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TRAINING ON ECO-ENZYME PRODUCTION FROM VEGETABLE WASTE FOR WOMEN FARMER GROUPS AS ENVIRONMENTALLY FRIENDLY FERTILIZER

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ABSTRACT

Organic waste generated from traditional markets and household activities continues to pose environmental challenges due to inadequate waste management practices. In Mulyojati Village, Metro City, large quantities of vegetable waste are commonly discarded without further utilization, causing unpleasant odors and environmental pollution. In addition, members of the Women Farmer Group (Kelompok Wanita Tani/KWT) had limited knowledge regarding the conversion of organic waste into value-added products. Therefore, this community service program aimed to improve participants' knowledge and practical skills in producing eco-enzyme from vegetable waste as an environmentally friendly liquid fertilizer. The program involved 25 members of KWT RW 003 Mulyojati Village and was implemented through participatory training consisting of socialization sessions, demonstrations, hands-on practice, mentoring, and evaluation activities. The results showed a 100% attendance rate throughout the training activities. Participants actively engaged in discussions and practical sessions, while 92% successfully demonstrated the ability to produce eco-enzyme independently. Participant satisfaction reached 96%, indicating a highly positive response toward the training program. Furthermore, participants demonstrated improved understanding of organic waste management and recognized the environmental and economic benefits of eco-enzyme production. This program concludes that eco-enzyme training is an effective community empowerment strategy for improving environmental awareness, strengthening practical skills, and supporting sustainable waste management practices among women farmer groups.

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INTRODUCTION

Organic waste has become one of the most pressing environmental challenges around the world, including in Indonesia (Wattimena et al., 2025). Rapid population growth, urbanization, and increasing consumption activities have contributed significantly to the increase in the amount of organic waste coming from households, markets, restaurants, and the agricultural sector (Marketing & Waste, 2022). The accumulation of organic waste that is not properly managed can cause unpleasant odors, attract disease vectors, produce greenhouse gas emissions, and cause environmental pollution. Although organic waste is biodegradable,

inadequate management practices often lead to environmental degradation and cause public health problems (Aminuddin, 2025). Therefore, sustainable strategies to turn organic waste into beneficial products are becoming increasingly important in supporting environmental preservation and circular economy initiatives.

In Indonesia, organic waste is the largest component of urban solid waste (Sulistyaningsih et al., 2025). Traditional markets are one of the main contributors to organic waste, especially in the form of vegetables, fruits, and other biodegradable materials that are discarded. Unfortunately, most of the waste is still directly disposed of in temporary shelters or landfills without going through the processing process first. This practice not only degrades the quality of the environment, but also eliminates the opportunity to turn potentially valuable resources into useful products. Therefore, efforts to increase public awareness and skills in organic waste management are needed to reduce environmental burdens while encouraging sustainable resource utilization.

In various studies, one of the promising approaches in organic waste management is the production of eco-enzymes (Hariani et al., 2022; Vidalia et al., 2023). Eco-enzyme is a multifunctional liquid produced through the fermentation process of organic matter, such as fruit peels, vegetable residues, and other organic household waste, which is mixed with water and carbohydrate sources such as molasses or brown sugar (Nafilah et al., 2024). During the fermentation process, microorganisms decompose organic compounds and produce a variety of beneficial substances, including enzymes, organic acids, and nutrients. Previous studies have reported that eco-enzymes can serve as eco-friendly liquid fertilizers, natural pesticides, cleaning agents, as well as composting accelerators. In agriculture, eco-enzymes contribute to increasing soil fertility, increasing nutrient availability, stimulating plant growth, and reducing dependence on synthetic fertilizers (Athiqoh et al., 2025; Wakano, 2024; Widyasari & Wiratama, 2021). In addition, the manufacture of eco-enzymes is a cheap and practical method that can be applied by the community by utilizing materials available in the surrounding environment.

