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Management of fruit and vegetable waste into ecoenzyme in Drien Rampak Village, West Aceh Regency

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ABSTRACT

The accumulation of waste in public areas of Drien Rampak Village remains an unresolved issue. The growing population has led to increased consumption and waste production. Currently, there is no waste management mechanism capable of addressing this problem effectively. The waste is predominantly household waste, such as organic fruit and vegetable residues. This activity aimed to provide training to the PKK women's group in Drien Rampak Village on making ecoenzymes as a solution for managing organic waste. The implementation included training and hands-on assistance. The stages of the activity were as follows: coordination with partners, education on waste management, ecoenzyme-making training, fermentation process, and ecoenzyme harvesting. The activity produced 100 liters of ecoenzyme using 30 kg of fruit and vegetable residues. Based on pre-test and post-test questionnaire results, significant improvements were observed in participants' attitudes, knowledge, and skills in managing household organic waste. The highest improvement was in attitudes (16.84-point difference), followed by skills (13.11-point difference) and knowledge (5.49-point difference).

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1. INTRODUCTION

Drien Rampak Village is located in Johan Pahlawan Subdistrict, West Aceh District, serving as part of the urban core of Meulaboh city, the district capital. The village is predominantly composed of office buildings, markets, schools, and public facilities, reflecting its role as a governmental and economic hub. With a population of 6,894 and an area of 6.40 km^2 (Badan Pusat Statistik Kabupaten Aceh Barat., 2022), Drien Rampak is densely populated. Most residents work as traders or employees in government and private sectors.

This high population density contributes to increased household consumption, resulting in significant waste production. According to the West Aceh Regency Environmental Service, urban waste in Johan Pahlawan Subdistrict reaches 100 tons daily, with Drien Rampak Village contributing the largest share. Waste types include food scraps, spoiled vegetables and fruits, dry waste, plastics, paper, and

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cans (Firmansyah, 2023). Despite efforts to implement the Reduce, Reuse, and Recycle (3R) principle, only 14% of waste is managed, while 66.39% ends up in landfills (Kementerian Lingkungan Hidup dan Kehutanan, 2018). Poor management of organic waste, although biodegradable, often results in foul odors, air pollution, and negative health and economic impacts, particularly for local businesses (Sharon et al., 2023).

Unfortunately, many landfills in Indonesia lack proper waste management systems (Yulistiar & Manggalau, 2023). Addressing this issue requires household-level solutions, such as processing organic waste into compost or ecoenzymes (Masjud et al., 2022). Ecoenzyme production, which involves fermenting fruit and vegetable scraps with water and brown sugar, is an accessible and practical method. This process not only reduces organic waste but also provides ecoenzyme liquid, a multipurpose product with applications as a natural cleaner, herbicide, pesticide, fertilizer, and air or water filter (Nangoi et al., 2022; Gumilar et al., 2023).

Research also highlights ecoenzyme's potential as a disinfectant due to the antimicrobial properties found in orange and lemon peels (Saleem & Saeed, 2020). Effective waste management through ecoenzyme production could significantly alleviate the burden on government waste systems, making households more self-sufficient.

This community service program aims to train the PKK women's group in Drien Rampak Village to produce ecoenzymes, equipping them with practical skills for managing organic waste. Through education and hands-on training, this initiative seeks to increase community awareness and competency in household waste management, fostering sustainable practices at the grassroots level.

2. METHODS

Activity Design

Community service activities were carried out at the Keuchik office of Drien Rampak village, Johan Pahlawan sub-district, West Aceh district in September – December 2023. The partners in this activity were the PKK women's group in Drien Rampak village. In this series of service activities, there were 35 participants, female. Activities were carried out in 6 main stages over a period of approximately 4 months.

Implementation Method

The activity implementation method consists of six stages as follows: (1) Coordination of activities; (2) Training to make ecoenzyme; (3) Making ecoenzymes; (4) Ecoenzyme harvesting; (5) Ecoenzyme packaging; (6) Evaluation.

Coordination of activities

At this stage the PKM team coordinates with partners regarding the implementation of activities. The team also conduct direct surveys of partners' conditions, plans the time and place for carrying out activities, and takes care of correspondence administration. Coordination was carried out with the PKK chairman and several member representatives and village heads.

