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The Role of Lactobacillus plantarum in Enhancing the Physical Quality and pH of Water Hyacinth (Eichhornia crassipes) Silage

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Abstract
This research investigated the impact of supplementing water hyacinth (Eichhornia crassipes) silage with Lactiplantibacillus plantarum on its physical properties (pH, odor, texture, color, and fungal growth) as well as palatability. A Completely Randomized Design (CRD) was employed with three treatments and six replications: P0 (control, no L. plantarum), P1 (L. plantarum at 10^5 CFU/ml), and P2 (L. plantarum at 10^6 CFU/ml). The variables measured were pH, color, aroma, texture, fungal presence, and palatability. Findings revealed that L. plantarum supplementation significantly influenced ($p < 0.05$) the color of the silage, but had no significant effect on pH, aroma, texture, fungal development, or palatability. The mean pH values for P1 and P2 were 4.1 and 4.2, respectively, compared with 4.0 in P0. In terms of palatability, P2 produced the highest intake (201.5 g), followed by P1 (118.6 g), whereas P0 showed minimal consumption. Overall, the results suggest that higher concentrations of L. plantarum improve the visual quality of water hyacinth silage, but provide limited enhancement of other physical attributes and palatability.

Keywords: *Eichornia crassipes, silage, Lactiplantibacillus plantarum*, physical quality, pH

1. INTRODUCTION

Feed is a critical factor that strongly influences growth, health, and productivity in livestock production systems. In Indonesia, the ruminant livestock sector faces significant challenges, particularly in ensuring consistent availability and quality of feed. Forages, as the primary feed resource, are highly seasonal: abundant during the rainy season but scarce in the dry season. This imbalance often results in reduced animal performance and decreased production efficiency (Sutardi et al., 2018).
Such conditions highlight the urgent need for innovative strategies to develop alternative feed resources that are affordable, available year-round, and practical for

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farmers to utilize. One promising approach is the use of organic waste materials and underutilized wild plants (Widyastuti et al., 2020). In this context, water hyacinth (*Eichhornia crassipes*) has emerged as a potential alternative feed resource. Water hyacinth is widely recognized as an invasive aquatic weed, capable of rapid growth that disrupts aquatic ecosystems. Latipudin (2014) reported that a single plant can spread to cover 1 m² within just 52 days, and up to 7 m² within a year. Its uncontrolled proliferation contributes to sedimentation, hinders fisheries and water transport activities, and deteriorates water quality (Amalia et al., 2022). Despite this negative reputation, water hyacinth contains certain nutrients that can be utilized as feed ingredients. However, its direct use in fresh form is constrained by its high moisture content and oxalic acid levels, which may cause oral irritation and reduce palatability (Prasetyo et al., 2019). These limitations necessitate processing methods to improve both its nutritive value and storage stability.

Ensiling is one of the most widely applied forage preservation techniques, relying on anaerobic fermentation by lactic acid bacteria (LAB). This process produces lactic acid, lowers pH, and suppresses spoilage microorganisms. Beyond extending shelf life, silage can also enhance digestibility and nutrient availability (Rahayu et al., 2017; Nugroho et al., 2021). The addition of microbial inoculants such as *Lactobacillus plantarum* has been shown to accelerate fermentation and improve silage quality (Fitriani et al., 2020). Previous studies have demonstrated that water hyacinth can be ensiled, particularly in the form of total mixed ration (TMR), and has the potential to substitute conventional feed sources such as forage–concentrate mixtures (Muktiani, 2013). Nevertheless, further studies are needed, as environmental conditions strongly influence the nutritional quality of water hyacinth.

The Brantas River, one of the major rivers in East Java, harbors large populations of water hyacinth. Utilizing water hyacinth from this river not only provides a representative source of raw material from public water bodies but also offers an ecological solution for managing its overpopulation (Hidayat et al., 2023). Therefore, this study aims to explore the potential of water hyacinth harvested from the Brantas River as a silage feed resource. Such utilization is expected to contribute to solving feed shortages in livestock production while simultaneously addressing environmental challenges posed by aquatic weed infestation in Indonesia.

