



Increase in nitrogen, phosphorus, and potassium of liquid fertilizer from fish canning waste and kepok banana peel (*Musa paradisiaca* L.)

Rieny Sulistijowati^{1,*}, Dwi Angriani Habie¹, Wila Rumina Nento¹, Elanemay Ivonne Peleh²

¹Department of Fishery Product Technology, Faculty of Marine and Fishery Technology, Universitas Negeri Gorontalo, Gorontalo, Indonesia.

²PT. Sinar Pure Foods International, Bitung, Sulawesi Utara, Indonesia.

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ABSTRACT

Canned fish industry production generates significant waste, which, if left untreated, can pollute the environment and have negative impacts. While solid waste from fisheries has been widely utilized, the utilization of liquid waste from fisheries remains uncommon. This research aims to analyze the chemical quality of liquid organic fertilizers and determine the best treatment between liquid waste from pelagic tuna canning and kepok banana peel extract. The research employed a laboratory experimental method with one treatment, which is different concentrations of liquid waste from fish canning and kepok banana peel extract, with four treatment levels and three replications: P0 (700 mL liquid waste from fish canning), P1 (600 mL liquid waste from fish canning + 100 mL kepok banana peel extract), P2 (550 mL liquid waste from fish canning + 150 mL kepok banana peel extract), and P3 (500 mL liquid waste from fish canning + 200 mL kepok banana peel extract). The parameters observed were nitrogen (N) content, phosphorus (P) content, and potassium (K) content. The research data were analyzed using a completely randomized design (CRD). The data analysis results stated that the treatment levels of P0, P1, P2, and P3 had a significant effect on the quality of liquid organic fertilizer and were statistically significantly different on the levels of nitrogen, phosphorus, and potassium of liquid organic fertilizer products. The results indicate the appropriate formulation for liquid organic fertilizers and the best chemical quality, which is treatment level P2 with a formulation of 550 mL liquid waste from fish canning, 150 mL kepok banana peel extract, 300 mL coconut water, and 40 mL EM4, yielding nitrogen (N), phosphorus (P), and potassium (K) values of 3.18%, 5.47%, and 5.54%, respectively. These values meet the quality standard requirements for liquid organic fertilizers according to Minister of Agriculture Regulation number 70/Permentan/SR.140/10/2011, which is between 3-6%.

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Introduction

Industrial production of fish canning produces residues in the form of liquid waste, which includes washing water and cooking water, as well as solid waste, such as red meat, offal, bones, heads, and fins. These wastes need to be treated efficiently to avoid pollution and unwanted odors, as well as to protect the health of employees and the surrounding community. Waste from fish canning can be utilized or processed into a variety of products, including fishmeal, fish silage, fish sauce, and fish oil. In addition, it can be utilized as feed ingredients for livestock, food industry purposes, and in the pharmaceutical field (Ndahawali *et al.*, 2016).

Liquid waste generated from the fish canning process comes from water used during washing, boiling, and residual heating. The liquid waste from fish washing was identified to contain organic materials such as nitrogen (595.89 mg/L), potassium (9.67 mg/L), phosphorus (79.77 mg/L), oil and fat (1004.5 mg/L) (Hasibuan *et al.*, 2015; Widiyanti and Hamidah, 2021). Liquid waste from fish cooking water contains 9.94% protein, 2.57% oil and fat, and 0.21% carbohydrates (Achyadi and Ikrawan, 2021). Based on this, innovation is needed to reduce liquid waste generated by the fishing industry. Fisheries liquid waste has the potential to be used as liquid fertilizer, alternative feed, biogas energy, plant

* Corresponding author.

Email address: rienysulistijowati@ung.ac.id

irrigation, and others (Ahuja *et al.*, 2020; Kumar *et al.*, 2018).

Fertilizer is an important component for plants to meet nutritional needs and help increase the productivity of plant growth optimally (Alam *et al.*, 2014). Based on the constituent materials, fertilizers can be classified into two types: chemical fertilizers (synthetic) and organic fertilizers (natural) (Koszel and Lorencowicz, 2015). Non-organic fertilizers or, often referred to as chemical fertilizers or synthetic fertilizers, are made from mineral materials or chemical compounds that have been processed so that they can be absorbed by plants (Mansyur *et al.*, 2021). Organic fertilizers are made from organic materials derived from plants or animals that have been processed. This fertilizer is used to supply the necessary nutrients to improve the physical, chemical, and biological quality of the soil (Alam *et al.*, 2014).

