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Ensiling Characteristics and Nutritive Value of Sugar Cane Tops

R.C. Khanal, A.N.F. Perera[1] and E.R.K. Perera[1]

Postgraduate Institute of Agriculture
University of Peradeniya
Peradeniya.

ABSTRACT. Sugar cane tops were collected and wilted overnight, chopped to about 2-3 cm lengths, mixed with or without urea and molasses, and ensiled in 1.5 l laboratory glass silos at room temperature for 8 weeks to investigate the ensiling characteristics and nutritive value. Pre-ensiled material and silage samples were analyzed for proximate and detergent fibre composition, water soluble carbohydrates (WSC), total solubles (TS), and in vitro dry and organic matter digestibility (IVDMD and IVOMD). Lactic acid (LA), pH and total volatile fatty acids (TVFA) in silage were also analyzed. Ensiling increased crude protein (CP), ether extract (EE), crude fibre (CF), acid detergent fibre (ADF), cellulose, and decreased dry matter (DM), total ash (TA), WSC, IVDMD and IVOMD. Addition of urea increased neutral detergent fibre (NDF), acid detergent lignin (ADL), ADF, cellulose, TA, pH, TVFA, and decreased LA and WSC significantly ($p<0.05$). Molasses increased DM, CP, EE, CF, WSC, IVDMD and IVOMD, and decreased pH, TVFA, hemicellulose, cellulose, ADF, NDF and ADL significantly ($p<0.05$). Silage was preserved well without any additive. Addition of urea was not beneficial. Addition of molasses was advantageous in improving ensiling characteristics of urea added material, but not in treatments without urea. Addition of molasses increased CP content, nutritive value and digestibility of the silage ($p<0.05$).

INTRODUCTION

Scarcity of feed and fodder for ruminant production has led to the utilization of fibrous agricultural residues that were traditionally underutilized. Sugar cane is cultivated in most of the tropical and sub-tropical countries for the crystal sugar industry. After the harvesting of cane stalk, a considerable amount of green tops that can be used for ruminant

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[1] Department of Animal Science, Faculty of Agriculture, University of Peradeniya, Peradeniya.

feeding is available. Under small scale farming it can immediately be fed after harvesting, as the quantity involved is small. But, under commercial scale, feeding of cane tops relies on rapid collection and transport.

As the availability of cane tops is seasonal, conservation becomes essential. It is also important to improve its nutritive value, as it is low in CP and high in fibre, resulting in poor utilization by the animal. Compared to rice or wheat straw, little attention has been given to preserve this valuable green matter or to increase its nutritive value through various pretreatments, eventhough it is better than these straws nutritionally (Preston, 1988).

Ensiling is a common method adapted to preserve green forage. Addition of urea to improve the CP content and molasses to obtain better fermentation characteristics is important prior to ensiling. A laboratory study was conducted to investigate the ensiling characteristics of green cane tops with or without urea and molasses, the effect of urea and molasses on nutritive value and ensiling characteristics of cane tops, and its potential as a feed for ruminants.

MATERIALS AND METHODS

Sugar cane tops (variety Co-775) were collected immediately after harvesting from Pelwatte Sugar Industries and transported to the Department of Animal Science, University of Peradeniya. Green tops were wilted overnight on a cemented floor under shade. Cane tops were then chopped to about 2 cm lengths, treated with urea and molasses (on DM basis) as follows:

T_0: Sugar cane tops only (control)
T_1: Sugar cane tops + 1% urea
T_2: Sugar cane tops + 1% urea + 3% molasses
T_3: Sugar cane tops + 1% urea + 6% molasses
T_4: Sugar cane tops + 1% urea + 9% molasses
T_5: Sugar cane tops + 1% urea + 12% molasses

Urea and molasses were thoroughly mixed with the chopped materials which were then ensiled in 1.5 l laboratory glass silos and kept in the laboratory at room temperature for 8 weeks. During fermentation, the silos were turned over to minimize the precipitation of added molasses. Pre-ensiled materials were deep frozen until analysis. All treatments were replicated five times.

Physical characteristics of the silage relating to its colour, aroma, texture and moulds were observed. Silage samples were dried in a forced air oven until constant weight is acheived, and then ground to pass through a 1 mm sieve. Proximate composition (AOAC, 1980), detergent fibre (Van Soest and Wine, 1967) and total solubles (inclusive of added urea and molasses) were on both ensiled and pre-ensiled material. In addition, silages were analyzed for lactic acid (LA) as per Barker and Summerson (1941), water soluble carbohydrate (WSC) according to Dubois *et al.*, (1956), total volatile fatty acid (AOAC, 1980), and pH (electrochemically). The invitro dry matter digestibility (IVDMD) and invitro organic matter digestibility (IVOMD) were determined in both ensiled and pre-ensiled material, as per Tilley and Terry (1963).

Data were statistically analyzed using analysis of variance, and means were separated by Duncans multiple range test (DMRT) using SAS package (SAS, 1985).

