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Original Article

Characterization of chemical composition of eco-enzyme derived from banana, orange, and pineapple pineapple peels

Caracterização da composição química da ecoenzima derivada de cascas de banana, laranja e abacaxi

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Abstract

Fruit peels such as Banana, Orange, and Pineapple can be used to produce eco-enzymes producing diverse chemical compounds. Eco-enzymes are derived from the organic fermentation process of the specified ingredients. The objective of this study was to characterize the organic compounds present in Eco-enzymes derived from various raw materials. The research phase involved the extraction of eco-friendly Eco-enzymes from different raw materials and the identification of the chemical compounds in them. The results of this study are expected to contribute to organic waste management, highlighting the importance of utilizing waste as an economically and environmentally viable resource and strategic steps in a more sustainable waste management. Data analysis of the Eco-enzyme extraction results was carried out using high-liquid chromatography (HPLC) to ascertain the levels of organic chemical compounds produced. The findings revealed eight organic compounds categorized into organic acids (acetic acid, citric acid, lactic acid, oxalic acid) Acetic acid compound in pineapple fermentation 1.83 (g/L). Citric acid compound in banana peel fermentation 3.39 (g/L). Lactic acid compounds in orange fermentation 4.89 (g/L). The highest oxalic acid compound was identified in orange fermentation with a content of 0.1764 (g/L).

Keywords: acid, eco enzyme, fermentation, sugar, chemical compound.

Resumo

Cascas de frutas, como banana, laranja e abacaxi, podem ser usadas para produzir ecoenzimas que produzem diversos compostos químicos. As ecoenzimas são derivadas do processo de fermentação orgânica dos ingredientes especificados. O objetivo deste estudo foi caracterizar os compostos orgânicos presentes nas ecoenzimas derivadas de várias matérias-primas. As fases de pesquisa envolveram a extração de ecoenzimas ecológicas de diferentes matérias-primas e a identificação dos compostos químicos nelas contidos. Espera-se que os resultados deste estudo contribuam para o gerenciamento de resíduos orgânicos, destacando a importância da utilização de resíduos como um recurso econômica e ambientalmente viável, e de etapas estratégicas em um gerenciamento de resíduos mais sustentável. A análise de dados dos resultados da extração da ecoenzima foi realizada usando cromatografia líquida de alta eficiência (HPLC) para verificar os níveis de compostos químicos orgânicos produzidos. Os resultados revelaram oito compostos orgânicos categorizados em ácidos orgânicos (ácido acético, ácido cítrico, ácido láctico e ácido oxálico), sendo: composto de ácido acético na fermentação do abacaxi (1,83 g/L); composto de ácido cítrico na fermentação da casca de banana (3,39 g/L), e compostos de ácido láctico na fermentação da laranja (4,89 g/L). O maior composto de ácido oxálico foi identificado na fermentação da laranja, com teor de 0,1764 g/L.

Palavras-chave: ácido, ecoenzima, fermentação, açúcar, composto químico.

1. Introduction

Household organic waste is still a problem that has not been resolved properly. The situation of waste that is increasingly abundant and piling up results in pollution of the surrounding environment (Hasibuan, 2016; Yulistia and Chimayati, 2021). Therefore, household organic waste must be reprocessed into versatile products such as eco-enzymes so as not to pollute the environment. One household organic waste that can be utilized as an

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eco-enzyme is fruit peels, pineapple peels, papaya peels, and a mixture of vegetable scraps (Rusdianasari et al, 2021; Novianti and Muliarta, 2021).

Eco enzyme is a multifunctional liquid that has several advantages, including the fermentation process does not require a large area or tub with certain specifications. In addition, the manufacture of eco enzyme strongly supports the concept of reuse (recycling) because it can utilize containers that are no longer used as fermentation containers such as bottles used for mineral water or other products (Benny et al., 2023; Wiryono et al., 2020). The manufacture and use of eco enzymes is preferred by the community because it is easier and cheaper (Hasanah, 2020).

Ecoenzyme is a dark brown solution of complex organic substances with a strong fresh sour aroma, produced by fermenting vegetable and fruit scraps with sugar and water added (Wiryono et al., 2020). The solution of eco-enzyme is formed after fermentation for three months (Hemalatha and Visantini, 2020). Ecoenzyme products that are not traded as a form of dedication by Dr. Rosukon Poompanvong (Researcher and environmentalist from the Organic Farming Association of Thailand) are expected to be a joint effort to overcome environmental problems (Surtikanti et al., 2021).

