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Integrated utilization of maize residues and kernels through silage and flour production

Yayat Hidayat[1], Anca Awal Sembada[2], Alfi Rumidatul[1], Marsinah[3], Tuti Juhaeti[4], Dedi Ruswandi[5]

[1]School of Life Sciences and Technology, Institut Teknologi Bandung, Indonesia
[2]Research Center for New and Renewable Energy, Institut Teknologi Bandung, Indonesia
[3]Universitas Mbojo Bima, Indonesia
[4]Central Bureau of Statistics of Republic of Indonesia, Indonesia
[5]Faculty of Agriculture, Universitas Padjadjaran, Indonesia
Corresponding Author: Alfi Rumidatul; Email: alfirumidatul@itb.ac.id

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ABSTRACT

Laju Village, Langgudu District, Bima Regency, is one of the major maize-producing areas in West Nusa Tenggara, Indonesia. However, maize harvest residues, including stalks, leaves, and husks, remain largely underutilized, while dried maize kernels are generally sold without further processing, resulting in relatively low economic returns for farmers. This community service program aimed to improve the income and self-reliance of maize farmers through the implementation of two appropriate technologies: the production of silage from maize harvest residues as livestock feed and the processing of maize kernels into maize flour as a value-added product. The program was implemented through four stages: an initial survey and socialization, theoretical and hands-on training on silage and maize flour production, one month of technical mentoring, and program evaluation using pre-test and post-test assessments. The program involved members of a maize farmer group in Laju Village. The results showed a substantial improvement in participants' knowledge and technical skills, with an average knowledge increase of 89.6% following the training. Participants successfully produced high-quality silage (pH 4.2) and maize flour with a yield of 82.5%, demonstrating the feasibility of both technologies at the community level. The integration of these two technologies increased the economic value of both maize harvest residues and maize kernels while reducing dependence on conventional livestock feed and the sale of unprocessed maize. Overall, this dual-technology approach proved to be an effective community empowerment model based on local agricultural resources, contributing to improved farmer livelihoods and promoting sustainable rural economic development.

INTRODUCTION

Maize (*Zea mays* L.) is one of Indonesia's most strategic food crops after rice and serves as a major agricultural commodity in West Nusa Tenggara Province, including Bima Regency. Laju Village, located in Langgudu District, Bima Regency, is one of the main maize-producing areas, where the majority of households depend on maize farming as their primary source of income. According to the 2024 statistics from the Bima Regency Statistics Agency and the West Nusa Tenggara Provincial Agricultural Office, the maize cultivation area in Langgudu District covers approximately 1,200 ha, with an average productivity of 5.7 tons ha^{-1}, making Laju Village a significant contributor to regional maize production (Azim, 2025). Despite this substantial production potential, the economic value of maize has not been fully optimized. In practice, most farmers in Laju Village sell maize only as dried kernels without further processing,

resulting in relatively low market prices and limited income generation. Furthermore, maize residues, including stalks, leaves, and husks, remain largely underutilized and are often left to decompose naturally or burned in the fields (Thola et al., 2022). These agricultural residues, however, have considerable potential to be converted into nutritious livestock feed through appropriate processing technologies (Sembada et al., 2024).

One proven and practical technology for addressing livestock feed shortages, particularly during the dry season, is silage production. Silage is produced through the fermentation of forage or agricultural residues using lactic acid bacteria, resulting in preserved, nutritious, and highly palatable animal feed (Harjono et al., 2021; Rasuli et al., 2022). Previous community empowerment programs have demonstrated that silage-making training significantly improves farmers' knowledge and technical skills while promoting feed self-sufficiency (Jaya et al., 2024; Yusuf et al., 2025; Hidayat et al., 2025). In addition to utilizing crop residues, maize kernels themselves possess substantial value-added potential when processed into maize flour. Diversification of maize into flour-based products has been widely recognized as an effective community empowerment strategy based on local resources because it extends shelf life, broadens market opportunities, and increases product value compared with marketing dried maize kernels alone (Martono et al., 2020; Wuryandari et al., 2021; Al Islamiyah et al., 2024; Rumidatul et al., 2025).

