

Technology Transfer for Anchovy Processing MSMEs in Pesisir Selatan Regency, West Sumatra

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ABSTRACT

Background: Small-scale fisheries micro, small, and medium enterprises (MSMEs) are vital to coastal livelihoods and local food systems in Indonesia. However, many anchovy-processing enterprises still rely on traditional methods with limited temperature control, non-food-grade equipment, and inadequate hygienic practices, resulting in inconsistent product quality and low processing efficiency.

Contribution: This program demonstrates a participatory triple helix model involving government, academics, and fishermen groups to transfer appropriate fish-processing technology to coastal MSMEs. It supported Pandawa Jaya and Teri Sakato through food-grade equipment, temperature monitoring, gas-based heating, hygienic handling training, and value-added product mentoring.

Method: A participatory community engagement approach was implemented through problem identification, needs assessment, solution design, technology introduction, hands-on training, continuous mentoring, and before-and-after evaluation.

Results: The intervention replaced mixed-material boiling containers with food-grade stainless-steel vessels, introduced steam thermometers, and shifted heating from firewood to gas. Processing time decreased from 15 to 8 minutes, while production capacity increased from 10 to 13 kg per batch. Product quality improved through more uniform color, cleaner appearance, more consistent texture, and fewer processing defects.

Conclusion: Community-university partnerships integrating appropriate technology, participatory training, and mentoring can improve food safety awareness, standardize processing practices, enhance production efficiency, and strengthen the sustainability and competitiveness of small-scale fisheries MSMEs.

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1. Introduction

Higher education institutions play an important role in promoting social development through community engagement and collaboration with local communities. Community and university partnerships enable academic institutions to apply research knowledge to real-world challenges while enriching teaching and learning. Through such collaborations, universities can support community development while providing students with opportunities for experiential learning and civic engagement. These partnerships promote mutual learning, strengthen local capacity, and facilitate knowledge exchange among researchers, students, and community members. Engaged scholarship, therefore, enables universities to generate socially relevant knowledge while empowering communities to address development challenges through participatory collaboration and knowledge sharing [1], [2].

In many community engagement initiatives, universities also serve as facilitators of knowledge transfer and technological innovation, supporting local economic development. Effective partnerships typically involve multiple stakeholders, including community enterprises, government agencies, and extension officers who provide technical and institutional support. In this study, such collaboration is conceptualized as participatory triple helix involvement, consisting of government institutions, academics, and community-based fisheries actors working together to support technology transfer and MSME capacity development. Through this multi-stakeholder collaboration, universities and community partners can jointly identify local challenges, develop contextually appropriate solutions, and evaluate the outcomes of development initiatives. [Figure 1](#) illustrates the participatory triple helix framework for technology transfer in coastal fisheries MSMEs, highlighting the interactions among government institutions, academics, and fishermen/MSME groups to improve processing practices, product quality, and market readiness.

Community engagement is particularly important in sectors where livelihoods depend heavily on traditional practices and limited technological resources. In many coastal regions of Indonesia, small-scale fisheries play a crucial role in supporting household income and employment while contributing significantly to national food security and regional economic development. Global fisheries assessments highlight the importance of strengthening sustainable aquatic food systems and improving fisheries value chains to enhance food security and support sustainable livelihoods [3]–[5]. Strengthening post-harvest handling and processing practices, therefore, represents an important strategy for improving the economic resilience of coastal fisheries communities.

Anchovy processing represents one of the key small-scale economic activities in many Indonesian coastal areas. Anchovies are commonly processed into dried or salted products that are widely consumed and traded in domestic markets. Despite their economic importance, anchovy processing in many small-scale enterprises still relies on conventional techniques that lack standardized procedures and adequate sanitation practices. The use of traditional processing equipment, the absence of temperature monitoring during boiling, and limited

knowledge of hygienic fish-handling practices frequently result in inconsistent product quality and increased risks of microbial contamination. Previous studies have shown that weaknesses in post-harvest handling and processing practices can lead to fish spoilage and quality deterioration, ultimately reducing market value and causing economic losses for small-scale fisheries enterprises [6], [7].

