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The Effect of Corn Stover and Pineapple Peel Ratio on Physical Characteristics, Fleigh Value, and Silage Dry Matter Changes

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ABSTRACT

The availability of forage during the dry season tends to decrease, which requires preservation technology to mantain feed availability and nutrient stability. Silage is a forage preservation technology that utilizes anaerobic fermentation to maintain nutritional quality of feed. This study aims to evaluate the effect of corn stover and pineapple peel ratios on the physical characteristics, Fleigh value, and dry matter changes of silage. This study used a completely randomized design (CRD) consisting of four treatments and five replicates. The treatments applied included T1 = 90% corn stover + 10% Pineapple peel, T2 = 80% corn stover + 20% pineapple peel, T3 = 70% corn stover + 30% pineapple peel, T4 = 60% corn stover + 40% pineapple peel. The chopped corn stover and pineapple peel were then mixed with molasses and fermented in plastic containers for 22 days. The data were analyzed using analysis of variance (ANOVA) followed by Duncan's multiple ranged test at a 5% significance level. The observed variables included the physical characteristics, Fleigh value, and dry matter changes. The results showed that the treatment had a significant effect on the color of silage (15.70-17.35; $P < 0.05$). Thereby, had no significant effect on aroma (20.20-20.70), texture (13.45-16.40), taste (17.55-19.10), Fleigh value (88,68-94,77), and dry matter change (7.21-25.20%). All parameters indicate that the silage results are in the good category. Combination of 60% corn stover and 40% pineapple peel can improve the color characteristic of silage without reducing fermentation quality.

Keywords: Corn Stover Silage, Pineapple Peel, Physical Characteristics, Fleigh Value, Dry Matter Changes

INTRODUCTION

The availability of high-quality feed is an important aspect of livestock production systems. In tropical countries such as Indonesia, forage availability fluctuates seasonally, especially during the dry when rainfall decreases significantly. This condition reduces forage production and increases the risk of inadequate nutrient intake of livestock. In addition, improper post-harvest storage methods may accelerate nutrient loss due to respiration and microbial activity. Therefore, effective preservation technology is required to maintain feed availability throughout the year.

Corn stover (*Zea mays*) consists all parts of the corn plant, including the stalk, leaves, and young corn cobs harvested at certain stage, and has the potential to be used as ruminant feed due to its high productivity and adaptability in tropical regions. According to data from Badan Pusat Statistik (2024) corn production in Indonesia reached 15.1 million tons in 2024. The nutrient content of corn stover consists of 31.2% dry matter, 23.55% crude fiber, 7.8% crude protein, 2.34% crude fat, 7.43% ash, and 55.66% % Nitrogen Free Extract (Mustika & Hartutik, 2021). The relatively high moisture content makes corn stover susceptible to deterioration and limits its storage stability if not preserved. One effective preservation method is ensiling through anaerobic fermentation. The success of the ensiling process is influenced by the availability of soluble carbohydrates as an energy source for lactic acid bacteria in producing lactic acid and lowering pH.

The potential source of additional carbohydrates is pineapple peel. Pineapple peel (*Ananas comosus*) is a by-product of pineapple processing that has the potential to be used as an additional ingredient in corn silage due to its abundant availability and high carbohydrates content. Pineapple peel accounts for 30-42% of the fruits (Sandika et al., 2017). Its abundant availability and relatively high soluble carbohydrates content make pineapple peel aid to the fermentation process. The nutrient content included 6.88% moisture, 5.92% ash, 5.16% crude protein, 1.46% crude fat, 13.96% crude fiber, and 66.63% Nitrogen Free Extract, with total carbohydrates content 17.53% (Ismayanti et al., 2025; Titisari et al., 2020). The presence of soluble carbohydrates has an important role in promoting the activity of lactic acid bacteria during fermentation (Azizah et al., 2012). Therefore, the adding pineapple peel to silage has the potential to improve the final quality of the silage.

Previous research conducted by Hasiib et al. (2024) showed that adding pineapple peel at levels of 5%, 10%, and 15% had not have a significant effect on the physical quality of silage. These findings indicate that the level of pineapple peel addition is not influencing the characteristics of silage. In addition, studies on Fleigh value and dry matter changes silage of pineapple peel are still limited. Therefore, this study was conducted to evaluate the effect of different ratios of corn stover and pineapple peel on physical characteristics, Fleigh value, and dry matter changes to determine the optimal combination in improving silage quality.

MATERIALS AND METHODS

Tools and Materials

The research was conducted at the Ruminant Animal Nutrition and Animal Feed Chemistry Laboratory, Faculty of Animal Husbandry, Padjadjaran University from July to September 2025. The materials used in the study included corn stover harvested 90 days after planting of a hybrid corn variety, pineapple peel from a honey pineapple processing industry in Subang, and molasses. The equipment used included an 8x6 m tarpaulin, a machete, an analytical scale, 10-liter plastic container, 40x60 cm plastic bags, a vacuum, a 105°C electric oven, aluminum dish, a desiccator, pliers, and a pH meter.