Training to make ecoenzyme

PKK women took part in the ecoenzyme making training activity as participants. Participants were given an explanation regarding ecoenzymes and their uses, then continued with the practice of

making ecoenzymes. In this activity, the PKM team worked together with participants to prepare the materials needed, especially leftover vegetable and fruit waste. Then the resource person and the team provided direction, demonstrated and assisted the process of making ecoenzyme. During the training and manufacturing process, students also accompany and help activity participants until completion. The PKM team also explained the time needed for ecoenzyme fermentation and how to harvest it.

Making ecoenzymes

The ecoenzyme making activity was carried out in the front yard of the Keuchik (Village Head) Drien Rampak office with participants from PKK members from Drien Rampak village. Making ecoenzymes begins with preparing tools and materials, such as containers, filters, scoops, fruit and vegetable waste, clean water and brown sugar. The container used is cleaned first using running water. Then the water is measured to 60% of the container capacity. Then these ingredients are added in a ratio of 10:3:1, 10 L of water, 3 kg of fruit or vegetable waste, and 1 kg of sugar. Stir all the ingredients, then cover tightly and leave for 3 months. The fermentation container is placed in a place with good air circulation and not exposed to direct sunlight.

The container is then opened during the first week to release the gas and prevent the container from exploding. Then stirring was carried out on the 7th day, 30th day and 90th day. After 3 months the ecoenzyme can be harvested and used. The successful ecoenzyme is characterized by a brown color and emits a fresh sour aroma typical of fermentation and does not have a foul smell.

Ecoenzyme harvesting

Ecoenzyme harvesting is carried out after fermentation for 3 months. Successful ecoenzyme is characterized by a brown color and emits a fresh sour aroma typical of fermentation. The container containing the ecoenzyme material is filtered using a filter cloth to separate the ecoenzyme liquid and the residue of fermented fruit and vegetable skins. The ecoenzyme liquid is then packaged, while the ecoenzyme dregs can be used for organic fertilizer.

Ecoenzyme packaging

Packaging of ecoenzyme liquid is done by placing the ecoenzyme liquid in a plastic bottle with a volume capacity of 0.5 – 1 liter. This is done to make it more practical when using ecoenzyme. Next, a label is given.

Evaluation

Evaluation is carried out at the end of the activity by providing a questionnaire to measure the level of community understanding and the usefulness of service activities. The aspects measured in the evaluation are attitudes, skills and knowledge. Evaluations were also carried out to assess the extent of success in making ecoenzyme products

Activity Implementation Schedule

The activity implementation schedule refers to Table 1.

Table 1. Activity implementation schedule

Activity	Objective	Time
Coordination of activities	Harmonize perceptions and agree on the time and place for carrying out activities	Second week of September 2023
Ecoenzyme production training	- Providing outreach and understanding about the importance of household waste management - Provide an explanation about ecoenzymes and how to make them	Third week of September 2023
Making ecoenzymes	Practicing making ecoenzymes from fruit and vegetable waste as raw material and fermenting for 3 months	Third week of September – third week of December 2023
Ecoenzyme harvesting	Train how to harvest ecoenzyme that has been fermented for 3 months	Third week of December 2023
Eoenzyme packaging	Train how to package ecoenzyme so that its use is practical and can last for a longer time	Third week of December 2023

3. RESULTS AND DISCUSSION

Results

Training on Making Ecoenzyme Based on Household Organic Waste

The ecoenzyme training activity was carried out in the yard of the Drien Rampak village keuchik office which was attended by PKK members. This training activity consists of 2 stages, namely explanation of the material from the resource person and practice. On this occasion the speaker explained the importance of waste management, the 3R approach in waste management, the introduction of ecoenzymes, the history of the discovery of ecoenzymes, how to select materials, how to make them, and the benefits of ecoenzymes for household and agricultural practices (Figure 1.). In this training session, participants were first provided with material through presentations from resource persons. Next, the material is practiced directly in the outdoor location provided. The ecoenzyme produced in this activity is a universal ecoenzyme which can be used as a cleaning fluid or organic fertilizer. The participants were enthusiastic in taking part in the ecoenzyme making activity. Ecoenzyme training materials can be accessed at the following link: https://drive.google.com/file/d/1xK4WNM0QBVwAHkgRXbAE76jpmaMhQmA2/view?usp=sharing.

