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Effect of Sugar Addition and Reversal in Rice Straw Composting Aerobically to Compost Maturity

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ABSTRACTS- The addition of sugar and the reversal of compost ingredients during this time are common in the hope that the composting process can take place faster. The addition of sugar is expected to increase microbial activity, while a more routine reversal is expected to meet the oxygen needs of microbes in aerobic composting. This research aims to analyze the effect of reversal and sugar addiction on the process of composting aerobic waste of rice straw. To date, there have been no studies that state that the addition of sugar to aerobic composting provides better compost maturity and quality following SNI-7763-2018 standards. To prove, research was conducted using 20 kg of rice straw with sugar doses of 0.4% and 0.8%. 2 treatments are reversals every 3 days and 6 days, with a composting time of 30 days. Each treatment was repeated 3 times, resulting in 18 trials in total. Based on the results of the study obtained C/N ratio on compost age 15 days have not been included in the category of mature compost. While the C/N ratio of compost at the age of compost of 30 days is in the range of 17.64-24.06. The results showed the C/N ratio between treatments at 30-day compost was no different ($p>0.05$). This means that the addition of sugar and more regular reversal frequencies are not required in aerobic composting of rice straw.

Keywords: Added sugar, Reversal, Aerobic composting. Rice Straw, Compost Maturity

I. INTRODUCTION

The decomposition of rice straw naturally takes quite a while, about 4-6 months (Abdulla 2007). The length of the process of weathering rice straw due to the presence of lignin and silica reduces the ability of microorganisms to perform decomposition (Howard et al., 2003; Sarnklong et al., 2010). Lignin is bound to hemicellulose and cellulose that form layered structures. This structure blocks the solution or enzymes that will be used to decipher cellulose and hemicellulose into constituent confectionery (Howard et al. 2003). Complex lignocellulose structure due to its high lignin content and harsh cellulose crystal structure limit degradation activity by microbes (Teghammar 2013).

Lignin is more easily degraded in aerobic conditions compared to anaerobic conditions. Under aerobic conditions, lignin is easily degraded by fungi of white and brown weathering species because during early fermentation it requires oxygen (Komilis and Ham 2003). Aerobic composting can be an option because the decomposition process is faster than anaerobic and becomes an effort in reducing methane emissions (Erses, Onay, and Yenigun 2008).

In aerobic composting, the oxygen needs in the compost heap should not be lower than 5% and composting to be optimal at an oxygen availability level of up to 10% (Roman, Martinez, and Pantoia 2015). Good aeration is indispensable for efficient composting and can be achieved by controlling and ensuring sufficient reversal frequency (Misra, Roy, and Hiraoka H 2003).

The addition of sugar during this time is common in composting, since sugar is the most important carbon (C) and energy source for soil microorganisms. Sugars are the most abundant organic compounds in the biosphere because they are monomers of all polysaccharides. Sugar plays a role in stimulating microbial activity and accelerating the composting process (Gunina and Kuzyakov 2015). The addition of sugar has an impact on the increased activity and growth of microbes indicated by increased heat or compost temperature (Laor, Raviv, and Borisover 2004). According to Mahae, Chalat, & Muhamud (2011), sugar is also potential to act as an antimicrobial, but antimicrobial activity depends on the type of microbe.

According to Lee (2016), microorganisms are naturally contained in all organic matter, water, air, and soil resulting in a high diversity of microorganisms. Microorganisms such as bacteria, fungi, and

