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In-vitro evaluation of silage production using banana waste and sweet potato plant

Evaluasi in-vitro produksi silase menggunakan limbah pisang dan tanaman ubi jalar

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A B S T R A C T

Banana stems and peels (*Musa paradisiaca*. Val), and sweet potato plants (*Ipomoea batatas*) are agricultural waste that can be used as animal feed to be processed into silage through a fermentation process. This study was conducted to evaluate the physical and chemical quality of silage. The physical quality examination includes aroma, color, texture, and fungal contamination levels. In comparison, chemical quality measurements include pH value, dry matter content, and score fleigh (SF). The design of this study used a Completely Randomized Design with 4 treatments and 5 replications. The treatments include, P1: 100% banana stems; P2: 100% sweet potato; P3: 50% banana stems + 50% banana peel; and P4: 50% sweet potato + 50% banana peel. The results of this study did not have a significant effect (P>0.05) on the physical and chemical quality of silage. The physical quality of silage was identified as being paler in color than the original feed ingredients, had a sour aroma, and no fungi were detected. The physical quality of the silage from banana stems, sweet potato plants, a combination of banana stems and banana peels, and a combination of sweet potato plants and banana peels showed equally good quality. However, the chemical quality of the silage produced did not meet the standards of good silage in terms of dry matter content (28.74-29.1%), pH value (5.9-5.6), and score fleigh (26.48-39.2).

A B S T R A K

Batang dan kulit pisang (Musa paradisiaca. Val), serta tanaman ubi jalar (Ipomoea batatas) merupakan limbah pertanian yang dapat dimanfaatkan sebagai pakan ternak untuk diolah menjadi silase melalui proses fermentasi. Penelitian ini dilakukan untuk mengevaluasi mutu fisik dan kimia silase. Pemeriksaan mutu fisik meliputi aroma, warna, tekstur, dan tingkat kontaminasi jamur. Sedangkan pengukuran mutu kimia meliputi nilai pH, kadar bahan kering, dan score fleigh (SF). Desain penelitian ini menggunakan Rancangan Acak Lengkap dengan 4 perlakuan dan 5 ulangan. Perlakuannya antara lain, P1: 100% batang pisang; P2: 100% ubi jalar; P3: 50% batang pisang + 50% kulit pisang; dan P4: 50% ubi jalar + 50% kulit pisang. Hasil penelitian ini tidak berpengaruh nyata (P>0,05) terhadap kualitas fisik dan kimia silase. Kualitas fisik silase teridentifikasi berwarna lebih pucat dari bahan pakan asal, beraroma asam, serta tidak terdeteksi adanya jamur. Kualitas fisik silase baik dari batang pisang, tanaman ubi jalar, kombinasi batang pisang dan kulit pisang, serta kombinasi tanaman ubi jalar dan kulit pisang menunjukkan kualitas yang sama baiknya. Namun, kualitas kimia dari silase yang dihasilkan belum sesuai dengan standar silase yang baik ditinjau dari kadar bahan kering (28,74-29,1%), nilai pH (5,9-5,6), dan score fleigh (26,48-39,2).

Kata kunci:
Batang pisang
Kulit pisang
Silase
Tanaman ubi jalar

INTRODUCTION

Livestock plays a crucial role in the agricultural systems of developing countries, particularly for subsistence and semi-commercial farmers. There is a significant opportunity to enhance food security and household incomes by boosting livestock production (Martauli et al., 2022). This is particularly the case for smallholder farmers involved in meat production. However, the challenge lies in the insufficient availability of affordable feed that meets the required quality and quantity standards.

Smallholder farmers are inseparable from the main problem of providing feed for their livestock in pig farming. The fluctuating price of commercial feed makes farmers choose to use ingredients available around the residence without going through the accord feed processing process. So it is not uncommon to find smallholder farms with suboptimal livestock production; even livestock experience decreased production rates.

