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Effects of Urea-Molasses, Maize Bran, and Ipil-ipil Leaf Meal on the Quality of Cogon Grass Silage at Different Harvesting Intervals

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Abstract

The study examines how varying harvesting intervals and processing methods affect the physicochemical and nutritional properties of Cogon grass (Imperata cylindrica Linn) silage. Its goal is to determine optimal practices for improving silage quality and nutritional value to support sustainable livestock feeding in tropical regions. A Completely Randomized Design (CRD) was used, with four treatments based on harvesting intervals (20, 25, 30, and 35 days) and three replications per treatment. Cogon grass silages were enhanced with 2.1% urea molasses, 5.12% maize bran, and 8.9% Ipil-ipil (Leucaena leucocephala) leaf meal to improve fermentation and nutrition. The 20-day interval (T1) had the highest dry matter (DM, 39.1%) and crude protein (CP, 9.25%), while the 35-day interval (T4) had the lowest (30.2% DM, 5.66% CP). Neutral detergent fiber (NDF) was highest in T1 (78.0%) and lowest in T3 (76.8%). Gross energy ranged from 4606 to 4832 cal/g, with no significant differences. Silage pH decreased with longer harvest intervals, with T4 recording the lowest pH (4.64), indicating better fermentation. Total soluble solids (TSS) were highest in T1 (0.80 °Brix) and lowest in T4 (0.12 °Brix). Sensory evaluations showed silages harvested at 20 and 25 days (T1 and T2) were most acceptable in color, odor, and moisture. Harvesting Cogon grass at 20–25 days and supplementing with urea molasses, maize bran, and Ipil-ipil leaf meal produced high-quality silage with enhanced nutrition and fermentation, offering a sustainable feeding strategy for tropical livestock.

Keywords*:* cogon grass, maize bran, harvesting intervals, Ipil-ipil leaf meal physicochemical analysis, urea molasses

1. Introduction

Silage fermentation is a complicated process that depends on pasture type, chemicals, and the environment (Ávila and Carvalho, 2020). Silage additives have long been studied for their ability to improve the nutritional content of silage while also reducing the dangers associated with the ensiling process (Henderson, 1993). These additives can improve fermentation, reduce nutrient losses, minimize aerobic deterioration during feed-out, improve silage hygiene, limit secondary fermentation, improve aerobic stability, and ultimately increase nutritive value, boosting animal productivity above and beyond the additive costs (Merensalmi and Virkki, 1991; Diogénes *et al*., 2023). McDonald *et al*. (1991) divided these additives into five categories: fermentation stimulants, inhibitors, aerobic deterioration inhibitors, nutrients, and absorbents, each of which plays a different function in silage production.

Despite advances in understanding silage fermentation, there remains a significant need for research, particularly on the effects of different harvesting intervals and additive combinations on the quality of Cogon grass (*Imperata cylindrica*) silage. This grass, though generally regarded as a weed, has the potential to provide feed for animals such as cattle, goats, carabaos, and sheep, particularly during droughts (Holm *et al*., 1977; Patiga *et al*., 2020). However, its low digestibility and protein content, and limited herbage production during dry seasons, pose challenges to animal nutrition and productivity (Yunus, 2000; Patiga *et al*., 2020).

Effective ensiling could significantly enhance the nutritional content and digestibility of Cogon grass, thereby increasing its utility as livestock feed. However, the effects of harvesting intervals and the application of targeted additives, such as maize bran and Ipil-ipil (*Leucaena leucocephala*) leaf meal, on the ensiling capacity of this grass still need to be explored. Given Cogon grass's limitations as cattle feed, this study aims to evaluate how harvesting intervals and processing methods, including the incorporation of maize bran and Ipil-ipil leaf meal, influence its ensiling potential.

