

APPLICATION OF SOLAR FEED FERMENTOR TECHNOLOGY TO IMPROVE THE EFFICIENCY OF FERMENTED FEED PRODUCTION AT BALEBAT FARM, KALIJAYA VILLAGE

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Abstract

The limited availability of feed during the dry season has been a major constraint for smallholder dairy goat farmers in Kalijaya Village, Ciamis Regency. Farmers traditionally rely on fresh fodder without preservation, resulting in low feed efficiency and unstable milk production. This community service program introduced the Solar Feed Fermentor System, a renewable energy-based technology designed to support sustainable fermented feed production. The implementation involved 20 farmer participants and included stages of socialization, training, mentoring, and evaluation. Results showed a significant improvement in farmers' knowledge and technical skills, with average understanding scores increasing from 62% to 86%. Feed production capacity increased from 20–30 kg/day to 120–150 kg/day, while processing time and energy costs were reduced by more than 50%. The adoption of solar energy minimized dependence on electricity and promoted environmentally friendly practices. This program demonstrates a replicable model of community empowerment integrating renewable energy, feed technology, and rural sustainability.

Keywords: Renewable Energy, Fermented Feed, Farmer Empowerment, Dairy Goats, Rural Sustainability

INTRODUCTION

Feed management is one of the most strategic issues in supporting the sustainability of smallholder livestock systems in Indonesia. Feed accounts for approximately 60–70% of the total livestock production cost, making its efficiency and availability key factors in improving productivity and farmer welfare (Makkar, 2018; Hayat *et al.*, 2024). The Indonesian government, through the Ministry of Agriculture, has emphasized the importance of developing feed technologies based on local resources and renewable energy as part of the national

livestock revitalization strategy to strengthen food security and promote the *green economy*. This policy direction aligns with sustainable development principles that focus on energy efficiency, carbon emission reduction, and rural economic independence.

In rural areas such as Kalijaya Village, Banjarnayar District, Ciamis Regency, feed scarcity—particularly during the dry season—remains a major challenge. Most farmers rely on fresh forage without preservation or further processing, resulting in fluctuating feed availability and inconsistent quality throughout the year. This situation leads to a decline in milk productivity, increased operational costs, and low efficiency in smallholder goat dairy farming. The Balebat Farm Goat Dairy Group, consisting of 20 active members managing around 317 dairy goats, faces similar conditions. Feed preparation is still performed manually, without fermentation techniques or renewable energy utilization, which causes inefficiency in time, labor, and cost.

These limitations indicate the urgent need for innovation in energy-efficient and sustainable feed processing technology. Previous studies have demonstrated that the adoption of renewable energy—particularly solar-based systems—can reduce production costs and enhance sustainability in smallholder livestock systems (Winkler *et al.*, 2018). Likewise, fermented feed technology has been proven to improve nutrient content, digestibility, and overall animal performance (Betchem *et al.*, 2024). However, few community empowerment programs have integrated feed fermentation and solar energy systems in a unified model, particularly within smallholder dairy goat farming contexts (Lendrawati *et al.*, 2023).

To address these challenges, this community service program introduced the Solar Feed Fermentor System, an appropriate technology innovation that combines feed fermentation processes with solar energy utilization. This technology enables farmers to produce fermented feed more efficiently, sustainably, and independently from the national power grid. Through participatory approaches—consisting of socialization, technical training, field practice, and mentoring—the program aims to enhance farmers' knowledge, skills, and independence in feed management.

This initiative represents an original model of appropriate technology adoption that integrates renewable energy innovation, local resource utilization, and farmer empowerment. The expected outcomes include improved production efficiency, higher feed quality, and stronger economic resilience among smallholder farmers, while also contributing to the achievement of the United Nations Sustainable Development Goals (SDGs), specifically SDG 7 (Affordable and Clean Energy), SDG 8 (Decent Work and Economic Growth), and SDG 12 (Responsible Consumption and Production).

