Effect of Molasses on Nutritional Quality of Cassava and Gliricidia Tops Silage

Ngo Van Man and Hans Wiktorsson*

Department of Animal Nutrition, University of Agriculture and Forestry, Thu Duc, Ho Chi Minh City, Vietnam

ABSTRACT : The study aimed to evaluate the influence of molasses in ensiling cassava and Gliricidia tops, common crop residues in the farming systems of Vietnam. Four levels of sugarcane molasses: 0, 30, 60 and 90 kg per tonne of fresh material, and two storage periods (2 and 4 months) for each of the two plant species: Cassava (*Manihot esculenta*, Crantz) and Gliricidia (*Gliricidia sepium*, Jacq.) were allocated in a 4×2 factorial completely randomized block design with 3 replicates. A total of 48 plastic bags, each one containing 10 kg herbage were used. Based on the colour, smell and mold appearance, all the silages were considered to be acceptable but with more spoiled silages with higher levels of additives. DM of herbages (25.8% and 22.4% in cassava and Gliricidia tops, respectively) were not changed during ensiling and the molasses additive had no significant effect on the silage DM. Contents of CP and NDF in the cassava tops silage decreased significantly with increased level of molasses and storage period, respectively. The mean pH values of non-molasses silages were 4.39 in cassava tops and 4.60 in Gliricidia tops. Increased additive levels significantly reduced silage pH in Gliricidia ($p<0.01$) but not in cassava tops silage ($p=0.10$). Longer storage period significantly reduced pH in both silages. The water soluble carbohydrate (WSC) concentrations of cassava tops and Gliricidia tops were reduced by 90 and 80%, respectively, after ensiling. Molasses addition increased significantly the silage WSC concentrations. HCN contents in the fresh cassava and Gliricidia tops were reduced by 68 and 43%, respectively, after 2 months ensiling, and were continuously reduced during storage. A reduction of 25% and 42% in the tannin content of fresh cassava and Gliricidia tops, respectively was found after ensiling. Storage time and molasses additive had little affect on the tannin content. Silage lactic acid concentrations were around 1,0% of DM in cassava and 1.7% of DM in Gliricidia top silages, and no effect of molasses additive and storage time was found. It is concluded that cassava and Gliricidia tops residues can be preserved successfully by ensiling, and only low levels of molasses additive are needed to improve silage fermentation.
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Key Words : Molasses Additive, Cassava Tops Silage, Gliricidia Tops Silage, Chemical Composition

INTRODUCTION

Fodder trees and shrubs play a significant role in livestock production in the farming systems of Asia and the Pacific region (Chen et al., 1991), as they are a good source of protein for livestock and reduce production costs. In Vietnam, many fodder trees and shrubs have been found in small scale farming systems. Cassava (*Manihot esculenta*), a main cash crop, and Gliricidia (Gliricidia sepium), a hedgerow and shade tree, are among the most promising leaf protein suppliers. Cassava leaf with an average of 21% crude protein (CP) can be collected as a by-product at root harvest, yielding up to 1.8 tonne dry matter (DM) ha^{-1} (Gomez and Valdivieso, 1984). Gliricidia, pruned one year after establishment in a cycle of 60 to 75 days, gave an annual dry weight leaf yield of 6 to 8 t/ha (Man, unpublished data). A yield of 23 tonnes ha^{-1} of Gliricidia was reported by Ella (1988). Fresh cassava and Gliricidia leaves are commonly fed as feed supplements to goats in this region, but rarely to cattle. Gliricidia has a strong unpleasant odour to humans, and cattle may go off feed when first introduced to a diet including Gliricidia, although goats did not seem to be affected (Nitis, 1991). Leaves from cassava and Gliricidia contain compounds such as cyanide (HCN) and tannin which have potentially negative effects on livestock performance and, for that reason, may limit the use of these fresh fodders to livestock. Heat treatment can considerably reduce both HCN and free tannin contents (Ravindran, 1993).

In dealing with the rainy season crop harvest, and due to the difficulties in hay storage, ensiling is considered to be the preservation technique with the greatest potential for protein rich foliage. However, as with many high CP legumes, those foliages can be difficult to ensile successfully, because they tend to have low concentrations of water soluble carbohydrates, high buffering capacity and low DM content when directly harvested (Mc.Donald et al., 1991). According to Petersson (1988), molasses should be added to protein rich forage to ensure successful fermentation, otherwise effects of molasses as silage additives are variable.

The present study was completed to determine the influence of increasing levels of molasses added to Gliricidia and cassava tops prior to ensiling.

