Hasanuddin J. Anim. Sci. Vol. 6, No. 2: 104-113
pISSN 2621-9182 eISSN 2621-9190
DOI: 10.20956/hajas.v6i2.31778

Organoleptic Test Characteristics of Corn Stover Silage Added with Several Legumes

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ARTICLE INFO

Article history:
Submission: November 14, 2023
Accepted: November 30, 2024
Published: December 27, 2024

ABSTRACT

The limited forage availability in the dry season is a limiting factor in a livestock business. The abundance of forage in the rainy season cannot be stored long without treatment. This is due to the high water content, so forage cannot be stored; there is a need for innovative feed technology. Silage is a feed processing technology using a method of preserving/fermenting feed in anaerobic conditions, which is placed in a silo with a water content of around 60-70%. The principle of forage fermentation is by microbes that produce a lot of lactic acid. This research aimed to determine corn straw silage's physical properties (organoleptic tests) by adding several types of legumes. According to data from the Directorate General of Animal Husbandry and Animal Health in 2022, the number of cattle in South Sulawesi Province was 18,610,000 head. The increase in production in 2022 compared to 2012 occurred in all regions in Indonesia, South Sulawesi Province. Corn produced was 1,420,154 tons, which shows that corn straw waste is abundant and can be used as forage using silage technology. The materials used are Bima Provit A1 (stay green), hybrid corn stover, and legumes. The treatments used were 95% corn stover silage (control), 70% corn stover silage + 25% Gamal legumes, 70% corn stover silage + 25% Lamtoro legumes, and 70% corn stover silage + 25% Indigofera legumes. Creating an acidic atmosphere can be accelerated by adding preservatives or additional ingredients (additives) in rice bran (5%). Organoleptic test parameters to determine silage's physical characteristics and quality, such as texture, color, and aroma. The results obtained were that the silage texture score in all treatments had an average value that was not much different and fell into the medium texture category, the silage color score in all treatments had good quality, brown and yellowish brown, the aroma score in all treatments had good quality.
Keywords: Corn stover silage, leguminosae, organoleptic test

INTRODUCTION

Fresh grass is a low-cost feed produced on-farm, with a good nutritive value for lactating cows, especially for nitrogen supply compared to conserved forages [1]. However, the availability and composition of fresh grass vary throughout the year. Thus, farmers frequently supplement grazed grass with other feeds when the grass is scarce and during dietary transitions. Grass-based dairy systems, such as organic farms that use few concentrates, commonly combine fresh grass with conserved forages, such as maize silage, in cow diets. Fresh grass is primarily rich in protein and degradable N compared to maize silage [2]. Thus, combining fresh grass and maize silage could help balance the nutritional value of diets. French technical guidelines recommend not supplementing fresh grass-based diets with N-rich concentrate when maize silage is less than 50% of the diet's dry matter (DM) [2]. The effects of this combination of forages on cow N balance and metabolism are not well known compared to those of full-time grazing or a total mixed ration with only conserved forages and concentrates [2].

The limited availability of forage in the dry season is a limiting factor in the livestock business, and the abundance of forage in the rainy season cannot be stored for an extended period without treatment. This is due to the high water content, so forage cannot be stored. There is a need for an effort or solution to ensure that the abundance of forage in the rainy season can be utilized in the dry season. This also requires continuity in the availability of feed. So, there is a need for innovative feed technology.

Maize (*Zea mays L.*) is a staple food and feed crop, with over 70% of global maize production used for livestock feed, particularly ruminants, as high-energy silage [3]. Silage maize, cultivated for this purpose, combines high yield potential, palatability, and energy value. Maize silage is an excellent supplement, especially during periods of fodder scarcity, such as dry seasons, owing to its abundant green mass (GM) and dry DM production, superior fermentability during storage, and high acceptance by meat and dairy animals. The leading regions in maize silage production include North America (with 40% of the global share), Europe, the Middle East, Latin America, and northern Asia. The market value of maize silage is projected to rise from 342 million to 677 million US dollars between 2022 and 2032 [3].

