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THE NUTRITIONAL COMPOSITION AND ACCEPTABILITY OF CACTI (*Opuntia ficus indica*)-LEGUME MIXED SILAGE

J. GUSHA[1], S. KATSANDE[1], P.I. ZVINOROVA[1] and S. NCUBE[2]

[1]*Department of Para-clinical Veterinary Studies, Faculty of Veterinary Studies University of Zimbabwe, Harare, Zimbabwe*
[2]*Makoholi Research Institute, P Bag 9182, Masvingo, Zimbabwe*

*E-mail: jtgusha@gmail.com

ABSTRACT: *The potential of making silage using dry browse legume hay (Acacia angustissima, Leucaena leucocephala, Calliandra callothrysus and Macroptilium Atropurpureum) mixed with fresh cactus (Opuntia ficus-indica) for winter supplementation of veld grass was evaluated using the proximate, tannins and the pH analyses. Chemical analysis revealed that N values were significantly increased (P<0.05). The N levels were 3.72, 4.5, 4.05, and 2.5% DM for A. angustissima, L. leucocephala, C. callothrysus and M. atropurpureum respectively, which were higher when compared to silage made from cereals. The NDF and ADF values were slightly higher than those reported in literature for cereal silages. The DM level of cactus –browse silage was very good (41%DM) considering that cactus normally have less than 10% DM. The silage pH was within the reported range, ranging from 3.97 to 4.11 on a pH meter. This was a good indicator of silage quality considering that low pH inhibit undesirable microbial activities. The tannins levels were lower in the silages but significantly different (P<0.05) between browse legume species. Ensiling lowered the tannin levels in the silage compared to the individual browse legume tannin levels. This study concluded that purely on compositional laboratory analysis, the legumes and cactus can be used to make silage which can be used by farmers during dry season.*

ORIGINAL ARTICLE

Key words: *Opuntia ficus indica, Silage, Browse Legumes, Tannins, pH, Nitrogen*

INTRODUCTION

Livestock play a very crucial role in poverty alleviation, food and nutritional security for the country (Gambiza, et al., 2000; Ngongoni et al., 2006, 2009; Odongo et al, 2010). However, fluctuations in both quality and quantity of feed make the sector unreliable and susceptible to high livestock mortality and low productivity (Vasta et al, 2008; Ngongoni et al, 2009). Therefore, there is need to conserve forage as silage for utilization in times of deficits, especially in dry season. The materials for making silage have been limited to cereals which lead to direct competition with humans. Utilization of cactus, which is readily available (Nefzauoi et al., 2010), and included in the list of invasive or weed species (Tibe et al., 2008) could be a solution in maximizing available feed for winter supplementation. However, cacti have low dry matter content and very low CP (Batista et al., 2003; Gebnemariam et al., 2006) making it very difficult to make silage (De Kock, 2001; Meiteka, 2008). Browse legumes are a good source of nitrogen (Mupagwa et al., 2003; Ngongoni et al., 2007) but with varied degree of digestibility due tannins (Nefzauoi et al., 2002; Ben Salem et al., 2004, 2005; Makkar, 2003). Mixing cacti with high soluble carbohydrates and browse hay with high nitrogen to improve dry matter and CP level in silage could be a way to provide high quality feed available for the dry season (Curek et al., 2009). The objective of this study was to determine the quality of silage produced when cacti and browse hay are mixed and ensiled as well as to evaluate the acceptability of this silage by ruminant animals.

MATERIALS AND METHODS

Study site

The experiment was conducted at Makoholi Research Station, 32 km North of Masvingo Town on 19^{0}50' S and 30^{0}47'E. Rainfall is unreliable both within and between seasons (mean annual 565mm and range from 133 - 1155mm). The altitude averages 1200m above mean sea level. The Station lies in agro-ecological region IV. Its soils are granite derived with typical arable topsoil, which consists of sand 96%, silt 2% and clay 2%. Soils are

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inherently infertile and plant growth and ranch cow fertility are severely limited by the unavailability of nitrogen and phosphorus.