However, existing community service programs have generally focused on only a single maize-processing technology, either converting maize residues into silage or processing maize kernels into flour. Consequently, there remains a lack of integrated community-based interventions that simultaneously address both major challenges faced by maize farmers: seasonal livestock feed shortages and the low economic value of unprocessed maize (Shah et al., 2025). This gap limits the overall socioeconomic impact of previous empowerment initiatives, as they fail to maximize the utilization of both maize residues and harvested kernels within the same farming system.

Therefore, this community service program was designed to enhance the knowledge and technical capacity of maize farmers in Laju Village through the implementation of two complementary appropriate technologies: (1) producing silage from maize harvest residues for livestock feed and (2) processing maize kernels into maize flour as a value-added product. By integrating these two technologies into a single community empowerment program, this initiative seeks to overcome the limitations of previous approaches and provide a more comprehensive strategy for increasing farmers' income (Knickel et al., 2018), improving resource utilization, strengthening livestock feed security during the dry season, and promoting sustainable economic independence among maize farming households in Laju Village, Langgudu District, Bima Regency.

METHODS

This community service program was conducted in Laju Village, Langgudu District, Bima Regency, West Nusa Tenggara Province, Indonesia, from February to April 2026. The target participants consisted of 25 members of the Maju Bersama Farmer Group, who were selected because they actively cultivate maize but have not yet utilized maize harvest residues or processed maize kernels into value-added products. The program adopted a participatory approach, actively involving farmers throughout all stages of the activities. Before implementation, permission was obtained from the Head of Laju Village.

The implementation procedures followed the stages commonly adopted in community service programs based on appropriate technology (Hidayat et al., 2025; Rumidatul et al., 2025), consisting of four phases: (1) an initial survey and socialization phase to identify farmers' needs and challenges related to maize residue utilization and maize processing; (2) theoretical instruction and hands-on training on silage production using maize harvest residues supplemented with rice bran (5 kg per 100 kg of fresh material) and a microbial fermentation solution (10 mL L^{-1}). The mixture was compacted in airtight containers and fermented for 21 days. Participants also received practical training on maize flour production using an FFC-45 disk mill, which included drying, milling, and sieving processes; (3) a one-month technical mentoring phase to ensure that participants were able to independently apply the introduced technologies; and (4) a final evaluation phase. The FFC-45 disk

mill used for maize flour production is presented in Figure 1.

The effectiveness of the program was evaluated using a descriptive comparative approach by comparing participants' pre-test and post-test scores. The assessment instrument consisted of 20 multiple-choice and Likert-scale questions designed to measure participants' knowledge of silage production and maize flour processing. The results were analyzed descriptively using percentage values. In addition, direct observations and simple quality assessments were conducted on the products produced during the practical sessions. Silage quality was evaluated based on color, aroma, texture, and pH measured using pH indicator paper, while maize flour quality was assessed based on color, fineness, and flour yield (%).

Figure 1. FFC-45 disk mill used for maize flour production during the community service training program

RESULTS AND DISCUSSION

Silage Production Training Activities

The training program was attended by 25 members of the Maju Bersama Farmer Group in Laju Village. The pre-test results revealed that most participants (88%) had limited knowledge of both silage production and maize flour processing. Before the program, maize harvest residues were generally left to decompose in the field or burned, while harvested maize was sold as dried kernels at an average price of approximately IDR 4,000 kg^{-1}.

During the silage production training, maize stalks and leaves were chopped into small pieces, mixed with rice bran and a microbial fermentation solution according to the formulation shown in Table 2, compacted into airtight containers, and fermented for approximately 21 days. The training activities are presented in Figure 2. The resulting silage exhibited desirable physical characteristics, including a greenish-brown color, a fresh acidic aroma, absence of mold, and good palatability for livestock, with an average pH of 4.2 (Table 2). These characteristics are consistent with those reported in previous community-based silage production programs (Hidayat et al., 2025; Rasuli et al., 2022; Yusuf et al., 2025). The successful production of high-quality silage demonstrates that this technology can provide an affordable and sustainable livestock feed source, particularly during the dry season when forage availability is limited.

