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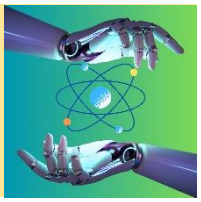

Utilisation of Agricultural Waste as Supplementary Feed for Ruminants in Kuta Karang Community, Aceh Besar

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Abstract

Feed availability remains a major constraint in large ruminant farming at the smallholder level. On the other hand, agricultural by-products such as rice straw, rice bran, tofu waste, and coconut cake have significant potential as alternative feed resources. This community service activity aimed to enhance farmers' knowledge and skills in utilising agricultural waste as supplementary feed for large ruminants. The activity was conducted in Gampong Kuta Karang, Darul Imarah District, Aceh Besar Regency, using a case study approach. The implementation stages included preliminary observation, counselling, training, practical demonstrations, and evaluation through pre- and post-tests. The data were analysed using descriptive quantitative methods, including mean values, percentage increases, and interpretation of changes in participants' knowledge. The results showed a significant improvement in participants' knowledge after the training program, as indicated by an increase in the average score from 52.6 (pre-test) to 82.6 (post-test), with an average gain of 30 points (±57%). This finding indicates that the applied methods, combining counselling, hands-on training, and mentoring, were effective in facilitating knowledge transfer and technology adoption among participants. In addition, participants demonstrated improved understanding of the types of agricultural waste, simple processing techniques, and the economic benefits of using such waste as livestock feed. Overall, this activity highlights that the utilisation of agricultural waste can serve as an alternative solution to support feed availability, improve farming efficiency, and promote sustainable livestock production systems at the community level.

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1. Introduction

Large ruminant farming, such as cattle and buffalo production, plays a crucial role in supporting food security and improving the economic welfare of rural communities. This sector contributes significantly to the supply of animal protein and serves as an important source of income for smallholder farmers. Despite its importance, the productivity of ruminant farming systems is still constrained by several factors, particularly the availability of feed resources. Feed shortages, especially during the dry season when forage availability declines, remain a major challenge that directly affects livestock productivity and farming efficiency [1], [2].

Feed availability is widely recognised as a key determinant of livestock productivity. In many developing countries, ruminant production systems rely heavily on natural forage and agricultural by-products, which are often seasonal, and the supply is inconsistent. The scarcity of quality feed,

particularly during prolonged dry periods, can lead to reduced animal performance, lower weight gain, and decreased reproductive efficiency [3], [4]. Therefore, alternative and sustainable feed resources are urgently needed to support continuous livestock production.

On the other hand, rural areas have abundant agricultural residues that are not being optimally utilised. Agricultural by-products such as rice straw, rice bran, tofu waste, and coconut cake have considerable potential as alternative feed resources for ruminants [5], [6]. Rice straw, for instance, is widely available in rice-producing regions and can serve as a basal feed when properly processed [7]. Similarly, agro-industrial by-products such as tofu waste and coconut meal contain valuable nutrients that can improve the nutritional quality of livestock diets [8], [9].

However, the direct use of agricultural waste as livestock feed is often limited by its low nutritional value and digestibility. Therefore, appropriate processing techniques, such as fermentation, ammoniation, and ration formulation, are required to enhance its nutritional quality and utilisation efficiency. Previous studies have shown that fermentation can significantly improve the digestibility and protein content of agricultural residues, thereby increasing their value as livestock feed [10], [11]. In addition, the use of feed additives and supplements can further enhance feed efficiency and animal performance [12].

The use of agricultural waste not only provides an alternative feed source but also helps reduce feed costs and promote environmentally sustainable farming practices. Efficient use of crop residues can minimise waste accumulation and environmental pollution while simultaneously improving the economic returns of livestock farming [13], [14]. Furthermore, integrating crop and livestock systems through the use of agricultural by-products has been recognised as a sustainable approach to improving resource efficiency in rural farming systems [15].

