AGRONES

JOURNAL OF AGRICULTURE, AGRIBUSINESS, WELFARE, TECHNOLOGY, HUMANITY, ENVIRONMENT, SOCIAL, AND ECONOMY

Volume 1 Nomor 2 July 2025 **E-ISSN: 3110-3495**

Study of Corn Silage Storage Management to Support Ruminant Livestock Nutrition

Hajar[1*], La Panga[2]

[1 2] Universitas Sulawesi Tenggara, Kendari, Indonesia
*Corresponding author: hambaallahhajar@gmail.com

ABSTRACT

Ruminant livestock productivity in Indonesia remains low, largely due to the lack of a consistently available supply of highly nutritious feed. Utilizing agricultural waste, such as corn, as a base material for silage is a potential solution to address feed constraints. Corn-based silage can provide consistent feed throughout the year and boasts a relatively high nutritional content. However, the main challenges with its use are long-term storage and stability against air exposure, which are crucial for feed quality and safety. Several studies have shown that extending storage time can improve digestibility, but can also increase the likelihood of silage quality degradation if storage methods are not optimal. Issues such as reduced nutritional value, the emergence of harmful microorganisms, and the risk of mycotoxin contamination are key concerns that must be addressed. Therefore, the objective of this study is to examine how storage time affects the nutritional quality of corn silage and to analyze the effectiveness of different storage methods in maintaining aerobic stability and preventing spoilage, particularly under complex tropical climate conditions. Corn silage quality is influenced by storage methods, fermentation time, and environmental temperature and humidity. Anaerobic storage using silos or airtight plastic with high compaction effectively maintains a low pH and prevents contamination. Optimal fermentation takes 60–90 days, while longer storage can degrade quality. Corn's high carbohydrate content supports good fermentation, making it a superior feed source during the dry season.

Keywords:, ***Corn Plants, Silage, Storage, and Nutrient Quality***

How to cite: Hajar, H., Panga, L (2025). *Study of Corn Silage Storage Management to Support Ruminant Livestock Nutrition*. Agrones: Journal of Agriculture, Agribusiness, Welfare, Technology, Humanity, Environment, Social, and Economy. Volume 1 Nomor 2 July 2025

INTRODUCTION

One of the factors contributing to low ruminant livestock productivity in Indonesia is the limited availability of sustainable, adequate quality feed. The availability of high-nutrient feed that is consistently available throughout the year is a vital component in supporting the development of the livestock sector (Hastuti et al., 2011). Therefore, feed provision must consider availability and cost-efficiency, which drives the need to utilize agricultural waste as an economical and easily accessible feed alternative (Herry et al., 2013).

The use of corn as a primary ingredient in silage production has become common practice in the livestock industry, particularly for dairy and beef cattle. The development of silage technology plays a crucial role in ensuring feed availability throughout the season, with silage storage systems directly impacting feed supply continuity. Although many previous studies have focused on the production and nutritional characteristics of corn silage, long-term storage and aerobic stability during the storage period have received little scientific attention. Kuchin (2023) emphasized that aerobic stability during storage is a critical challenge, as it can trigger degradation of silage quality through spoilage, nutrient loss, and potential microbial contamination, all of which negatively impact animal health.

Extending the storage period of rehydrated corn silage from 15 to 60 days has been shown to improve dry matter and starch digestibility. However, without the application of additives or appropriate storage techniques, the risk of silage quality deterioration also increases (Oliveira et al., 2020). Therefore, there is an urgent need to fill this research gap by evaluating various storage strategies and their impact on feed quality, particularly in tropical climates with more complex environmental dynamics.

Nutritional quality assessment of corn silage generally includes several parameters, such as dry matter loss rate, lactic acid content, pH, ammonia concentration, and the population of pathogenic microorganisms. These aspects are crucial because various studies have confirmed that the fermentation process plays a significant role in determining the nutritional value and storage stability of silage. For example, Rossi et al. (2023) reported that storing silage for 240 to 360 days increased dry matter intake (DMI) and feed utilization efficiency in sheep, although it had no significant impact on carcass growth performance. Meanwhile, research by Sariçiçek et al. (2016) showed a significant decrease in crude protein and crude fiber levels after 132 days of storage, followed by an increase in free nitrogen extractives.

