

Effect of molasses and cassava meal on chemical composition, pH, and organoleptic characteristics of cocoa pod husk silage

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ABSTRACT

The objective of this research was to determine the most effective treatments molasses, cassava meal, and their combination on dry matter (DM), organic matter (OM), pH, and organoleptic characteristics of cocoa pod husk silage. The study was conducted from June to July 2025 at the Laboratory of Animal Nutrition and Feed, Department of Animal Science, Faculty of Agriculture, University of Lampung. Cocoa pod husk was ensiled using four treatments with three replications: T0 (control), T1 (10% molasses), T2 (10% cassava meal), and T3 (5% molasses + 5% cassava meal). Data were analyzed using analysis of variance (ANOVA), followed by the least significant difference (LSD) test. The results showed that treatments significantly affected DM and OM, with the highest values observed in T2 (20.99% DM and 18.84% OM). Silage pH ranged from 4.28 to 5.20, and T1 produced the lowest pH, indicating more favorable fermentation. Organoleptic traits were not significantly affected, and all silages remained acceptable in sensory quality. In conclusion, molasses and cassava meal improve the chemical quality of cocoa pod husk silage without altering its sensory properties, suggesting their potential as effective additives to enhance the use of agricultural by-products as ruminant feed.

INTRODUCTION

The increased provision of alternative feed sources for ruminants, particularly as sources of fiber and energy, is essential due to the limited availability of forage. One potential solution to this issue is the utilization of agricultural waste, which holds promise as a substitute for conventional feed. Cocoa pod husks, in particular, present significant potential as an alternative feed resource for ruminants. Cocoa (*Theobroma cacao* L.) is one of Indonesia's leading plantation commodities, with a very high production volume. While the economically valuable part of the cocoa plant is the bean, the pod husk often discarded as waste during bean processing remains underutilized. If not managed properly, cocoa pod husks can cause environmental

pollution, as their use is still very limited and they are often disposed of without further application (Erika, 2013). According to data from Statistics Indonesia and the International Cocoa Organization (ICCO), Indonesia ranked seventh among the world's largest cocoa producers in 2022, with a production of 650.6 tons. The province of Lampung contributed 7.41% of this total. Based on this production, cocoa pod husks constituting approximately 70–75% of the cocoa fruit account for an estimated 455.4 to 487.95 tons of agricultural waste in 2022.

Various processing methods can be applied to enhance the utilization of cocoa pod husks while maintaining their quality and function, including physical, chemical, and biological treatments. One widely used biological method is the production of silage, which involves



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fermenting the husks through microbial activity especially by lactic acid bacteria. Silage is a type of preserved animal feed produced through anaerobic fermentation, where the absence of oxygen creates a favorable environment for anaerobic bacteria to convert organic matter into simpler compounds. This process results in the production of lactic acid, which lowers the pH and helps preserve the feed (Tira et al., 2024).

Molasses serves as a primary energy source for microbes during fermentation. Due to its high sugar content, molasses is commonly used as a feed additive and is recognized for its good nutritional value (Larangahen et al., 2016). It contains large amounts of sugars, amino acids, and minerals, with an acidic pH range (approximately 4.5 to 5.6) and sucrose content between 25% and 40%. As such, the addition of molasses during silage preparation can significantly enhance feed quality (Dhalika, 2021).

In addition to molasses, the inclusion of cassava flour (locally known as tepung gaplek) can further improve the fermentation quality of cocoa pod husk silage. Due to its high starch content, cassava flour is a good carbohydrate source that supports microbial fermentation by supplying readily fermentable substrates. The carbohydrates in cassava flour are easily converted into lactic acid by fermentative microorganisms, which helps create an acidic environment that accelerates fermentation and inhibits the growth of undesirable microbes. According to Waluwandja et al. (2023), cassava flour serves as a viable source of water-soluble carbohydrates (WSC) that can promote fermentation during silage production. Moreover, cassava flour is easy to produce independently, ensuring its availability and simplifying the silage-making process for farmers who require accessible and effective additives.