There are two types of organic fertilizers: solid organic fertilizer (POP) and liquid organic fertilizer (POC). When compared, POC is better than POP because the nutrients are available faster and more effectively when used on plants. In addition, POC has a role as a plant growth stimulant. Nutrients from fertilizers can be absorbed directly by the leaves and stems of plants through stomata or pores that help stimulate plant growth (Sundari *et al.*, 2014).

Fish waste is used as organic fertilizer with the aim of obtaining fertilizer containing various essential nutrients for plants, dealing with waste problems, and improving soil structure. The utilization of fish waste helps to reduce environmental pollution caused by the disposal of fish processing waste without considering its adverse effects on the ecosystem (Hapsari and Welasih, 2013). The weakness of liquid organic fertilizer derived from fishery waste is the low potassium (K) content. Therefore, the addition of kepok banana peel is expected to increase the potassium content in liquid organic fertilizer. The potassium content in kepok banana peel is around 9.32 - 10.6 mg per 100 g (Okorie *et al.*, 2015).

In comparison, ambon banana peel contains 882.38 mg potassium and 117 mg phosphorus per 100 g (Taslim *et al.*, 2021), while raja banana peel contains 312.63 ± 4.13 mg/100 g potassium, 46.41 ± 28.42 mg/100 g phosphorus, and 291.95 ± 0.40 mg/100 g nitrogen (Oyeyinka & Afolayan, 2019). However, after being processed into liquid organic fertilizer, the potassium content obtained only reached 0.29%, while phosphorus and nitrogen were 0.01% each for liquid fertilizer from ambon banana peel (Zulfania *et al.*, 2023), so it did not meet the set standards.

Studies on making liquid organic fertilizer (POC) from fishery liquid waste have been carried out, including Fitria *et al.*, (2008) making POC from fishery industry liquid waste using acetic acid and EM4 (Effective Microorganism 4), Hairuddin *et al.*, (2018) making POC from the milkfish wash water, Holifah (2019) making POC from anchovy stew water, and Astuti (2019) making POC from fish processing liquid waste. However, the results of research on liquid organic fertilizer (POC) from fishery liquid waste have not found the right formulation, so it has not met the quality standards of liquid organic fertilizer content. This research was conducted to find the right formulation and meet the quality standards of liquid organic fertilizer based on the Minister of Agriculture Regulation Number 70/Permentan/SR.140/10/2011, namely nitrogen 3-6%, phosphorus 3-6%, and potassium 3-6%.

Materials and Methods

Location and time of research

This research was conducted in December 2023. The manufacture of liquid fertilizer products was carried out at the Laboratory of the Faculty of Fisheries and Marine Sciences, Gorontalo State University and the chemical testing of macro nutrients was carried out at the Chemistry Laboratory of the Faculty of Mathematics and Natural Sciences, Gorontalo State University.

Tools and Materials

The materials used in this research are fish canning liquid waste, coconut water, kepok banana peel extract, brown sugar and Effective Microorganism (EM4). The liquid waste used came from washing and boiling baby tuna (Katsuwonus pelamis, bluefin, and yellowfin). The waste was obtained from the first basin of the Waste Water Treatment Plant (WWTP) at PT. Sinar Pure Foods International located in Bitung, North Sulawesi. The tools used include 1.5 L bottles, measuring cups, blenders, knives, filters and scales.

Method

This research uses a laboratory experimental method. This research includes making liquid organic fertilizer and conducting chemical tests (nitrogen, phosphorus, and potassium). The manufacture of this liquid organic fertilizer is a modification of research conducted by Mulyadi *et al.*, (2013) and Rasmito *et al.*, (2019). This study consists of 1 treatment, namely different concentrations of fish

canning liquid waste and banana peel extract with 4 levels and 3 replications.

Making banana peel extract is 1,000 g of banana peel waste finely chopped, added 40 g of brown sugar, and 100 mL water. Subsequently, it is blended and filtered to get the extract, and added with water until the limit mark in a 500 mL measuring cup. Following that, fish canning liquid waste, kepok banana peel extract, coconut water, and EM4 according to the treatment levels in Table 1 was put into the bottle, closed, and shaken until homogeneous. Further, fermented anaerobically in a place that is not exposed to sunlight for 10 days.

