temperature, moisture content, and pH was effectively accomplished by the experiments that were carried out. The ideal combination of the 46days study are combinations two (Temperature=High, Moisture Content=High, pH=Low), three (Temperature=High, Moisture Content=Low, pH=High), and four (Temperature=High, Moisture Content=Low, pH=Low) according to the largest percentage decrease in volume. Remarkably, the difference in maturation time was not as great as first thought, indicating that these parameters may not be substantially accelerated in terms of the total breakdown process. Large-scale industries should not use these parameters because of the difficulties and complexities involved in regulating them. The intricate details of careful control are challenging and expensive. It's interesting to note that in terms of labor efficiency and financial effectiveness, letting the compost unregulated worked better. This suggests that, in some operational circumstances, a less interventionist and more naturalistic approach to the decomposition process may prove to be more advantageous in practice than strict parameter control. These findings highlight the necessity of optimizing food waste decomposition procedures through a sophisticated and context-specific approach.

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Competing Interest

All authors declared no competing interest.

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