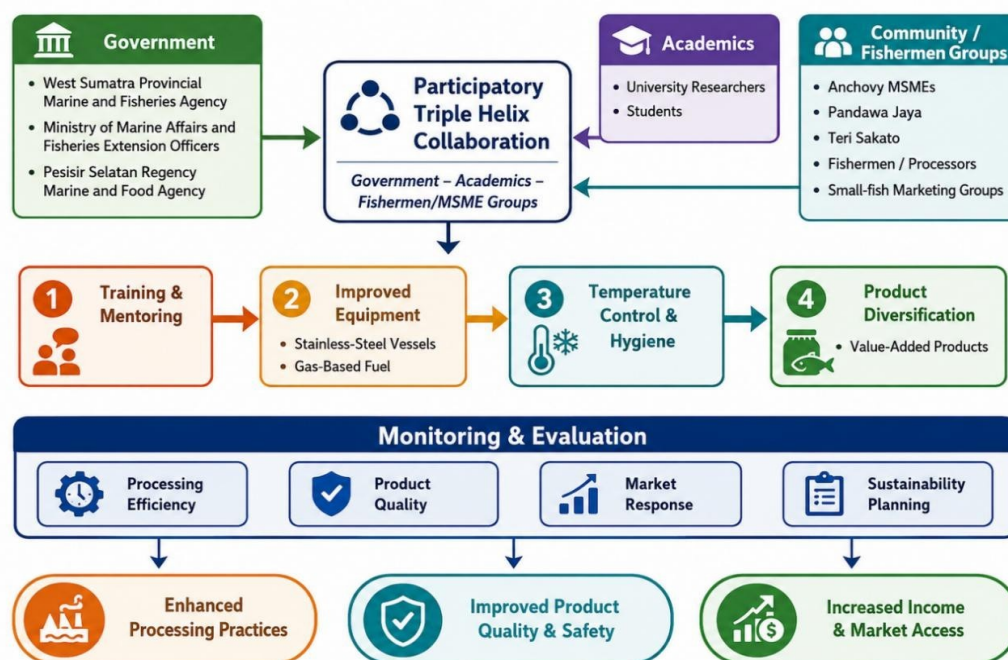


Figure 1. Participatory triple helix framework for technology transfer in coastal fisheries MSMEs

Small-scale anchovy-processing MSMEs commonly face several structural and operational challenges. These include limited access to food-grade processing equipment, insufficient knowledge of temperature-controlled processing techniques, dependence on traditional energy sources such as firewood, and limited product diversification. These constraints reduce production efficiency and limit processors' ability to meet modern food safety standards and market requirements. Table 1 summarizes the main challenges commonly observed in traditional anchovy-processing MSMEs.

Improving processing practices through appropriate technology and knowledge transfer offers a potential solution to these challenges. Technology transfer initiatives aim to introduce practical innovations suited to local conditions and accessible to small-scale processors. The adoption of food-grade processing equipment, temperature-controlled boiling processes, and improved hygienic handling techniques can enhance production efficiency, strengthen food safety practices, and improve product consistency. When combined with training and mentoring activities, such interventions can significantly improve processors' technical capacity and support the sustainability of small-scale fisheries enterprises. Research on food safety practices among fish handlers also highlights the importance of education and capacity building to improve food safety knowledge and promote safer handling behaviors in fish processing environments [8]–[10].

Table 1. Common challenges faced by traditional anchovy-processing MSMEs

Aspect	Common Condition in Traditional Processing	Implications
Processing equipment	Non-food-grade containers	Risk of contamination and poor sanitation
Temperature control	No monitoring system	Inconsistent boiling and product quality
Energy source	Firewood-based heating	Unstable temperature and low efficiency
Processing knowledge	Limited food safety awareness	Higher contamination risk
Product diversification	Single product type	Limited market competitiveness

While many studies have examined technological improvements in fisheries processing, relatively few have explored how community–university partnerships can facilitate the adoption of appropriate technologies among small-scale fisheries MSMEs. Limited research has examined how participatory engagement, collaborative learning, and knowledge exchange between universities and community partners can support technology adoption and capacity development in small-scale fish-processing enterprises. Understanding how these partnerships operate in practice is therefore important for advancing community-engaged scholarships and designing effective development interventions in coastal fisheries sectors.

Community–university partnerships provide a promising framework for implementing technology-transfer initiatives in small-scale fisheries communities. Practice-based engagement projects reported in community engagement journals demonstrate how community service initiatives can combine knowledge exchange, capacity building, and experiential learning opportunities for students. For example, a student-led community service program in Indonesia integrated oral health education with capacity building for community health workers, demonstrating how university–community collaboration can strengthen community capacity while providing valuable field-based learning opportunities for students [11].

Building on this perspective, Universitas PGRI Sumatera Barat (UPGRISBA), Indonesia, particularly through its entrepreneurship program, implemented a community–university partnership program to strengthen anchovy-processing MSMEs in the coastal area of Pesisir Selatan Regency, West Sumatra. The program collaborated with a local anchovy-processing enterprise operating under the Pandawa Jaya and Teri Sakato business groups. Prior to the intervention, the enterprise relied primarily on traditional processing methods such as salting and sun-drying, with limited adoption of improved processing technologies, inadequate food safety practices, and minimal product diversification. The general socio-economic characteristics of the coastal anchovy-processing community are summarized in Table 2. The table highlights the importance of anchovy processing as a key livelihood activity and its contribution to local economic development.

Table 2. Socio-economic characteristics of the coastal anchovy-processing community

Aspect	Description
Main livelihood	Capture fisheries and fish processing
Key commodity	Anchovy (<i>teri mandeh</i>)
Processing scale	Household and small-scale MSMEs
Main products	Dried and salted anchovies
Market distribution	Local and regional markets

In response to these challenges, a community engagement initiative launched a series of technology transfer and capacity-building activities to improve anchovy processing practices. The program includes the introduction of food-grade stainless steel boiling equipment equipped with temperature monitors, a transition from wood-fired heating systems to gas-fired systems, training in hygienic fish handling practices, assistance in developing value-added anchovy products, and the introduction of information technology to support point-of-sale operations. Through collaboration between university researchers, students, local processors, fisheries extension officers, and local government representatives, this program aims to improve processing practices, enhance product quality and food safety, and strengthen the competitiveness and sustainability of anchovy processing SMEs in coastal fishing communities.