Table 1. Formulation of liquid organic fertilizer

Material	Treatment Level (P)			
	P0	P1	P2	P3
Fish canning liquid waste (mL)	700	600	550	500
Kepok banana peel filtrate (mL)	0	100	150	200
Coconut water (mL)	300	300	300	300
Efectif Microorganism 4 (EM4) (mL)	40	40	40	40

Data analysis

This study consists of 1 treatment, namely different concentrations of fish canning liquid waste and kepok banana peel extract, with 4 treatment levels and 3 replications. The parameters observed were nitrogen (N), phosphorus (P), and potassium (K) levels. Data from the N, P, and K tests were analyzed using a completely randomized design (CRD), tested using one-way ANOVA with a 5% significance level and further tested using Duncan.

Results

Nitrogen

The nitrogen content of liquid organic fertilizer produced in this study is in the range between 0.63 - and 3.18% (Figure 1). The highest nitrogen content was at the P2 treatment level (550 mL fish canning liquid waste: 150 mL kepok banana peel extract), which was 3.18%, and the lowest nitrogen content was at the P0 treatment level (700 mL fish canning liquid waste), which was 0.63%. Based on the Minister of Agriculture Regulation number 70/Permentan/SR.140/10/2011, the recommended nitrogen content in liquid organic fertilizer is 3-6%. In this study, the P2 treatment level (550 mL fish canning waste: 150 mL kepok banana peel extract) has met the established quality standards.

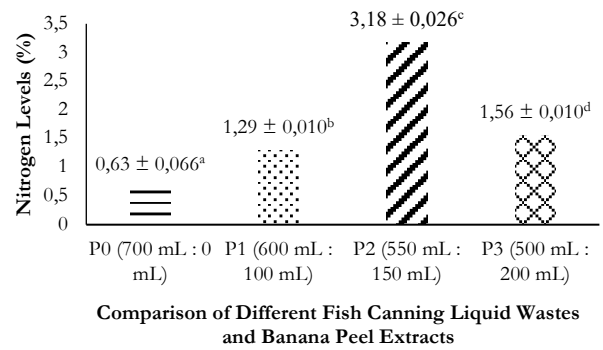


Figure 1. Nitrogen levels of fish canning liquid waste and kepok banana peel extract

The results of the ANOVA cad test in Table 2 show $p < 0.05$, meaning that the treatment levels (P0, P1, P2, and P3) of fish canning liquid waste and kepok banana peel extract with different concentrations have a significant effect on the quality of liquid organic fertilizer. Duncan's further test results show that the treatment levels of P0, P1, P2, and P3 are statistically significantly different in the nitrogen content of liquid organic fertilizer products.

Table 2. ANOVA test results of nitrogen levels of fish canning liquid waste and kepok banana peel extract

NITROGEN	ANOVA				
	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	10.545	3	3.515	2637.128	.000
Within Groups	.011	8	.001		
Total	10.556	11			

Phosphorus

The phosphorus content of liquid fertilizer produced in this study ranged from 2.47 - 5.47%. The highest phosphorus content of liquid organic fertilizer is at the P2 treatment level (550 mL of fish canning liquid waste: 150 mL kepok banana peel extract), which is 5.47%, and the lowest phosphorus content is at the P0 treatment level (700 mL of fish canning liquid waste) which is 2.47%. Based on the Minister of Agriculture Regulation number 70/Permentan/SR.140/10/2011, the recommended phosphorus level in liquid organic fertilizer is 3-6%. In this study, phosphorus levels at the P1, P2, and P3 treatment levels have met the established quality standards.

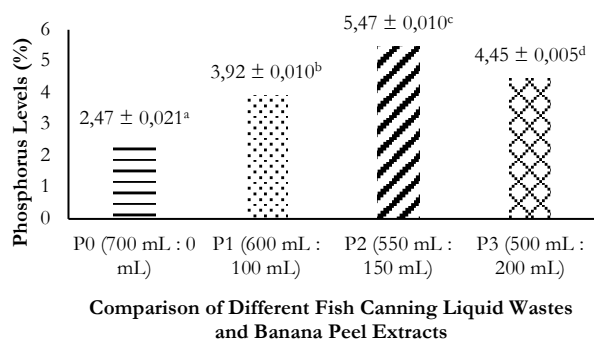


Figure 2. Phosphorus levels of fish canning liquid waste and kepok banana peel extract

The ANOVA test results in Table 3 show $p < 0.05$, meaning that the treatment levels (P0, P1, P2, and P3) of fish canning waste and kepok banana peel extract with different concentrations have a significant effect on the quality of liquid organic fertilizer. Duncan's further test results show that the treatment levels of P0, P1, P2, and P3 are statistically significantly different in the phosphorus content of liquid organic fertilizer products.