This eco-enzyme liquid has many benefits, including being able to act as an anti-fungal, anti-bacterial and insecticidal agent and can be used as a cleaning or disinfecting agent and even heal wounds (Hasanah, 2020. Eco enzymes can also be used for various applications such as plant fertilizer, can also reduce the concentration of pollutants in wastewater and as a conservation of the surrounding environment because eco enzyme can neutralize various pollutants that pollute the environment (Fadlilla et al., 2023; Rasit and Mohammad, 2018). According to Tong and Liu (2020) the final result of eco enzyme formed in the form of vegetable or fruit residues that can be used as compost, while for liquid eco enzyme can be used in various fields.

Orange peels contain several compounds that can be utilized further, such as the essential oil content in them. Orange peels contain a variety of substances, the most dominant of which are essential oils and pectin). Sweet orange peel contains essential oil. The content of essential oil in orange peel is 2.49%. Chemically, orange peel contains essential substances consisting of components such as terpenes, sesquiterpenes, aldehydes, esters, and sterols (Mohsin et al., 2022). Pineapple peel has active substances including anthocyanins, vitamin C, and flavonoids. In addition, there are bromelain enzymes and tannins (Rivera et al., 2023) Pineapple peel positively contains tannins, saponins, steroids, flavonoids, phenols, and other compounds. Contains a total antioxidant of 38.95 mg/100 g with bioactive components in the form of vitamin C of 24.40 mg/100 g, beta carotene of 59.98 ppm, flavonoids 3.47%, quercetin 1.48%, phenols 32.69 ppm, and saponins 5.29% (Sofia 2020.

Ismail et al. (2024) identified the active compounds contained in eco-enzymes derived from vegetable sources by using high liquid chromatography (HPLC) technique for chemical composition analysis and isolated compounds that have high potential biological activity. Eco-enzymes produced from vegetable and fruit peels sources for bioremediation applications were tested by characterizing the chemical composition of eco-enzymes and evaluating their effectiveness in cleaning up environmental pollution, such as industrial effluents and soil pollution (Istanti and Utami, 2022). According to (Liew et al., 2018), the quantitative analysis by ultra performance liquid chromatography (UPLC) proved that the fruit peels of C. sinensis contains six flavonoid compounds, including catechin, epigalocatechin, vit, rutin, luteolin and apigenin.

These properties of eco-enzyme reveal the chemical compounds it contains. According to research by Rusdianasari. in 2021, the sour aroma detected in the eco-enzyme liquid comes from flavonoid compounds that offer antibacterial benefits. Similarly, another study conducted by Salsabila and Winarish (2023) explained that the variation in the pH level of the eco-enzyme liquid was due to acetic acid compounds. Extensive research on the characteristics of eco-enzymes has been conducted, evidenced by studies such as Ismail,s research in 2024 that utilized vegetable and fruit waste materials, as well as Esparza et al (2020) research in 2020 that examined eight different combinations of vegetable and fruit waste, with a focus on organoleptic tests or eco-enzyme characteristics. In contrast, this study explores the content of eco-enzyme chemical compounds derived from fruit raw materials.

Based on the reality in the field that the use of organic waste such as fruit waste has not been utilized properly. Therefore, initial research is needed to characterize the content of chemical compounds contained in eco enzymes originating from fruit peels and waste. Especially fruit that is often found in traditional markets such as bananas, oranges and pineapples. So that with knowledge regarding the characterization of chemical compounds originating from banana, orange and pineapple peels, they can be used more efficiently in the future.

2. Research methods

2.1. Sample preparation

The research on eco-enzyme production was conducted at the Ecology and Environment Laboratory of the Faculty of Life and Environment, University of Kuningan, by fermenting eco-enzyme raw materials derived from the prepared raw materials shown in Figure 1, namely oranges peel, pineapples peel, and bananas peel. The process of making eco-enzymes is carried out in the following stages: (i) Mixing of raw materials 100 g of sugar with 1,000 ml of water. (ii) The result of mixing was fermented for three months. (iii) After two months, it was allowed to stand until the eco enzyme liquid could be harvested. (iv).