The research gap addressed in this article concerns the limited attention to how community–university partnerships facilitate technology adoption among small-scale fisheries MSMEs. Previous studies have examined fish-processing technology primarily from technical, food-safety, or product-quality perspectives. However, fewer studies have explained how participatory engagement, collaborative learning, and continuous mentoring support MSMEs in adopting appropriate technologies in real production settings. Therefore, this article advances the novelty of a partnership-based technology-transfer model, rather than merely reporting the delivery of equipment.

The following program question guides this study: How does community–university collaboration improve technology adoption, processing efficiency, product quality, and capacity development among anchovy-processing MSMEs in Pesisir Selatan Regency? Therefore, this study aims to examine how the UPGRISBA community–university partnership facilitated the transfer of appropriate processing technologies to anchovy-processing MSMEs and how the intervention contributed to improved processing practices, product consistency, production efficiency, and MSME capacity.

2. Method

2.1. Program Location and Community Partners

The community engagement program was implemented in a coastal fisheries area in Pesisir Selatan Regency, West Sumatra, Indonesia, where small-scale fisheries and fish processing activities play an important role in supporting local livelihoods. Anchovy (*teri*

mandeh) processing represents one of the main household-based economic activities in the region. The program collaborated with local anchovy-processing MSMEs operating under the Pandawa Jaya and Teri Sakato business groups. These enterprises mainly produce dried and salted anchovies that are distributed to local and regional markets.

Prior to the intervention, anchovy processing relied largely on traditional methods, including boiling, salting, and sun-drying using conventional equipment. Processing activities were conducted without standardized temperature control or hygienic handling procedures, resulting in inconsistent product quality and reduced production efficiency. To provide a clear overview of the intervention setting, partner groups, participant composition, and stakeholder involvement, Table 3 presents the program location, partners, and participants.

Table 3. Profile program location, partners, and participants

Profile Element	Description
Program location	Coastal fisheries area, Pesisir Selatan Regency, West Sumatra, Indonesia
Partner with MSME groups	Pandawa Jaya and Teri Sakato
Main commodity	Anchovy (teri mandeh)
Processing scale	Household-based and small-scale fisheries MSMEs
Main Products before the program	Dried and salted anchovies
Processors/training participants	25 fishermen/processors from anchovy processing and marketing groups
Government/fisheries agency involvement	5 personnel from the Functional Quality Supervisor division in the field of Strengthening the Competitiveness of Marine and Fisheries Products at the West Sumatra Provincial Marine and Fisheries Service
Student involvement	University students (20)
Student roles	Field coordination, product sampling and testing, logo and packaging design, financial-reporting assistance using a point-of-sales application, and sales and marketing system development
Program duration	October – December 2025

The participant composition reflects the triple helix's participatory involvement, comprising government institutions, academics, and community-based fisheries actors. The government component included the West Sumatra Provincial Marine and Fisheries Agency, extension officers from the Ministry of Marine Affairs and Fisheries, and the Pesisir Selatan Regency Marine and Food Agency. The academic component consisted of university researchers and students, while the community component involved fishermen and MSME groups engaged in the processing and marketing of small fish, particularly anchovies. This composition ensured that the program combined institutional support, academic knowledge, technical extension services, and local production experience.

2.2. Participatory Community Engagement Approach

The program adopted a participatory community engagement approach grounded in triple helix collaboration among government, academics, and community-based fisheries actors. Rather than repeating actor-specific roles, this section emphasizes how these stakeholders worked together to ensure that technological interventions were aligned with local production conditions, users' operational capacity, and affordability constraints. By involving processors and supporting institutions throughout the program, the intervention sought to promote practical technology adoption rather than one-way equipment delivery.

Participatory engagement was implemented through joint problem diagnosis, discussion of feasible technologies, hands-on demonstrations, implementation support, and reflective evaluation. In this process, processors were treated as co-learners and co-implementers rather than passive recipients of technology. The technology-transfer program, therefore, combined the introduction of appropriate processing technologies with capacity-building activities, including training sessions, practical demonstrations, and continuous mentoring. This approach is consistent with community engagement principles, which combine local knowledge, institutional support, and academic expertise to produce workable solutions.

2.3. Stages of Technology Transfer Implementation

The technology transfer initiative was implemented through several sequential stages: problem identification, needs assessment, technology introduction, training, implementation, and monitoring and evaluation. The overall framework of these activities is illustrated in Figure 2.

