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Effect of Substrate Size and Stirring on the Effectiveness of Fermentation of Organic Waste Using Composter Cash

I Made Rajendra [a]
M. Yusuf [b]
Nyoman Sugiartha [c]

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Abstract

Based on studies and research conducted by several researchers, it was found that the parameters that affect the effectiveness of waste fermentation include stirring and chopping the substrate in addition to temperature conditioning, the type and intensity of adding bio activators, and the type of organic waste (substrate). This study aims to produce an innovative composter barrel product that has the function of stirring and chopping in one compact tool. Tool testing is directed at liquid fertilizer products that are produced with an approach to the appropriate type of test. The results of the research that have been done show that the variation of counting does not have a significant effect on the quality of the liquid fertilizer, while stirring is very influential. For this reason, the innovative composter vat is recommended to add a stirring component while chopping is not required.

Corresponding author:
M. Yusuf,
Engineering Department, Politeknik Negeri Bali, Indonesia.
Email address: yusuf@pnb.ac.id

[a] Engineering Department, Politeknik Negeri Bali, Indonesia
[b] Engineering Department, Politeknik Negeri Bali, Indonesia
[c] Engineering Department, Politeknik Negeri Bali, Indonesia

1 Introduction

The problem of waste is not new. For a long time, various programs, discussions, seminars, and even the political consumption of various parties have appeared, but their implementation has not yet resolved the main problem until now. The people's habit of littering is so massive that it is almost difficult to change this behavior. The modernization lifestyle that has penetrated is not accompanied by the treatment of waste where its development has not shown significant progress.

It is not easy to solve the waste problem, especially if it is only left to the government. Garbage is a complex problem that can be resolved with collective steps. The community plays a very important role because it is responsible for the first chain of problems. The correct treatment of waste by each citizen will probably solve about 80 percent of the problem.

One simple method of processing waste is composter, which is changing organic waste into compost. This method uses tools in the form of a metal or plastic barrel. Organic waste generated by households such as food scraps in the form of vegetables, fruit, fish, and meat are put into specially designed composter vats and periodically sprayed with bio activators so that the fermentation process occurs. The fermentation process will produce two types of products, namely liquid and solid fertilizers (Pascual *et al.*, 1999; Li *et al.*, 2011; Tognetti *et al.*, 2007).

Currently, composter vats have been widely used by the community, especially households. The advantage of this barrel, apart from being affordable, the technology applied is quite simple so it is easy to operate. Also, the size of this tool is not so large that it is suitable for households who have houses with narrow land.

Given the simple technology, the results are not optimal. The drawback of the barrel model above lies in the fermentation process which takes a long time. The first liquid fertilizer product is produced in 7 (seven) days from the pouring of the waste, then solid fertilizer is produced after fermentation lasts 1 (one) month. The long process is not yet effective for processing household waste that is generated every day. To overcome this, a more innovative composter barrel model is needed by adding new techniques.

The technique that can be applied to make fermentation faster is the stirring process. Several studies on waste fermentation stated that stirring would provide sufficient contact between bacteria and the substrate and be able to homogenize the substrate in the reactor (Ramadhani & Nuraini 2018; Utomo & Sudarno 2014). Variation with 3 (three) times stirring was able to produce a total volume of biogas greater than the variation without stirring (Sanadi *et al.*, 2019; Wisnu *et al.*, 2013). The highest level of methane gas was obtained from a variation of 600 rpm, namely 29.31%. The more C / N content the better the material will be used as a substrate. The volume of biogas increases as the stirring speed increases (Pratiwi *et al.*, 2017). Based on some of the research results, it can be stated that stirring the substrate in the vat will be able to accelerate the fermentation reaction so that compost production is expected to be faster.

In addition to the stirring process, to speed up the fermentation or decomposition of the substrate it can be done by reducing its size. To accelerate the decomposition, the size of organic matter must be reduced in composting (Breitenbeck & Schellinger, 2013; Hong & Park, 2005; Mirghorayshi *et al.*, 2020). The number of natural decomposer microorganisms in the soil is small, so it is necessary to reduce the size of the organic matter so that the surface area is large and can be easily decomposed by microorganisms. Other studies which stated that the size of the chopped affected the decomposition process included; Small chopped results ranging from 2-5 mm can accelerate compost fermentation in large quantities and as desired (Sunge *et al.* 2019), the size of the tankos chop smaller than 10 cm is the most suitable chunk size for use in composting with Trichoderma decomposter sp for three months following the compost criteria based on SNI number 19-730-2004 (Okalia *et al.*, 2018). Based on the above background, an innovative composter barrel design was made which has the function of stirring and shredding.