2. LITERATURE REVIEW

2.1 Water Hyacinth (*Eichhornia crassipes*)

Water hyacinth is widely recognized as an invasive aquatic weed with rapid growth that threatens aquatic ecosystems. However, this plant also provides ecological benefits such as phytoremediation, as it can absorb pollutants and heavy metals from water (Rezania et al., 2016). In Indonesia, water hyacinth grows abundantly in nutrient-rich waters and contains moderate nutritional value, including crude protein of 9.8–12% and crude fiber of 16.8–24.6% (Riswandi, 2014).

2.2 *Lactobacillus plantarum*

Lactobacillus plantarum is one of the lactic acid bacteria (LAB) widely used in silage fermentation. It is Gram-positive, rod-shaped, and homofermentative, capable of converting up to 95% of glucose into lactic acid, thereby rapidly lowering silage pH (Rahayu, 2010). Its adaptability to a wide pH range (3.4–8.8) makes it effective for improving fermentation quality and feed preservation.

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2.3 Silage pH

The pH level of silage serves as a crucial indicator of fermentation quality. Good silage generally has a pH between 3.8 and 4.2, while values above 4.5 indicate poor fermentation and nutrient loss (Rusdi et al., 2021). A rapid decrease in pH ensures the dominance of lactic acid bacteria and prevents the growth of spoilage microorganisms, making pH monitoring essential in silage evaluation.

2.4 Silage Color

Silage color reflects the effectiveness of the fermentation process. High-quality silage maintains a greenish-yellow appearance similar to the original forage, while dark brown or black indicates overheating or aerobic deterioration (McDonald et al., 2011). Factors such as oxygen exposure and storage temperature greatly influence the final color and nutritive quality of silage.

2.5 Silage Aroma

Aroma is an important sensory characteristic in evaluating silage quality. Well-preserved silage typically emits a fresh acidic smell, which indicates lactic acid fermentation and pH stabilization between 3.5 and 4.5 (Wati et al., 2018). In contrast, unpleasant or foul odors signify microbial contamination and reduced silage quality.

2.6 Silage Texture

Texture is a physical attribute that influences livestock acceptance. Good silage has a crumbly, non-sticky texture, reflecting proper moisture balance and fermentation conditions (Minson, 2012). Excess water results in slimy silage susceptible to fungal growth, whereas excessive dryness may lead to harder silage with reduced intake potential.

2.7 Mold in Silage

Mold contamination indicates aerobic deterioration, usually caused by oxygen penetration during storage. Surface layers are most prone to mold growth, which reduces lactic acid concentration and overall silage quality (McDonald et al., 2011). Proper sealing and compaction are therefore critical to prevent fungal contamination and ensure silage safety.

2.8 Feed Palatability

Palatability determines the extent to which livestock willingly consume feed, influenced by its color, aroma, texture, and taste. Feeds with pleasant aroma and favorable texture are generally more consumed, leading to better intake and animal performance (Yusmadi et al., 2008). Thus, palatability is a key factor in evaluating silage as a practical livestock feed.

3. METHODS

3.1 Time and Location

The study on water hyacinth silage production was conducted in Banggle Village, Kanigoro District, Blitar, East Java, Indonesia. The experimental activities were carried out from June 18, 2025, to July 10, 2025, while data analysis was performed after all data were collected.

3.2 Research Materials

Materials:

- Fresh water hyacinth (*Eichhornia crassipes*)
- Feed concentrate

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- Lactic acid bacteria inoculant (*Lactobacillus plantarum*) at doses of 10^5 and 10^6 CFU/ml
- Transparent plastic bags and black plastic covers
- Clean water

Equipment:

- Knife and chopper
- Digital scale
- pH meter
- Fermentation containers (plastic bags, 3 kg capacity)

3.3 Experimental Design

The experimental design used was a Completely Randomized Design (CRD) with three treatments and six replications. The observed variables included silage pH, mold growth, and aroma. Each treatment was replicated six times to ensure data accuracy and reliability.