Figure 1. Presentation of material about ecoenzymes and the practice of making ecoenzymes

Ecoenzyme Fermentation

The ecoenzyme fermentation process lasts for 3 months. In the first month, observations need to be made and the container opened every week. This is so that the gas produced in the first month can be released. Ecoenzyme fermentation is carried out using the batch culture principle, namely fermentation by inserting the media and inoculum simultaneously into the bioreactor and taking the product at the end of fermentation. In a batch system, the media material and inoculum are input into the bioreactor at almost the same time, and as the process progresses there will be changes in conditions in the bioreactor (nutrients will be reduced and products and waste will be reduced). in the batch process there is only one cycle where bacterial growth and methane gas production decrease over time because no new substrate is fed into the reactor. The fermentation process in making ecoenzyme involves microorganisms such as *Saccharomyces cerevisiae*, *Yersinia* sp., *Bacillus* sp., *Trichoderma* sp. and *Penicillium* sp. (Varshini & Gayathri, 2023).

The results of ecoenzyme fermentation for 3 months in the first month will produce alcohol, then in the second month it will produce vinegar and in the third month it will produce enzyme. After 3 months, the successful eco-enzyme liquid will turn dark brown and smell like vinegar. The eco-enzyme can be filtered using gauze or a filter. In some conditions, the liquid often changes to black which indicates fermentation failure. To overcome this condition, the solution can be to add sugar to repeat the fermentation process. Harvesting was carried out after 3 months of fermentation, indicated by the solution becoming cloudy brown and having a strong sweet and sour aroma (Figure 2).

Figure 2. Ecoenzyme fermentation process from the first month to the 3rd month

Ecoenzyme Harvesting

Ecoenzyme harvesting is carried out after fermentation for 3 months. The harvesting process was also followed by PKK members. This activity begins with an explanation regarding how to harvest ecoenzymes and the principles of fermentation. Apart from that, it also explains how to use ecoenzyme for various things, especially as a cleaning fluid and plant fertilizer. Harvesting is done by separating the ecoenzyme dregs from the liquid through gradual filtration (Figure 3). This is to minimize residue in the ecoenzyme liquid.

The packaging is carried out in clear bottles that are tightly closed (Figure 4). The results of the ecoenzyme harvest are then distributed to participants so they can be used. Ecoenzyme harvest results show physical characteristics in the form of aroma, color, pH, total dissolved solid (TDS) and temperature in accordance with Table 2.

Figure 3. Ecoenzyme harvesting activities
Figure 4. Ecoenzyme products

Tabel 2. Ecoenzyme characteristic

Observation Parameters	Results
Aroma	Fresh sour, dominantly orange
Color	Brown
pH	3,72
TDS	1030 ppm
Temperature	27°C

Ecoenzymes that are successfully fermented well are characterized by the appearance of a fresh aroma typical of the fermentation results. A good ecoenzyme can also be seen from an acidic pH below 4.0. pH measurements were carried out on the fermentation results using a pH meter. Apart from that, good ecoenzyme characteristics are also indicated by relative TDS values of 1132-1300 and temperatures ranging from 25-32°C. TDS measurements are carried out using a TDS meter and temperature measurements with a thermometer. If the temperature is still high, it is certain that the ecoenzyme fermentation process is still running so it cannot be harvested.

Evaluation

At the end of the activity, a post test was carried out which aimed to measure the increase in participants' attitudes, knowledge and skills after the activity was carried out. Based on the survey results in Figure 4, it shows the differences in the evaluation results of attitudes, knowledge, and skills before and after training. The highest increase was in the afective aspect with a difference of 16.84, followed by the skills aspect with a difference of 13.11 and the attitude aspect with a difference of 5.49 points.