The hilly topography and dry climate of Manggarai Raya have led to the area's continued dependence on the agricultural sector as its main economic structure. BPS NTT (2024b) reported that banana production in Manggarai Regency reached 73,000 quintals in 2023, while sweet potato production reached 1,354 tonnes in 2022 (BPS NTT, 2024a). Manggarai's high banana and sweet potato production generates a significant amount of banana waste, typically disposed of as organic waste or utilized as animal feed. This waste can potentially cause environmental pollution if not managed properly. However, this surplus of agricultural waste in the Manggarai Raya area can serve as an alternative solution for farmers seeking to meet the feed needs of their pigs.

The silage method can process agricultural waste to enhance its use as pig feed (Suryani et al., 2020). Utilization of banana and sweet potato waste through the ensilage method is expected to improve the physical and chemical quality of silage. Several studies have demonstrated that agricultural waste silage is an effective and cost-efficient feed processing system for small farmers. Silage, a preservation technology that uses microbes, has the potential to improve feed quality and increase livestock productivity (Khan et al., 2021).

MATERIALS AND METHODS

The Integrated Laboratory of Agriculture and Animal Husbandry, Universitas Katolik Indonesia Santu Paulus Ruteng, conducted the research from September to October 2023. The materials utilized include banana stems and peels (*Musa paradisiaca* Val.), sweet potato plants (*Ipomoea batatas*), 3% Effective Microorganism-4 (EM4), 5% other feed ingredients (rice bran), and 3% sugar. Manggarai Raya widely produces agricultural wastes such as banana stems and peels (*Musa paradisiaca* Val) and sweet potato plants (*Ipomoea batatas*). The nutritional composition of these materials is detailed in Table 1.

Table 1. The nutritional composition of banana stems and peels and sweet potato leaves

Nutritional Composition	Banana peel (%)*	Banana stems (%)**	Sweet potato leaves (%)***
Ash	15.3	25.12	14.22
Dry matter	89.01	87.77	88.46
Carbohydrates	40.47	28.15	34.7
Crude Fat	13.1	14.23	1.15
Crude Protein	8.60	3.00	22.51
Crude Fiber	50.3	29.40	24.29
Calcium	9.83	2.13	0.79
Phosphor	0.49	1.35	0.38

Sources: *(Yosephine et al., 2012); **(Devri et al., 2020); ***(Yigibalom et al., 2018)

The equipment used includes a chopper, a 20 kg capacity scale, a 5 kg capacity digital scale, a 500 g capacity digital scale, a vacuum sealer, vacuum plastic, aluminium foil, a digital pH meter, and a set of laboratory equipment for dry matter (DM) analysis. Banana stem and sweet potato are then chopped to a thickness of 0.5 cm. Each treatment unit will have a weight of 500 grams, and the ensilage process lasts for 14 days.

This study uses an experimental method with a Completely Randomized Design of 4 treatments and 5 replications. The treatment design is as follows:

P1 : 100% banana stems
P2 : 100% sweet potato
P3 : 50% banana stems + 50% banana peels
P4 : 50% sweet potato + 50% banana peels

The study focused on evaluating the physical and chemical quality of silage banana by product (*Musa paradisiaca.* Val) and sweet potato by product (*Ipomoea batatas*). Physical quality was evaluated based on aroma, color, texture, and level of fungal contamination (LFC). Chemical quality was determined by examining pH, DM, and score fleigh (SF). The score fleigh was calculated using the equation: score fleigh = 220 + [(2 × dry matter (%)) 15] - (40 × pH) (Ozturk et al., 2006). The physical quality data of the silage was analyzed descriptively, and the chemical quality data was analyzed using ANOVA. If the chemical quality data showed significant differences, Duncan's Multiple Range Test was conducted.

RESULTS AND DISCUSSION

Physical Quality of Silage

Table 2 showed the results of observations on the physical quality of banana and sweet potato stem silage.