RESULTS AND DISCUSSION

Upon opening the silos after 8 weeks, all the silages exhibited a satisfactory colour, aroma and texture. T_0 and T_1 had a golden green colour and T_2 and T_3 a golden yellow. As the level of molasses was increased, colour of the silage tended to become darker due to the colour of molasses. Mould development was negligible and was confined to the top layer which had trapped air during ensiling. Texture of the silage was satisfactory and pliable.

Proximate and cell wall composition of the pre-ensiled material and the silages are given in tables 1 and 2, respectively. Except in T_1, a small reduction in DM was observed in silage as compared to the pre-ensiled material. This is obviously a result of the loss of some soluble nutrients during fermentation, effluent production and secondary fermentation of silage (McDonald, 1981). In all treatments except T_1 the CP content increased following ensiling (Tables 1 and 2). This could be resulted from pre-wilting (Michna *et al.*, 1991) which increases the DM content of the material and inhibits the degradation of amino acids (Seyfarth *et al.*,1989). Reduction in CP of T_1 may be attributed to the addition of urea. Addition of urea to fibrous residues is not advantageous (Mehra *et al.*, 1989), as urea increases the loss of N by degrading half of the protein in fresh forage (Reuter and Weissbach, 1983). Degradation of CP increases amino acids (Philip and Buchanan-Smith, 1982), and pronounced degradation of these amino acids occurs with the production of butyric acid (Reuter and Weissbach, 1983). This is common in silages treated with urea and having a pH >4.5 (Perera and Perera, 1994). However, CP content of T_1 was higher than T_0.

Table 1. Composition and digestibility of the pre-ensiled material.

Constituents	Treatments					
g/kg	T_0	T_1	T_2	T_3	T_4	T_5
Composition						
DM	252	267	290	304	317	326
Total Ash	73	72	74	77	80	82
CP	59	73	72	72	74	73
EE	49	47	43	41	42	34
CF	322	337	318	300	283	270
NDF	671	674	637	616	583	555
ADF	379	379	370	346	323	310
ADL	45	46	45	43	42	42
Cellulose	334	333	325	300	283	273
Hemicellulose	292	294	267	270	260	245
Total Solubles	330	326	363	384	417	445
WSC	155	154	184	207	232	256
Digestibility						
IVDMD	521	529	542	582	614	650
IVOMD	511	528	600	608	642	681

All the values except DM are on DM basis.

Molasses inclusion significantly ($P<0.05$) increased the CP content (Table 2). Similar results were obtained by Sanchez and Guzman (1983) in *Napier* grass and Magno *et al.* (1986) in whole plant sugar cane silage. The observed increase in TA and EE contents of the silage may be due to the addition of urea and molasses (Chauhan and Kakkar, 1981; Wanapat, 1988) or of wilting (Michna *et al.*, 1991).

Table 2. Proximate and detergent fibre composition of green cane top silage.

Constituents (g/kg)	Silages T_0	T_1	T_2	T_3	T_4	T_5	CV %
DM	248^{c}	273^{bc}	288^{ab}	288^{ab}	301^{ab}	307^{a}	7.74
TA	65^{b}	71^{a}	68^{ab}	67^{ab}	70^{a}	70^{a}	4.28
CP	65^{d}	68^{d}	76^{c}	80^{bc}	84^{ab}	90^{a}	6.80
EE	47^{c}	45^{c}	51^{bc}	66^{a}	58^{ab}	69^{a}	14.90
CF	347^{ab}	369^{a}	323^{bc}	312^{c}	279^{d}	271^{d}	6.54
NDF	724^{b}	745^{a}	622^{c}	560^{d}	522^{e}	487^{f}	2.47
ADF	421^{b}	465^{a}	384^{c}	370^{cd}	349^{d}	318^{e}	5.37
ADL	37^{b}	45^{a}	39^{b}	37^{b}	36^{b}	33^{c}	5.79
Cellulose	383^{b}	402^{a}	351^{c}	333^{d}	313^{e}	286^{f}	1.88
Hemicellulose	303^{a}	299^{a}	232^{b}	190^{c}	173^{c}	170^{c}	6.60
TS*	277^{e}	260^{e}	378^{d}	440^{c}	478^{b}	513^{a}	4.32

* TS = Total Solubles including added urea and molasses.
All the values except DM are on DM basis.
Values in the same row with different superscripts are significantly different ($p<0.05$).

Most of the fibre components except lignin increased with ensiling (Tables 1 and 2). Hemicellulose increased in T_0 and T_1, but decreased with the addition of molasses, due to the release of pentose sugars which contribute some of the TS in these silages. Increase in fibre component in herbage following ensiling is common (Wanapat, 1988). This reduces the digestibility of silage compared to fresh herbage. Reduction in cell wall contents of T_2, T_3, T_4 and T_5 was due to molasses addition. Total solubles increased and cell wall contents decresed, in the molasses added silages (Magno *et al.*, 1986) due to the release of pentose sugars from hemicellulose, while the added molasses remained unfermented. The ADL content of the silage was lower than the pre-ensiled material, but the reason was not clear.