Aceh Besar Regency has considerable potential for the development of ruminant livestock based on the availability of agricultural residues, estimated at approximately 197,510 tons of dry matter [16]. In Gampong Kuta Karang, most residents are engaged in farming and livestock activities using traditional management systems. Although agricultural waste is abundant in this area, its utilisation as livestock feed remains limited due to insufficient knowledge and technical skills among farmers. This condition indicates a gap between resource availability and its effective utilisation.

Based on initial observations, the community's limited knowledge and skills in processing agricultural waste into nutritious livestock feed highlight the need for targeted intervention. Therefore, this community service activity aims to enhance farmers' knowledge and skills in utilising agricultural waste as supplementary feed for large ruminants. Specifically, this study aims to (1) describe the implementation process of the community service program and (2) analyse the changes in participants' knowledge before and after the intervention. In addition, this program is expected to introduce practical, applicable feed-processing techniques, promote the use of local resources, and ultimately improve livestock productivity and farmers' welfare.

2. Methodology

This study employed a community service-based case study approach to assess the effectiveness of utilising agricultural waste as supplementary feed for large ruminants. The activity was conducted in Gampong Kuta Karang, Darul Imarah District, Aceh Besar Regency. The target participants were 20 local farmers actively engaged in crop farming and smallholder livestock production. The implementation of this program was carried out through several structured stages, including preparation, implementation, data collection, and evaluation.

The preparation stage involved preliminary field surveys, coordination with local authorities, and identification of community needs. This stage aimed to understand the existing conditions related to livestock feeding practices and the availability of agricultural waste resources. In addition, discussions and informal interviews were conducted with farmers to identify key constraints, particularly regarding feed availability and the utilisation of local resources. Based on these findings, training materials, tools, and schedules were prepared to ensure the program addressed the community's specific needs.

The implementation stage consisted of several integrated activities, including counselling, training sessions, and practical demonstrations. The counselling sessions provided theoretical knowledge on the importance of utilising agricultural waste, the types of potential feed materials, and their nutritional value. The training sessions focused on introducing simple processing techniques such as chopping, fermentation, and feed formulation. Furthermore, practical demonstrations were conducted to enable participants to apply the techniques directly, including the preparation of supplementary feed (concentrate) using locally available materials such as rice bran, tofu waste, and coconut meal. This hands-on approach was intended to enhance participants' understanding and technical skills.

The data collection stage was carried out using a quantitative approach, with pre- and post-test assessments. The pre-test was administered before the training to measure participants' initial knowledge of agricultural waste utilisation. After the completion of the training and demonstration activities, a post-test was conducted to evaluate the improvement in participants' understanding. In addition, observations were conducted during the training sessions to assess participants' engagement and practical skills. Supporting qualitative data were also collected through discussions and participant feedback to provide a more comprehensive evaluation of the program.

The data analysis used descriptive quantitative methods. The analysis included calculating the mean scores for the pre-test and post-test, determining the percentage increase in knowledge, and interpreting changes in participants' understanding. The formula used to calculate the percentage increase was based on the difference between post-test and pre-test scores divided by the pre-test score, then multiplied by 100%. The results were then interpreted to determine the effectiveness of the training program in improving participants' knowledge and skills.

The mentoring and follow-up stage was conducted after the training activities to ensure the program's sustainability. During this stage, participants were assisted in applying the techniques learned, particularly in processing agricultural waste into livestock feed. The mentoring process aimed to address challenges farmers encountered and strengthen their confidence in adopting the introduced technology. Continuous interaction between the facilitators and participants was maintained to support knowledge transfer and practical application.

The final stage was monitoring and evaluation, which aimed to assess the program's overall success. Monitoring observed participants' adoption of feed processing techniques, while evaluation measured the program's impact on participants' knowledge and skills. The effectiveness of the program was determined based on the improvement in test scores, participant participation, and their ability to apply the techniques independently. The results of this evaluation served as a basis for improving future community service programs and promoting the wider adoption of agricultural waste utilisation in livestock farming.

