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Original Article

Comparison of Chemical Composition and Quality of Maize, Sorghum and Hybrid Napier Grass CO-3 Silages Using Bag or Bucket Silos

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ABSTRACT

This study investigated the effect of bag and bucket silos on the chemical composition and quality characteristics of silage made from maize, sorghum, and Coimbatore-3 (CO-3) grass cultivated in the eastern province of Sri Lanka. Each fodder was harvested at 50% of the flowering stage, chopped, and ensiled into the aforementioned silo types. After 30 days, sensory parameters, chemical, and fermentation characteristics of silage such as pH, lactic acid (LA), dry matter content (DM), ash, crude protein (CP), crude fiber (CF) ether extract (EE), water-soluble carbohydrate (WSC), and ammonia nitrogen (NH_3-N) were measured. The results revealed that the texture of sorghum and maize was better than CO-3 grass and all silages were free from molds. Silo type had a non-significant (p<0.05) effect on the color and texture of the silage of three forage cultivars. The bag silo had the better sensory characteristic compared with the bucket silo for each fodder. The DM and the CF content of silage were significantly (P< 0.05) higher in the bag silo. The lowest LA and the highest pH content were observed in CO-3 silage compared to sorghum and maize in both silos. The highest WSC% of maize (4.86%, 3.67%), sorghum (4.29%, 3.18%), and CO-3 (2.22%, 2.21%) silages were observed in bag silo followed by bucket silo respectively. The present research revealed that both physical and chemical properties of silages made out of bag silo were better in quality than bucket silo and the silage produced from the bag recommended feeding ruminants as it contains a higher livestock nutritional value.

Introduction

The world livestock production system has a poor productivity rate due to low-quality forage and seasonality. The livestocks' inability to provide adequate output during times of forage scarcity exemplifies problems in the production of livestock products throughout the year. The high output of livestock depends on the availability of sufficient quantities of quality forage and, in developing countries, the inadequacy of quality forage is a crucial constraint of productive livestock production. In Sri Lanka, the growth of the livestock sector is hampered by a range of constraints. The lack of supply of quality feedstuff can be a significant aspect (Houwers et al., 2015). While grazing is the cheapest animal rearing method in Sri Lanka, it may not inherently be the most profitable. Seasonal deficiencies in the quantity and quality of feed available for grazing limits production in most regions (Tamang, 2015). Forage conservation can fill the feed gaps by transferring high-quality forage feed from periods of surplus to time of deficit (Sahoo, 2018). Ensiling is the ideal forage conservation method to overcome this problem. In general, silage is characterized as more quality feed than hay because less time is needed to wilt the forage, causing a small reduction in the feed nutritive value (Ramos et al., 2016).

In practice, various types of silos are used for silage processing, such as pit, bunker, pile, trench silo, tower, and plastic bag systems. (Rafiuddin et al., 2017). A key feature of silage bags is that it allows the conservation of obtainable fodder in small quantities, over an extended period. Bags are very much convenient for filling, packing, sealing, handling, and feeding out (Batra et al., 2016; Reiber et al., 2009). Most of the farmers

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cultivate sorghum, maize, hybrid Napier grass (*Pennisetumpurpureum* x *Pennisetumamericanum*) CO-3, and CO-4 as forage crops in Sri Lanka. Maize is the second-largest coarse grain for which approximately 30,000 hectares of land are devoted annually in Sri Lanka. Maize silage has consistently high feed value, high energy content is extremely palatable, and is environmentally sustainable (Densley et al., 2011). Furthermore, maize silage can effectively recycle plant nutrients, in particular large quantities of nitrogen and potassium (Bean, 2012).

Sorghum is cultivated as an important crop in the dry and intermediate zone of the country during the Maha and Yala season. It is a strong alternative to maize because its phenotypic properties promote planting, handling, processing, and are more suited to drought and low soil fertility (Borba et al., 2012). The other significant characteristic of sorghum is that it will regrowth after each harvesting (Perazzo et al., 2014). Further sorghum cultivars are commonly recommended for high-quality silage production because of a high proportion of dry matter and grain yield. Hybrid Napier CO-3 variety was developed by researchers at the Tamil Nadu Agricultural University (TNAU) and introduced to Sri Lanka in 1999. It is superior to other types of Napier. CO-3 fodder grass has a potential for high yield, high content of dry matter, and crude protein. Furthermore, it has profuse tillering, fast regeneration capability, less pest and disease in adverse conditions, high leaf to stem ratio, and high palatability (Premaratne and Premalal. 2006).

