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Effect of Fermentation Duration and Coconut Fiber-Banana Peel Ratio on Characteristics of Liquid Organic Fertilizer

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Abstract: *Coconut and banana plants play a significant role in Balinese customs and religious practices. The waste generated from their use primarily consists of coconut fiber (35%) and banana peel (40%). This study aimed to produce liquid organic fertilizer by varying the fermentation duration and the ratio of coconut fiber to banana peel to assess their effects on the resulting characteristics. The study followed the standards outlined in the Decree of the Minister of Agriculture Number 261/KPTS/SR.310/M/4/2019. A factorial randomized block design was used with two factors: fermentation duration (14, 21, and 28 days) and coconut fiber-banana peel ratios (1:0, 1:15, and 1:30). The findings indicated that fermentation duration and the coconut fiber-banana peel ratio had no significant impact on pH but significantly affected NPK content. Fermentation duration significantly influenced temperature, while the fiber-peel ratio significantly impacted organic carbon content. The pH and organic carbon content did not meet the Decree of the Minister of Agriculture standards, but temperature (average 25.69℃)meet an aerobic fermentation standard (in the range of 3℃-70℃) and the NPK content meets the specifications of the Decree of the Minister of Agriculture in several treatments namely F1A1 2.73%, F1A2 2.51%, F1A3 2.56%, F2A3 2.35%, and F3A3 2.61%.*

Keywords: *banana peel, coconut fiber, fermentation duration, liquid organic fertilizer, material ratio*

I. Introduction

Indonesia is passed by the equator so that it has a tropical climate that affects the existing biodiversity and one of the plants known to live in this climate is coconut. According to data from the Directorate General of Plantations, until now coconut production in Indonesia has reached 2,886 tons with Riau, North Sulawesi, and East Java as the three largest coconut producing provinces in Indonesia [1]. Bali is one of the coconut producing provinces in Indonesia with a coconut producing area of 70,288 ha and coconut production of 67,331 tons in 2023 [1].

Coconuts can be found in almost all areas of Bali. The largest coconut-producing district in Bali is Jembrana Regency followed by Tabanan Regency and Karangasem Regency [2]. Coconut has a very dominant role in the lives of Balinese people. According to Adiputra & Wardi [3], the economic value of coconut can be seen from the products made from coconut plants which are generally used in traditional and religious purposes. In its utilization, coconut produces waste or by-products that can be used as fire wood such as fronds, leaves, coir, and coconut shells. Mardiatmoko & Mira [4] stated that the highest by-product component of old coconut fruit is coconut fiber as much as 35% with a utilization pattern that is still quite low [5].

Coconut fiber as a by-product if not utilized properly will become waste. According to Obeng [6] the common way is to burn coconut fiber or just leave it alone, but the burning process can spread pollutants into the air which are harmful to breathing. In addition to coconut fiber, banana fruit is an important commodity and is included in the top ten production crops with the largest production area and global calories. Indonesia, especially Bali, besides being utilized in the food and economic fields, bananas also have an important role in the fields of custom and religion. The demand for bananas will increase dramatically before religious holy days and therefore, in addition to cultivating bananas, they are also imported from outside Bali to meet the high demand [7].

In the process of utilization, the part of the banana fruit that is processed is only the pulp so that it will still leave waste or waste in the form of banana peels [8]. Husnawati [9] also mentioned that banana processing produces waste in the form of banana peels as much as 40%. In addition to having a negative impact on the environment, the presence of waste can have a negative impact on human health so that good waste treatment is needed. According to

Adi [9], processing waste into liquid organic fertilizer can add value to the waste. The content of nutrients in coconut coir in the form of potassium (K), phosphorus (P), sodium (Na), calcium (Ca), and magnesium (Mg) which can help increase plant growth can be used as liquid organic fertilizer [10].

Meanwhile, Rahayu [11] mentioned that banana peels also contain nutrients needed by plants such as sodium, protein, sulfur, calcium, phosphorus, potassium, zinc, and magnesium so that banana peels are suitable for liquid organic fertilizer. The purpose of this study was to determine the effect on the characteristics of liquid organic fertilizer produced in accordance with the technical specifications of liquid organic fertilizer according to the Decree of the Minister of Agriculture Number 261/KPTS/SR.310/M/4/2019 [12] with the treatment of variations in fermentation time for 14 days, 21 days, and 28 days and the ratio of yellow coconut fiber-banana peel horn, namely: 1:0, 1:15, and 1:30.