Actinomycetes act as decomposers. Van der Wurff, Fuchs, Raviv, & Termorshuizen (2016) revealed that it is difficult to generalize the presence of microbes in composting raw materials, as they are controlled by a number of factors namely organic material type, moisture content, and temperature. In a study, Stella, Emmyrafedziawati, Matthews, & Kamal (2015) found a consortium of microbes consisting of 30 types of bacteria that have the ability to degrade cellulose, hemicellulose, and lignin in the soil. In addition, about 85-99% of bacteria cannot yet be cultivated with known cultural techniques in the laboratory (Hongoh and Toyoda 2011; Lok 2015; Stewart 2012). Bacteria that do not grow on the standard media of the laboratory tend to play an important role in the cycle of carbon, nitrogen, and other elements, as well as impacting organisms and the surrounding environment (Stewart 2012).
The maturity of compost has so far been one of the important parameters for evaluating the quality of compost, especially in the United States (Brewer et al., 2001). The C/N ratio of compost becomes one of the parameters used to determine the maturity of compost (Bazrafshan et al. 2016). Other common parameters used to assess the stability and maturity of compost include organic material content, dissolved organic carbon, humification, ammonia and nitrates, pH, and electrical conductivity (Wichuk and McCartney 2010). The parameters measured in this study are temperature, C/N, N, P, K, C-organic, and pH.

II. METHODS

Composting research was conducted using 20 kg of rice straw with sugar doses of 0.4% and 0.8%. The dose of sugar up to 0.8% (0.8 g of sugar for 1 kg of compost) in anaerobic composting using EM4 is said to be quite effective for bacterial development because bacteria get enough food intake, so the composting process is faster (Yuniwati, Iskarima, and Padulemba 2012). Before use, sugar is first mixed into 1 liter of water until homogeneous. The sugar water is then watered into the compost ingredients and stirred well.
The rice straw used comes from ciherang varieties and is taken from the SubakTegehan area, Banjarangkan, Klungkung. The rice straw used is 105 days after planting (HST). Rice straw is taken from a swath of rice paddies belonging to Made Sudana. The research was conducted at a meeting building belonging to winangun animal livestock group, Klungkung-Bali. The composting place uses a burlap sack with a diameter of 75 cm and a height of 110 cm. Composting time from June 30-July 31, 2018.
The study used a randomized group design (RAK) factorial patterns. Composting uses 2 treatments namely reversal every 3 days and 6 days, with a length of composting time of 30 days. According to Muliarta et al. (2019), rice straw can be composted within 35 days with a reversal every 7 days. Each treatment was repeated 3 times, resulting in 18 trials in total. The distance between blocks is 50 cm and the distance between treatments is 30 cm. Composting treatment is presented in Table 1.

Table1.
Treatment in composting rice straw.

Code	Treatment
C1	No Sugar with reversal once every 3 days
C2	No Sugar with reversal once every 6 days
C3	With Sugar 0.4 % (8 g) and reversal once every 3 days
C4	With Sugar 0.4 % (8 g) and reversal once every 6 days
C5	With Sugar 0.8 % (16 g) and reversal once every 3 days
C6	With Sugar 0.8 % (16 g) and reversal once every 6 days

Temperature measurements are performed during the composting process using a mercury thermometer. The thermometer is placed in the middle of the compost heap to measure lethal contours. The measurement of compost parameters is done twice on the 15th and 30th day to determine the speed of maturation of compost from each treatment. Some of the compost parameters measured are temperature, C/N, pH, C-organic, N, P, and K ratios.
The analysis used in this study is a variety of fingerprint (Anova) according to the design specified. If the treatment is real, follow-up analysis is performed with Duncan Multiple Range Test (DMRT) at 5% with the help of SPSS Software Version 20 for Windows.

III. RESULTS AND DISCUSSION

3.1 Temperature

The highest composting temperature reached 52.10 ^{o}C in the C6 treatment (composting with 16 grams of added sugar and a reversal once every 6 days) and occurred on the 5th day. While the lowest temperature occurs on the 30th day of treatment C1 (composting without added sugar and reversal once every 3 days.

The higher the dose of sugar given, the higher the temperature. The increase in temperature is thought to occur because microbes found in compost and water used in composting get more energy sources, resulting in increased microbial activity, and an impact on temperature increases. This result is in line with the opinion of Laor, Raviv, and Borisover (2004) which states that the addition of sugar has an impact on the increased activity and growth of microbes indicated by increased heat or compost temperature. So the addition of sugar only increases the temperature at an early stage, because microbes get C which can be used directly for energy and increased activity (Figure 1).

