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Original Article

Effectiveness of Composter with Magic Compos System Forward Reverse Design Through Temperature and Humidity Control on Composing Quality

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ABSTRACT

Household waste management is an important concern in an effort to reduce the potential negative impact on public health due to organic waste generation. This study aims to analyze differences in compost maturation rates based on variations in the time interval of the turning process in Magic Compost, differences in compost maturation rates based on the type of organic waste, differences in C/N ratio, carbon content, and moisture content in compost, differences in nitrogen, phosphorus, and potassium levels in compost, and differences in temperature, pH, and color in compost based on household organic waste criteria. This research uses an experimental approach with a posttest without a control group design and applies a randomized complete group design (RAKL). The tool used is Magic Compost, which is equipped with a temperature and humidity controller. The results showed a significant difference in the rate of compost maturation based on the time interval variation of the turning process on Magic Compost (p value = 0.000). The best turning time interval is 12 hours. There was a difference in the rate of compost maturation based on the type of organic waste generated by households, with mixed waste compost maturing the fastest and rice/starch waste maturing the slowest (p value = 0.001). While there was no difference in the C/N ratio (p value = 0.202), there were significant differences in the carbon content and moisture content of the compost based on the type of organic waste (p values = 0.042 and 0.000). However, there was no difference in the nitrogen and phosphorus content of the compost (p value = 0.144 and p value = 0.663). There was a difference in potassium levels in the compost based on the type of organic waste (p value = 0.000). The temperature of the resulting compost showed no significant difference (p value = 0.000), but there were differences in the pH and color of the compost based on household organic waste criteria (p values = 0.048 and 0.007). This study provides important insights into organic waste management through composting with Magic Compost, which can be an effective solution for reducing the negative public health and environmental impacts caused by organic waste generation.

Keywords: *Magic Compost, Turning Time, Compost Maturation Rate*

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INTRODUCTION

Household waste is waste consisting of the remains of foodstuffs, vegetables, fruit peels, used wrappers and food processing waste[1]. Household waste management needs to be carried out to reduce the generation of organic waste that can trigger diarrhea, skin and respiratory diseases[2]. With the support of science, composting methods are very important to be carried out by every individual or community group.

Currently, there are many methods of processing household waste independently, for example by sorting before disposal to the TPS by reusing especially inorganic waste such as plastic and making compost with a simple method of putting organic waste into a container and given an EM4 activator, the waste will become compost in about 7-8 weeks[3]. The problem with composting is that there is a wide choice of methods and activators used[4], length of composting time[5], temperature and humidity[6,7] and type of compostable organic material[8], size of organic matter[9] as well as turning the compost [10] which affects the result of compost maturation and the content of C, N and P in compost.

The Composter with Magic Compos System Forward Reverse Design is an innovative composting system that utilizes temperature and humidity control to enhance composting quality. This system aims to optimize the composting process by creating an ideal environment for microorganisms to break down organic matter effectively. The forward and reverse design of the system ensures efficient mixing and aeration, which are crucial for composting. Temperature and moisture control also play a key role in the composting process. By maintaining temperature and humidity at optimal levels, these systems encourage the growth of beneficial microorganisms while inhibiting the growth of pathogens that could potentially harm human health. The result is the production of high-quality compost that is free from contaminants and rich in nutrients.

Several previous studies have investigated the effectiveness of temperature and moisture control in improving compost quality. The results of these studies show that the use of temperature and moisture control technologies can have positive results in the context of composting[11,12]. Therefore, this research aims to further examine and provide a deeper understanding of the "Composter with Magic Compos Forward Reverse Design System" system as a potential method in improving the quality of compost produced. By effectively controlling temperature and humidity, it is hoped that this research can make an important contribution to the development of waste management practices that are more environmentally friendly and have a positive impact on human health and the surrounding ecosystem.

METHOD

This research is an experimental study with a posttest without control group design approach with various treatments. The research design uses a Complete Randomized Group Design, which is a randomized group design with all treatments tried on each existing group with the aim of making the diversity of experimental units within each group as small as possible while the differences between groups are as large as possible[13].