* Address reprint request to Hans Wiktorsson. Department of Animal Nutrition and Management, Swedish University of Agricultural Sciences, PO Box 7024, 75007 Uppsala, Sweden. E-mail: Hans.Wiktorsson@huv.slu.se
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MATERIALS AND METHODS

Experimental design

Sugarcane molasses application rates of 0, 30, 60 and

90 kg per tonne of fresh material, and two storage periods (2 and 4 months) for each of two plant species (cassava, *Manihot esculenta*, Crantz and Gliricidia, *Gliricidia sepium*, Jacq.) were allocated in a 4x2 factorial complete randomized block design with 3 replicates. A total of 48 plastic bags with 10 kg per bag of fresh material were prepared.

Silage making

Cassava tops were collected right after root harvesting in January 1999. Only the tops with the green stem and its leaf canopy were collected and were on average 40 to 60 cm in length. The Gliricidia tops were harvested at 2 months regrowth from the hedgerows of the UAF (University of Agriculture and Forestry, Ho Chi Minh City) Experimental Farm. The tops were chopped into pieces of 3 to 4 cm length. The fresh and chopped forages were mixed with the molasses and placed in polyethylene bags, compacted by hand, bound with a string, and pressed by placing one 2 kg bag of sand on each bag. Before mixing the fresh and chopped tops with molasses, four separate samples from each species were collected for chemical analyses.

Data collection and laboratory analysis

Silage samples were collected for chemical analysis on two occasions, 2 and 4 months after ensiling. The physical characteristics of the silages, colour, presence of fungi and smell, were evaluated and the following determinations were made: toluene DM (dried and corrected for volatiles according to Lingvall and Ericson (1981), pH (pH-ORION model 420 A), water soluble carbohydrate (WSC), tannin, HCN, total N, ash, and EE were analyzed using the procedures described by AOAC (1984). ADF and ash-free NDF were analyzed according to Van Soest and Robertson, (1980). VFA (acetic, butyric and lactic acid) were determined with an HPLC technique (Shimadzu, Japan 3081-09202-20ATD-E).

Table 1. The mean and range (-) chemical composition of molasses, fresh Gliricidia and cassava tops

	Molasses	Cassava tops	Gliricidia tops
No. of samples	2	4	4
DM g kg^{-1}	642	258 (244-268)	224 (212-236)
% in DM			
CP	9.5	21.1 (20,2-21.8)	21.0 (20,1-21.7)
EE	nd[1]	10.4 (10.3-10.6)	10.2 (9.8-10.6)
NDF	nd	56.2 (53.3-58.4)	54.6 (52.6-56.4)
ADF	nd	37.1 (36.6-38.2)	38.6 (37.7-39.2)
Ash	nd	6.8 (6.6-6.9)	6.8 (6.5-6.9)
Tannin	nd	3.8 (2.9-4.6)	5.8 (5.3-6.2)
WSC	37.5	6.3 (5.8-6.9)	5.4 (4.8-6.1)
HCN mg $100g^{-1}$	nd	97.8 (82.9-116.3)	24.9 (21.7-28.2)

[1] Not determined.

Statistical methods

Data were subjected to an analysis of variance (ANOVA) using the General Linear Model (GLM) procedure of Minitab (1998). When the F test was significant ($p<0.05$). Tukey's test for paired comparisons was used (Minitab, 1998).

RESULTS

Chemical composition of silage materials

The mean content of CP, EE, NDF, ADF and ash in cassava tops and Gliricidia tops were very similar (Table 1). The DM and WSC content, the main factors affecting the success of ensiling, were higher in cassava tops than in Gliricidia tops. Higher values of tannins and lower levels of HCN were found in the Gliricidia tops than in the cassava tops.

Physical quality of silage

Observations at 2 and 4 months after ensiling (Table 2) showed a normal colour appearance of cassava and Gliricidia tops silages. Silage colour was pale green to brownish yellow 2 months after ensiling and changed to a yellowish brown colour after 4 months of storage. Added

Table 2. Apparent quality classification of cassava and Gliricidia top silage (Si.) at different amounts of molasses additive and 2 or 4 months (m) storage period

	Molasses treatment							
Storage (m)	O (Zero) %		3%		6%		9%	
	2	4	2	4	2	4	2	4
Cassava silage								
Colour	Gy	Yb	Gy	Yb	By	Yb	By	Yb
Molds	As	T1-2	As	T1-2	As	T3-4	As	T3-4
Acceptable	A	A	A	A	A	A+S	A	A+S
Gliricidia silage								
Colour	PG	Gy	Gy	Yb	By	Yb	By	By
Molds	As	T1-2	T1-2	T3-4	T1-2	T3-4	T3-4	T4-5
Acceptable	A	A	A	A+S	A	A+S	A+S	A+S