2 Materials and Methods

This research is experimental research through object testing in the form of compost and liquid fertilizer produced by innovative composter vats. The size of the substrate is divided into 3 variants, namely chopped, medium (± 50mm), and small (± 10mm) chopped. While the stirring process was carried out with 3 treatments based on the intensity of stirring in one day, namely without stirring, stirring once (morning), stirring twice in the morning and evening. The test data design matrix is shown in Table 1.

The required number of composter barrels is 10 (ten) pieces. 2 (two) pieces for samples without treatment (control), while 8 (eight) pieces for samples with treatment, where each treatment uses 2 barrels, according to the matrix in Table 1. Composter room temperature data collection is taken twice, morning and evening every day for 15 days. While samples in the form of liquid fertilizer were taken on days 5, 10, and 15. The object of research was in the form of liquid fertilizers and then tested the content of organic C, N, PK, pH, and DHL (Electrical Conductivity), and the volume of liquid fertilizer formed, measured based on the altitude level.

Table 1
Substrate Variance vs Stirring Matrix

Variant		stirring intensity (n / day)		
		P1 (without stirring)	P2 (stirring 1 time)	P3 (stirring 2 times)
substrate size (mm)	C1 (chopped medium 50mm)	composter barrel C	composter barrel D	composter barrel E
	C1 (small chopped 10mm)	composter barrel B		
	C3 (not chopped)	composter barrel A		

The test result data is then analyzed graphically to get a picture so that the treatment that gives the optimum result can be determined. The material used as the test sample is organic waste which is commonly produced by households. Waste samples were taken from several households in Denpasar City. Considering that the types of waste are quite diverse, each composter includes a variety of waste with the same composition to obtain valid data. Types of waste used are vegetables such as spinach, kale, banana leaves, eggplant, tomatoes, and the like. The number of samples was 10 kg per barrel with the same variety.

The bio activator that will be used for fermentation is EM4. EM4 is a type of EM (Effective Micro Organism) in the form of a brown solution with a pH of 3.5-4.0. EM4 consists of 95% lactobacillus which functions to decompose organic matter without causing high heat because anaerobic microorganisms work with the power of enzymes. In this study, EM4 was obtained by buying on the market. The dose of EM4 was administered only once during the first entry of waste by spraying it five times. Before being sprayed, EM4 was mixed with water in a ratio of 1: 25.

The tool used in this study was an innovative composter barrel which was designed to have the function of chopping and stirring. The design proposed in this study initially led to prototyping, but along the way, there were several obstacles in terms of procurement, such as expensive production costs because it required expensive investments in making casting molds. To meet the needs of this research, a replacement barrel is used on the market but has a shape that can be modified according to the expected design. The composter barrel used is a barrel that is commonly used as a container for chemicals. The volume of the barrel is 30 liters made of plastic. The design drawings and the barrels used are as shown in Figure 1.

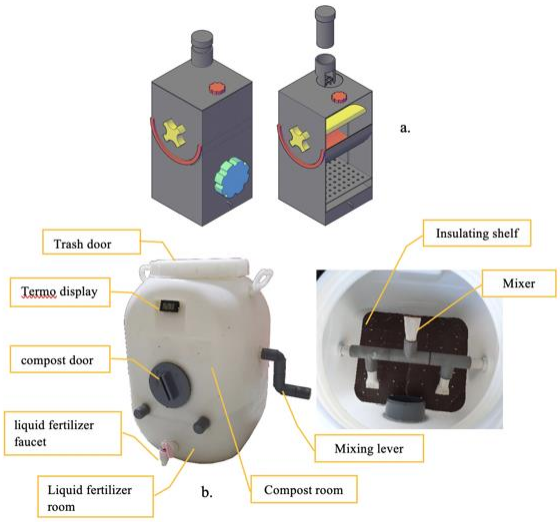


Figure 1. (a). design concept (b). tong komposter inovatif

3 Results and Discussions

3.1 Test results

Research on the effect of substrate size and stirring on the effectiveness of fermentation of organic waste using composter bins has been carried out. The test sample was in the form of liquid fertilizer which was taken on the 5th, 10th, and 15th days.

