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SHORT COMMUNICATION

FERMENTATION CHARACTERISTICS AND NUTRIENT COMPOSITION OF BROWSES ENSILED WITH MAIZE FODDER

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ABSTRACT

Browses are important sources of feed and are widely used for animal nutrition to enhance productivity. They are commonly ensiled with other forages such as maize *(Zea mays)*. However, the fermentation pattern and chemical composition of browses, that are commonly used are largely unknown. Thus, a study was carried out in laboratory silos to determine the fermentation pattern and chemical composition of *Calliandra (Calliandra calorthyrsus)*, *Gliricidia (Gliricidia sepium)* and *Leucaena (Leucaena leucocephala)* browses ensiled with maize *(Zea mays)* forage. The browses were mixed with maize fodder in the proportion of 0, 10, 20, 30, 40, and 50% on dry matter (DM) basis and ensiled in triplicate 2 kg lots in polythene bags which acted as silos and allowed to ferment for 30 days. There was good fermentation in all the silages as indicated by adequate levels of lactic acid ranging between 2.85 to 3.13% dry matter and pH ranging from 3.99 to 4.06. Butyric acid levels were low ranging from 0.04 to 0.14 up to 20% browse addition. Whereas maize silage had 6.25% crude protein, the 30% browse/ maize silages had crude protein content of 12.82, 11.37 and 11.89% for *Calliandra*/maize, *Gliricidia*/maize and *Leucaena*/maize, respectively. *Gliricidia*/maize silages exhibited the best fermentation and nutrient patterns.

Key Words: Animal nutrition, chemical composition, dry matter

RÉSUMÉ

Le forage est une importante source d'aliment et est largement utilisé dans le diet des animaux pour augmenter leur productivité. Ils sont généralement fermentés avec d'autres forages comme le maïs *(Zea mays)*. Cependant, la tendance de la fermentation et la composition chimique du forage, qui sont communément utilisés sont largement inconnues. Par conséquent, cette étude était conduite dans le laboratoire silo pour déterminer la tendance de la fermentation et la composition chimique de *Calliandra (Calliandra calorthyrsus)*, *Gliricidia (Gliricidia sepium)* et *Leucaena (Leucaena leucocephala)* le forage fermenté avec le forage de maïs *(Zea mays)*. Le forage était mélangé avec le mais dans le proportion de 0, 10, 20, 30, 40 et 50% sur base de la matière sèche et était fermenté en triplet de 2 kg dans un sachet en plastic qui acta comme silo et permit de fermenter pour 30 jours. Il avait une bonne fermentation dans tous les fourrages ensilés comme l'indiquent les niveaux adéquats de l'acide lactique variant entre 2.85 et 3.13% de matière sèche et le pH variant entre 3.99 et 4.06%. Les niveaux d'acide butyrique étaient faibles rangea de 0.04 a 0.14 jusqu'à 20% addition de fourrage. Le sillage de mais contenait 6.25% de protéines. Le 30% de fourrage/ sillage à base de maïs contenait 12,82; 11,37; et 11,89% de protéines, respectivement pour *Calliandra*/ maïs, *Gliricidia*/ maïs et *Leucaena*/ maïs. Le sillage de *Gliricidia*/ maïs a exhibé la meilleure fermentation et était le plus nutritif.

Mots Clés: Nutrition animale, composition chimique, matière sèche

INTRODUCTION

Fast growing nitrogen-fixing trees have been found to have a lot of potential for use in mixed crop/livestock production systems (Jones *et al.*, 1992; Topps, 1992; Sabiiti and Cobbina, 1992). The trees remain green throughout the year, provide high quality fodder with crude protein (CP) ranging between 120 to 298 g kg^{-1} dry matter (DM) (Topps, 1992) and maintain soil fertility (Sabiiti and Cobbina, 1992). Nevertheless, tree foliages contain anti-nutritional factors, which affect their adequate utilisation by animals (Topps, 1992). The most prevalent of these factors are tannins and phenolics (Bareeba and Aluma, 2000). Methods for alleviation of the effects of anti-nutritional factors in tree foliages include supplementation, dilution, detoxication, feeding the forages in combination, wilting, heating and drying (Topps, 1992). Ensiling could also be used since the silo environment affects the chemical composition of ensiled materials (Weiss *et. al.*, 1986; Charmley and Veira, 1990; Tamminga *et. al.*, 1991). Also, ensiling tree foliages with low protein grass fodders or maize forage produces diets higher in N than either grass or maize fodder alone. However, the fermentation characteristics and chemical composition of ensiled browses are largely unknown. In this study Calliandra *(Calliandra Calliandra calorthyrsus)*, Gliricidia *(Gliricidia sepium)* and Leucaena *(Leucaena leucocephala)* forages commonly used by farmers in Uganda, were ensiled with maize *(Zea mays)* fodder to determine the fermentation characteristics and chemical composition of the resulting silages.