Silage is a feed processing technology using a method of preserving/fermenting feed in anaerobic conditions (without air) which is placed in a silo with a water content of around 60-70% where the principle of forage fermentation is by microbes which produce a lot of lactic acid. The lactic acid produced during the fermentation process will act as a preservative to prevent the growth of spoilage microorganisms. Silage is a feed processing technology that reduces nutrient loss and preserves feed.

Ruminant production is frequently highlighted as a contributor to the emission of greenhouse gases and pollutants such as NO_3^- and NH_3 [4]. In ruminant livestock production systems, the pivotal role of forage intake cannot be overstated, accounting for a substantial portion of their dietary requirements, ranging from approximately 40 to 90% [5]. A decline in the intake of fibrous feedstuffs, notably those rich in Neutral Detergent Fiber (NDF), precipitates a reduction in ruminal pH levels, leading to the onset of digestive disorders [6]. Increasing the proportion of maize silage in fresh grass diets could decrease N excretion in manure by decreasing dietary N concentration [7].

The number of cattle in South Sulawesi Province was 18,610,000 head, and based on the results of the KSA survey by BPS in 2023 [8], the corn harvest area in South Sulawesi Province was 177,861.46 ha. In BPS records, the harvest area Corn from this year's Area Sample Frame (KSA) survey consists of three types of harvest: forage, young, and shelled harvest. Over the last 10 years, corn production increased 42.73% compared to 2012 17.64 million tons. The increase in production in 2022 compared to 2012 occurred in all regions in Indonesia. In South Sulawesi

Province, the amount of corn produced was 1,420,154 tons. In 2012, it was 1,833,902 tons; corn straw waste is abundant and can be used as forage using silage technology.

Maintaining feed nutrition using a feed processing technology (silage) is essential because good nutrition increases cow production and productivity. In addition to preserving feed, silage also helps increase digestibility.

Antinutritional substances in some legume plants require treatment to reduce or eliminate these limiting factors by applying silage technology. Several types of legumes, such as Gamal, Lamtoro, and Indigofera, can be processed into silage and mixed with corn stover. This research aimed to determine the physical properties of corn stover silage (organoleptic tests) by adding several types of legumes.

MATERIALS AND METHODS

Time and Place of Research

This research was conducted from September to October 2023 at the Feed Chemistry Laboratory, Faculty of Animal Husbandry, Hasanuddin University, Makassar.

Research Methodology

The materials used are Bima Provit A1 (stay green), hybrid corn stover, and legumes. The tools used are a chopper, transparent plastic (silo), insulation, neat rope, and bucket. Corn straw and legumes are used with a water content of 60-70%, which is optimal for making silage, then chop the corn stover to a size of ± 3-5 cm. Next, corn stover is mixed with legumes according to the following treatment:

A. Corn stover 95 % (control)
B. Corn stover 70 % + Gamal 25 %
C. Corn stover 70 % + Lamtoro 25 %
D. Corn stover 70 % + Indigofera 25 %

Creating an acidic atmosphere can be accelerated by adding preservatives or additional ingredients (additives) to rice bran (5%). The ingredients that have been thoroughly mixed are put into a transparent plastic bag (silo) with a size of 3 kg, then compacted by pressing and using a vacuum until it is completely solid, after that the plastic bag is closed tightly by tying it using neat rope and insulation so that become airtight (anaerobic) and incubated for 21 days. Next, the silage is opened, and a physical test/organoleptic test is carried out.

Organoleptic test parameters to determine silage's physical characteristics and quality, such as texture, color, and aroma. The organoleptic test used seven panelists/respondents from animal husbandry students [9].

An organoleptic test is performed by taking several samples of treated silage with several repetitions, then assessing by paying attention to Table 1. The data obtained is then analyzed and discussed descriptively.

Table 1. How to Assess Silage Organoleptic Tests

Criteria	Characteristics	Score	Average
	Soft	1-3	2
Texture	Medium	4-6	5
	Hard	7-9	8
	Blackish brown	1-3	2
Color	Brown	4-6	5
	Yellowish brown	7-9	8
	Not sour	1-3	2
Aroma	A Few Sour	4-6	5
	Sour	7-9	8

RESULTS AND DISCUSSIONS

The physical quality of the silage mixture of corn stover and legumes was objectively assessed by seven panelists who came from animal husbandry students. Evaluation of the physical quality of the silage is known by removing the silage sample from the silo after one week. Before being evaluated, the silage is first aired to reduce the inherent ammonia odor and make it easier to identify [10].