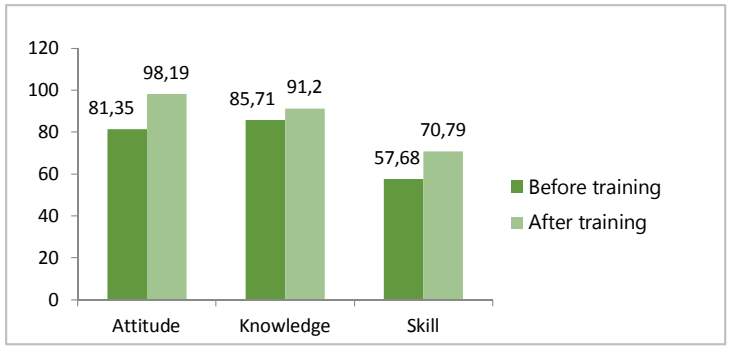

Figure 5. Comparison of the average values of attitudes, knowledge, and skills in aspects of household organic waste utilization

From the affective aspect, it indicates that the participants have a good understanding of the actions that must be taken to manage organic waste. From the knowledge aspect, it is also known that participants can differentiate well between types of organic waste, as well as understand the functions and benefits that can be gained if organic waste such as fruit peels and vegetable waste is reused. As for the skills aspect, participants received information regarding how to make ecoenzyme, which is a technique that can be applied at home to process organic waste.

Discussion

Ecoenzymes are an alternative waste management method that can be chosen to reuse leftover fruit and vegetable peels that are no longer used. The ecoenzyme produced from 30 kg of fruit and vegetable waste is 100 liters of ecoenzyme liquid. Every household in 1 week produces a minimum of 2-3 kg of organic waste. For this amount of waste, 10 liters of ecoenzyme can be produced. If every household can apply this method, the generation of organic waste in waste storage can be minimized.

Ecoenzyme is a liquid obtained from the fermentation of organic materials such as leftover fruit and vegetable peels. The results of this fermentation can be used to make organic fertilizer, cleaning fluid for floors, toilets, and bathrooms as well as aromatherapy (Septiani et al., 2021; Dodo et al., 2023). When used as a cleaning fluid, ecoenzymes can be used directly or mixed with soap. Meanwhile, when used as organic fertilizer, ecoenzymes need to be diluted, for example 5 ml mixed with 100 ml of water for spraying on plant leaves. The ingredients used in making this ecoenzyme are water, sugar and fruit and vegetable waste, with the ratio used being 10:1:3. The remaining fruit used is orange peel, watermelon, mango, carrot, pineapple, dragon fruit, apple, pear, and papaya. Meanwhile, the sugar used is brown sugar which has been melted first. This is done so that it is easily dissolved in water. There are several material selection criteria that need to be considered when making ecoenzymes. Fruit skins that contain fat such as avocado or coconut skin should not be used. Then very hard skin such as coconut shells or seeds are not included because it will affect the fermentation process. It is also ensured that leftover fruit and vegetable ingredients are not rotten or moldy, and are not already cooked.

The ecoenzyme that has been made is then closed tightly and placed in a shady place and protected from direct sunlight. Then fermented for 3 months. In the first month the ecoenzyme will produce alcohol so that the smell of alcohol comes out of the eco-enzyme solution and releases ozone gas (O_3) which can reduce CO_2 in the atmosphere which traps cloud heat so this can reduce the problem of global warming and the greenhouse effect. Eco-enzyme the fermentation mechanism is to break down glucose to produce pyruvic acid. Under anaerobic conditions, pyruvic acid will undergo decomposition into acetal aldehyde, then the acetal aldehyde is converted by alcohol dehydrogenase into ethanol and carbon dioxide. Acetobacter bacteria will convert alcohol into acetal aldehyde and water, then the acetal aldehyde will be converted into acetic acid. Another factor that can influence alcohol production in eco-enzymes is the life phase cycle of microorganisms. In the growth phase, yeast metabolic activity increases, resulting in the process of converting sugar into alcohol to occur more quickly. Meanwhile, in the exponential phase, the number of yeasts increases which results in more sugar being converted into alcohol (Fadilah et al., 2018).