In this study, additives were applied at a total inclusion level of 10% (fresh-weight basis) because levels around 5–10% are commonly used to supply sufficient fermentable carbohydrates for rapid pH decline in tropical silages. Molasses at approximately 10% has been reported to enhance lactic acid fermentation and reduce pH in Napier/elephant grass silage (Yunus et al., 2000) and in other forages (Alli et al., 1984). Cassava-derived additives can contribute fermentable carbohydrates

and increase dry matter, which is beneficial for wet substrates and is associated with improved fermentation profiles in cassava-based silages (Pongsub et al., 2022; Bakare et al., 2023). Therefore, we compared 10% molasses (T1), 10% cassava meal (T2), and a 5%+5% combination (T3) while keeping total additive levels constant to evaluate the relative contributions of soluble sugars versus dry-matter adjustment (Muck, 2010; Kung et al., 2018).

This study aims to investigate the effects of adding molasses, cassava flour, and a combination of both on the dry matter content, organic matter content, pH value, and organoleptic characteristics of cocoa pod husk silage.

MATERIALS AND METHODS

Research Materials

The materials used in this study included Trinitario cocoa pod husks obtained from Way Lima, Lampung. The cocoa pods selected were physiologically mature, typically indicated by a yellowish skin color, and free from small holes. Cassava flour was sourced from Pringsewu, while molasses was purchased from an agricultural supply store in Bandar Lampung. The equipment used in this research included scales, buckets, plastic bags, a chopping machine, and tarpaulin. For chemical and organoleptic analyses, tools such as a blender, analytical balance, porcelain crucibles, petri dishes, oven, furnace, desiccator, tongs, pH meter, labeling paper, questionnaire sheets, and writing instruments were utilized.

Research Method

This study employed an experimental method using a Completely randomized design (CRD) consisting of four treatments and three replications, resulting in a total of 12 samples. The treatments were as follows:

T0: Cocoa pod silage without the addition of molasses and cassava flour (control);

T1: Cocoa pod silage with the addition of 10% molasses;

T2: Cocoa pod silage with the addition of 10% cassava flour;

T3: Cocoa pod silage with the addition of 5% molasses and 5% cassava flour.

The procedure began with the preparation of equipment and materials for cocoa pod silage production. Fresh cocoa pod husks were chopped using a chopper machine and then sun-dried to reduce the moisture content. For the control treatment, 3 kg of partially dried cocoa husks were packed tightly into plastic silos to eliminate air spaces, then placed into buckets and sealed.

For the molasses treatment, 3 kg of cocoa husks were mixed with 10% molasses until homogeneous, packed into plastic silos, compacted, and sealed in buckets. The silage was stored for 21 days in a shaded area away from direct sunlight. In the cassava flour treatment, 3 kg of cocoa husks were mixed with 10% cassava flour, homogenized, and similarly packed, sealed, and stored. The combination treatment involved mixing 3 kg of cocoa husks with 5% molasses and 5% cassava flour, followed by the same silage-making process.

The parameters observed included chemical composition (dry matter and organic matter contents), pH measurement, and organoleptic characteristics (texture, color, and aroma). The data obtained were analyzed using Analysis of variance (ANOVA), and if significant differences were found, a Least significant difference (LSD) test was conducted for further comparison.

RESULTS AND DISCUSSION

Chemical Composition (Dry Matter and Organic Matter) of Cocoa Pod Husk Silage

The results of the study indicated that the average percentage of dry matter and organic matter content in cocoa pod husk silage, following the addition of molasses and cassava flour, ranged from 17.79% to 20.99% and 14.94% to 18.84%, respectively. The mean values of dry matter and organic matter content in cocoa pod husk silage for each treatment group are presented in Table 1.

