J. T. K. L.
JURNAL TEKNIK KIMIA DAN LINGKUNGAN

J. Tek. Kim. Ling. 2023, 7 (1), 39-47
p-ISSN : 2579-8537, e-ISSN : 2579-9746
http://jurnal.polinema.ac.id/index.php/jtkl
DOI: http://dx.doi.org/10.33795/jtkl.v7i1.356

Valorization of Waste Cooking Oil into Liquid Organic Fertilizer by Anaerobic Fermentation Method

Budi Santoso[1,*], Arista Putri Permatasari[1], Sisilia Pratama[1], Prahady Susmanto[1], R.R. Yunita Bayu Ningsih[2]

[1] Department of Chemical Engineering, Sriwijaya University, Jl. Srijaya Negara, Palembang 30128, Indonesia
[2] Department of Mining Engineering, Sriwijaya University, Jl. Srijaya Negara, Palembang 30128, Indonesia

ABSTRACT

Liquid organic fertilizer is a type of fertilizer that has a liquid form with a brownish color and is commonly used in agriculture as a supporting material for the main fertilizer. Liquid organic fertilizer can be produced through the fermentation process of organic matter, such as plant residues, animal or human waste, and organic waste so that it will not damage the environment. The manufacture of liquid organic fertilizer in this study uses waste cooking oil as raw material which will be fermented anaerobically for 21 days with the use of EM4 activator volume of 10 mL and 50 mL. This study was conducted to determine how much potential used cooking oil waste can be converted into liquid organic fertilizer. The results showed that the best concentration of nitrogen, phosphorus, potassium, and carbon organic in liquid organic fertilizer was obtained at 10 mL volume of EM4 activator. The best nitrogen concentration is 0.520 ppm, the best phosphorus concentration is 12.213 ppm, the best potassium concentration is 12013.825 ppm, and the best organic carbon concentration is 2.10%.

***Keywords*:** EM4 activator, fermentation, liquid organic fertilizer, waste cooking oil.

1. INTRODUCTION

Wasted cooking oil has a high content of saturated fatty acids, where these fatty acids are included in carboxylic acids. Carboxylic acids improve the soil's biological condition and stimulate and activate the biological and physiological processes of microorganisms in the soil. Wasted cooking oil has a higher content of saturated fatty acids caused by the frying process that changes the unsaturated chains in its constituent compounds. The composition of unsaturated fatty acids in wasted cooking oil by 30%, and saturated fatty acids by 70%; this wasted cooking oil can potentially become a liquid organic fertilizer. Liquid organic fertilizer is a solution resulting from the decay of organic materials such as plant residues, animal and human waste, and other organic wastes whose nutrient content is more than one type. Liquid organic fertilizers are generally applied to leaves containing essential macro- and micronutrients. Plants readily absorb elements in liquid organic fertilizer because of their liquid form [1]. Liquid organic fertilizer can be made with Effective Microorganism 4 (EM4) decomposing activator, rice bran, and rice water.

EM4 is a mixed culture of various microorganisms to convert organic compounds into nutrients. These microorganisms are Lactobacillus sp., Actinomycetes sp., yeast., *Streptomycetes sp.*, and *Rhidopseudomonas sp.* [2]. Rice bran has a high carbohydrate content of around 58-74%, so it can be used as a source of nutrients for microorganisms. Rice bran contains 55% potassium and 1.44% phosphorus, so it can be used as an additive to improve the quality of fertilizer nutrients. Rice washing water is

[*]Corresponding author: Budi Santoso
Department of Chemical Engineering, Sriwijaya University
Jl. Srijaya Negara, Palembang 30128, Indonesia
E-mail: budisantosokimia@unsri.ac.id

Received : November 03, 2022
Accepted : April 17, 2023

a good source of nutrients for plant growth because it contains vitamins, carbohydrates, and nutrients, such as 91.11 ppm potassium, 60.55 ppm phosphorus, and 70.55 ppm nitrogen. Liquid organic fertilizer can be made through anaerobic and aerobic fermentation processes. Aerobic and anaerobic fermentation are two types of cellular respiration. Anaerobic fermentation does not require oxygen while aerobic requires oxygen. The manufacture of this liquid organic fertilizer uses anaerobic fermentation. Organic waste will be converted into carbon dioxide and methane by microbes in a specific time and temperature range, according to the working principle of anaerobic fermentation [3]. Various types of waste are commonly used in the research and production of liquid organic fertilizer.