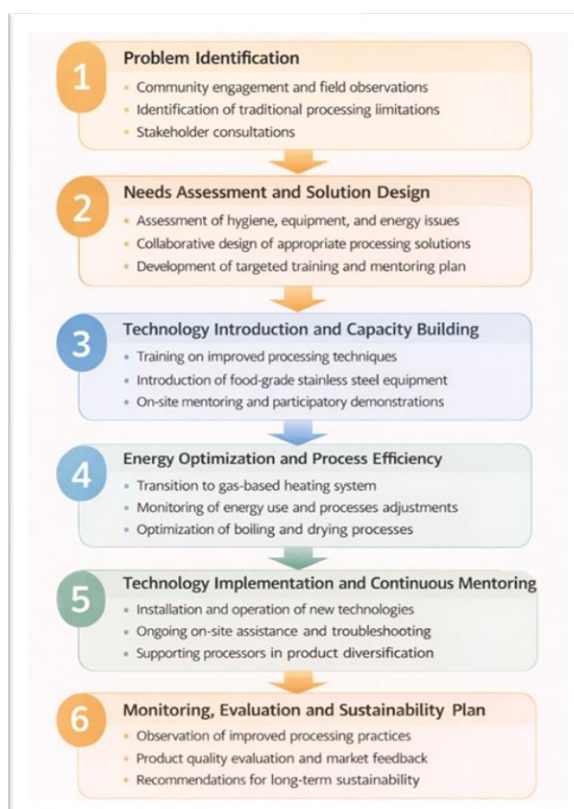


Figure 2. Stages of technology transfer implementation in the anchovy-processing program

2.4. Problem Identification

The first stage involved identifying the technical and operational challenges faced by anchovy-processing MSMEs. Preliminary field observations were conducted at the processing site, followed by participatory consultations with processors from the Pandawa Jaya and Teri Sakato groups, fisheries extension officers, local government representatives, and the academic team from UPGRISBA. This stage enabled the triple helix actors to jointly identify technical, hygienic, and market-related constraints faced by anchovy-processing MSMEs.

The consultations enabled processors to share their experiences regarding existing processing practices and operational constraints. This participatory process ensured that the proposed technological interventions were relevant and feasible within the local production context. The consultation activities during this stage are illustrated in [Figure 3](#), which shows discussions among university researchers, anchovy processors, fisheries extension officers, and government representatives. These discussions facilitated knowledge exchange between academic experts, institutional stakeholders, and community practitioners, enabling the identification of appropriate technological improvements.



Figure 3. Problem-identification meetings and field consultations involving triple helix actors. University researchers, anchovy processors, fisheries extension officers, and government representatives

[Table 4](#) summarizes the main challenges identified during the preliminary assessment. The assessment revealed several key constraints, including the use of non-food-grade boiling containers, the absence of temperature monitoring during boiling, reliance on firewood as the

primary energy source, and limited diversification of anchovy-based products. These factors reduce processing efficiency and limit small enterprises' ability to meet modern food-safety standards and expand market opportunities. Table 4 summarizes the main challenges identified during the preliminary assessment.

Table 4. Key Processing challenges identified during the preliminary assessment

Processing Aspect	Observed Condition	Implication
Boiling equipment	Non-food-grade materials	Potential contamination
Temperature control	No thermometer used	Inconsistent boiling
Energy source	Firewood	Unstable heating
Product	Limited product	Restricted market
Diversification	variation	opportunities

2.5. Needs Assessment and Solution Design

Following the problem identification stage, a needs assessment was conducted to identify appropriate technological solutions to improve hygiene conditions, stabilize boiling temperatures, and enhance processing efficiency without imposing excessive financial burdens on local processors.

During this stage, existing processing equipment and production workflows were evaluated collaboratively with MSME partners. Field observations revealed that traditional boiling equipment was made from mixed materials that were difficult to clean and did not meet food-grade standards. Figure 4 presents an example of the conventional boiling equipment used prior to the intervention, illustrating its limitations in maintaining food safety and process control.



Figure 4. Traditional mixed-material boiling equipment and firewood-based heating were used before the technology transfer

During this stage, existing processing equipment and production workflows were evaluated collaboratively with MSME partners. Field observations revealed that traditional boiling equipment was made from mixed materials that were difficult to clean and did not meet food-grade standards. Based on the assessment results, several technological interventions were designed, including the introduction of food-grade stainless steel boiling vessels, the installation of steam thermometers for temperature monitoring, and the replacement of firewood with a gas-based fuel system.

These technologies were selected because they were affordable, easy to maintain, and compatible with the MSME partners' existing production scale. The key technological interventions implemented in the program are summarized in [Table 5](#).

Table 5. Technology interventions introduced in the anchovy processing program

Intervention	Description	Expected Benefit
Stainless steel boiling vessel	Food-grade boiling container	Improved sanitation and food safety
Steam thermometer	Temperature monitoring device	Controlled boiling process
Gas-based fuel	Alternative heating system	Stable and Efficient heating
Training and mentoring	Capacity-building activities	Improved technical knowledge

2.6. Some Common Mistakes

Improved processing technologies were introduced through a series of hands-on training sessions and technical mentoring activities. The main equipment introduced consisted of food-grade stainless-steel boiling vessels integrated with a gas-based stove and a lid-mounted temperature gauge. This temperature gauge provides accurate temperature readings during the boiling process. It has a maximum temperature limit of 85°C, enabling processors to monitor and regulate boiling conditions more consistently during anchovy processing. The improved equipment used during the program is illustrated in [Figure 5](#).