The results showed that the addition of molasses and cassava flour had a highly significant effect ($P < 0.05$) on increasing the dry matter and organic matter content of cocoa pod husk silage. Cassava flour, with its high dry matter content (93.80%), was effective in absorbing moisture, resulting in the highest dry matter content in treatment T2 (10% cassava flour). In contrast, T3 (a combination of 5% molasses and 5% cassava flour) showed lower dry matter content due to its reduced moisture absorption capacity. This finding is consistent with Desnita et al. (2015), who reported that the addition of cassava flour effectively reduces moisture content and increases dry matter levels due to its hygroscopic properties. Furthermore, the presence of complex carbohydrates in cassava flour supports a more stable fermentation process (Jasin et al., 2014). Although molasses is liquid in form, it contains simple sugars that promote rapid fermentation and help stabilize dry matter content.

Treatment T2 (10% cassava meal) produced the highest dry matter (DM) because cassava meal has high DM and starch content and can function as an absorbent, thereby reducing excess moisture and potential effluent losses in wet ensiling materials. Cocoa pod husk is generally characterized by high initial moisture and may release leachate during ensiling, which helps explain why the control T0 (without additives) tended to show the lowest DM due to less favorable preservation conditions (Meza-Sepúlveda et al., 2025). Although molasses is a liquid additive, its high concentration of water-soluble carbohydrates supports rapid lactic acid fermentation, faster pH decline, and better nutrient preservation, which can improve DM recovery compared with untreated silage (Muck, 2010; Kung et al., 2018). Similar improvements in silage quality have also been reported when molasses is included at levels around 10% in other forage/by-product silages. Therefore,

Table 1. Effect of Treatments on the dry matter and organic matter content of cocoa pod husk silage

Parameters	Treatments			
	T0	T1	T2	T3
Dry matter (%)	17.79±0.74 ^a	20.82±0.79 ^{bc}	20.99±1.07 ^c	19.76±1.33 ^b
Organic matter (%)	14.94±0.73 ^a	18.15±0.78 ^{bc}	18.84±0.91 ^c	17.43±1.57 ^b

Note: Different superscript letters indicate a statistically significant difference ($P < 0.05$)

the higher DM observed in T1–T3 relative to T0 likely reflects a combination of added dry matter (particularly from cassava meal) and more efficient fermentation due to greater availability of fermentable substrates (Kung et al., 2018; Muck, 2010).

The addition of molasses and cassava flour also significantly increased the organic matter content. Treatment T2 (10% cassava flour) yielded the highest organic matter content, owing not only to its moisture-absorbing properties but also to its content of complex carbohydrates that promote stable fermentation. Organic matter content is positively correlated with dry matter levels and is influenced by ash content the higher the ash, the lower the organic matter. Organic matter content correlates with dry matter levels, and higher organic matter indicates better feed quality due to a greater concentration of nutrients. Variations in organic matter are related to lactic acid bacteria activity during the ensiling process, which utilize nutrients to produce organic acids (Cahyo et al., 2015).

Treatment T2 (10% cassava flour) resulted in the highest organic matter content and was significantly different from T3, while T1 did not differ significantly from either T2 or T3. This indicates that the 10% cassava flour addition

(T2) was more effective in maintaining organic matter levels compared to the combination treatment (T3), as cassava flour has better moisture absorption and provides complex carbohydrates that support stable fermentation. This is in line with the findings of Wijaya et al. (2025), who reported that varying levels of fermented rice bran significantly affected the organic matter content of corn stover silage. These results are further supported by Wachidan et al. (2024), who stated that the addition of 4–6% molasses significantly improves silage quality by enhancing lactic acid production, which plays a key role in preserving organic matter during fermentation.

Organoleptic Evaluation of Cocoa Pod Husk Silage

The results of the organoleptic evaluation of cocoa pod husk silage showed that the addition of molasses and cassava flour yielded relatively favorable average scores, with color ranging from 3.16 to 3.79, aroma from 3.22 to 3.53, and texture from 3.02 to 3.11. However, statistically, the treatments had no significant effect ($P>0.05$) on any of the three organoleptic parameters assessed. The effects of molasses and cassava flour addition on the organoleptic values of cocoa pod husk silage are presented in Table 2.

