

INTEGRATED RUMINANT FEEDING SYSTEMS UTILIZING AGRO-INDUSTRIAL BY-PRODUCTS THROUGH ELEPHANT GRASS-BASED SILAGE

Ahmad Azhary¹, Munir², Rahmawati Semaun³

^{1,2,3} Animal Husbandry Study Program, Faculty of Agriculture, Animal Husbandry, and Fisheries, Universitas Muhammadiyah Parepare, Jl. Jend. Ahmad Yani Km. 6, Bukit Harapan, Soreang, Parepare, Sulawesi Selatan, Indonesia, 91131

*e-mail koresponden: ahmadazhary2002@gmail.com

Article history:

Received: July 27, 2024

Accepted: October 10, 2024

Published: October 25, 2024

Keywords:

agro-industrial by-products, complete feed silage, elephant grass silage, fermentation quality, integrated ruminant feeding system, sustainable livestock production.

ABSTRACT

Integrated ruminant feeding systems utilizing agro-industrial by-products offer a sustainable solution to feed constraints in tropical livestock production. This study evaluated the physical quality and fermentation characteristics of elephant grass-based complete feed silage formulated with different proportions of tofu by-product and rice bran. A completely randomized design with four silage formulations was applied. Silage was anaerobically fermented for 21 days and assessed for organoleptic properties (aroma, color, texture, and fungal growth) and pH value. The results showed that silage formulation did not significantly affect aroma, texture, or pH ($P>0.05$), with all treatments exhibiting characteristics of good-quality silage, including a pleasant acidic aroma, compact texture, and acceptable pH values ranging from 3.93 to 4.50. In contrast, fungal growth and color were significantly influenced by treatment ($P<0.01$). Increasing the proportion of rice bran reduced fungal growth and improved silage color, indicating enhanced fermentation stability. The formulation with the highest rice bran proportion demonstrated the most favorable overall silage quality. In conclusion, elephant grass-based complete feed silage integrated with agro-industrial by-products can produce stable and high-quality silage. These findings support the development of integrated and sustainable ruminant feeding strategies that improve resource efficiency and promote circular agriculture.

Kata kunci:

kualitas fermentasi, peternakan berkelanjutan, produk samping agroindustri, silase pakan komplit, silase rumput gajah, sistem pakan ruminansia terpadu.

ABSTRAK

Sistem pakan ruminansia terpadu yang memanfaatkan produk samping agroindustri merupakan solusi berkelanjutan untuk mengatasi keterbatasan pakan pada sistem peternakan tropis. Penelitian ini bertujuan mengevaluasi kualitas fisik dan karakteristik fermentasi silase pakan komplit berbasis rumput gajah dengan proporsi ampas tahu dan dedak padi yang berbeda. Penelitian disusun menggunakan rancangan acak lengkap dengan empat formulasi silase. Silase difermentasi secara anaerob selama 21 hari dan dievaluasi berdasarkan sifat organoleptik (aroma, warna, tekstur, dan pertumbuhan jamur) serta nilai pH. Hasil penelitian menunjukkan bahwa perbedaan formulasi tidak berpengaruh nyata terhadap aroma, tekstur, dan nilai pH ($P>0,05$). Seluruh perlakuan menghasilkan silase berkualitas baik dengan aroma asam yang khas, tekstur kompak, dan nilai pH yang masih dapat diterima (3,93–4,50). Sebaliknya, warna dan pertumbuhan jamur dipengaruhi secara nyata oleh perlakuan ($P<0,01$). Peningkatan proporsi dedak padi mampu menurunkan pertumbuhan jamur dan memperbaiki warna silase, yang menunjukkan fermentasi lebih stabil. Formulasi dengan proporsi dedak padi tertinggi memberikan kualitas silase terbaik secara keseluruhan. Kesimpulannya, silase pakan komplit berbasis rumput gajah yang terintegrasi dengan produk samping agroindustri berpotensi mendukung pengembangan sistem pakan ruminansia terpadu, efisien, dan berkelanjutan.

INTRODUCTION

Sustainable agricultural systems currently face major challenges related to resource-use efficiency, feed security for livestock, and the management of agro-industrial waste. In the ruminant livestock sector, seasonal fluctuations in forage availability, particularly in tropical regions, represent one of the main constraints on animal productivity (Feitosa et al., 2022; Fetzl et al., 2017). Reliance on fresh forage not only increases the risk of feed shortages during the dry season but also reduces the overall efficiency of livestock production systems (Duguma & Janssens, 2021; Tulu et al., 2023).

In this context, the concept of integrated ruminant feeding systems has gained increasing attention (Kusumo et al., 2017; Moorby & Fraser, 2021). This approach emphasizes the integration of forage production, utilization of agro-industrial by-products, and feed preservation technologies to create systems that are efficient, sustainable, and resilient to climate variability (Michael et al., 2021). One of the key strategies within such systems is the use of high-biomass forage combined with agro-industrial residues as alternative feed resources with added value.

Elephant grass (*Pennisetum purpureum*) is a widely used forage species in tropical ruminant production systems due to its high biomass yield and strong adaptability (Anggraini & Yulianto, 2023; Suherman, 2021). However, its high moisture content and limited shelf life make elephant grass susceptible to rapid quality deterioration if not utilized promptly (Chen et al., 2022; Lemos et al., 2020). Therefore, processing elephant grass into silage represents a strategic solution to ensure year-round feed availability while improving the stability of ruminant feeding systems (Daniel et al., 2019).