Gy: Greenish yellow; Yb: Yellowish brown; By: Browish yellow; PG: Pale green; As: Absent; T'number': Only on top with 'number'cm in thickness; A: Acceptable; A+S: Acceptable with spoiled silage.

molasses increased the brown colour in the silage. Molds were not seen in the cassava tops silage 2 months after ensiling but appeared and increased with the amount of molasses additive and the time of storage. In the top layer of the Gliricidia tops silage treated with molasses molds were observed 2 months after ensiling, and the mold layer increased in thickness with the time of storage. The smell was good for all treatments. Based on the colour, smell and mold appearance, the silages without additive or low level of additive, were considered to be acceptable in the shorter storage period, and to be acceptable, except for molded layer, after long-term storage and with high levels of additive.

Chemical composition of cassava and Gliricidia tops silage

The dry matter of the fresh cassava and Gliricidia tops was 25.8% and 22.4% (Table 1) respectively, and changes with time were rather small after ensiling on all treatments (Table 3 and 4). There was a trend towards decreased DM content of cassava tops silage with storage time (p=0.08).

Crude protein content of cassava and Gliricidia tops were around 21% of DM (Table 1) and changes after ensiling in the non-additive silages were small. Molasses additive reduced the CP content of the silages, especially at the higher levels of molasses addition (Table 1, 3 and 4). The reduction was significant in the cassava tops silage ($p<0.001$) but not in Gliricidia tops silage (p=0.11). Storage time did not significantly reduce the CP content of the silages.

Plant total fibre expressed as NDF contents in the fresh material (Table 1) decreased by 8% and 4% after ensiling in the non-additive cassava tops and Gliricidia tops silage, respectively (Table 3 and 4). Higher additive levels significantly decreased silage NDF content in Gliricidia tops silage. Storage period reduced NDF content significantly in cassava tops silage but not in Gliricidia top silage. ADF and ash contents of the two silages were not significantly changed due to the experimental treatments.

The results for pH, WSC and fermentation products are summarized in Tables 3 and 4. The mean pH values of the non-molasses silages were 4.39 in cassava and 4.60 in Gliricidia. Added molasses significantly decreased silage pH in Gliricidia tops silage, while only a trend was found in

Table 3. The effect of molasses and storage period on quality of cassava top silage

Treatment	pH	DM	CP	EE	NDF	ADF	Ash	Lactic acid	Acetic acid	WSC	Tannin	HCN
		g kg^{-1}	% DM									mg/100 g
Molasses level (kg/t)												
0	4.39	267	21.7^{a}	11.9	51.4	37.2	7.2	0.97	0.23	0.65^{a}	2.87	28.19
30	4.21	266	19.9^{ab}	12.6	47.4	37.0	6.7	0.95	0.24	1.16^{b}	2.84	27.10
60	4.29	274	19.3^{b}	13.6	45.9	38.4	7.0	0.99	0.23	1.44^{c}	3.07	27.10
90	4.28	277	18.3^{b}	12.6	47.3	37.0	6.7	0.99	0.23	1.35^{c}	2.66	26.56
P*	0.10	0.41	0.00	0.26	0.09	0.77	0.64	0.13	0.36	0.00	0.95	0.77
Storage time												
2 months	4.38^{a}	280	20.0	12.5	50.0^{a}	37.4	6.6	0.96	0.23	1.14	2.83	30.90^{a}
4 months	4.21^{b}	264	19.6	13.8	46.1^{b}	37.5	7.2	0.99	0.24	1.16	2.89	23.58^{b}
P	0.01	0.08	0.32	0.66	0.02	0.94	0.10	0.06	0.13	0.10	0.89	0.00

* Probability of a larger F value for the treatment.

a,b,c Means within columns with differing superscript letters are significantly different ($p<0.05$).

Table 4. The effect of molasses and storage period on quality of Gliricidia tops silage

Treatment	pH	DM	CP	EE	NDF	ADF	Ash	Lactic acid	Acetic acid	WSC	Tannin	HCN
		g kg^{-1}	% DM									mg/100 g
Molasses level (kg/t)												
0	4.60^{a}	217	20.3	9.6	52.7^{a}	35.4	7.1	1.74	0.56	1.17^{a}	3.16	11.38
30	4.54^{ab}	222	21.1	9.3	51.4^{a}	37.1	6.6	1.63	0.57	1.44^{b}	2.91	11.92
60	4.47^{bc}	218	19.6	9.6	43.7^{b}	38.2	7.0	1.58	0.56	1.32^{b}	3.66	13.55
90	4.38^{c}	226	18.6	9.8	44.0^{b}	37.7	7.2	1.62	0.55	1.49^{b}	2.88	10.29
P*	0.01	0.88	0.11	0.99	0.01	0.41	0.91	0.07	0.96	0.00	0.41	0.34
Storage time												
2 months	4.72^{a}	226	20.3	8.7	48.3	37.3	7.3	1.60	0.55	1.34	3.39	14.10^{a}
4 months	4.27^{b}	215	19.5	10.4	47.6	37.0	6.6	1.68	0.57	1.37	2.91	9.48^{b}
P	0.00	0.27	0.20	0.15	0.63	0.80	0.26	0.06	0.61	0.46	0.20	0.01