Figure 2. Test sample in the form of liquid fertilizer (a) testing sample I (b) testing II (c) testing III

The data on the results of testing liquid fertilizer samples are presented in Table 2 below.

Table 2
Data on organic content in liquid fertilizer

Day to:	PH	DHL (mmhos/cm	C Organic (%)	N Total (%)	C/N Ratio	P available (%)	K available (%)
Tong A							
5	7.9	21.75	0.39	0.70	0.56	0.30	2.03
10	7.9	20.50	0.39	1.10	0.35	0.45	2.71
15	7.8	19.10	1.17	1.20	0.98	0.65	2.84
Tong B							
5	7.9	21.50	1.17	0.90	1.30	1.00	2.43
10	7.7	19.80	0.39	0.95	0.41	1.10	2.79
15	7.7	13.30	0.39	1.30	0.30	3.12	2.91
Tong C							
5	7.9	23.60	0.78	0.80	0.98	0.67	2.56
10	7.8	20.10	0.39	0.85	0.46	0.68	2.67
15	7.7	19.60	0.78	1.10	0.71	1.42	2.81
Tong D							
5	7.7	19.70	0.78	0.70	1.11	1.53	2.76
10	7.6	18.10	0.39	0.90	0.43	1.52	2.77
15	7.6	13.00	0.39	1.00	0.39	2.04	2.76
Tong E							

5	7.8	17.40	0.78	0.70	1.11	1.00	2.69
10	7.6	16.40	0.78	0.90	0.87	1.37	2.81
15	7.6	13.30	1.17	1.10	1.06	2.81	2.81

3.2 Analysis based on chopped size

The chopped variation is divided into 3 (three) types, namely trash in composter barrel A is not chopped, composter barrel B is finely chopped (10mm) and in composter barrel, C is medium chopped (50mm). To determine the effect of chopping size on the quality of the liquid fertilizer produced, stirring was not carried out in the three bins. The analysis used is a graphical analysis of the distribution or changes that occur based on the length of the process (day n).

The fermentation process involves organic decomposition that results in or requires an energy change. These energy changes can be monitored by looking at temperature changes. The composter room temperature distribution is shown in Figure 3 below.

