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From Waste to Value: Empowering Communities through Used Cooking Oil Upcycling into Aromatherapy Candles in Balikpapan

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Abstract

Used cooking oil is commonly discarded as household waste, creating environmental risks while leaving its potential value underutilized. This community service program aimed to improve the knowledge and practical skills of residents and the Waste Bank community in Atlantic Village, RT 63, Balikpapan, in transforming used cooking oil into value-added aromatherapy candles. The program employed a participatory approach involving problem identification, environmental awareness, demonstration, hands-on practice, product evaluation, and the development of a Standard Operating Procedure (SOP). Program outcomes were evaluated through pre-test and post-test assessments (N = 30), direct observation of participants' practical activities, and observation of the resulting candle products. The results showed improvements across all assessed knowledge indicators. Mean scores increased from 1.67–2.17 before the training to 4.20–4.47 after the training, with a high overall normalized gain (N-Gain = 0.79); the highest post-training score was for understanding of product quality consistency (4.47, up from 2.17). Participants were also able to perform the main production stages, including oil filtration, ingredient mixing, fragrance and color addition, molding, and packaging. The resulting candles were further developed through follow-up activities involving wax processing, product decoration, independent product photography, and packaging. These activities allowed participants to improve the appearance and presentation of the products for potential marketing purposes. In addition, a Standard Operating Procedure (SOP) was developed as a practical reference to support safer and more consistent production. These findings indicate that hands-on training and follow-up assistance in used cooking oil upcycling can strengthen community knowledge and practical skills while creating opportunities for value-added community-based activities. However, further mentoring is needed to assess the sustainability of production and the actual economic outcomes.

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INTRODUCTION

Rising household cooking oil consumption has led to an increase in used cooking oil (WCO) generation. Improper disposal of WCO into drainage systems and the environment can contribute to sewer blockages, water and soil contamination, and broader environmental degradation. Therefore, effective WCO management should not only focus on reducing its environmental burden but also on recovering its potential as a secondary resource (Azwin et al., 2024; Foo et al., 2022; Juwono et al., 2024). Beyond its disposal as household waste, WCO has considerable potential for valorization into various value-added products. Previous studies have reported the utilization of WCO as a feedstock for biodiesel, biolubricants, liquid detergents, soaps, biosurfactants, solvents, polymer-related materials, asphalt additives, and other bio-based products. These applications demonstrate that WCO can be regarded not merely as a waste stream but as a

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secondary resource that can support resource recovery and circular economy practices (Awogbemi et al., 2021; Foo et al., 2022; Caporusso et al., 2025).

Among these valorization pathways, the conversion of WCO into candles is a relatively accessible option for community-level production, as the process can be implemented using basic filtration, heating, blending with structuring agents, fragrance addition, and molding. Experimental studies have demonstrated the technical feasibility of incorporating refined WCO into candle formulations. For example, WCO, combined with palm stearin and essential oil, has been evaluated for melting point, burning time, organoleptic characteristics, and user preference, indicating its potential as a candle-making feedstock (Ramadhani et al., 2023).

Compared with conventional candle production based on virgin wax materials such as paraffin, the principal advantage of WCO-based candles is not necessarily superior combustion performance, but their environmental and resource-recovery value (Rizqi et al., 2025; Sari & Kusumastuti, 2025). Conventional waxes such as paraffin, soy wax, and beeswax exhibit distinct melting and combustion characteristics that depend on their composition and wick configuration (Furlong et al., 2023). In contrast, the use of WCO provides an opportunity to divert an existing household waste stream from inappropriate disposal and transform it into a functional product. Thus, WCO-based aromatherapy candles can offer a distinctive value proposition by integrating waste reduction, resource recovery, and potential household-level economic activity (Bachtiar et al., 2022; Firdausi et al., 2024; Nuriskasari et al., 2022).

The Atlantic Village Housing Complex (RT.63) in Balikpapan City is a residential area with significant potential for effective household waste management, supported by an active Waste Bank. However, preliminary assessments indicate that used cooking oil generated by residents is not being used optimally, with the majority discarded after use. This situation highlights the need to enhance residents' knowledge and skills in techniques for transforming used cooking oil into value-added products that can be produced independently in their own neighborhood.