Akib and Setiawati [4] utilized whey waste as an organic liquid fertilizer through anaerobic fermentation. Whey waste contains organic materials, particularly high complex proteins and amino acids in the form of suspended and dissolved solids. The variables measured were the content of organic C, C/N Ratio, and total N, P_2O_5, and K_2O contents. The results showed fermented whey waste had increased the organic C and C/N ratio but decreased P_2O_5 and K_2O contents.

Elfidiah and Roni [5] make liquid organic fertilizer from palm oil liquid waste. Palm Oil Mill Effluent (POME) contains macronutrients such as N, P, and K. Palm oil waste in anaerobic ponds 1 and 2 has physical characteristics in the form of brown, highly smelly, and foamy colors that are influenced by microbial activity. Anaerobic pond 3 has odorless and slightly foamy characteristics, while anaerobic pond 4 has a dark brown, slightly smelly, and slightly foamy color. This study analysis shows that the largest N, P, and K values are found in anaerobic ponds 1.

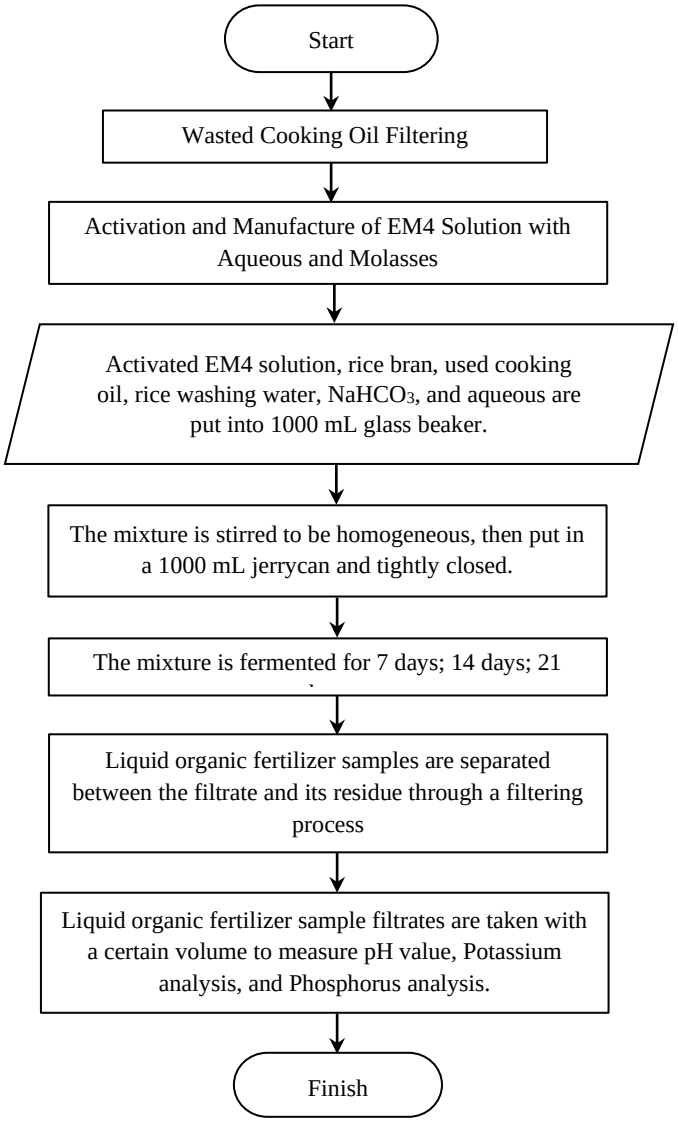
Ardiyanti, et al. [6] researched efficient compost fertilizer using cooking oil with saponification reaction. The reaction changes the used cooking oil turn into fatty acid and glycerol and then mixed with a stirring technique with fermented liquid compost for 4 months. After the two ingredients are mixed, the NPK content in Efficient Compost Fertilizer can be calculated. Fatty acids that have carbon chain groups make it easy to bond with other compounds, so the result of NPK in compost can be bonded perfectly. Efficient Compost Fertilizer has a higher NPK value than ordinary compost.

