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Empowering Coastal Communities through Training on Blue Swimming Crab Shell Waste Utilization for Feed Pellet Production in Nisombalia Village

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ABSTRACT

Blue swimming crab shell waste is a by-product of fisheries processing that remains underutilized and has potential for further development through waste valorization. This community service activity aimed to facilitate members of the SIPARESO Creative Economy Group in practicing the utilization of blue swimming crab shell flour as an additional ingredient in the production of feed pellet prototypes and to describe the implementation of the practical process, participants' responses, and the outputs produced. The activity was conducted on August 9, 2026, in Kuri Caddi Hamlet, Nisombalia Village, Marusu District, Maros Regency, South Sulawesi, Indonesia, involving 15 group members. A participatory hands-on approach was employed, comprising education, demonstration, guided group practice, mentoring, and evaluation. Data were collected through observations of group practice implementation, participant interviews, and documentation of the process and outputs. The nominal formulation used approximately 5 kg of ingredients, including 0.5 kg of blue swimming crab shell flour, representing approximately 10% of the total formulation. The results showed that the group was able to carry out the basic stages of ingredient preparation, mixing, steaming, and other processing procedures, with varying levels of assistance required across stages. Participants viewed the utilization of blue swimming crab shells as an alternative approach to utilizing fisheries by-products; however, its sustainability remains dependent on the availability of equipment and materials, process standardization, and continued technical assistance. Overall, the activity demonstrated the feasibility of transferring simple processing technology for the utilization of blue swimming crab by-products at the coastal community group level.

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INTRODUCTION

Coastal areas possess fisheries resources that play an important role in supporting local livelihoods and economic activities. One economically valuable fishery commodity commonly found in coastal areas is the blue swimming crab (Portunus pelagicus). The utilization and processing of fishery commodities generate not only economically valuable primary products but also various side streams, including heads, bones, skins, viscera, and shells. These side streams are often treated as waste even though they contain components that can potentially be recovered and utilized for various purposes. Advaitha et al. (2026) explained that seafood side streams offer opportunities for valorization through the recovery and reuse of their constituent components, thereby supporting resource efficiency, waste reduction, and the implementation of circular economy principles. The utilization of fishery side streams is therefore becoming increasingly important in efforts to develop more sustainable aquatic food production systems.

One potentially valuable side stream is crustacean shell waste. Blue swimming crab shells are not merely residual materials from processing activities; they contain various components, particularly chitin and minerals, that offer opportunities for a range of applications. Tissera et al. (2021), in their study of blue swimming crab (Portunus pelagicus) shell waste, demonstrated that crab shells can serve as a source material for the extraction of chitin and chitosan. More recent studies have also indicated that crustacean shell waste can be directed toward various valorization pathways, allowing materials previously regarded as waste to be repositioned as secondary resources (Advaitha et al., 2026). Consequently, the issue of shell waste extends beyond residue management to include how these materials can be reutilized through approaches that are appropriate to the conditions and capacities of local communities. In Indonesia, crab shell waste has also been utilized through community-based processing initiatives, including its conversion into chitosan, demonstrating opportunities to transform locally available shell waste into value-added materials (Fatnah et al., 2024).

The utilization of fishery side streams is consistent with the paradigms of the circular economy and blue economy. At the community level in Indonesia, similar approaches have been applied by integrating crab waste utilization with the economic empowerment of fishing households and the development of locally based blue-economy initiatives (Sianturi et al., 2025). Within a circular economy framework, residual materials are retained within cycles of use through reuse, processing, or transformation into other products, thereby minimizing resource losses. Seafood side-stream upcycling has been explored for various applications, including food, animal feed, fertilizers, pharmaceuticals, and energy (Ambarasan et al., 2024). In the context of the blue economy, the valorization of fishery side streams is also relevant because the sustainable use of marine resources is concerned not only with increasing production but also with improving resource efficiency and reducing material waste. The sustainable processing of seafood side streams can therefore contribute to the development of a circular blue economy (Venugopal, 2026).