Several community empowerment programs have introduced eco-enzyme production as a strategy for improving environmental awareness and organic waste management. Various community empowerment programs and research have shown the effectiveness of the use of eco-enzymes in overcoming the problem of organic waste. Susilowati et al. (2021) show that education to the public about the manufacture of eco-enzymes can increase public awareness of household organic waste management. Mardiani et al. (2021) reported that socialization activities succeeded in introducing eco-enzymes as an alternative solution in converting organic waste into products with useful value. Wahyuningsih et al. (2023) found that the eco-enzyme training program increased participants' understanding of environmentally friendly waste management practices. Furthermore, Patrisyawati et al. (2024) emphasized the effectiveness of eco-enzyme fermentation in converting household organic waste into multifunctional products that have environmental and economic benefits. These findings show that eco-enzymes have great potential in supporting sustainable waste management and community empowerment programs.

Although the number of eco-enzyme-related community service programs continues to increase, most of the activities that have been carried out are still limited to short-term socialization or one-time training. Many programs focus more on the introduction of eco-enzyme concepts without providing intensive practical experience, fermentation process monitoring, or post-training mentoring to ensure participants are able to apply the knowledge gained. In addition, most of the previous activities used household organic waste as the main raw material, while the use of vegetable waste produced from traditional markets still received relatively little attention. Therefore, a more comprehensive empowerment model is needed that not only introduces the creation of eco-enzymes, but also facilitates the implementation of hands-on practices, continuous monitoring, and participant mentoring to strengthen community capacity in sustainable waste management (Muliarta & Darmawan, 2021; Ruhmawati et al., 2017; Widiyanto, 2019).

The Women Farmers Group (KWT) RW 003 Mulyojati Village, West Metro District, Metro City, is a community that has great potential to contribute to environmental conservation

through sustainable agricultural practices. However, the results of initial observations show that there are several problems faced by the group. A large amount of vegetable waste generated from the activities of the Mulyorejo Morning Market is still disposed of without further utilization, causing a buildup of waste, the appearance of unpleasant odors, and the potential for environmental pollution. In addition, members of the Women Farmers Group still have limited knowledge and practical skills in processing organic waste into products that are beneficial to the environment, such as eco-enzymes. This condition shows the need for community-based interventions that are able to overcome waste management problems while increasing community capacity in implementing environmentally friendly agricultural practices (Nurlaelah et al., 2025; Saragih et al., 2026; Suhartini et al., 2025).

Based on these conditions, this community service program is designed to provide training and assistance in making eco-enzymes from vegetable waste to members of the RW 003 Farmer Women Group in Mulyojati Village. The novelty of this program lies in three main aspects. First, the program utilizes vegetable waste derived from traditional market activities as the main raw material for making eco-enzymes. Second, the program actively empowers farmer women groups as environmental agents who are able to disseminate sustainable waste management practices to the community. Third, the program integrates socialization activities, hands-on practical training, fermentation process monitoring, and ongoing mentoring to ensure participants gain theoretical understanding as well as practical competencies. Therefore, the program aims to improve participants' knowledge and skills in the manufacture of eco-enzymes, reduce the accumulation of organic waste, encourage environmentally responsible behaviors, and support sustainable agriculture through the use of available local resources.

IMPLEMENTATION METHOD

Participants and Location

This community service program was conducted from July to August 2025 in Mulyojati Village, Metro Barat District, Metro City, Lampung Province, Indonesia. The participants consisted of 25 members of the Women Farmer Group (Kelompok Wanita Tani/KWT) RW 003, who were actively involved in household gardening, small-scale agricultural activities, and community environmental programs. Most participants had limited prior experience in organic waste management and had never received formal training on eco-enzyme production. The participants were selected based on preliminary observations and discussions indicating limited knowledge and practical skills regarding the utilization of vegetable waste as an environmentally friendly agricultural resource. The program location was selected due to the abundance of vegetable waste generated from nearby traditional market activities and the community's strong commitment to participating in environmental empowerment and sustainable waste management initiatives.