Table 3. ANOVA test result of phosphorus levels of fish canning liquid waste and kepok banana peel extract

ANOVA					
PHOSPHORUS	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	13.996	3	4.665	26850.078	.000
Within Groups	.001	8	.000		
Total	13.997	11			

Potassium

The potassium content of liquid organic fertilizer produced in this study ranged from 1.89 - 5.54%. The highest potassium content of liquid organic fertilizer was in the P2 treatment level (550 mL fish canning waste: 150 mL kepok banana peel extract), which was 5.54%, and the lowest potassium content was in the P0 treatment level (700 mL fish canning waste: 0 mL kepok banana peel extract) which was 1.89%. Based on the Minister of Agriculture Regulation number 70/Permentan/SR.140/10/2011, the recommended potassium content in liquid organic fertilizer is 3-6%. In this study, treatment levels P1 (600 mL fish canning waste: 100 mL kepok banana peel extract), P2 (550 mL fish canning waste: 150 mL kepok banana peel extract), and P3 (500 mL fish canning waste: 200 mL kepok banana peel extract) have met the established quality standards.

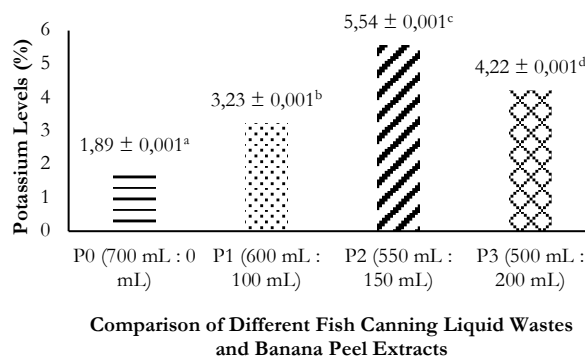


Figure 3. Potassium levels of fish canning liquid waste and kepok banana peel extract

ANOVA test results in Table 4 showed $p < 0.05$, meaning that the treatment levels (P0, P1, P2, and P3) of fish canning liquid waste and kepok banana peel extract with different concentrations had a significant effect on the quality of liquid organic fertilizer. The treatment levels of P0, P1, P2, and P3 are statistically significantly different in the potassium content of liquid organic fertilizer products after further Duncan's test.

Table 4. ANOVA test result of potassium of fish canning liquid waste and kepok banana peel extract

ANOVA					
POTASSIUM	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	21.472	3	7.157	3532962.381	.000
Within Groups	.000	8	.000		
Total	21.472	11			

Discussion

Nitrogen

Nitrogen is a gas in the atmosphere, colorless, odorless, and tasteless. Nitrogen is important for plant growth as it is used in chlorophyll (the green pigment in plants), proteins, and DNA. Plant growth slows down, and leaf color pales when nitrogen is deficient (Jiao et al., 2024).

Nitrogen levels increase due to nitrifying bacteria that decompose organic matter and convert ammonia into nitrate so that nitrogen in the fermentation process increases. Microorganisms also contribute a number of single-cell proteins obtained during the fermentation process, and nitrogen will be released back as part of the fertilizer after the

decomposition process is complete. [Aditya et al., \(2015\)](#) stated that protein is the main form of organic nitrogen. Microorganisms break down proteins into nitrogen (N).

The volume of fish wastewater used in each treatment caused differences in total nitrogen content. total nitrogen content produced increases along with the amount of fish waste used. Based on the research of [Aditya et al., \(2015\)](#), if the base material has a high nitrogen content, it is easier to decompose and produce fertilizer with higher nitrogen levels. The more biodegradable the material, the faster the fermentation time required. However, if the fermentation process lasts too long, the nutrients that have already decomposed may be further degraded, reducing the quality of the available nutrients. This is due to the decomposing bacteria that may be exhausted or even die as they run out of available food in the waste for the fermentation process.

Based on the results of research by [Alam et al., \(2014\)](#), industry fishery wastewater added with EM4 produces higher parameters than without the addition of EM4 concentration. This is because the composition of the mixed materials is different, so it has an impact on the amount of nutrients contained. The addition of EM4 acts as a bioactivator that can help decompose organic compounds and the content of NPK (nitrogen, phosphorus, and potassium) in the liquid waste of the fishing industry.