MATERIALS AND METHODS

The browses, *Calliandra, Gliricidia* and *Leucaena* leaves (leaf and petiole) and maize at milk stage (3 months after planting) were chopped to 3 to 5 cm to facilitate packing. The browses were then mixed with maize fodder in the proportion of 0, 10, 20, 30, 40, and 50% DM basis and ensiled in triplicate 2 kg lots in polythene bags which acted as silos. They were allowed to ferment for 30 days. A completely randomised experimental design was used. The DM of the materials at ensiling were; 30, 24, 29 and 25% for *Calliandra, Gliricidia, Leucaena* and maize, respectively. The weights of the fermented materials were determined on opening of the bags to determine the DM losses during fermentation.

The DM of the silages was determined by drying samples to constant weight at 60°C in a forced-air oven (Termak, Type TS 11, Bergem-Norway). Water extracts from the silages were used for determination of the volatile fatty acids, pH and ammonia nitrogen (NH_3-N). The water extracts were prepared by shaking 100 g of the silages in 800 ml of water for two hours on a mechanical shaker (Burrell Wrist-action shaker). After shaking, water was added to make 1 L. The extracts were filtered through two layers of cheesecloth. Lactic, butyric and acetic acids were determined by fractional distillation and titration using standard procedures in the Department of Animal Science, Makerere Universitry. The pH of the water extracts was also determined. Determination of NH_3-N was done by distillation into boric acid and titration. The DM losses were determined as the difference between the total DM of the ensiled materials before and after ensiling. Dried samples of the silages were ground through a 1mm sieve and stored in airtight sample bottles until analysis was done. Samples were analysed for organic matter (OM), crude protein (CP), calcium (Ca) and phosphorus (P) according to AOAC (1990) and Carbon according to Waikley and Black (1934). Non protein nitrogen (NPN) was determined by the trichloro acetic acid method (Gaines, 1977). Neutral detergent fibre (NDF), acid detergent fibre (ADF) and acid detergent lignin (ADL) were determined as described by Van Soest and Robertson (1985). Neutral detergent fibre nitrogen (ADFN) and acid detergent fibre nitrogen (ADFN) were obtained by determining N in the NDF and ADF residues, respectively.

The data were subjected to analysis of variance using the General Linear Model (GLM) procedure of Statistical Analytical Systems (SAS) Institute Inc. (1999). Where significant differences were obtained, means were compared using standard error of difference of means (SE) at significance level of 5 % (Steel *et al.*, 1997).

RESULTS AND DISCUSSION

Fermentation characteristics. The fermentation characteristics of the silages are shown in Tables 1-5. *Calliandra*/maize silages had the highest DM content ($P \leq 0.05$), followed by *Leucaena*/ maize (Table 1). *Gliricidia*/maize silages had the highest mean levels for acetic acid ($P \leq 0.05$) than *Calliandra*/maize *or Leucaena*/maize silages. Butyric acid concentration was less than 0.2% DM in all the silages indicating little or no undesirable butyric acid fermentation in all the ensiled combinations. However, lactic acid concentration was lowest in *Calliandra*/maize silages ($P \leq 0.05$), and therefore, would not store as well as *Gliricidia* /maize and *Leucaena*/maize silages. A lactic acid level of 3 to 13% and butyric acid level of less than 0.2% DM is necessary for proper silage preservation (Mahana, 1997). Lactic acid and NH_3-N concentrations and DM losses were lowest in *Calliandra*/maize silages ($P \leq 0.05$), which indicated that fermentation in *Calliandra*/ maize was limited compared to the other silages. *Gliricidia*/maize silages fermented best. The fact that fermentation in *Calliandra*/maize silages was limited implied that anti-nutritional factors in *Calliandra*/maize remained unaltered. Their negative effects on the utilisation of *Calliandra* silages would therefore be unabated.