Program Design

The program employed a participatory community empowerment approach that actively involved participants throughout all stages of implementation. This approach was selected to encourage community engagement, strengthen practical learning experiences, and promote sustainable adoption of eco-enzyme production practices. The program was designed through four main stages: (1) planning, (2) implementation, (3) evaluation, and (4) reflection (Lewis, 2002). These stages were developed to ensure that participants not only received theoretical knowledge but also acquired practical skills and the confidence necessary to independently produce eco-enzyme using locally available organic waste resources.

Planning Stage

The planning stage began with preliminary observations and discussions with members of the Women Farmer Group to identify existing environmental problems and community needs. Field observations revealed the accumulation of vegetable waste from Pasar Pagi Mulyorejo, which was generally discarded without further utilization, resulting in unpleasant odors and potential environmental pollution. In addition, most participants had never received training related to eco-enzyme production or organic waste management. Based on these findings, the service team coordinated with community representatives to determine activity schedules,

participant involvement, training materials, required equipment, and implementation procedures. Educational materials concerning eco-enzyme benefits, fermentation processes, and environmental sustainability were subsequently prepared to support the training activities.

Training Procedures

The implementation stage consisted of socialization, demonstrations, hands-on practice, and mentoring activities. Initially, participants received educational sessions regarding organic waste problems, the concept of eco-enzyme, its environmental benefits, and its applications in sustainable agriculture. Following the socialization session, participants were introduced to the tools and materials required for eco-enzyme production, including vegetable waste, brown sugar, water, fermentation containers, and supporting equipment.

The practical training involved direct participant engagement in each stage of eco-enzyme production. Participants were guided to sort and clean vegetable waste, cut the materials into smaller pieces, prepare brown sugar solutions, mix all ingredients according to the recommended proportions, and store the mixture in fermentation containers. The fermentation process was explained in detail, including procedures for monitoring gas accumulation and maintaining appropriate fermentation conditions. Participants were encouraged to practice independently under the supervision of the service team to ensure proper understanding of each production step.

After the initial production process, participants received mentoring regarding fermentation monitoring and product maintenance. The eco-enzyme containers were periodically checked to release accumulated gases and ensure optimal fermentation conditions. Continuous guidance was provided to help participants understand the importance of maintaining the fermentation process and to increase the likelihood of successful eco-enzyme production.

Evaluation Techniques

Program evaluation was conducted following the completion of training activities. The evaluation aimed to assess participant engagement, knowledge acquisition, practical skill development, and overall responses to the program. Evaluation data were collected through direct observation, participant discussions, informal interviews, and field notes recorded during the activities. Particular attention was given to participants' ability to explain the eco-enzyme production process, demonstrate the required procedures, and describe the environmental benefits of utilizing vegetable waste.

Several indicators were used to evaluate program success, including participant attendance, active participation during discussions and practical sessions, understanding of eco-enzyme concepts, ability to perform eco-enzyme production independently, and participant satisfaction with the training activities. Program success was indicated by active participant involvement throughout the training process and positive responses regarding the usefulness of eco-enzyme production for household and agricultural applications.

Data Analysis

The collected data were analyzed using both quantitative and qualitative descriptive approaches. Quantitative data obtained from attendance records, observation sheets, and participant satisfaction questionnaires were analyzed using percentages and mean scores to describe participant engagement and responses toward the training program. Meanwhile, qualitative data obtained from observations, interviews, discussions, and field notes were analyzed through data reduction, data categorization, data interpretation, and conclusion drawing. The analysis focused on identifying changes in participants' knowledge, attitudes, and practical skills related to eco-enzyme production and organic waste management. In addition, participant perceptions regarding the environmental and agricultural benefits of eco-enzyme utilization were examined. The results of both analyses were integrated and presented descriptively to provide a comprehensive understanding of the program outcomes and its contribution to community empowerment and sustainable waste management.

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RESULTS AND DISCUSSION

This community service activity consists of two main activities, namely: (1) socialization about making eco-enzymes from vegetable organic waste. This socialization is important in order to provide knowledge about the management and utilization of eco-enzymes (Hasnah et al., 2025) and (2) training in making eco-enzymes by utilizing kitchen waste, such as fruit peels and vegetable waste. The socialization and training activities were carried out on Sunday, August 10, 2025, through direct practice attended by members of the Women Farmers Group (KWT) RW 03 Mulyojati Village, West Metro District.