The challenge, however, was not only the lack of awareness of WCO waste but also the limited practical capacity to convert it into a standardized, potentially marketable product. This condition highlights the need for a community-based intervention that combines environmental awareness, practical production skills, and basic product standardization. This community service program therefore aimed to improve the knowledge and practical skills of residents and the Waste Bank community of RT 63 in transforming WCO into value-added aromatherapy candles, with support from a Standard Operating Procedure (SOP) to ensure safer, more consistent production.

MATERIALS AND METHODS

Materials

The primary materials used in this community service activity included used cooking oil (WCO) as the main ingredient, stearic acid as the solidifying agent, fragrance oil for aroma, wax crayons for colorants, cotton wicks, glass containers, label stickers, and packaging materials. The production process also involved basic equipment, including a portable gas stove, an aluminum pot, a measuring cup, a digital scale, a thermometer, and a stirring utensil. These materials and equipment were used during the initial candle-making training and subsequent product development activities.

Methods

This community service activity was conducted at the Atlantic Village Housing Complex (RT 63), Balikpapan City, targeting the local Waste Bank community and residents. The activity employed the Participatory Action Research (PAR) method, actively involving the community from the problem identification and implementation stages through to program evaluation. Through this approach, residents acted not merely as training participants but as active contributors at every stage, ensuring that the solutions provided were well-aligned with the partners' specific needs and circumstances. This community service activity was carried out systematically, following a planned workflow. The detailed stages of the program's implementation, ranging from initial identification to the closing phase, are visually presented in the flowchart (Fig. 1).



Fig. 1. Stages of implementing community service activities

Participants

The participants consisted of 30 residents and members of the Waste Bank community at Atlantic Village Housing Complex (RT.63), Balikpapan.

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Participants were involved in the training activities, including the introduction to aromatherapy candle production, demonstrations, and hands-on practice. The participants were coordinated through the local community and the Waste Bank administrators with the support of the RT 63 head. All 30 participants completed both the pre-test and post-test questionnaires, and their responses were used to evaluate changes in knowledge following the training activities.



(a)

(b)

(c)

Fig. 2. The hands-on training at the Atlantic Village Housing Complex (RT 63): (a) participants and the implementation team preparing the oil–stearic acid mixture on a portable stove; (b) heating of the mixture while glass containers were prepared for molding; (c) a participant pouring the colored mixture into a container during the molding stage under the team's guidance

The activity began with a preparatory phase that included team coordination, field observations, identification of partner needs, and a pre-test administered via Google Forms to assess participants' baseline knowledge of the use of used cooking oil. Subsequently, participants received a presentation on the environmental impact of used cooking oil, followed by a demonstration of the aromatherapy candle-making process and hands-on practice under the guidance of the implementation team. Hayati et al. (2024) explain that combining education, demonstrations, and hands-on practice is an effective approach for enhancing community understanding and skills in training programs focused on used cooking oil utilization. A similar approach was adopted by Gustya et al. (2024) through participatory training, which enabled participants to independently practice each stage of making aromatherapy candles (Fig. 2).

Formulation and Production Procedure

The production procedure consisted of several main stages. (1) WCO filtration: used cooking oil was filtered to remove remaining food particles and visible impurities. (2) Ingredient preparation and mixing: The filtered oil was combined with stearic acid and heated using a portable stove while being stirred until the ingredients were properly mixed. (3) Addition of color and fragrance: wax crayons were added as colorants, followed by fragrance oil to provide the desired aroma. (4) Molding: The mixture was poured into prepared containers fitted with wicks and left to solidify. (5) Finishing and packaging: The finished candles were decorated, arranged, and packaged to improve their appearance and presentation. During the follow-up assistance, participants repeated the production process, practiced wax processing, and developed product decorations under the guidance of the implementation team. Based on these activities, an SOP was prepared as a practical reference to help the community carry out the production process more consistently (Table 1).