Meanwhile, food-processing industries generate various by-products with considerable potential for use as livestock feed, such as tofu dregs and rice bran. Tofu dregs are soybean-based agro-industrial residues that still contain relatively high levels of protein and energy (Alwi et al., 2021; Febrina et al., 2022; Kamble & Rani, 2020; Mahyudi & Husinsyah, 2020), whereas rice bran serves as an important source of readily fermentable carbohydrates and energy (Alexandri et al., 2020; Hidayat et al., 2021; Spaggiari et al., 2021). Integrating these by-products into ruminant feeding systems not only has the potential to improve the nutritional quality of silage but also supports the principle of valorization of agro-industrial by-products within a circular and sustainable agriculture framework.

Although numerous studies have reported the utilization of elephant grass (Nisa et al., 2020; Suherman, 2021; Utari, 2018), tofu dregs (Afzalani et al., 2017; Ashari, 2019; Sari et al., 2016), or rice bran individually in animal feed (Zhang YC, et al., 2021), research that positions these three components as part of an integrated ruminant feeding system based on complete feed silage remains limited (Suganda et al., 2022; Wong et al., 2019). Most previous studies have focused on nutrient composition or animal performance, whereas comprehensive evaluations of physical quality and fermentation characteristics of silage as early indicators of integrated feed system success have received less attention, particularly in the context of simultaneous utilization of multiple agro-industrial by-products.

In fact, the physical quality of silage—such as aroma, color, texture, fungal growth, and pH value—constitutes key parameters that determine fermentation stability, feed safety, and animal

acceptability (Ávila & Carvalho, 2020; Kung et al., 2018; Oladosu et al., 2016; Sofyan et al., 2017). These parameters play a critical role in ensuring that integrated feeding systems are not only conceptually sustainable but also practically applicable at the farm level (Farda et al., 2023; Suryapratama & Rahayu, 2020).

Based on this background, the present study aims to evaluate the physical quality and fermentation characteristics of elephant grass-based silage combined with tofu dregs and rice bran as part of an integrated ruminant feeding system. The findings of this study are expected to provide scientific contributions to the development of sustainable integrated agricultural systems through the efficient and value-added utilization of agro-industrial by-products as alternative feed resources.

RESEARCH METHODOLOGY

Time and Location of the Study

This study was conducted from January to February 2024 and consisted of two main stages. The first stage involved the preparation of complete feed silage based on elephant grass, which was carried out at the Laboratory of the Faculty of Agriculture, Animal Science, and Fisheries, Universitas Muhammadiyah Parepare. The second stage comprised the evaluation of the physical quality and fermentation characteristics of the silage, conducted at the Laboratory of the Faculty of Agriculture, Animal Science, and Fisheries, Campus II, Universitas Muhammadiyah Parepare.

Materials and Equipment

The materials used in this study included elephant grass (*Pennisetum purpureum*) as the primary forage source, tofu dregs and rice bran as agro-industrial by-products, mineral mix, and a microbial inoculant solution (EM4). Elephant grass was obtained from plantation areas in Pinrang Regency, while tofu dregs were sourced from local tofu-processing industries in the same region.

The equipment used consisted of a digital balance, machetes and cutting boards for chopping the materials, plastic bags used as silos, measuring cylinders, spray bottles, mixing tools, and a digital pH meter for measuring silage acidity.

Experimental Design and Treatments

The experiment was arranged in a Completely Randomized Design (CRD) with four treatments and three replications. The treatments were formulated based on varying proportions of tofu dregs and rice bran in complete feed silage formulations, while maintaining a constant proportion of elephant grass across all treatments. The treatment formulations were as follows:

- S1: 50% elephant grass + 30% tofu dregs + 19% rice bran + 1% mineral mix
- S2: 50% elephant grass + 25% tofu dregs + 24% rice bran + 1% mineral mix
- S3: 50% elephant grass + 20% tofu dregs + 29% rice bran + 1% mineral mix
- S4: 50% elephant grass + 15% tofu dregs + 34% rice bran + 1% mineral mix

These treatments were designed to evaluate the effects of gradual substitution between tofu dregs and rice bran on the physical quality and fermentation characteristics of silage within an integrated ruminant feeding system.

Silage Preparation Procedure

Elephant grass and tofu dregs were chopped into approximately ± 3 cm lengths to enhance homogeneity and facilitate the fermentation process. All feed ingredients were thoroughly mixed

according to their respective treatment formulations. The microbial inoculant (EM4) was applied at a ratio of 1 mL EM4 per 1 L of water and evenly sprayed onto the feed mixture.

The mixture was then gradually placed into silos while being compacted to minimize oxygen presence and establish anaerobic conditions. The silos were tightly sealed and stored at room temperature for 21 days to allow the fermentation process to take place.

Observed Parameters

Physical Quality of Silage

The physical quality of silage was evaluated organoleptically based on aroma, color, texture, and fungal growth. Assessment was performed using a scoring system ranging from 1 to 4 for each parameter, following the criteria described by 2010 McDonald et al. (Filippi et al., 2018; McDonald et al., 2001; Thompson et al., 2018).