The independent variables in this study are the time interval of the reversal process, the type of organic waste produced by households, namely vegetables, rice and flour, meat and fish and fruits and variations in the time interval for reversing magic compost. The dependent variables in this study are the rate/time of compost maturation, C/N ratio, N, P, K, carbon, moisture content, color, temperature, and pH in compost produced using magic compost. The confounding variables in this study were temperature, humidity, length of turning and rotation speed of the magic compost tool. These variables were controlled according to the results of previous research, namely temperature 35-45 degrees Celsius, humidity 40-60%, 1 minute turning time and fan settings according to temperature conditions and bioactivator (EM4) 2.5 ml every 10 cm thickness.

The object of research focuses on organic waste from households. Laboratory tests were conducted at the Laboratory of the Faculty of Agriculture, Tanjung Pura University Pontianak. Tests to analyze the chemical content of mature compost such as C/N ratio elements, N, P and K and compared with SNI standards. The stages of this research in general are the preparation of materials and equipment, designing according to the results of the initial stage of research on the dimensions of the magic compost and organic material containers, setting the work of the reciprocating machine, setting the fan and battery and setting the microcontroller for monitoring temperature and humidity, testing the tool and making reports. The design of the tool design includes the activities of calculating the optimal dimensions of magic compost and light weight to carry, designing the inner space area, designing the volume of the container, setting the working time of the reciprocating machine for compost turning, setting the fan, battery and microcontroller and designing the compost container cover.

The compost material is household waste in the form of leftover vegetables, rice, side dishes and fruit and as an activator using EM4. The composting process using the Magic Compos (Forward Reverse) composter starts with the separation of waste that will be processed, including organic waste such as vegetable scraps, food scraps, and pieces of meat or fish scraps. Waste is chopped to a size of 1-2 cm. The chopped waste is put into the composter with a thickness of 10 cm interspersed with 2.5 ml EM4 in an alternating manner until a height of 30 cm. The composter is turned on by pressing on and the temperature is set to 35-450C, humidity 40-60%. If there is an increase in temperature or humidity, the fan is turned on. During the composting process, stirring is done every day by tapping the stirring button on the composter.

Data analysis using Anova's difference test to analyze differences in compost maturation rates based on variations in the time interval for turning the composting process in magic compost and differences in the length of compost maturation based on variations in organic waste (vegetables, rice and flour, meat and fish, and fruit). While testing differences in C/N ratio, N, P, K, Carbon, Moisture content, temperature, pH and color of compost based on the type of organic waste (vegetables, rice and flour, meat and fish, and fruit) using the Kruskal wallis non-parametric difference test.

RESULTS

The composter tool is designed with a compost reversal tool with a test time of 12, 18, 24 and 48 hours and to determine the difference in compost maturation rate, Nitrogen, Phospor, Potassium, Carbon C / N ratio, moisture content, temperature, pH and color of compost produced based on the type of waste after the magic compost tool is set back the most effective reversal time interval with compost maturation rate.

Table 1. Test result of the difference between turning time interval on compost maturation rate

Time Lapse	Mean	Standard deviation	Lower Bound	Upper Bound	p-Value
12	7.33	0.51640	6.7914	7.8753	0.000
18	8.00	0.63246	7.3363	8.6637	
24	8.50	0.54772	7.9252	9.0748	
48	10	0.63246	9.3363	10.6637	

Based on Table 1, it is known that the reversal time interval with the fastest compost maturation rate is at an interval of reversal every 12 hours and the longest at an interval of 48 hours. The results of the difference test analysis with one-way ANOVA obtained a p-value of 0.000, meaning that there is a difference in compost maturation rate with variations in the reversal time interval. To determine the significance value of the difference between the variation of the reversal time interval, it was further tested with LSD, with the results in Table 2.

Table 2. LSD further test results

Reversal process time interval (hour)		Sig.	95% Confidence Interval	
			Lower Bound	Upper Bound
12	18	0.062	-1.3706	0.0373
	24	0.002*	-1.8706	-0.4627
	48	0.000*	-3.3706	-1.9627
18	24	0.154	-1.2040	0.2040
	48	0.000*	-2.7040	-1.2960
24	48	0.000*	-2,2040	-0.7960

Table 3. Analysis results of temperature, pH, and color in compost based on the time interval of the turning process

Reversal time interval	Temperature (^{0}C)	pH	Color	Water content
12 hours	28	7,6	Brown	35
18 hours	30	7,6	developed	35
24 hours	30	7	developed	45
48 hours	35	6,5	developed	55

Based on table 3, the time interval for turning with good compost criteria according to SNI 19-7030-2004 based on the criteria of temperature, pH, color, and moisture content is the best time interval for turning every 24 hours. Furthermore, using a 24-hour turning interval in the composting process, compost is matured with variations in the type of organic waste produced by households.