These findings emphasize the importance of regular quality monitoring during storage to avoid nutrient degradation that can reduce overall feed value.

Damage to silage has the potential to cause significant economic losses and negatively impact livestock production performance. Keller et al. (2013) suggested that storing silage in non-airtight conditions can trigger mold growth and the formation of dangerous mycotoxins, such as aflatoxin and deoxynivalenol. This view aligns with the findings of Kuchin (2023), who emphasized that controlling several critical parameters, such as compaction level, feed-out rate, and cover quality, significantly determines the aerobic stability of silage and directly contributes to the success of the fermentation process and feed safety. This literature review aims to examine the effect of storage duration on the nutritional quality of corn silage. The impact of using different storage methods on aerobic stability and silage deterioration and fermentation can be used to evaluate long-term storage

METHODS

This research employed a mixed methods approach with a sequential explanatory design, beginning with the collection and analysis of qualitative data to evaluate the storage quality of corn silage. As a methodology, this approach reflects a philosophical foundation that guides the data collection and analysis process, integrating qualitative and quantitative elements across various research stages. As a method, this approach emphasizes the collection, analysis, and integration of quantitative and qualitative data within a single study or across a series of studies. Its primary premise is that combining these two approaches can yield a more comprehensive understanding of the research problem than using either approach alone (Creswell, 2023).

RESULTS AND DISCUSSION

A literature review shows that the storage quality of corn-based silage is significantly influenced by several technical and environmental factors, which ultimately have a significant impact on livestock production efficiency and the need for livestock competency development. In general, corn silage is a highly nutritious and efficient feed source if the fermentation and storage processes are carried out properly. However, the final quality of silage is highly dependent on various parameters such as storage method, ambient temperature and humidity, dry matter content, and storage duration (Kung, 2010). Suboptimal storage—for example, due to exposure to air or high temperatures—can trigger microbiological and chemical deterioration, characterized by increased ammonia levels, slow pH reduction, and mold growth (Keller et al., 2013; Bai et al., 2022).

In the context of fermentation, storing silage at high temperatures (around 30°C) does accelerate pH reduction through the activity of microorganisms such as Leuconostoc and Weissella, but can also reduce the diversity of beneficial microbes if storage is prolonged (Bai et al., 2022). Other studies have shown that storage periods exceeding 120 days tend to decrease crude protein and fiber levels, as well as increase dry matter loss (Sariçiçek et al., 2016; Gao et al., 2013). Efforts to optimize silage quality, such as through the addition of exogenous enzymes, have been shown to improve feed efficiency and dry matter digestibility in silage with high moisture content (Salvo, 2019). Furthermore, the physiological stage of the corn plant at harvest significantly influences the nutrient content and final structure of silage (Gao et al., 2013).

As technology advances, the link between silage storage and the application of artificial intelligence (AI)-based learning is gaining attention in the context of livestock education. Several studies indicate that AI technology can be used to automatically monitor silage storage conditions through the integration of Internet of Things (IoT) sensors (Viviane et al., 2023). This technology enables the analysis of parameters such as temperature, humidity, and visual conditions to detect deterioration early. This AI-based system not only supports data-driven decision-making by farmers, but also serves as an interactive learning medium through real-time simulations and visualizations (Masooda et al., 2025).

The use of artificial intelligence (AI) in livestock education has significantly contributed to creating personalized, adaptive, and interactive learning processes. Deep learning models such as MobileNetV2 have been successfully applied to classify corn plant diseases with high accuracy (Alkanan & Gulzar, 2024), and similar approaches have great potential for use in silage storage management training, for example, in detecting fermentation failures or identifying fungal growth through image analysis. These studies indicate that farmers who gain direct access to visual information and sensory data through AI-based applications tend to be more responsive in anticipating silage quality declines.

In various local contexts, such as Japan and Brazil, silage storage technologies utilizing automatic balers and plastic bag packaging have proven effective in reducing nutrient losses and increasing production efficiency (Nemoto, 2017; Queiroz et al., 2025). These innovations not only boost efficiency in crop rotation but also empower food crop farmers to produce feed independently, thereby supporting national feed security. However, challenges such as the risk of mycotoxin contamination remain unresolved, particularly in non-airtight storage conditions, which can potentially increase aflatoxin levels (Keller et al., 2013).