These issues are particularly relevant to Nisombalia Village, Marusu District, Maros Regency, South Sulawesi, Indonesia. Nisombalia is a coastal village with considerable blue swimming crab fishery potential, where approximately 336 active fishers depend economically on this commodity. Blue swimming crab management in the area faces several challenges, ranging from pressure on catches and suboptimal post-harvest management to the limited utilization of processing side streams. Blue swimming crab processing activities have been reported to generate approximately one ton of shell waste per week, which has not yet been optimally utilized. This condition indicates a gap between the availability of fishery side-stream materials and the community's capacity to transform them into products with potential for further utilization. Previous community-based initiatives in Kuri Caddi have similarly identified the underutilization of blue swimming crab shell waste and explored its conversion into value-added products, including crab-shell seasoning powder (Sahribulan et al., 2024).

Addressing the shell-waste problem in Nisombalia requires more than simply introducing the concept of waste management. Community-based experiences in Indonesia further indicate that the utilization of crab shell waste requires not only technological introduction but also training, mentoring, and the strengthening of community capacity to transform waste into usable products (Fatnah et al., 2024; Seprianto et al., 2025). Efforts are needed to translate the potential of these materials into technologies that can be understood and practiced by local communities. This is particularly important because seafood side-stream valorization is not solely a technical matter of material processing. Advaitha et al. (2026) indicated that the development of seafood side-stream valorization continues to face technical, economic, regulatory, and user-acceptance challenges. At the community level, therefore, the introduction of technology needs to take into account local capacities, ease of processing, the availability of materials and equipment, and the potential for activities to continue after the formal assistance program has ended.

One alternative introduced to the community in Nisombalia Village was the utilization of blue swimming crab shell flour as an additional ingredient in the production of feed pellet prototypes. This approach was not intended to imply that blue swimming crab shell waste is a feed ingredient that has already been demonstrated to meet the nutritional requirements of cultured organisms. Rather, it represented an initial attempt to utilize a fishery side stream by transforming the material into a product prototype. The literature indicates that seafood side streams may have potential applications in feed production. Indonesian studies have specifically investigated the incorporation of blue swimming crab shell flour into feed formulations for different target organisms (Kurnia et al., 2016; Nurjannah et al., 2017; Hamka et al., 2020; Fadilat et al., 2022). However, its use requires careful consideration of material characteristics, processing methods, formulation, and the nutritional requirements of the target organism. Accordingly, the use of blue swimming crab shell flour in this activity was positioned within the stages of technology transfer and prototype development, rather than as an attempt to demonstrate the nutritional quality or biological effectiveness of the resulting product.

The need for technology transfer provided the basis for conducting the training with the SIPARESO Creative Economy Group in Nisombalia Village. Similar community empowerment initiatives in Indonesian coastal areas have demonstrated the relevance of participatory training and mentoring in converting crab shell waste into value-added products and strengthening the productive capacity of coastal community groups (Mustafa et al., 2026; Sianturi et al., 2025). Community groups are important actors because the sustainability of fishery side-stream utilization at the local level depends considerably on their ability to understand processing procedures, use appropriate technologies, organize production activities, and continuously develop innovations. Within the rajut laut program, the utilization of blue swimming crab waste was positioned as part of creative-economy development and community institutional strengthening through training and mentoring. Through a practice-based approach, participants not only received information about the potential utilization of blue swimming crab shell waste but also directly participated in the stages of feed pellet prototype production, allowing knowledge transfer to take place through practical experience.

Although previous studies have demonstrated the potential for utilizing blue swimming crab shell waste through various pathways, including chitosan production, food products, and feed-related applications (Fatnah et al., 2024; Sahribulan et al., 2024; Sianturi et al., 2025; Mustopa & Risladiba, 2026), translating this potential into simple technologies that can be introduced and practiced by coastal community-based economic groups remains an important aspect of community empowerment. The gap addressed by this activity lies not in the development of a novel feed formulation, but in transferring knowledge and providing practical experience in the utilization of blue swimming crab shell waste to a community group that had not previously optimized the use of this material. This positioning is important for distinguishing an empowerment-oriented community service activity from experimental research designed to evaluate the nutritional composition, safety, or effectiveness of a feed formulation.