Rasmito, et al. [2] discuss the manufacture of liquid organic fertilizer by fermenting tofu liquid waste, starter filtrate of banana peels and cabbage, and EM4 bio activators. This fermentation process is carried out anaerobically with variations in the length of time of 4 hours, 5 days, 10 days, and 15 days. The optimum research results were obtained in the fermentation process with a duration of 10 days and a ratio of 40 mL/ 100 mL (EM4/ Starter). Based on the research results, the Nitrogen parameter value is 1.24%, P_2O_5 content value is 1.01%, and K_2O content value is 3.36%. Tanti, et al. [7] examined liquid organic fertilizer from catfish waste and banana peel pupae by aerobic means. This research began with the preparation process of fish waste and banana peels that had been fermented for 13 days with the help of water; after the mixture was formed, an EM4 activator with varying volumes was added. After the mixture is mixed well, it will be fermented for 7 days. This study concludes that sample A is the best result because it obtained a C-Organic of 5.04; Nitrogen 2.95; Phosphorus 4.54; and Potassium 5.04, where this value has met agricultural standard No. 70 Permentan SR.140/10/2011.

Using simple composting technology, liquid organic fertilizer can be made from livestock waste materials [8]. The composter used in this study was made simply by using a plastic container (gallon) which is quite thick and equipped with a lid. The liquid organic fertilizer made in the study was carried out by fermentation in an anaerobic atmosphere. This study's liquid organic fertilizer products had the highest NPK content of 0.16%, 153.75 mg/L, and 663.98 mg/L. Nitrogen, Phosphorus, and Potassium fertilizer analysis

results as a whole could not meet the standards.

2. RESEARCH METHODS



2.1 TOOLS AND MATERIALS

Various equipment has been used in this research. Those are beaker glass (1000 mL, 100 mL, 50 mL), 100 mL measuring glass, funnel, spatula, stirring rod, filter paper, analytical balance, scissors, cutter, 1000 mL jerrycan, 600 mL respirator bottle, hose, nipple, glue, solder, filter, 250 mL sample bottle, universal pH, marker, and pH meter. The materials have been used in this research was 10 and 50 mL agricultural EM4, 100 grams of rice bran, aqueous and EM4 with the ration 10:1, 10 mL molasses, 50 mL rice washing water, 50 mL waste cooking oil, and 10 grams sodium bicarbonate.

2.2 PREPARATION OF RAW MATERIAL

1) 50 mL of wasted cooking oil is filtered first to separate the oil from the remaining frying crud.
2) Rice bran of 100 grams is weighed using an analytical balance sheet.
3) Activating the EM4 solution using various volumes of 10 mL and 50 mL EM4 with a ratio of EM4 to diluent 1:10 with addition of 10 mL molasses through a fermentation process for 5 days.

2.3. FERMENTATION STEPS

1) The rice bran is put into a 1000 mL glass beaker and then added with 50 mL of wasted cooking oil.
2) The activated 10 mL and 50 mL EM4 solution are added to the mixture, and then stirred.
3) 50 mL of rice washing water is added to the mixture, then stirred.
4) Aquadest of 200 mL are added to the mixture, then stirred until the mixture is homogeneous.
5) 10 grams of sodium bicarbonate is added to raise the pH of the mixture so the final pH value in the range of 4-6, then stirred until homogeneous.
6) The mixture is then put into a 1000 mL jerrycan for fermentation in 21 days.
7) After the fermentation time ends, the sample is filtered and taken as much as 100 mL for the pH analysis process and elements of Nitrogen, Phosphorus, Potassium, and C-Organic.

The determination of variation in the volume of EM4 activators (Effective Microorganism 4) used in this study was determined based on several journals and thesis references that have been obtained so that the lowest and highest EM4 volume limits were chosen, namely 10 mL and 50 mL. The two variations in EM4 volume will be reviewed for results, then analyzed and studied more deeply in the discussion section.