Organoleptic Scoring System for Silage Quality

The organoleptic evaluation of silage quality was conducted using a structured scoring system to assess aroma, color, texture, and fungal growth (Table 1). Each parameter was evaluated independently using a numerical scale ranging from 1 to 4, based on established silage quality assessment criteria by 2010 McDonald et al. (Filippi et al., 2018; Thompson et al., 2018). Higher scores indicated better silage quality.

Aroma was evaluated based on the intensity and characteristics of fermentation odor, where scores reflected the transition from undesirable odors to typical lactic acid fermentation aromas. Color assessment focused on visual similarity to the original forage material and color changes resulting from fermentation. Texture was evaluated based on physical integrity and moisture condition of the silage material. Fungal growth was assessed visually by estimating the proportion of silage surface area affected by mold growth. All organoleptic observations were conducted after the completion of the fermentation period (21 days) to ensure consistency across treatments.

Table 1. Organoleptic scoring criteria for silage quality.

Score	Criteria			
	Aroma	Color	Texture	Fungal growth
1.00–2.00	Less fresh odor or odor not characteristic of silage fermentation	Pale green or color deviating from the natural forage color	Coarse or excessively wet texture	Extensive fungal growth (>5% of total silage mass)
2.01–3.00	Fresh odor	Green color close to the natural color of forage	Moderately compact texture	Moderate fungal growth (2–5% of total silage mass)
3.01–4.00	Pleasant acidic aroma characteristic of high-quality silage	Dark green to greenish-brown, indicating well-preserved silage	Fine, compact, non-clumped, and non-watery texture	No visible fungal growth

Silage pH Value

Silage pH was measured using a digital pH meter to assess acidity as an indicator of fermentation success. The classification of silage quality based on pH values followed the criteria proposed by Macaulay (2004).

Data Analysis

The collected data were statistically analyzed using analysis of variance (ANOVA) according to the Completely Randomized Design (CRD). When significant differences among treatments were detected, Duncan's multiple range test was applied to determine differences between treatment means.

RESULTS AND DISCUSSION

Silage Aroma

The results indicated that treatments S1 (EG + 40% Tofu By-product), S2 (EG + 30% Tofu + 10% Rice Bran), S3 (EG + 20% Tofu + 20% Rice Bran), and S4 (EG + 10% Tofu + 30% Rice Bran) had no significant effect ($P > 0.05$) on the aroma of complete feed silage based on elephant grass supplemented with tofu by-product and rice bran. The aroma scores ranged from 3.10 to 3.16 across treatments (Figure 1.a). According to the established organoleptic scoring criteria, these values fall within the 3.01–4.00 category, indicating a pleasant acidic aroma characteristic of high-quality silage.

The uniformity of aroma among treatments suggests that the fermentation process occurred effectively and remained relatively stable despite differences in the proportions of tofu by-product and rice bran. The dominant acidic aroma reflects the activity of lactic acid bacteria fermenting soluble carbohydrates into organic acids, primarily lactic acid, which suppresses the growth of spoilage microorganisms.

These findings are consistent with Kung et al. (2018) and Oladosu et al. (2016), who reported that an acidic aroma is a key indicator of successful silage fermentation. Guo et al. (2023) and Zhang Q et al. (2021), also emphasized that anaerobic conditions during ensiling promote the dominance of lactic acid bacteria and the development of the desired silage aroma. Therefore, in terms of aroma, all silage formulations evaluated in this study met the criteria for good-quality silage.

Fungal Growth

In contrast to aroma, the treatments exerted a highly significant effect ($P < 0.01$) on fungal growth in the silage. Fungal growth scores showed a decreasing trend with increasing proportions of rice bran and decreasing tofu by-product, with the highest score observed in EG + 40% Tofu By-product (2.86) and the lowest in EG + 10% Tofu + 30% Rice Bran (2.40) (Figure 1.b).

Based on the scoring criteria, all treatments remained within the 2.01–3.00 category, indicating moderate fungal growth (2–5%). However, treatment S4 (EG + 10% Tofu + 30% Rice Bran) exhibited the lowest intensity of fungal contamination. This finding suggests that formulations with higher proportions of rice bran create more stable fermentation conditions that are less conducive to fungal growth.

Biologically, rice bran serves as a readily fermentable carbohydrate source that accelerates lactic acid production, resulting in a more rapid decline in silage pH and inhibition of fungal development. In contrast, tofu by-product has a relatively high moisture content; when used in larger amounts, it may increase substrate moisture and potentially promote fungal growth if anaerobic conditions are not fully maintained.

These results are consistent with Silalahi et al. (2023), who reported that fungal presence in silage is often associated with oxygen infiltration and high moisture levels. Sulistyono et al. (2020), also emphasized that good-quality silage should exhibit minimal fungal growth. Accordingly, treatment S4 (EG + 10% Tofu + 30% Rice Bran) can be considered the formulation that most closely meets the criteria for high-quality silage in terms of microbiological safety.

Silage Texture

The analysis showed that variations in the proportions of tofu by-product and rice bran did not significantly affect ($P>0.05$) silage texture. Texture scores ranged from 3.10 to 3.16 across all treatments (Figure 1.c). According to the scoring criteria, these values fall within the 3.01–4.00 category, indicating a fine, compact texture that is non-clumped and non-watery.

