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PROCESSING USED COOKING OIL INTO AN ENVIRONMENTALLY FRIENDLY PRODUCT AS A CREATIVE ECONOMIC SOLUTION

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Abstract

Used cooking oil (UCO) from institutional kitchens poses environmental and health risks if improperly disposed of. This community programme, jointly organised by Politeknik Negeri Sriwijaya and Politeknik Malaysia Merlimau, aimed to introduce a simple method for converting UCO into solid soap, an eco-friendly and economically valuable product. The activity employed an applied mixed-methods design, comprising pre-assessment, technical training, hands-on practice, and post-evaluation. Participants learned about UCO purification, saponification, and safe handling of NaOH. Results indicate a substantial increase in participants' knowledge and awareness, with 100% of respondents demonstrating improved understanding of UCO hazards and soap-making procedures. Practical implementation was successful, yielding approximately 150 bars of solid soap during the workshop. All participants expressed willingness to continue soap production independently due to its low cost, environmental benefits, and potential for micro-enterprise. The programme demonstrates that simple, community-based technical interventions can effectively enhance practical competence and promote sustainable waste valorisation. This model shows strong potential for replication in similar educational and community settings.

Keywords: Used Cooking Oil, Saponification, Community-Based Training. Circulate Economy, Solid Soap Production.

INTRODUCTION

Used cooking oil (UCO), which is no longer edible after frying or cooking, is a significant waste product from homes, canteens, and institutional kitchens—especially those where frying is a frequent practice. Repeated heating increases harmful compounds that are linked to cancer and heart risk (Thushari & Babel, 2022). Improper disposal—often into drains or soil—blocks pipes, reduces soil fertility, and pollutes water, as UCO has high chemical oxygen demand (COD) and low biodegradability (Santander-Bossio, López-González, & Rivera, 2025). These problems highlight an urgent need for improved UCO management, particularly in communities and schools. A situational analysis at Al-Amalul Khair Islamic Boarding School in Palembang showed a serious waste problem. The school houses 495 students and 25 teachers. They prepare three daily meals and generate about 30 litres of UCO every day. There is no standard system for waste management. Focus Group Discussions (FGDs) found strong interest among teachers and students in practical training to convert UCO into usable products. This supports earlier findings that pesantren communities require affordable, user-friendly waste solutions (Nugroho, Ekawati, Wardana, Kalista, & Yuliansya, 2024).

Biodiesel remains the primary use for UCO. However, studies show that making solid soap from UCO is more cost-effective and provides immediate community benefits (Zayed, Hussein, & Ragab, 2024). Converting UCO into soap supports the circular economy by reducing waste, adding value, and promoting community businesses (Budiyoko & Furqon, 2025). This international project, conducted by Politeknik Negeri Sriwijaya (Polsri) and Politeknik Malaysia Merlimau (PMM) and funded by PNBP Polsri 2025, specifically aimed to empower the Al-Amalul Khair Islamic Boarding School community through practical training. The key objectives were to enhance participants' knowledge and skills in processing UCO into solid soap, to assess the environmental and economic benefits experienced by participants, and to provide a replicable model for integrating technical skills with

sustainable micro-enterprise development. The programme included structured training, hands-on soap production, and entrepreneurship motivation. The project addresses the following questions:

1. How effective is UCO-to-soap training in enhancing participants' knowledge and skills?
2. What environmental and economic benefits are perceived by the community?
3. How can this model strengthen vocational education and sustainable micro-enterprise development?

This study addresses the literature gap on community-driven, education-based UCO valorisation, especially within Islamic boarding schools—a sector often overlooked in sustainability efforts. It also demonstrates how UCO valorisation can be replicated as a creative economic initiative that supports environmental stewardship and local empowerment.

LITERATURE REVIEW

Used Cooking Oil: Environmental and Health Implications

Global UCO production is estimated to be 40–70 million tons per year (Kumar, Sharma, & Gupta, 2025), primarily from households, restaurants, and institutional kitchens. Improper disposal causes environmental damage, including clogged sewage systems, increased water toxicity, and ecological harm (Thushari & Babel, 2022). Frying causes heat-induced oxidation, resulting in the formation of toxic aldehydes and hydroperoxides, rendering UCO unsafe for consumption but suitable for chemical conversion (Soni, 2024). In Indonesia, small-scale food industries often reuse cooking oil too many times, which raises peroxide values well above the edible limit of 10 meq O_2/kg, sometimes reaching 20–40 meq O_2/kg (Asyiah, 2009). This creates health and environmental problems.