In Sri Lanka, silage production is becoming common and different types of the silo are practiced by both smallholder farmers and commercial level with an increase in farm production and profitability. However, there are limited studies assessing the impact of silo forms on silage characteristics. Therefore, the aim of the current research was to analyze the characteristics of silo types (bag and bucket) on the chemical properties, fermentation, and sensory characteristics of silages produced from maize, sorghum, and CO-3 grass.

Materials and Methods

The experiment was performed at a farmer's field in the Ampara district in Sri Lanka (7.2944° N, 81.8607° E) from January 2019 to June 2019. To prepare bag and bucket silos already established CO-3, fodder maize, and fodder sorghum cultivars were selected from the farm. Fodder sorghum was harvested at its flowering stage while maize was taken at its milky stage and CO-3 grass was harvested at the age of 45 days after planting and the forages were cut uniformly to a height of 10 cm from ground level. Harvested forage was chopped into small pieces (3 cm in length) by using a forage chopper (FOB GC - 4C). The black polythene bags to hold 5 kg silo was made by using a baler machine (FOB HQ850) and they were wrapped with special polyethylene (Stretch Films) by a bale wrapper machine (FOB RXHW - 0810). Nine bag silos were prepared from each maize, CO-3, and sorghum fodders. All the bags were numbered and placed under the shed for fermentation at room temperature (around 30°C). To prepare the bucket silos of fodder were harvested from each maize, sorghum, and CO-3 respectively on a day-to-day basis. Each harvested forage sample was chopped into small pieces (3 cm in length) using a forage chopper (FOB GC - 4C) and utilized to make 27 sets of bucket silo.

Sensory analysis

Silos were opened after 30 days of the fermentation period and samples were taken for chemical composition and quality examination. Three subject matter experts were carried out for physical examination such as odor, color, and structure. The silage quality was determined by the score of the DLG (Deutsche Landwirtschafts-Gesellschaft). The total quality score obtained from the sum of odor, structure, and color scores is the DLG score (0-20 points) (Ergün et al*.,* 2013).

The grading was carried out by the same person allowed for quality analysis of the silages for odor, color, and structure to prevent personal bias. Equation 1 was applied to calculate the Flieg score (FS) according to Kilic (1986), where FS score of 81-100 regarded as very good, 61-80 as good, 41-60 as a medium, 21-40 as low, and 0-20 as poor quality silage. Moreover, based on the individual scores obtained for smell, color, and structure of FS were applied to calculate the cumulative FS and ranked as poor, medium, good, and very good.

$$FS = [220 + (2 \times \text{silage DM ratio} - 15)] - 40 \times \text{silage pH value} \quad [1]$$

Chemical analysis

In order to determine pH, lactic acid (LA), dry matter content (DM), ash, crude protein (CP), crude fiber (CF), ether extract (EE), water-soluble carbohydrate (WSC), and ammonia nitrogen (NH_3-N), chemical analysis was conducted for the three different forage silage. The finely ground samples of maize, sorghum, and CO-3 silage were analyzed for DM, ash, CP, CF, and EE under the procedure of AOAC (2005). Around 25 g of each silage was taken immediately after the opening of the silo. The 100 ml of distilled water was used to overflow the sample silage. The diluted content was then drained by a cheese tube after 10 min with a blender, and an automated pH meter was used to measure the pH. The collected liquid was further filtered using Whatman 54 filter paper and stored a 20 °C using a spectrophotometer 1000 series for analyzing lactic acid and soluble carbohydrates (24). Approximately 250g of sample was also taken from each silo dried at 60°C for 72 hours for DM% in a hot-air oven.

Statistical analysis

The data were evaluated by measurements of variance, using the SAS procedure of General Linear Model SAS (SAS 9.1.3), and the Fisher's least significant difference test was used to compare the differences of means among main effects, which were considered to be significant when P<0.05.

Results

The effect of the silo type on sensory properties such as color, structure, odor, and FS has been shown in Table 1. The silo type had a non-significant influence on the silage color and structure of the three forage species. However, the score for the odor for maize and CO-3 indicated a significant value (P < 0.05) among the silo type. Collectively maize and sorghum showed "Good" quality class with a high DLG score compared with CO-3 silage in both bucket and bag silo. One of the most relevant metrics used to determine the consistency of silage is the FS, which is calculated on the basis of the regression equation between the DM and the pH of the silage. Flieg Score for maize (108.78 and 125.00), sorghum (94.04 and 120.20), and CO-3 silages (71.78 and 63.14) were presented in Table 1. Numerically higher FS was observed in maize silage in both bag and bucket silo. When the appropriate pH and DM ratio in the silage is ensured, the FS is high. All three forage silages were free from mold and both maize and sorghum silage had a better sensory appearance compared with CO-3 (Table 1). Therefore, the results indicate that the maize and sorghum silages possess better features for ideal silage production from both silos and the bag silo exhibited high-quality characteristics than the bucket silo for the three forages.