Table 4. Results of statistical test analysis of differences in waste type with compost maturity rate.

Maturity Rate	Sum of Squares	df	Mean Square	F	p-value
Between Groups	17.200	4	4.300	7.963	0.001
Within Groups	10.800	20	0.540		
Total	28.000	24			

Based on table 4, the p value of 0.001 means that there is a significant difference between the type of waste used as compost material and the rate of compost maturation carried out using magic compost according to the settings of temperature, humidity, and duration of turning. Meanwhile, to find out the differences between each variation, further tests were carried out using the LSD test. The results of the analysis of differences between each type of waste and the rate of compost maturation using the LSD test can be seen in Table 5.

Table 5. LSD test

Type of Waste		Sig.	95% Confidence Interval	
			Lower Bound	Upper Bound
Vegetables	Rice/Starchy	0.007*	-2.3695	-.4305
	Meat/Fish	0.003*	-2.5695	-.6305
	Fruit	0.211	-1.5695	.3695
	Mixed	0.211	-.3695	1.5695
Rice/Starchy	Meat/Fish	0.672	-1.1695	.7695
	Fruit	0.101	-.1695	1.7695
	Mixed	0.000*	1.0305	2.9695
Meat/Fish	Fruit	0.044*	.0305	1.9695
	Mixed	0.000*	1.2305	3.1695
Fruit	Mixed	0.018*	.2305	2.1695

Based on table 5, there are differences in the rate of compost maturation between the types of vegetable waste with rice or flour, vegetables with meat or fish, rice or flour with a mixture of organic waste, meat or fish with fruit and a mixture, and fruit with a mixture of organic waste. The difference in the type of organic waste used as compost material on the levels of nitrogen, phosphorus, and potassium produced in composting using magic compost was tested using the Krulkal-Wallis non-parametric statistical test. The results of the analysis can be seen in Table 6.

Table 6. Distribution of N, P and K levels in Compost Based on Waste Type

Type of waste	Nitrogen (%)			Phospor (%)			Potassium (%)		
	≥ 0.4	< 0.4	p-value	≥ 0.1	< 0.1	p-value	≥ 0.2	< 0.2	p-value
Vegetables	100	0		80	20		60	40	
Rice/Starchy	40	60		80	20		0	100	
Meat/Fish	60	40	0.144	80	20	0.663	60	40	0.007*
Fruit	100	0		60	40		100	0	
Mixed	60	40		100	0		100	0	

Based on table 6, it can be seen that there are differences in potassium levels in compost produced using magic compost with variations in the type of organic waste (0.007), and there are no significant differences in nitrogen and phosphorus levels in the compost produced (0.144 and 0.663). Vegetables and fruits based on 5 repetitions of the composting process have 100 percent levels ≥ 0.4; the mixture has 100 percent phosphorus levels ≥ 0.1 in the resulting compost; and the types of fruit waste and mixture have 100 percent potassium levels ≥ 0.2. While the type of organic rice or flour waste has potassium levels in the resulting compost < 0.2, The carbon content, water content, and C/N ratio of compost produced using magic compost and the results of the difference analysis based on the type of waste can be seen in Table 7.

Table 7. Distribution of Carbon content, Water content and C/N Ratio in Compost Based on Waste Type

Type of waste	Carbon (%)			Water content (%)			Ratio C/N (%)		
	9.8-32	<9.8/>32	p-value	<50	≥50	p-value	10-20	< 10/>20	p-value
Vegetables	60	40	0.042*	20	80	0.000*	80	20	0,292
Rice/Starchy	20	80		100	0		80	20	
Meat/Fish	60	40		100	0		40	60	
Fruit	100	0		0	100		60	40	
Mixed	100	0		100	0		100	0	