Nitrogen levels have decreased due to organic matter that has not been degraded properly. [Tanti et al., \(2019\)](#) stated that samples that did not decompose properly and the materials used to make organic fertilizer were incomplete, causing low nitrogen levels. According to [Hapsari and Welasih \(2013\)](#), the length of fermentation time also affects the hydrolysis process, the longer the hydrolysis time, the higher the solubility of the protein so that the ability of proteolytic enzymes to break peptide bonds increases. However, at some point the enzyme will be damaged and not work properly anymore, resulting in a decrease in the the soluble protein..

Enzymes produced during fermentation can affect the final product of the fertilizer, including nitrogen levels. These enzymes play a role in breaking down organic matter (complex compounds) into simpler forms (compounds) that are easier for plants to absorb, such as protease enzymes are responsible for breaking down proteins into amino acids, which can be converted into ammonium nitrogen used by plants. Thus, the fermentation process involving enzyme activity can increase the availability of nitrogen nutrients in liquid organic fertilizer, which

in turn can affect the final yield of the fertilizer and the growth and yield of plants using the organic fertilizer ([Liu et al., 2014](#)).

Another thing that can cause low nitrogen content is the presence of other microorganisms that compete with effective microorganism 4 (EM4), which can inhibit the growth and activity of microorganisms. There are microorganisms identified in kepok banana peel that can trigger competition with EM4, namely *Streptococcus* sp, *Enterobacter* sp, and *Pseudomonas* sp. These microorganisms play a role in the fermentation process ([Ogonna et al., 2017](#)).

Plants need nitrogen in large quantities because it is very important for the formation and growth of plant vegetative parts such as leaves, stems, and roots. Plant leaves will turn yellow if they lack nitrogen because their development is disrupted due to incomplete metabolism ([Purwati, 2017](#)). According to [Holifah \(2019\)](#), the availability of nitrogen is important for plants because it helps the formation of proteins and acids and affects plant height and diameter.

Phosphorus

Generally, phosphorus is found in the form of phosphate in soil and water ([Kour et al., 2020](#)). Phosphorus is important for root growth, seed development, and flower and fruit formation. It is also required for plant energy metabolism. Phosphorus deficiency can lead to stunted plant growth, poor seed formation, and purple leaf color ([Jiao et al., 2024](#)).

Phosphorus content is related to nitrogen content. [Aditya et al., \(2015\)](#) stated that the growth of microorganisms that can decompose phosphorus increases along with the amount of nitrogen contained. As a result, the level of phosphorus in organic matter and fertilizer increases along with the level of phosphorus in the material.

Fishery wastewater has a fairly high phosphorus content of about 79.77 mg/L ([Widiyanti and Hamidah, 2021](#)), kepok banana peel of 0.60 mg in 100 g ([Okorie et al., 2015](#)), coconut water has a fairly high phosphorus content of 15 mg/100 mL ([Palungkun, 2006](#)). Coconut water also has auxins and cytokinins that can encourage the growth of buds on some plants, such as orchids that are watered with coconut water. The use of coconut water can have a good impact on plant growth.

The addition of Effective Microorganism 4 (EM4) solution resulted in a higher final parameter compared to the condition without the EM4 concentration. . The reason is the difference in the

composition of the ingredients mixed, it affects the nutrients contained in it. When making fish waste organic fertilizer, EM4 is added as a bioactivator because it contains microbes that can accelerate the fermentation process in simplifying complex compounds from the materials used. The resulting fish waste liquid organic fertilizer has a high absorption to plant growth (Zahroh *et al.*, 2018).

The decrease in phosphorus levels at the P3 treatment level (500 mL fish canning waste: 200 mL banana peel extract) is thought to be caused by the presence of other microorganisms that compete with effective microorganism 4 (EM4), which inhibits the growth and activity of microorganisms. According to Ogonna *et al.*, (2017), there are microorganisms identified in the kepok banana peel that can help the fermentation process in the form of *Streptococcus* sp, *Enterobacter* sp, and *Pseudomonas* sp.

Enzymes produced from the fermentation process when making liquid organic fertilizer can affect the final result of phosphorus levels. Phosphatase enzymes help release phosphate from organic compounds, increasing the availability of phosphorus to plants. This is in accordance with the research of Larasati *et al.*, (2018), phosphatase enzyme is produced by phosphate bacteria that are able to dissolve unavailable phosphate into available so that it can be absorbed by plants. Thus, the fermentation process involving enzyme activity can increase the availability of phosphorus nutrients in liquid organic fertilizer, which can affect the final yield of the fertilizer as well as the growth and yield of plants fertilized by the liquid organic fertilizer (Liu *et al.*, 2014). According to Hapsari and Welasih (2013), fermentation time is an important factor that can affect the type and amount of enzymes produced during the fermentation process. Enzymes are produced gradually as nutrient availability increases, and enzyme activity can reach a peak before decreasing, which can cause inhibition of enzyme activity and a decrease in final yield.