2. Methodology

2.1 Treatments and Experimental Design

The study was conducted at Cebu Technological University-Barili Campus, Cebu, Philippines. Cogon grass was collected early morning from the pasture area in April 2023, specifically on the 20th, 25th, 30th, and 35th days following the last harvest. The Cogon grass was air-dried to achieve 60-75% dry matter (DM) and chopped into 2-3 cm lengths. Urea molasses, maize bran, and Ipil-ipil leaf meal were used as silage additives at 2.1% of the silage mass, with molasses added at five times the urea concentration (Patiga *et al*., 2020). The proportions of maize bran and Ipil-ipil leaf meal were determined based on their metabolizable energy (ME) and crude protein (CP) content to meet target silage quality. Using Pearson's Square Method, the additives were blended at 75% maize bran and 25% Ipil-ipil leaf meal to achieve approximately 10% CP. Consequently, maize bran and Ipil-ipil leaf meal were added at 1.575% and 0.525% of the silage mass, respectively. This combination ensured an optimal balance of energy and protein to enhance the silage's nutritional and fermentation properties.

The silage material was compacted, and air was withdrawn from the plastic silage bags, which were then stored at a room temperature of approximately 25-27 °C inside a plastic drum with a clamp lid. After 60 days of anaerobic fermentation, the bags were opened, and the silage samples were evaluated, dried, and ground for chemical analyses. The experiment followed a completely randomized design (CRD) with three replicates and a one-way analysis of variance (ANOVA) treatment design for the utilization of cogon grass as silage as shown in Table 1.

Table 1. Treatment design for the utilization of Cogon grass as silage

Treatments	Harvesting Intervals	Cogon Grass Silage Additives
T_1	20 days after last harvest	Urea molasses (2.1% of silage mass) + Maize bran (1.575% of silage mass) + Ipil-ipil leaf meal (ILM) (0.525% of silage mass)
T_2	25 days after last harvest	
T_3	30 days after last harvest	
T_4	35 days after last harvest	

2.2 Chemical Analysis

Conventional methods for nutrient evaluation of silage, including dry matter (DM), crude protein (CP), and energy, were conducted following the standard procedures of the Association of Official Analytical Chemists (AOAC, 2005). Neutral Detergent Fiber (NDF) was analyzed using the detergent extraction method (Van Soest, 1993). The DM, CP, and gross energy (GE, cal/g) were calculated using Equations 1, 3 and 5 respectively.

$$\%\ Dry\ Matter = 100 - \%\ Moisture\ Content \tag{1}$$

where the Moisture content is calculated using Equation 2.

$$\%\ Moisture\ Content = \frac{Fresh\ sample\ wt\ (g) - Dry\ sample\ wt\ (g)}{Fresh\ sample\ wt\ (g)} \ x\ 100 \tag{2}$$

$$\%\ Crude\ Protein = \%N\ x\ 6.25 \tag{3}$$

where the percent nitrogen (*%N*) is calculated using Equation 4.

$$\%N = \frac{(Amount\ of\ titrant - Blank\ titrant)(N\ of\ Std\ HCl)\ (\frac{14}{1000})}{Weight\ of\ sample\ (g)} \ x\ 100 \tag{4}$$

$$GE, cal/g = \frac{2374\ (\mathrm{Tf} - \mathrm{Ti}) - (length\ of\ unburned\ fused\ wire\ x\ 2.3) - amount\ of\ titrant}{Weight\ of\ sample\ (g)} \tag{5}$$

where:

T_f – is the final temperature, 15 minutes after ignition.

T_i – is the initial temperature, 15 minutes before ignition.

The neutral detergent fiber is calculated using Equation 6.

$$\%NDF = \frac{(weight\ of\ crucible + weight\ of\ residue) - weight\ of\ crucible}{weight\ of\ sample} \ \mathrm{x}\ 100 \tag{6}$$

2.3 Physico-chemical Characteristics

The pH of the silage was measured using a HANNA HI 2213 pH/ORP meter (Hanna Instruments, Romania) or a Milwaukee digital pH meter with a glass electrode (Milwaukee Instruments, USA). Titratable Acidity (TA) was calculated as a percentage of lactic acid using Equation 7:

$$\% \text{ Lactic acid} = \frac{(N\ of\ NaOH)(amount\ of\ titrant)\ (\frac{90}{1000})}{5} \times 100 \quad (7)$$

Total soluble solids (TSS) measurement was obtained using an ATAGO digital pocket refractometer (PAL-1, ATAGO Co. Ltd., Japan) with a 0-80% Brix capacity.