Table I. Effects of silo types on the quality characteristic of three different forage silages.

		Silo types	
Silages	**Parameters**	**Bucket Silo**	**Bag Silo**
Maize	Color	1.62	1.65
	Structure	3.52	3.6
	Odor	11.05^{b}	11.85^{a}
	DLG Score	16.19^{b}	17.10^{a}
	Quality class	Good	Good
	Flieg score	108.78^{b}	125.00^{a}
Sorghum	Color	1.59	1.43
	Structure	3.24	3.3
	Odor	10.23	10.59
	DLG Score	15.06	15.32
	Quality class	Good	Good
	Flieg score	94.04^{b}	120.20^{a}
CO-3	Color	1.1	1.23
	Structure	3.12	3.05
	Odor	7.26^{b}	8.12^{a}
	DLG Score	11.48^{b}	12.4^{a}
	Quality class	Medium	Medium
	Flieg score	71.78^{a}	63.14^{b}

a,b Values within the same row with different numerical superscripts differ significantly (P<0.05).

The proximate characteristic of each silage such as DM, ash, CP, CF, and EE was showed in Table 2. Silo types significantly (P<0.05) affected the DM and CF of three ensiled forages. The highest CF was observed in bag silo than bucket silo for maize (31.77 and 30.19), sorghum (35.39 and 34.03), and CO-3 (33.86 and 32.93) silages, respectively. Conversely, the silo type had no significant impact on ash, CP, and EE concentration in all three types of silages. For the proximate values, bag silo had a greater impact on sorghum silage. All of the proximate parameters of sorghum silage were not significantly higher in the bag silo than in the bucket silo (Table 2).

The silo type significantly (P < 0.05) effect on pH of the ensiled maize, sorghum, and CO-3 forages. A higher pH value was observed in bucket silo than bag silo for maize (3.97 ± 0.32 3.66 ± 0.04) and sorghum (4.04 ± 0.32 and 3.57 ± 0.02) silages, respectively. The pH of CO-3 silage from the bucket was around 4.32 which was good enough for tropical grass silage, whereas the representation value of 4.59 in bag silo was very high due to the low dry matter content of CO-3 at the time of ensiling. Significantly the lowest LA content was found in CO-3 silage relative to maize and sorghum silage in both bucket and bag silos (Table 3). The results showed that silo type had a significant effect on WSC percent of maize and sorghum silage. The WSC percent of maize (3.67 ± 0.23 and 4.86 ± 0.05) and sorghum (3.18 ± 0.23 and 4.29 ± 0.04) corresponding to bucket and bag silos. The same pattern was observed for the N-NH3 (%) in the maize and sorghum silage in buckets and bag silos.

Table 2. Effects of silo types on proximate composition of three different forage silages

Silo types			
Silages	**Parameters**	**Bucket Silo**	**Bag Silo**
Maize	Dry Matter (%)	31.29± 1.90[1b]	33.20± 0.72[a]
	Ash (%)	10.16 ±0.92	9.42 ±0.22
	Crude Fiber (%)	30.19 ±0.53[b]	31.77± 0.40[a]
	Crude Protein (%)	9.14 ± 0.37	9.25 ± 0.09
	Ether Extract (%)	4.06 ± 0.18	3.64 ± 0.18
Sorghum	Dry Matter (%)	25.32± 1.58[b]	29.00± 0.66[a]
	Ash (%)	10.72 ±0.45	10.81 ±0.06
	Crude Fiber (%)	34.03 ±0.66	35.39 ±0.31
	Crude Protein (%)	10.41 ±0.72	10.54 ±0.39
	Ether Extract (%)	5.60 ± 0.35	5.31 ± 0.08
CO-3	Dry Matter (%)	19.79 ± 1.57[b]	20.87 ± 0.64[a]
	Ash (%)	13.31 ±0.99	14.76 ± 0.13
	Crude Fiber (%)	32.93 ±0.84[b]	33.86 ± 0.47[a]
	Crude Protein (%)	14.84 ±0.49	14.58 ± 0.35
	Ether Extract (%)	6.24 ±0.35	6.44± 0.18

a,b,c Values within the same row with different numerical superscripts differ significantly (P<0.05).
The values are expressed as Mean ± SE.

