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Bioconversion of Siwalan Waste into Liquid Organic Fertilizer to Support Sustainable Agriculture in Ngujuran Village

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A B S T R A C T

Organic waste from siwalan processing in Ngujuran Village, Bancar Subdistrict, Tuban Regency is not being used optimally, potentially causing environmental pollution. This community service activity aims to improve farmers' knowledge and skills in processing siwalan fruit peel waste into liquid organic fertilizer (LOF). Methods included socialisation, demonstration-based training, and evaluation using pre- and post-test instruments. The results showed increased participants' knowledge and technical skills in making LOF from siwalan waste. This Activity produced two main outputs: LOF products and a simple fermentation tool innovation called GALAKSI (Galon Airlock Kulit Siwalan/Siwalan Peel Airlock Gallon), which the community can replicate independently. This program supports community-based agricultural waste management, reduces dependence on chemical fertilizers, and encourages a sustainable, environmentally friendly agricultural system.

Contribution to Sustainable Development Goals (SDGs):
SDG 2: Zero Hunger
SDG 12: Responsible Consumption and Production
SDG 13: Climate Action
SDG 15: Life on Land

1. INTRODUCTION

1.1. Research Background

Siwalan is a palm that grows abundantly in coastal areas and provides benefits from every part of the plant, from leaves and stems to fruits and sap. In Tuban Regency, siwalan is a leading plantation commodity, with production reaching 1,821.82 in 2024. In addition, Bancar Subdistrict, one of the siwalan-producing areas, contributed 28.91, indicating that this plant serves as an economic backbone for the local community [1].

Organic waste in siwalan processing requires attention. This waste is generally not optimally utilised and is often disposed of directly into the environment, potentially causing pollution, unpleasant odours, and environmental degradation. The amount of organic waste continues to increase as agricultural land in Indonesia expands, especially during the post-harvest period [2]. Organic waste needs to be processed to provide optimal benefits to the community.

Organic waste's nutritional content and essential elements can be used to produce products such as compost, biogas, liquid fertilizer, briquettes, and bioethanol. Organic fertilizer is a material derived from plant, animal, or other organic waste residues that have undergone a biological engineering process, resulting in a more stable structure and nutrients that plants can absorb more easily [3]. Furthermore, processing liquid organic fertilizer is relatively easy, quick, plant-absorbable, and simple to apply [4]. Organic waste also contains nutrients that can be utilized as a more environmentally friendly liquid organic fertilizer [5]. However, utilization of this waste at the community level remains suboptimal.

Challenges include suboptimal utilization of siwalan waste, limited knowledge and skills in processing waste into value-

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added products, and persistent reliance on chemical fertilizers in agricultural activities. These issues are priorities because they directly affect the community's environmental and economic well-being.

This community service aims to increase the community's knowledge and skills in processing siwalan waste into liquid organic fertilizer, reducing dependence on chemical fertilizers and encouraging the productive, sustainable use of waste. Good organic waste management can also reduce environmental pollution and enhance the community's economic value [6].

1.2. Research Objective

This community service activity aims to improve community knowledge and skills in processing siwalan waste into liquid organic fertilizer through bioconversion technology. Additionally, this Activity aims to encourage sustainable use of agricultural waste, reduce reliance on chemical fertilizers, and support environmentally friendly agriculture by utilizing local resources.

2. MATERIALS AND METHODS

This community service activity used socialisation and training through demonstrations. The socialisation method involved providing materials on using siwalan waste and the importance of sustainable organic waste management. Subsequently, the training method involved demonstrating how to make liquid organic fertiliser (LOF) from siwalan waste so participants could understand the process systematically.

This Activity was held in Ngujuran Village, Bancar Subdistrict, Tuban Regency on Wednesday, April 13, 2025, located at the Ngujuran Village Hall Post. The partners in this Activity were community groups in Ngujuran Village. A total of 30 participants, purposively selected as farmers and siwalan processors, attended the training. This group has access to sufficient siwalan waste but previously lacked adequate knowledge and skills to turn it into value-added products.