Valorisation Pathways for UCO

Biodiesel has long been a focus of UCO reuse research (Santander-Bossio, López-González, & Rivera, 2025). Now, interest is growing in non-fuel products such as soap, candles, lubricants, and cleaners. These need lower costs and are more accessible to communities (Ahadito, 2024; Zayed, Hussein, & Ragab, 2024). Soap making, which involves mixing fat or oil with an alkali to form soap and glycerin, is a suitable community education activity. It needs little equipment, gives quick, clear results, and supports small businesses (Azme, Mokhtar, Jalaluddin,, & Hassan, 2023). Octarya (2025) demonstrated that the addition of natural ingredients, such as eco-enzyme or lemongrass, enhances the antimicrobial properties of UCO-based soap. Nugroho et al. (2024) found that soap making in pesantren increases awareness and reduces reliance on commercial detergents.

Circular Economy and Community-Based Innovation

The circular economy means reducing waste and keeping materials in use. Converting UCO into soap transforms waste into a useful product (Budiyoko & Furqon, 2025). Community service by vocational schools fosters environmental knowledge and skills (Putri, 2024), highlighting the important role schools play in green solutions. Hartini et al. (2025) confirmed that training empowers communities by building technical skills and supporting small-scale entrepreneurship. Such programmes fit Indonesia's SDG 12 (Responsible Consumption and Production) and SDG 8 (Decent Work and Economic Growth).

Gaps in Current Literature

While UCO-to-biodiesel is well researched, community-led soap production is less explored. Studies often lack:

- assessment of economic viability;
- integration with vocational education;
- International collaboration dynamics.

The present study addresses these gaps by combining international partnerships, hands-on training, and evaluation of learning outcomes, providing rarely documented empirical evidence in this research domain.

METHOD

This activity employed a community-based approach, incorporating pre-assessment, technical training, and evaluation. The programme took place at Al-Amalul Khair Islamic Boarding School, involving students and teachers.

3.1 Procedures

1. Pre-Assessment:
   Baseline data on UCO disposal practices and environmental awareness were collected through short interviews and pre-training questionnaires.

2. Technical Training:
   Participants received instruction on UCO purification and saponification chemistry. The hands-on session followed the sequential steps of:
   - filtering and heating UCO,
   - preparing NaOH solution,
   - controlled mixing at an appropriate temperature,
   - moulding, and
   - curing.
3. Post-Assessment:
   Knowledge gain and behavioural intention were measured using post-training questionnaires and reflection discussions.

3.2 Data Analysis

Quantitative data were analysed descriptively, while qualitative statements were coded to identify recurrent themes.

RESULTS AND DISCUSSION

Pre-Training Assessment

The initial assessment revealed that most participants had a limited understanding of proper UCO disposal and its associated environmental risks. Although some students had previously observed informal reuse of UCO in the school kitchen, they were unfamiliar with purification methods or saponification chemistry. This aligns with prior findings that UCO handling in community settings generally lacks standard procedures (Azme, Mokhtar, Jalaluddin,, & Hassan, 2023). The pre-training questionnaire confirmed this baseline: only 65% of participants demonstrated correct knowledge related to UCO degradation effects and safe handling practices.

Training and Practical Performance

The hands-on workshop demonstrated strong participant engagement and successful implementation of each technical step. Under supervision, participants carried out:

1. Filtration and heating to remove water and food residues.
2. Preparation of NaOH solution using controlled dilution.
3. Temperature-controlled mixing of oil and lye until a trace of formation occurs.
4. Moulding and initial curing of solid soap.

Participants showed minimal difficulty in following these sequential steps, confirming the suitability of the simplified soap-making procedure for community implementation. This is consistent with Zayed et al. (2024), who noted the accessibility of UCO saponification for lay users.