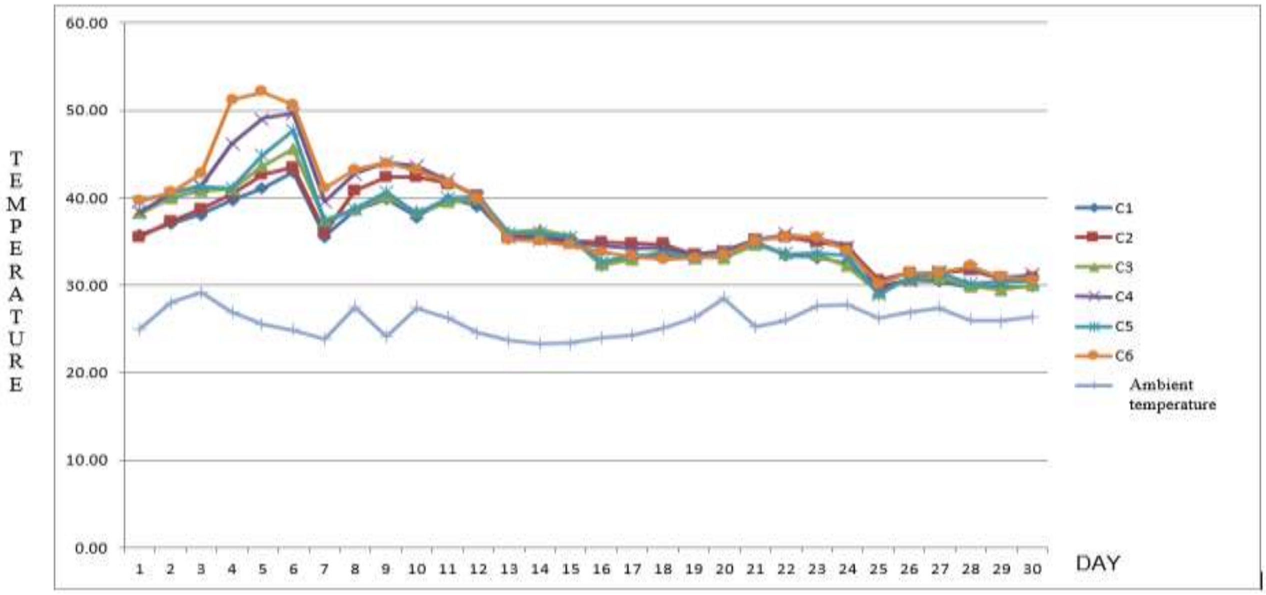

Figure 1.
Temperature changes during the composting process.

The composting temperature between the reversal treatment once every 3 days and once every 6 days looks different, where the composting temperature with the reversal treatment once 3 days tends to be lower. It is thought to occur because the reversal process every 3 days inhibits the process of microbial activity, so the temperature increase does not occur optimally. This means that overly routine compost reversals can inhibit the process of degradation of organic matter and inhibit the maturation process of compost. Temperature increases exceeding 55 to 60 °C are also not good for the composting process because it causes the microbial activity to drop drastically (Tuomela et al. 2000). Temperature is clearly a key variable in composting, as it affects the types of organisms that tend to thrive in compost piles (Boulter, Boland, and Trevors 2000; Hassen et al. 2002; Hubbe, Nazhad, and Sánchez 2010; Taiwo and Oso 2004). Temperature changes during composting indicate that organic matter goes through different phases such as mesophylic, thermophilic, cooling, and maturation (Chandna et al. 2013; Tuomela et al. 2000).

3.2 pH

The lowest pH decrease occurred in C6 treatment which reached 5.50 and occurred for two days on the 5th and 6th days (Figure 2). The decrease in pH is thought to be due to microbes decomposing sugar and other carbon sources. In general, in the early stages of composting, mesophylic microbial communities convert easily decomposed substrates such as sugars and proteins, the rapid degradation process results in rising temperatures and increased production of organic acids (Atalia et al. 2015; Hellmann et al. 1997; Roman, Martinez, and Pantoia 2015; van der Wurff et al. 2016). This phase lasts about two to eight days (Roman, Martinez, and Pantoia 2015).