* Probability of a larger F value for the treatment.

abc Means within columns with differing superscript letters are significantly different ($p<0.05$).

cassava tops silage (p=0.10). Storage period significantly decreased the pH-values of both silages. The means lactic acid contents of the cassava and Gliricidia tops silages were 1.0 to 1.7% of DM, respectively, and no effects of molasses addition or of storage period were found. The mean concentrations of acetic acid in cassava and Gliricidia tops silages were 0.23 and 0.56% of DM, respectively, and treatment affects were not found. Butyric acid was not detected in the silages.

The mean WSC content of fresh Gliricidia and cassava tops were reduced by 80 to 90% after ensiling in the non-additive silages, respectively (Table 1, 3 and 4). Molasses additive significantly increased the silage WSC content. Higher levels of additive resulted in significantly higher content of WSC both in cassava and Gliricidia tops silages. Storage time had no effect on WSC content.

The HCN contents in the fresh cassava and Gliricidia tops were 97.8 and 24.9 mg 100 g^{-1} (Table 1) and were reduced by 68 and 43%, respectively, after two months of ensiling (Table 3 and 4). The HCN content decreased with longer storage. At four months after ensiling the reductions were 76 and 62% compared to the fresh material contents in cassava and Gliricidia tops, respectively. A significant difference in silage HCN content was found between 2 and 4 months storage. The level of molasses additive had no significant effect on the silage HCN content.

The tannin contents of cassava and Gliricidia tops were reduced after ensiling. The reduction at two months after ensiling was greater in Gliricidia tops (42%) than in cassava tops silage (25%). Changes in the tannin contents of both tops silages with storage time after ensiling were not significant. The level of molasses additive did not affect the silage tannin content.

DISCUSSION

In this study the quality of the cassava and Gliricidia tops silages without additive were acceptable. These silages had sufficiently low pH values, around 4.27 with Gliricidia and 4.21 with cassava, at 4 months after ensiling (Tables 3 and 4). The pH value is often used as the criterion for assessing silage quality. With DM contents between 250-350 g kg^{-1} and pH values below 4.5, most silage samples can be considered to be good (Pettersson, 1988). Addition of molasses and longer storage time reduced pH values. However the small difference among treatments makes the ranking of silage quality difficult. In the present study, all cassava and Gliricidia tops silage could be considered to be of good or medium quality when using pH as criteria. Butyric acid content is another silage parameter, and quality is considered to be good when the concentration is below 0.1 g kg^{-1} fresh material (Lättemäe, 1997). No butyric acid was detected in any of these silage samples, which confirms the conclusion of good quality silage. With no or low levels of molasses additives no fungus (mold) was found in the silages at 2 months, and little was found in the top layer at 4 months. The presence of mold in silage is undesirable because it uses silage nutrients and toxins are sometimes produced. The results of the visual evaluation (Table 2) clearly showed the increasing problems with molds and spoiled silages with increasing amount of molasses and longer storage periods.

In the present study the DM content of herbage materials was sufficiently high to avoid seepage and no effluent was found in the bottom of the non-additive treatments. Silage DM increased only slightly with the addition of molasses. These results are not in line with those of Lättemäe et al. (1996) who showed a significant DM increase between non, low and high levels of molasses additive and ascribed these to the added DM from the additive. In the present study, molasses effluent was seen in the bottom of the high additive silage bags. The comparatively low DM content combined with the run-off of molasses in the high level additive treatments in the hot environment may be the cause of the difference.

The crude protein content in the fresh material was not changed after ensiling without additives. Losses, which might occur, are mostly due to the run off of proteolytic end products with the effluent. The proteolytic activities are merely restricted when the pH of the fermented silage is 4.3 or lower (Carpintero et al., 1979) and in good silage the process will stop earlier and limit the loss of protein. Tannin concentrations in the cassava and Gliricidia tops might limit the proteolytic activities and reduced the loss of silage CP (soluble NPN) as reported by Albrecht and Muck (1991). In the present study the constant CP content in the silages without additives indicates that high quality silage had been made. The CP contents in both silages were reduced with the increased inclusion of molasses. The reduction was expected, because molasses only contains 95 g CP kg^{-1} DM compared with around 200-210 g CP kg^{-1} DM in the non-additive silage.