Based on the results of the Kruskall-Wallis statistical test, there is a significant difference between the type of waste with carbon content and moisture content in compost produced using the composting process with magic compost, with a p value of 0.042 and 0.00. While the C/N ratio in the compost produced shows no significant difference between the types of waste with a p value of 0.292, The type of vegetable waste had a carbon content between 9.8 and 32 percent in the resulting compost; 80 percent produced compost with a moisture content of ≥50; and 80 percent of the C/N ratio was between 10 and 20. The type of organic waste derived from rice or starch 80 percent has carbon levels between <9.8 and >32 in the resulting compost; 100 percent produces compost with a moisture content of <50; and 80 percent has a C/N ratio between 10 and 20. The type of waste that comes from meat or fish 60 percent has carbon levels between 9.8 and 32 in the resulting compost; 100 percent produces compost with a moisture content of <50; and 60 percent has a C/N ratio between <10 and >20. The type of waste originating from fruits 100 percent has carbon levels between 9.8 and 32 in the resulting compost; 100 percent produces compost with a moisture content of ≥50 and 60 percent of the C/N ratio between 10 and 20. While the type of waste that comes from a mixture of household organic waste, 100 percent, has carbon levels between 9.8 and 32 in the resulting compost, 100 percent produces compost with a moisture content of <50 and a 100 percent C/N ratio between 10 and 20.

The results of temperature, pH and color tests on compost produced through composting using magic compost based on the type of organic waste and statistical difference tests using Kruskall Wallis based on variations in waste types can be seen in Table 8.

Table 8. Distribution of temperature, pH and color in compost based on waste type

Type of waste	Temperature (%)			pH (%)			Color (%)		
	≤30^0C	>30	p- value	6.8-7.5	<6.8/>7.5	p- value	developed	chocolate	p-value
Vegetables	100	0	1.000	60	40	0.048 *	80	20	0.061
Rice/Starchy	100	0		100	0		40	60	
Meat/Fish	100	0		100	0		80	20	
Fruit	100	0		40	60		20	80	
Mixed	60	40		100	0		100	0	

Based on the results of the Kruskall-Wallis statistical test, there are significant differences between the types of waste with pH and color in compost produced using the composting process with magic compost, with a p value of 0.048 and 0.061. While the temperature of the compost produced shows no significant difference between the types of waste with a p value of 1.000,

The type of vegetable waste has a temperature of ≤300 °C in the resulting compost; 60 percent produces compost with a pH between 6.8 and 7.5 and a blackish color of as much as 80%. The type of organic waste derived from rice or starch produced by 100 percent has a temperature ≤300 °C and a pH between 6.8 and 7.5 in the compost produced by 100 percent, and 60 percent produces brown compost. The type of waste originating from meat or fish at 100 percent has a temperature of ≤300 °C and a pH between 6.8 and 7.5 in the compost produced by 100 percent, and 80 percent produces blackish compost. The type of waste originating from fruits: 100 percent has a temperature of ≤300 °C in the resulting compost; 60 percent produces compost with a pH <6.8 or >7.5; and 80 percent of the compost is brown in color. While the type of waste originating from a mixture of household organic waste has a temperature of ≤300 °C in the resulting compost, 100 percent produces compost with a pH between 6.8 and 7.5, and 100 percent of the compost produced is blackish in color.

DISCUSSION

In the context of composting, the turning interval in the composting process with Magic Compos is a key factor in achieving effective results. The results showed that the effective turning interval to achieve an optimal compost maturation rate is 24 hours. This method may differ from the Berkeley method, where turning is done every 48 hours after the waste has been left for 4 days. This difference is due to the fact that the Berkeley method does not involve careful control of temperature and humidity, as well as different waste piles.

Turning in the composting process serves several important purposes. First, turning helps to keep the pile conditions ideal for the decomposition process carried out by microorganisms. Secondly, turning helps control the moisture content during the composting process, which has a significant impact on the activity of decomposing microbes. The optimal compost material content is between 40 and 60%, which favors the activity of decomposing microorganisms. In addition, turning also helps to reduce excess moisture, dissipate excessive heat, and reduce the size of the waste into smaller particles, facilitating the decomposition process. The activation stage of compost materials involves shredding, applying decomposers, and stirring to even out the decomposition process, remove excess heat, introduce fresh air, and help break down waste into smaller particles[14,15].