Sample preparations

Four browse legume trees biomass were harvested separately between January and March. The harvested biomass were air dried under shade for five days to approximately 88% dry matter (DM) before being separately stored in a dry place with proper ventilation. Each browse hay was then mixed with fresh cut cactus *(Opuntia ficus indica*) before ensiling. The native species of cactus was used and the spines were removed using fire before maceration. The silage was made using 60 % fresh cactus and 40 % browse hay and ensiled in polythene bags on a weight/weight basis. Two percent molasses was added in the mixture to enhance fermentation. Ten bags of each containing twenty kilograms of treatment were made as replicates. The silage was incubated for 42 days in a rodents free room. After 42 days of incubation a sample was taken from each treatment bag for analysis. The samples were analysed for pH and oven dried. The samples were ground through a 3mm screen, using a Wiley hammer mill and analysed for chemical composition and silage quality. The other treatment bags were used in palatability feeding trial using goats, beef and dairy cattle at Makoholi research Station.

Chemical composition analysis

The *Opuntia ficus-indica*-legume silage was analysed for dry matter (DM), organic matter (OM), Nitrogen (N), (AOAC, 2000). Neutral detergent fibre (NDF) and acid detergent fibre (ADF) were determined according to the procedure of Goering and Van Soest (1970). Total ash was obtained by igniting a dried sample in a muffle furnace at 600^{o}C for 24 hours and calcium and phosphorous was determined by the EDTA method and spectrophotometer method, respectively. The total condensed tannins (TCT) in the silage was analysed using the Butanol-HCl method by Swain and Hillis (1959) and modified by Porter et al. (1986). Silage pH was determined using a pH meter.

Palatability studies with Mashona cows

Sixteen lactating beef cows were used to evaluate acceptability of the silages made out of cactus and browse legume hay. In a complete randomized block design, twelve cows were assigned into four treatment diets. Each animal was given 3 kgs of silage per day in the morning before they were taken to the paddocks for grazing. The amount eaten was measured and refuse was also measured. The study was carried for ten days. The data was then analysed.

Dairy crossbreed trial

Sixteen dairy cows were randomly assigned to four treatment diets. The cows were offered 3 kgs of treatment diet per day after milking. The amount eaten that was and that was left out, was measured. The trial lasted for 10 days and the data was analysed. The animals were allowed graze after the treatment diet was offered.

Goats trial

Sixteen lactating Small East African goats were used to assess the acceptability of the silage made out of cactus and browse legume hay. In completely randomized design twelve goats were assigned to four treatment diets with four replicates per treatment. The goats were offered 500 grams of the treatment diet per day. The feed eaten was measured so as the refusals.

Statistical analysis

Analysis of variance on the chemical composition of the silage was carried out using the GLM procedure of SAS (SAS, 2000). Contrasts were carried out to examine the effect of browse type on N, ADF TCT and pH of the silage quality. Comparison of treatment means was done using the Tukeys method.

The following model was used:

$Y_{ijk} = \mu + V_i + \varepsilon_{ijk}$

Where;

Y_{ijk} = Response variable being DM, CP, ADF, NDF, Ca, P and TCT of each cactus-legume silage

μ = Overall mean common to all observations;

V_i = Effect of the i^{th} treatment (*Leucaena leucocephala*, *A angustissima, C callothrysus*, and *Macroptilium atropurpureum);*

ε_{ij} = Random residual error distributed as N (0,1 σ^2_E).

Analysis of variance was done using PROC GLM procedure of SAS (SAS, 2000) for acceptability of silage.

The following model was used;

$Y_{ijk} = \mu + V_i + \varepsilon_{ijk}$

Where;

Y_{ijk} = Response variable being (Intake);

μ = Overall mean common to all observations;

V_i = Effect of the i^{th} treatment diet; (Cactus-Bana grass, Cactus-*Leucaena leucocephala*, Cactus-*A angustissima*, and Cactus-M atropurpureum*)*

ε_{ij} = Random residual error distributed as N (0,1 σ^2_E).