Silage Production

Corn stover and pineapple peel were wilted for 12 hours to reduce moisture content. Both materials were chopped into 2-3 cm lengths to ensure uniform particle size. The chopped corn stover and pineapple peel were then mixed according to the treatment ratios. Molasses was added at 4% of the fresh weight of the mixture. All silage ingredients were mixed until homogeneous on a tarpaulin. The mixture was placed into plastic containers lined with a capacity of 10 L. The material was compacted to remove air and create anaerobic conditions. The containers were tightly sealed and stored at room temperature for 22 days to allow the fermentation process. Silage samples were collected from each experimental unit at the end of the fermentation period using the sampling method at five points (right, left, center, top, bottom) for assessment of physical characteristics, pH measurement for Fleigh value, and dry matter content measurements.

Observed Variables

Physical Characteristics

The quality of silage can be assessed through physical characteristics after the fermentation process is complete. The assessment was carried out by 20 semi-trained panelists who were previously given a brief explanation of the evaluation criteria and scoring procedures. The panelists consisting of laboratory staff, laboratory assistants, and students from the Faculty of Animal Husbandry at Padjadjaran University. The assessment of the physical characteristics of silage used assessment criteria based on Table 1.

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Table 1. Silage Physical Characteristics Assessment Criteria

Criteria	Physical Characteristics	Score
Color	Yellowish green	25
	Blackish brown	10
	Black is close to the color of compost	0
Aroma	Fragrant like fruit and slightly sour	25
	Want to try it but it's sour and smells good	20
	The sour smell is getting stronger or the smell is not noticeable	10
	Like a mushrooms and compost smells bad	0
Texture	Dry but when held it feels soft and tender	25
	The water content feels a bit high but not wet	10
	High water content, feels wet and little muddy	0
Taste	Sweet and sour like yoghurt	25
	Slightly sour	20
	tasteless	5
	not delicious	0
Total		100

Source: Untari (2008)

Fleigh Value

The Fleigh value was used to evaluate silage quality by relating dry matter content to the pH of silage. The pH value was determined by collecting a representative silage sample and measuring it using a digital pH meter that had been previously calibrated with standard buffer solutions. The Fleigh value was calculated based on the dry matter content and pH of the silage using the formula proposed by Kilic (1984):

$FP = 220 + (2 \times \%\ DM – 15) – (40 \times pH)$.

Dry Matter Content

Dry matter content was determined through moisture analysis. The moisture content was measured by drying the feed sample in an oven at 105°C for 24 hours until a constant weight was achieved. After drying, the samples were placed in desiccator to remove residual moisture vapor, weighed to obtain the final dry weight. Dry matter content was calculated using the following formula:

$$\text{Dry Matter Content (\%)} = 100\% - \left(\frac{B-(C-A)}{B} \times 100\%\right)$$

Description:

A= Weight of the aluminum dish

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B = Weight of the sample before oven drying

C = Weight of the aluminum dish + the sample after oven drying

Dry matter change in silage was determined by calculating the difference between the dry matter content before fermentation and after fermentation. The obtain values were then applied to the following formula:

Dry Matter Change (%) = $\frac{A-B}{A} \times 100\%$

Description:

A = Dry matter content of silage before fermentation (%)

B = Dry matter content of silage after fermentation (%)

Data Analysis and Method

This study was conducted using an experimental method based on a Completely Randomized Design (CRD), comprising four treatments with five replications each. The treatments included the following:

T1 = 90% Corn Stover + 10% Pineapple Peel

T2 = 80% Corn Stover + 20% Pineapple Peel

T3 = 70% Corn Stover + 30% Pineapple Peel

T4 = 60% Corn Stover + 40% Pineapple Peel

A total of 20 experimental units were used in this study. Data were analyzed using analysis of variance (ANOVA) to determine the effect of treatment, with SPSS software. If significant differences were observed, Duncan's Multiple Range Test was performed at a 5% significance level to compare treatment means.

RESULTS AND DISCUSSION

This study evaluated the effects of varying ratios of corn stover and pineapple peel on physical characteristics, Fleigh value, and dry matter changes. The findings are summarized in Table 2.

Table 2. The Effect of Corn Stover and Pineapple Peel Ratio on Physical Characteristics, Fleigh Value, and Dry Matter Changes of Silage.