3.4 Experimental Procedure

3.4.1 Water Hyacinth Silage Preparation

- Fresh water hyacinth was chopped into 3–5 cm pieces using a chopper.
- The chopped material was wilted under shade for 24 hours.
- Wilted water hyacinth was mixed thoroughly with rice bran to reduce excess moisture.
- *Lactobacillus plantarum* inoculant was added according to treatment levels (P0 = no inoculant; P1 = 1×10^5 CFU/ml; P2 = 1×10^6 CFU/ml).
- Three kilograms of the mixture were weighed for each plastic silo.
- The mixture was tightly packed into transparent plastic bags, tied with raffia, and sealed with tape.
- Each bag was double-wrapped with an additional plastic layer and covered with a black plastic bag.
- The silage was stored at room temperature (27 °C) for 21 days.

3.5 Research Variables

3.5.1 pH

A total of 5 g of silage was mixed with 25 ml of distilled water, and pH was measured using a calibrated pH meter with buffer solutions. Measurements followed the method of Ummah (2019).

3.5.2 Aroma

Silage aroma was evaluated by trained panelists after 21 days of fermentation. The scoring scale was:

- 3 = strong acidic aroma
- 2 = slightly acidic aroma
- 1 = Stink Odor

Evaluation was conducted following Supriyati and Ridwan (2016).

3.5.3 Mold Growth

Mold present on the silage was collected, weighed, and expressed as a percentage of total silage mass. The method referred to Qo'iyum et al. (2019).

3.5.4 Texture

Silage texture was assessed directly by touch, using the following scoring scale:

3 = crumbly, non-slime texture
2 = moist, slightly slimy

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1 = slimy, soft texture
Measurements were carried out according to Qo'iyum et al. (2019).

3.5.5 Color

Color was visually evaluated by trained panelists with the following categories:
3 = greenish-yellow
2 = yellowish-brown
1 = dark brown
Evaluation followed the method of Qo'iyum et al. (2019).

3.5.6 Palatability

Palatability was measured by offering 2 kg of silage to sheep, equivalent to their daily feed allowance, and recording the amount consumed within 24 hours. Results were calculated as percentages of total feed offered. The method referred to Sukma et al. (2023).

3.6 Data Analysis

Data were analyzed using Analysis of Variance (ANOVA) based on the statistical model described by Montgomery (2021). When significant effects ($P < 0.05$) were detected, mean comparisons were further tested using Duncan's Multiple Range Test (DMRT).

4. RESULTS

The results of water hyacinth silage with the addition of *Lactobacillus plantarum* on physical quality and pH are presented in the following table:

Characteristics	P0(Control)	P1 (*L. plantarum* 1 × 10^5 CFU/ml)	P2 (*L. plantarum* 1 × 10^6 CFU/ml)
pH	4.0	4.1	4.2
Odor (score)	2.67	2.10	2.10
Texture (score)	2.73	2.53	2.43
Color (score)	2.33^b	2.70^a	2.70^a
Mold (%)	0.00	0.34	1.09
Palatability (%)	100.00	94.06	90.30

Note: Different superscripts (a, b) within the same row indicate significant differences (P < 0.05).

4.1 Silage pH

The results showed that the pH of water hyacinth silage ranged from 3.8 to 4.4. The lowest pH was observed in the control treatment (P0) at 3.8, while the highest was found in P2 at 4.4. All treatments, however, produced silage within the ideal pH range for good fermentation.

These findings are consistent with Astawo et al. (2025), who reported that 21-day water hyacinth silage had a pH of around 4.1–4.2. Similarly, Zhao et al. (2020) noted that the addition of *Lactobacillus plantarum* efficiently lowered pH by enhancing lactic acid production. Interestingly, in this study, the pH in P2 was higher, which may be due to an excessive inoculant dose that accelerated substrate depletion and slowed fermentation in the later storage phase. This differs from Koc et al. (2017), who reported that proportional inoculant application resulted in a stable decrease in pH.

4.2 Silage Color

Color is an important visual parameter for evaluating fermentation success. In this study, the silage color ranged from greenish-yellow to yellowish-brown, indicating that fermentation proceeded well without signs of spoilage such as dark brown discoloration. Treatments P1 and P2 produced brighter color compared to P0.