Table 3. Effects of silo types on fermentation characteristics of three different forage silages

		Silo types	
Silages	**Parameters**	**Bucket Silo**	**Bag Silo**
Maize	pH	3.97 ± 0.32[1a]	3.66 ± 0.04[b]
	LA (%)	8.46 ± 0.50[b]	9.93 ± 0.13[a]
	WSC (%)	3.67 ± 0.23[b]	4.86 ± 0.05[a]
	$N\text{-}NH_3$ (%)	2.18 ± 0.16[a]	1.13 ± 0.74[b]
Sorghum	pH	4.04 ± 0.32[a]	3.57 ± 0.02[b]
	LA (%)	7.64 ± 0.34[b]	9.28 ± 0.09[a]
	WSC (%)	3.18 ± 0.23[b]	4.29 ± 0.04[a]
	$N\text{-}NH_3$ (%)	2.55 ± 0.10[a]	1.82 ± 0.55[b]
CO-3	pH	4.32 ± 0.66[b]	4.59 ± 0.10[a]
	LA (%)	3.11 ± 0.30[a]	1.99 ± 0.10[b]
	WSC (%)	2.21 ± 0.26	2.22 ± 0.26
	$N\text{-}NH_3$ (%)	8.69 ± 0.96[b]	10.04 ± 0.18[a]

a,b,c Values within the same row with different numerical superscripts differ significantly (P<0.05).
The values are expressed as Mean ± SE.

Discussion

The effects of different silo types on sensory characteristics and chemical composition of different forage were compared by several findings of previous studies (Batra et al.,2016, Bean. 2012). In this study overall, FS was higher in bag silo compare to the bucket silo for the maize and sorghum silage were in line with Rafiuddin, (2016), who reported the effect of the flowering stage on nutritive value, physical quality, and digestibility of silages made from cereal fodders.

In this study, DM content was higher in bucket silos than bag silos for all three fodder silages. Ensile at proper forage moisture levels and keep a good, workable space between the buckets could be the reason for a higher DM value in bucket silos. Przyby et al. (2018) found that the film-wrapped bales of maize straw silage had the lowest dry matter quality, which is in line with the findings of this research. It is difficult to condense a substrate with a high content of dry matter. As a result, adverse aerobic conditions develop, leading to overheating and the growth of molds and fungi. The CP, CF values of sorghum and maize reported by Heuzé et al. (2017), are in accordance with the results obtained from the present study.

According to Zaklouta et al. (2011) and Amorim et al. (2020), pH values 4.2 or below are considered acceptable for well-preserved silages, as plant proteolytic enzymes, enterobacteria, and clostridium are limited in this range.

As a result, maize and sorghum silages, which showed little variation in both bag and bucket silos, are also within the recommended range. The variation in pH occurred due to the initial WSC% during ensiling as Amer et al. (2012) revealed, maize and sorghum contain more carbohydrates compared to CO-3. Therefore, the result indicated that the quality of CO-3 silage was poor compared to the other two types of silages. In this study, bag silos of maize and sorghum silages had lower pH levels than bucket silos.

According to Panditharatne et al. (1986), the LA content of well-preserved tropical silage can be between 3-13% on a dry matter basis. Therefore, maize and sorghum silages have the ability to be ideal for making silage compared to CO-3silage from both bucket and bag silos. This might be due to the high amount of CP in CO-3 silage relative to sorghum and maize silage. Zaklouta et al. (2011) reported that good quality silage is characterized by 5% of CP, probably or below of ammonia nitrogen content, which is similar to the data obtained for maize and sorghum silage in both bucket and bag silos of the present study. The fermentation characteristics of maize and sorghum were better than CO-3. Whether the silage was made in a bucket or a bag, the dry matter content and WSC percent of the forage at the time of ensiling played a big role in the fermentation.

Conclusion

For maize and sorghum forages, a bag silo produces a more effective yield in terms of physical and chemical characteristics than a bucket silo, and it is best to have maize or sorghum ensiled using the bag silo for animal feeding. Ultimately the present study recommends that bag silo is more consistent with ambient temperature, thereby improving the silage quality.

Conflict of interests

The authors have declared that no competing interests exist.

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