Parameter	Treatment			
	T1	T2	T3	T4
Color	15.80±0.84^{a}	15.70±1.14^{a}	16.45±0.41^{ab}	17.35±0.63^{b}
Aroma	20.25±0.77	20.20±0.65	20.40±1.13	20.70±1.68
Texture	14.60±0.58	16.40±2.66	13.45±0.41	16.10±2.45
Taste	19.10±1.18	17.95±1.63	17.55±1.16	18.70±0.99
Fleigh Value	88.68±4.12	90.45±8.91	92.03±5.00	94.77±10.93
Dry Matter Changes (%)	7.12±8.88	12.83±14.45	16.29±14.13	25.21±21.83

Data are presented as mean ± SD. Based on ANOVA, only the color was significantly affected by the treatments ($P < 0.05$), whereas Aroma, Texture, Taste, Fleigh value, and dry matter changes showed no significant among all treatments ($P > 0.05$). Different superscript letters indicate significant differences exclusively within the color row. T1 = 90% Corn Stover + 10% Pineapple Peel; T2 = 80% Corn Stover + 20% Pineapple Peel; T3 = 70% Corn Stover + 30% Pineapple Peel; T4 = 60% Corn Stover + 40% Pineapple Peel.

Physical Characteristics

Color

Analysis of variance showed that different ratios of corn stover and pineapple peel had a significant effect on silage color ($P < 0.05$). The average silage color score ranged from 15.80 to 17.35, with the lowest score obtained by T2 (15.70), followed by T1 (15.80), T3 (16.45), and the highest score in T4 (17.35). Silage containing 40% pineapple peel exhibited the highest color score, indicating better preservation of visual quality during fermentation.

The yellowish-green color observed suggests that fermentation occurred without excessive heating, which may indicate efficient lactic acid fermentation by lactic acid bacteria. The rapid production of lactic acid can accelerate the decline in pH during ensiling, thereby inhibiting undesirable microbial activity and preventing excessive heat generation, which helps preserve chlorophyll and maintain the visual quality of silage. These results showed a better final color compared to the findings of Septia et al. (2025), in which the addition of 15% pineapple peel resulted in a brownish-green color despite being the highest treatment level in that study. The difference in color may be attributed to the use of additional additives in the previous experiment.

Silage color changes are influenced by heat generated during fermentation. These findings are consistent with Kurniawan et al. (2015), who reported that good quality silage retains a color similar to the original material. Elevated temperatures during fermentation cause the green color of corn stover to shift toward yellowish tones (Hasiib et al., 2024). The slightly brownish coloration observed in T1, T2, and T3 was caused by pigment transformation during fermentation. This is in line with the opinion of Aglazziyah et al. (2020) who reported that the brownish-green color of silage is influenced by pheophytin pigment, which is a derivative of chlorophyll that has lost magnesium ions due to an increase in temperature during the fermentation process, causing the central atom of chlorophyll to become unstable.

Aroma

Analysis of variance showed that different ratios of corn stover and pineapple peel had no significant effect on silage aroma ($P > 0.05$). The average silage aroma score ranged from 20.25 to 20.70. The inclusion of pineapple peel up to 40% did not significantly improve silage aroma. All treatments produced silage with a similar aroma, characterized by a typical sour fermentation odor without any foul smell. The characteristics sour aroma observed in silage containing pineapple peel was associated with the activity of lactic acid bacteria during fermentation, which dominated the conversion of soluble carbohydrates into lactic acid (Septia et al., 2025). This suggests that increasing the proportion of pineapple peel may enhance lactic acid production, thereby contributing to a more pronounced acidic aroma.

No rotten or ammonia like odor was detected, indicating that there is no excessive proteolysis. In line with the opinion of Rasuli et al. (2022) that good quality silage typically produces a characteristic sour fermentation aroma, whereas a rotten or ammonia like odor indicates poor silage quality. The presence of ammonia odor is commonly associated with excessive proteolysis, namely the breakdown of protein into ammonia due to the activity of putrefactive microbes such as *Clostridium* sp. which may negatively affect silage quality (Kung Jr. et al., 2018).

Texture

Analysis of variance showed that different ratios of corn stover and pineapple peel had no significant effect on silage texture ($P > 0.05$). The average silage texture score ranged from 14.60 to 16.40. The inclusion of pineapple peel up to 40% did not improve silage texture. All treatments produced silage classified in the good category, although the texture was slightly moist but not excessively wet. The moist texture of the silage indicated a balance between the materials moisture content and the fermentation outcomes that support microbial activity without resulting in a mushy or slimy condition.

These findings consistent with Aglazziyah et al. (2020), who report that good quality silage is characterized by an intact physical structure, non-slimy texture, minimal structural changes, and resembles to the original material before fermentation. The fermentation process may influence the formation of stable silage texture through the degradation of fiber components by fermentative microorganisms. According to Li et al. (2024), the addition of pineapple residue to corn based silage can increase lactic acid bacteria activity and accelerate pH reduction, resulting in natural softening of plant tissue due to the breakdown of some lignocellulose components.