Implementation of Community Service Activities

This community service (PKM) activity was implemented through several systematic stages, from preparation to evaluation. These stages were designed to ensure that the process of knowledge and technology transfer to the community could be conducted effectively and provide tangible impacts for farmers in Gampong Kuta Karang, Darul Imarah District, Aceh Besar Regency.

Preparation Stage

The initial stage of the activity began with conducting surveys and coordinating with village officials, farmer groups, and the local community to present the PKM activity plan. At this stage, the implementation team also conducted field observations and identified problems faced by the community related to the utilisation of agricultural waste and the availability of livestock feed. This activity aimed to determine real field conditions, identify local resource potential, and assess community needs so that the implemented program would be appropriately targeted.

In addition, during the preparation stage, extension materials were developed, training tools and materials were prepared, and the activity schedule was arranged. This stage is an essential component of community service activities because, through problem identification and community coordination, the implementation team can design solutions that meet partners' needs. The preparation stage in PKM activities is generally conducted through observation, community discussions, and Focus Group Discussions (FGD) to determine appropriate solutions to the problems faced by the target group.

Figure 1: Survey and Focus Group Discussion (FGD)

Material Delivery

The materials presented included the importance of using agricultural waste as an alternative feed for large ruminants, the types of agricultural waste that can be used as livestock feed, the nutritional content of agricultural waste, and the economic and environmental benefits of its use. The methods used consisted of lectures, discussions, direct question-and-answer sessions with participants, and simulations of supplementary feed formulation.

This participatory approach was applied to ensure participants could understand the material presented and to allow them to express the challenges they face in their daily livestock activities. The delivery of this material aimed to improve community knowledge of feed processing technology based on agricultural waste, enabling participants to understand the potential of locally available resources better. The materials presented include:

Figure 2: Ingredients for supplementary feed formulation for ruminant livestock

Agricultural waste is a potential alternative feed resource for ruminant livestock. It generally originates from crop residues and plantation by-products that still contain fibre and nutrients that ruminants, such as cattle, goats, and buffalo, can utilise. Ruminant animals can digest high-fibre materials through microbial activity in the rumen, allowing various agricultural wastes to be used as alternative feed sources. The utilisation of agricultural waste as livestock feed can improve farming efficiency while reducing environmental pollution caused by its accumulation [16], [17].

Rice Straw

Rice straw is among the most abundant agricultural waste products in rice production areas. Each hectare of rice field can produce approximately 7 tons of rice straw after harvest. Rice straw has a high fibre content and can be used as a feed source for ruminants, especially after processing such as fermentation or ammoniation to improve its nutritional value and digestibility [18]. Fermentation of rice straw has been shown to improve feed quality and livestock productivity, and economic factors significantly influence farmers' technology adoption [19]. In addition, using rice straw can reduce agricultural waste and support sustainable farming practices [20]. Fermentation also improves the proximate composition of ammoniated rice straw, including crude protein, crude fibre, and fibre fractions [21], [22].

Tofu Waste

Tofu waste is a by-product of tofu production that can be utilised as livestock feed. It contains valuable nutrients, particularly as a protein source. Fermentation using microorganisms such as Trichoderma viride and Saccharomyces cerevisiae can improve the nutritional value of the product, including its crude protein and organic matter content [23]. Currently, tofu waste is often used in fresh form, limiting its storage period; therefore, introducing fermentation technology is necessary to improve its shelf life and utilisation [24].

Coconut Cake

Coconut cake is a by-product of coconut oil processing. It contains high levels of crude protein and fibre. However, its use as livestock feed requires treatment, such as fermentation, to reduce its crude fibre content and improve digestibility. Fermentation also increases its protein content, making it more suitable for ruminant diets [25], [26].

Rice Bran

Rice bran is a by-product of rice milling, with rice as the main product. It is available in fine and coarse forms and is commonly used as poultry feed. However, rice bran can also be used in ruminant rations because it contains fibre, protein, and carbohydrates. Improper storage can reduce its quality due to spoilage; therefore, maintaining appropriate moisture levels and applying fermentation with probiotics are necessary to preserve its quality and extend its shelf life.

