EMPOWERING WHITELEG SHRIMP FARMERS THROUGH RICE HUSK-BASED BIOFERTILIZER PRODUCTION AS A SUPPORT FOR SUSTAINABLE AQUACULTURE IN PASAREAPUA, SOUTHEAST SULAWESI, INDONESIA

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Abstract: This community engagement program aimed to enhance the technical capacity of whiteleg shrimp (Litopenaeus vannamei) farmers through the production of rice husk-based biofertilizer. This initiative served as a strategy for valorizing local resources and as a supporting input for more sustainable aquaculture practices. The activity was implemented with a shrimp-farming partner group in Pasareapua, Southeast Sulawesi, Indonesia, employing a participatory-educational approach. This approach consisted of needs assessment, socialization, technical training, hands-on biofertilizer production, field mentoring, and reflective evaluation. The results indicated that the partner group significantly improved its understanding of rice husk utilization, solid-state fermentation, basic quality control, and the potential integration of biofertilizer production into circular-economy-oriented pond management. Furthermore, the activity successfully developed a concise standard operating procedure, a comprehensive technical knowledge package, and a follow-up plan to facilitate independent production. Overall, the integration of agricultural residues with aquaculture needs presents a practical, low-cost, and replicable community empowerment model for coastal shrimp-farming communities.

Keywords : *Whiteleg Shrimp Farming, Biofertilizer Production, Agricultural Waste Utilization, Community-Based Aquaculture, Sustainable Coastal Development*

INTRODUCTION

Whiteleg shrimp (*Litopenaeus vannamei*) is a strategic aquaculture commodity due to its high economic value, relatively short production cycle, and continuously expanding market demand. However, increased farming intensity often poses challenges concerning water quality management, organic matter accumulation, production input requirements, and the declining carrying capacity of pond environments. These conditions necessitate community service innovations that not only focus on production improvement but also enhance farmers' capacity to manage local resources efficiently and sustainably.

In coastal and rice-producing areas, rice husk is an abundant agricultural residue that is often underutilized. Rice husk can serve as an organic amendment, microbial carrier, or biofertilizer component through controlled fermentation and composting processes. Recent studies have demonstrated that agricultural residues can be converted into value-added biofertilizers and bioinputs that support circular economy practices, reduce waste burdens, and enhance organic matter functionality in food production systems (Bibi et al., 2023; Kurniawan et al., 2025; Orlandella & Fiore, 2025; Rocha et al., 2024).

The utilization of rice husk as a biofertilizer material is particularly pertinent for empowering whiteleg shrimp farmers, as it facilitates the integration of agricultural and aquaculture sectors. This approach aligns with the concept of a biocircular economy in aquaculture, where waste streams and local organic materials are valorized into production inputs or environmental management resources. In whiteleg shrimp farming, effective organic matter and water quality management are critical, as organic waste and stocking density can significantly influence the stability of the rearing medium, shrimp health, and growth performance (Mohammadi et al., 2023; Paena et al., 2023).

This community service was designed to address the partner group's needs, particularly the requirement for practical technical knowledge on processing rice husk into a simple biofertilizer that can support more environmentally responsible farming practices. The activity also positioned the partner group as the central actor through a participatory-educational approach, enabling technology transfer via hands-on practice, discussion, and field mentoring. Accordingly, the intervention was not limited to information delivery; it was intended to build operational competence, strengthen commitment to continuity, and create opportunities for replication among other shrimp farmers in Pasareapua, Southeast Sulawesi, Indonesia.

The objective of this community service was to improve the partner group's knowledge and skills in producing rice husk-based biofertilizer, to develop a simple standard operating procedure, and to introduce a model for agricultural residue utilization as a supporting component of sustainable whiteleg shrimp farming. This article presents the implementation process, activity achievements, technical discussion, and future directions for the sustainability of the empowerment model.

METHODS

Research Location

This activity was implemented with a whiteleg shrimp (Litopenaeus vannamei) farming partner group in Pasareapua Village, Southeast Sulawesi Province, Indonesia. The principal partner was a local shrimp-farming group. The activity adopted a participatory-educational approach designed to strengthen the partner group's technical capacity through collaborative learning, hands-on practice, and field-based mentoring.

Data Collection Techniques

Data collection was carried out through partner coordination, needs assessment, participatory observation, field discussions, and direct documentation of the biofertilizer production process. The collected information covered the availability of rice husk, partner readiness, required tools and materials, production workflow, fermentation constraints, quality indicators, and follow-up plans for independent production.

Data Analysis

The activity data were analyzed descriptively and qualitatively by comparing the initial partner condition with the achievements observed after training and mentoring. The analysis focused on partner understanding, production skills, simple quality control, and business sustainability. Evaluation was conducted through reflective discussion, observation of practical performance, identification of constraints, and the collaborative formulation of a replication plan.