Water soluble carbohydrate content of the fresh cane tops (Table 1) was higher than that of many tropical grasses. This revealed that addition of soluble carbohydrates is not necessary to obtain a satisfactorily preserved silage. However, molasses increased CP content and nutritive value of the silage (Table 2). It was confirmed by the pH level, VFA and LA content (Table 3) of the respective silages. Control (T_0) had the lowest pH, lowest VFA and highest LA associated with substantial residual WSC. Water soluble carbohydrate content of T_1 was significantly ($p<0.05$) lower than all other treatments. Higher levels of WSC in T_2, T_3, T_4 and T_5 were primarily due to the added molasses and to a lesser extent to the release of pentose sugars from hemicellulose. This can be observed from the amount of WSC utilized during ensiling as a percentage of initial WSC. Silage which had lower pH had lower TVFA and higher LA compared to others. The TVFA content of T_0 was significantly lower ($p<0.05$). Urea addition increased the TVFA by increasing the buffering capacity through ammonia (Shirley *et al.*, 1972). Molasses reduced the TVFA content of the silage, but not to the level of T_0.

Table 3. Water soluble carbohydrates, pH, LA, TVFA and in vitro digestibilities of green cane tops silage.

Variables	Silages						CV %
	T_0	T_1	T_2	T_3	T_4	T_5	
WSC (g/kg)	81^c	33^d	64^c	95^{bc}	118^{ab}	142^a	25.90
pH	3.9^c	4.8^a	4.1^b	4.1^b	4.1^b	4.1^b	1.35
LA (g/kg)	68^a	30^c	54^b	53^b	53^b	54^b	15.25
TVFA(μmol/ml)	63^c	158^a	68^c	85^{bc}	86^{bc}	112^b	20.70
IVDMD (g/kg)	483^e	464^e	533^d	621^c	686^b	718^a	3.66
IVOMD (g/kg)	493^d	493^d	561^{cd}	611^{bc}	673^{ab}	723^a	9.10
WSC utilized as % of initial	47.7	78.6	65.2	54.1	49.1	44.5	-

Values in the same row with different superscripts are significantly different ($p<0.05$).
Water soluble carbohydrates, LA, IVDMD and IVOMD are on DM basis.

The pH of the silage is one of the most important criterian used in determining its quality. Well preserved silage has a pH of <4.2 (McDonald, 1981; Perera and Perera, 1994) achieved predominantly through LA fermentation. Lower pH is associated with higher LA as they are negatively correlated (Masuko *et al.*, 1985). The lowest pH and highest LA values were found in T_0 ($p<0.05$). Addition of urea increased pH and lowered LA. Increase in pH in response to added urea was due to the release of ammonia by urease activity, which increased the buffering capacity of the silage; as urea itself is a weak base (McDonald, 1981). In all molasses added silages pH and LA were 4.1 and 53-54 g/kg, respectively. Addition of 3% molasses reduced the pH which was increased by urea. But, no more reduction in pH was observed when molasses were added in higher proportions. The inclusion of 3% molasses increased the LA content that was reduced by urea. However, in molasses added silages pH was significantly higher, and LA was significantly lower than the control silage ($p<0.05$). This may be due to the availability of sufficient WSC in cane tops. The added molasses did not improve the fermentation characteristics.

Digestibility of both pre-ensiled material as well as silage was satisfactory with or without urea and molasses. Both IVDMD and IVOMD were lower for silage compared to fresh herbage owing to the increased fibre constituents, despite the increased TS and reduced hemicellulose in some silages. Reduction in digestibility was greater for silages without molasses, because NDF, ADF, cellulose and hemicellulose contents were higher than those in silages with molasses. The increase in TS improved digestibility only when the level reached 475 g/kg DM (T_4) where added molasses was 9% of the DM. Addition of urea tended to reduce the digestibility due to poor preservation (Flynn, 1988) and higher levels of NDF, ADF, ADL, cellulose and hemicellulose. But, molasses significantly ($p<0.05$) increased both IVDMD and IVOMD, owing to the reduced levels of these variables than in T_0 and T_1. The digestibility values of fresh cane tops were similar to those reported by Wanapat (1986). For whole sugar cane Magno *et al.*, (1986) reported a digestibility value around 65%.

CONCLUSIONS

Results of this study revealed that cane tops alone can be preserved well by ensiling without any additives. Addition of urea was not advantageous and that of molasses was so only in relatively higher proportions. Ensiled cane tops can provide a valuable source of feed in ruminant livestock production, specially during leaner periods. However, further research under field conditions is needed when preserving sugar cane tops by using additives to improve the crude protein content and nutritive value without impairing the fermentation process, to fully utilize this cheaper source of green matter.

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