Figure 5. Food-grade stainless-steel boiling vessel with gas-based heating and a temperature gauge for controlled anchovy boiling

Training activities were conducted using participatory learning methods, including practical demonstrations, interactive discussions, and on-site mentoring during actual processing operations. Through these activities, processors were guided in operating the improved equipment, reading the temperature gauge, monitoring boiling temperatures, and maintaining hygienic processing practices. Maintaining appropriate thermal conditions

during fish boiling is important for ensuring product safety and quality. Controlled thermal treatment can reduce microbial contamination, improve product stability, and support more standardized processing outcomes [12]–[14].

2.7. Technology Implementation and Mentoring

After the training phase, processors implemented improved technologies in their daily production activities. The university team provided continuous mentoring to support processors in operating the equipment, maintaining hygienic processing conditions, and adapting production workflows.



Figure 6. Training, on-site demonstrations, and mentoring activities to improve anchovy processing and hygienic handling

Figure 6 illustrates the mentoring activities conducted during the implementation stage. Through on-site supervision and demonstrations, the project team assisted processors in operating the improved equipment, maintaining proper hygiene practices, and implementing more efficient processing techniques. The mentoring sessions also created opportunities for dialogue between processors and the university team, allowing participants to share experiences and discuss operational challenges encountered during technology adoption.

2.8. Monitoring and Evaluation

Monitoring and evaluation were conducted using a descriptive before-and-after approach. To strengthen the evaluation's academic rigor, the assessment combined direct observation, hygiene and process-control checklists, participant discussions, documentation of process changes, taste-test feedback, and laboratory analysis of value-added anchovy products. Data validity was strengthened through triangulation across field observations, processor feedback, visual documentation, and laboratory test results.

Table 6 and Table 7 presents the evaluation framework used in the program, including the aspects measured, measurement methods, instruments or data sources, evaluators, and the assessment timeframe. The framework was designed to capture both technical improvements, such as equipment use, temperature control, processing time, and production capacity, and capacity-building outcomes, such as improved hygiene practices, product diversification, and processor participation.

Table 6. Evaluation indicators, measurement methods, instruments, evaluators, and timeframe

Aspect Measured	Measurement Method	Instrument/Source	Evaluator	Timeframe
Processing equipment	Comparison of equipment before and after intervention	Observation checklist and photographs	University team and processors	Before and after implementation
Temperature control	Observation of thermometer use and ability to maintain boiling conditions	Temperature-control checklist/boiling log	University team and processors	During training and mentoring
Processing hygiene	Assessment of washing, sorting, surface cleanliness, and handling practices	Hygiene-practice observation checklist	University team and fisheries extension officers	Before and after mentoring
Production efficiency	Comparison of boiling time, heating stability, labor adjustments, and production capacity	Process-time records, processor interviews, and production-capacity documentation; processing time decreased from 15 to 8 minutes, while production capacity increased from 10 to 13 kg	University team and MSME partners	Before and after gas-based heating

Table 7. Evaluation indicators, measurement methods, instruments, evaluators, and timeframe

Aspect Measured	Measurement Method	Instrument/Source	Evaluator	Timeframe
Product quality	Observation of color uniformity, cleanliness, texture, and processing defects	Product-quality checklist and photographs	University team and processors	After product batches
Product diversification	Development and acceptance of value-added products	Taste-testing feedback and stakeholder discussion notes	University team, MSMEs, and fisheries office stakeholders	During the product development stage
Laboratory quality information	Nutritional composition of anchovy jerky	BPSJI laboratory test report	External laboratory	After product development

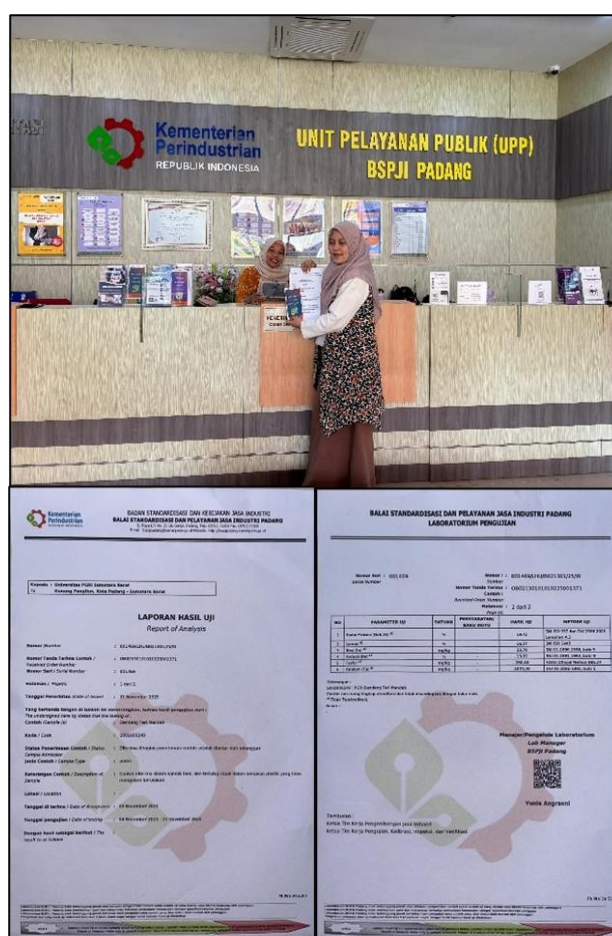


Figure 7. Laboratory submission and test-report documentation for nutritional analysis of the anchovy jerky product