Based on these considerations, this community service activity aimed to provide members of the SIPARESO Creative Economy Group with practical experience in utilizing blue swimming crab shell waste as an additional ingredient in the production of feed pellet prototypes and to describe the implementation of the practical process, participants' responses, and the products generated during the activity. The activity was expected to serve as an initial step toward strengthening the group's capacity to utilize fishery side streams more productively while providing a basis for further development, including process standardization, product characterization, nutritional and safety analyses, feeding trials, and economic feasibility assessment before the product is directed toward broader production and utilization.

METHOD

2.1 Location, Time, and Target Participants

The community service activity was conducted on August 9, 2026, in Nisombalia Village, Marusu District, Maros Regency, South Sulawesi, Indonesia. The activity was part of the RAJUT LAUT program, which integrates sustainable blue swimming crab management with institutional strengthening and the development of a creative economy based on the utilization of blue swimming crab side streams. Within the program design, the utilization of blue swimming crab waste was positioned as a form of social and economic innovation developed through community capacity building, training, and mentoring.

The target participants were 15 members of the SIPARESO Creative Economy Group in Nisombalia Village. The group members participated in the training and practical activities involving the utilization of blue swimming crab shell waste as an additional ingredient in the production of feed pellet prototypes. The target group was selected in accordance with the RAJUT LAUT program's orientation toward strengthening community institutions while promoting the utilization of blue swimming crab shell waste to produce products with potential for further development. This was consistent with the community needs assessment, which identified the creation of added value through waste utilization as one of the program needs.

2.2 Implementation Approach

The activity employed a participatory hands-on training approach. This approach positioned participants not merely as recipients of information but as active participants in material processing and prototype production. Operationally, the activity consisted of four main stages: (1) education, (2) demonstration, (3) guided group practice, and (4) evaluation and reflection.

During the education stage, participants received information on the definition and types of fish feed, forms of manufactured feed, raw materials for pellet production, the utilization of blue swimming crab shell flour, vitamins and supplements, production equipment, formulation, and production procedures. The training materials designated fish meal and corn flour as the main ingredients, rice bran as a supporting ingredient, crab shell flour as an additional ingredient, and tapioca flour as a binder.

The demonstration stage involved presenting the procedures and the use of the required materials and equipment. Participants subsequently engaged in group practice under the guidance of the implementation team. The group-based approach was adopted to provide participants with direct experience in following the production stages while encouraging interaction and the division of roles among group members. The final stage consisted of evaluation and reflection to document process implementation, challenges encountered during practice, participant responses, and the products generated.