The relatively uniform and high-quality texture observed across treatments indicates that chopping, compaction, and fermentation processes were well managed in all silage formulations. A fine and compact texture suggests that the moisture content of the material remained within an optimal range that supported anaerobic fermentation without causing excessive effluent or slimy conditions.

These findings are in line with Silalahi et al. (2023) and Suryaningsih (2022), who stated that good-quality silage is characterized by a compact, non-watery, and easily handled texture. Wang et al. (2016), further highlighted that silage texture is strongly influenced by the balance between moisture content and the availability of energy substrates for lactic acid bacteria. Thus, from a textural perspective, all treatments met the standards for good-quality silage.

Silage Color

The treatments had a significant effect ($P<0.01$) on silage color. Color scores increased progressively from EG + 40% Tofu By-product (2.33) to EG + 10% Tofu + 30% Rice Bran (3.00) (Figure 1.d). According to the scoring criteria, treatments S1–S3 were classified within the 2.01–3.00 category, indicating a green color close to that of the original forage, whereas S4 (EG + 10% Tofu + 30% Rice Bran) reached the upper limit of this category and approached the 3.01–4.00 category, which represents dark green to greenish-brown coloration typical of well-preserved silage.

Silage color that closely resembles the original forage indicates minimal degradation of plant pigments during fermentation. This suggests that formulations with higher proportions of rice bran support faster and more stable fermentation, thereby reducing color deterioration caused by undesirable microbial activity.

These results are consistent with Rasuli et al. (2022), who reported that silage color similar to the original forage is an indicator of good physical quality. Aglazziyah et al. (2020) also noted that high-quality silage generally exhibits a bright green to greenish-brown color, depending on forage type and fermentation conditions.

Silage pH Value

The results showed that the treatments did not significantly affect ($P>0.05$) silage pH values, which ranged from 3.93 to 4.50 (Figure 1.e). Based on pH quality classification, treatments EG + 30%

Tofu + 10% Rice Bran (pH 4.20) and EG + 10% Tofu + 30% Rice Bran (pH 3.93) were categorized as very good, while EG + 40% Tofu By-product and EG + 20% Tofu + 20% Rice Bran (pH 4.50) were classified as good.

This pH range indicates that fermentation was effective across all treatments, with lactic acid bacteria dominating the process and reducing pH to levels suitable for silage preservation. The lower pH observed in treatment S4 (EG + 10% Tofu + 30% Rice Bran) reflects more intensive fermentation, which aligns with the lower fungal growth recorded for this treatment.

These findings are in agreement with Aglazziyah et al. (2020), who stated that very good-quality silage typically has a pH range of 3.2–4.2. Seftiana et al. (2023) also emphasized that the interaction between moisture content and microbial activity plays a critical role in determining pH dynamics during fermentation. Therefore, in terms of pH, all treatments produced acceptable silage, with the best overall performance observed in formulation S4 (EG + 10% Tofu + 30% Rice Bran).