Potassium

Potassium is a water-soluble mineral commonly found in soil in ionic form. It functions in the regulation of osmotic pressure in plant cells, water and nutrient transport, and enzyme activation. It also helps plants deal with environmental challenges such as drought and extreme temperature fluctuations. Potassium deficiency can cause plants to become more susceptible to disease, less drought-tolerant, and affect fruit and seed development (Jiao *et al.*, 2024).

From the results of the study, it can be seen that the treatment level P0 (700 mL fish canning waste: 0 mL banana peel extract) obtained a potassium content of 1.89%. It can be observed that without the addition of kepok banana peel, the potassium content of fish canning waste is nearly sufficient to meet the quality standards. According to Zhang *et al.*, (2023) and Terkula *et al.*, (2023), fishery wastewater can help plant growth because it is rich in organic matter, nitrogen, phosphorus, potassium, and other minerals. Fishery wastewater can be harmful if disposed of directly into the environment, but this nutrient-rich waste can be utilized as organic fertilizer and soil conditioning.

The addition of effective microorganism 4 (EM4) solution to fisheries industry wastewater results in higher parameters than without the addition of EM4 concentration. Alam *et al.*, (2014) suggested that if the materials mixed are different, it will cause changes in the nutrients contained therein, and the use of EM4 acts as a bioactivator that can change organic compounds and NPK content in the wastewater of the fishing industry and the basic ingredients used.

The increase in potassium levels occurred due to the addition of kepok banana peel extract in the composition of liquid organic fertilizer. According to Lepongbulan *et al.*, (2017), the addition of banana peel volume has the potential to increase potassium levels. This is due to the high potassium content in banana peel, which is below the water content, which is around 9.32 - 10.6 mg/100 g before decomposition, so the addition of banana peel extract volume will increase the potassium content.

The activity of microorganisms present in the material can affect the increase in potassium content because they act as catalysts. Bacteria and fungi bind and store potassium in cells, and when decomposition occurs, potassium is released again for nutrient availability. The ratio of raw material composition affects the nutrient content produced. The selection of appropriate organic fertilizer raw materials and the application of effective fermentation technology will produce high-quality fertilizers that can be effectively utilized by plants (Alam *et al.*, 2014).

The formation of organic acids during fermentation will increase the solubility of Ca, P and K nutrients, thus creating more K⁺. The breakdown of organic matter will reduce the availability of phosphorus and potassium that can be exchanged with liquid organic fertilizer. The cause is the activity of microorganisms that not only decompose phosphorus and potassium but also utilize them in their metabolic processes (Fitria *et al.*, 2008).

The decrease in potassium levels is thought to be caused by the presence of other microorganism sources that cause organic matter that is not degraded properly. According to Ogonna et al., (2017), there are microorganisms identified in kepok banana peel that play a role in the fermentation process in the form of Streptococcus sp, Enterobacter sp, and Pseudomonas sp. This can trigger competition with effective microorganism 4 (EM4) so that it can inhibit the growth and activity of microorganisms. According to Alam et al., (2014), the potassium content of each sample is due to the composition of the ingredients mixed differently, thus affecting the nutrients contained.

According to Hapsari and Welasih (2013), potassium deficiency causes leaves to shrivel and dry out because potassium is needed to accelerate the process of carbohydrate assimilation. Potassium in plants plays a role in many vital functions, including as a carbohydrate transporter, catalyst in protein formation, mineral regulation, balancer of chemical reactions in cells, growth regulator, and improves fruit quality and resistance to pests and diseases (Aditya et al., 2015).

Conclusion

Based on the study results, it can be concluded that the right liquid organic fertilizer formulation and the best chemical quality are found at the P2 treatment level with a formulation of 550 mL fish canning liquid waste and 150 mL kepok banana peel extract and 300 mL coconut water additives and 40 mL EM4 with nitrogen (N), phosphorus (P), and potassium (K) values of 3.18%, 5.47%, and 5.54%, respectively, which have met the quality standard requirements based on the Minister of Agriculture Regulation number 70/Permentan/SR.140/10/2011.