These results align with Driehuis et al. (2018), who explained that 21-day silage fermentation generally preserves a greenish color because respiration and enzymatic activity are suppressed during proper fermentation.

4.3 Silage Aroma

Silage aroma is a key indicator of organoleptic quality and feed acceptance. Observations showed that P0 had the most desirable aroma, characterized by a fresh acidic smell typical of fermentation. In contrast, P1 and P2 exhibited sharper odors, likely due to higher acid concentrations resulting from inoculant addition.

While Kung et al. (2018) reported that *L. plantarum* addition usually improves aroma by accelerating lactic acid formation, in this study, excessive inoculant levels appeared to have the opposite effect, producing a sharper and less favorable odor.

4.4 Silage Texture

Texture plays an important role in feed intake. All treatments produced acceptable textures, neither too soft nor too hard. However, P0 had the most ideal texture, being soft and easy to chew. Treatments P1 and P2 resulted in slightly denser silage, likely due to faster fermentation and reduced moisture content.

This finding is consistent with Cai et al. (2020), who noted that excessively rapid fermentation can cause moisture loss, resulting in firmer silage.

4.5 Mold Growth

Mold presence indicates suboptimal fermentation or oxygen contamination during storage. In this study, no mold was observed in P0, whereas small amounts were detected in P1 and P2. The mold growth in inoculated treatments was likely due to imperfect sealing or oxygen leakage during storage. Driehuis and Elferink (2000) explained that mold may develop when oxygen infiltrates silage, even under ongoing fermentation.

Nevertheless, the detected levels were minimal and did not compromise overall silage quality, making it still suitable for feeding. Interestingly, this contrasts with Wilkinson and Davies (2013), who reported that *L. plantarum* inoculants typically suppress mold growth, suggesting that the mold occurrence here was more related to technical storage issues than biological factors.

4.6 Feed Palatability

Palatability reflects livestock preference and is measured through feed consumption. The highest palatability was found in P0 (without inoculant), with 100% consumption, indicating that control silage was most preferred by sheep. In P1, feed intake slightly decreased to 94.06%, while P2 showed the lowest intake at 90.30%.

Although all treatments maintained relatively high consumption, there was a clear trend that higher doses of *L. plantarum* reduced feed palatability. This suggests that inoculant addition, especially at higher levels, may alter silage characteristics in ways that reduce its acceptance by animal.

6. CONCLUSION

Water hyacinth (*Eichhornia crassipes*) can be processed into good-quality silage with acceptable pH, color, texture, and aroma. The control treatment (P0) produced the best results, showing ideal fermentation, no mold, and the highest palatability, while higher doses of *Lactobacillus plantarum* tended to reduce feed acceptance. Overall, water hyacinth silage is a potential alternative feed for ruminants and a practical solution for managing aquatic weeds.

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REFERENCES

Amalia, R., Handayanta, E., & Sutrisno, C. I. (2022). Pemanfaatan eceng gondok sebagai bahan pakan alternatif untuk ternak ruminansia. Jurnal Peternakan Indonesia, 24(1), 45–53.

Astawo, H., Syamsuddin, N., & Darsan, A. (2025). Fermentation quality of water hyacinth silage with lactic acid bacteria inoculant. Journal of Animal Feed Research, 12(2), 67–74.

Cai, Y., Benno, Y., Ogawa, M., & Kumai, S. (2020). Effect of lactic acid bacteria inoculants on the fermentation and nutritive value of silage. Animal Feed Science and Technology, 274, 114–123.

Driehuis, F., & Elferink, S. J. W. H. O. (2000). The impact of the quality of silage on animal health and food safety: A review. Veterinary Quarterly, 22(4), 212–216.

Driehuis, F., Wilkinson, J. M., Jiang, Y., Ogunade, I., & Adesogan, A. T. (2018). Silage review: Animal and human health risks from silage. Journal of Dairy Science, 101(5), 4093–4110.

Fitriani, L., Nurhaita, & Suryani, A. (2020). The effect of Lactobacillus plantarum inoculant on the quality of corn silage. Jurnal Ilmu Ternak dan Veteriner, 25(2), 83–91.