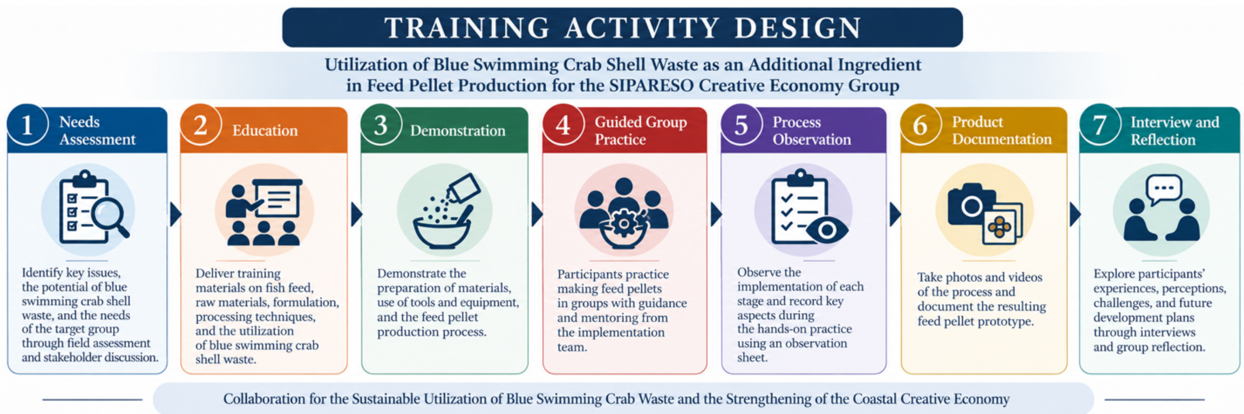

Figure 1. Training Activity Design

2.3 Materials and Equipment

The materials used in the practical activity consisted of fish meal, corn flour, fine rice bran, blue swimming crab shell flour, tapioca flour as a binder, and vitamins and supplements. Supporting materials introduced during the process included Top Mix, EM4, molasses, and yeast. The training materials specifically included EM4, Top Mix, molasses, and yeast among the vitamins and supplements used in the processing procedure.

The main equipment used or introduced during the activity included weighing and mixing equipment, a grinding machine, and a pellet-making machine. Other supporting equipment used during the practical activity was adapted to the requirements of material preparation, steaming, fermentation, drying, and product handling.

2.4 Feed Pellet Prototype Formulation

The formulation introduced during the training was designed to produce approximately 5 kg of mixture. It consisted of 1.8 kg of fish meal, 1.8 kg of corn flour, 0.5 kg of fine rice bran, and 0.5 kg of blue swimming crab shell flour, resulting in 4.6 kg of main and supporting ingredients. Subsequently, 0.385 kg of tapioca flour was added as a binder, together with 0.015 kg of vitamins/supplements, bringing the total formulation to approximately 5 kg.

Table 1. Formulation Used in Feed Pellet Prototype Production

No.	Ingredient	Amount (kg)	Proportion (%)
1.	Fish meal	1.800	36.00.00
2.	Corn flour	1.800	36.00.00
3.	Fine rice bran	0,34722222	10.00
4.	Blue swimming crab shell flour	0,34722222	10.00
5.	Tapioca flour	0,26736111	07.07
6.	Vitamins/supplements	0.015	00.03
	Total	5.000	100.00.00

Based on this composition, blue swimming crab shell flour accounted for approximately 10% of the total formulation. Therefore, in this activity, crab shell flour was positioned as an additional ingredient rather than a primary ingredient in the feed pellet prototype.

2.5 Feed Pellet Prototype Production Procedure

The practical procedure followed the training materials used during the activity. First, each ingredient was weighed according to the specified formulation. The raw materials were then thoroughly mixed with the vitamins. Tapioca flour was dissolved in hot water and subsequently incorporated into the mixture as a binder. After mixing, the material was steamed for approximately 30 minutes.

In the subsequent stage, a solution of molasses, EM4, and yeast mixed with approximately 500 mL of water was added to the material. The mixture was then subjected to fermentation for two days or longer, followed by drying and pelletizing using a pellet-making machine. This sequence followed the procedure specified in the training materials.

Saya menggunakan “was subjected to fermentation” daripada *was fermented* karena lebih tepat untuk menjelaskan tahapan prosedural tanpa mengklaim karakteristik atau keberhasilan fermentasi secara biologis.

2.6 Data Collection and Activity Evaluation

The activity was evaluated using a descriptive approach based on observations of group practice implementation, interviews, and documentation of the process and products. These three sources of data were used to provide complementary perspectives on the implementation of the training activity.

First, observations focused on the implementation of the group practice rather than on the individual abilities of the 15 participants. The observed aspects included preparation and weighing of ingredients, preparation of crab shell flour, ingredient mixing, preparation of the binder, steaming, preparation of fermentation materials, fermentation, drying, pelletizing, implementation of sanitation and occupational safety practices, product formation, and final product handling. Each stage was classified into three categories.

Table 2. Categories Used to Assess Activity Implementation

No.	Category	Operational Definition
1.	Implemented with minimal guidance	The group was able to carry out the stage with minimal guidance
2.	Implemented with assistance	The stage could be completed but required guidance or assistance from the implementation team
3.	Not yet implemented	The stage could not be completed during the observed process

Field notes and documentation were used as supporting evidence for interpreting the implementation of each stage.