Texture

The following results were obtained from observations regarding the texture of silage. For the silage texture assessment, the average texture scores in treatment 1, treatment 2, treatment 3, and treatment 4, respectively, were (5.6 medium) (4.1 medium) (4.7 medium) and (3.6 currently). Silage scores in all treatments had an average similar value and fell into the medium texture category. This is due to objective assessment by panelists who could not differentiate between soft, medium, and hard textures.

Good-quality fermentation has a fresh texture that is still like the initial feed ingredients before treatment [11]. The results were because, at the beginning of the fermentation process, the corn stover was conditioned at a water content suitable for the fermentation process of 70% so that the resulting texture was also the same, namely medium textured. The texture of silage is influenced by the water content of the material at the start of fermentation [12]. Silage with a high water content (>80%) will show a slimy and soft texture, while silage with a low water content (<30%) will have a dry texture. Good-quality silage is one whose texture is not smooth, watery, moldy, or lumpy [12]. To assess this texture, a sense of touch is needed to distinguish between good-quality silage and not. The texture quality obtained is in the medium category. Therefore, it is crucial to maintain fermentation quality to get better results. Poor silage texture is identified by having high water content, feeling slightly muddy, and having a persistent smell that requires washing hands with soap to eliminate [13].

Table 2. Results of Corn Strover Silage Texture Assessment Scores

Panelists	Corn Stover Silage		Corn Stover Silage + Gamal		Corn Stover Silage + Lamtoro		Corn Stover Silage + Indogofera	
	Texture	**Score**	**Texture**	**Score**	**Texture**	**Score**	**Texture**	**Score**
1	Medium	5	Medium	4	Soft	3	Soft	2
2	Medium	4	Soft	2	Medium	4	Soft	2
3	Medium	6	Medium	6	Medium	6	Medium	5
4	Medium	6	Medium	4	Medium	4	Medium	4
5	Medium	5	Soft	3	Medium	6	Medium	6
6	Medium	6	Medium	6	Medium	6	Medium	5
7	Hard	7	Medium	4	Medium	4	Soft	1
Average	Medium	5.6	Medium	4.1	Medium	4.7	Medium	**3.6**

The texture score of the silage produced is moderate, possibly also due to forage conditions in the plant growth process and the cutting used during silage making, which influences the fermentation process. Ensiling is an anaerobic bacterial-based fermentation process dominated by lactic acid bacteria (LAB), which produce the lactic acid required for pH decline and inhibition of non-acid-resistant undesirable microbes [14]. The biochemistry of ensiling sounds simple, but it can be complex when interactions occur among chemical and microbial factors. Numerous factors have been reported to affect the fermentation quality of silage. These material characteristics, including epiphytic microbiota, dry matter (DM), water-soluble carbohydrates (WSC), and buffering capacity (BC), are the most crucial. As forage matures, chemical and microbial compositions undergo dramatic changes. Therefore, forage ensiled at different maturities differ significantly in fermentation quality. However, on the diurnal scale, various plant metabolic events, such as photosynthesis and nutrient assimilation, are regulated by the circadian clock and show daily oscillation patterns. The chemical composition variation was considerable between forage cut in the morning and afternoon. In addition, the aerial part of the plant is a highly diverse and dynamic environment. It is exposed to various environmental stresses, including nutrient shortage, UV radiation, and desiccation. The Phyllosphere community also exhibits variations in diurnal and temporal patterns. Although chemical and microbial diurnal variations have long been recognized, it is surprising that few studies have investigated the effects of the time of day for harvest on the fermentation characteristics of forages.