2.4 Sensory Evaluation

Sensory evaluation was conducted by twenty (20) experienced and trained panelists. A 1–7 point Hedonic scale was used, where 7 indicated "like extremely" and 1 indicated "dislike extremely," combined with descriptive scoring. The evaluated attributes included color, odor, texture/moisture, and general acceptability, following the methodology of Greub and Cosgrove (2006) (Table 2).

Table 2. Scoring scale for the sensory attributes of Ensiled Cogon Grass

Color	Odor	Moisture	General Acceptability
6 – olive to slightly yellowish-green 5 – yellowish-green to slightly brownish 4 – light tan 3 – deep brown/ black 2 – whitish gray 1 – pink caused by severe mold development	7 – very light, barely perceptible pleasant alcohol 6 – very definite, pleasant acetic acid 5 – slight alcohol odor 4 – definite fruity, yeasty 3 – slight burnt odor 2 – strong sour putrid 1 – ammonia/foul odor	5 - No free or very light 4 – slightly too dry but no heat damage or mold 3 – excess water can be squeezed out 2 – excessively dry 1 – slimy or soggy	7 – extremely like 6 – moderately like 5 – slightly like 4 – neither like nor dislike 3 – slightly dislike 2 – moderately dislike 1 – extremely dislike

2.5 Analysis of Data

Data gathered were analyzed using one-way analysis of variance (ANOVA) for nutrient composition, and treatment means were compared using Tukey's Honestly Significant Difference (HSD) test with the Statistical Tool for Agricultural Research (STAR) version 2.0.1. Sensory attribute analysis was performed using Statistix version 10.0, where judges or panelists were considered as blocks.

3. Results and Discussion

3.1 Chemical Composition of the Silages

Table 3 shows the chemical composition of Cogon grass silages as influenced by harvesting intervals. The dry matter (DM) levels for silages harvested at 20 days (T_1) and 25 days (T_2), both treated with urea molasses, maize bran, and Ipil-ipil leaf meal (*ILM*), ranged from 36.7% to 39.1%, slightly surpassing the ideal silage DM content. This increase in DM is due to the high dry matter content of urea and molasses, improving the overall silage preservation. Nursoy *et al*. (2003) and Murat *et al*. (2003) found that urea, particularly when combined with molasses, increases silage DM levels by enhancing fermentation and minimizing nutrient losses during storage. T_1 had the highest crude protein (*CP*) level, followed by T_2, T_3, and T_4. Notably, there were no significant differences in gross energy (*GE*) between treatments despite considerable variations in neutral detergent fiber (NDF). The significant increase in CP in T_1 is associated with increased CP levels in Cogon grass (5.5%CP), and ILM (35.4% CP) found 25 days after cutting (Table 3). It is necessary to incorporate both urea and ILM; urea provides non-protein nitrogen (NPN), while ILM provides true protein. This combination enhances CP content and promotes microbial protein synthesis during fermentation, improving the nutritional quality of the silage (Nguyen *et al*., 2009).

Maize bran improves the nutritional profile by providing carbohydrates that promote microbial development during fermentation, thereby improving digestibility and overall silage quality (Sultana *et al*., 2016). The highly fermentable carbohydrates in maize bran, urea, and ILM create a suitable environment for beneficial microorganisms.

In contrast, Nasrullah *et al*. (2002) found a decline in CP content in silages harvested at longer intervals, such as T_4, when the CP level decreased to 4.13%. This drop is attributable to the maturation of Cogon grass, which often results in reduced nutritional quality. Recent studies on tropical grass silages highlight the critical roles of urea, molasses, ILM, and maize bran in increasing fermentation efficiency and protein content, emphasizing their importance in optimizing silage quality for sustainable livestock production (Mäna *et al*., 2023; Islam *et al*., 2023). These studies show that using such additives can significantly increase the nutritional content of silages, resulting in better cattle health and productivity.