Second, semi-structured interviews were conducted to obtain information on participants' experiences during the activity, their perceptions of blue swimming crab shell waste utilization, stages perceived as easy or difficult, technical constraints, equipment and material requirements, and their views regarding the potential continuation of the activity. The interviews were used as a source of qualitative information and were not intended to generate numerical scores.

Third, documentation was conducted throughout the implementation stages and for the resulting products. The documentation included photographs or records of the materials, mixing process, processing stages, equipment use, pelletizing, drying, and the final form of the prototype. The documentation served as physical evidence supporting the observation and interview findings.

2.7 Data Analysis

The data were analyzed using qualitative descriptive analysis. Observation findings were presented in an implementation matrix covering the implementation status of each practical stage, the level of assistance required, and relevant observations recorded during each stage. Means, standard deviations, individual success percentages, and statistical tests were not used because the practical activity was conducted at the group level and no individual-level skill measurements were performed.

Interview data were analyzed through data reduction, initial coding, category grouping, and theme identification. Relevant participant statements were grouped according to similarities in meaning to identify themes related to perceptions of waste utilization, practical experiences, technical constraints, supporting requirements, and sustainability potential. The final themes were derived from the available interview data rather than predetermined in advance.

Documentation data were analyzed descriptively to confirm the implementation of the practical stages and the presence of a physical output in the form of a feed pellet prototype. Information obtained from observations, interviews, and documentation was subsequently compared through triangulation of data sources and evidence to enhance the credibility of the description of the activity outcomes.

RESULTS AND DISCUSSION

3.1 Implementation of Practice-Based Training

The training on the utilization of blue swimming crab shell waste as an additional ingredient in feed pellet prototype production was conducted on August 9, 2026, in Nisombalia Village, Marusu District, Maros Regency, South Sulawesi, Indonesia. The activity involved 15 members of the SIPARESO Creative Economy Group. The training was part of the community empowerment activities implemented under the RAJUT LAUT program, one of whose orientations is the development of a creative economy through the utilization of blue swimming crab side streams.

The activity employed a participatory hands-on training approach consisting of educational sessions, demonstrations, guided group practice, and evaluation/reflection. This approach positioned SIPARESO members as active participants in the practical activities, enabling them not only to acquire information about crab shell waste utilization but also to participate directly in processing the materials into a prototype product.

The training covered an introduction to fish feed, types and forms of feed, pellet ingredients, the utilization of blue swimming crab shell flour, binders, vitamins and supplements, formulation, equipment, and production procedures. In the training materials, fish meal and corn flour were designated as the main ingredients, rice bran as a supporting ingredient, crab shell flour as an additional ingredient, and tapioca flour as a binder.

The practice-based nature of the activity was particularly important because the challenge faced by the community involved not only the availability of shell waste but also limited experience in transforming this material into other product forms. Accordingly, the activity focused on knowledge transfer and practical experience as an initial stage of group capacity development, rather than on evaluating the effectiveness of a particular feed formulation.

Figure 2. Delivery of Training Materials on Feed Pellet Prototype Production to Members of the SIPARESO Creative Economy Group

Figure 3. Group Practice in Mixing Ingredients for Feed Pellet Production with the Addition of Blue Swimming Crab Shell Flour

Figure 4. Processing Equipment Used or Demonstrated during the Training Activity

The hands-on component was important because the empowerment process extended beyond the transfer of information. Direct participant involvement enabled the group to gain experience in understanding the sequence of processing stages, material consistency, division of tasks, and equipment use. In the context of the circular economy, Cooney et al. (2023) emphasized that communication, education, and stakeholder engagement are important elements in the transition toward more circular utilization of seafood side streams.

3.2 Implementation of the Formulation and Processing Stages

One of the main aspects introduced during the training was the use of blue swimming crab shell flour as an additional ingredient in the feed pellet prototype formulation. The training formulation was designed to produce approximately 5 kg of mixture, consisting of 1.8 kg of fish meal, 1.8 kg of corn flour, 0.5 kg of fine rice bran, 0.5 kg of blue swimming crab shell flour, 0.385 kg of tapioca flour, and 0.015 kg of vitamins/supplements.