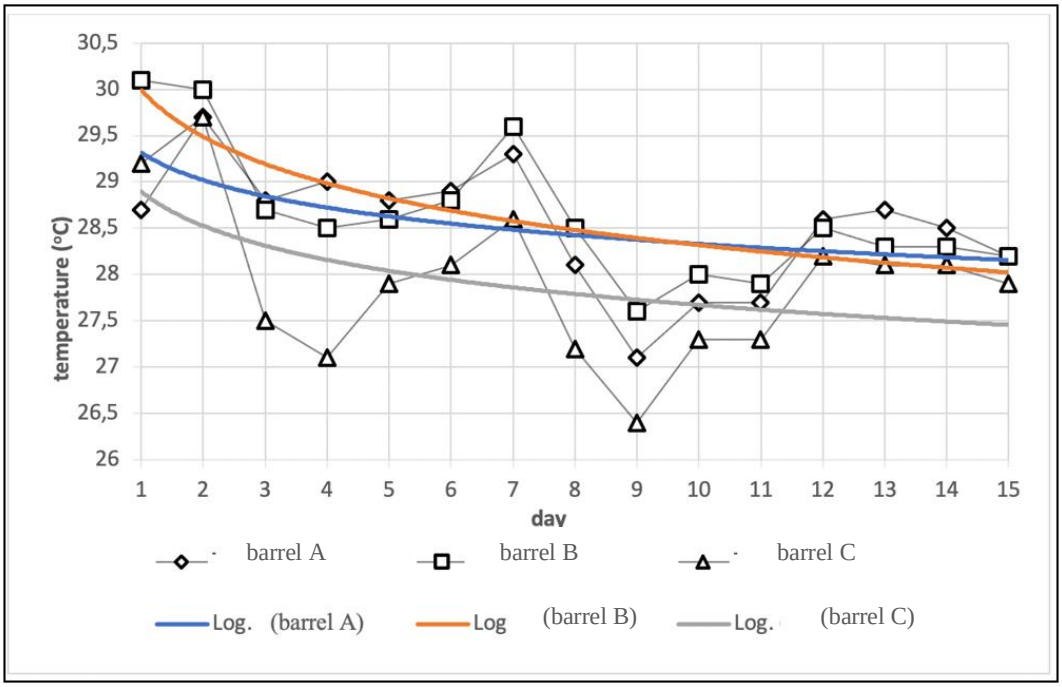


Figure 3. Temperature distribution in the morning measurement composter room

Based on the temperature change graph in Figure 3 above, it can be seen that the gradient of temperature change at composter barrel B is the sharpest, followed by composter barrel C and the smallest gradient is experienced by Tong A. At composter barrel B, the initial temperature (day 1) looks very high, this illustrates the process of very fast fermentation due to the larger contact surface area so that it is more sensitive to the activity of microorganisms. This temperature decrease indicates that the fermentation process is decreasing until finally, the temperature becomes constant. In composter barrel A, where the waste is not chopped, it shows that the fermentation process is slow so that the final temperature is higher than in composter barrel B.

Based on the temperature criteria for organic fertilizer or compost according to SNI number 19-730-2004, the best temperature for compost is following the temperature of groundwater, with an explanation that the temperature in groundwater can be absorbed by plant roots in an aerobic atmosphere and is not more than 30 ° C. Generally, the three chopping treatments show that the final temperature is still acceptable even though there are differences in measurements between morning and evening, this is due to the heat reception factor of the sun during the day.

Composter barrels have the same dimensions so that to measure the volume of liquid fertilizer produced can be determined by the level height observed at the bottom of the barrel. The volume change graph is shown in Figure 4 below.

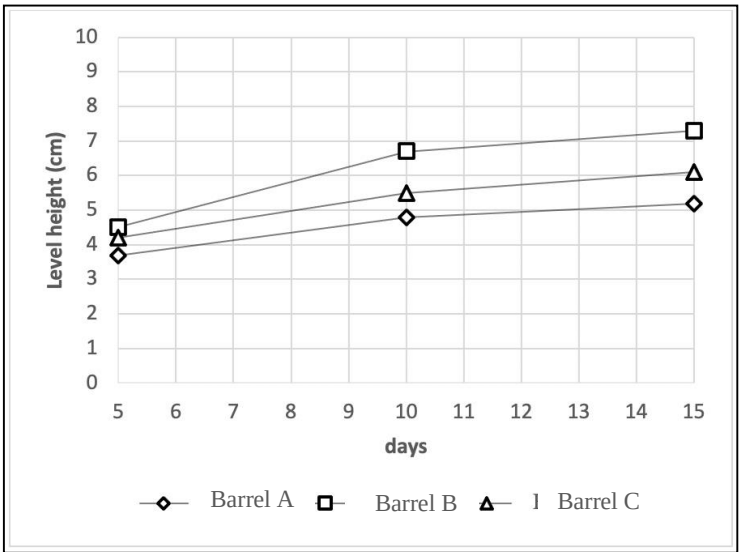
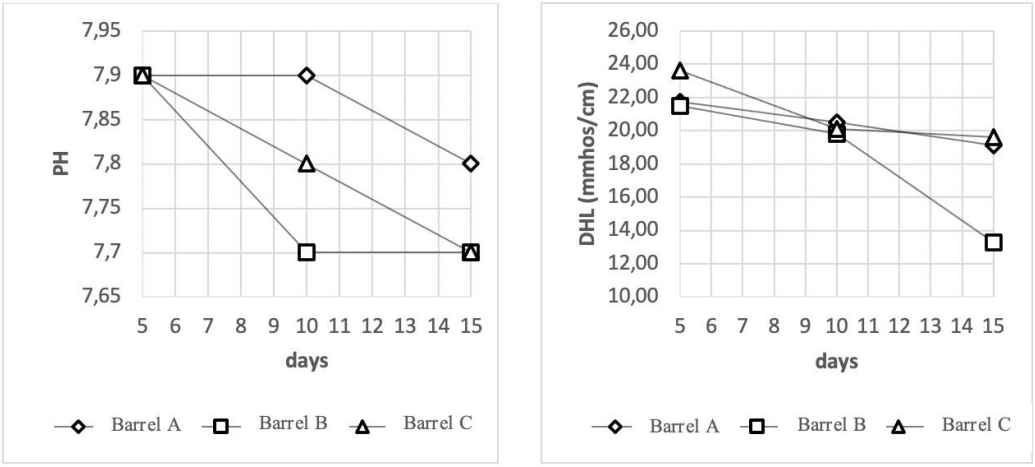