Table 1. Program Design and Implementation Stages of Rice Husk-Based Biofertilizer Production

Stages	Main activities	Process outputs	Achievement indicators
Preparation	Partner coordination, raw material mapping, and module development	Inventory of required tools and materials	The partner group understood the activity plan
Socialization	Introduction to the circular economy and benefits of rice husk utilization	Agreement on the roles of the team and the partner group	The partner group accepted the activity and actively participated in discussions
Training	Practical formulation, fermentation, and packaging	A simple SOP for biofertilizer production	The partner group was able to explain the production stages
Mentoring	Monitoring of the fermentation process and physical quality attributes	Notes on constraints and process improvements	The partner group was able to correct moisture and aeration conditions
Evaluation	Reflection on achievements and replication planning	Follow-up business plan	The partner group committed to applying the technology

RESULTS AND DISCUSSION

Rice Husk Resource Potential

The rice husk resource potential was identified systematically through coordination between the implementing team and the shrimp-farming partner group. At this stage, the team mapped field needs, local raw material potential, and the partner group's readiness to participate in the entire activities. Such preparation is essential because a simple technology-based community service must align material characteristics, partner capacity, and the intended business objectives.

Figure 1. Preparation activities and coordination between the implementing team and the whiteleg shrimp-farming partner in Pasareapua,.

The availability of rice husk as the main raw material was a key enabling factor. Rice husk has potential as a carrier material, organic amendment, and compost component because of its relatively light, porous structure and its compatibility with other organic materials. Recent studies indicate that fermented rice husk or rice husk combined with microbial agents can contribute to improved organic matter properties and humification processes (Li et al., 2024; Sarin et al., 2024; Zhai et al., 2025). On this basis, the training was directed toward processing rice husk into a biofertilizer that could be produced easily by the partner group.

Characteristics of Partner Needs and Technology Dissemination

The dissemination of biofertilizer technology commenced with an introduction to the activity objectives, the defined roles of each participating party, and the importance of utilizing agricultural residues to support whiteleg shrimp farming. The partner group was actively encouraged to comprehend that effective waste management not only contributes to environmental cleanliness but also possesses the potential to generate added economic value. This approach aligns seamlessly with zero-waste and waste valorization principles, which fundamentally position organic residues as valuable resources rather than disposable waste (Chen et al., 2024; Kurniawan et al., 2025).

Discussions with the partner group revealed that shrimp farmers require technologies that are characterized by simplicity, cost-effectiveness, ease of implementation, and independence from complex laboratory equipment. Therefore, the socialization materials were prepared using accessible technical language, emphasizing practical steps, and providing illustrative examples of common process constraints, such as excessive moisture, strong odor, uneven fermentation, and improper storage. Through this comprehensive socialization process, the partner group progressively developed an understanding that successful biofertilizer production is contingent upon a balanced composition of materials, appropriate moisture content, adequate aeration, and sufficient fermentation time.

Technical Production and Fermentation Process

The technical production and fermentation process became the core of the community service because the partner group was not only provided with explanations but also directly involved in production practice. The activity began with selecting clean rice husk, removing coarse impurities, and adjusting the moisture content. The rice husk was then mixed with supporting organic materials and a bioactivator and fermented under conditions that enabled stable microbial activity. Solid-state fermentation is particularly important because this technology is widely used to convert agro-industrial waste into value-added products (Bibi et al., 2023; Kalaiselvan et al., 2025; Mirsalami & Mirsalami, 2024).

During practice, the partner group was trained to recognize physical indicators of material maturity, including reduced sharp odor, darker color, more crumbly texture, and relatively stable material temperature. These simple indicators are important because farmers require quality-control tools that can be applied independently. At this stage, the team also emphasized that the biofertilizer product should not be positioned as a complete substitute for all aquaculture inputs, but as part of an organic matter management and local waste utilization strategy that must be accompanied by regular pond water quality monitoring.

The training results showed that the partner group was able to follow the production workflow from material preparation to storage. The most notable skills acquired were the ability to adjust material moisture and conduct material turning during fermentation. This achievement is important because improper moisture conditions often lead to anaerobic, odorous, and non-uniform fermentation. Practice-based learning made it easier for the partner group to understand that product quality is determined not only by material composition, but also by process discipline.

Figure 2. Practical Steps for Producing Biofertilizer from Rice Husk. No. 1 and 2: Mixing sliced banana stems with dry rice husk; No. 3: Mixing the bioactivator during the organic material fermentation process; No. 4: Applying the bioactivator to the organic material mixture.

Table 2. Achievements in Partner Capacity Aspects.