Feed Additives and Feed Supplements

Feed additives and feed supplements are additional components added to rations to complement nutritional requirements and improve feed efficiency, rather than serving as primary feed ingredients. Examples include molasses as an energy source to enhance feed intake and palatability [27], urea as a non-protein nitrogen (NPN) source for rumen microbes to support microbial protein synthesis [28], and mineral mixtures to fulfil macro- and micro-mineral requirements and support growth and reproduction. The inclusion of feed supplements in rations typically ranges from 2–5%, and their use must be carefully controlled to prevent adverse effects on animal health.

3. Result & Discussion

Ration Formulation for Large Ruminants

The formulation of rations for beef cattle was developed using locally available feed resources, including rice bran, tofu waste, and coconut cake, supplemented with molasses, urea, and mineral

mixtures to meet the nutritional requirements of ruminant livestock. The inclusion of energy sources, protein, and non-protein nitrogen (NPN), such as urea, has been shown to enhance microbial protein synthesis efficiency in the rumen, thereby improving livestock performance [28].
The combination of these ingredients produced a ration with a crude protein content of approximately 13–14%, which is suitable for beef cattle fattening. The use of locally available agricultural by-products not only reduces feed costs but also increases the sustainability of livestock production systems by utilising resources that would otherwise go underutilised.

Table 1. Ration formulation for large ruminant livestock

Material	Percentage
Rice bran	40 %
Tofu waste	30 %
Coconut cake	25 %
Molasses	3 %
EM-4	0.5 %
Minerals + salt	1.5 %
Total	**100**

The ration formulation presented in **Table 1** demonstrates a balanced composition of locally available feed ingredients designed to meet the nutritional requirements of large ruminant livestock. Rice bran constitutes the largest proportion (40%) and serves as a primary energy source, followed by tofu waste (30%) and coconut cake (25%) as important protein sources. The inclusion of molasses (3%) enhances palatability and provides readily available energy, while EM-4 (0.5%) functions as a microbial starter to support fermentation and improve feed digestibility. Additionally, minerals and salt (1.5%) are incorporated to meet essential macro- and micro-mineral requirements for optimal growth and metabolic function. Overall, this formulation reflects an efficient use of agricultural by-products to produce a nutritionally adequate, cost-effective feed ration, supporting improved livestock performance and sustainable farming practices.
This formulation demonstrates that agricultural waste can be effectively transformed into nutritionally adequate feed when properly processed and combined. The balance between energy, protein, and fibre is essential to ensure optimal rumen function and animal growth.

Demonstration of Supplementary Feed (Concentrate) Production
During this stage, participants were introduced to the practical aspects of ration formulation and feed processing techniques. The demonstration included step-by-step procedures for mixing feed ingredients, preparing agricultural waste, and applying fermentation processes to improve feed quality and shelf life.
In addition to theoretical explanations, participants were allowed to practice the feed-mixing process directly. This hands-on approach allowed participants to gain practical experience and better understand how the technology is applied. Through this demonstration, participants were expected to be able to independently produce supplementary feed using locally available materials in their own farming systems.
Training combined with practical demonstrations has been recognised as an effective method for community service activities, as it significantly enhances participants' technical skills and their capacity to adopt introduced technologies [16]. The results of this activity indicate that participatory learning methods are crucial in ensuring the successful transfer of knowledge and skills.
Figure 3 illustrates the practical demonstration of supplementary feed (concentrate) preparation for ruminant livestock using locally available agricultural by-products. The activity involved direct community participation in measuring, mixing, and processing feed ingredients such as rice bran, tofu waste, and coconut cake, along with the addition of molasses and other supplements. The hands-on approach enabled participants to clearly understand each stage of feed formulation, from raw material preparation to mixing. This type of experiential learning is essential in rural community development,

as it bridges the gap between theoretical knowledge and practical application. Through direct involvement, participants gained technical skills more effectively than with conventional lecture-based methods.