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References

Achyadi, N. S., Y. Ikrawan. 2021. Pengaruh perbandingan air rebusan ikan bandeng presto dengan gula aren terhadap karakteristik saus ikan. *Pasundan Food Technology Journal*, 8(1): 26-33.
Aditya, S., Suparmi, Edison. 2015. Study of manufacture solid organic fertilizer from fisheries waste. *JOM Faperika: Jurnal Online Mahasiswa Fakultas Perikanan dan Ilmu Kelautan Universitas Riau*, 2(2): 1-11.

Ahuja, I., E. Dauksas, J. F. Remme, R. Richardsen, A. Loes. 2020. Fish and fish waste-based fertilizers in organic farming – With status in Norway: A review. *Waste Management*, 115: 95-112.
Alam, J. S., M. Ramadhany, B. Dwicaksono, B. Suharto, L. D. Susanawati. 2014. Effect of effective microorganisms additions on the wastewater from fishing industry for organic liquid fertilizers. *Jurnal Sumberdaya Alam dan Lingkungan*, 1(1): 7-11.
Astuti, A. D. 2019. The utilization of boiled fish waste water. *Jurnal Litbang: Media Informasi Penelitian, Pengembangan dan IPTEK*, 10(2): 144-122.
Fitria, Y., B. Ibrahim, D. Desniar. 2008. Pembuatan pupuk organik cair dari limbah cair industri perikanan menggunakan asam asetat dan effective microorganisme. *Jurnal Sumberdaya Perairan - Akuatik*, 1(2): 23-26.
Hairuddin, R., M. Yamin, A. Riadi. 2018. Respon pertumbuhan tanaman anggrek (*Dendrobium sp.*) pada beberapa konsentrasi air cucian ikan bandeng dan air cucian beras secara *in vivo*. *Jurnal Perbal: Pertanian Berkelanjutan*, 6(2): 23-29.
Hapsari, N., T. Welasih. 2013. Pemanfaatan limbah ikan menjadi pupuk organik. *Jurnal Teknik Lingkungan*, 2(1): 1-6.
Hasibuan, M., Budijono, S. Harahap. 2015. N, P and K content in the EM4 fermented made from mixed fish market and tofu industry liquid wastes to the growth of *Azolla microphylla*. *JOM Faperika: Jurnal Online Mahasiswa Fakultas Perikanan dan Ilmu Kelautan Universitas Riau*, 2(2): 1-7.
Holifah, S. 2019. Pengolahan limbah air rebusan ikan teri menjadi pupuk organik cair dan aplikasinya terhadap hasil tanaman bayam (*Amaranthus sp.*). *Agromix*, 10(2): 100-113.
Jiao, H., R. Wang, W. Qin, J. Yang. 2024. Screening of rhizosphere nitrogen fixing, phosphorus and potassium solubilizing bacteria of *Malus sieversii* (Ldb.) Roem. and the effect on apple growth. *Journal of Plant Physiology*, 292(1): 1-12.
Koszel, M., E. Lorencowicz. 2015. Agricultural use of biogas digestate as a replacement fertilizers. *Agriculture and Agricultural Science Procedia*, 7(1): 119-124.
Kour, D., K. L. Rana, A. N. Yadav, N. Yadav, M. Kumar, V. Kumar, P. Vyas, H. S. Dhaliwal, A. K. Saxena. 2020. Microbial biofertilizers: Bioresources and eco-friendly technologies for agricultural and environmental sustainability. *Biocatalysis and Agricultural Biotechnology*, 23: 101487.
Kumar, V., A. U. Muzaddadi, S. Mann, R. Balakrishnan, K. Bembem, Y. Kalnar. 2018. Utilization of fish processing waste: A waste to wealth approach. *Compendium of ICAR Summer School Emerging Post-Harvest Engineering and Technological Interventions for Enhancing Farmer's Income*, 4(24): 127-131.
Larasati, E. D., M. I. Rukmi, E. Kusdiyantini, R. C. B. Ginting. 2018. Isolasi dan identifikasi bakteri pelarut fosfat. *Biomia: Berkala Ilmiah Biologi*, 20(1): 1-8.
Lepongbulan, W., V. M. A. Tiwow, A. W. M. Diah. 2017. Analisis unsur hara pupuk organik cair dari limbah ikan mujair (*Oreochromis mosambicus*) Danau Lindu dengan variasi volume mikroorganisme lokal (MOL) bonggol pisang. *Jurnal Akademika Kimia*, 6(2): 92.
Liu, L., T. Li, X. Wei, B. Jiang, P. Fang. 2014. Effects of a nutrient additive on the density of functional bacteria and the microbial community structure of bioorganic fertilizer. *Bioresource Technology*, 172: 328-334.
Mansyur, N. I., E. H. Pudjiwati, A. Murtilaksono. 2021. *Pupuk dan Pemupukan*. Z. Hanum (ed.). 1st ed. Syiah Kuala University Press.
Mulyadi, Y., Sudarno, E. Sutrisno. 2013. Studi penambahan air kelapa pada pembuatan pupuk cair dari limbah cair ikan terhadap kandungan hara makro C, N, P, dan K. *Jurnal Teknik Lingkungan*, 2(4): 1-14.
Ndahawali, D. H., F. Wowiling, Risnawati, S. Pongoh, S. Kaharu, S. H. Gani, S. M. Sasara. 2016. Studi proses pengalengan ikan di PT Sinar Pure Foods International Bitung. *Buletin Matric*, 13(2): 42-53.
Ogonna, U. S., J. Okpalla, U. C. Okafor. 2017. Effect of microorganisms and storage environments on ripening and spoilage of plantain (*Musa paradisiaca*) fruits sold in Eke Awka market. *Journal UGC*, 3(10): 186-190.
Okorie, Eleazu, Nwosu. 2015. Nutrient and heavy metal composition of plantain (*Musa paradisiaca*) and banana (*Musa sinensis*) peels. *Journal of Nutrition & Food Sciences*, 5(3): 1-3.