IMPLEMENTATION METHOD

The community service activity was conducted for four months at Balebat Farm, a goat dairy farming group located in Kalijaya Village, Banjaranyar District, Ciamis Regency. The partner group, led by Dendi, consists of 20 active members managing approximately 317 dairy goats. The activity was carried out collaboratively by lecturers and students of Universitas Perjuangan Tasikmalaya and Universitas Jenderal Soedirman, focusing on the application of appropriate technology for feed production and farmer capacity building.

The implementation method combined technical innovation transfer and participatory training, aiming to enhance farmers' knowledge, skills, and independence in producing fermented feed using renewable energy-based systems.

1. Activity Stages

The activity began with a needs analysis and resource mapping involving the Balebat Farm group to identify problems related to feed availability, nutritional quality, and production efficiency. Based on the identified issues, several steps were designed and implemented as follows:

- a. Pre-Test: Conducted to measure the farmers' initial understanding of feed formulation, fermentation processes, and sustainable feed management. The pre-test was carried out through a questionnaire and discussion session.
- b. Socialization of Program and Technology: Introduction of the concept of energy-efficient fermented feed production using the *Solar Feed Fermentor System*, including an explanation of tools, materials, and safety aspects.
- c. Installation and Demonstration of Technology: The team installed the integrated Solar Feed System, consisting of solar panels (2×120 WP Solana Mono), feed chopper, feed mixer, and fermentor units. The installation included a solar charge controller, inverter (Hanaya 15000 W), and OVO battery (12V 150Ah). Demonstrations were conducted to show how sunlight energy is converted and stored to operate the machines.
- d. Training and Practice: Farmers participated in practical sessions on feed preparation and fermentation techniques. The process started from chopping green fodder, mixing with bran, molasses, and EM4, to storing the mixture in sealed drums for 21 days. During this session, operational trials of the solar-powered chopper and mixer were conducted, with performance duration reaching 50–60 minutes of continuous operation under sunlight.
- e. Mentoring and Evaluation: Follow-up mentoring ensured that farmers were able to operate, maintain, and troubleshoot the system independently. Evaluation was performed continuously through observations and group discussions.
- f. Post-Test: Conducted to evaluate improvements in knowledge and technical skills. Although the pre- and post-test questions differed slightly, they covered similar conceptual domains (feed processing, energy efficiency, and fermentation safety). The results indicated a marked increase in farmers' understanding and confidence in applying the technology.

2. Implementation Schedule

The summary of implementation activities is presented in Table 1.

Table 1. Schedule of Fermented Feed Production Activities at Balebat Farm, Kalijaya Village

No	Date	Activity Description
1	03 August 2025	Coordination meeting and identification of Balebat Farm problems
2	11 October 2025	Socialization of the Solar Feed Fermentor technology and material introduction
3	15 October 2025	Installation of solar panel system, feed chopper, mixer, and fermentor units
4	18 October 2025	Training and practice of fermented feed production
5	20 October 2025	Mentoring on operation and maintenance of solar feed system
6	22 October 2025	Post-test and evaluation of farmers' understanding and system performance

3. Tools and Materials

The Solar Feed Fermentor system applied in this program consisted of several main components, including two solar panels (2×120 WP Solana Mono), a battery unit (OVO 12V 150Ah), a solar charge controller (SCC), an inverter (Hanaya 15000 W), and a set of feed processing machines comprising two feed choppers (1 HP motor, 900 W), one feed mixer (1 HP motor), and fermentation drums with sealed covers. The complete set of equipment provided to the partner is illustrated in Figure 4. The feed ingredients used for the fermentation process included green fodder (Napier grass and corn stalks), rice bran, molasses, and EM4, which were mixed to a homogeneous texture before being stored in airtight fermentation drums.



Figure 1. Feed Processing Equipment Provided to Partner Farmers at Balebat Farm, Kalijaya Village.

The equipment package includes: (a) *Solar Feed Chopper 1* for coarse chopping, (b) *Solar Feed Chopper 2* for fine chopping, (c) *Solar Feed Mixer* for homogenizing feed ingredients, and (d) a 1 HP (900 W) electric motor used as the power source for the chopper and mixer units.

