Ensiling Property and Nutritional Quality of Palmyrah (*Borassus flabellifer*) Leaves Incorporated Corn (*Zea mays*) or Sorghum (*Sorghum bicolor* (L.) moench) Silage

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ABSTRACT: *A laboratory experiment was designed to examine the effects of inclusion of palmyrah (Borassus flabellifer) leaves on the ensiling and nutritional quality of silage prepared with forage sorghum (Sorghum bicolor (L.) moench) or corn (Zea mays). Corn and sorghum were replaced with different proportions of palmyrah leaves (viz. 0%, 10%, 20%, 30% (w/w)) in fresh matter basis in preparing eight treatments for the experiment where silage prepared with only corn or sorghum were considered as controls (viz. 0% palmyrah leaves). Silage was packed air tightly in laboratory silos and kept for four weeks in a temperature controlled room at 30 °C. Chemical composition and ensiling parameters were determined using standard procedures. Dry matter, crude fiber, pH and water soluble carbohydrate contents of the silage increased with the increase of palmyrah leaves, but ash and lactic acid contents decreased. Further, the increase of palmyrah leaves increased ($p < 0.05$) the crude protein content of corn silages but decreased ($p < 0.05$) the crude protein content of sorghum silages. The results revealed that the treatment of 10% replacement with palmyrah leaves was acceptable when the chemical composition and ensiling parameters of silage were considered. Therefore, a mixture of 10% palmyrah leaves with corn or sorghum is recommended for making quality silages.*

Keywords: *Ensiling characters, nutritional quality, palmyrah leaves, silage*

INTRODUCTION

The development of the livestock sector in Sri Lanka is hindered by many constraints, where the unavailability of quality feed is a major factor. Natural pasture and crop residues, which are low in quality and quantity are the main feed resources for ruminants in Sri Lanka (Ibrahim *et al*., 1999). Natural forage production follows the seasonal rainfall pattern of the Island (Houwers *et al*., 2015). Therefore, the use of available feed resources in combination with the adoption of new feeding techniques is one strategy to overcome forage shortage for ruminants.

By virtue of the extensive rooting system, palmyrahs are able to withstand severe drought conditions while providing quality green fodder during dry periods in the Northern and Eastern parts of Sri Lanka. The mature leaf (lamina) of palmyrah (*Borassus flabellifer*) is a

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potential forage for ruminants, especially in areas where there is a scarcity of grass and other leafy materials (Theivendirarajah, 2008). However, sole diet of palmyrah leaves may be rejected by ruminants due to coarse texture. Feeding value of palmyrah leaves may be enhanced by mixing them with improved forages available in the region. Further, growing and ensiling whole crop corn or sorghum hybrids are widely used during the dry season or for supplementation in addition to grazing in Sri Lanka (Houwers *et al*., 2015). A considerable amount of research has been done to study the quality of corn *(Zea mays)* and sorghum *(Sorghum bicolor (L.) moench)* silages (Jabbari *et al*., 2011;Heuze *et al*., 2017). However, information on the ensiling characteristics of corn or sorghum with palmyrah leaves is lacking. Therefore, a laboratory experiment was conducted to examine the effects of adding palmyrah leaves in different proportions to forage sorghum or corn on the ensiling and nutritional quality of silages.

MATERIALS AND METHODS

Preparation of palmyrah leaves added silages

The materials used in this study were obtained from an ongoing field experiment in a farmer's field, in the Thavasikulam village (8.74158 ^{0}N latitude, 80.47671 °E longitudes; 104 meters elevation), 5 km South West of Vavuniya town in Sri Lanka. Fodder corn (variety Pacific 984) and fodder sorghum (variety Sugargraze) were used in the study. The crops were harvested at 10th week after planting. Mature fresh, green leaves (i.e. a single lamina weighing about 2 kg) of palmyrah were obtained from the black skin fruit variety. Chopped corn and sorghum were ensiled replacing 0%, 10%, 20%, and 30% of corn or sorghum by palmyrah leaves on wet weight basis as shown in Table 1. There were eight treatments among which silages without palmyarh leaves were considered as controls (i.e. 100% corn or 100% sorghum).