Table 1. Candle formulation per candle (household measures and equivalent mass)

Component	Household measure
Purified WCO	100 mL
Stearic acid	1 tablespoon
Essential oil	10 drops
Wax crayon (colorant)	¼ crayon

Program outcomes were evaluated using two main approaches: knowledge assessment and direct observation of practical activities. Knowledge was measured using a five-item pre-test and post-test questionnaire administered to 30 participants before and after the candle-making training. Each item represented a knowledge indicator and was assessed using a five-point Likert scale (1 = not know, 5 = very know). The indicators covered knowledge of production materials, understanding of production steps, fragrance-mixing techniques, the importance

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of product quality consistency, and the importance of implementing an SOP. In addition, participants' involvement in the production process was observed during the demonstration and hands-on practice. The evaluation results were presented descriptively, comparing average pre- and post-test scores to identify changes in participants' knowledge after the training.

The quality of the aromatherapy candles was evaluated descriptively through direct observation of the production process and the resulting products. The evaluation focused on the implementation of each production stage, including used cooking oil filtration, ingredient mixing, fragrance and color addition, candle molding, decoration, and packaging. Follow-up activities also included product photography to improve the visual presentation of the candles. However, specific technical characteristics, such as solidification time, melting point, burning duration, flame stability, and soot formation, were not quantitatively tested in this program. Production costs per candle were also not calculated because detailed records of material, energy, and packaging expenses were not collected.

The effectiveness of the training was evaluated using pre-test and post-test questionnaires completed by 30 participants. The questionnaire consisted of five knowledge indicators, each assessed on a five-point Likert scale. The results were analyzed descriptively by comparing the mean scores before and after the training. Knowledge improvement was also summarized using the normalized gain (N-Gain) method (Hake, 1998), calculated from the pre-test and post-test group means using the formula (post-test mean − pre-test mean)/(5 − pre-test mean). The N-Gain results were categorized as high (≥ 0.70), medium (0.30–0.69), and low (< 0.30). This analysis was used to describe changes in participants' knowledge following the training activities.

RESULTS AND DISCUSSION

This section first reports how participants performed during the training, then the gains in knowledge, the quality and cost of the resulting candles, and finally what the evidence does and does not show about the program's sustainability

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Participation and practical performance

The activity involved 30 residents and members of the Waste Bank community at RT 63 who participated in the candle-making training. The training followed a sequence of environmental education, production demonstrations, and guided hands-on practice. Participants were introduced to the process of filtering used cooking oil, mixing the ingredients, adding colorants and fragrance oil, and molding the candles. During the activity, the implementation team provided direct assistance to help participants understand and perform each production stage. The follow-up activity further strengthened their practical experience through repeated wax processing, candle decoration, product photography, and packaging. These activities provided participants with opportunities to develop their production skills and improve the presentation of the resulting products.

Knowledge improvement

Mean scores increased across all five knowledge indicators after the training (Table 2). On a five-point scale, the pre-test means ranged from 1.67 to 2.17, while the post-test means increased to 4.20 to 4.47. The overall mean score increased from 1.85 before the training to 4.33 after the training. The normalized gain (N-Gain)(Hake, 1998), calculated from the group means, was 0.79, which falls into the high category (g ≥ 0.70). The N-Gain values across the five indicators ranged from 0.76 to 0.81, indicating improvements across all assessed topics.

The highest post-test mean was observed for understanding the importance of product quality consistency (4.47). Meanwhile, the largest increases in mean scores were found in understanding the production steps and the importance of implementing an SOP, both increasing by 2.60 points. These results indicate that participants gained a better understanding of the materials, production procedures, fragrance-mixing techniques, product quality consistency, and the role of an SOP in the candle-making process. The improvement was achieved through a combination of material presentations, demonstrations, and hands-on practice. However, the evaluation was based on descriptive comparisons of pre-test and post-test scores; therefore, no statistical significance test was conducted.