3. RESULTS AND DISCUSSION

Waste cooking oil was obtained from the kemplang factory "Ucit" in the KM.5 area, Palembang. This waste cooking oil will be used as raw material in this study to manufacture liquid organic fertilizer that will be fermented anaerobically. In this study, Effective Microorganism 4 (EM4) was also used, acting as an inoculant to improve soil quality and speed up the fermentation process. This study began with the activation of fermented microorganisms in EM4, which was carried out by adding molasses to EM4 and aqueous based on a ratio of 1:10. Molasses will serve as an additional nutrient for the growth and breeding of microorganisms. The fermentation process in this study will be carried out with a fermentation time of 21 days with variations in EM4 volumes of 10 mL and 50 mL. The results obtained from this study will be analyze based on the parameters of pH value, Nitrogen content, Phosphorus content, Potassium content, and C-Organic content.

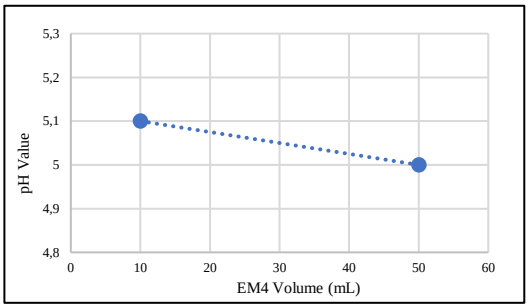


Figure 1. The Relationship Between the Ratio of Volume Activator EM4: Volume Molasses to pH

The fermentation process can occur in the optimum pH range, which is 6.5 to 7.5 so that to reach the pH value range, the sample mixture to be fermented is first increased by the pH value with $NaHCO_3$. Figure 1 shows the value of the measurement results of the liquid organic fertilizer sample, where it can be seen that the pH value of the liquid organic fertilizer sample at a fermentation time of 21 days with an EM4 activator volume of 10 mL and 50 mL is in the same value range. It shows no significant difference in the activity of microorganisms in converting organic matter into organic acids during the fermentation process. Longer fermentation time causes more carbohydrates used by microbes for metabolism, so the ability of microbes to produce lactic acid will increase and will be measured as a decrease in pH value.

Nitrogen is a nutrient that plays a vital role in liquid organic fertilizers. Nitrogen in liquid organic fertilizers plays a role in stimulating growth and giving the leaves a green color. If there is a lack of nitrogen, it will cause plant growth and development to be disturbed. It is due to chlorophyll's formation, essential in disturbed photosynthesis. This nitrogen concentration study was performed with a UV-Vis spectrophotometer and the reagent Nitrite LR (HI-93707-0) for nitrite calorimetry.

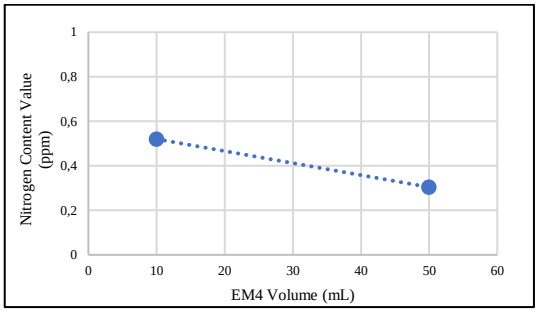


Figure 2. The Relationship Between the Ratio of Volume Activator EM4: Volume Molasses to Nitrogen Content

EM4 (Effective Microorganisms), as a decomposer in the fermentation process, only takes 4-7 days to remodel organic waste into nutrients in organic fertilizers. In addition to accelerating the fermentation process, microorganisms that decompose organic matter contained in EM4 can also act as a provider of fermented microorganisms. In this study, additional nutrients and food for fermented microorganisms were obtained by adding 10 mL of molasses in each variation of research variables. Figure 2 shows the value of Nitrogen content. The highest nitrogen concentration value in liquid organic fertilizer from this study was obtained in the ratio of activator and molasses volume 1: 1 with an EM4 activator volume of 10 mL and nitrogen concentration value of 0.520 ppm.

The high nitrogen concentration can be caused by decomposing organic matter into more optimal nutrients.

The decrease in nitrogen concentration that occurs in the study results with an activator volume of 50 mL can be caused by the length of fermentation time. The nitrogen concentration in this liquid organic fertilizer will decrease the longer it will be due to the change of nitrogen into amino acids and ammonia. Amino acids are used by microorganisms as an energy source, while ammonia as a nitrification process. In theory, the large volume of EM4 affects the increase in nitrogen content; the more microorganisms, the decomposition process of organic matter to produce ammonia and nitrogen is also higher [9]. The decrease in nitrogen concentration can also be caused by the C-organic content that increases during the evaporation process into CO_2 [10].