The study showed a reduction of NDF content in cassava tops silage during the ensiling, but a constant silage ADF content. Hemicellulose was the main fiber component to be affected. Morrison (1979) reported that 10-20% of the hemicelluloses were solubilized during a 150 day ensiling period. A higher ratio of hemicellulose reduction (25%) was reported by Nishino et al. (1999). In the present study, a reduction of around 24% and 2% of hemicellulose content in cassava and Gliricidia tops, respectively, was observed. These figures are based on the NDF and ADF contents in the herbages before ensiling and after 4 months storage period. The reduction of NDF with the increased rate of molasses addition was due to the non-NDF content of molasses.

The WSC in herbage is the main substrate for microbial growth. Therefore, concentration of WSC is subsequently reduced during fermentation. The reduction in the non-additive treatments was higher in cassava silage. Differences in the WSC components and fermentative characteristics between plant parts and plant species (McDonald, 1981) may contribute to the differences in the degree of the reduction. More variable results were obtained in residual WSC at increased levels of molasses, probably because part of the added sugars was lost in the effluent. It was expected that a higher dose of molasses should result in a higher residual WSC and improve silage quality, as reported by Lättemäe et al. (1996) but in our study high levels of molasses additives resulted in more molasses running off. Haigh and Parker (1985) suggested that a critical WSC concentration in herbage for successful preservation as silage without additives is 30 g kg^{-1} DM. In legumes Zelter (1960) suggested a higher WSC level of 120 g kg^{-1} DM because of low dry matter at harvest. In our study the WSC content of cassava and Gliricidia tops were in the middle of the range of the two authors.

With regard to the total concentration of WSC, non-additive silage had nearly the same lactic acid concentration compared to the silage treated with additives, suggesting that WSC was not the sole substrate for LAB. Starch, the main storage carbohydrate in leaf and stem, may be a substrate after the attack of enzymes in the initial ensiling process, although the majority of lactic acid bacteria do not attack starch (McDonald et al., 1991). However, the lactic acid concentration, which was in the range of some common tropical herbage silages (Aminah et al., 1999), was still low compared to the values for temperate legume silages (Lättemäe et al., 1996).

The HCN content of fresh cassava tops was 4 times higher compared with the content in Gliricidia tops and this high content needs to be reduced for better use of this protein source in the Tropics. Sun-drying and boiling are simple methods to reduce HCN content, due to the action of endogenous linamarase on glucosides following loss of cell integrity or tissue damage. In the handling and ensiling process in this study, chopping, slight wilting during the preparation, pressing and the initial environment of the aerobic phase created good conditions for reducing the HCN. When the pH in the silage was lowered the enzyme activities were restricted and this reduced the speed of HCN elimination during storage. In our experiment the HCN contents of cassava tops silage were reduced with storage time after ensiling (Table 3), but no effect was found of additive levels. The same results were found by Hang (1998) and Phuc et al. (2000) in their studies on cassava leaf silage. The reduction of HCN content was similar in both Gliricidia tops and cassava tops, but both in percentage and in absolute figures the reduction was much greater in cassava tops than in Gliricidia tops. While the reductions in cassava were from 98 mg HCN 100 g^{-1} to 31 mg after 2 months, and 24 mg HCN after 4 months, the reductions in Gliricidia tops were only from 25 mg HCN 100 g^{-1} in fresh tops to 14 mg or 9 mg HCN after 2 and 4 months, respectively.

The tannin contents of the silage materials were in the range of some common tropical high protein leaves (Mahyuddin et al., 1988; Ahn et al., 1989). The contents were reduced in the initial period of ensiling, and may relate to the formation of tannin-protein complexes. Maldonado et al. (1995) reported the insoluble tannin and plant leaf protein complex was established in the pH range 3.5-5.5. In ensiling sorghum with different tannin contents, Rodriguez et al. (1998) reported that tannin concentration decreased with increase in the duration of fermentation. The reduction was not related to the time of storage and level of molasses additive in the present study.

CONCLUSIONS

Cassava and Gliricidia tops can be preserved by common ensiling methods with or without additives. Molasses additive improved the fermentation and applying low levels will aid the preservation process and limit the ensiling losses. Ensiling improved the products by markedly reduce HCN and to a lesser extent the tannin content of the raw materials. The levels of protein of cassava and Gliricidia tops were maintained efficiently by ensiling.

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