Figure 4. Changes in volume of liquid fertilizer based on a variation of chopping

Figure 4 shows that composter barrel B with the smallest chopped shows the largest volume change, followed by medium chopping and without chopping. This proves that the chopping results in a larger surface area of the waste and the pores are also increasing, making it easier for the liquid fraction to escape.

The pH value was measured in samples taken on days 5, 10, and 15. Changes in the pH value as in Figure 5 (a) indicate that the chopping treatment had a significant effect on the pH value. On the 15th day, the pH value of the waste with small chunks has the same value as the medium chopping, but the decrease in the pH value is experienced more quickly by small chunks. According to SNI 19-7030-2004 regarding the standard of domestic waste compost, a good pH value ranges from 6.80 to 7.49 so that this liquid fertilizer does not meet the requirements. For this reason, the fermentation process still takes time for the pH value to approach neutral.

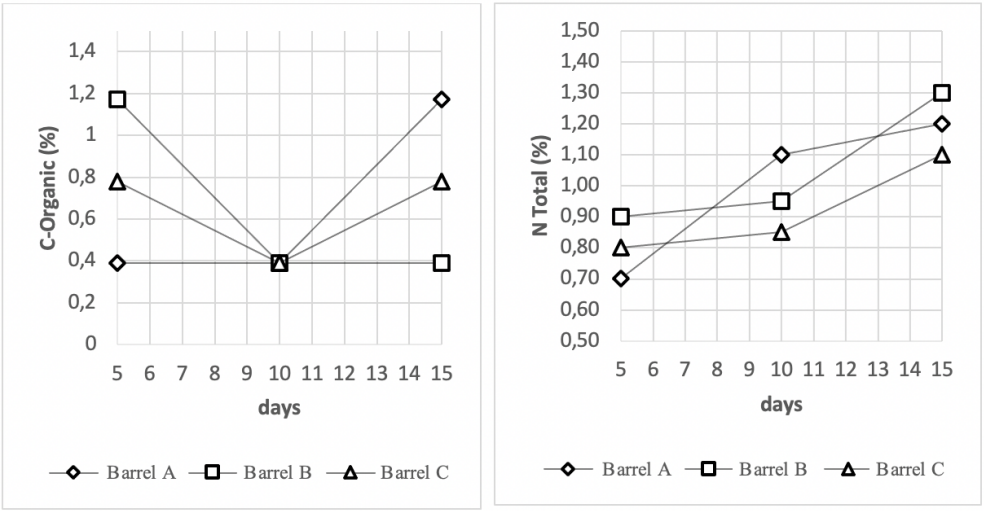


(a) (b)

Figure 5. (a) Change in pH value (b) electrical conductivity based on a variation of chopping