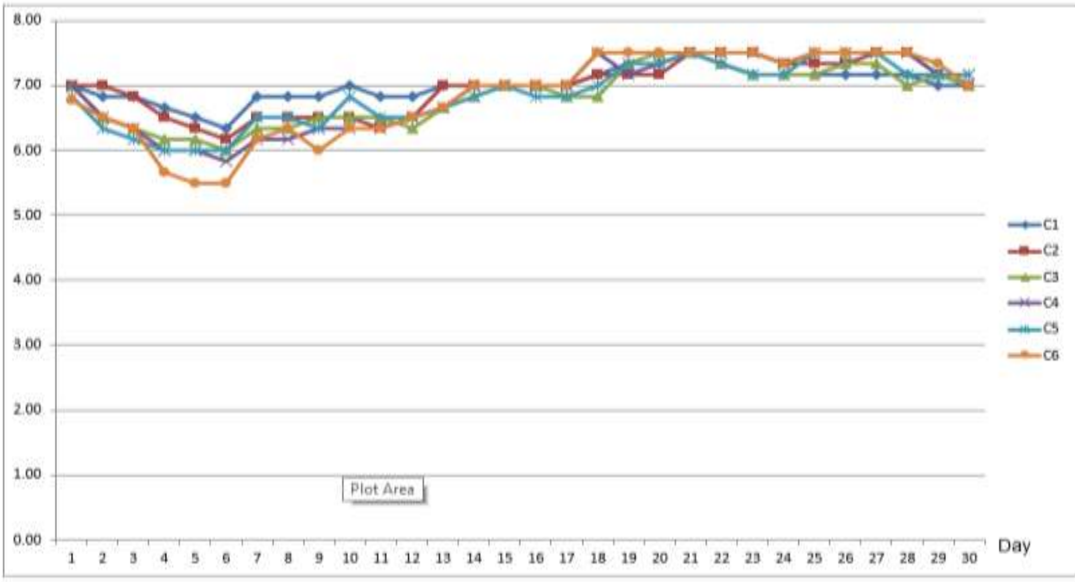

Figure 2.
PH changes during the composting process

The pH value strongly affects the decomposition process, where the decomposition process runs very slowly because acidic conditions interfere with the activity of decomposer bacteria (C. Sundberg, Smårs, and Jönsson 2004; C Sundberg et al. 2013; Cecilia Sundberg 2005). The combination of temperatures above 40 °C and pH below 6 is a combination of conditions that greatly hinder the composting process (Cecilia Sundberg 2005). PH levels are one of the important characteristics of composting processes since pH determines the survival of microorganisms and each group has optimal pH for growth and propagation (Atalia et al. 2015; Roman, Martinez, and Pantoia 2015). Most bacterial activity occurs at pH 6.0-7.5, while most fungal activity occurs at pH 5.5 to 8.0 (Roman, Martinez, and Pantoia 2015).

Changes in pH occur during the composting process because, in the early stages of composting, the pH is acidified by the formation of organic acids. Entering the thermophilic phase, due to the conversion of ammonium into ammonia, the pH rises to finally stable at a near-neutral value (Roman, Martinez, and Pantoia 2015). As for the pH of mature compost based on laboratory test results, presented in Table 2 and the results of the fingerprint analysis showed that there was no significant difference to the pH variable either at the age of 15 days or 30 days at the 6th treatment ($p>0.05$).