Overall, the literature review emphasizes the need for an integrated approach to storing corn-based silage, combining optimal fermentation techniques with the use of modern digital technology. This is where AI-based learning becomes highly relevant as a practical educational tool for farmers, both through online training and automated monitoring systems. This integration not only increases the effectiveness of knowledge transfer but also opens up opportunities for creating more efficient and sustainable precision farming practices. The results of this review also underscore the importance of synergy between researchers, extension workers, and technology developers in designing AI-based learning curricula that align with real-world needs.

Thus, AI-based learning not only serves as a means of increasing cognitive capacity but also as an instrument for technical empowerment of farmers in data-driven decision-making, particularly in the storage and management of corn silage. Improving digital literacy through this approach is expected to strengthen farmers' readiness to face the challenges of climate change, unstable feed quality, and the demands of sustainability in future livestock production systems

CONCLUSION AND IMPLICATIONS

Based on the results of the study and analysis of various methods and durations of corn-based silage storage, it can be concluded that silage quality is significantly influenced by the interaction between storage technique, fermentation time, and environmental conditions such as temperature and humidity. Optimal storage must create a stable anaerobic environment to support maximum lactic acid bacteria activity, resulting in silage with characteristics of low pH, high lactic acid content, and minimal ammonia and mold contamination. Storage approaches using closed containers, such as silos or airtight plastic bags (silage bags), with a high degree of compaction, have proven more effective in maintaining nutritional stability than open or unprotected storage methods. The recommended storage period is between 60 and 90 days, during which the nutrient quality of silage tends to remain stable. However, beyond this period, the potential for quality degradation increases due to the activity of aerobic microorganisms after the silage is opened.Corn, the primary ingredient in silage production, also exhibits superior fermentation properties, primarily due to its high water-soluble carbohydrate content, which acts as a primary substrate for fermentative microbes. Therefore, corn silage has significant potential as a high-quality and sustainable feed source, particularly in the face of feed shortages during the dry season or famine.

To produce high-quality silage, a tightly closed and airtight storage method, such as a vertical or horizontal silo, or a special plastic bag, is required to prevent oxygen ingress and mold growth. Corn should be harvested at optimal maturity, namely the dough stage with a dry matter content of 30–35%, to support ideal fermentation. Silage storage should not exceed 90 days if unopened, and once opened, it should be used immediately to maintain its aerobic stability. The use of additives such as lactic acid inoculants or exogenous enzymes is also important to accelerate fermentation and maintain silage quality. Policy support from the government or educational institutions is essential for the provision of small-scale fermentation and storage facilities, especially for smallholder farmers, to ensure a sustainable feed supply throughout the season.

REFERENCES

Alkanan, M., & Gulzar, Y. (2024). Enhanced corn seed disease classification: Leveraging MobileNetV2 with feature augmentation and transfer learning. Frontiers in Applied Mathematics and Statistics. 9:1320177. Doi : https://doi.org/10.3389/fams.2023.1320177

Bai, J., Ding, Z., Su, R., Wang, M., Cheng, M., Xie, D., & Guo, X. 2022. Storage Temperature Is More Effective Than Lactic Acid Bacteria Inoculations in Manipulating Fermentation and Bacterial Community Diversity, Co-Occurrence and Functionality of the Whole-Plant Corn Silage. Microbiology Spectrum. 10(2). Doi : https://doi.org/10.1128/spectrum.00101-22

Creswell, J.W. and Creswell, J.D. (2023) Research Design: Qualitative, Quantitative and Mixed Methods Approaches. Sage Publications Ltd.

Gao J.L, Wang P., Zhou C.H., Li P.,Tang H.Y., Zhang J.B., Cai Y.2019. Chemical composition and in vitro digestibility of corn stover during field exposure and the fermentation characteristics of silage prepared with microbial additives. Asian-Australas J Anim Sci. 32(12):1854–1863. Doi: 10.5713/ajas.18.0886

Hajar, H., Panga, L., Sasmita, F., Oge, L., Hastian, H., & Harudin, L. (2022). Characteristics of rats and ectoparasites on animal quarantine health in ports. Jurnal Sultra Sains, 4(2), 10–20.