Phosphorus in liquid organic fertilizers plays a role in transporting metabolic energy, stimulating root growth, seed formation, and fruit ovation. The phosphorus concentration analysis was performed using a UV-Vis spectrophotometer.

The highest phosphorus concentration in liquid organic fertilizers that are produced at an EM4 activator volume of 50 mL is 14.857 ppm. Phosphorus content is affected by the acidity of the solution, where the acidity of the solution will increase as the fermentation time goes by [11]. The decomposition process is improving, which is indicated by increasing phosphorus concentration. As the fermentation time goes by, the decomposing microorganisms will reach equilibrium, that is, the condition that the number of microbes produced is equal to the number of dead microbes. At this time, the activity of microbes decreases. At this time, the activity of microbes decreases. Phosphorus in liquid organic fertilizer is higher due to the activity of proteolytic bacteria in EM4 that is capable to break down protein into amino acids [12].

The number of microorganisms to the availability of food must be directly proportional because sufficient food will help the work of microorganism activities during the fermentation process [13]. In Figure 3, it can be seen that the relationship between the ratio of EM4 activator and volume molasses to a concentration of phosphorus in liquid organic fertilizers. The best phosphorus concentration value was obtained at 50 mL EM4 volume.

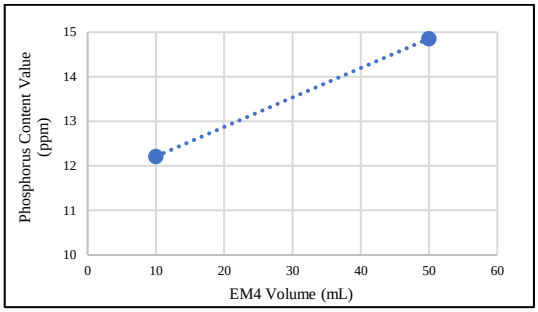


Figure 3. The Relationship Between The Ratio of Volume Activator EM4: Volume Molasses to Phosphorus Content

Based on the analysis results in this study, the phosphorus concentration value at EM4 volume is 50 mL higher than the EM4 volume variation of 10 mL. When the number of microorganisms and food sources are directly proportional, the need for microorganisms to carry out fermentation activities is satisfied, which makes the fermentation process run as smoothly as possible. It can also be caused by the activity of decomposing microorganisms that last optimally during the fermentation process.

The increase and decrease in the phosphorus concentration's value in each variation in fermentation time can be influenced by the activity of microorganisms, where at a fermentation time of 7 days, and the new microorganisms decompose organic matter into organic acids only, while at fermentation times of 14 and 21 days, new microorganisms work to decompose the organic acids that have been formed into elements that plants can absorb. The stages of the anaerobic fermentation process do not require oxygen, namely the overhaul of complex compounds, the change of simple compounds into organic acids, and the decomposition of organic acids into nutrients to produce high value products [14].

Potassium plays a role in the absorption of water and nutrients from the soil and the transport of leaf assimilation products to plant tissues. Potassium elements are essential in plants, if they lack these elements, they develop slow growth with pale yellow leaves. Potassium concentration analysis will be performed using an AAS spectrophotometer with a standard solution of potassium standard solution.

The highest concentration value of potassium in liquid organic fertilizers is produced with an EM4 activator volume of 10 mL, which is 12013.825 ppm. In Figure 4 it can be seen that the concentration values of potassium in the volume variations of 10 mL and 50 mL have significant differences values. This can be due to factors affecting the concentration of potassium, not only from the time of fermentation but also the activity of microorganisms during the fermentation.