The before-and-after evaluation indicated practical improvements in processing performance, particularly in production efficiency: processing time decreased from 15 to 8 minutes, and production capacity increased from 10 to 13 kg. Laboratory testing focused on the nutritional composition of dendeng teri (anchovy jerky). It was conducted at the Center for Standardization and Industrial Services (BPSJI) of the Ministry of Industry of the Republic of Indonesia. The evaluation focused on several indicators, including improvements in processing hygiene, temperature control, production efficiency, product quality consistency, and the development of diversified anchovy-based products. [Figure 7](#) illustrates the application of the laboratory testing process and the results for nutritional analysis of the dendeng teri product.

3. Results and Discussion

3.1. Improvements in Processing Practices

The monitoring and evaluation activities revealed several improvements in anchovy-processing practices following the implementation of the technology transfer program. Prior to the intervention, anchovy processing in participating MSMEs relied primarily on traditional equipment and manual production methods. Boiling containers made from mixed materials were commonly used, and the boiling process was conducted without temperature monitoring. In addition, firewood served as the primary heating source, resulting in unstable temperatures and requiring continuous manual adjustments during processing.

After the introduction of improved processing technologies, several important changes were observed. The use of food-grade stainless steel boiling vessels equipped with steam thermometers enabled processors to monitor boiling temperatures more accurately and maintain more stable heating conditions. This improvement enabled processors to control cooking time better and reduce variability in the boiling process. In addition, the stainless-steel equipment improved sanitation conditions because it is easier to clean and less prone to contamination than traditional boiling containers.

Improved hygiene practices were also observed during processing activities. Processors demonstrated greater awareness of hygienic fish-handling practices, including improved washing procedures, cleaner processing surfaces, and more careful handling of anchovies during sorting and drying stages. These improvements are important because poor sanitation during fish processing can increase the risk of microbial contamination and spoilage of products. Studies on fish processing have similarly reported that improved hygienic workflows and good manufacturing practices significantly reduce contamination risks and improve product quality [15], [16]. The comparison of processing conditions before and after the technology transfer intervention is summarized in [Table 8](#).

The table illustrates how the introduction of food-grade equipment, temperature-monitoring devices, and improved hygienic practices contributed to more standardized, controlled processing procedures. These improvements demonstrate that relatively simple technological interventions, when combined with training and mentoring, can significantly enhance production practices among small-scale fisheries MSMEs.

Table 8. Comparison of anchovy processing practices before and after the technology transfer intervention

Indicator	Before Intervention	After Intervention
Boiling equipment	Mixed-material container	Stainless steel food-grade vessel
Temperature monitoring	Not available	Steam thermometer installed
Energy source	Firewood	Gas-based fuel
Processing hygiene	Limited sanitation	Improved hygienic handling
Process control	Manual estimation	Temperature-controlled boiling

3.2. Improvements in Production Efficiency and Technology Adoption

In addition to improving processing practices, the technology-transfer program contributed to increased production efficiency and strengthened technology adoption among anchovy-processing MSMEs. Prior to the intervention, anchovy boiling was carried out using traditional firewood stoves. This method often produces fluctuating heat levels, making it difficult for processors to maintain consistent boiling temperatures. As a result, processors had to manually adjust the fire continuously, increasing labor requirements and risking uneven cooking conditions.

The introduction of gas-based heating systems provided a more stable, controllable, and practical heat source for the boiling process. Processors reported that gas heating enabled them to reach boiling temperatures more quickly and maintain more consistent thermal conditions during production. Improved heat stability reduced the need for continuous manual adjustment, simplified the boiling process, and made production activities easier to manage. Quantitative monitoring also indicated that processing time decreased from 15 to 8 minutes, while production capacity increased from 10 to 13 kg after the intervention, suggesting that the shift to gas-based heating contributed to measurable improvements in production efficiency.

These changes can be interpreted through diffusion of innovation theory. The technologies introduced demonstrated a clear relative advantage by improving sanitation, heat stability, and work efficiency. They were also compatible with the existing production scale, were not overly complex to operate, and produced benefits that were directly observable during daily processing activities. These characteristics help explain why processors were able to adopt the equipment and improved practices after hands-on demonstrations and continuous mentoring [17]–[19]. The finding also aligns with technology-adoption studies showing that MSMEs are more likely to accept new technology when they perceive it as useful, easy to operate, affordable, and directly relevant to business performance [20]–[22].