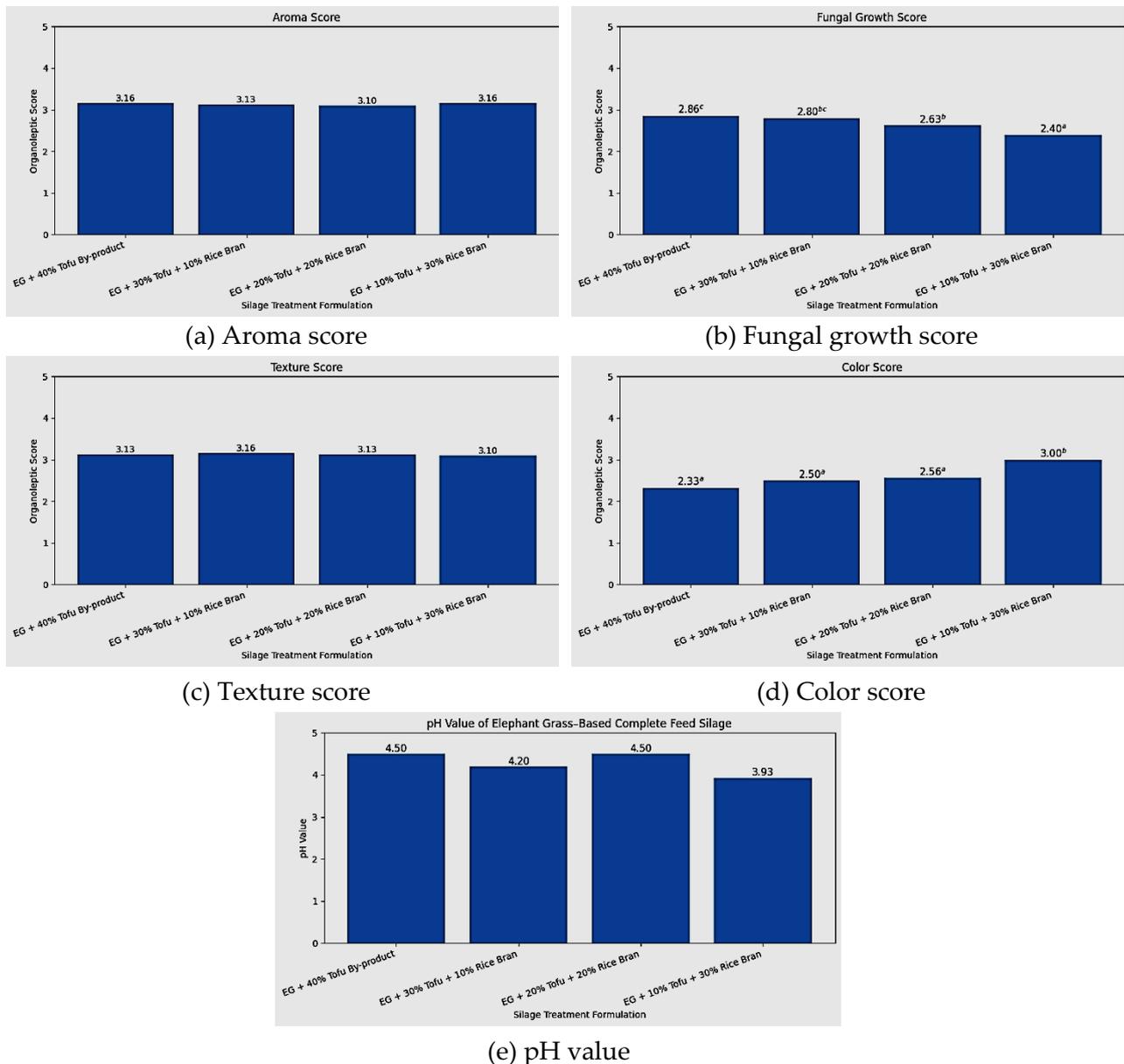


Figure 1. Organoleptic characteristics and pH value of elephant grass-based complete feed silage formulated with different proportions of tofu by-product and rice bran.

Implications for Integrated Ruminant Feeding Systems

Overall, the results of this study demonstrate that integrating elephant grass with tofu by-product and rice bran in the form of complete feed silage can produce silage with good physical quality and favorable fermentation characteristics. Treatment S4 (EG + 10% Tofu + 30% Rice Bran) consistently exhibited the best performance across most parameters, particularly in reducing fungal growth, maintaining silage color, and achieving an optimal pH.

These findings reinforce the concept of integrated ruminant feeding systems, in which the utilization of agro-industrial by-products not only enhances resource-use efficiency and agricultural sustainability but also produces stable, safe, and high-quality ruminant feed. Consequently, this study provides a strong scientific basis for the development of integrated ruminant feeding strategies aligned with the principles of sustainable agriculture and circular economy.

CONCLUSION

This study demonstrates that the integration of elephant grass with agro-industrial by-products, specifically tofu by-product and rice bran, in the form of complete feed silage can effectively enhance the physical quality and fermentation stability of ruminant feed within an integrated agricultural system. Across all treatments, the silage produced exhibited favorable organoleptic characteristics and acceptable pH values, indicating that the ensiling process was technically successful and biologically stable.

Among the evaluated formulations, the silage containing a higher proportion of rice bran and a lower proportion of tofu by-product consistently showed superior performance, particularly in reducing fungal growth, maintaining desirable silage color, and achieving a lower and more stable pH. These findings highlight the critical role of readily fermentable carbohydrate sources in accelerating lactic acid fermentation and improving silage preservation, especially when high-moisture agro-industrial by-products are incorporated into the feed system.

From a broader perspective, the results provide empirical evidence supporting the development of integrated ruminant feeding systems that valorize agro-industrial by-products as alternative feed resources. Such systems contribute not only to improved feed security and livestock productivity but also to the reduction of agro-industrial waste and environmental burdens. This aligns closely with global priorities related to sustainable agriculture, circular economy, and climate-resilient food systems.

In terms of policy relevance, the findings suggest that promoting on-farm silage technologies and encouraging the utilization of locally available agro-industrial by-products can serve as practical strategies to strengthen smallholder and commercial livestock systems, particularly in tropical regions facing seasonal feed shortages. Therefore, this study provides a scientific basis for policymakers, extension services, and development programs to integrate feed preservation and by-product utilization into sustainable livestock development frameworks.

Future research should focus on evaluating animal performance, nutrient digestibility, and economic feasibility to further validate the scalability and long-term benefits of this integrated feeding approach under diverse production conditions.