II. Research Method

2.1 Place and Time of Research

This research was conducted in Batubulan Village, Sukawati District, Gianyar Regency, Bali. Laboratory analysis was conducted at the Industrial Environment Laboratory, Process Engineering and Quality Control Laboratory and Postharvest Laboratory, Faculty of Agricultural Technology and Soil Laboratory, Faculty of Agriculture, Udayana University. The research was conducted from July to November 2024.

2.2 Experimental Design

This study used a factorial pattern Randomized Group using two factors, namely the length of fermentation (14 days, 21 days, and 28 days) and the coconut fiber-banana peel ratio (1:0, 1:15, and 1:30). The combination of the first factor and the second factor treatment obtained 9 experimental treatments and grouped as many as 2 groups based on the processing time, so 18 experimental units were obtained. The research design can be seen in Table 1.

Table 1. Experimental design

Fermentation Time (F)	Coconut Fiber-Banana Peel Ratio (A)		
	A1 (1:0)	A2 (1:15)	A3 (1:30)
F1 (14 days)	F1A1	F1A2	F1A3
F2 (21 days)	F2A1	F2A2	F2A3
F3 (28 days)	F3A1	F3A2	F3A3

2.3 Research Implementation

Coconut fiber was weighed as much as 10 g for one experimental unit and put into a fermenter/reactor bottle and then added banana peels according to the experimental treatment (0 g, 150 g, and 300 g), 100 mL of sugar solution, 100 mL of local microorganisms, and 1 L of distilled water and then stirred/shaken evenly then tightly closed and fermented during the experimental time (14 days, 21 days, and 28 days).

On the last day of each experimental treatment according to the length of fermentation, the finished liquid organic fertilizer is characterized by dark yellow or blackish brown bath water, sour smell, and white spots or membranes on the surface of the solution. Subsequently, filtering was carried out [13].

2.4 Data Analysis

Data analysis conducted in this study included pH (pH meter), temperature (thermometer), organic carbon content, and NPK. The data obtained were then analyzed using analysis of variance (ANOVA) to determine the effect of treatment on each observation variable. If it has a real effect, then a follow-up test BNJ (Differential Real Honest) 5% [14] will be conducted using Minitab software. The best treatment was then determined by the effectiveness index test.

III. Results and Discussion

3.1 pH

In this study, the results of the analysis of variance showed that the treatment of fermentation duration and the ratio of coconut fiber-banana peel and the interaction between the two did not significantly affect (P>0.05) the pH value produced from each treatment. The average value of liquid organic fertilizer can be seen in Table 2.

Table 2. Average pH values of liquid organic fertilizer

Fermentation Time (F)	Coconut Fiber-Banana Peel Ratio (A)			Average
	A1 (1:0)	A2 (1:15)	A3 (1:30)	
F1 (14 days)	3,45±0,13	3,39±0,15	3,44±0,01	3,41±0,08[a]

F2 (21 days)	3,49±0,13	3,34±0,09	3,28±0,04	3,37±0,05[a]
F3 (28 days)	3,50±0,08	3,50±0,04	3,46±0,02	3,48±0,03[a]
Average	3,46±0,03[a]	3,41±0,06[a]	3,39±0,02[a]	

Notes: Different letters behind the mean values in the same row or column indicate significant differences at the 5% error level ($p<0.05$). Data is the average of two experimental groups.

Table 2 shows that the highest average pH was found in treatments F3A1 (28 days fermentation time, coconut fiber-banana peel ratio 1:0) and F3A2 (28 days fermentation, coconut fiber-banana peel ratio 1:15), which were 3.50. Meanwhile, the lowest average pH was found in treatment F2A3 (21 days fermentation, coconut fiber-banana peel ratio 1:30), which was 3.28. According to Cesaria [15], the pH should not be too high because it will result in reduced nitrogen due to the ammonia change process and the pH should also not be too low because it will result in the death of decomposing microorganisms.

Changes in the pH of each treatment A (coconut fiber-banana peel ratio) against each treatment F (fermentation duration) tend to decrease in F2 (fermentation duration of 21 days) due to the formation of organic acids into simpler compounds. Then, the pH will rise again due to the decomposition of protein and also the release of ammonia [16]. This is in line with the research of Wulandari [17] in which the pH tends to decrease at the beginning to middle of the fermentation time then increases again at the end of the fermentation process.

Based on the technical specifications of liquid organic fertilizer according to the Decree of the Minister of Agriculture Number 261/KPTS/SR.310/M/4/2019, the pH is in the range of 4-9 [12] therefore the pH of liquid organic fertilizer in this study has not met the technical specifications because the pH is in the range of 3.28-3.50.