Table 3. Chemical compositions of different ages of Cogon grass as silages and chemical analysis result

Treatment	% DM	% CP	GE (cal/g)	% NDF
T_1	39.1[a]	9.25[a]	4832	78.0[a]
T_2	36.7[b]	8.98[b]	4727	77.2[b]
T_3	33.2[c]	4.94[cd]	4308	76.8[bc]
T_4	30.2[cd]	5.66[c]	4606	77.4[d]
p - value	0.003***	0.0476***	0.7999[ns]	0.005***
Chemical Analysis Result				
	% DM	% Crude Protein	% GE	% NDF
Ipil-ipil Leaf Meal	89.10	35.4	2500	40.1
Maize Bran	90.02	9.98	3200	15.0
Cogon Grass	30.15	5.5	2200	75.97

Means within column with dissimilar letter superscripts are significantly different (p<0.05)

3.2 Physico-chemical Characteristics of the Silages

As shown in Tables 4 and 5, the physicochemical parameters of Cogon grass-based silages revealed substantial differences across treatments for pH, total soluble solids (TSS), and titratable acidity (TA). Changes in silage pH before and after ensiling of grass-based silages were found to differ significantly between the two treatments (T_3 and T_4); however, pH values of T_1 and T_2 are comparable. This indicates that the high pH values brought about by adding urea molasses could be due to the ammonia (NH_3) from urea and the subsequent formation of ammonium compounds, which partially neutralize organic acids formed during ensiling (Henning *et al.*, 1990). Additionally, according to Patiga *et al*. (2020), the age of Cogon grass could also influence the environment's acidity. This suggests that the maturity of Cogon grass has a significant impact on anaerobic fermentation and, as a result, may disrupt the fermentation process.

The low pH for silage material was found in T_3 and T_4, which were harvested 30 and 35 days after the last cutting, respectively. This suggests that the maturity of Cogon grass may be a factor, and that a longer anaerobic fermentation period is required to develop organic acids. Similarly, tropical grasses and legumes, as stated by Woolford (1984), have low water-soluble carbohydrate levels, which are essential for successful ensilage. As a result, they possess a higher buffering capacity, and their proteins are more susceptible to proteolysis. However, Titterton *et al*. (1998) emphasized the importance of mixing legumes with cereal crops, wilting, silage additives, and small-scale silos in enhancing the quantities of fermentable carbohydrates, reducing buffering, preventing proteolysis, and creating silage of superior quality.

Table 4. Physico-chemical characteristics of different ages of Cogon Grass as silages

Treatment	pH	TSS (^{0}Brix)	TA (% lactic acid)
T_1	8.80^a	0.80^a	0.038^a
T_2	8.57^b	0.47^b	0.020^b
T_3	5.46^{bc}	0.23^c	0.011^c
T_4	4.64^c	0.17^{cd}	0.09^{cd}
p – value	*0.010****	*0.005****	*0.02***

Means within column with dissimilar letter superscripts are significantly different (p<0.05)

Table 5. Physico-chemical characteristics of different ages of Cogon grass with additives before and after ensiling

	Before ensiling			After ensiling		
Treatments	pH	TA (% lactic acid)	TSS (^{0}Brix)	pH	TA (% lactic acid)	TSS (^{0}Brix)
T_1	5.55^a	0.028^a	1.10^b	8.80^a	0.025^a	0.80^a
T_2	5.41^c	0.020^b	1.20^a	8.57^b	0.016^b	0.47^b
T_3	5.45^b	0.016^c	0.40^d	6.64^d	0.014^c	0.18^c
T_4	5.46^b	0.015^{bc}	0.50^c	6.46^c	0.010^{cd}	0.12^d
p – value	*0.037*	*0.025*	*0.047*	*0.012*	*0.010*	*0.051*

Means within column with dissimilar letter superscripts are significantly different (p < 0.05).

Table 5 illustrates the difference in TSS of grass-based silages before and after ensiling, showing that TSS reduced after ensiling, indicating the breakdown and utilization of soluble solids for microbial growth, with T_1 showing a very significant result (p-value < 0.001). According to Hill and Leaver (1999), ensiling with urea at levels exceeding 1% of the overall mixture decreases the conversion of certain carbohydrates to lactic acid. Since acidic conditions are essential for the stability of stored silage, the alkaline nature of urea results in higher pH conditions, decreasing the conversion of soluble solids.