After the fermentation results were obtained, the identification analysis of organic chemical compounds contained was carried out at the Faculty of Science and Technology ITB using a set of HPLC Shimadzu LC20A shown in Figure 2. Furthermore, the identification of chemical compounds of alkaloids, flavonoids, steroids, saponins, terpenoids and tannins was carried out using

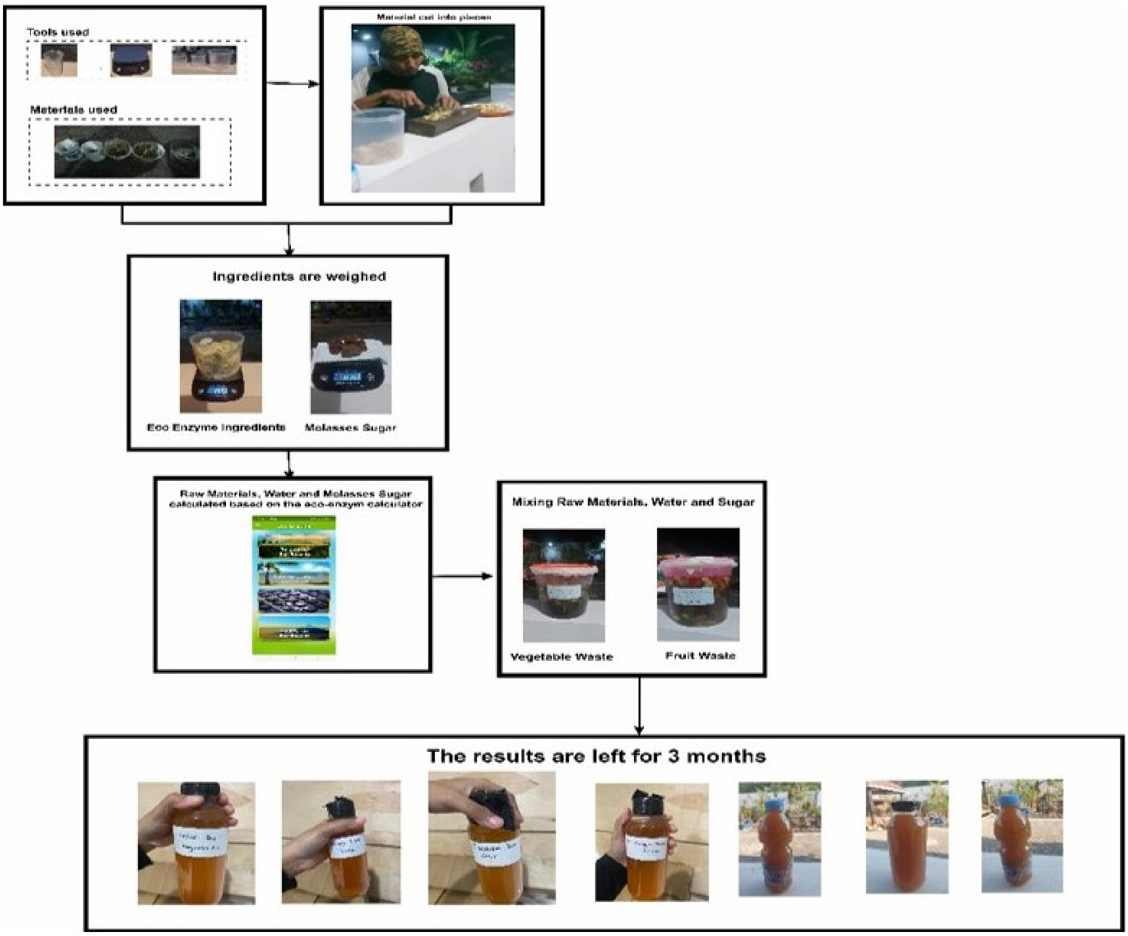

Figure 1. Fermentation of raw materials (a) Pineapple peel fermentation (b) orange peel fermentation (c) banana peel fermentation.

the HPLC (High Performance Liquid Chromatography) method Shimadzu LC20A. (v) At the time of sample analysis, the stationary phase column used was column type C-18, then the mobile phase used was a solution of acetonitrile and 0.1% phosphoric acid in a ratio of 2:98. The eluent was 0.4 ml/min and measurements were made at a wavelength of 210 nm.