The effect of increasing levels of browse addition of *Calliandra, Gliricidia* and *Leucaena* are given in Tables 2, 3, and 4, respectively. Each level of browse addition in *Calliandra*/maize silages significantly increased DM content of the silages (Table 2). Acetic acid concentration significantly reduced at 30% level of browse addition. Similarly, acetic acid in *Gliricidia*/maize silages reduced with the 30% level of browse addition (Table 3). Butyric acid content significantly reduced at 20% level of browse addition in *Leucaena*/maize silages (Table 4), but it was not affected in *Calliandra*/ maize and *Gliricidia*/maize silages (Table 4). Addition of browse therefore, could have deterred undesirable butyric acid fermentation. Butyric

TABLE 1. Browse effect on fermentation characteristics of the browse/maize silages made in laboratory silos

Characteristic	Browse/maize silages			
	Calllandra	*Gliricidia*	*Leuccaena*	SE
DM	33.64^{a}	29.58^{c}	30.6^{b}	0.21
Acetic acid	1.25^{b}	1.46^{a}	1.33^{ab}	0.05
Butyric acid	0.11	0.09	0.14	0.04
Lactic acid	2.64^{b}	3.16^{a}	3.02^{a}	0.08
PH	3.98	4.04	4.03	0.03
NH_3-N(% Total N)	2.36^{b}	2.97^{a}	2.81^{a}	0.001
DM losses	12.73^{c}	18.67^{a}	15.92^{b}	0.41

^{abc} Values followed by different superscripts in the same row are significantly different (P > 0.05)

TABELE 2. Fermentation characteristics of *Calliandra*/maizesilages made in laboratory silos

Characteristic	Browse level						
	0	10	20	30	40	50	SE
DM	30.03^{e}	31.35^{ed}	34.53^{b}	32.73^{bc}	36.27^{ab}	36.73^{a}	0.51
Acetic acid	1.59^{a}	1.33^{b}	1.23^{ab}	1.12^{b}	1.24^{ab}	1.01^{bc}	0.13
Butyric acid	0.16	0.10	0.05	0.13	0.12	0.07	0.09
Lactic acid	3.03^{a}	3.16^{a}	2.85^{a}	2.51^{ab}	2.28^{b}	2.01^{bc}	0.21
pH	3.97	3.94	3.99	3.85	4.02	3.97	0.08
NH_3-N(% Total N)	3.73^{a}	3.24^{ab}	2.38^{b}	1.68^{c}	1.61^{c}	1.52^{d}	0.003
DM Losses	19.90^{a}	17.70^{a}	9.87^{b}	10.87^{b}	9.30^{b}	8.73^{b}	1.01

^{abcde} Values followed by different superscripts in the same row are significantly different (P< 0.05) acid fermentation was more prevalent in low DM silages even when at low silage pH (Mahanna, 1997).

All the silages had similar and barely sufficient levels of lactic acid although it decreased with the 30% level of browse addition in *Calliandra*/maize silages. All the silages had sufficiently low pH levels. The concentration of NH_3-N significantly decreased with addition of browse in all the silages. This suggests that there is limited fermentation, proteolysis or deamination of protein in the silages. The DM losses significantly decreased at 10 and 20% levels of browse addition. Thus, the 20 and 30% levels of browse addition were the turning point for most of the fermentation characteristics. Fermentation was poor or limited with higher levels of browse addition. Further addition of browse would produce poor silage. Besides, the limited fermentation with higher levels of browse addition would not alter the anti-nutritional factors particularly in *Calliandra*/maize. The overall mean values of the fermentation characteristics according to the levels of browse addition are given in Table 5. Taking the level of NH_3-N as an indication of the extent of fermentation, browse addition of over 30% would negatively affect fermentation and the quality of the silage.

Nutrient composition. The mean values comparing composition of the three browse/maize silages is given in Table 6. *Calliandra*/maize silages had similar OM levels with *Leucaena*/maize silages but were significantly lower than for *Gliricidia*/maize silages (Table 6). *Gliricidia*/maize silages had similar CP levels with *Leucaena*/maize silages but were significantly higher ($P \leq 0.05$) than for *Calliandra*/maize silages (Table 6). *Gliricidia*/maize silages had the highest NPN level although it had the same level of CP with *Leucaena*/maize silages. *Calliandra*/maize silages had the lowest level of NPN.

Also, *Calliandra*/maize silages had the highest levels of fibre fractions (NDF and ADF) and ADL, which are less prune to fermentation. These

TABLE 3. Fermentation characteristics of *Gliricidia*/maize silages made in laboratory silos

Characteristic	Browse level						
	0	10	20	30	40	50	SE
DM	30.03	29.00	29.53	29.83	29.30	29.80	0.51
Acetic acid	1.59^{a}	1.38^{ab}	1.78^{a}	1.42^{ab}	1.41^{ab}	1.16^{b}	0.13
Butyric acid	0.17	0.10	0.04	0.05	0.07	0.11	0.09
Lactic acid	3.03	2.77	3.13	3.15	3.30	3.57	0.21
pH	3.97	3.98	4.00	4.05	4.07	4.15	0.08
NH_3-N(% Total N)	3.73^{a}	2.87^{bc}	3.00^{b}	2.84^{bc}	2.61^{c}	2.72^{c}	0.003
DM Losses	19.90^{a}	22.60^{ab}	18.97^{ab}	17.37^{ab}	17.53^{a}	15.67^{bc}	1.01

^{abc} Values followed by different superscripts in the same row are significantly different (P< 0.05).