Table 2.
pH rice straw compost at the end of composting

Treatment	pH Rice Straw	pH Compost		SNI Standard 7763-2018
		Age 15 days	Age 30 days	
C1	6	8.31 a	7.98 a	
C2	6	8.38 a	7.79 a	
C3	6	8.04 a	7.88 a	
C4	6	8.39 a	8.04 a	4-9
C5	6	8.20 a	7.68 a	
C6	6	8.10 a	7.96 a	
DMRT 5%		0.467	0.445	

Description :

- The numbers followed by the same letter in the same column are no real difference in the Duncan Multiple Range Test (DMRT) 5%.
- C1 (No Sugar with reversal once every 3 days); C2 (No Sugar with reversal once every 6 days); C3 (With Sugar 8 g and reversal once every 3 days); C4 (With Sugar 8 g and reversal once every 6 days); C5 (With Sugar 16 g and reversal once every 3 days); C5 (With 16 g sugar and 6-day reversal).

When compared to the SNI standard, the pH value of rice straw compost obtained in accordance with SNI standards. These results are in line with the van der Wurff et al. (2016), that the pH value of compost is usually relatively high around 7.2-8.5. Based on the technical requirements of organic solid fertilizer stipulated in Regulation of the Minister of Agriculture No. 70/Permentan/SR.140/10/2011 on Organic

Fertilizer, Biofertilizer and Soil Improvement mentioned that the pH of solid organic fertilizer ranges from 4-9.

3.3 C/N ratio of compost.

The C/N ratio of rice straw compost aged 15 days have not been included in the category of mature compost, so it cannot yet be used for fertilization. While the C/N ratio of compost age of 30 days is seen to be lower than the age of 15 days (Table 3) and in accordance with SNI standards. This indicates the degradation of organic matter in the form of c reduction because it is used by microorganisms as a source of food or energy. The C/N ratio decreases during the composting process, due to the loss of part of carbon into CO_2 gas, while indicating that organic compounds are decomposed by microbes (Che Jusoh, Abd Manaf, and Abdul Latiff 2013; van der Wurff et al. 2016).
The higher the dose of sugar given, the lower the C/N ratio. Statistically, it shows that the difference in C/N ratio across all treatments is not significant ($p>0.05$). This means that the addition of sugar and the frequency of more routine reversals are not necessary, as they do not provide better compost maturity.

Table 3.
C/N ratio of rice straw compost

Treatment	C/N Rice Straw	C/N Compost		SNI Standard 7763-2018
		Age 15 days	Age 30 days	
C1	52.51	31.38 a	24.06 a	
C2	52.51	34.53 a	22.64 a	
C3	52.51	26.68 a	21.60 a	
C4	52.51	31.00 a	20.20 a	Max 25
C5	52.51	30.99 a	18.56 a	
C6	52.51	30.81 a	17.97 a	
DMRT 5%		9.465	4.967	

Description :
- The numbers followed by the same letter in the same column are no real difference in the Duncan Multiple Range Test (DMRT) 5%.
- C1 (No Sugar with reversal once every 3 days); C2 (No Sugar with reversal once every 6 days); C3 (With Sugar 8 g and reversal once every 3 days); C4 (With Sugar 8 g and reversal once every 6 days); C5 (With Sugar 16 g and reversal once every 3 days); C5 (With 16 g sugar and 6-day reversal).

The addition of sugar that is a source of carbon is thought to trigger a rapid increase in organic acids, which causes the pH to drop to acid. This conjecture is in line with the opinion of De Bertoldi, Vallini, and Pera (1983) which states the decomposition of carbon sources by microbes produces organic acids that cause a decrease in pH at the beginning of composting. Acidic pH conditions affect microbial respiration rates and lower degradation rates (Ameen, Ahmad, and Raza 2016; Wang, Lee, and Liao 2015). Overly frequent reversals (once every 3 days) are also thought to inhibit the process of C degradation by microbes.
Other studies have suggested that sugar in aerobic fermentation will be converted into hydrogen peroxide (H_2O_2) by lactic acid bacteria by utilizing oxygen. The presence of hydrogen peroxide can inhibit performance or have anti-microbial properties (Condon, 1987). Hydrogen peroxide is also able to react with other compounds forming compounds that have an antimicrobial effect called the lactoperoxidase system (Reiter and Härnulv, 1984). The addition of an insulated dose of sugar at pH 7.0 and a temperature of 35 °C will turn off bacterial species such as *Escherichia coli*, *Pseudomonas aeruginosa*, *Klebsiella pneumonia*, and *Staphylococcus aureus*(Chirife et al. 1983).