Table 3. Feed Pellet Prototype Formulation Used in the Training Activity

No.	Ingredient	Amount (kg)	Proportion (%)	Role in the formulation
1	Fish meal	01.08	36.00.00	Main ingredient
2	Corn flour	01.08	36.00.00	Main ingredient
3	Fine rice bran	00.05	10.00	Supporting ingredient
4	Blue swimming crab shell flour	00.05	10.00	Additional ingredient
5	Tapioca flour	0,26736111	07.07	Binder
6	Vitamins/supplements	0.015	00.03	Additional ingredient
	Total	05.00	100.00.00	

Based on this formulation, blue swimming crab shell flour accounted for approximately 10% of the total mixture. This proportion reinforces the fact that the activity did not use crab shell waste as the primary ingredient of the pellets but rather as an additional ingredient in the prototype. This distinction is important to prevent the term “blue swimming crab shell waste utilization” from being interpreted as implying that all or most of the pellet ingredients were derived from shell waste.

The utilization of blue swimming crab shells has a conceptual basis within the valorization of crustacean waste. Crustacean shells constitute a biomass source containing components such as chitin and minerals and have been investigated for various applications. However, the presence of these components does not automatically indicate that the prototype formulation used in this activity possesses specific nutritional qualities.

Therefore, the utilization of crab shells in the SIPARESO activity was positioned as a form of material valorization, while the chemical and nutritional characteristics of the resulting product require further testing. Previous Indonesian studies provide empirical support for the technical possibility of incorporating blue swimming crab shell flour into feed formulations. Kurnia et al. (2016) evaluated crab shell meal in diets for juvenile black tiger shrimp, while Nurjannah et al. (2017), Hamka et al. (2020), and Fadilat et al. (2022) investigated its incorporation into animal feed formulations. Nevertheless, these studies involved experimental evaluation of feed characteristics or biological responses; therefore, their findings should not be interpreted as evidence of the nutritional adequacy or biological effectiveness of the prototype produced in the present community service activity.

3.3 Feed Pellet Production Process

The production process began by weighing the ingredients according to the specified formulation. The raw materials and vitamins were then thoroughly mixed. Tapioca flour was dissolved in hot water before being incorporated into the mixture as a binder. The mixture was subsequently steamed for approximately 30 minutes.

Following steaming, a solution of molasses, EM4, and yeast prepared with approximately 500 mL of water was added to the mixture. The next stage involved fermentation for two days or longer, followed by drying and pelletizing using a pellet-making machine.

The overall process can be summarized as follows:

Ingredient weighing → Mixing → Addition of tapioca binder → Steaming for approximately 30 minutes → Addition of molasses, EM4, and yeast → Fermentation for ≥2 days → Drying → Pelletizing → Feed pellet prototype

Figure 5. Process Flow for Feed Pellet Prototype Production with the Addition of Blue Swimming Crab Shell Flour

This sequence demonstrates that crab shell waste processing did not occur as a stand-alone activity but was integrated into the formulation and pellet production process. From a valorization perspective, this approach illustrates a shift in the function of the material from a processing residue to an input for another production process. However, because fermentation required at least two days, prototype production constituted a series of processes extending beyond the main training session held on August 9, 2026. Therefore, the main training session and the subsequent production stages need to be distinguished in the activity documentation to ensure accurate reporting of the production timeline.

3.4 Implementation of Group Practice

Observations showed that the group was able to carry out the basic processing stages with varying levels of assistance. Relatively straightforward stages tended to be completed with minimal guidance, whereas stages involving formulation control, material consistency, fermentation, and machine operation required more intensive assistance.