Table 1. Composition of silage in different treatments

Treatment / Ingredient (%)	T1	T2	T3	T4	T5	T6	T7	T8
Corn	100	90	80	70	_	_	_	_
Sorghum	_	_	_	_	100	90	80	70
Palmyrah	0	10	20	30	0	10	20	30

The materials were firmly packed into double-lined polyethylene bags and the open end was vacuum sealed using a vacuum pump (single-stage 5 Pa rotary vane economy Vacuum Pump). The weight of each laboratory bag silo was about 1 kg. The experimental design was Complete Randomized Design (CRD) with 5 replicates for each treatment. Laboratory silos were stored in a temperature controlled room at 30°C until opened after 4 weeks for chemical analysis.

Laboratory analysis of silages

The representative samples from each of the pre-ensiled and ensiled materials were dried in an oven at 60 °C until a constant weight was reached. The samples were then ground to pass through 1 mm sieve using a laboratory grinder (Waring® laboratory blender). The samples were analysed for dry matter (DM), ash, ether extract (EE) and crude fiber (CF) contents according to the corresponding AOAC methods (AOAC, 2005).

Water extracts were prepared by homogenising 10 g of the ensiled mixtures in 100 ml of distilled water in the laboratory grinder for 2 minutes. The homogenate was filtered through filter paper and the pH of filtrate was immediately measured using a compact pH meter (model B-212; Horiba, Kyoto). The water extracts of silage were analysed for water soluble carbohydrates (WSC) (Thomas, 1977) and lactic acid (LA) using a colorimetric method developed by Barker and Summerson (1941) and modified by Taylor (1996). Ammonia nitrogen concentration was measured in the supernatant using a phenol-hypochlorite reaction (Weatherburn, 1967).

Statistical analyses

The data were subjected to Analysis of Variance Procedures (ANOVA) using Statistical Analysis Software version 9.1.3 (SAS, 2009). Mean comparisons were done using Duncan's multiple range test (DMRT). Simple linear regression analysis was done to quantify the relationship between the percentage of palmyarh leaves and CP content of ensiled materials (Snedcor and Cochran, 1994).

RESULTS AND DISCUSSION

Proximate compositions of pre-ensiled materials

The proximate composition of pre-ensiled forages is given in Table 2. The CP content of sorghum was two times higher than that of corn. The CF content of all fodder species was above 35%. The proximate composition of corn and sorghum are in agreement with other workers (Chaudhary *et al*., 2012; Heuze *et al*., 2016; Sarmini and Premaratne, 2017). The DM, CP and ash contents of palmyrah leaves found in the present study were in agreement with the report of Mohanajeyaluxmi (1986) and Perera (1992).

Table 2. Proximate composition of the corn, sorghum and palmyrah leaves at the time of ensiling†,††

Crops	DM%	CP%	CF%	EE%	Ash%	NFE%
Corn	$32.7^{b} \pm 0.01$	$7.35^{a} \pm 0.09$	$35.2^{c} \pm 0.60$	$2.45^{c} \pm 0.01$	$1\ 0.7^{a} \pm 0.18$	$44.4^{a} \pm 0.94$
Sorghum	$15.6^{c} \pm 0.02$	$14.4^{c} \pm 0.01$	$38.3^{b} \pm 0.15$	$3.74^{b} \pm 0.05$	$11.8^{a} \pm 0.02$	$31.9^{b} \pm 0.89$
Palmyrah	$46.5^{a} \pm 0.71$	$11.9^{b} \pm 1.42$	$40.1^{a} \pm 1.96$	$4.37^{a} \pm 0.03$	$6.37^{b} \pm 0.46$	$31.4^{b} \pm 1.74$

† Mean ± Standard Error
†† Means with different superscripts within a coloumn are significantly different (p<0.05).
DM: dry matter, CP: crude protein, CF: crude fiber, EE: ether extract, NFE: Nitrogen free extract.