During the composting stage, the temperature of the compost pile will increase, and this is followed by an increase in the pH of the compost. Application of EM4 (Effective Microorganism 4) is one of the commonly used methods in the composting process. EM4 contains various types of decomposing microorganisms that play a role in breaking down organic matter into compost. Microorganisms such as Actinomycetes sp. bacteria have an important role in the decomposition process of organic matter into quality compost. In the context of composting household waste, understanding the time interval for turning, controlling temperature and humidity, and using decomposing microorganisms such as EM4 are important factors in achieving optimal results. Environmentally friendly waste management practices that have a positive impact on human health and the surrounding ecosystem can be realized through the application of efficient composting methods[14,16].

The results of this study showed a significant effect of the type of organic waste on the rate of compost maturity, with a p-value of 0.01. This can be explained by the variation of content characteristics in compost materials that differ between types of organic waste. The fastest rate of compost maturation occurs in mixed organic waste. This is due to the fact that mixed organic waste tends to have a complementary composition, including a balanced nitrogen, phenol, potassium, and carbon content. This study is consistent with previous findings, which state that optimal compost materials contain elements such as cellulose, nitrogen, phosphorus, potassium, and carbon in a certain balance with a moisture content between 40 and 50%. Vegetable waste, for example, has the potential to contain a variety of decomposing bacteria, such as those found in EM4 products.

In addition, the C/N ratio (carbon-to-nitrogen ratio) in waste can also be influenced by the type of organic waste and its characteristics. Moisture content below 50% requires the addition of water for microorganisms to grow properly. During composting, testing the moisture of the waste by holding and squeezing it can be an easy and effective method to determine if water addition is required. Low nitrogen content in organic matter can slow down the composting process. Based on the classification of organic matter, plant and animal remains can be divided into two categories: materials that are easily decomposed and materials that are slow to decompose. Easily decomposed materials include starch, hemicellulose, cellulose, protein, and water-soluble materials. In contrast, materials such as lignin, waxes or fats, and tannins fall into the category of materials that are difficult to decompose[4].

In addition, moisture content above 60% may result in less air available for microbial activity and may cause unpleasant odors. On the other hand, if the moisture content is below 50%, the composting process will take longer to reach maturity. Similarly, pH plays an important role in nutrient availability and plant growth. Soil pH conditions around 6-7 generally support the absorption of nutrients by plant roots, while acidic or alkaline soils can affect the availability of these nutrients. Therefore, controlling pH in the composting process is key to producing quality compost. In addition, temperature also plays a very important role in the composting process, especially in reducing pathogens and harmful microbes and inhibiting weed growth. Temperatures below 20 °C can indicate the failure of the composting process, so the temperature is set in the range of 40–60 °C to achieve optimal results[16–18].

It is important to note that while the types of organic waste may not differ in terms of compost temperature, they may result in differences in the pH and color of the resulting compost. This is consistent with the finding that different types of organic waste produce compost with different pH and color characteristics. Therefore, understanding the characteristics of different types of organic waste is important when producing compost according to the desired quality criteria[19,20]. In composting using Magic Compos, the activation stage involves chopping the organic waste into small pieces, adding a decomposer such as EM4 to as much as 2.5 ml, and stirring to even out the decomposition process. This stage aims to ensure that oxygen and easily degradable compounds are available to mesophilic microbes. Then, the temperature of the compost pile is increased to support thermophilic microbial activity (45–60 °C), which will decompose organic matter into CO2, water vapor, and heat. The EM4 application contains various decomposing microorganisms that play a role in the composting process.

This research shows that composting with Magic Compost can produce compost that meets the quality criteria based on SNI 19-7030-2004. In this process, controlling temperature, humidity, turning interval, and understanding the characteristics of different types of organic waste play a key role in achieving optimal results. Along with more progress in this research, the next area of study could be different ways of using decomposers and moving Magic Compost around. This could lead to a more effective method that helps with managing organic waste and plant growth.

CONCLUSION

In this study, the Magic Compost was set with temperatures ranging from 40-50°C, a rotation time of 60 minutes, and variations in the reversal interval between 12, 18, 24, and 48 hours. The study also included fan settings corresponding to a temperature rise of more than 70°C. This study shows that the 12-hour turning interval setting in Magic Compost and mixed waste composting can significantly increase the compost maturation rate, providing optimal results in the organic waste composting process. This has positive implications for efficient household waste management and composting.

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