Table 5 shows the titratable acidity (*TA*) change of grass-based silages before and after ensiling. It demonstrates that the *TA* values of Cogon grass decreased after ensiling compared to the original material. A significant difference in *TA* (before and after ensiling) was observed in the grass-based silages, with notable modifications occurring during the ensiling process. The addition of urea molasses was found to increase lactic acid production, and it was also noted that the incorporation of maize bran and Ipil-ipil leaf meal, along with harvesting Cogon grass 20 days after the last cutting, influenced the higher levels of lactic acid production. This observation aligns with the findings of Neelkantan and Singh (1976), who reported that comparatively high levels of lactic acid production were present under similar conditions.

3.3 Sensory Qualities of the Grass Silages

Table 6 shows Cogon grass silage's mean sensory descriptors and sensory acceptability scores, evaluating sensory qualities such as color, odor, moisture, and overall acceptability. The color of the grass silages was described as "light tan". The color acceptability scores for the grass silages ranged from 4.30 to 5.70, placing them in the "slightly like" to "neither like nor dislike" category. Only T_1 and T_2 were described as "slightly like" by the panelists.

There were substantial changes in the odor of cogon grass-based silage (Table 6). The odor of the silages ranged from "definite fruity, yeasty" to "slight alcohol odor." The odor acceptability score ranged from 4.13 to 5.38, indicating "moderately dislike" to "moderately like." The respondents rated cogon grass as "neither liked nor disliked" at 30 (T_3) and 35 (T_4) days after the last harvest. According to Olorunnismo and Ososanya (2015), ammonia synthesis in ensiled forages supplemented with a specific level of urea results in a relatively pleasant odor and coloring in the silage.

The moisture content of cogon grass-based silage samples ranged from "slimy or soggy" to "no free water can be squeezed out" (Table 6). The moisture acceptance score for the silage product ranged from 5.58 to 6.50, falling into the "no free or very light" categories. T_1 and T_2 were the treatments that the panelists liked the least.

Table 6 shows the mean converted rankings of the various sensory acceptability scores, demonstrating no significant differences. The general acceptance scores of the grass-based silages ranged from 4.20 to 5.48, indicating "neither like nor dislike" to "slightly like." The results showed that the 20- and 25-day cogon grass with maize bran + Ipil-ipil leaf meal was the most desirable silage based on the 4.20 to 4.83 mean of acceptability score. This suggests that the age of the cogon grass could affect silage quality. According to Patiga *et al.* (2020a) (2020b), to capitalize on the use of grasses, they should be harvested early.

Table 6. Sensory evaluation results of different ages of Cogon grass as silages

Treatments	Color	Description	Odor	Description	Moisture	Description	General Acceptability	Description
T_1	5.70	yellowish-green to slightly brownish	5.38	slight alcohol odor	6.50	No free or very light	5.48	slightly like
T_2	5.63	yellowish-green to slightly brownish	5.35	slight alcohol odor	6.45	No free or very light	5.35	slightly like
T_3	4.90	light tan	5.20	slight alcohol odor	5.95	No free or very light	4.20	neither like nor dislike
T_4	4.30	light tan	4.13	definite fruity, yeasty	5.58	No free or very light	4.83	neither like nor dislike
p – value	*0.07*		*0.07*		*0.07*		*0.07*	

Means within column with dissimilar letter superscripts are significantly different ($p<0.05$).

4. Conclusion and Recommendation

This study shows that harvesting cogon grass every 20 to 25 days by adding 2.1% urea molasses, 5.12% maize bran, and 8.9% Ipil-ipil leaf meal significantly enhances silage quality. The 20-day interval, in particular, yields the highest dry matter (39.1%) and crude protein (9.25%), along with optimal fermentation conditions.

For best results, producers should adopt a 20-day harvesting schedule. Future research should examine different supplement levels, monitor fermentation regularly, and explore the long-term impacts on livestock health and productivity.

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