The activity began with socialisation on the activity plan and the delivery of objectives to the community. Before the socialisation and training activities, participants took a pre-test to determine their initial knowledge of using organic waste and producing liquid organic fertiliser. The procedure for implementing the Activity was carried out through the following stages:

2.1. Pre-test

The Activity began with a pre-test administered to all participants to assess their initial knowledge of using siwalan waste and producing liquid organic fertiliser. The pre-test results identified participants' baseline understanding before they attended the socialisation and demonstration activities.

2.2. Demonstration

Following the pre-test, the Activity continued with material on siwalan waste management and a demonstration on making liquid organic fertilizer. The service team conducted the demonstration, showing each stage of making liquid organic fertilizer. The demonstration used a 10:1:1 formulation ratio: 4.17 litres of water, 0.42 litres of molasses, and 0.42 litres of EM4. The team then combined this liquid mixture with 5 kg of chopped siwalan peel waste. The team processed the mixture using the GALAKSI tool (Siwalan Peel Airlock Gallon). Through this demonstration, participants were expected to understand better how to turn siwalan waste into an easy-to-apply liquid organic fertiliser.

2.3. Post-test

After the socialisation and demonstrations, participants took a post-test to measure their understanding after joining the Activity. The pre-test and post-test results were then analyzed using the average score and the percentage increase in participants' knowledge as indicators of the community service activity's success.

3. RESULT AND DISCUSSION

This community service activity was carried out in Ngujuran Village, Bancar Subdistrict, Tuban Regency, involving siwalan farmers as participants. This Activity met the community's needs, especially in efforts to turn siwalan waste into products with utility value. This aligns with findings that residue from sorting vegetables and fruits, which is often discarded, can be reused through product diversification or value-added processing [7]. The activity was implemented through socialisation, demonstrations, and pre- and post-tests, as planned in the community service method.



Fig.1. Outreach Activity on Siwalan Waste Utilization

The Activity began with a presentation on using siwalan waste as a base material for making liquid organic fertiliser. Community-led sorting of agricultural products can significantly reduce post-harvest waste [8]. This material helped participants understand that siwalan fruit peel waste, previously underused, could be processed into useful agricultural products. In addition, participants learned the importance of processing organic waste to minimise environmental pollution and reduce dependence on chemical fertilisers. Fundamentally, socialization activities related to biopesticides aim to encourage farmers to gradually switch to organic fertilizers to create a sustainable agricultural system [9].

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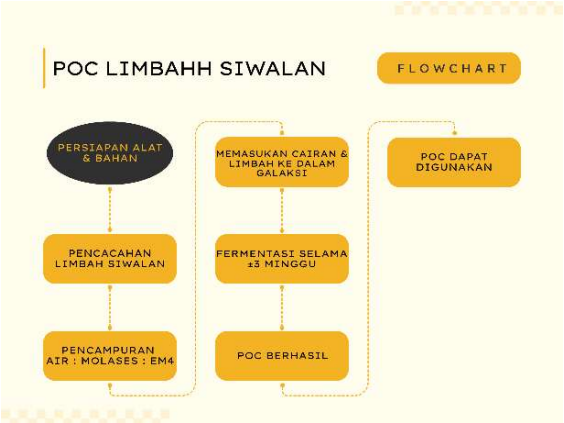


Fig.2. Siwalan Waste POC Flowchart

The process of making liquid organic fertilizer from siwalan fruit peel waste is carried out through several stages, namely the preparation of materials and tools, chopping the siwalan peels, inserting the materials into the GALAKSI tool, adding water, sugar or molasses, and EM4 with a ratio of 10:1:1, mixing the materials, the fermentation process, up to the retrieval of the LOF product through a faucet. Technically, this aligns with findings that a successful nutrient cycle in circular agriculture is positively affected by using liquid fertilizer suited to plant needs [10]. Making LOF from post-harvest organic waste residue can also help farmers achieve fertilizer independence because it is economical and environmentally friendly [11].



Fig.3. GALAKSI Tool as a POC Fermentation Container

The tool used in this Activity is named "GALAKSI," which stands for Galon Airlock Kulit Siwalan (Siwalan Peel Airlock Gallon). This tool is a simple innovation: a gallon container modified for fermenting liquid organic fertilizer. The gallon lid has an airlock that releases fermentation gases without repeatedly opening the lid, and the gallon bottom has a faucet to collect liquid organic fertiliser after fermentation is complete. The GALAKSI tool is an important output because it is simple, easy to make, and reusable by the community.