Proximate composition of ensiled materials

Proximate composition of silages prepared by incorporating different proportions of palmyrah leaves is given in Table 3. Sorghum-based silages (T5, T6, T7 and T8) had higher (p<0.05) CP, CF and ash contents than those of corn-based silages (T1, T2, T3 and T4). Further, the results obtained for the proximate composition of corn silage (T1) and sorghum silage (T5) is in agreement with the findings of Jabbari *et al*. (2011) and Heuze *et al*. (2017).

Table 3. Proximate composition of different silages†,††

Treatment	DM (%)	CP (%)	CF (%)	Ash (%)
T1	$24.2^{d} \pm 0.01$	$5.90^{h} \pm 0.01$	$29.1^{f} \pm 0.11$	$8.88^{abc} \pm 0.17$
T2	$26.8^{c} \pm 0.32$	$8.10^{g} \pm 0.04$	$30.7^{e} \pm 0.23$	$8.27^{bc} \pm 0.45$
T3	$30.1^{b} \pm 0.01$	$9.10^{f} \pm 0.02$	$32.1^{d} \pm 0.25$	$7.39^{bcd} \pm 0.21$
T4	$30.7^{a} \pm 0.02$	$10.5^{e} \pm 0.21$	$34.1^{c} \pm 0.13$	$6.57^{d} \pm 0.29$
T5	$14.3^{h} \pm 0.31$	$13.1^{a} \pm 0.03$	$34.4^{bc} \pm 0.20$	$10.2^{a} \pm 0.44$
T6	$15.9^{g} \pm 0.03$	$12.8^{b} \pm 0.07$	$35.6^{b} \pm 0.16$	$10.0^{a} \pm 1.31$
T7	$17.8^{f} \pm 0.01$	$12.1^{c} \pm 0.10$	$36.8^{b} \pm 0.02$	$9.97^{ab} \pm 0.18$
T8	$22.1^{e} \pm 0.29$	$11.1^{d} \pm 0.04$	$39.5^{a} \pm 0.19$	$9.02^{abc} \pm 0.38$

† *Mean ± Standard Error*
†† *Means with different superscripts within a column are significantly different ($p<0.05$)*
DM: dry matter, CP: crude protein, CF: crude fiber,
T1: 100% corn silage, T2: 90% corn + 10% palmyrah leaves added silage, T3: 80% corn + 20% palmyrah leaves added silage, T4: 70% corn + 30% palmyrah leaves added silage, T5:100% sorghum silage, T6: 90% sorghum + 10% palmyrah leaves added silage, T7: 80% sorghum + 20% palmyrah leaves added silage, T8: 70% sorghum + 30% palmyrah leaves added silage

Addition of palmyrah leaves increased ($p<0.05$) the DM content of both corn and sorghum silages compared to controls. This is due to the high DM content of palmyrah leaves compared to corn or sorghum (Table 2). According to Table 3, increasing the level of palmyrah leaves has increased ($p<0.05$) the CP content of corn silages (T2, T3 and T4), and showed a linear relationship (R^2 >98%). This is due to the higher CP content of palmyrah leaves than that of corn (Table 2). However, the CP content of sorghum based silages (T6, T7 and T8) decreased ($p<0.05$) with increasing levels of palmyrah leaves.

The CF content of all silages was above 29%. Furthermore, the addition of palmyrah leaves has contributed to increase ($p<0.05$) the CF content in corn silages (T2, T3 and T4) compared to the control (T1). This is due to the high CF content of palmyrah leaves compared to corn (Table 2). The ash content of ensiled materials reduced ($p>0.05$) with the increase levels of in palmyrah leaves.

Ensiling characteristics of silage

Ensiling parameters of silages with different proportions of palmyrah leaves are given in Table 4. Addition of palmyrah leaves increased ($p<0.05$) the pH of both corn and sorghum silage compared to control. In the present study, the pH of corn based silages (T1, T2, T3 and T4) ranged between 3.77 and 4.03 whereas the pH of sorghum based silages (T5, T6, T7 and T8) ranged between 3.80 and 4.40. According to Zaklouta *et al.* (2011), well-preserved corn silage is characterised by a pH value of 4.2 or below. Hence, the pH of corn based silages (T2, T3, T4) was not affected by the inclusion of palmyrah leaves up to 30%. However, when 20% and 30% palmyrah leaves replacement were done to sorghum based silages, the pH increased above 4.2. Khota *et al.* (2009) have shown that the lowering of pH below 4.0 inhibits the growth of enterobacteria and clostridia, which break down protein in the silage to form ammonia.