4. Technical Implementation

The implementation of this program adopts the principle of utilizing renewable energy for feed processing to enhance efficiency and sustainability in livestock production systems (Paris *et al.*, 2022). The application of small-scale fermentation technology in rural livestock communities has been proven to improve production consistency and reduce dependency on conventional energy sources (Adami *et al.*, 2020).

The integration of photovoltaic energy in agricultural feed production represents an environmentally friendly and sustainable innovation to reduce operational costs while maintaining productivity (Adami *et al.*, 2020). The concept of fermented feed technology also contributes to better nutrient utilization, feed preservation, and animal performance improvement, which supports the sustainability of smallholder dairy farming (Priyadi and Aziez, 2024).

Overall, the combination of solar-based energy systems and fermentation technology serves as a model for appropriate technology applications that empower rural farmers to achieve energy independence and improve livestock productivity in developing regions.

RESULTS AND DISCUSSION

1. Description of Program Implementation

The community service program was implemented at the Balebat Farm Goat Dairy Group, located in Kalijaya Village, Banjarnayar District, Ciamis Regency, Indonesia. The activity involved 20 active farmer participants who are members of the Balebat Farm group. In addition, five students from Universitas Perjuangan Tasikmalaya participated as facilitators, assisting in field coordination, documentation, and technical support during the implementation process. The activity began with an opening and program socialization session, officially inaugurated by Mr. Yosep Kurniawan, the Head of Kalijaya Village. In his opening remarks, he expressed his appreciation and support for the collaboration between the university and the local government in promoting community empowerment through the application of appropriate technology in livestock production.

The implementation consisted of several stages, beginning with a program orientation to explain the objectives, benefits, and sequence of activities. Subsequently, two technical materials were presented in different sessions:

1. Feed fermentation production training, delivered by Titin Widyastuti, which covered the principles of feed fermentation, its biological benefits for improving dairy goat productivity, and the formulation of feed using locally available ingredients.
2. Equipment utilization training, delivered by Anri Kurniawan, which introduced the components of the Solar Feed Fermentor System, including the solar power unit, feed chopper, feed mixer, and fermentor, as well as procedures for operation, maintenance, and safety.

Following the classroom session, participants joined a practical field training where they applied the knowledge gained by performing feed chopping, mixing, and fermentation using local materials such as Napier grass, corn stalks, rice bran, molasses, and EM4. During this

session, participants practiced operating the solar-powered chopper and mixer units, which are integral components of the Solar Feed Fermentor system. The final stage involved mentoring and on-site monitoring, aimed at ensuring that all participants could operate and maintain the system independently. During this phase, farmers showed increased enthusiasm, teamwork, and initiative in implementing the feed fermentation process. Documentation of the activity includes photographs from the classroom and field sessions, illustrating active participation of farmers and students during the implementation (Figure 2).



Figure 2. Community engagement activities at Balebat Farm, Kalijaya Village: (a) Socialization session with farmer participants, and (b) Training session on fermented feed production.

2. Technology Application and System Performance

The technology applied in this community service program is the Solar Feed Fermentor System, a renewable energy-based innovation designed to support efficient and sustainable fermented feed production at the farmer group level. The system integrates several feed processing units—feed choppers, feed mixer, and feed fermentors—that operate using electrical power generated from solar energy. As shown in Figure 3, the Solar Feed Fermentor system consists of two feed choppers (coarse and fine cutters), a feed mixer, a box controller, and solar panels (Solana Mono type, 120 WP × 2 units). Energy generated by the solar panels is stored in a 12V 150Ah OVO battery, monitored through a Solar Charge Controller (SCC) equipped with safety fuses and circuit breakers (MCB), and then converted from DC to AC current using a Hanaya 15000 W inverter. This configuration enables the system to power the feed processing machines with a motor capacity of 1 HP (900 W) each.

The operational process begins with the feed chopping stage, where fresh forages such as Napier grass, corn stalks, or cassava leaves are cut into small particles using two types of choppers. The coarse chopper produces longer cuts for roughage, while the fine chopper creates smaller particles suitable for fermentation. The chopped materials are then transferred into the feed mixer, where additional ingredients such as rice bran, molasses, and EM4 are added and thoroughly mixed until homogeneous. The mixed feed is subsequently placed in sealed fermentation drums, where it undergoes anaerobic fermentation for approximately 21 days until ready for feeding.