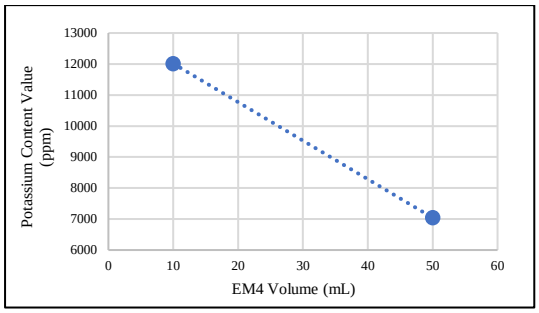


Figure 4. The Relationship Between The Ratio of Volume Activator EM4: Volume Molasses to Potassium Content

This organic carbon (C-Organic) content indicates the presence of organic matter in liquid organic fertilizers. The best liquid organic fertilizers must contain macro-harvest elements, especially N, P, K, and C-Organic because they are the most widely needed elements for plants. C-Organic content plays a role in the improvement of soil quality and fertility, making it very important in the growth and development of plants. Analysis of c-organic content in liquid organic fertilizers was carried out using the Total Organic Carbon Analysis.

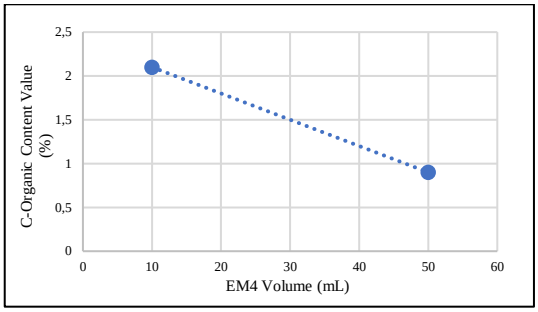


Figure 5. The Relationship Between the Ratio of Volume Activator EM4: Volume Molasses to C-Organic Content

The results of the analysis of C-Organic content in liquid organic fertilizers were obtained at a volume ratio of EM4 and molasses of 1:1, with an EM4 volume of 10 mL. The C-Organic content was 2.10%, while the C-Organic content in the 50 mL activator volume was 0.90% (Figure 5). The C-Organic content of fertilizer can determine the production of plants as a result of the influence of the plant or soil media. The higher the C-Organic content, the more plant production will also increase. This is because if the C-Organic content is high, then the plant's ability to absorb nutrients will be higher, thus increasing the growth and development process of more optimal plants [15].

The liquid organic fertilizer produced by this study will be compared to the Regulation of the Minister of Agriculture No. 261 / KPTS / SR.310 / M / 4 / 2019 on the Minimum Technical Requirements for Organic Fertilizers, Biodiversity Fertilizers, and Soil Fertilizers and also Ministerial Decree No. 02 / Pert / HK. 060 / 2 / 2006 on the Minimum Technical Requirements of Organic Fertilizers. Based on the results of the study, the pH value of the liquid organic fertilizer obtained was in the range of 5 to 5.1, indicating that the pH value of this study was in accordance with the pH range according to the quality standard, which is 4-9. The content of nitrogen, phosphorus, potassium, and c-organic in liquid organic fertilizers from this study will also be compared to the quality standards of elementary N, P_2O_5, K_2O, and C-Organic. Based on the analysis results, it can be seen that the highest N

content is 0.0001%, the highest P_2O_5 is 0.0068%, the highest K_2O is 2.89%, and the highest C-Organic is 2.10%.

If the results of the analysis of P_2O_5, K_2O, and C-Organics in this study are compared with that of the Minister of Agriculture No. 02/ pert / HK.060 / 2 / 2006 which has a quality standard value of 55% for P_2O_5 and K_2O, 44.5% for C-Organics.

The results of this study can be said to have met the minimum technical requirements of liquid organic fertilizers. If the total content of N, P_2O_5, and K_2O elements is compared with the quality standard according to the Ministry of Agriculture No. 261 which ranges from 2-6%, then it can be said that the liquid organic fertilizer from this study has also met the quality standard requirements with a total value of 2.9017% for the volume of EM4 10 mL activators. However, for the volume variation of the EM450 mL activator, the total macro element N, P_2O_5, and K_2O obtained was only 1.7038% which did not meet the quality standards according to the Ministry of Agriculture No. 261.

The C-Organic content of this study has also not been met when compared to the quality standards according to the Ministry of Agriculture No. 261. It is a C-Organic minimum of 10%. This can be due to the non-optimal activity of fermentation microorganisms, and human errors that are likely to occur during the study.