REFERENCES

- Afzalani, A., Musnandar, E., & Raguati, R. (2017). Efek Suplementasi Ampas Tahu dan Mineral Zn-Cu Organik terhadap Pertambahan Bobot Badan pada Penggemukan Sapi Bali yang Diberi Pakan Rumput Rawa (*Hyampaeacne amplexicaules* Rudge Ness). *Jurnal Ilmiah Ilmu-Ilmu Peternakan*, 20(2), 97-108. <https://doi.org/10.22437/jiiip.v20i2.5137>
- Aglazziyah, H., Ayuningsih, B., & Khairani, L. (2020). Pengaruh penggunaan dedak fermentasi terhadap kualitas fisik dan pH silase rumput gajah (*Pennisetum purpureum*). *Jurnal Nutrisi Ternak Tropis dan Ilmu Pakan*, 2(3). <https://doi.org/10.24198/jnttip.v2i3.30290>
- Alexandri, M., López-Gómez, J. P., Olszewska-Widdrat, A., & Venus, J. (2020). Valorising agro-industrial wastes within the circular bioeconomy concept: The case of defatted rice bran with emphasis on bioconversion strategies. *Fermentation*, 6(2), 42. <https://doi.org/10.3390/fermentation6020042>
- Alwi, H. A., Damat, D., & Putri, D. N. (2021). Karakteristik Fisikokimia dan Organoleptik Snack Bar Berbasis Tepung Ampas Tahu, Tepung Kacang Merah (*Phaseolus Vulgaris* L.) dan Kacang Kedelai (*Glycine Max.*). *Food Technology and Halal Science Journal*, 4(1), 23-38. <https://doi.org/10.22219/fths.v4i1.15620>
- Anggraini, M., & Yulianto, R. (2023). Profil Produksi Hijauan Rumput Gajah (*Pennisetum purpureum*) di Universitas Jember Kampus Bondowoso. *Jurnal Peternakan Lingkungan Tropis*, 6(2), 63-69. <http://dx.doi.org/10.30872/jpltrop.v6i2.11714>
- Ashari, A. (2019). Uji Proksimat Pakan Ternak Berprotein Tinggi Berbahan Dasar Cacing Tanah, Ampas Tahu, dan Daun Gamal. *Jurnal Ilmu Fisika: Teori dan Aplikasinya*, 1(2), 25-29.
- Ávila, C. L. S., & Carvalho, B. F. (2020). Silage fermentation—updates focusing on the performance of micro-organisms. *Journal of Applied Microbiology*, 128(4), 966-984. <https://doi.org/10.1111/jam.14450>
- Chen, C., Xin, Y., Li, X., Ni, H., Zeng, T., Du, Z., ... & Yan, Y. (2022). Effects of *Acremonium* cellulase and heat-resistant lactic acid bacteria on lignocellulose degradation, fermentation quality, and microbial community structure of hybrid elephant grass silage in humid and hot areas. *Frontiers in Microbiology*, 13, 1066753. <https://doi.org/10.3389/fmicb.2022.1066753>
- Daniel, J. L. P., Bernardes, T. F., Jobim, C. C., Schmidt, P., & Nussio, L. G. (2019). Production and utilization of silages in tropical areas with focus on Brazil. *Grass and forage Science*, 74(2), 188-200. <https://doi.org/10.1111/gfs.12417>
- Duguma, B., & Janssens, G. P. (2021). Assessment of livestock feed resources and coping strategies with dry season feed scarcity in mixed crop–livestock farming systems around the gilgel gibe catchment, Southwest Ethiopia. *Sustainability*, 13(19), 10713. <https://doi.org/10.3390/su131910713>
- Farda, F. T., Tantaló, S., Sirat, M. M. P., Ermawati, R., Fauzi, T. A., Rivai, M., ... & Alfarizki, A. (2023). Pelatihan Fermentasi Pakan Rumput Pakchong dan Daun Singkong dengan Metode Silase sebagai Pakan Sapi Potong di Desa Margomulyo Kecamatan Tegineneng Kabupaten Pesawaran. *Jurnal Pengabdian Fakultas Pertanian Universitas Lampung*, 2(2), 1-12. <https://doi.org/10.23960/jpfp.v2i2.7834>
- Febrina, D., Wahyono, T., Mulianda, R., Qomariyah, N., Nurfitriani, R. A., Khairi, F., ... & Prastyo, A. B. (2022). Kualitas Fisik Silase Rumput Gajah dan Ampas Tahu Segar dengan Penambahan Sirup Komersial Afkir. *Jurnal Ilmu Nutrisi dan Teknologi Pakan*, 20(2), 73-77. <https://doi.org/10.29244/jintp.20.2.73-77>
- Feitosa, O. D. S., Leite, R. D. C., Alexandrino, E., Pires, T. D. J. S., Oliveira, L. B. T. D., Paula Neto, J. J. D., & Santos, A. C. D. (2022). Forage performance and cattle production as a function of the