Table 2. Effect of treatments on the organoleptic properties of cocoa pod husk silage

Parameter	Treatments			
	T0	T1	T2	T3
Color	3.16±0.24	3.79±0.73	3.47±0.09	3.36±0.28
Aroma	3.22±0.08	3.53±0.16	3.32±0.24	3.52±0.09
Texture	3.02±0.16	3.10±0.15	3.11±0.14	3.02±0.17

Note: Different superscript letters indicate a statistically significant difference ($P<0.05$)

Color Score Assumptions (Zakariah et al., 2015):

- 1 – 1.9: Black
- 2 – 2.9: Dark brown
- 3 – 3.9: Brown
- 4 – 4.9: Yellowish brown

Aroma Score Assumptions:

- 1 – 1.9: Rotten
- 2 – 2.9: Slightly acidic
- 3 – 3.9: Acidic
- 4 – 4.9: Fresh acidic

Texture Score Assumptions:

- 1 – 1.9: Very clumped and slimy
- 2 – 2.9: Moderately clumped and slimy
- 3 – 3.9: Slightly clumped and slightly slimy
- 4 – 4.9: Not clumped and not slimy

In terms of color, the addition of 10% molasses, 10% cassava flour, and their 5% combination did not significantly alter the color of cocoa pod husk silage. This may be attributed to the naturally dominant brown color of the

cocoa husk, making it difficult for panelists to detect visual differences among treatments. This assessment aligns with the findings of Zakariah et al. (2015), who stated that high-quality silage should maintain a color similar to its original material, and is further supported by Buhi et al. (2023), who described good silage color as ranging from brown to yellowish, accompanied by a characteristic acidic fermentation aroma.

Regarding aroma, no significant differences were observed among treatments. This outcome is likely due to relatively homogeneous fermentation processes across all treatments. Although molasses and cassava flour serve as substrates for microbial activity, their addition did not produce discernible differences in aroma intensity. These results are consistent with the study by Buhi et al. (2023), which noted that good silage typically has a sweet-sour aroma, although this may vary depending on the uniformity and stability of the fermentation process.

Similarly, the addition of molasses and cassava flour did not significantly affect the texture of cocoa pod husk silage. The texture scores remained within an acceptable range (above score 3), indicating no signs of spoilage such as severe clumping or excessive sliminess. The lack of significant differences may be attributed to relatively stable moisture content and the 21-day fermentation period, which allowed for the development of a uniform texture. These findings are in line with those of Landupari et al. (2020), who reported that the addition of 0–6% molasses did not significantly influence the texture of elephant grass silage. Furthermore, David et al. (2021) stated that a sufficiently long fermentation period contributes to a more homogeneous silage texture due to the stabilization of plant structure.

Although the treatments did not result in significant differences in organoleptic parameters, the overall findings indicate that the addition of molasses and cassava flour still provided acceptable visual and textural qualities in the silage. This is supported by Ali et al. (2022), who emphasized that good-quality silage is characterized by a fresh, soft, and non-clumped texture, features that remained consistent across all treatments in the present study.

Moreover, a study by (Chaudhary et al., 2021; Marhaeniyanto et al., 2022), which utilized agro-industrial waste to produce pomegranate peel silage, also demonstrated that organoleptic characteristics such as color and aroma are primarily influenced by the base material and fermentation conditions, rather than solely by additive use. This further supports the notion that the intrinsic characteristics of the feed material play a dominant role in determining the visual quality and aroma of silage.

pH Value of Cocoa Pod husk Silage

The results showed that the average pH values of cocoa pod husk silage, following the addition of molasses and cassava flour, ranged from 4.28 to 5.20. The mean pH values for each treatment are presented in Figure 1.