Knowledge improvement

Product development was evaluated through direct observation of the candle-making activities and the resulting products. During the initial training, participants practiced filtering used cooking oil, mixing the ingredients, adding colorants and fragrance oil, and molding the candle mixture into containers. The activities were continued through follow-up assistance, in which participants practiced wax processing and candle molding to strengthen their understanding of the production stages.

Further product development activities focused on candle decoration, product photography, and packaging (Fig. 3). Participants were given opportunities to decorate their candles to improve their visual appearance and develop product characteristics. They also practiced taking product

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Table 2. Pre-test and post-test knowledge scores of participants

Indicator	Pre-test (mean ± SD)	Post-test (mean ± SD)	N-Gain
Knowledge of materials	1.90 ±	4.33 ±	0.78
Understanding of production steps	1.80 ±	4.40 ±	0.81
Fragrance-mixing technique	1.73 ±	4.20 ±	0.76
Importance of product quality consistency	2.17 ±	4.47 ±	0.81
Importance of an SOP	1.67 ±	4.27 ±	0.78
Overall (mean of five indicators)	**1.85 ±**	**4.33 ±**	**0.79**

Note: N-Gain = (post-test mean − pre-test mean)/(5 − pre-test mean). N-Gain values were calculated from group means. The categories are high (≥ 0.70), medium (0.30–0.69), and low (< 0.30)

Table 3. Descriptive evaluation of aromatherapy candle products

Parameter	Method	Result
Production process	Direct observation of the candle-making activities	Participants practiced filtering used cooking oil, mixing ingredients, adding colorants and fragrance oil, and molding the candles.
Product appearance	Visual observation of the resulting candle products	Candle products were further developed through decoration activities.
Product finishing	Observation of the final production activities	Participants practiced finishing work, decorating candles, and preparing the finished products.
Product photography	Observation of participants' practical activities	Participants practiced taking product photographs using mobile phones by applying lighting, shooting angles, and composition.
Packaging	Direct observation of packaging	Participants practiced packaging the finished candles to improve their products [the remaining text is cut off in the provided screenshot].

Note: Product evaluation was conducted descriptively through observation of the training activities and resulting products. Quantitative technical testing was not conducted.



(a) (b) (c) (d)

Fig. 3. Aromatherapy candle production and product development activities: (a) and (b) candle molding and solidification processes in glass containers; (c) candle decoration and product finishing during the follow-up activity; and (d) finished aromatherapy candle products after packaging.

photographs with mobile phones, applying basic techniques in lighting, shooting angles, and composition. The finished products were subsequently packaged to improve their presentation and readiness for potential marketing activities.

These activities demonstrate that the program covered not only the basic candle-making process but also the development of product appearance and presentation. An SOP was also prepared as a practical reference to support the implementation of more consistent production procedures. However, the program did not include quantitative technical testing of candle performance, such as solidification time, melting point, burning duration, flame stability, or soot formation. Therefore, the product evaluation was limited to observations of the production process, product appearance, decoration, and packaging (Table 3).

Cost of production

Producing aromatherapy candles from used cooking oil offers an opportunity to transform household waste into value-added products. The

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materials used in the production process included used cooking oil, stearic acid, fragrance oil, wax crayons, cotton wicks, and glass containers, as well as supporting materials for labeling and packaging.

Table 4. Cost of goods sold (COGS) per batch and per candle

Component	Quantity per batch	Unit price (IDR)	Cost (IDR)
Used cooking oil	2000 mL	0	0
Stearic acid	2000 g	50.000	100.000
Essential oil	10 pcs	13.000	130.000
Wax crayon	3 pcs	12.000	36.000
Glass container	35 pcs	5.000	175.000
Fuel (LPG for the gas stove)	4 pcs (230 g each)	29.000	116.000
candle wick	1 pcs	8.000	8.000
Total batch cost			565.000
Candles per batch	15		
COGS per candle			37.667
Selling price per candle			65.000
Gross margin per candle (%)			42,05%

Based on the recorded material and fuel expenses, the total production cost per batch was IDR 565,000, producing 15 candles. The fuel cost consisted of four LPG canisters, each weighing 230 g and costing IDR 29,000. Accordingly, the estimated cost of goods sold (COGS) was IDR 37,667 per candle. With a proposed selling price of IDR 65,000 per candle, the estimated gross margin was 42.05% (Table 4). These calculations indicate the potential economic value of converting used cooking oil into aromatherapy candles. However, further production and sales records are needed to verify the consistency of production costs, actual selling prices, and gross margins across subsequent batches. This information will help assess the economic feasibility and potential of the candle products to generate additional income for the Waste Bank community.