- seasonality of a Brazilian tropical region. *Acta Scientiarum. Animal Sciences*, 44, e53779. <https://doi.org/10.4025/actascianimsci.v44i1.53779>
- Fetzel, T., Havlik, P., Herrero, M., & Erb, K. H. (2017). Seasonality constraints to livestock grazing intensity. *Global Change Biology*, 23(4), 1636-1647. <https://doi.org/10.1111/gcb.13591>
- Filippi, M., Preziosa, P., Meani, A., Ciccarelli, O., Mesaros, S., Rovira, A., ... & Rocca, M. A. (2018). Prediction of a multiple sclerosis diagnosis in patients with clinically isolated syndrome using the 2016 MAGNIMS and 2010 McDonald criteria: a retrospective study. *The Lancet Neurology*, 17(2), 133-142.
- Guo, X., Xu, D., Li, F., Bai, J., & Su, R. (2023). Current approaches on the roles of lactic acid bacteria in crop silage. *Microbial Biotechnology*, 16(1), 67-87. <https://doi.org/10.1111/1751-7915.14184>
- Hidayat, C., Wina, E., & Sopiyan, S. (2021). Manfaat senyawa bioaktif dedak padi untuk pakan fungsional ternak ayam. *WARTAZOA*, 31(2), 79. <http://dx.doi.org/10.14334/wartazoa.v31i2.2676>
- Kamble, D. B., & Rani, S. (2020). Bioactive components, in vitro digestibility, microstructure and application of soybean residue (okara): A review. *Legume Science*, 2(1), e32. <https://doi.org/10.1002/leg3.32>
- Kung Jr, L., Shaver, R. D., Grant, R. J., & Schmidt, R. J. (2018). Silage review: Interpretation of chemical, microbial, and organoleptic components of silages. *Journal of dairy Science*, 101(5), 4020-4033. <https://doi.org/10.3168/jds.2017-13909>
- Kusumo, D., Priyanti, A., & Saptati, R. A. (2017). Prospek pengembangan usaha peternakan pola integrasi. *Sains Peternakan: Jurnal Penelitian Ilmu Peternakan*, 5(2), 26-33. <https://doi.org/10.20961/sainspet.v5i2.4924>
- Lemos, M. F., Andrade, A. P., Silva, P. H. F. D., Santos, C. O., Souza, C. F. B., Silva, M. A. V., ... & Oliveira, P. M. D. (2020). Nutritional value, fermentation losses and aerobic stability of elephant grass (*Pennisetum purpureum* Schum.) silage treated with exogenous fibrolytic enzymes. *Acta Scientiarum. Animal Sciences*, 42, e48272. <https://doi.org/10.4025/actascianimsci.v42i1.48272>
- Macaulay. (2004). The Use of Ice in The Treatment of Acute Soft-Tissue Injury. *The American J. of Sports Medicine*, 32, 251-257.
- Mahyudi, F., & Husinsyah, H. (2020). Kontribusi Produk Sekunder Ampas Tahu pada Usaha Industri Rumah Tangga UD. Dua Putri di Desa Gunung Antasari Kecamatan Simpang Empat Kabupaten Tanah Bumbu Provinsi Kalimantan Selatan. *Ziraa'ah Majalah Ilmiah Pertanian*, 45(2), 127-134. <https://dx.doi.org/10.31602/zmip.v45i2.3000>
- McDonald, W. I., Compston, A., Edan, G., Goodkin, D., Hartung, H. P., Lublin, F. D., ... & Wolinsky, J. S. (2001). Recommended diagnostic criteria for multiple sclerosis: guidelines from the International Panel on the diagnosis of multiple sclerosis. *Annals of Neurology: Official Journal of the American Neurological Association and the Child Neurology Society*, 50(1), 121-127. <https://doi.org/10.1002/ana.1032>
- Michael, P., de Cruz, C. R., Mohd Nor, N., Jamli, S., & Goh, Y. M. (2021). The potential of using temperate-tropical crossbreds and agricultural by-products, associated with heat stress management for dairy production in the tropics: a review. *Animals*, 12(1), 1. <https://doi.org/10.3390/ani12010001>
- Moorby, J. M., & Fraser, M. D. (2021). New feeds and new feeding systems in intensive and semi-intensive forage-fed ruminant livestock systems. *Animal*, 15, 100297. <https://doi.org/10.1016/j.animal.2021.100297>
- Nisa, Z. K., Ayuningsih, B., & Susilawati, I. (2020). Pengaruh penggunaan dedak fermentasi terhadap kadar lignin dan selulosa silase rumput gajah (*Pennisetum purpureum*). *Jurnal Nutrisi Ternak Tropis dan Ilmu Pakan*, 2(3). <https://doi.org/10.24198/jnttip.v2i3.30289>