With increased proportions of palmyrah leaves, the LA content of silages decreased ($p<0.05$), whereas the WSC of the silages increased ($p<0.05$) (Table 4) in both corn and sorghum based silages. Zaklouta *et al.* (2011) reported that well-preserved silage is characterised by a lactic acid content of 4% or above. Hence, the LA content of sorghum silages with 0%, 10% and 20% levels of palmyrah leaves satisfied the acceptable quality.

Table 4. Ensiling parameters of different silages[†,††]

Treatment	pH	LA (%)	WSC (%)	NH_3-N (%)
T1	$3.77^{e} \pm 0.03$	$3.88^{c} \pm 0.10$	$1.72^{d} \pm 0.27$	$0.53^{c} \pm 0.01$
T2	$3.80^{e} \pm 0.00$	$2.88^{d} \pm 0.08$	$2.00^{d} \pm 0.19$	$0.25^{d} \pm 0.01$
T3	$4.00^{d} \pm 0.00$	$2.61^{de} \pm 0.26$	$2.46^{c} \pm 0.06$	$0.26^{d} \pm 0.01$
T4	$4.03^{d} \pm 0.03$	$2.54^{e} \pm 0.61$	$2.75^{c} \pm 0.22$	$0.26^{d} \pm 0.02$
T5	$3.80^{e} \pm 0.00$	$5.36^{a} \pm 0.66$	$1.82^{d} \pm 0.16$	$1.60^{a} \pm 0.11$
T6	$4.13^{c} \pm 0.03$	$4.63^{b} \pm 0.22$	$2.91^{b} \pm 0.17$	$1.65^{a} \pm 0.01$
T7	$4.27^{b} \pm 0.03$	$4.18^{c} \pm 0.14$	$3.52^{a} \pm 0.10$	$1.64^{a} \pm 0.01$
T8	$4.40^{a} \pm 0.00$	$2.93^{d} \pm 0.01$	$3.61^{a} \pm 0.21$	$1.37^{b} \pm 0.01$

[†] Mean ± Standard Error
[††] Means with different superscripts within a column are significantly different ($p<0.05$)
LA: lactic acid, WSC: Water soluble carbohydrate,
T1: 100% corn silage, T2: 90% corn + 10% palmyrah leaves added silage, T3: 80% corn + 20% palmyrah leaves added silage, T4: 70% corn + 30% palmyrah leaves added silage, T5:100% sorghum silage, T6: 90% sorghum + 10% palmyrah leaves added silage, T7: 80% sorghum + 20% palmyrah leaves added silage, T8: 70% sorghum + 30% palmyrah leaves added silage

The LA concentration of corn silages was low ($p<0.05$) compared to sorghum silages. Further, the LA content of corn and sorghum (T1 and T5) silages was low than the values reported by Zbigniew and Lucyna, (2011) and Heuze *et al*. (2016). This could attribute to the difference in maturity of the crops at the time of ensiling.

As shown in Table 4, ammonia nitrogen content of the all the silages of the present study was below 2%, and could be categorised as good in quality. Zaklouta *et al.* (2011) reported that very good quality silage is characterised by an ammonia nitrogen content of 5% or below. The low ammonia nitrogen in this study shows that palmyrah leaves are good source of WSC which will lower the pH and thereby reduce the ammonia nitrogen production.

CONCLUSIONS

Considering the ensiling characteristics and nutritional parameters the replacement of 10% palmyrah leaves in corn or sorghum silages showed the acceptable values. Therefore, a mixture of 10% palmyrah leaves (fresh matter basis) with corn or sorghum is recommended for making quality silage in the northern region of Sri Lanka.

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