During field implementation, the system demonstrated stable performance under sunlight exposure, with an effective operational time of 50–60 minutes per day, sufficient for producing approximately 120–150 kg of fermented feed per session. The dual solar panel setup provides

enough power to operate both the chopper and mixer units simultaneously, reducing dependency on grid electricity and fuel-based energy sources. This solar-based feed fermentation technology not only ensures continuous feed availability during the dry season but also promotes environmentally friendly and cost-efficient livestock management. The system offers a practical and replicable model for rural farming communities seeking to achieve energy independence while maintaining high-quality feed production.

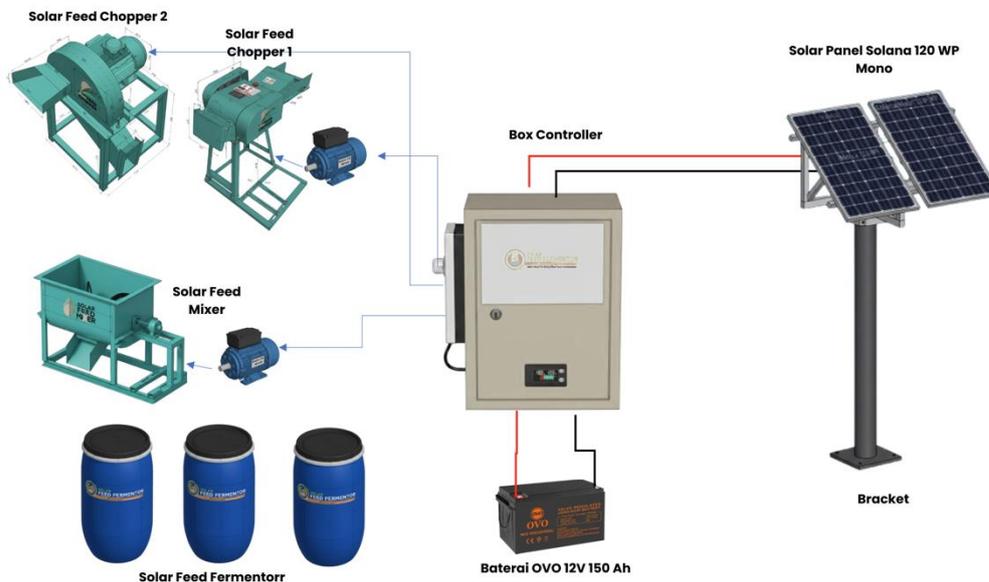


Figure 3. Schematic Diagram of the Solar Feed Fermentor System Installed at Balebat Farm, Kalijaya Village

3. Improvement of Farmers' Knowledge and Skills

The evaluation of farmers' knowledge and awareness regarding the use of fermented feed (*silage*) was conducted through pre-test and post-test questionnaires administered to all 20 participants. The pre-test aimed to assess participants' initial understanding of silage benefits, required materials, and processing methods, while the post-test evaluated their knowledge improvement and willingness to apply the technology after attending the training. The pre-test results indicated that most participants had limited knowledge and experience related to silage production. Only 25% of the farmers had previously heard of silage, and fewer than half (40%) understood its purpose as a feed preservation method during the dry season. Despite this, most participants (60%) showed an initial willingness to adopt fermented feed once introduced to its potential benefits.

After the training and field practice using the Solar Feed Fermentor System, there was a notable improvement in both understanding and enthusiasm among farmers. The post-test results showed that 95% of participants clearly understood the purpose and advantages of silage, 90% could identify the correct materials, and 85% expressed confidence in making silage independently. Additionally, 95% of the farmers stated a willingness to apply the technology in their daily livestock management. Overall, the average knowledge score increased from 62% (pre-test) to 86% (post-test), indicating a significant improvement in both theoretical knowledge and practical readiness.