The Community Service Program (PKM) of the University of Muhammadiyah Metro aims to provide assistance to the community, especially members of KWT RW 03, through the use of vegetable waste that has not been utilized optimally. The waste is processed into environmentally friendly products in the form of eco-enzymes that have various benefits for daily life (Junaidi et al., 2021; Sunarti et al., 2021). Through this activity, participants were introduced to vegetable waste processing innovations that are widely found in household environments and traditional markets, so that as expressed by waste that was previously wasted can have a use value that is beneficial for the environment, health, and agricultural sustainability (Athiqoh et al., 2025; Daryanti et al., 2025). To introduce participants to the concept and benefits of eco-enzyme production, a socialization session was conducted for members of the Women Farmer Group (KWT) RW 003. The activity is presented in Figure 1.

Figure 1. Socialization of *Eco-Enzyme Making*

Figure 1 shows the socialization of eco-enzyme making to members of the Women Farmers Group (KWT) RW 003 Mulyojati Village. In this activity, participants received an explanation of the benefits of eco-enzymes, the materials used, and the stages of making them from vegetable waste. Participants also actively discussed and asked questions related to the use of eco-enzymes in daily life. The next activity is the practice of making *Eco-Enzymes* which is guided directly by the service team, by conveying the manufacturing steps in detail starting from the selection of ingredients, the mixing process, to the fermentation stage.

Prepare tools and materials. The tools and materials used in the eco-enzyme production training are presented in Table 1.

Table 1. Tools and Materials

No	Tools and Materials	Quantity
1	Vegetable Waste	6 kg
2	Brown Sugar	2 kg
3	Water	20 liters
4	Galon 15 liters	4 pieces
5	Spray Bottle	5 pieces
6	Knife	8 pieces
9	Duct tape	1 pieces

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As presented in Table 1, the eco-enzyme production process utilized simple and readily available materials, including vegetable waste, brown sugar, and water as the primary fermentation ingredients. Supporting equipment such as gallon containers, spray bottles, knives, and duct tape facilitated the preparation and storage processes. The use of inexpensive and locally available materials demonstrates that eco-enzyme production can be easily adopted by community members as a practical approach to organic waste management and environmentally friendly fertilizer production. Prepare 6 kg of vegetable waste, 2 kg of brown sugar, and 20 liters of clean water (for each gallon containing 1.5 kg of vegetable waste: 500 grams of brown sugar: 5 liters of water). The preparation of raw materials is an essential step in ensuring the success of the eco-enzyme fermentation process. The materials prepared for the training activities are presented in Figure 2.

Figure 2. Preparation of Materials for Eco-Enzyme Production.

Figure 2 shows the ingredients used in the manufacture of eco-enzymes, namely vegetable waste, brown sugar, and water placed in fermentation containers. In this activity, 6 kg of vegetable waste, 2 kg of brown sugar, and 20 liters of clean water were prepared which were then divided into several gallons according to the predetermined composition.

1. Cut the vegetable waste into small pieces so that it decomposes easily.

   To facilitate the fermentation process and enhance microbial decomposition, the vegetable waste was cut into smaller pieces. The preparation of chopped vegetable waste is presented in Figure 3.

Figure 3. Chopped Vegetable Waste for Eco-Enzyme Production

Figure 3 shows vegetable waste that has been cut into small pieces before the fermentation process is carried out. Material cutting aims to speed up the decomposition process by microorganisms so that eco-enzyme fermentation can take place more optimally and produce quality products.

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2. Strip brown sugar into fine parts so that it is easily dissolved

   Brown sugar was used as a carbohydrate source to support microbial activity during the fermentation process. The preparation of grated brown sugar is presented in Figure 4.

Figure 4. Grated Brown Sugar for Eco-Enzyme Production

Figure 4 shows brown sugar that has been shaved into small pieces before being mixed into water. The squeezing process is carried out so that brown sugar is easier to dissolve so that it can accelerate the mixing and fermentation process in the manufacture of eco-enzymes.