2.2. Data analysis

Preliminary Preparation Column Selection and Column Temperature: Ensure that the C18 column is properly attached to the HPLC system and the column temperature is set at 30 degrees Celsius. Preparation of Mobile Phase, preparation of Mobile Phase solution: Mix astinitrile and 0.1% H3PO4 solution in proper proportion (2:98) to obtain the required mobile phase. Ensure that the solution has been filtered to avoid contamination of the column. Preparation of Standard Solution: Standard solution in eco-enzyme testing plays an important role as a reference to identify through peak retention time and measure the concentration of organic acids in the chromatogram contained in the eco-enzyme solution to be tested. This test uses various levels of solution to create a calibration curve. The following levels and standard solutions were tested. Dilution of samples from the fermentation of vegetable and fruit raw materials: Prepare 20 µL of eco-enzyme solution each. Wavelength and Flow Rate Setting: Set the detector at 210 nm wavelength and set the flow rate at 0.4 mL/min. Identification of Organic Acids: Identify each peak that appears according to the expected organic acid based on the retention time and response characteristics of the detector at the set wavelength. Figure 3 below shows the flow chart of eco-enzyme analysis using HPLC.

3. Results and Discussion

3.1. Analysis of organic chemical compounds from pineapple, banana, orange peels

Based on the results of the analysis of fermented pineapple raw material samples using the HPLC test method, organic acid chemical compounds were identified in the fermented samples as shown in Figure 4. Four organic acid compounds contained in the sample were identified by HPLC, including oxalic acid, lactic acid, acetic acid, and citric acid. Each organic chemical compound was identified at different retention times. Oxalic acid was identified at retention time 7.758, lactic acid was identified at retention time 12.167, acetic acid was identified at retention time 12.942, and citric acid was identified at retention time 16.725.

Analysis of samples of fermented banana peel raw materials using HPLC test method identified organic acid chemical compounds in the fermentation samples as shown in Figure 5. Four organic acid compounds contained in the sample were identified by HPLC, including oxalic acid, lactic acid, acetic acid, and citric acid. Each organic chemical compound was identified at different retention times. Oxalic acid identified peak at retention time 7.458, lactic acid identified at retention time 12.175, acetic acid identified at retention time 12.808, and citric acid identified at retention time 16.308.

Analysis of samples of fermented Citrus raw materials using HPLC test method identified organic acid chemical compounds in the fermentation samples as shown in Figure 6. Four organic acid compounds were identified by HPLC, including oxalic acid, lactic acid, acetic acid, and citric acid. Each organic chemical compound was identified at different retention times. Oxalic acid identified peak at retention time 7.275, lactic acid identified peak at retention time 12.200, acetic acid identified peak at retention time 13.325, and citric acid identified peak at retention time 16.400.

Figure 2. Shimadzu LC20A HPLC.

3.2. Concentration of organic acid compound levels against area

Based on the analysis of fermented samples of pineapple, banana, and orange peels raw materials using the HPLC test method, chemical compounds of organic acids were identified in the fermentation samples. Identified by HPLC are four organic acid compounds contained in each sample, including oxalic acid, lactic acid, acetic acid, and citric acid. Based on the levels of these organic acid compounds, the area of each organic acid compound is also known.

3.3. Acetic acid

Acetic acid compounds in all samples were detected differently by HPLC based on the level of lactic acid area obtained. At the level of 0.01 area 14832, at 0.1 area 136679, at the level of 1 area 1484816, at the level of 5 area 7795049, at the level of 10 16319310. In Figure 7 below it can be seen the position of the level against the area.