Table 2. Comparison of Pre-Test and Post-Test Results on Farmers' Understanding of Silage

No	Indicator	Pre-Test (%)	Post-Test (%)
1	Understanding of the term <i>silage</i>	25	95
2	Knowledge of materials used in silage	40	90
3	Awareness of silage as a feed preservation method	45	95
4	Confidence to make silage independently	35	85
5	Willingness to use fermented feed	60	95
Average Score		62	86

These results demonstrate that the training successfully enhanced farmers' comprehension of silage technology, improved their practical ability to produce fermented feed, and strengthened their motivation to implement the technology on their farms. The participatory learning approach—combining theoretical sessions, practical demonstrations, and mentoring—proved effective in improving both knowledge and behavioral change among rural livestock farmers.

4. Impact on Feed Production and Efficiency

The implementation of the Solar Feed Fermentor System at Balebat Farm had a significant impact on the efficiency and productivity of fermented feed production. Prior to the program, the group relied solely on fresh green fodder as feed, without any processing or preservation. This method was labor-intensive, inconsistent in quality, and highly dependent on seasonal availability. During the dry season, feed scarcity often caused a decline in milk production and increased maintenance costs (Maleko *et al.*, 2018). After the installation and training in the use of the Solar Feed Fermentor, the farmers began producing fermented feed (silage) using locally available materials such as Napier grass, corn stalks, rice bran, molasses, and EM4. The introduction of solar-powered machinery enabled the group to significantly increase their feed processing capacity while maintaining product uniformity and quality.

Before the program, farmers could only process approximately 20–30 kg of feed per day, using manual chopping and mixing methods. After adopting the Solar Feed Fermentor technology, production capacity increased to 120–150 kg per day, representing nearly a fivefold increase in output. The use of the solar-powered chopper and mixer also reduced feed preparation time by over 50%, as the machines can operate continuously for 50–60 minutes using stored solar energy. The quality of the feed also improved noticeably. The resulting silage was more homogeneous in texture, had a pleasant fermented aroma, and could be stored for up to 21 days without spoilage. The consistent fermentation process enhanced nutrient preservation and digestibility, contributing to better animal health and productivity. The overall efficiency improvement can be seen in Table 3.

Table 3. Comparison of Feed Production and Efficiency Before and After Program Implementation

No	Indicator	Before Program	After Program	Improvement
1	Average feed production capacity	20–30 kg/day	120–150 kg/day	↑ 5× increase
2	Feed processing time	2–3 hours/day (manual)	1 hour/day (solar-powered)	↓ 50% faster
3	Feed quality and uniformity	Uneven texture, perishable	Homogeneous, storable up to 21 days	Improved consistency
4	Energy source used	Manual labor / electricity	Renewable solar energy	Sustainable, low-cost
5	Operational cost efficiency	High labor and energy cost	Reduced cost through solar utilization	↓ 30–40% savings

These findings indicate that the integration of renewable energy-based technology not only improved feed production efficiency but also contributed to sustainable livestock management practices. The Solar Feed Fermentor system enabled farmers to utilize local biomass efficiently, reduce production costs, and ensure feed availability throughout the year. Furthermore, the environmentally friendly energy source aligns with the goals of Sustainable Development Goal (SDG) 7 — Affordable and Clean Energy, and SDG 8 — Decent Work and Economic Growth by promoting technological empowerment and rural economic resilience.

5. Socio-Economic and Environmental Benefits

The implementation of the Solar Feed Fermentor System at Balebat Farm generated not only technical and production improvements but also considerable socio-economic and environmental impacts for the farmer community in Kalijaya Village. From a socio-economic perspective, the introduction of renewable energy technology increased farmers' self-sufficiency and reduced their dependency on conventional energy sources such as electricity and fuel. The ability to process feed independently using solar power reduced the need for daily purchases of fresh forage and minimized labor time. Farmers reported that feed preparation time was reduced by almost 50%, allowing them to allocate more time for other productive activities such as herd management and milk handling.