Figure 2. Hands-on training on silage production from maize harvest residues

Maize Flour Production Training Activities

The maize flour processing training involved drying maize kernels, milling them using the FFC-45 disk mill, and sieving the flour to obtain a fine and uniform particle size. The milling machine used during the training is shown in Figure 1, while the practical training activities are presented in Figure 3. Participants successfully produced maize flour with an average yield of 82.5% (Table 2). The resulting flour had a pale-yellow color and fine texture (80-mesh), making it suitable for further processing into value-added food products, such as cookies, porridge, and composite flour, as reported in previous maize-processing community empowerment programs (Martono et al., 2020; Wuryandari et al., 2021; Rumidatul et al., 2025).

Figure 3. Hands-on training on maize flour production.

Training Outcomes and Economic Impact

The comparison between pre-test and post-test scores (Table 1) demonstrated a substantial improvement in participants' knowledge, with the average score increasing from 44.2 to 83.8, representing an overall improvement of 89.6%. These findings are consistent with previous community service programs that reported significant gains in participants' knowledge and practical skills following training on silage production and maize processing technologies (Hidayat et al., 2025; Rumidatul et al., 2025). The results indicate that combining classroom instruction with hands-on practice and continuous technical mentoring is an effective approach for transferring appropriate agricultural technologies to farming communities.

Table 1. Comparison of participants' knowledge scores before and after the training

Indicator	Pre-test	Post-test	Improvement (%)
Knowledge of silage production	45,6	82,4	80,7
Knowledge of maize flour processing	42,8	85,2	99,1
Overall average	44,2	83,8	89,6

Table 2. Physical quality characteristics of the produced silage and maize flour

Parameter	Result
Silage color	Greenish-brown
Silage aroma	Fresh acidic
Silage pH	4.2
Maize flour color	Pale yellow
Maize flour fineness	Fine (passed through an 80-mesh sieve)
Maize flour yield (%)	82.5

From an economic perspective, the adoption of these two technologies offers promising opportunities to improve farmers' livelihoods. Producing silage from maize residues is estimated to reduce livestock feed costs by approximately IDR 150,000 per animal per month. Meanwhile, processed maize flour has an estimated market value of around IDR 10,000 kg^{-1}, which is considerably higher than the selling price of dried maize kernels (approximately IDR 4,000 kg^{-1}). Consequently, integrating residue utilization with value-added maize processing has the potential to enhance household income while promoting more efficient use of agricultural resources. To ensure the long-term sustainability of the program, the establishment of a farmer-group-based business unit and continued technical assistance from local agricultural extension agencies are recommended, enabling the technologies introduced through this program to be maintained, expanded, and replicated in other farmer groups throughout Langgudu District.

CONCLUSIONS

This community service program successfully improved the knowledge and practical skills of maize farmers in Laju Village, Langgudu District, Bima Regency, in implementing two appropriate technologies: silage production from maize harvest residues for livestock feed and maize flour processing from maize kernels. The evaluation results demonstrated an 89.6% increase in participants' knowledge after the training. Participants were able to produce high-quality silage with a pH of 4.2 and maize flour with a yield of 82.5%, indicating that both maize residues and harvested kernels can be transformed into value-added products with economic potential.

The integration of silage production and maize flour processing proved to be an effective community empowerment approach for maximizing the utilization of local maize resources, strengthening livestock feed security, and creating additional income opportunities for farming households. This dual-technology approach addresses both the underutilization of maize harvest residues and the low market value of dried maize kernels, providing a more comprehensive and sustainable model than single-technology interventions. To ensure long-term sustainability, the establishment of a farmer-group-based business unit and continued technical assistance from local government agencies and other relevant stakeholders are recommended to facilitate the wider adoption and replication of these technologies.

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