Outcomes and limitations

Table 5 summarizes the program's before-and-after indicators. The results show improvements in participants' knowledge of materials (1.90 to 4.33), understanding of production steps (1.80 to 4.40), fragrance-mixing techniques (1.73 to 4.20), quality consistency (2.17 to 4.47), and the importance of SOP implementation (1.67 to 4.27). In practical terms, the program successfully converted approximately 2 L of used cooking oil into 15 aromatherapy candles and produced a written SOP as a production guideline. The estimated production cost was IDR 37,667 per candle, with a proposed selling price of IDR 65,000 and a gross margin of 42.05%.

Table 5. Partner problems, interventions, and measured before-and-after indicators

Problem and intervention	Indicator	Before	After
Used cooking oil discarded; training on filtering and processing	Knowledge of materials (1–5)	1.90	4.33
	Used cooking oil converted into products.	Discarded	2 L into 15 candles
Limited practical skills; demonstration and hands-on practice	Understanding of production steps (1–5)	1.80	4.40
	Fragrance-mixing technique (1–5)	1.73	4.20
	Participants completing all stages independently.	Not measured	Not measured
No standardized quality; SOP development and guidance	Importance of quality consistency (1–5)	2.17	4.47
	Importance of an SOP (1–5)	1.67	4.27
	Written SOP	None	1 document, 8 steps
No product with clear added value; containers, labeling, packaging	Finished, labeled candles	0	35 units
	Unit production cost (COGS)	Not calculated	IDR 37.667
	Gross margin at selling price IDR 65.000	Not calculated	42,05%

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However, the program had several limitations. Knowledge assessments relied on self-rated Likert-scale questionnaires administered immediately after training, and no control group was involved. Product quality testing was conducted on [number] batch(es), while participants' ability to complete all production stages independently was not formally measured. The short program duration also prevented an assessment of long-term production consistency and actual sales performance. Therefore, further mentoring over 3–6 months, supported by production and sales records, is needed to evaluate the sustainability and economic potential of the candle products as an additional source of income for the Waste Bank community.

CONCLUSION

This community service program demonstrated that hands-on training can improve participants' knowledge and practical skills in transforming used cooking oil into aromatherapy candles. The program combined environmental awareness, practical demonstrations, hands-on production, product evaluation, and the development of a Standard Operating Procedure (SOP) to support safer and more consistent production. The evaluation showed improvements across all assessed indicators, with scores increasing from 1.67–2.17 before the training to 4.20–4.47 after the training. The overall normalized gain was high (N-Gain = 0.79), and understanding of product quality consistency reached the highest post-training score (4.47, from 2.17). In addition, participants were able to produce aromatherapy candles with a solid texture and improved product appearance through decoration and packaging activities. The estimated cost of goods sold was IDR 37,667 per candle, based on a proposed selling price of IDR 65,000. These results indicate that upcycling used cooking oil can serve as a practical approach to household waste management while creating opportunities for community-based value-added activities. However, the program's short duration limited the assessment of long-term production sustainability and actual economic outcomes. Further mentoring is therefore recommended to support product standardization, market development, financial management, and continuous production.

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CONFLICT OF INTEREST

The authors declare that there is no conflict of interest regarding the implementation of this activity or the preparation of this article.

AUTHOR CONTRIBUTIONS

All authors contributed equally to the planning process, the implementation of the community service activity, data collection and analysis, the drafting of the scientific article, and the approval of the final manuscript for publication.

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