Table 4. Implementation of Group Practice by the SIPARESO Creative Economy Group

No.	Observed aspect	Implementation status	Notes
1	Preparation and weighing of ingredients	Implemented with minimal guidance	The group followed the specified ingredient composition
2	Preparation of crab shell flour	Implemented with minimal guidance	The material could be prepared as an additional component
3	Ingredient mixing	Implemented with minimal guidance	Participants were directly involved in the mixing process
4	Preparation of binder	Implemented with assistance	Guidance was required regarding mixing and consistency
5	Steaming	Implemented with minimal guidance	The process followed the demonstrated procedure
6	Preparation of fermentation materials	Implemented with assistance	Technical guidance was required regarding the ingredients and process sequence
7	Fermentation	Implemented as a subsequent stage with assistance	Required time and monitoring
8	Drying	Implemented as a subsequent process	Required control of material conditions
9	Machine operation/pelletizing	Implemented with assistance	Equipment operation still required guidance
10	Sanitation and material handling	Implemented with guidance	Further standardization is required
11	Prototype formation	Implemented	The resulting product was positioned as a prototype
12	Product handling	Implemented	The product was not used as a basis for claims regarding product quality

These findings were not interpreted as measures of individual competence. Because the practical activity was conducted collectively, the unit of interpretation was the implementation of the group process. The stages requiring assistance indicate that successfully following a training session should not be equated with independent production capability. Such independence would require the group to reproduce the process with consistent formulation and process quality without substantial dependence on the implementation team. Therefore, the training output is more appropriately understood as initial technology-transfer experience rather than evidence of established technical competence.

3.5 Participants' Perceptions of Blue Swimming Crab Waste Utilization

The interviews revealed several major themes. Participants perceived that blue swimming crab shells, which had previously been underutilized, could potentially be redirected as an input into another production process. Basic stages such as ingredient preparation and mixing were perceived as relatively easy to understand through direct practice, whereas formulation, fermentation, and machine operation were considered to require further assistance.

Participants also highlighted the availability of equipment and supporting materials as an important factor in continuing the activity. Interest in utilizing shell waste does not, by itself, ensure the sustainability of production if the group lacks access to machinery, materials, standardized procedures, and continued technical assistance.

Table 5. Themes Identified from Participant Interviews

No.	Theme	Summary of findings
1	Change in perceptions of waste	Crab shells were perceived as materials that could be utilized as inputs in a production process
2	Ease of basic processing stages	Ingredient preparation and mixing were relatively easy to follow
3	Technical constraints	Formulation, fermentation, and equipment operation still required guidance
4	Equipment requirements	Machinery and supporting materials were considered necessary for continuity
5	Interest in further development	Participants expressed interest in continuing the activity with further assistance
6	Need for continued assistance	The group still required procedure standardization and further technical capacity building

These responses suggest that an important outcome of the community service activity was not limited to the formation of a prototype product but also included an emerging understanding that processing side streams could be repositioned as resources. This is consistent with the concept of seafood side-stream upcycling, in which residual materials are redirected as new inputs into production systems (Anbarasan et al., 2024). Nevertheless, participants' interest should not be equated with readiness to operate an independent enterprise. At this stage, such interest is more appropriately regarded as an initial foundation for further capacity development. This emerging perception is consistent with community empowerment experiences reported in other Indonesian coastal areas, where practical training in crab shell utilization has encouraged communities to reconsider shell waste as a potentially useful material rather than merely a processing residue (Fatnah et al., 2024; Mustafa et al., 2026).

3.6 Training Product and Potential Added Value

The activity produced feed pellets incorporating blue swimming crab shell flour. The prototype demonstrated that crab shell material could be incorporated as one component of a formulation and processing procedure at the community-group level.

Importantly, this output represents proof of practice rather than proof of efficacy. The product has not undergone proximate analysis or assessments of nutritional composition, safety, digestibility, palatability, or feeding trials. Therefore, it cannot be concluded that the prototype meets feed standards for any particular species.

3.7 Waste Utilization from a Circular Economy Perspective

The utilization of blue swimming crab shells as an additional ingredient in the prototype can be situated within an initial circular economy framework. In a linear system, crab shells are discarded after processing activities. Under a circular approach, a portion of this material is redirected as an input into another process.

Cooney et al. (2023) explained that seafood side-stream utilization can contribute to increasing the circularity of production systems, while Venugopal et al. (2023) demonstrated that more sustainable approaches to side-stream processing can support waste reduction and the optimization of marine biomass. Anbarasan et al. (2024) also identified feed as one potential utilization pathway for seafood side streams.