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RESULTS

The chemical composition of the silage

Chemical analysis results for the four silages are shown in Table 1. The results showed that *Cactus-L. leucocephala* silage (CLLS) (4.51%) had higher nitrogen% (N%) than other silages, *Cactus-A. angustissima* (CAAS) (3.72%), Cactus-*C. callothrysus* (CCCS) (4.05%) and Cactus-*M. atropurpureum* silage (CMAS) (2.50%). The silages were significantly different (P<0.05) in nitrogen. The silages had no significant differences in levels of NDF, however they were significantly different in ADF so as the level of tannins. The tannins content were significantly different being highest in CCCS and lowest in CMAS. The pH levels were also significantly different with lowest pH being observed in CCLS and highest in CMAS.

Table 1 - The chemical composition values of the silages used in the experiment

Composition	Silage mixture				Significance	LSD	Grand mean
	CLLS	CAAS	CCCS	CMAS			
Tannins	3.38^{c}	4.58^{b}	8.39^{a}	2.45^{d}	***	0.57	4.48
%DM	37^{a}	39^{ab}	41^{bc}	43^{c}	***	3.4	40
%Ash	9.19^{a}	10.61^{a}	9.62^{a}	9.32^{a}	***	1.78	9.16
%OM	89.8^{b}	87.3^{a}	86.4^{b}	89.5^{b}	***	5.7	88.4
%N	4.51^{a}	3.72^{c}	4.05^{b}	2.50^{d}	***	0.2	2.85
%NDF	54.4^{a}	53.3^{a}	54.6^{a}	56.7^{a}	***	2.69	54.7
%ADF	23.4^{c}	27.2^{ab}	24.7^{bc}	29.6^{a}	***	1.7	24.4
%P	0.98^{a}	0.84^{a}	0.65^{a}	0.74^{a}	***	0.67	0.06
%Ca^{2+}	1.4^{a}	1.432^{a}	0.91^{c}	0.97^{b}	***	0.07	0.81
pH	3.97^{a}	4.06^{b}	4.03^{ab}	4.11^{b}	***	0.8	4.04

^{abc} Means in the same row with different superscripts differ; *** - P>0.001. LSD = least significant difference; CLLS – Cactus-*Leucaena leucocephala* silage; CAAS – Cactus- *Acacia angustissima* silage ; CCCS – Cactus – *Calliandra callothrysus* silage; CMAS – Cactus – *Macroptilium atropurpureum* silage.

Acceptability of cactus-browse silage

The results showed that dairy cows, beef cows and goats can consume cactus browse silage freely without notable challenges. There was no significant different (P < 0.05) in silages consumption by large ruminants namely Dairy crossbred cow and Mashona beef cows. However, the consumption slightly changed in small ruminants with CLLS having the highest consumption rate when compared to other silages. All the results are presented in table 2 below.

Table 2 - Consumption of cactus browse silage

Diet/silage	Animal species		
	Mashona Beef cows Kg/day	Dairy crossbred cows Kg/day	Lactating goats Grams/day
CLLS	2.97^{a}	3.00^{a}	457^{a}
CAASs	2.95^{a}	3.00^{a}	420^{ab}
CCCS	2.91^{a}	2.98^{a}	397^{b}
CMAS	2.90^{a}	2.97^{a}	333^{c}
Probability	P <0.05	P <0.05	P <0.05
LSD	0.24	0.11	0.47
Grand mean	2.94	2.98	413

^{abc} Means in the same row with different superscripts differ

DISCUSSION

Silage quality

The quality of silage measured using the chemical composition was higher than the normal silage made from maize and other grass. It was also more improved silage as compared to the quality of silage obtained by Curek and Ozen (2004), which was low in CP. The total N or CP was higher (166 g/kg DM) on average than the average of 110 g/kg DM in maize silage (McDonald et al., 2002). The silage which was made using *Macroptilium atropurpureum* had the least CP (15.6 %) value but which was higher than the average for cereals silages (11.0%) (McDonald et al., 2002; Nefzaoui et al., 2010). The Calcium (Ca) and Phosphorous (P) values of legumes were higher than of cereal and this is depicted in the silage mineral value. The high Ca and P in the silage should be a positive output considering that cactus is known to have low phosphorous and the addition legumes has complementary effects. Mixing cactus with low fibre dry legume hay improved the DM content, Ca and P levels resulting in the production of well balanced silage for dairy, beef and small ruminants. Cactus have very low DM and it is difficult to make silage using it fresh or wilted (Nobel, 2001). However, in this study the silage which was made had high DM (410g/kg) which was higher than the 210g/kg DM reported by McDonald et al. (2002) for