3.4. C-Organic

The addition of sugar and the difference in reversal frequency does not cause the c-organic content of compost to differ between treatments ($p>0.05$), both during the compost life of 15 days and 30 days. C-organic compost content is 30 days old overall in accordance with SNI standards which provide a minimum limit of 15% (Table 4).

Table 4.
C-organic content of rice straw compost

Treatment	C Rice Straw	C Compost		SNI Standard 7763-2018
		Age 15 days	Age 30 days	
C1	35.18	30.40 a	27.67 a	
C2	35.18	32.20 a	25.33 a	
C3	35.18	30.03 a	26.67 a	
C4	35.18	31.47 a	27.00 a	Min 15
C5	35.18	31.60 a	24.33 a	
C6	35.18	27.30 a	25.67 a	
DMRT 5%		-	3.752	

Description :

- The numbers followed by the same letter in the same column are no real difference in the Duncan Multiple Range Test (DMRT) 5%.
- C1 (No Sugar with reversal once every 3 days); C2 (No Sugar with reversal once every 6 days); C3 (With Sugar 8 g and reversal once every 3 days); C4 (With Sugar 8 g and reversal once every 6 days); C5 (With Sugar 16 g and reversal once every 3 days); C5 (With 16 g sugar and 6-day reversal).

The decrease in C is an indication of the degradation of organic matter caused by microbial activity, where C decreases due to oxidation into CO_2(Tiquia, Richard, and Honeyman 2002; Wu et al. 2010). Microbes utilize C as an energy source and use nitrogen for protoplasmic synthesis (Abdul Kadir, Azhari, and Jamaludin 2017; Kalatzi et al. 2016). During the composting process, the amount of metabolic carbon used by microbes is much higher than nitrogen, leading to a decrease in the C/N ratio (Wu et al. 2010).

3.5 Content N

Laboratory test results showed that there was an increase in N content throughout the treatment. Statistically, the addition of sugar dose and the difference in reversal frequency does not cause differences in N values between treatment (P>0.05) and N compost content is also still below SNI standard (Table 5).

Table 5.
N content of rice straw compost

Treatment	N Rice Straw	N Compost		SNI Standard 7763-2018
		Age 15 days	Age 30 days	
C1	0.67	0.99 a	1.28 a	
C2	0.67	0.94 a	1.21 a	
C3	0.67	1.13 a	1.31 a	
C4	0.67	1.04 a	1.34 a	Min 2
C5	0.67	1.03 a	1.31 a	
C6	0.67	0.90 a	1.31 a	
DMRT 5%		0.257	0.251	

Description :

- The numbers followed by the same letter in the same column are no real difference in the Duncan Multiple Range Test (DMRT) 5%.
- C1 (No Sugar with reversal once every 3 days); C2 (No Sugar with reversal once every 6 days); C3 (With Sugar 8 g and reversal once every 3 days); C4 (With Sugar 8 g and reversal once every 6 days); C5 (With Sugar 16 g and reversal once every 3 days); C5 (With 16 g sugar and 6-day reversal).

The increase in N content is thought to occur due to the mineralization process N in the early stages of composting. This allegation is in line with Chatterjee et al. (2013) which states in the early stages of composting mineralization N. Mineralization N is the process by which organic N is converted into inorganics available to plants and is the result of microbial activity (Crohn 2004; Gilmour 2011). Mineralization of N relatively increases gradually over time and temperature, where the temperature becomes the most important factor affecting mineralization levels (Bai et al. 2011; Crohn 2004).

3.6. Content P

Compost P content decreased in compost age 30 days from 0.2% to about 0.14-0.15%. Compost P content is also still well below SNI standard (Table 6).