Furthermore, the interaction between facilitators and participants during the demonstration fostered an active learning environment, where participants could ask questions, share experiences, and immediately apply the techniques being introduced. This participatory method not only improved technical competence but also increased participants' confidence in adopting the technology independently. The visual and practical nature of the activity, as shown in **Figure 3**, reinforces the effectiveness of demonstration-based training in enhancing knowledge retention and skill acquisition. Consequently, such approaches play a significant role in accelerating the adoption of agricultural waste utilisation technologies, ultimately contributing to improved feed efficiency, reduced production costs, and sustainable livestock farming practices at the community level.

Figure 3: Practical Demonstration of Supplementary Feed (Concentrate) Preparation for Ruminant Livestock

Mentoring Stage

Following the training activities, mentoring was conducted to assist participants in applying the introduced technologies in real field conditions. This stage aimed to ensure that participants could implement agricultural waste processing techniques effectively and address any challenges encountered during application.

The mentoring process also strengthened the relationship between the facilitators and the community, enabling continuous knowledge transfer. Through direct assistance, participants gained confidence in adopting new practices and integrating them into their livestock management systems. This approach is essential to ensure the sustainability of community-based interventions.

Monitoring and Evaluation

The final stage of the PKM activity involved monitoring and evaluation to assess the program's effectiveness and impact. Monitoring was conducted to observe the extent to which participants adopted the introduced feed processing technologies. Evaluation focused on measuring improvements in participants' knowledge and skills after participating in the program.

The evaluation was conducted using pre-test and post-test methods, supported by discussions and direct observation of participants' ability to apply feed processing techniques. The results showed a significant improvement in participants' knowledge. The average pre-test score was 52.6, while the post-test score increased to 82.6, indicating an average improvement of 30 points (±57%).

These findings confirm that training and practical demonstration methods are highly effective in improving community knowledge and skills in processing agricultural waste into livestock feed [10]. Furthermore, the increase in participants' knowledge indicates that livestock feed technology transfer can be well accepted by the community, particularly when accompanied by hands-on practice and continuous mentoring [27].

Table 2. Results of participants' knowledge improvement based on pre-test and post-test

No	Participant Name	Pre-test	Post-test	Increase
1	Participant 1	50	80	30
2	Participant 2	55	85	30
3	Participant 3	60	85	25
4	Participant 4	45	75	30
5	Participant 5	50	80	30
6	Participant 6	55	82	27
7	Participant 7	60	88	28
8	Participant 8	52	83	31
9	Participant 9	48	78	30
10	Participant 10	53	84	31
11	Participant 11	57	86	29
12	Participant 12	49	79	30
13	Participant 13	51	81	30
14	Participant 14	54	85	31
15	Participant 15	56	87	31
16	Participant 16	47	77	30
17	Participant 17	58	86	28
18	Participant 18	52	82	30
19	Participant 19	50	80	30
20	v 20	55	85	30

Table 2 shows a significant improvement in participants' knowledge following the implementation of the training program on the utilisation of agricultural waste as livestock feed. The pre-test scores ranged from 45 to 60, indicating that participants initially had a limited understanding of feed processing techniques. After the training and practical demonstrations, the post-test scores increased substantially, ranging from 75 to 88. The average increase in scores was approximately 30 points, with individual improvements ranging from 25 to 31 points. This consistent increase across all 20 participants indicates that the training program was highly effective in enhancing participants' knowledge. The results also suggest that the combination of theoretical instruction, hands-on practice, and mentoring significantly contributed to learning outcomes. Participants who initially had lower pre-test scores showed comparable improvements to those with higher initial knowledge, indicating that the training approach was inclusive and effective for participants with varying educational backgrounds. Overall, the findings

confirm that participatory training methods can significantly improve knowledge and skills related to livestock feed processing, thereby supporting the adoption of agricultural waste utilisation technologies at the community level.