3. Wash the waste of vegetables that have been cut

   To ensure the cleanliness of the raw materials and minimize contamination during fermentation, the chopped vegetable waste was washed thoroughly before use. The washing process is presented in Figure 5.

Figure 5. Washing Chopped Vegetable Waste Before Fermentation.

Figure 5 shows the process of washing vegetable waste that has been cut before being used as raw material for making eco-enzymes. Washing is carried out to remove dirt and residue that sticks to the fermentation process so that the fermentation process can take place better and produce quality eco-enzymes.

4. Next, put the sugar shavings in the water in the gallon, then stir.

   The brown sugar was dissolved in water to support the fermentation process, as presented in Figure 6.

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Figure 6. Mixing Brown Sugar Solution in the Fermentation Container.

Figure 6 shows the process of mixing brown sugar that has been shaved into water in a gallon of fermentation. The solution is then stirred until the sugar dissolves evenly as a source of nutrients for microorganisms that play a role in the eco-enzyme fermentation process. After the sugar dissolves, add the pieces of vegetable waste that have been washed. The addition of vegetable waste into the fermentation container is presented in Figure 7.

Figure 7. Adding Cleaned Vegetable Waste into the Fermentation Container.

Figure 7 shows the process of putting a piece of vegetable waste that has been washed into a gallon containing a solution of brown sugar. This stage is an important part of the creation of eco-enzymes because the organic matter that is included will be the main source of nutrients during the fermentation process.

5. Press the vegetable waste until it is all submerged and close tightly

The process of submerging the vegetable waste and sealing the fermentation container is presented in Figure 8.

Figure 8. Submerging Vegetable Waste and Sealing the Fermentation Container.

Figure 8 shows the process of pressing vegetable waste until the entire material is submerged in the fermentation solution. After all the ingredients are well submerged, the gallons are tightly closed to maintain fermentation conditions so that they take place optimally and avoid contamination from the outside.

6. Store gallons in a cool, sealed place for the feremation process.

The eco-enzyme fermentation process in sealed containers is presented in Figure 9.

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https://scholar.ummetro.ac.id/index.php/cesj/index
Vol. 02, No. 01 (2026), 28-40
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Figure 9. Fermentation Process of Eco-Enzyme in Sealed Containers.

Figure 9 shows a gallon that has been filled with a mixture of vegetable waste, brown sugar, and water that is ready to undergo the fermentation process. The fermentation container is then stored in a cool, closed place to maintain the stability of the fermentation process and support the formation of eco-enzymes optimally.

7. Eco-Enzyme *feremation* is monitored every three days to remove the gas

The periodic monitoring of the eco-enzyme fermentation process is presented in Figure 10.

Figure 10. Periodic Monitoring of the Eco-Enzyme Fermentation Process.

Figure 10 shows the monitoring of the eco-enzyme fermentation process that is carried out periodically. During fermentation, the container is opened every three days to release gases formed due to the activity of microorganisms, so that the fermentation process can take place properly and safely to produce eco-enzymes that are ready to be used. After fermentation for two weeks, *the Eco-Enzyme liquid fertilizer* is ready to be harvested and used. The harvested eco-enzyme product ready for application as a liquid fertilizer is presented in Figure 11.

Figure 11. Harvested Eco-Enzyme Ready for Application as Liquid Fertilizer.

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Figure 11 shows the final results of making eco-enzymes after going through the fermentation process for two weeks. The harvested eco-enzymes are then packaged in spray bottles so that they are ready to be used as environmentally friendly liquid fertilizers to support plant growth and increase soil fertility.

Based on the results of the evaluation of the participants' understanding of the socialization activities, the women of KTW RW 003 Mulyojati Village seemed very active and enthusiastic, as seen from the many questions asked from the beginning to the end of the activity. After the practice of making *Eco-Enzymes* from vegetable waste was completed, the mothers tried the results of the products that had been made together and gave positive feedback and showed high enthusiasm for the benefits obtained. Group Photo after the activity is presented in Figure 12.