Table 6.
P content of rice straw compost

Treatment	P Rice Straw	P Compost		SNI Standard 7763-2018
		Age 15 days	Age 30 days	
C1	0.2	0.27 a	0.15 a	
C2	0.2	0.30 a	0.14 a	
C3	0.2	0.26 a	0.15 a	
C4	0.2	0.25 a	0.14 a	Min 2
C5	0.2	0.29 a	0.14 a	
C6	0.2	0.27 a	0.15 a	
DMRT 5%		0.081	-	

Description :

- The numbers followed by the same letter in the same column are no real difference in the Duncan Multiple Range Test (DMRT) 5%.
- C1 (No Sugar with reversal once every 3 days); C2 (No Sugar with reversal once every 6 days); C3 (With Sugar 8 g and reversal once every 3 days); C4 (With Sugar 8 g and reversal once every 6 days); C5 (With Sugar 16 g and reversal once every 3 days); C5 (With 16 g sugar and 6-day reversal).

In the composting process, P is prone to decline, where loss can be caused by runoff (Che Jusoh, Abd Manaf, and Abdul Latiff 2013; Fuentes et al. 2006; Tiquia, Richard, and Honeyman 2002). The total concentration of P in compost is very important to give an idea of how much P is added to the soil when compost is applied to the soil (Prasad 2013). The results showed that the P content in each treatment was not different ($p>0.05$). This means that the treatment of the sugar dose and the frequency of reversal given does not provide a significant difference in P content.

3.7. Content K

Based on the results of laboratory tests, there was a gradual increase in compost K content, ranging from compost age 15 days which contained K to about 0.53-0.79% and then to 4.51-5.59% in compost aged 30 days. However, the results showed that K content between treatments in compost at 15 days was no different ($p>0.05$), nor did the content of K between treatments at 30 days old compost nor did it differ ($p>0.05$). The content of K compost in all treatments has met SNI standards that require a minimum of 2% (Table 7).

Table 7.
Content K rice straw compost

Treatment	K Rice Straw	pH Compost		SNI Standard 7763-2018
		Age 15 days	Age 30 days	
C1	0.24	0.53 a	3.59 a	
C2	0.24	0.70 a	4.62 a	
C3	0.24	0.53 a	4.67 a	
C4	0.24	0.55 a	4.97 a	Min 2
C5	0.24	0.79 a	5.59 a	
C6	0.24	0.69 a	4.51 a	
DMRT 5%		0.630	1.969	

Description :

- The numbers followed by the same letter in the same column are no real difference in the Duncan Multiple Range Test (DMRT) 5%.
- C1 (No Sugar with reversal once every 3 days); C2 (No Sugar with reversal once every 6 days); C3 (With Sugar 8 g and reversal once every 3 days); C4 (With Sugar 8 g and reversal once every 6 days); C5 (With Sugar 16 g and reversal once every 3 days); C5 (With 16 g sugar and 6-day reversal).

The increase in the content of K in straw compost is thought to have occurred due to the mineralization process and due to the presence of solvent microbes K. One of the fungi that have the ability as a solvent K namely Aspergillus(Assad et al. 2010). Meanwhile, bacteria that can be solvent K are bacteria from the genus *Pseudomonas sp*. (Parmar KB, Mehta BP, and Kunt 2016) and solvent bacteria K of the genus *Paenibacillus sp*. (Liu, Lian, and Dong 2012).

IV. CONCLUSION

Composting rice straw does not require the addition of sugar, because the addition of sugar only increases the temperature at the beginning of composting, but does not provide better composting quality. The frequency of compost reversal is only done once every 6 days in composting rice straw aerobically for 30 days. More routine reversal frequencies interfere with the decomposition process and do not provide faster compost maturity. Composting rice straw without added sugar and frequency reversal once 6 days able to produce mature compost within 30 days. But it has not been able to produce compost quality following SNI-7763 standard 2018 because the content of N and P is still below the minimum required limit.

Based on the results of the research, further research is needed using compost materials other than rice straw. Similarly, further research is needed using an active aeration system. In composting rice straw needs to be tested by adding N and P binding microbes to produce compost by SNI standard 7763-2018.

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