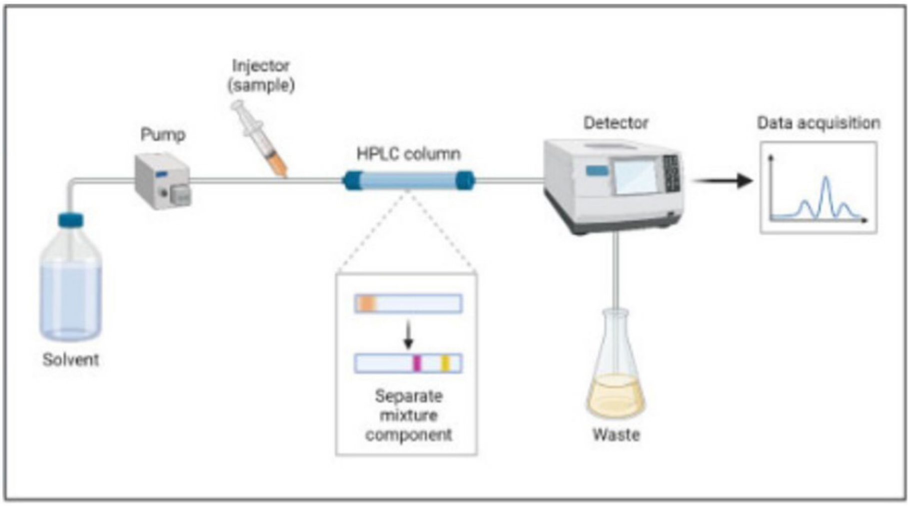

Figure 3. Sample analysis using HPLC.

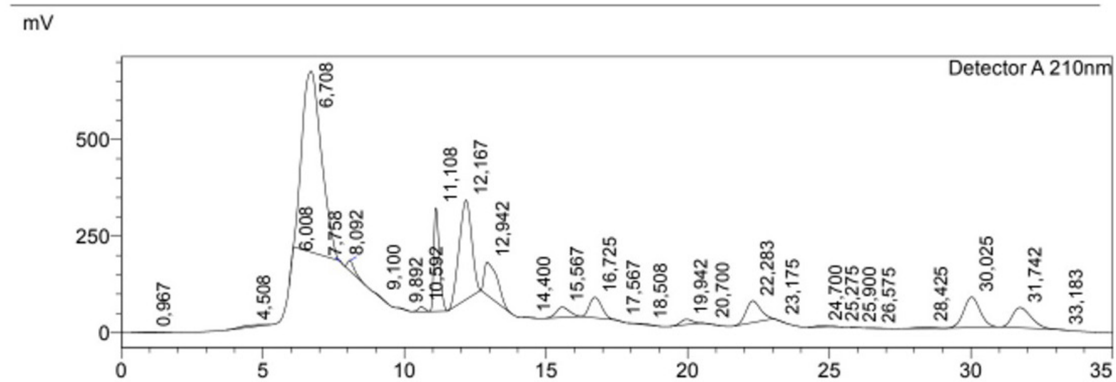

Figure 4. HPLC results of pineapple fermentation.

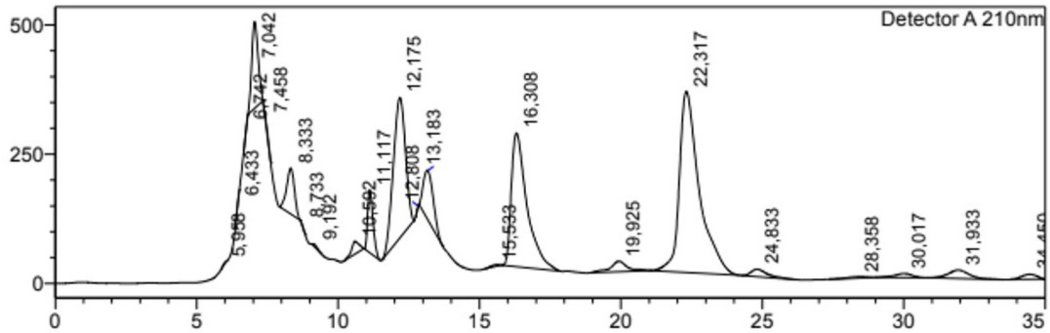

Figure 5. HPLC Result of Banana peel Fermentation.