3.2 Temperature

The results of the analysis of variance in this study showed that the treatment of fermentation duration had a significant effect ($P < 0.01$) while the treatment of coconut fiber-banana peel ratio and the interaction between the two had no significant effect ($P>0.05$) on liquid organic fertilizer temperature. The average value of liquid organic fertilizer temperature can be seen in Table 3.

Table 3. Average temperature values of liquid organic fertilizer

Fermentation Time (F)	Coconut Fiber-Banana Peel Ratio (A)		
	A1 (1:0)	A2 (1:15)	A3 (1:30)
F1 (14 days)	23,95±0,07[b]	24,30±0,28[b]	24,25±0,21[b]
F2 (21 days)	26,75±0,21[a]	26,30±0,14[a]	26,35±0,35[a]
F3 (28 days)	26,65±0,35[a]	26,20±0,28[a]	26,50±0,14[a]

Notes: Different letters behind the mean values in the same row or column indicate significant differences at the 5% error level ($p<0.05$). Data is the average of two experimental groups.

Table 3 shows that the highest average temperature was found in treatment F2A1 (21 days fermentation, coconut fiber-banana peel ratio 1:0) of 26.75 ℃ which was not different from treatments F3A1, F3A3, F2A3, F2A2, and F3A2. Meanwhile, the lowest average temperature was found in the F1A1 treatment (14 days fermentation, coconut fiber-banana peel ratio 1:0) of 23.95 ℃ which was not different from the F1A3 and F1A2 treatments.

The temperature of all coconut fiber-banana peel ratio treatments (A1, A2, A3) increased in the 21 days fermentation treatment (F2) due to the decomposition process of organic materials that produce heat, in line with the research of Marjenah [18] with the temperature increasing at the beginning towards the middle of the fermentation process and then began to fall slowly towards the end.

This decrease in temperature is also caused by the remaining organic materials starting to thin out so that the decomposition process also begins to slow down. The temperature in this study ranged from 23.95℃-26.75℃ which is the normal temperature of fermentation because it is carried out aerobically which is possible in the range of 3℃-70℃ [19].

3.3 Organic Carbon Content

The results of the analysis of variance in this study showed that the treatment of fermentation duration had no significant effect (>0.05) while the treatment of coconut fiber-banana peel ratio had a significant effect (<0.01) and the interaction between the two had no significant effect (>0.05) on the organic carbon content of liquid organic fertilizer. The average value of organic carbon content of liquid organic fertilizer can be seen in Table 4.

Table 4. Average value organic carbon content of liquid organic fertilizer (%)

Fermentation Time (F)	Coconut Fiber-Banana Peel Ratio (A)			Average
	A1 (1:0)	A2 (1:15)	A3 (1:30)	
F1 (14 days)	2,54±0,28	1,76±0,28	1,95±0,55	2,08±0,16[a]
F2 (21 days)	2,98±0,21	2,15±0,28	1,95±0,00	2,34±0,15[a]
F3 (28 days)	2,93±0,28	1,76±0,28	2,15±0,83	2,28±0,32[a]
Average	2,80±0,04[a]	1,89±0,00[b]	2,02±0,42[b]	

Notes: Different letters behind the mean values in the same row or column indicate significant differences at the 5% error level ($p<0.05$). Data is the average of two experimental groups.

Table 4 shows that the average value of organic carbon content is highest in the treatment F2A1 (21 days fermentation, coconut fiber-banana peel ratio 1:0) at 2.98%. While the average value of the lowest organic carbon content was found in the F1A2 treatment (fermentation duration of 14 days, coconut fiber-banana peel ratio of 1:15) and F3A2 (fermentation duration of 28 days, coconut fiber-banana peel ratio of 1:15) at 1.76%. The different organic carbon content of liquid organic fertilizer in each treatment is influenced by the ratio of coconut fiber to banana peel due to the process of breaking down these materials during fermentation [20].

Treatment F2A1 (21 days fermentation, coconut fiber-banana peel ratio 1:0) showed that liquid organik fertilizer using only coconut fiber without the addition of banana peel had the highest organic carbon content because coconut fiber in the fermentation process is broken down into cellulose, hemicellulose, and lignin compounds that have a very complex structure so that when fermentation takes place, most of the carbon remains in organic form [21] while banana peel tends to be more organic, whereas, banana peels tend to be more easily broken down with mineral content such as potassium (K) as well as nitrogen (N), phosphorus (P), and carbohydrates into organic acid compounds or carbon dioxide (CO2) during the fermentation process [22]. Therefore, the treatment with the addition of banana peel tends to have a lower organic carbon content compared to the treatment without the addition of banana peel.