Figure 1. Overview of Programme Introduction and Practical Implementation

Figure 1 shows the combined opening session, where participants received instructions on programme objectives and safety procedures, alongside the hands-on workshop in which they practised each step of UCO purification and saponification. The figure illustrates the smooth transition from theoretical briefing to practical implementation. It reflects strong participant engagement throughout the training activities.

Figure 2. Finished soap bars produced by participants

Figure 2 displays the solid soap bars produced by participants during the hands-on saponification session using purified used cooking oil (UCO). The figure demonstrates the successful application of the step-by-step procedure, resulting in uniform soap bars with consistent texture and colour. This outcome indicates that participants were able to execute the production method effectively and achieve a marketable-quality product. Approximately 150 bars of solid soap were produced, indicating good material utilisation and effective teamwork among participants.

Post-Training Evaluation and Knowledge Gain

Post-training questionnaires showed significant improvement in understanding, with 100% of participants demonstrating correct knowledge about UCO hazards, purification requirements, and safe saponification procedures. This confirms the effectiveness of technical demonstrations as a teaching method, supporting the findings of Hartini et al. (2025).

Participants also indicated that the practical workshop increased their confidence in producing UCO-based soap independently.

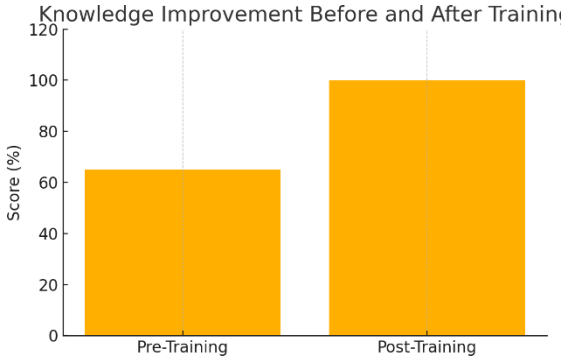

Figure 3. Knowledge Improvement on UCO Recycling within the Circular Economy Framework.

Figure 3 illustrates a substantial improvement in participants' understanding of UCO recycling within the circular economy framework, with knowledge levels increasing from 65% before training to 100% afterwards. This sharp increase demonstrates the effectiveness of the instructional briefing and hands-on module in strengthening conceptual and procedural understanding.

Intention to Practice and Perceived Benefits

All respondents (100%) expressed willingness to continue soap production independently at home or within the school environment. The primary reasons included:

- low production cost,
- environmentally friendly waste reduction,
- potential for small-scale entrepreneurship,
- practical skills that can be applied immediately.

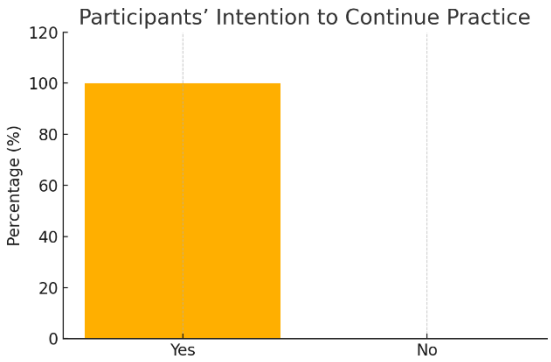

Figure 4. Participants 'Intention to Apply Circular Economy Practices Through UCO-to-Soap Production

Figure 4 shows that all participants expressed a strong intention to apply circular economy practices through UCO-to-soap production. The 100% "Yes" response indicates high motivation and readiness to implement the technique independently, suggesting that the training not only improved knowledge but also successfully encouraged sustainable behaviour change. Open-ended comments emphasised that the activity was *easy*, *useful*, and *should be repeated regularly*, indicating sustained interest beyond the initial training. This is aligned with community empowerment principles, suggesting that hands-on, low-cost technologies yield higher user adoption rates (Budiyoko & Furqon, 2025).

Overall Programme Outcomes

The results collectively indicate that the intervention achieved its core objectives:

- Improved knowledge of UCO hazards and soap-making chemistry.
- Successful execution of UCO purification and saponification steps.
- High participant satisfaction, supported by visual documentation.
- Strong intention to practice, enabling sustainability and replication of the activity.
- Production of marketable soap products, supporting creative economic outcomes.

Overall, the programme demonstrated that a simplified technical module, supported by hands-on guidance, is highly effective in improving environmental literacy and practical competence in community settings.