Fig.4. Participants filled out the Pre-test and Post-test.

The Activity was evaluated by comparing the pre-test and post-test results. The pre-test was given before the delivery of materials and demonstrations to determine the participants' initial knowledge and skills. The post-test was given after the Activity to assess changes in participants' understanding and skills.

Table 1. Participant Pre-Test and Post-Test Result

Assessed Aspect	Understanding of Agricultural Waste Management	Technical Skills in Making LOF
Before Activity (%)	93.33	82.22
After Activity (%)	93.33	84.44
Increase (%)	0	2.22

Based on Table 1, the pre-test knowledge score averaged 4.67 (93.33%). After the Activity, the post-test knowledge score remained at 4.67 (93.33%). This consistently high baseline knowledge reflects participants' daily involvement in siwalan processing as their primary livelihood, resulting in strong foundational awareness. Therefore, future training programs must move beyond basic awareness and focus on deeper cognitive shifts, such as understanding complex biochemical processing mechanisms. The limited knowledge gain suggests that most participants already had a basic understanding of organic waste before the Activity, but still needed to shift toward more productive waste-processing practices. Providing materials will be more effective when paired with hands-on practice, as farmers' satisfaction and willingness to adopt agricultural innovations depend heavily on their in-depth understanding of the program's long-term benefits [3].

In terms of skills, the average score increased from 4.11 (82.22%) during the pre-test to 4.22 (84.44%) during the post-test. The 2.22% increase indicates that demonstrating how to make liquid organic fertiliser positively affected participants' skills. This increase reflects participants' understanding of the technical stages of making LOF, from chopping siwalan fruit peels and using the GALAKSI tool to mixing water, sugar, and EM4, as well as the function of the airlock and faucet on the fermentation tool. This skill improvement is vital for the community to process agricultural waste into liquid organic fertiliser (LOF). This step is considered effective in boosting the efficiency and success of sustainable agricultural systems [12].

Overall, the average pre-test result was 4.39 (87.78%), while the post-test average increased to 4.44 (88.89%). Thus, the overall increase was 1.11 percentage points. Although the increase was not large, these results still show a positive change after the Activity. These results indicate that the socialization and

demonstration methods effectively support participants' capacity building. The resulting LOF product also has strong sustainability prospects; liquid fertilizer formulations derived from waste, combined with organic activators, have great potential to become environmentally friendly fertilization solutions without damaging the soil ecosystem [13].

This program's sustainability potential is significant because the raw material, siwalan fruit peel waste, is available in the community environment of Ngujuran Village. Regarding quality control, the final LOF product showed successful initial bioconversion based on physical characteristics, including standard liquid colour and fermented odour. However, subsequent studies will include comprehensive laboratory testing for pH levels and precise NPK (Nitrogen, Phosphorus, Potassium) content to validate the product's chemical parameters and agronomic safety. This is supported by the fact that sustainable agriculture depends heavily on how farmers adopt organic cultivation methods and optimise local raw materials [14]. Thus, this community service activity not only provides knowledge on using siwalan waste but also teaches farmers practical skills to process waste into liquid organic fertilizer. This program can also continue as part of community-based organic waste management that supports eco-friendly agriculture and the sustainable use of local resources.

4. CONCLUSION

Based on the results of the community service activities in Ngujuran Village, this program effectively improved local farmers' technical skills in processing siwalan peel waste into liquid organic fertilizer (LOF) by 2.22%. In comparison, their foundational understanding of agricultural waste management remained robust and stable at 93.33%. Furthermore, implementing the GALAKSI (Galon Airlock Kulit Siwalan) fermentation tool provided the community with a practical, replicable technology. With abundant siwalan waste, this bioconversion initiative has strong sustainability potential to reduce reliance on chemical fertilizers. For future directions, we recommend monitoring farmer adoption rates over upcoming harvest seasons and conducting definitive laboratory assessments of pH and NPK nutrient parameters to ensure the product's long-term viability.

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