Based on the technical specifications of liquid organic fertilizer according to the Decree of the Minister of Agriculture Number 261/KPTS/SR.310/M/4/2019, the organic carbon content is a minimum of 10% [12], therefore the organic carbon content of liquid organic fertilizer in this study has not met the technical specifications because the organic carbon content in all treatments only ranges from 1.76%-2.98%.

3.4 NPK (Nitrogen, Phosphorus, Potassium) Content

In this study, the results of the analysis of variance showed that the treatment of fermentation duration and the ratio of coconut fiber-banana peel and the interaction between the two had a significant effect (<0.01) on the NPK content of liquid organic fertilizer. The average value of NPK content can be seen in Table 5.

Table5. Average valueNPK contentof liquid organic fertilizer (%)

Fermentation Time (F)	Coconut Fiber-Banana Peel Ratio (A)		
	A1 (1:0)	A2 (1:15)	A3 (1:30)
F1 (14 days)	2,73±0,05[a]	2,51±0,02[a]	2,56±0,10[a]
F2 (21 days)	1,69±0,03[b]	1,74±0,04[b]	2,35±0,26[a]
F3 (28 days)	1,72±0,04[b]	1,81±0,03[b]	2,61±0,03[a]

Notes: Different letters behind the mean values in the same row or column indicate significant differences at the 5% error level ($p<0.05$). Data is the average of two experimental groups.

Table 5 shows that the highest average value of NPK content was found in the F1A1 treatment (fermentation time of 14 days, coconut fiber-banana peel ratio of 1:0) at 2.73% which was not different from the treatments F3A3, F1A3, F1A2, and F2A3. While the average value of the lowest NPK content was found in treatment F2A1 (21 days fermentation, coconut fiber-banana peel ratio 1:0) of 1.69% which was not different from treatment F3A1, F2A2, and F3A2.

Nitrogen acts as a food or energy source for microorganisms for the growth of their cells while phosphorus, if available in sufficient quantities, will be sufficient for microorganisms to synthesize nucleic acids and ATP [23] and potassium which functions to regulate enzymatic activity as well as the osmotic balance of microorganism cells. The average value of nitrogen and phosphorus content obtained was lower than the average value of potassium content.

According to Qoniah [24], nitrogen and phosphorus content have an attachment to each other because the lower the nitrogen content, the lower the activity of microorganisms in breaking down phosphorus and vice versa. Agnesia & Sulistyaningsih [25] also added that metabolism by microorganisms also results in nitrogen being assimilated and volatilized (lost freely in the air).

Meanwhile, the relatively high potassium content is due to the liquid organic fertilizer material in the form of coconut fiber which is broken down into cellulose, hemicellulose, and lignin compounds that have a very complex structure so that the breakdown occurs quite slowly and stably [21] and banana peels which according to Sunaryadi & Jasili [26] also play a role in increasing potassium content because they are rich in this element but have properties that are more easily broken down [22].

Based on the technical specifications of liquid organic fertilizer according to the Decree of the Minister of Agriculture Number 261/KPTS/SR.310/M/4/2019, the NPK content is a minimum of 2-6% [12], therefore the NPK content of liquid organic fertilizer in this study has met the technical specifications in several treatments namely F1A1 2.73%, F1A2 2.51%, F1A3 2.56%, F2A3 2.35%, and F3A3 2.61%.

IV. Conclusion

The treatment of fermentation duration and the ratio of coconut fiber-banana peel did not significantly affect the pH value, significantly affected the treatment of fermentation duration and did not significantly affect the treatment of coconut fiber-banana peel on temperature value, did not significantly affect the treatment of fermentation duration and significantly affected the treatment of coconut fiber-banana peel on c-organic content, and significantly affected the treatment of fermentation duration and the ratio of coconut fiber-banana peel on NPK content.

The pH and organic carbon content did not meet the Decree of the Minister of Agriculture standards, but temperature (average 25.69°C)meet an aerobic fermentation standard (in the range of 3°C-70°C)and the NPK content meets the specifications of the Decree of the Minister of Agriculture in several treatments namely F1A1 2.73%, F1A2 2.51%, F1A3 2.56%, F2A3 2.35%, and F3A3 2.61%.

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