Figure 5. Group photo with participants, facilitators, and collaborators

CONCLUSION

This study demonstrates that a simplified UCO-to-soap conversion module, supported by structured technical training and hands-on practice, is highly effective for improving environmental literacy and practical skills among participants. The programme led to significant knowledge gains, successful execution of each production step, and a strong intention to continue independent soap-making. The production of approximately 150 solid soap bars confirms the feasibility of implementing this method in resource-limited community settings. Participants recognised the environmental and economic value of valorising UCO, aligning the activity with the principles of the circular economy and community empowerment objectives. The positive response, combined with documented improvements in knowledge and intention to practice, indicates that this intervention can be sustainably replicated

in other educational institutions. Overall, the programme successfully achieved its objectives by integrating environmental education, technical competence, and creative economic potential in a practical and accessible format.

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REFERENCES

Ahadito, B. R. (2024). Soap prouction from waste cooking oil: A systematic review. *Indonesian Journal of Fundamental and Applied Chemistry, 9(2)*, 76–85. doi:https://doi.org/10.37160/ijfac.v9i2.376

Asyiah, N. (2009). Nilai peroksida minyak goreng hasil pemanasan pada berbagai suhu. *urnal Chemica, 10(2)*, 45–50.

Azme, S. N., Mokhtar, N. M., J. N., & Hassan, A. (2023). Recycling waste cooking oil into soap: Knowledge transfer and process evaluation. *Journal of Technology and Sustainability, 4(1)*, 15–24. doi:https://doi.org/10.1234/jts.v4i1.2023

Budiyoko, & Furqon, M. (2025). Circular economy breakthrough: Converting used cooking oil into sustainable biodiesel through the penta-helix model. *EJAK: Journal of Economics and Policy, 18(1)*, 88–102. doi:https://doi.org/10.15294/jejak.v18i1.14724

Hartini, S., Pratama, M., & Rahmawati, E. (2025). Innovation in the utilization of used cooking oil waste into eco-friendly soap for urban communities. *Community Empowerment Journal, 7(1)*, 45–53. doi:https://doi.org/10.31603/ce.12265

Kumar, A., Sharma, V., & Gupta, R. (2025). Valorization of used cooking oil: Challenges, current status, and future outlook. *Sustainable Materials and Technologies, 32*, 100905. doi:https://doi.org/10.1007/s43621-025-00905-7

Nugroho, D. H., Ekawati, L., Wardana, S. K., Kalista, A., & Yuliansya. (2024). Pembuatan Sabun Padat Dari Minyak Jelantah Sebagai Solusi Limbah Cair Domestik Pada Pesantren Zaadul Ma'ad Kota Palembang. *Jurnal Abdimas Indonesia, 4(3)*, 959-970. Retrieved from https://dmi-journals.org/jai

Octarya, Z. (2025). Sustainable solid soap production using recycled cooking oil enhanced with eco-enzyme and lemongrass extract. *Acta BioIna, 4(1)*, 32–40. doi:https://doi.org/10.1234/actabioina.v4i1.191

Putri, D. K. (2024). Soap-making project based on used cooking oil as a learning model for environmental awareness. *Jurnal Penelitian Pendidikan IPA, 10(4)*, 2134–2142. doi:https://doi.org/10.29303/jppipa.v10i4.7701

Santander-Bossio, M. A., López-González, A. D., & Rivera, R. (2025). From waste to energy: Cooking oil recycling for biodiesel and circular economy. *Sustainability, 17(14)*, 6560. doi:https://doi.org/10.3390/su17146560

Soni, H. (2024). Recent advances in the production of soap from used cooking oil. *E3S Web of Conferences, 438*, 03014. doi:https://doi.org/10.1051/e3sconf/202443803014

Thushari, I., & Babel, S. (2022). Environmental impacts and valorization opportunities of used cooking oil: A comparative review. *Journal of Environmental Management, 316*, 115302. doi:https://doi.org/10.1016/j.jenvman.2022.115302

Zayed, L., Hussein, A., & Ragab, A. (2024). Utilizing used cooking oil and organic wastes in homemade soaps. *Processes, 12(6)*, 1279. Retrieved from https://doi.org/10.3390/pr12061279