Hidayat, A., Rahmawati, N., & Prabowo, H. (2023). Pemanfaatan eceng gondok Sungai Brantas sebagai pakan alternatif ternak ruminansia. Jurnal Sumberdaya Hayati, 9(1), 15–22.

Irawati, N., Firmansyah, R., & Anggraeni, R. (2019). Penggunaan inokulan Lactobacillus plantarum pada silase eceng gondok berbasis TMR. Jurnal Nutrisi Ternak Tropis, 2(1), 25–32.

Koc, F., Coskuntuna, L., & Ozduven, M. L. (2017). The effects of homofermentative and heterofermentative lactic acid bacteria inoculants on the fermentation quality and aerobic stability of maize silage. Asian-Australasian Journal of Animal Sciences, 30(4), 515–521.

Latipudin, D. (2014). Pertumbuhan dan potensi eceng gondok sebagai pakan alternatif. Buletin Pertanian, 18(2), 77–83.

Montgomery, D. C. (2021). Design and analysis of experiments (10th ed.). Wiley.

Muktiani, A. (2013). Potensi pemanfaatan eceng gondok dalam ransum total campuran (TMR) untuk ternak ruminansia. Jurnal Ilmu dan Teknologi Peternakan, 3(2), 45–52.

Mutmainah, S., Muktiani, A., & Prasetiyono, B. W. H. E. (2014). Physical quality and pH of water hyacinth silage with Lactobacillus plantarum addition. Animal Agriculture Journal, 3(2), 149–157.

Nugroho, T., Yusiati, L. M., & Hartadi, H. (2021). The role of lactic acid bacteria in silage fermentation of tropical forage. Jurnal Peternakan Tropika, 9(2), 33–40.

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DOI: https://doi.org/10.35457/josar.v10i2.5023

Nurkholis, M., Hidayat, R., & Sucipto, T. (2018). The effect of Lactobacillus plantarum inoculation on banana peel silage quality. Jurnal Nutrisi Ternak Tropis, 1(1), 11–18.

Prasetyo, H., Santosa, U., & Cahyani, R. D. (2019). Kandungan nutrisi eceng gondok dan potensinya sebagai pakan alternatif. Jurnal Ilmu Peternakan Indonesia, 24(3), 210–217.

Qo'iyum, A., Widiyanto, & Bintara, S. (2019). Pengaruh lama fermentasi terhadap kualitas fisik silase pakan ternak. Jurnal Peternakan Nusantara, 5(1), 55–63.

Rahayu, E. S., Maryanto, & Hidayat, T. (2017). Peran bakteri asam laktat dalam fermentasi silase. Agripet, 17(1), 27–34.

Supriyati, H., & Ridwan, Y. (2016). Organoleptic assessment of silage quality. Buletin Nutrisi Ternak, 12(2), 65–72.

Sutardi, T., Purbowati, E., & Santosa, U. (2018). Ketersediaan hijauan dan tantangan penyediaan pakan ruminansia di Indonesia. Jurnal Peternakan Indonesia, 20(1), 1–10.

Ummah, S. (2019). Pengaruh penggunaan inokulan terhadap kualitas pH silase. Jurnal Nutrisi dan Pakan Ternak, 13(2), 91–98.

Widiarso, A., Prabowo, H., & Mulyani, S. (2023). Effect of Lactobacillus plantarum levels on pH and quality of cabbage waste silage. Jurnal Nutrisi Ternak Tropis, 6(1), 22–29.

Widyastuti, T., Kurniawan, B., & Astuti, R. (2020). Pemanfaatan limbah organik sebagai bahan pakan alternatif ternak ruminansia. Jurnal Ilmu Ternak, 10(1), 55–62.

Wilkinson, J. M., & Davies, D. R. (2013). The aerobic stability of silage: Key findings and recent developments. Grass and Forage Science, 68(1), 1–19.

Zhao, J., Dong, Z., Li, J., Chen, L., Bai, Y., Jia, Y., & Shao, T. (2020). Effects of Lactobacillus plantarum on fermentation quality and microbial community of silage prepared with alfalfa and whole-plant corn. Journal of Applied Microbiology, 129(1), 139–150