The color of the silage can indicate potential issues during the ensilage process. Silage color is an important factor in assessing its physical quality. In a recent study, it was observed that the silage produced had a lighter color compared to the original feed material. This color change is likely due to the activity of plant enzymes caused by the presence of oxygen in the silage packaging, especially in areas between the piles of fermented feed materials. The presence of oxygen prevents the establishment of anaerobic conditions, which can slow down the growth of lactic acid bacteria (LAB). Silage processed with molasses supplementation provides carbohydrates for lactic acid bacteria (LAB) to colonize, leading to improved pH reduction. Vacuum sealing removes oxygen and preserves silage color, inhibiting respiration and proteolysis while preventing clostridia bacteria activation (Mcdonald et al., 2022). The color changes in silage-making are influenced by the Maillard reaction during fermentation (Datta et al., 2019). If the silage possesses a blackish hue, it is indicative of poor quality.

The aroma of silage is an important indicator of its quality. In this study, the silage has a sour aroma similar to acidic tapai. This sour aroma, characteristically associated with anaerobic microbial activity, particularly that of lactic acid bacteria, is indicative of a normal fermentation process. Conversely, an abnormal, putrid odor would signify contamination or spoilage. According to Oladosu et al. (2016), lactic acid bacteria that colonize during the fermentation process are responsible for producing a sour aroma. In the process of silage production, anaerobic bacteria are actively involved in generating organic acids, resulting in the emission of a sour odor within the silage. As the ensilage progresses and oxygen becomes depleted, the environment becomes anaerobic, hindering fungal growth and allowing only acid-forming bacteria to remain active. As such, the presence of a sour odor serves as a reliable indicator of the successful ensilage process, signifying the attainment of the requisite acidic condition for effective ensilage (Herlinae & Yemima, 2015).

The texture of the silage produced in this study is still intact in the form of agricultural waste. The texture of the silage is influenced by the water content of the forage (Wati et al., 2018). The study found that banana stem silage and the combination of banana stem and banana peel produce a hard texture, while sweet potato plant silage and the combination of sweet potato plants and banana peel result in a soft texture. Additionally, the presence of microorganisms during fermentation can cause damage to the structure of rigid feed ingredients, resulting in a softer rice straw texture and contributing to

Table 2. Physical Quality of Silage

Treatment	Variable physical			
	Color	Aroma	Texture	Level of Fungal Contamination
P1	Yellow	Sour	Hard	Not Found
P2	Dark brown	Sour	Soft	Not Found
P3	Yellow - brownish	Sour	Hard	Not Found
P4	Dark green	Sour	Soft	Not Found

Note: P1: 100% banana stems, P2: 100% sweet potato, P3: 50% banana stems + 50% banana peels, P4: 50% sweet potato + 50% banana peels improved livestock digestibility (Suningsih et al., 2019).

Furthermore, the absence of fungi in the produced silage suggests an optimal fermentation process, wherein lactic acid bacteria effectively prevent the growth of unwanted fungi. According to findings by Herlinae & Yemima (2015), the fermentation process shifts to an anaerobic condition once oxygen is depleted for respiration. In these anaerobic conditions, fungal growth ceases, and only acid-forming bacteria remain active. The normal fermentation process promotes the growth of lactic acid bacteria (Bira et al., 2020) which increase in number when substrate is added (Ficoseco et al., 2018), and inhibit processes other than fermentation.

The use of silage feed for pigs is believed to improve feed metabolism by increasing the population of microorganisms in the animals' digestive tracts. In a study by Tang et al. (2021), it was found that incorporating fermented feed into the pigs' diet led to positive changes in the composition of intestinal microbes. This included a significant decrease in the presence of pathogenic bacteria such as Escherichia–Shigella, which belongs to the Proteobacteria phylum, and a significant increase in beneficial bacteria such as Clostridium, which belongs to the Firmicutes phylum. It gave a more diverse population of beneficial microbes and bacteria which may have improved the health status of the pigs or improved metabolic rates, thereby helping to increase feed conversion rates.