Silage quality in maize is influenced primarily by the content of cell wall components and stalk sugar content. The cell wall, comprising much of the plant used for silage, needs to be better digested by ruminants [3], limiting the nutritional value of silage. Constituents of the cell wall are cellulose (~45%), hemicellulose (~45%), and lignins (~10%) [15], which display varying degrees of digestibility. Among ruminants, cellulose and hemicellulose digestibilities range from 50% to 90% and 20% to 80%, respectively [16]. Lignin concentration is inversely correlated with cell wall digestibility [3] and varies with genetic background. The presence of lignin in the cell wall matrix hinders its digestion in ruminants owing to its resistance to degradation by rumen microbes. Lignin concentration is the most influential component affecting cell-wall digestibility in commercial maize hybrids, accounting for over 50% of the variation in the trait [3].

The main stages where losses occur are field harvesting, silo respiration and fermentation, effluent production, and oxygen exposure during storage and feed-out phases [17]. Silage additives affect fermentation patterns and aerobic stability according to their specific mode of action [18]. For corn silages, bacterial inoculants do not appear to result in consistent reductions in ethanol [19]. Overall, the fermentation phase of the ensiling process is thought to last 7 to 45 days [20]. However, recent research indicates that fermentation continues for much longer in whole-plant corn silage [21].

Color

Based on the results of the observations regarding the silage color (Table 3). The average silage color scores in treatments 1, 2, 3, and 4 are (6.7) (6.3) (5.6) and (4.0), respectively. Treatment 1's average silage color score differed from those in treatments 2, 3, and 4, while treatment 2's was the same as in treatments 3 and 4.

Table 3. Results of Corn Stover Silage Color Assessment Scores

Panelists	Corn Strover Silage		Corn Strover Silage + Gamal		Corn Strover Silage + Lamtoro		Corn Strover Silage + Indogofera	
	Color	**Score**	**Color**	**Score**	**Color**	**Score**	**Color**	**Score**
1	Brown	5	Brown	5	Brown	6	Brown	6
2	Yellowish Brown	8	Yellowish Brown	7	Blackish Brown	3	Blackish Brown	3
3	Yellowish Brown	8	Brown	6	Brown	6	Blackish Brown	3
4	Yellowish Brown	7	Yellowish Brown	7	Yellowish Brown	7	Brown	6
5	Yellowish Brown	7	Yellowish Brown	8	Yellowish Brown	8	Brown	5
6	Yellowish Brown	7	Brown	6	Brown	6	Blackish Brown	3
7	Brown	5	Brown	5	Blackish Brown	3	Blackish Brown	2
Average	Yellowish Brown	6.7	Brown	6.3	Brown	5.6	Brown	4.0

The panelist test results showed that the color scores in all treatments had good quality, brown and yellowish brown. The good silage colors are light brown and yellowish with a sour smell [11]. Corn stover silage used as the main ingredient for making silage is brownish yellow. Good quality silage is indicated by bright and brownish green, depending on the material [22]. Based on these results, silage color fell into the brown and yellowish brown categories in all treatments. This is because, physically, the silage has the same appearance, so the panelist's assessment using the five senses does not find any differences, so the scores tend to be the same.

The color of the silage, which did not change with each treatment with the addition of bran, was thought to be due to the stable temperature factor in the silo. The color changes in plants experiencing insulation are caused by aerobic respiration, which occurs as long as the oxygen supply is still there and the plant's oxygen runs out [12]. An airtight environment will have a higher temperature, allowing color changes to occur in the initial phase of enzymation. Respiration occurs at the beginning of making silage, producing CO_2, water, and heat. If this process occurs for too long, the temperature will become high, damaging the color of the forage.

Besides the smell of vinegar, wet silage with excessive acetic acid also presents a yellow color, especially at the bottom of a silo, because the influence of compaction will further increase the moisture content in this area [20]. Silage quality is generally influenced by forage maturity, water content, material particle size, storage during ensiling, and additives [23].

Aroma

The following results were obtained in Table 4 based on observations regarding the aroma of silage. The results of the silage aroma quality assessment show that the average silage aroma scores in treatment 1, treatment 2, treatment 3, and treatment 4 are (4.9), (6.1), (7.1), and (5.4), respectively.