At the Indonesian community level, crab shell utilization has likewise been incorporated into coastal empowerment and blue-economy initiatives through the transformation of processing residues into products with potential economic value (Sianturi et al., 2025; Mustafa et al., 2026; Mustopa & Risladiba, 2026). These experiences support the relevance of circular-economy thinking in community-based fisheries waste utilization, although the actual economic and environmental impacts need to be evaluated separately.

The SIPARESO activity, however, does not demonstrate the establishment of a fully circular economy. The available evidence is limited to the reutilization of a portion of a processing side stream as an input into a prototype product. Economic impacts, resource efficiency, and production sustainability were not measured. This limitation is important to prevent the concept of the circular economy from being used as an overly broad normative claim. In this article, therefore, the circular economy serves as a conceptual framework rather than a measured outcome variable.

3.8 Sustainability Challenges and Future Development

Several further steps are required to support the sustainability of the activity. First, the formulation and production procedures need to be standardized so that the process can be reproduced consistently. The stages of crab shell flour preparation, mixing, fermentation, drying, and pelletizing should be incorporated into a simple standard operating procedure (SOP) that can be used by the group.

Further strengthening of the technical capacity of SIPARESO members is also required to reduce dependence on the implementation team. The ability to operate machinery, control the formulation, maintain sanitation, and manage the fermentation process represents an important component of progress toward independent production.

Product development also requires laboratory analysis, including at least proximate analysis and basic material characterization. If the prototype is subsequently developed as feed for a particular cultured organism, the formulation should be adjusted to the nutritional requirements of the target organism and followed by safety testing and feeding trials. Once the technical and biological aspects have been adequately addressed, an economic feasibility analysis will be required to assess material costs, energy consumption, labor, equipment depreciation, cost of production, production capacity, and market potential. Until such an analysis is conducted, the notion of “economic added value” should be regarded as potential rather than demonstrated.

CONCLUSIONS

The training on the utilization of blue swimming crab shell waste as an additional ingredient in feed pellet prototype production was implemented with the SIPARESO Creative Economy Group in Nisombalia Village, involving 15 participants. The activity employed a participatory hands-on approach comprising education, demonstration, guided group practice, and evaluation through observations of process implementation, interviews, and product documentation. The formulation introduced during the training incorporated blue swimming crab shell flour at 10% of the total formulation of approximately 5 kg, thereby positioning the crab shell flour as an additional ingredient rather than the primary ingredient of the feed pellet prototype.

At the community service level, the training provided the group with direct experience in following the stages of blue swimming crab shell waste utilization through feed pellet prototype production. The implementation of the practical activities demonstrated the potential for simple technology transfer at the community-group level while also identifying technical stages that still require further assistance. Therefore, the main contribution of this activity lies in introducing the utilization of blue swimming crab side streams and providing practical group experience as an initial step toward developing the capacity of coastal communities to apply the principles of waste valorization and the circular economy.

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AUTHOR CONTRIBUTION STATEMENT

MA contributed to the conceptualization, project coordination, methodology, supervision, data interpretation, and preparation of the original manuscript. MN contributed to the methodology, implementation of the training activities, and data collection. MU and AS contributed to the implementation of the community service activities, participant facilitation, observation, and documentation. MF contributed to the technical aspects of feed pellet prototype production, training implementation, and interpretation of the activity outcomes. RP, RS, YA, and AN contributed to field implementation, participant assistance, data collection, documentation, and activity evaluation. All authors contributed to reviewing and editing the manuscript and approved the final version for publication.

AI DISCLOSURE STATEMENT

The authors used ChatGPT (OpenAI) during the preparation of this manuscript to assist with English-language translation, language refinement, and improvement of academic readability. The AI tool was not used to generate research data, conduct data analysis, or determine the findings and conclusions of the study. After using the tool, the authors thoroughly reviewed, verified, and edited the generated content to ensure its accuracy and consistency with the original data and the actual implementation of the community service activity. The authors take full responsibility for the content of the publication.

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