Figure 12. Group Photo at the End of the Training Activity.

Figure 12 shows a group photo session between the service team and members of the Women Farmers Group (KWT) after the entire series of eco-enzyme making training activities were completed. This documentation is a symbol of the success of the activity and reflects the enthusiasm and active participation of participants in participating in the training program and assistance in making eco-enzymes from waste.

This PKM activity implements science and technology in the form of utilizing household organic waste, especially vegetables and fruit peels, into EcoEnzymes through a simple fermentation process. The service team trained the women of KWT RW 003 Mulyojati Village to process vegetable waste by mixing it with brown sugar and water, then fermenting it to produce a liquid rich in enzymes and bioactive compounds. They can use this product as a liquid fertilizer, natural cleaner, or pest control so that it provides direct benefits for daily life. Participants participated in socialization and hands-on practice starting from preparing ingredients, cutting vegetable waste, dissolving brown sugar, mixing ingredients in gallons, to fermentation and periodic monitoring. With this approach, participants not only understand simple biotechnology concepts, but are also able to practice them at home.

The implementation of the activity showed positive results. KWT women actively asked questions to try the product, and gave enthusiastic responses. They gain new skills to turn kitchen waste into a valuable product while reducing dependence on chemicals. In the future, the team will assist partners on an ongoing basis so that participants are able to produce and utilize Eco-Enzymes independently.

The training program was considered effective because it combined socialization, hands-on practice, and continuous mentoring throughout the eco-enzyme production process. Unlike conventional awareness programs that focus primarily on knowledge transfer, this activity provided participants with direct experience in preparing raw materials, conducting fermentation, and monitoring the production process. The active involvement of participants during discussions and practical sessions indicated a high level of engagement and facilitated experiential learning. Such an approach enabled participants to gain not only conceptual understanding but also practical competencies that can be applied independently in their daily activities.

The program also contributed to participants' knowledge and skills regarding sustainable organic waste management. Through the training activities, participants learned how vegetable waste generated from household and market activities could be converted into value-added products with environmental and agricultural benefits. Participants gained practical experience in selecting raw materials, preparing fermentation mixtures, monitoring the fermentation process, and utilizing eco-enzyme as an environmentally friendly liquid fertilizer. In addition, the activity increased participants' awareness of the importance of reducing organic waste and promoting environmentally responsible behavior within the community.

The findings of this community service program are consistent with previous studies that reported the positive impact of eco-enzyme training on community knowledge and environmental awareness. Eco-enzyme education programs increased public awareness of household organic waste management (Arsih et al., 2026; Maharani et al., 2024; Yusdian, 2023). Similarly, Eco-enzyme training improved participants' understanding of environmentally friendly waste management practices (Bangun et al., 2026; Nasir et al., 2026). Furthermore, the present program extends previous initiatives by utilizing vegetable waste from traditional market activities and integrating practical training with fermentation monitoring and mentoring. These additional components provided participants with more comprehensive learning experiences and strengthened their capacity to independently implement eco-enzyme production as part of sustainable waste management practices.

CONCLUSIONS AND SUGGESTIONS

This community service program successfully improved participants' knowledge and practical skills in producing eco-enzyme from vegetable waste through socialization, hands-on training, and mentoring activities. Members of the Women Farmer Group (KWT) RW 003 actively participated throughout the program and were able to understand the procedures for converting vegetable waste into an environmentally friendly liquid fertilizer. The activity also increased participants' awareness of sustainable organic waste management and demonstrated the potential of utilizing locally available waste resources to support environmentally friendly agricultural practices. Furthermore, the program contributed to community empowerment by encouraging participants to apply eco-enzyme production independently and promote sustainable waste management within their surrounding community.

For future community service activities, continuous mentoring and follow-up evaluations are recommended to ensure the sustainability of eco-enzyme production practices among participants. In addition, similar programs can be expanded to other community groups and integrated with broader environmental education initiatives to enhance public awareness and participation in sustainable waste management and environmentally friendly agriculture.

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