Capacity Aspect	Baseline condition	Achievement after the activity
Raw-material knowledge	Rice husk was perceived as a low-value agricultural residue	The partner group understood the function of rice husk as a biofertilizer material and organic carrier
Production skills	No simple production SOP was available	The partner group understood the workflow for production, fermentation, turning, maturation, and packaging
Quality control	The partner group was not familiar with physical maturity indicators	The partner group was able to monitor odor, texture, color, moisture, and material temperature
Business sustainability	Agricultural residue utilization had not yet been connected to pond-farming activities	The partner group developed a follow-up plan for independent production and limited replication

Characteristics of Partner Capacity Improvement

Partner capacity improvement was strengthened through mentoring to ensure that the partner group did not merely replicate procedures but also thoroughly comprehended the technical rationale underpinning each stage. During mentoring, the team underscored the paramount importance of maintaining simple yet informative records, including the date of mixing, turning frequency, odor condition, moisture condition, and visual observations. Such systematic records provide a robust basis for optimizing subsequent production cycles.

The evaluation results indicated that program success was supported by three main factors. First, the readily available raw material in the vicinity of the partner location rendered the technology highly feasible for sustained implementation. Second, the production process necessitated minimal investment in expensive equipment, thereby facilitating its adoption by small-scale farmers. Third, the activity's delivery through hands-on practice enabled the partner group to more clearly discern the intricate relationship among the fermentation process, product quality, and its potential application within shrimp farming systems.

The primary constraints identified included the time required to achieve material maturity, inherent variations in rice husk quality, and the necessity of establishing a new habit of diligent process recording. These constraints can be effectively addressed through continuous mentoring, the development of user-friendly control sheets, and repeated small-scale trials prior to broader application. Within the context of whiteleg shrimp farming, any application of biofertilizer must invariably be accompanied by rigorous water quality monitoring, particularly for parameters such as pH, dissolved oxygen, ammonia, and organic matter. This is crucial because shrimp performance is profoundly influenced by the stability of the rearing environment (Jing et al., 2025; Mohammadi et al., 2023; Paena et al., 2023).

Figure 3. Mentoring and evaluation activities for the rice husk-based biofertilizer production process with partners.

Sustainability and Replication Prospects

The sustainability and replication prospects of this program demonstrate that shrimp farmer empowerment can be strengthened by integrating two local resources: agricultural residues and the technological needs supporting aquaculture. The utilization of rice husk as a biofertilizer material not only introduced novel knowledge to the partner group but also broadened the perspective that pond-farming sustainability can be robustly established through material efficiency, waste reduction, and locally based innovation. Studies on agricultural bioinputs consistently indicate that the fermentation and processing of organic residues can yield materials that effectively support sustainable agriculture and circular economy systems (Renganathan et al., 2024; Riddech et al., 2025; Rocha et al., 2024).

From the farmers' perspective, the primary benefit of the activity was the substantial improvement in technical capacity to independently produce supporting inputs. This enhanced autonomy is critically important because farmers frequently encounter fluctuations in input prices, limited access to technology, and the inherent risk of dependence on external products. With a simple standard operating procedure, the partner group can conduct repeated trials, adjust material composition, and develop production processes according to local conditions. Nevertheless, product development must continuously prioritize safety, ensure material maturity, and assess application suitability to prevent excessive organic loading in pond systems.

This activity also holds considerable potential for replication among other shrimp-farming communities situated in coastal areas with similar resource characteristics. Replication can be effectively facilitated through farmer-to-farmer training initiatives, small-scale demonstrations, and collaborative partnerships with universities for basic quality testing. Future activity enhancements should encompass comprehensive nutrient content analysis, rigorous microbiological testing, thorough application safety assessments, and pragmatic economic analysis to ascertain production cost efficiency. Through these strategic steps, rice husk-based biofertilizer can evolve beyond merely a training output to become a more structured supporting enterprise for sustainable shrimp farming.

Figure 4. Fermentation process of rice husk-based organic materials for biofertilizer production.

CONCLUSIONS

This community engagement program on rice husk-based biofertilizer production for whiteleg shrimp farmers in Pasareapua, Southeast Sulawesi, Indonesia enhanced the partner group's knowledge and skills in utilizing agricultural residues as supporting inputs for fostering more sustainable aquaculture practices. Structured across distinct stages of preparation, socialization, technical training, hands-on production, mentoring, and reflective evaluation, the activity fostered a systematic technical understanding of material formulation, fermentation processes, fundamental quality control, and strategic planning for independent production. This model demonstrates considerable potential as a circular-economy-based empowerment strategy, effectively bridging the local availability of rice husk with the imperative for innovation in whiteleg shrimp farming. To ensure the safe, measurable, and economically beneficial application of biofertilizer for farmers, the activity warrants continued efforts, including rigorous product quality testing, water quality monitoring, and facilitated replication.

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