Hajar, H. (2025). Nutritional Transformation of Ruminant Feed: A Literature Review on the Role of Fermentation in Enhancing Productivity. International Journal of Agriculture Technology, Agribusiness, and Environment, 1(1), 50-58.

Hastuti, D. Shofia Nur A, dan Baginda Iskandar M. 2011. Pengaruh perlakuan teknologi amofer (amoniasi fermentasi) pada limbah tongkol jagung sebagai alternatif pakan berkualitas ternak ruminansia. J. Ilmu Pertanian 7 (1) : 55-65

Kung, L. (2010). Understanding the biology of silage preservation to maximize quality. California Alfalfa & Forage Symposium.

Kuchin, N. (2023). Problem of aerobic stability in the harvesting and use of corn silos. Adaptive Fodder Production. 3 (10):69-87 Doi:10.33814/AFP-2222-5366-2023-3-69-87

L.A.M. Keller, M.L. González Pereyra, K.M. Keller, V.A. Alonso, A.A. Oliveira, T.X. Almeida, T.S. Barbosa, L.M.T. Nunes, L.R. Cavaglieri, C.A.R. Rosa. 2012. Fungal and mycotoxins contamination in corn silage: Monitoring risk before and after fermentation. Journal of Stored Products Research 52 (1):42–47. Doi:10.1016/j.jspr.2012.09.001

Masooda, S. Patrekar, S. R, S. R. Kunder, A. Bhat and N. P. B, 2025. AgriScan: Next-Gen Corn Leaf Disease Detection and Analysis Using Deep Learning Models. 2025 3rd IEEE International Conference on Industrial Electronics: Developments & Applications (ICIDeA), Bhubaneswar, India, 2025, pp. 1-6. Doi: 10.1109/ICIDeA64800.2025.10963328.

Nemoto, E. (2017). Establishment of self-sufficient concentrate by an ear corn silage production system. JARQ, 51(3), 209–215. https://doi.org/10.6090/JARQ.51.209

Oge, L. (2025). Postharvest physiological studies on the quality and shelf life of tropical fruits: A literature review. International Journal of Agriculture Technology, Agribusiness, and Environment, 1(1), 18–27.

Oliveira, K. S., Salvati, G., Morais, G., Carvalho-Estrada, P. de A., Santos, W. P., et al. (2020). Effect of Length of Storage and Chemical Additives on the Nutritive Value and Starch Degradability of Reconstituted Corn Grain Silage. Agronomy. 13(1):209 Doi:10.3390/agronomy13010209

Rossi, L. G., Rabelo C.H.S., . Andrade M.E.B., Siqueira G.R., Vicente E.F., Nogueira D.A., Reis R.A., 2023. Effects of Storage Length on Lamb Productivity with Corn Silage. Animal Feed Science and Technology.Vol 304:115751. https://doi.org/10.1016/j.anifeedsci.2023.115751

Saricicek, B. Z., Yildirim B., Kocabas Z., Demir E.O. 2016. Effect of Storage Time on Nutrient Composition of Corn Silage. Turkish Journal of Agriculture4 (11):934-939, 2016 Doi: https://doi.org/10.24925/turjaf.v4i11.934-939.746

Taridala, S., Ode, M. F., Hiromi, R., Amin, H., Mukaddas, J., Harudin, L., ... & Zulkifli, M. (2024). Spatial analysis of rice field development in supporting sustainable food security in West Muna Regency. International Journal of Management and Education in Human Development, 4(04), 1465–1472.

Viviane I., Emmanuel M., Rene M., Joseph H., Elias B. 2023. Development of AI-Based Maize Storage Monitoring System Using IoT. IC&C Conference. pp. :38-42. Doi: https://doi.org/10.1109/IC-C57619.2023.00014

Queiroz, A. C. M.; Cardoso, M. V. S. B.; Souza, M. S.; Pitirini, J. S.; Rondina, D.; Bernardes, T. F.; Faturi, C.; Silva, T. C. and Rêgo, A. C. 2025. Effect of storage condition and time on the quality of relocated whole-plant corn silages in bags. Revista Brasileira de Zootecnia. 54(2):e20240055. Doi: 10.37496/rbz5420240055