The reduction in operational costs was also evident. Before the program, feed processing relied on manual chopping or electricity from the local grid, which resulted in additional expenses for energy and labor. After the installation of the solar-powered system, farmers experienced a 30–40% reduction in operational expenses, as the solar energy provided a sustainable and cost-free power source once the system was in operation. This cost efficiency directly contributed to the improvement of farmers' household income and strengthened the economic resilience of the group. Furthermore, the improved feed quality and consistency positively affected dairy goat productivity. With a steady supply of nutrient-rich fermented feed, milk production became more stable, resulting in higher economic value for the group's dairy products. This also opened new opportunities for product diversification and local market development under the Balebat Farm brand.

From an environmental standpoint, the use of solar energy has directly contributed to the

reduction of carbon emissions and the dependency on non-renewable energy. The Solar Feed Fermentor System demonstrated that small-scale farmers could adopt clean energy technology that supports both environmental conservation and rural economic growth (Makinde and Obikoya, 2024). The overall program outcomes align with several United Nations Sustainable Development Goals (SDGs), particularly SDG 7 (Affordable and Clean Energy), SDG 8 (Decent Work and Economic Growth), and SDG 12 (Responsible Consumption and Production). The integration of renewable energy, feed technology, and community empowerment reflects a holistic model of sustainable rural development where technology adoption translates into long-term social and economic benefits.

CONCLUSION

The implementation of the Solar Feed Fermentor System at Balebat Farm, Kalijaya Village, has effectively improved the efficiency and sustainability of feed production. Farmers' knowledge and skills in making fermented feed increased significantly, leading to higher productivity and reduced operational costs. The use of solar energy not only lowered dependence on conventional electricity but also supported environmentally friendly livestock practices. This program serves as a replicable model of community empowerment through appropriate technology aligned with sustainable development goals.

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REFERENCES

- Adami, L., M. Schiavon, V. Torretta, L. Costa, and E. C. Rada. (2020). Evaluation of conventional and alternative anaerobic digestion technologies for applications to small and rural communities. *Waste Management*. 118:79-89.
- Betchem, G., A. R. Monto, F. Lu, L. F. Billong, and H. Ma. (2024). Prospects and application of solid-state fermentation in animal feed production: A review. *AFMA Matrix*. 33:28-33.
- Hayat, M. K., M. M. Mumtaz, M. Ahsan Ali, A. Huaira, M. Ur Rehman, M. A. Shabbir, M. Usman, and A. Afzal. (2024). Optimizing Livestock Feed Systems: A Multi-Faceted Approach for Sustainable and Resilient Animal Agriculture; A Comprehensive Review. *J. Plant Biota*. 3:27-33.
- Lendrawati, L., T. Afriani, and E. Ratni. (2023). Empowering Goat Farming: Implementing Complete Silage Rations from Local Resources in Talawi Hilie Village. *Andalasian International Journal of Social and Entrepreneurial Development*. 3:14-20.
- Makinde, P., and E. Obikoya. (2024). Implementation of solar system for electricity generation for rural farmers: A review. *World Journal of Advanced Research and Reviews*. 22:458-471.
- Makkar, H. (2018). Feed demand landscape and implications of food-not feed strategy for food security and climate change. *Animal*. 12:1744-1754.
- Maleko, D., G. Msalya, A. Mwilawa, L. Pasape, and K. Mtei. (2018). Smallholder dairy cattle feeding technologies and practices in Tanzania: failures, successes, challenges and prospects for sustainability. *International Journal of Agricultural Sustainability*. 16:201-213.
- Paris, B., F. Vandorou, D. Tyris, A. T. Balafoutis, K. Vaiopoulos, G. Kyriakarakos, D. Manolakos, and G. Papadakis. (2022). Energy use in the EU livestock sector: A review recommending energy efficiency measures and renewable energy sources adoption. *Applied Sciences*. 12:2142.
- Priyadi, S., and A. F. Aziez. (2024). Addition To Green-Based Feed Preparations With Fermentation Technology Innovation Good Ruminant Feeding Practices. *Journal of Community Capacity Empowerment*. 2:28-33.
- Winkler, B., I. Lewandowski, A. Voss, and S. Lemke. (2018). Transition towards renewable energy production? Potential in smallholder agricultural systems in West Bengal, India. *Sustainability*. 10:801.