Improved energy systems are widely recognized as an important factor in enhancing productivity among small-scale food-processing enterprises. Previous studies have shown that adopting improved heating technologies can increase processing efficiency, reduce energy consumption, and improve production consistency in small-scale fish-processing operations [23], [24]. The findings of this program are consistent with these observations, as processors

indicated that the new heating system improved process control and supported more efficient production. The use of a steam thermometer further supported the adoption of more reliable and standardized processing practices. By monitoring temperature changes during boiling, processors could better regulate the cooking process and reduce the risk of under- or over-processing anchovies. This improvement not only contributed to production efficiency but also encouraged the development of more standardized production procedures, thereby strengthening the practical adoption of appropriate processing technology among MSME partners.

3.3. Improvements in Product Quality and Food Safety

The improvement in product quality can be attributed to better control of thermal conditions during processing. Maintaining appropriate boiling temperatures is essential for ensuring the safety and stability of processed fish products. Adequate thermal treatment during boiling helps reduce microbial contamination and prevents spoilage during storage. Research on seafood processing has shown that controlled heating processes improve product safety, texture, and shelf life of processed fish products [25], [26].

Another important factor contributing to improved product quality was the improved sanitation of the processing environment. Stainless steel equipment reduces the risk of contamination and allows processors to maintain cleaner processing surfaces. As a result, the final anchovy products appeared more hygienic and visually appealing. These improvements are particularly important for small-scale processors seeking to expand their market opportunities, since product appearance and consistency are key factors influencing consumer acceptance. The observed improvements in product quality indicators are summarized in Table 9, which shows differences in color uniformity, product cleanliness, texture consistency, and processing defects before and after the technology transfer program.

Table 9. Observed improvements in anchovy product quality

Product Quality Indicator	Observation Before Program	Observation After Program
Color uniformity	Uneven color	More uniform color
Product cleanliness	Moderate	Improved hygiene
Texture	Inconsistent	More consistent texture
Processing defects	Occasionally overcooked	Reduced defects

3.4. Product Diversification and Market Response

In addition to improving traditional anchovy-processing practices, the program encouraged processors to explore opportunities for product diversification. Prior to the intervention, the participating MSMEs mainly produced conventional salted and dried anchovies. Although these products are widely consumed, the limited product variety restricts opportunities for value addition and market expansion.

Through mentoring and product-development activities, processors were introduced to the concept of value-added anchovy products, including flavored anchovies and anchovy-based snack products. These activities involved collaborative experimentation in product formulation and processing techniques. Processors learned how to modify seasoning, drying conditions, and packaging to create new product variations that could appeal to a broader range of consumers.

Examples of the diversified anchovy products developed during the program are presented in [Figure 8](#). The development of new product variations provided processors with opportunities to increase the economic value of their products and differentiate them from conventional anchovy products available in the market.



Figure 8. Example of diversified value-added anchovy products developed through the program

To assess the initial market response, taste tests were conducted in collaboration with the West Sumatra Provincial Marine and Fisheries Office. Participants provided feedback on product taste, texture, and overall acceptability. This activity also demonstrated the role of the triple helix in linking academic product development support, government feedback, and fishermen/MSME participation to assess the market potential of diversified anchovy-based products. The responses were generally positive, suggesting that diversified anchovy products have potential for further market development. The taste-testing activities are illustrated in [Figure 9](#).

Although the feedback indicated encouraging acceptance, the evaluation remained descriptive. Future assessments should convert this feedback into measurable indicators, such as average sensory scores, number of participants, and willingness-to-purchase responses. This would strengthen the evidence base for assessing consumer acceptance and market feasibility of diversified anchovy products.

Product diversification is widely recognized as an effective strategy for enhancing the competitiveness of fisheries products. Studies have shown that developing value-added seafood products can increase product value, improve market competitiveness, and create additional income opportunities for small-scale fisheries enterprises [27]–[29]. The results of

this program, therefore, demonstrate that technology transfer, when combined with product innovation and triple-helix collaboration, can support the economic development of coastal fisheries MSMEs.



Figure 9. Triple helix stakeholder taste-testing and discussion of diversified anchovy-based products with government representatives, academics, and anchovy-processing MSMEs

3.5. Community and Institutional Impact

Beyond technical improvements in processing technology and product development, the program generated broader social and institutional benefits for the participating MSMEs and the surrounding coastal community. From a technical perspective, processors gained knowledge of temperature-controlled boiling, hygienic fish handling, the use of food-grade processing equipment, and standardized production procedures. From an economic perspective, the introduction of improved technology and value-added anchovy products created opportunities to increase product value, expand market access, and reduce dependence on single commodity form.

Economically, the introduction of improved processing technologies and value-added products created opportunities to increase product value and expand market access. The ability to produce a diverse range of anchovy products may help processors reach new consumer segments and reduce reliance on a single product type.

Socially, the program strengthened participatory triple helix collaboration among government institutions, academics, and community-based fisheries actors. The government component, represented by the West Sumatra Provincial Marine and Fisheries Agency, fisheries extension officers from the Ministry of Marine Affairs and Fisheries, and the Pesisir Selatan Regency Marine and Food Agency provided institutional support, technical guidance, and market-related feedback. The academic component contributed research-based knowledge, student participation, product-development assistance, and continuous mentoring. Meanwhile, fishermen and MSME groups contributed local production knowledge, participated in technology adoption, and tested improved processing and marketing practices in [Table 10](#). This collaboration facilitated knowledge exchange, built trust among participating actors, and strengthened the local support system for the development of anchovy-processing MSMEs [30].