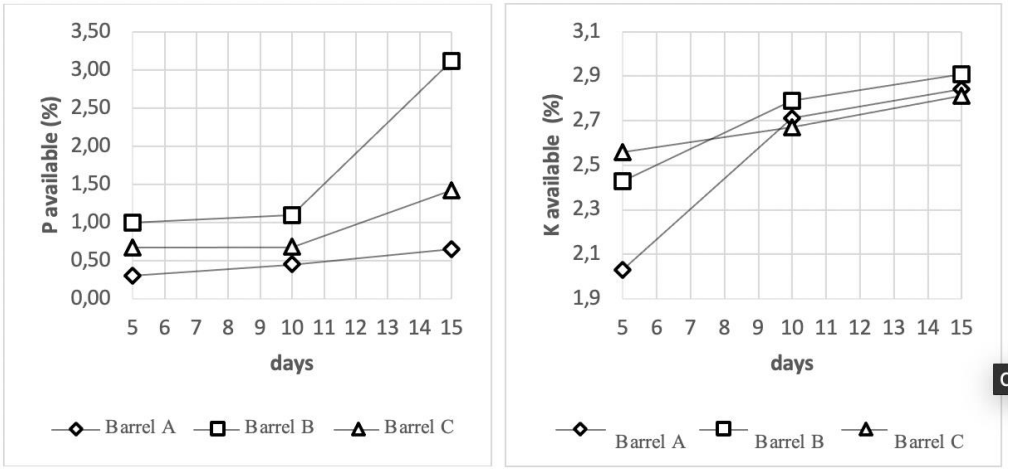
Electrical Conductivity (DHL) in liquid fertilizer for each treatment has seen changes in the period of sampling. The value of DHL was significantly reduced for the small chopped waste, compared to the medium chopped and

unchopped waste. This shows that the chopped variation affects the DHL value. Illustration of changes in the value of DHL is presented in Figure 5 (b).
The following shows the changes in the values of C-Organic, N, P, and K in Figure 6 and Figure 7.



(a) (b)

Figure 6. (a) Change in C-organic value (b) N value based on count variation



(a) (b)

Figure 7. (a) Change in P-value and (b) K value based on chopped variation

The C-Organic content in the three samples showed very low values ranging from 0.4 to 1.2%, this value is far below the SNI standard, namely 9.8 to 32%. This is because the waste has not been maximally decomposed. If we look at the changes that have occurred as shown in Figure 6 (a), then the trash that is not chopped has an increasing trend, while medium chopped is relatively fixed, and small chopped decreases.

Based on the available N, P, and K values presented in Figure 6 and Figure 7, it can be seen that waste with small chops tends to give the highest value. The total N content on the 15th day shows a value of 1.3% and has met the SNI, namely at least 0.4%. Meanwhile, the available P content shows a value of 3% and this is above that required by SNI, which is at least 0.1%. The available K content shows a value of 2.9% while the minimum SNI value of 0.2% means that it meets the requirements.

Based on SNI standards, the C / N ratio value ranges from 10 to 20, but in this study the resulting value is still very low, ranging from 0.2 to 1 for the three chopped variations, as shown in Figure 5.8. This is influenced by the very

low value of C-Organic where the decomposition process has not occurred optimally. The tendency of the value to increase is experienced by the waste that is not chopped, while the ones that are chopped small decrease.

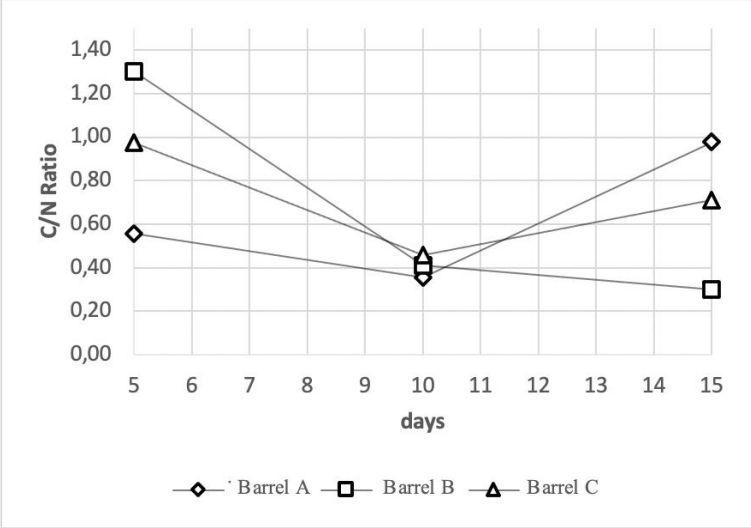


Figure 8. C / N ratio change based on Count Variation

Based on the parameters generated in the analysis above, a resume table can then be created as follows:

Table 3
Summary of Test Results Parameters Based on Chopped Size

Parameter	Not chopped (barrel A)	Small Chopped (barrel B)	Medium Chopped (barrel C)
Temperature	Tends to be stable	Descending with a high gradient	Descending on medium gradient *
Vol. fertilizer	Low gain	Height increase *	Moderate increase
pH	Stable - decreases towards neutral pH	Decreasing - stable (above neutral pH)	Decreases towards neutral pH *
DHL	Descending with small gradient *	Descending high gradient	Descending with small gradient *
C-Organic	Increase *	Descending	Steady at low numbers
N Total	Increase with steady gradient *	Increase with a high gradient	Increase with medium gradient *
P available	Increase with a small gradient	Increase with a high gradient*	Increase with a medium gradient
K available	Increase with big gradient *	Increase with a medium gradient	Increase with a small gradient
C/N Ratio	Increase with big gradient *	Descending	Increase with a small gradient

(*) qualify

Standard soil fertility parameters (soil pH, the content of C-organic matter, total N, available P and K available) are very important factors about plant growth, plant production, and function and diversity of soil microorganisms (Bonfante *et al.*, 2019; Stewart *et al.*, 2020). Based on the required standards, the waste that is not chopped has 4 fulfilled conditions, while small chunks are only 1 and medium chunks 2 requirements. Thus it can be concluded that for the manufacture of liquid fertilizer using an innovative composter bin in this study, the waste does not have to be chopped.

3.3 Analysis based on stirring intensity

The stirring process aims to spread microorganisms to all parts of the waste so that it can accelerate the fermentation. The effectiveness of stirring intensity on the quality of the liquid fertilizer produced can be observed by changes in its value or parameter.

The variation of stirring intensity was divided into 3 (three) types, namely the waste in composter barrel C was not stirred, composter barrel D was stirred once a day in the morning, and composter barrel E was stirred twice a day in the morning and evening. To determine the effect of the intensity of stirring on the quality of the liquid fertilizer produced, the waste in the three barrels was chopped with the same size, namely 10 cm (medium size). The analysis used is a graphical analysis of the distribution or changes that occur based on the length of the process (day n).
Based on the parameters generated in the analysis above, a resume table can then be created as follows:

Table 4
Summary of test results parameters based on stirring intensity

Parameter	Not Chopped (barrel C)	Stirring intensity 1 time (barrel D)	Stirring intensity 2 time (barrel E)
Temperature	Descending on a medium gradient	Descending on a medium gradient	Descending with small gradient *
Vol. fertilizer	Low gain	Moderate increase	Height increase *
pH	Decreases towards neutral pH *	Decreasing - stable (above neutral pH) *	Decreasing - stable (above neutral pH) *
DHL	Descending with small gradient - steady *	Descending with a big gradient	Descending with a small gradient
C-Organic	Stable	Descending	Increase*
N Total	Increase with a high gradient	Increase with a moderate gradient	Increase with a high gradient *
P available	Increase with a small gradient	Increase with a small gradient	Increase with a high gradient *
K available	Increase with a moderate gradient *	Stable	Stable
C/N Ratio	Decreasing towards stable	Descending	Increase with a small gradient *

(*) qualify

Based on the required standards and the test result parameters, the intensity of twice stirring has 7 conditions, while the intensity of one-time stirring has 1 condition, while without stirring 3 conditions. Thus it can be concluded that for the manufacture of liquid fertilizer using the innovative composter vat in this study, the intensity of stirring twice gave optimal results.

4 Conclusion

Based on the results and discussion above, it can be concluded that:

1) Domestic organic waste can be processed into liquid fertilizer through the composting method using a composter barrel.
2) Composter barrel can be made from new or used plastic barrels that can be modified according to the compost mechanism required
3) Some references state that the process of accelerating compost fermentation means that the waste must be chopped first. However, in this study, chopping variations did not have a significant effect on the yield of liquid fertilizer; This means that the waste that goes into the composter bin may not be chopped.

4) The variation in the intensity of stirring carried out in this study has a very significant effect on the liquid fertilizer produced, therefore the recommendation offered is that the innovative composter barrel must have a stirring component so that the liquid fertilizer is produced optimally.

Conflict of interest statement
The authors declared that they have no competing interests.

Statement of authorship
The authors have a responsibility for the conception and design of the study. The authors have approved the final article.

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