Liquid organic fertilizers can be produced through the fermentation of organic wastes, such as fruit waste, vegetables, animal excrement, and other types of waste containing organic matter. This is because during the fermentation process, the organic matter contained in various types of wastes will be decomposed by fermentation microorganisms into good natural elements for plants. In Table 1 below, differences in pH and macro elemental content in various types of organic wastes resulting from anaerobic fermentation processes can be seen.

Table 1. Comparison of pH, N, P_2O_5, K_2O, and C-Organic POC Values with Other POC

Types of Liquid Organic Fertilizer	Parameter				
	pH	N (%)	P_2O_5 (%)	K_2O (%)	C-Organic (%)
POC from waste cooking oil	5.0–5.1	0.0001	0.0068	2.89	2.10
POC from waste fruits	5.6-5.7	1.6700	0.1400	0.10	0.50
POC from liquid waste of VCO	5-6	1.1206	0.0017	2.41	0.67
POC from waste of kerupuk kulit factory	5-7	0.0070	0.0006	0.002	10.34

According to Table 1 above, it can be seen that the pH value range of organic fertilizer produced by fermentation of used cooking oil waste with fermentation results of other types of organic waste is not significantly different. However, if the liquid organic fertilizer is produced by conventional fermentation compared to the liquid organic fertilizer sold on the market, it can be seen that the pH of the liquid organic fertilizer is in the neutral pH range, this can be due to the addition of chemicals that maintain the pH of the fertilizer during the packaging process.

The content of P_2O_5, K_2O, and C-Organic in liquid organic fertilizers in this study is low compared to liquid organic fertilizers from other organic waste fermentation, but quite good. This suggests that the liquid organic fertilizer produced by fermentation of used cooking oil waste in this study has potential if applied in agriculture. The Nitrogen

content of this study has the smallest value when compared to liquid organic fertilizers from other waste fermentation products, it can be influenced by the waste content of used cooking oil containing little organic matter, so that fermentation microorganisms can convert only a small amount of organic matter into organic acids. This is due to the long fermentation time.

Table 2. Comparison pH, N, P_2O_5, and K_2O POC Values of Research Results with Commercial POC

Types of Liquid Organik Fertilizer	Parameter			
	pH	N (%)	P_2O_5 (%)	K_2O (%)
POC from waste cooking oil	5.0-5.1	0.0001	0.0068	2.896
POC NASA	7.5	0.12	0.03	0.31
POC Super Terobos	9.1	7.56	2.17	3.48

Organic fertilizers have been sold commercially, including Nasa fertilizer and Super Terobos fertilizer. The comparison of commercial fertilizer value with fertilizer from the fermentation of used cooking oil waste from this study in Table 2. Based on Table 2 it can be seen that the difference in pH, N, P_2O_5, and K_2O values of commercial liquid organic fertilizers with conventional organic fertilizers is quite far away, but the total value of macro-harvest elements has met the quality standard of Kepmen No. 261 and Permentan No. 2. The use of liquid organic fertilizer is the fast release where the absorption of natural elements by plants is easier due to the spread method in the application. So that in a short time the natural elements can be directly utilized by plants. In inorganic fertilizers, the element of harvesters cannot be directly utilized by plants, because inorganic fertilizers are slow release, and releasing the element of harvesters takes time gradually. Continuous use of inorganic fertilizers can affect soil quality and also damage the environment, although the availability of natural elements is abundant, it is recommended that organic fertilizers be used in both solid and liquid form.

4. CONCLUSION

The best concentrations of Nitrogen, Phosphorus, Potassium, and C-Organic in liquid organic fertilizers obtained from this study were 0.520 ppm, 12.213 ppm, 12013.825 ppm, and 2.10%. The best ratio of EM4 activators and molasses was obtained at a 1:1 ratio, consisting of 10 mL of molasses and 10 mL of EM4 where pH, P_2O_5, K_2O, and C-Organic liquid organic fertilizers has complied with standard quality of Permentan No. 02 in 2006 and also pH values and total macro element has complied with standard quality of Kepmen No. 261 in 2019. The Factors affecting the macronutrient content of liquid organic fertilizers are the raw material ratio, fermentation time, and microorganism activity during fermentation.