Chemical Quality of Silage

The chemical quality of banana silage and sweet potato stem silage is presented in Figure 1. The study found that the dry matter content did not show a significant effect, but there was a decrease in the dry matter content in each treatment. This decrease is believed to be caused by slow fermentation, leading to excessive utilization of dry matter during ensiling. Silage quality is indicated by the level of dry matter loss during ensiling, and the decrease in dry matter content is thought to be due to the loss of dry matter used by bacteria during their activities. According to Kurnianingtyas et al. (2012), a decrease in dry matter can occur in both the aerobic and anaerobic stages.

In the aerobic stage, respiration continues, leading to the conversion of glucose, a fraction of dry matter, into CO_2, H_2O, and heat. In the anaerobic stage, glucose is converted into ethanol and CO_2 by microorganisms. The increase in water content causes nutrient decomposition, contributing to the decrease in dry matter content. This is corroborated by Surono & Budhi (2006), who stated that increasing water content during ensiling results in decreased dry matter content and increased dry matter loss.

The pH analysis showed no significant effect, with all treatments exhibiting a pH range of 5.6-5.9, signifying poor-quality silage. Dryden (2021) classified silage quality into categories based on pH levels, with pH 3.2-4.2 considered very good, pH 4.2-4.5 considered good, pH 4.5-4.8 considered moderate, and pH> 4.8 considered poor. This is believed to be due to the silage not reaching optimal anaerobic conditions, leading to suboptimal growth of lactic acid bacteria and a lack of glucose as an energy source. Blackwell (2020) mentioned that sufficient glucose availability can accelerate the growth and colonization of lactic acid bacteria, inhibiting the growth of pathogenic bacteria that can negatively affect silage odor.

The results of the score fleigh analysis showed no significant effect. This study revealed a poor score fleigh value, ranging from 25 to 40%. The fleigh scores for silage quality are classified as very good (85-100%), good (60-80%), moderate (55-60%), bad (25-40%), and very bad (<20%) (Idikut et al., 2009). The score fleigh is determined by the dry matter content and pH of the silage. A higher dry matter content and lower pH result in a higher score fleigh. A higher dry matter value indicates better feed preservation, while a lower pH indicates successful fermentation. At the end of the ensilage process, minimal dry matter loss, decreased pH, softer texture, and a sour aroma indicate a successful fermentation process (Yosef et al., 2009).

CONCLUSIONS

Based on the findings of the study, it was observed that banana stem silage, sweet potato plants, a combination of banana stems and banana peels, as well as a mixture of sweet potato plants and banana peels, exhibited good physical qualities as silage.

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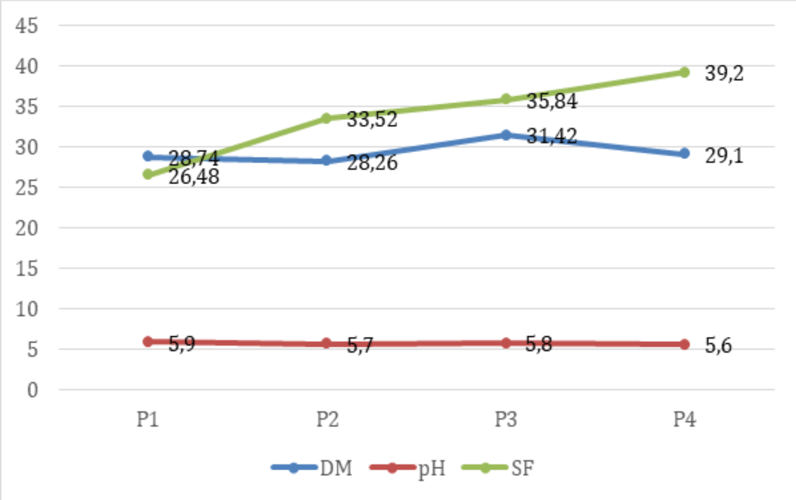

Figure 1. Chemical quality of silage. DM: Dry matter, pH: Potentially of Hidrogen, SF: Score Fleigh

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