Taste

Analysis of variance showed that different ratios of corn stover and pineapple peel had no significant effect on silage taste ($P > 0.05$). The average silage taste score ranged from 17.55 to 19.10. The inclusion of pineapple peel up to 40% did not improve the taste of silage. All treatments produced silage with a taste characterized by the typical fresh sourness fermentation. The fresh sour taste of silage result from the conversion of carbohydrates into lactic acid during fermentation, which leads to a decrease in pH and gives silage its characteristic sour taste (Joneri et al., 2025).

Pineapple peel contains soluble sugars such as glucose, fructose, and sucrose, which serve as energy sources for lactic acid bacteria. The addition of pineapple peel can accelerate the fermentation process and increase lactic acid production, which have an important role in creating a fresh sour taste in silage. In line with the opinion of Li et al. (2024), the availability of additional carbohydrate substrates from pineapple peel can increase lactic acid concentration, stabilize pH, and produce a distinctive sour taste accompanied by a pleasant aroma. Additionally, the bromelain enzyme contained in pineapple peel plays a role in breaking down protein and crude fiber, thereby preventing the formation of ammonia and other volatile compounds that can cause a bitter taste.

Fleigh Value

The Fleigh value is one of the indicators used to evaluate silage fermentation quality through a calculation that reflects the relation between dry matter content and pH silage. According to Kilic (1984), a Fleigh value of 80–100 indicates that the fermentation of silage is of very good quality, 60–80 is good, 40–60 is fairly good, 20–40 is moderate, and a Fleigh value of < 20 indicates poor fermentation quality. Analysis of variance showed that the different ratios of corn stover and pineapple peel had no significant effect on the Fleigh value of silage ($P > 0.05$). However, there is a tendency toward higher Fleigh value was observed with increasing proportions of pineapple peel, suggesting a potential improvement in fermentation characteristics.

The Fleigh value obtained from silage of corn stover and pineapple peel ranged from 88.68–94.77. Based on the Fleigh value index proposed by Kilic (1984), these value falls into the category of very good category (80–100), indicating that the fermentation process was optimal and stable. The Fleigh value produced is directly proportional to the dry matter content and inversely proportional to the pH. This is in line with the opinion of Septian et al. (2024) reported that higher dry matter content combined with lower pH results in higher Fleigh values.

The inclusion of pineapple peel in silage provided additional soluble carbohydrates that served as substrate for lactic acid bacteria, potentially enhancing microbial activity and increasing lactic acid production. This process contributes to a more rapid decline in pH and producing higher Fleigh value. This statement is confirmed by Aglazziyah et al. (2020) stated that the availability of soluble carbohydrates can stimulate the growth of lactic acid bacteria and improve the efficiency of the ensiling process. Similarly, David et al. (2021) stated that an increase in lactic acid population increases fermentation intensity, results in a decrease in pH silage.

Dry Matter Changes

Dry Matter Changes during the ensiling process are influenced by initial plant respiration and microbial metabolic activity during fermentation. Analysis of variance showed that different ratios of corn stover and pineapple peel had no significant effect on silage dry matter changes ($P > 0.05$). Dry matter changes ranged from 7.21% to 25.21%. although the differences were not statistically significant, there was a tendency for dry matter changes to increase with higher proportions of pineapple peel.

Dry matter changes in silage generally occurred during the early phase of ensiling when oxygen was still available. At this stage, plant cells continued aerobic respiration, oxidizing carbohydrates into CO_2 and heat, thereby reducing dry matter content. Suryani et al. (2017) explained that early respiration is one of the primary factors contributing to dry matter loss before completely anaerobic conditions are established. Once oxygen was depleted, fermentation by lactic acid bacteria becomes the dominant process. During this stage, carbohydrates were converted into lactic acid, water, and a small amount of gas. Kuncoro et al. (2015) stated that the fermentative activity during the anaerobic phase also contributes to dry matter loss as part of substrate conversion into fermentation products.

Wróbel et al. (2023) reported that dry matter loss is associated with the activity of epiphytic microbiota, which utilize fermentable substrates and produce CO_2 during metabolism. Although the highest dry matter change in present study reached 25.21%, this condition was not accompanied by a decline in fermentation quality, as indicated by the Fleigh value, that remained within very good category (88.68-94.77). This finding indicate that the observed dry matter changes remained within the biological dynamics of fermentation and did not reflect deterioration of silage quality.

CONCLUSIONS

The Ratio of corn stover and pineapple peel had a significant effect on silage color ($P < 0.05$). However, it had no significant effect on aroma, texture, taste, Fleigh value, and dry matter changes ($P > 0.05$). All treatments produced silage classified as very good quality based on the Fleigh value. The inclusion of pineapple peel up to 40% in silage can be applied without reducing physical or fermentation quality, and has the potential to improve the color characteristics of silage.

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