Discussion of Knowledge Improvement

The improvement in participants' understanding is clearly illustrated in **Figure 4**, which compares pre-test and post-test scores. The graph indicates a consistent increase in knowledge among all participants, demonstrating the effectiveness of the training program.

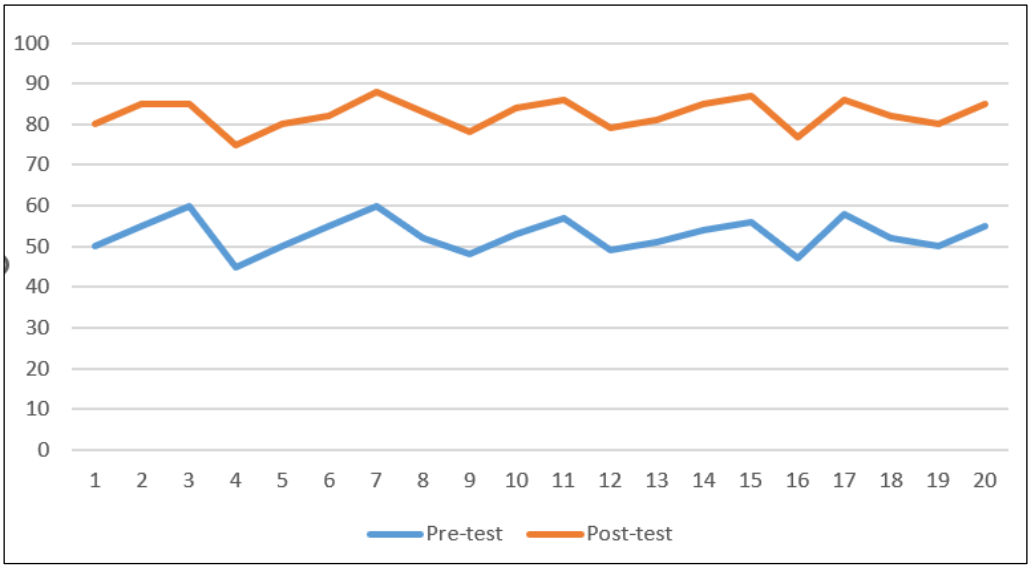

Figure 4. Graph of participants' understanding before PKM (Pre-Test) and after PKM (Post-Test)

The results suggest that the combination of theoretical explanation, practical demonstration, and mentoring creates an effective learning environment. Participants not only gained knowledge but also developed practical skills that can be directly applied in their daily livestock activities. This aligns with previous findings that participatory and practice-based learning approaches significantly enhance technology adoption in rural communities.

Overall Impact of the Program

Based on the implementation stages and evaluation results, the PKM activity successfully improved the community's knowledge, skills, and awareness of the use of agricultural waste as a supplementary feed for large ruminants. Participants demonstrated a better understanding of feed types, processing techniques, and the economic benefits of using agricultural waste. In addition, this activity encouraged the community to use local resources more efficiently, which can help reduce feed costs and improve livestock productivity. Ultimately, the program has the potential to enhance the overall efficiency of livestock farming systems and improve the welfare of farmers in Gampong Kuta Karang.

4. Conclusion

Based on the results of the community service activities conducted in Gampong Kuta Karang, Darul Imarah District, Aceh Besar Regency, it can be concluded that the extension and training activities on the utilisation of agricultural waste as supplementary feed for ruminant livestock were successfully implemented and had a positive impact on improving the knowledge and skills of the community. The evaluation results based on pre-test and post-test showed a significant increase in participants' knowledge, with the average score improving from 52.6 to 82.6, representing an increase of approximately 57%. This finding indicates that the methods applied, combining extension, training, and

practical demonstrations, were effective in enhancing community understanding. Furthermore, participants were able to identify various types of agricultural waste suitable for livestock feed and demonstrated an understanding of simple processing techniques, such as fermentation and ration formulation. Therefore, the utilisation of agricultural waste has strong potential as an alternative solution to address feed shortages, improve livestock farming efficiency, and support more sustainable environmental management.

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