- Oyeyinka, B. O., A. J. Afolayan. 2019. Comparative evaluation of the nutritive, mineral, and antinutritive composition of *Musa sinensis* L. (banana) and *Musa paradisiaca* L. (plantain) fruit compartments. *Plants*, 8(598): 1-14.
- Palungkun, R. 2006. Aneka produk tanaman kelapa. *Penebar Swadaya*, 13th ed.
- Sundari, I., W. F. Ma'ruf, E. N. Dewi. 2014. The utilization of EM4 bioactivator and fish flour to the specifications of liquid organic *Gracilaria* sp. seaweed fertilizer. *Jurnal Pengolahan dan Bioteknologi Hasil Perikanan*, 3(3): 88-94.
- Purwati, A. D. 2017. Uji kandungan N dan P pupuk organik cair kombinasi batang pisang dan sabut kelapa dengan penambahan kotoran ayam sebagai biokaktivator. *Repository Universitas Muhammadiyah Surakarta*, 13(3): 1-10.
- Rasmito, A., A. Hutomo, A. P. Hartono. 2019. Pembuatan pupuk organik cair dengan cara fermentasi limbah cair tahu, starter filtrat kulit pisang dan kubis, dan bioaktivator EM4. *Jurnal IPTEK*, 23(1): 55-62.
- Tanti, N., Nurjannah, R. Kalla. 2019. Pembuatan pupuk organik cair dengan cara aerob. *Jurnal Ilmu Teknologi*, 14(28): 2053-2058.
- Taslim, T., R. S., T. M. 2021. Kadar kalium dalam buah pisang ambon. *Jurnal Farmasi Udayana*, 10(1): 100-106.
- Terkula, B., D. Torsabo, C. E. N. Che, F. Wahab, S. Rozaimah, S. Abdullah, H. Abu, N. A. Kasan. 2023. A study on the recovery and characterization of suspended solid from aquaculture wastewater through coagulation/flocculation using chitosan and its viability as organic fertilizer. *Journal of Agriculture and Food Research*, 11: 1-12.
- Widiyanti, A., L. N. Hamidah. 2021. Pengolahan limbah cair bekas pencucian ikan menggunakan *Scirpus grossus*. *Journal of Research and Technology*, 7(1): 61-70.
- Zahroh, F., Kusrinah, S. M. Setyawati. 2018. Perbandingan variasi konsentrasi pupuk organik cair dari limbah ikan terhadap pertumbuhan tanaman cabai merah (*Capsicum annum* L.). *Journal of Biology and Applied Biology*, 1(1): 50-57.
- Zhang, J., C. Akyol, E. Meers. 2023. Nutrient recovery and recycling from fishery waste and by-products. *Journal of Environmental Management*, 348: 1-14.
- Zulfania, C., A. V. Candra, S. M. Sholihah. 2023. Pemberian pupuk organik cair limbah kulit pisang ambon terhadap tanaman sawi pagoda (*Brassica narinosa* L.). *Jurnal Ilmiah Respati*, 14(1): 31-42.

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