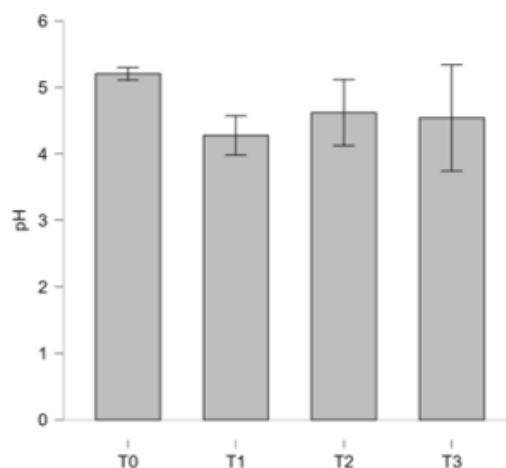


Figure 1. Bar plot of pH values of cocoa pod husk silage under each treatment.

The pH measurement of cocoa pod husk silage (Figure 1) demonstrated that the application of additives had a clear effect on the fermentation process. The control treatment (T0) exhibited the highest pH value, approximately 5.3, indicating suboptimal fermentation due to the limited formation of organic acids. Silage without the addition of molasses and cassava flour resulted in the highest pH (5.20), likely due to the fermentation process relying solely on the natural sugar content present in the cocoa pod husk. This finding is supported by Marhaeniyanto et al. (2022), who reported that the ensiling

of elephant grass without additives led to suboptimal lactic and acetic acid production, as nutrient availability for acid formation was limited to that provided by the silage material itself.

Conversely, treatment T1 resulted in the lowest pH value, approximately 4.3, indicating a more rapid pH decline and higher fermentation efficiency. Treatments T2 and T3 showed pH values in the range of 4.6–4.7, although the acidity reduction was still less pronounced than in T1. The success of T1 in lowering pH is consistent with the optimal range (3.8–4.2) for achieving stable, high-quality silage, as also reported by Azizah et al. (2020) who noted that a desirable pH range lies between 4.2 and 4.5, the addition of molasses and table sugar at varying levels significantly affected ($P < 0.05$) the pH of elephant grass silage.

Herawati et al. (2017) emphasized that for the ensiling process to proceed rapidly and effectively, the inclusion of additives such as molasses rich in readily fermentable carbohydrates is essential. These carbohydrates accelerate lactic acid production, which is critical for creating anaerobic conditions and reducing silage pH to optimal levels. Zakariah et al. (2015) also noted that carbohydrates from cassava flour can stimulate lactic acid production by lactic acid bacteria (LAB), effectively lowering silage pH. Similarly, Jasin et al. (2014) stated that cassava flour contains high levels of carbohydrates that serve as an energy source for LAB, ultimately enhancing lactic acid formation, accelerating pH reduction, and improving silage quality.

Overall, the comparison of pH values across treatments revealed that the combination of molasses and cassava flour (T1) was the most effective in creating an acidic environment conducive to the fermentation of cocoa pod husk silage, in line with the characteristics of high-quality silage. Molasses and cassava flour play a key role in supplying soluble carbohydrates that support fermentative microbial activity, enhance lactic acid production, and reduce pH toward the ideal range for quality preservation. This strategy offers a promising approach for optimizing the use of agricultural by-products such as cocoa pod husks into nutritious and shelf-stable livestock feed.

CONCLUSIONS

Adding molasses, cassava flour, or their combination to cocoa pod husk silage affected chemical composition and pH but did not significantly change organoleptic traits. The 10% cassava flour treatment produced the highest dry matter (20.99%) and organic matter (18.84%), while 10% molasses resulted in the lowest pH (4.28), indicating better fermentation conditions. Color, aroma, and texture remained acceptable across all treatments. Overall, molasses and cassava flour improve the chemical quality of cocoa pod husk silage without compromising sensory quality, supporting its potential as an alternative ruminant feed from agricultural by-products.

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