Table 4. Results of Corn Stover Silage Aroma Assessment Scores

Panelists	Corn Stover Silage		Corn Stover Silage + Gamal		Corn Stover Silage + Lamtoro		Corn Stover Silage + Indogofera	
	Aroma	Score	Aroma	Score	Aroma	Score	Aroma	Score
1	Sour	7	Sour	7	Sour	8	A Few Sour	6
2	A Few Sour	5	A Few Sour	4	Sour	7	Not Sour	3
3	A Few Sour	3	Sour	7	Sour	8	A Few Sour	6
4	A Few Sour	4	A Few Sour	6	Sour	7	A Few Sour	6
5	Not Sour	3	Sour	7	Sour	7	A Few Sour	6
6	A Few Sour	5	A Few Sour	6	Sour	7	A Few Sour	6
7	Sour	7	A Few Sour	6	A Few Sour	6	A Few Sour	5
Average	A Few Sour	4.9	A Few Sour	6.1	Sour	7.1	A Few Sour	5.4

In treatment 1, treatment 2, and treatment 4, the silage aroma was in the few sour aroma categories. Meanwhile, treatment 3 was in the sour aroma category. The smell of silage is closely related to pH. In this study, when harvested, the silage pH was in the range of 3.8-4, which shows that the silage is reasonably good quality. Apart from pH, the temperature of the silage at the time it is harvested determines the success of the silage made. The temperature of the silage produced from all treatments ranged between 27-28^{o}C, which categorized the silage as good quality because the harvest temperature was several degrees below the environmental temperature. The silage is successful if the harvest temperature is several degrees below the environmental temperature (5-10^{o}C) [24].

Good silage will have an acidic aroma resembling tape. This acidic condition allows the development of lactic acid bacteria to carry out the fermentation process. In acidic conditions, fungi cannot grow; only bacteria, especially acid-forming bacteria, are active. Thus, the sour aroma can be used as an indicator of the success of the silage process.

The silage water content is too low, which increases the silage temperature. A silage water content that is too high stimulates mold growth and triggers the development of butyric acid, which decreases the quality of the silage [26].

Well-fermented silages should not have a strong, particular odor because lactic acid, the primary organic acid from the fermentation, is nearly odorless. However, most silages tend to have a mild odor of vinegar (acetic acid) because this acid is produced in the second highest concentration after lactic acid and is very volatile. Smelling silages with very high concentrations of acetic acid will often leave a burning sensation in one's eyes and nose. Silages with a fruity, sweet odor are mistakenly associated with being a well-fermented, stable feed. These smells are generally due to high alcohol (ethanol) concentrations produced mainly by yeasts and many bacteria. Furthermore, the alcohols may react with acids in the silage, producing esters and adding to the fruity aroma. Some well-fermented, stable corn silages with no signs of fungal contamination or deterioration have been described to smell like nail polish or nail polish remover with acetone-like overtones [20].

Lactic acid bacteria stop growing when they run out of sugar for fermentation [26]. These bacteria preserve and ferment forage crops in inoculated silages, and the metabolites produced by LAB in silage directly affect silage fermentation quality. Furthermore, assessing the metabolites of ensiling systems can provide important information regarding the silage's nutritional value and fermentation quality and its impacts on animal health and welfare [27].

Competition between lactic acid bacteria and other microorganisms (Enterobacteriaceae: *Escherichia*, *Klebsiella*, and *Erwinia*: Clostridia spores, fungi, and mold) in the fermentation process causes poor silage quality [26]. Enterobacteria are principal competitors of LAB for available sugars during fermentation. The diurnally enriched enterobacteria may increase their competition with LAB, restrain LAB development, and further retard the fermentation [28].

Lactobacillus is the main bacteria in lactic acid fermentation during ensiling [29]. The low compaction and delayed sealing adversely impact silage quality [30].

CONCLUSIONS

The silage texture score for all treatments has an average similar value and falls into the medium texture category. Silage color scores in all treatments were of good quality, namely brown and yellowish brown. The aroma score in all treatments was good quality, with a few sour and sour.

ACKNOWLEDGEMENT

Thank you to the panelists for their contribution to carrying out organoleptic tests.

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