- Oladosu, Y., Rafii, M. Y., Abdullah, N., Magaji, U., Hussin, G., Ramli, A., & Miah, G. (2016). Fermentation quality and additives: a case of rice straw silage. *BioMed research international*, 2016(1), 7985167. <https://doi.org/10.1155/2016/7985167>
- Rasuli, N., Wibowo, D. N., & Taufik, M. (2022). Kajian Kualitas Silase Rumput Gajah (*Pennisetum purpureum*) dengan Penambahan Lamtoro (*Leucaena leucocephala*), Dedak, dan Jagung Giling: Study of The Quality of Napier Grass Silage (*Pennisetum purpureum*) with The Addition of Lamtoro (*Leucaena leucocephala*), Brand, and Milled Corn. *Jurnal Agrisistem*, 18(1), 28-34. <https://doi.org/10.52625/j-agr.v18i1.223>
- Sari, D. D. K., Astuti, M. H., & Asi, L. S. (2016). Pengaruh pakan tambahan berupa ampas tahu dan limbah bioetanol berbahan singkong (*Manihot utilissima*) terhadap penampilan sapi Bali (*Bos sondaicus*). *Buletin Peternakan*, 40(2), 107-112.
- Seftiana, L., Rizki, A. S., & Hadi, A. P. (2023). Penguatan Kapasitas Usaha Masyarakat Melalui Proses Fermentasi Pembuatan Tape Singkong (*Manihot Utilissima*) Di Dusun Limbungan Kecamatan Gunung Sari Lombok Barat. *Al Hayat: Jurnal Pengabdian Masyarakat*, 1(2), 43-53. <https://doi.org/10.62588/ahjpm.2023.v1i2.039>
- Silalahi, H., Sangadji, I., & Fredriksz, S. (2023). Quality Of Pakchong Grass Silage (*Crimson Pennywort Cv. Thailand*) with The Addition Of Different Of Molasses As Ruminant Feed. *Jurnal Agrosilvopasture-Tech*, 2(1), 202-209. <https://doi.org/10.30598/j.agrosilvopasture-tech.2023.2.1.202>
- Sofyan, A., Widyastuti, Y., Utomo, R., & Yusiati, L. M. (2017). Improving physico-chemical characteristic and palatability of king grass (*Pennisetum hybrid*) silage by inoculation of *Lactobacillus plantarum*-*Saccharomyces cerevisiae* consortia and addition of rice bran. *Buletin Peternakan*, 41(1), 61-71. <https://doi.org/10.21059/buletinpeternak.v41i1.12980>
- Spaggiari, M., Dall'Asta, C., Galaverna, G., & del Castillo Bilbao, M. D. (2021). Rice bran by-product: From valorization strategies to nutritional perspectives. *Foods*, 10(1), 85. <https://doi.org/10.3390/foods10010085>
- Suganda, A., Salman, D., Baba, S., & Fahmid, I. M. (2022, December). Cattle corporation village program as small-scale farmer group empowerment to support National beef self sufficiency. In *IOP Conference Series: Earth and Environmental Science* (Vol. 1114, No. 1, p. 012041). IOP Publishing. 10.1088/1755-1315/1114/1/012041
- Suherman, D. (2021). Karakteristik, produktivitas dan pemanfaatan rumput gajah hibrida (*Pennisetum purpureum cvthailand*) sebagai hijauan pakan ternak. *Maduranch: Jurnal Ilmu Peternakan dan Ilmu Agribisnis*, 6(1), 37-45. <http://dx.doi.org/10.53712/maduranch.v6i1.1071>
- Sulistyo, H. E., Subagiyo, I., & Yulinar, E. (2020). Kualitas silase rumput gajah (*Pennisetum purpureum*) dengan penambahan jus tape singkong. *Jurnal Nutrisi Ternak Tropis*, 3(2), 63-70.
- Suryaningsih, Y. (2022). Penerapan teknologi silase untuk mengatasi keterbatasan hijauan pakan ternak pada musim kemarau di Desa Arjasa Kecamatan Arjasa Kabupaten Situbondo. *Mimbar Integritas: Jurnal Pengabdian*, 1(2), 279-289. <https://doi.org/10.36841/mimbarintegritas.v1i2.2084>
- Suryapratama, W., & Rahayu, S. (2020, November). Kualitas Organoleptik dan Fisik Ampas Tahu yang Difermentasi Kapang *Neurospora sitophila* dan *Trichoderma viridae* sebagai Bahan Pakan Konsentrat. In *Prosiding Seminar Nasional Pembangunan dan Pendidikan Vokasi Pertanian* (Vol. 1, No. 1, pp. 61-72). <https://doi.org/10.47687/snppvp.v1i1.126>
- Thompson, A. J., Banwell, B. L., Barkhof, F., Carroll, W. M., Coetzee, T., Comi, G., ... & Cohen, J. A. (2018). Diagnosis of multiple sclerosis: 2017 revisions of the McDonald criteria. *The Lancet Neurology*, 17(2), 162-173.
- Tulu, D., Gadissa, S., Hundessa, F., & Kebede, E. (2023). Contribution of climate-smart forage and fodder production for sustainable livestock production and environment: Lessons and

-
- challenges from Ethiopia. *Advances in Agriculture*, 2023(1), 8067776. <https://doi.org/10.1155/2023/8067776>
- Utari, A. (2018). Pemanfaatan Limbah kulit buah aren sebagai pupuk kompos terhadap evaluasi nutrisi silase rumput gajah pada ternak ruminansia. *Eksakta: Jurnal Penelitian dan Pembelajaran MIPA*, 3(1), 9-24.
- Wang, S., Yuan, X., Dong, Z., Li, J., Guo, G., Bai, Y., ... & Shao, T. (2016). Characteristics of isolated lactic acid bacteria and their effects on the silage quality. *Asian-Australasian journal of animal sciences*, 30(6), 819. <https://doi.org/10.5713/ajas.16.0589>
- Wong, C. C., Moog, F., & Chen, C. P. (2019). Forage and ruminant livestock integration in tree crop plantations of Southeast Asia. Edited Reynolds, S. In *Grasslands* (pp. 403-431). CRC Press.
- Zhang, Q., Guo, X., Zheng, M., Chen, D., & Chen, X. (2021). Altering microbial communities: a possible way of lactic acid bacteria inoculants changing smell of silage. *Animal Feed Science and Technology*, 279, 114998. <https://doi.org/10.1016/j.anifeedsci.2021.114998>
- Zhang, Y. C., Luo, M., Fang, X. Y., Zhang, F. Q., & Cao, M. H. (2021). Energy value of rice, broken rice, and rice bran for broiler chickens by the regression method. *Poultry Science*, 100(4), 100972. <https://doi.org/10.1016/j.psj.2020.12.069>