In the second month the eco-enzyme liquid will emit a sour smell which is the smell of acetic acid, the color of the eco-enzyme liquid will start to become clearer and the smell will start to change to sour and the skin of the fruit will start to fall to the bottom. On the surface there is white fungus which is involved in the fermentation process (Figure 2). In the second month, the ecoenzyme fluid produces vinegar (Putri et al., 2016). The formation of organic acids such as acetic acid occurs after the formation of alcohol in the ecoenzyme fermentation process. This is because the alcohol contained in

the fermentation system reacts with oxygen and produces carboxylic acid compounds (Rohmah et al., 2020). In this third month the ecoenzyme has produced enzymes so that after fermentation for 3 months the ecoenzyme is suitable for harvest. Ecoenzymes can be declared successful if a brownish liquid is formed and has a sour odor (Agnafia et al., 2022).

Ecoenzyme that has been harvested has a pungent and fresh sour orange peel aroma. The sour aroma produced comes from the acetic acid contained in the ecoenzyme product liquid. Acetic acid generally gives a sour taste and sour aroma to liquids or food (Buckle et al., 2009). Acetic acid is produced from the metabolic process of bacteria which is naturally found in fruit and vegetable waste. The anaerobic metabolic process or what is commonly referred to as the fermentation process is an attempt by bacteria to obtain energy from carbohydrates in anaerobic conditions (without oxygen) and with by-products in the form of alcohol or acetic acid (depending on the type of microorganism). This fermentation process is the result of enzyme activity produced by bacteria or fungi. Both substances have properties as disinfectants (Larasati et al. 2020). According to Varshini and Gahayatri (2023), Ecoenzyme fermentation can be said to be successful if a brownish solution is formed and has a material-like odor (no foul smell) and a sour aroma. This is in accordance with the results of the fermentation carried out, where the color of the Ecoenzyme product underwent a change from being originally clear brown (the original color of the palm sugar solution) to becoming cloudy brown. A good ecoenzyme can also be seen from the pH which must be below 4.0, having a relative TDS, namely, 1132-1300 ppm (Gumilar, 2023). The success of Ecoenzyme can also be seen in the temperature of the liquid produced. Based on the research results of Gaspersz & Fitrihidajati (2022), it shows that the optimal ecoenzyme temperature for fruit and vegetable waste is 25-32^{o}C. In making ecoenzyme, containers made of plastic are used. The use of glass containers is not recommended because they can break due to microbial fermentation. Fermentation produces alcohol and acetic acid which have disinfectant properties. During the fermentation process, carbohydrates are converted into volatile acids and the organic acids present in the waste also dissolve in the fermentation solution due to the natural acidic pH of the waste enzymes. In the fermentation process, glucose is broken down to produce pyruvic acid. Pyruvic acid under anaerobic conditions will undergo decomposition by pyruvate decarboxylase into ethanol and carbon dioxide, where the acetobacter bacteria will convert alcohol into acetaldehyde and water which will then be converted into acetic acid (Septiani et al., 2021). Based on Galintin et al. (2021), ecoenzyme contains several hydrolytic enzymes such as amylase, lipase, and protease, so it can be used as a cleaning fluid and accelerates the decomposition of organic waste.

4. CONCLUSION AND RECOMMENDATIONS

Community service activities with a focus on utilizing fruit and vegetable waste into ecoenzymes have been completed. Through this activity the participants have produced universal ecoenzyme products from 100 liters of fruit and vegetable waste by utilizing 30 kg of fruit and vegetable waste. Ecoenzyme can be used as a cleaning fluid in pure form and can be used as an organic fertilizer by dilution. Based on the evaluation results, there was an increase in the aspects of participants' attitudes, knowledge, and skills in managing household organic waste. The highest increase was in the attitude aspect with a difference of 16.84 points, followed by the skills aspect with a difference of 13.11 points, and the knowledge aspect with a difference of 5.49 points.

Training and assistance activities for managing organic waste into eco enzymes are carried out within a limited time. So, to ensure the sustainability of this activity, it is recommended that mentoring activities be carried out until the community is confirmed to be proficient in processing ecoenzymes. Apart from that, it is also necessary to carry out training regarding eco enzyme business opportunities so that people can get greater benefits from waste management.

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