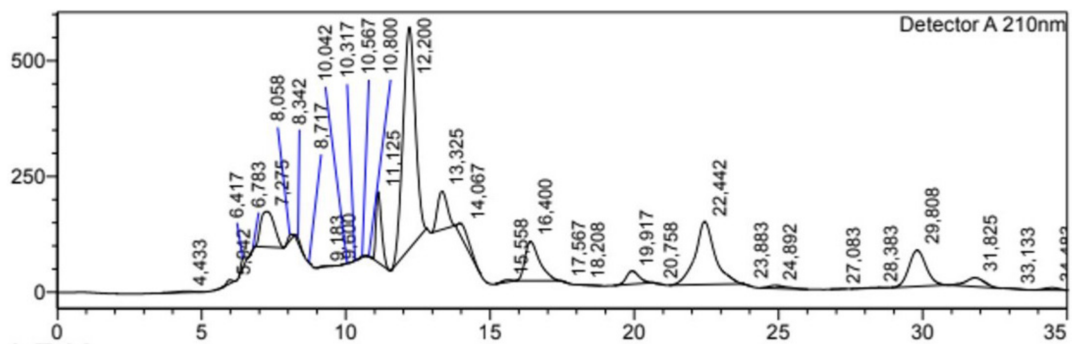

Figure 6. HPLC Result of Citrus Fermentation.

3.4. Lactic acid

Lactic acid compounds in all samples were detected differently by HPLC based on the level of lactic acid area obtained. At 0.1 level, the area is 336064, at 0.5 the area is 1449755, at 1 level the area is 2989231, at 1.5 level the area is 4429537, at 2 level 5935753. In Figure 8 below it can be seen the position of the level against the area.

3.5. Citric acid

Citric acid compounds in all samples were detected differently by HPLC based on the level of lactic acid area obtained. At level 5 area 14547234, at level 10 area 28960443, at level 15 area 43586158, at level 20 area 58375699, at level 30 86936751. In Figure 9 below it can be seen the position of the level against the area.

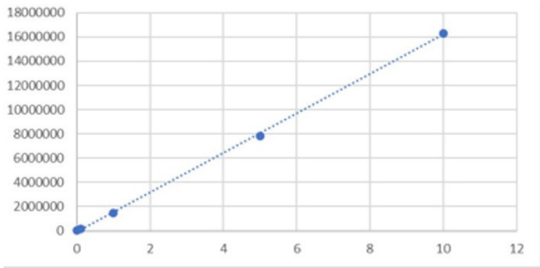

Figure 7. Position of acetic acid compound content against area.

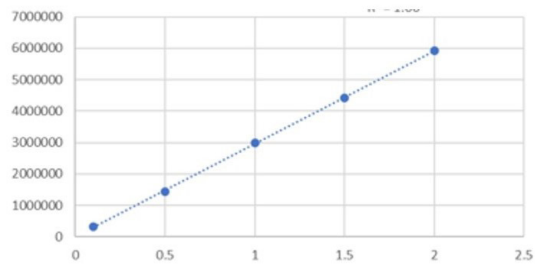

Figure 8. Position of lactic acid compound content against area.

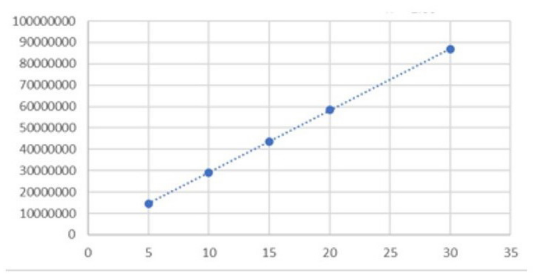

Figure 9. Position of citric acid compound content against area.

3.6. Oxalic acid

Oxalic acid compounds in all samples were detected differently by HPLC based on the area content of lactic acid obtained. Lactic acid at the 0.05 level the area is 1607105, lactic acid at the 0.1 level the area is 2962061, lactic acid at the 0.5 level the area is 15479890, lactic acid at level 1 the area is 22784374, and lactic acid. At level 5, an area of 75252386 is obtained. The Figure 10 below shows the position of this level relative to this area.

3.7. Evaluation and recording of results

The concentration of each organic acid compound in the eco-enzyme solution based on the HPLC analysis results can be seen in Table 1 below. Each fermented raw material has a value of organic acid compound area, organic acid compound content, and the average percentage of organic acid content contained in the sample.