Table 10. Summarizes the main program outcomes and community impacts, including observed changes and the supporting evidence for each impact category

Impact Category	Observed Outcomes	Evidence/Source
Technical impact	Adoption of food-grade processing equipment, gas-based heating systems, and temperature-monitoring practices	Observation and before and after comparison
Production efficiency	Improved heat stability, reduced manual adjustment, and reduced processing time	Observation, processor, discussion, and processing-time records
Product quality	More consistent color, texture, cleanliness, and processing outcomes	Product-quality observation and visual documentation
Economic opportunity	Development of diversified anchovy-based products with potential for market expansion	Product-development activities and taste-testing feedback
Community capacity	Increased knowledge of food safety, hygienic handling, temperature control, and improved processing techniques	Training and mentoring observation
Student learning	Improved student understanding of MSME challenges, needs assessment, community engagement, and collaborative problem-solving	Student participation in field activities and mentoring
Institutional collaboration	Strengthened participatory triple helix collaboration among government institutions, academics, fisheries extension officers, and fishermen/MSME anchovy-processing groups	Program documentation, stakeholder discussions, field consultations, training activities, and taste-testing sessions

As seen in [Table 10](#), the partnership model also created reciprocal learning. MSME partners gained access to appropriate technology, practical demonstrations, and continuous mentoring, while students gained experiential learning in community engagement, needs assessment, and collaborative problem-solving. This supports the theoretical contribution of the study: community–university partnerships can function as a mechanism for translating academic knowledge into locally adoptable innovation, especially when technological tools are

accompanied by trust-building, demonstration, and continuous mentoring [31]–[33]. This interpretation is also consistent with recent service-learning and community-engaged learning literature, which shows that community-based academic activities can strengthen students' academic, social, civic, and practical learning outcomes while addressing real community needs [34], [35].

Overall, the findings demonstrate that integrating appropriate technology transfer, participatory training, product innovation, and continuous mentoring can improve the technical capacity, product quality, production efficiency, and economic potential of small-scale fisheries MSMEs. These outcomes highlight the importance of community–university partnerships as a practical approach to supporting sustainable development in coastal fisheries communities.

Based on the findings and research results that have been obtained, several things can be done in the future for further research. First Future activities should assist MSMEs in completing the administrative and technical requirements for product legality and certification. This includes support for obtaining the P-IRT certificate, halal certification, food-safety certification, and product-label compliance. Such support is essential for strengthening consumer trust, expanding access to formal markets, and improving the readiness of anchovy-based products for broader distribution.

Second, Modern packaging technology should continue to be developed to improve shelf life, product appearance, hygiene protection, branding, and market readiness. In this program, the modern packaging design has been finalized; however, it has not yet been launched on the market because the product is still awaiting the processing of the P-IRT certificate, halal certification, and food-safety certification. The finalized packaging design, pending market introduction, is shown in Figure 10. This packaging is expected to support product differentiation and enhance the competitiveness of value-added anchovy products compared with conventional products in local and regional markets.



Figure 10. Finalized modern packaging design pending product certification and market launch

Fourth, digital marketing should become the next stage of capacity-building. MSMEs need training in product photography, marketplace registration, social media content creation, digital payment systems, and customer feedback management. These skills would help processors expand their customer reach, improve customer engagement, and adapt to changing consumer purchasing behavior. Fifth, future evaluation should apply more rigorous mixed-method indicators, including processing-time measurement, fuel-cost comparison, production-output records, hygiene scores, sensory-test scores, and post-program sales monitoring. This agenda would enable future studies to examine not only immediate changes in processing practices but also long-term economic resilience, market access, and technology sustainability among coastal fisheries MSMEs.

4. Conclusion

This study demonstrates that a community–university partnership effectively strengthened the capacity and performance of anchovy-processing MSMEs through appropriate technology transfer and participatory capacity-building. The intervention successfully addressed major processing constraints by introducing food-grade equipment, temperature-controlled boiling systems, gas-based heating technology, improved hygienic handling practices, and product diversification. The findings confirm that successful technology adoption depends not only on the provision of equipment but also on participatory engagement, hands-on training, continuous mentoring, and institutional collaboration. Practically, the program improved processing hygiene, product consistency, food-safety awareness, value-added product development, competitiveness, and market readiness. The study further highlights the importance of a participatory triple helix approach involving universities, government institutions, and fishermen/MSME groups in supporting sustainable technology adoption, innovation, and institutional strengthening within coastal fisheries communities. Future community engagement programs should further strengthen the participatory triple helix model by ensuring continuous coordination among government institutions, academics, and fishermen/MSME groups involved in anchovy processing and marketing. This collaboration is important to sustain technology adoption, support certification readiness, improve product standardization, and expand market access for value-added anchovy products. Future programs should therefore move beyond general dissemination and focus on a staged sustainability agenda.

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