REFERENCES

[1] M. Febrianna, S. Prijono, N. Kusumarini, Pemanfaatan Pupuk Organik Cair untuk Meningkatkan Serapan Nitrogen serta Pertumbuhan dan Produksi Sawi (Brassica juncea L.) pada Tanah Berpasir, *Jurnal Tanah dan Sumberdaya Lahan*, vol. 5, no. 2, pp. 1009-1018, 2018.

[2] A. Rasmito, A. Hutomo, A. P. Hartono, Pembuatan Pupuk Organik Cair dengan Cara Fermentasi Limbah Cair Tahu, Starter Filtrat Kulit Pisang dan Kubis, dan Bioaktivator EM4, *Jurnal IPTEK*, vol. 23, no. 1, pp. 55-62, 2019.

[3] N. M. Witariadi, B. R. T. Putri, Teknologi Fermentasi untuk Meningkatkan Kualitas Pupuk Organoplus, *Buletin Udanaya Mengabdi*, vol. 17, no. 3, pp. 93-98, 2018.

[4] M. A. Akib, H. Setiawati, Fermentation of Whey Waste as Organic Liquid Fertilizer "PUCAFU", *Agrotech Journal*, vol. 2, no. 2, pp. 7-13, 2017.

[5] Elfidiah, K. A. Roni, Liquid Waste Palm Oil Plantations as Liquid Fertilizer. *Journal of Computational and Theoretical Nanoscience*, vol. 16, no. 12, pp. 5166-5170, 2019.

[6] A. D. Ardiyanti, L. Adhitama, R. Wahyutiyani, Efficient Compost Fertilizer with Addition of Fatty Acid Results of Used Cooking Oil Saponification Reaction, *Proc. Internat. Conf. Sci. Engin*, vol.3, pp. 125-128, 2020.

[7] N. Tanti, Nurjannah, R. Kalla, Pembuatan Pupuk Organik Cair dengan Cara Aerob, *ILTEK*, vol. 14, no. 2, pp. 2053-2058, 2019.

[8] I. G. A. Kasmawan, G. N. Sutapa, I. M. Yuliara, Pembuatan Pupuk Organik Cair Menggunakan Teknologi Komposting Sederhana, *Buletin Udayana Mengabdi*, vol. 17, no. 2, pp. 67-72, 2018.

[9] H. Yua, B. Xie, R. Khan, G. Shen, The Changes in Carbon, Nitrogen Components and Humic Substances During Organic-Inorganic Aerobic Co-Composting, *Journal Bioresource Technology*, vol. 271, pp. 228-235, 2019.

[10] A. H. I. Nurrahma, M. Melati, Pengaruh Jenis Pupuk dan Dekomposer terhadap Pertumbuhan dan Produksi Padi Organik, *Bul. Agrohorti*, vol. 1, no. 1, pp. 149-155, 2013.

[11] M. Makiyah, Analisis Kadar N, P, dan K pada Pupuk Cair Limbah Tahu dengan Penambahan Tanaman Matahari Meksiko (*Thitonia diversivolia), Under Graduates Thesis*, Universitas Negeri Semarang, 2013.

[12] Sulfianti, Risman, I. Saputri, Analisis NPK Pupuk Organik Cair dari Berbagai Jenis Air Cucian Beras dengan Metode Fermentasi yang Berbeda, *Jurnal Agrotech*, vol.11, no.1, pp. 36-42, 2021.

[13] R. Syafri, Chairil, D. Simamora, Analisa Unsur Hara Makro Pupuk Organik Cair (POC) dari Limbah Industri Keripik Nenas dan Nangka Desa Kualu Nenas dengan Penambahan Urin Sapi dan EM4, *Photon: Jurnal Sain Dan Kesehatan*, vol. 8, no. 1, pp. 99-104, 2017.

[14] P. K. Atmodjo, Optimalisasi Gula Cair dan pH Medium untuk Fermentasi Alkohol dari Jus Curucuma xanthorihiza, *Biota*, vol. 2, no. 3, pp. 97-104, 2017.

[15] S. Rosniawaty, R. Sudirja, M. Ariyanti, S. Mubarok, A. Wahyudin, Pengaruh Bahan Organik terhadap Kesuburan Tanah serta Pertumbuhan dan Fisiologi Tanaman Kakao Muda Hasil Transplanting di Tanah Inceptisol, *Jurnal Kultivasi*, vol. 20, no. 3, pp. 160-167, 2021.