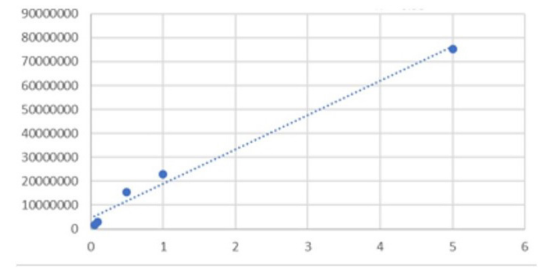

Figure 10. Position of Oxalic acid compound content against area.

The concentration of each organic acid compound in the eco-enzyme solution based on the HPLC analysis results can be seen in Table 1 below. Each fermented raw material has a value of organic acid compound area, organic acid compound content, and the average percentage of organic acid content contained in the sample.

The results of HPLC analysis on the solution of pineapple fermentation compounds obtained the highest sample area is on lactic acid compounds with an area of 8022268, the highest content is lactic acid 2.72 (g/L), with the highest percentage content of lactic acid with 2.73%.

HPLC analysis of the banana peel fermentation compound solution obtained the highest sample area of citric acid compounds with an area of 10040534, the highest content of citric acid 3.39 (g/L), with the highest percentage content of citric acid with 3.38%.

In the solution of citrus fermentation compounds, the highest sample area is obtained in the lactic acid compound with an area of 14266022.00, the highest content is lactic acid 4.89 (g/L), with the highest percentage content of lactic acid with 4.88%.

Compared as a whole from the fermentation of raw materials analyzed using HPLC can be identified each content of organic acid compounds contained therein. The highest acetic acid compound is identified in pineapple fermentation with a content of 1.83 (g/L). The highest citric acid compound is identified in banana peel fermentation with a content of 3.39 (g/L). The highest lactic acid compound is identified in orange fermentation with a content of 4.89 (g/L). The highest oxalic acid compound is identified in orange fermentation with a content of 0.1764 (g/L). The results of eco-enzyme with a ratio of molasses, organic waste, and water before adding essential oil and high-water dilution on pathogenic microbe analyses by the Health Laboratory of Semarang show that eco-enzyme as the aseptic aerosol spray is effective due to its biocidal effect could reduce the total viable count of the pathogen from 61% to 38% just in an hour (Barman et al., 2022). (Mubarok et al., 2020) found that incorporating a high amount of orange peel into the overall organic waste used for eco-enzyme production could lead to a greater production of a specific biocidal flavonoid known as hesperidin. This compound exhibits antibacterial, antifungal, antiviral, cell aggregation inhibition, and UV protecting properties. After the fermentation process, the natural antibacterial characteristics of fruit peels become more potent due to the breakdown of organic substances,

Table 1. The concentration of each organic acid compound in the eco-enzyme solution based on the results of HPLC analysis.

Sample		Sample Area				Level (g/L)				Average Content (%)			
		Acetic Acid	Citric Acid	Lactic Acid	Oxalic Acid	Acetic Acid	Citric Acid	Lactic Acid	Oxalic Axid	Acetic Acid	Citric Acid	Lactic Acid	Oxalic Acid
Pineapple	1	2890604	1612548	7962488.00	4193	1.83	0.54	2.72	0.0003	1.10	0.54	2.73	0.0003
	2	500505	1618534	8022268.00	3796	0.37	0.54	2.74	0.0003				
Banana	1	2350741	9976500	8141117.00	70965	1.50	3.37	2.78	0.0049	1.48	3.38	2.79	0.01
	2	2290609	10040534	8164464.00	345889	1.47	3.39	2.79	0.0241				
Orange	1	1934507	2976178	14211902.00	2532449	1.25	1.00	4.88	0.1764	1.28	1.00	4.88	0.17
	2	2048481	2979871	14266022.00	2329353	1.32	1.00	4.89	0.1622				

resulting in the creation of bioactive compounds or phytochemicals, also known as secondary metabolites (Sadh et al., 2018).

4. Conclusion

From the raw materials for making eco-enzymes from fruit peels bananas, pineapples, and oranges, there are differences in the concentration of organic chemical compounds contained in each fermentation sample. The highest lactic acid compound was identified in orange peel fermentation, the highest citric acid compound was identified in banana peel fermentation, and the highest acetic acid was identified in pineapple peel fermentation. Based on these results, the development of derivative products from eco-enzymes can be more effective according to the needs to be made.

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