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maize as the average. The silage was higher in ADF (21-27 %) compared to maize silage of less than 22 % and this is explained by the fact that the silage was made from browse hay which was totally dry before ensiling. The process of ensiling done using cactus and browse hay improved the DM for cactus which is normally too low to make silage.

It was observed that the TCT was lower in silage than in the individual browse species reported by Makkar (2003), Mupangwa et al. (2003) and Ngongoni et al. (2007). The values reported by D'melo et al. (1995) were higher than the findings in this study. This could be attributed to the explanation by Makkar (2003) that storage, drying, chemical treatment and solid state fermentation can be used in detanninification of feedstuffs. The levels of tannins should have been lowered by the biochemical process that took place during the fermentation activities in the silo. He reported that a decrease in the value of total phenol, condensed tannins and protein precipitation capacity by 55, 77 and 65% at day 1, 72 and 89 of ensiling respectively. Higher temperatures were reported to have an effect on the protein precipitation of tannin and the total condensed tannins. During the ensiling process temperature rises above 37°C, which was reported by Makkar (2003) to have a detanninifiction effect. There are a number of chemical and biochemical reactions that took place in silo bags that affect the pH and thus causing a reduction in total condensed tannins. Makkar (2003) also reported that 40 % ethanol removed about 70 % of the tannins in oak leaves; the findings are supported by the finding in this study.

Silage pH as an indicator of Quality

Silage pH was ranging from 4.0 to 4.23. The values were lower than pH 4.8 which was referred as good silage indictor in *(*Mugweni et al., 2000; McDonald et al., 2002; Curek and Ozen, 2004). The lower the pH the high the soluble sugars in the silage ingredients. The cactus has high soluble sugars (Ben Salem and Abidi, 2009) that were fermented and adequately reduce the pH to the range that can preserve the silage. Also the addition of molasses at 2% w/w could have the contribution effect on lowering the pH to the acceptable levels. McDonald et al. (2002) reported that legumes are more buffered than grass and are consequently more difficult to ensile satisfactorily. This was not the case in this study and could be attributed to high soluble sugar cactus and the addition of molasses which ferment and the acid produced increased the hydrogen ion concentration to a level at which the undesirable bacteria are inhibited.

Acceptability of the silage to livestock

All the categories of livestock used in the study consumed the silage without any notable challenges. There was no problem of laxative effects due to high water content in cactus as the dry mater level was improved with the addition of browse and forage hay. The crude protein level was also improved through the addition of browse hay. These diets could be safely be used as supplements due to their high levels of crude protein. In the small ruminants trial, goats on cactus-*M. Atropurpureum* consumed slightly less than other cactus-browse silage. This could be attributed to the higher levels of ADF than other species in the trial (Mupangwa et al., 2003). Considering that the smallholder and communal farmers in Zimbabwe experiences eight month feed deficit period, the use of cactus and browse should go a long way in livestock production and poverty alleviation. Dairying in small holder farming communities have challenges of quality feed leading to low milk yield and high cow mortality (Ngongoni et al., 2006; Mupangwa et al., 2003). The silages can be used to improve milk production especially in drier areas of Zimbabwe where cactus is a common green plant during the dry season.

CONCLUSIONS

The study showed that browse legumes and cactus can make good quality silage. Although the quality can be compromised by the amount of tannins, it was observed that ensiling reduced the amount of tannins. Finally the silage has the potential to bridge the perennial feed deficit gap experienced in subtropical and tropical Africa from April to November. Utilization of these feed resources will improve ruminant livestock productivity especially in drought prone areas of the region.

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