TABLE 4. Fermentation characteristics of *Leucaena*/maize silages made in laboratory silos

Characteristic	Browse level						
	0	10	20	30	40	50	SE
DM	30.03	30.60	30.70	30.30	30.87	31.37	0.51
Acetic acid	1.59^{a}	1.29^{a}	1.31^{a}	1.34^{a}	1.29^{a}	1.18	0.13
Butyric acid	0.39^{a}	0.14^{a}	0.14^{a}	0.07^{b}	0.09^{b}	0.02^{b}	0.09
Lactic acid	3.03	2.98	3.10	3.08	3.02	3.89	0.21
pH	3.97	3.73	4.06	4.06	4.11	4.25	0.08
NH_3-N(% Total N)	3.73^{a}	2.89^{b}	2.79^{bc}	2.46^{cd}	2 .67^{c}	2.32^{c}	0.003
DM Losses	19.90^{a}	17.03^{b}	16.33^{b}	17.37^{ab}	12.70^{bcd}	12.17^{bcd}	1.01

^{abcd} Values followed by different superscripts in the same row are significantly different (P< 0.05).

factors would result in limited fermentation in *Calliandra*/maize silages as shown by the low lactic acid levels in *Calliandra*/maize silages. *Calliandra*/maize silages also had the highest levels of fibre N (NDFN and ADFN), which is less soluble, besides having the lowest levels of CP. These factors could have contributed to *Calliandra*/maize silages having the lowest NPN levels.

The fibre fractions (NDF and ADF) and ADL known to be resistant to fermentation and fibre N, which is less soluble were significantly higher in *Leucaena*/maize than in *Gliricidia*/maize silages. Therefore, greater solubilization of N occurred in *Gliricidia*/maize than in *Leucaena*/maize silages giving rise to significantly higher levels of NPN in *Gliricidia*/maize silages although the two silages had similar levels of CP.

The results in Table 7 show the nutient composition according to level of browse addition. The results show that each level of browse addition significantly increased CP content of the silages. The fibre fractions (NDF and ADF) significantly increased with browse addition. However, browse silages had significantly lower levels of NDFN. The content of ADFN was not affected by browse addition. The content of ADL increased significantly with addition of browse. Fermentation therefore, was limited in the silages with higher levels of browse addition as evidenced by the significantly higher pH levels in the 40 and 50% browse silages (Table 5). The limited fermentation would lower the quality of the silage with high levels of browse addition and leave anti-nutritional factors unaltered.

Nutrient composition of *Calliandra*/maize silages show that the 20 to 30% levels of browse addition could give optimal levels of CP, NPN, NDF, ADF, NDFN, ADFN and ADL and there would be no further advantage in additional browse

TABLE 5. Effect of level of browse addition on fermentation characteristics of the browse/maize silages made in laboratory silos

Characteristic	Browse level						
	0	10	20	30	40	50	SE
DM	30.03^{e}	30.38^{de}	31.59^{bc}	30.96^{cd}	32.14^{ab}	32.63^{a}	0.29
Acetic acid	1.59^{a}	1.33^{b}	1.44^{ab}	1.29^{bc}	1.31^{bc}	1.12^{c}	0.07
Butyric acid	0.24^{a}	0.11^{ab}	0.08^{b}	0.08^{b}	0.09^{ab}	0.07^{b}	0.05
Lactic acid	3.03	2.97	3.03	2.91	2.87	2.82	0.12
pH	3.97^{bc}	3.88^{c}	4.02^{bc}	3.99^{bc}	4.07^{ab}	4.18^{a}	0.05
NH_3-N(%Total N)	3.73^{a}	3.00^{ba}	2.72^{bc}	2.33^{c}	2.31^{c}	2.19^{d}	0.001
DM Losses	19.90^{a}	19.11^{a}	15.06^{b}	15.20^{b}	13.18^{c}	12.19^{c}	0.58

^{abcde} Values followed by different superscripts in the same row are significantly different ($P < 0.05$)

TABLE 6. Browse effect on nutrient composition of the browse/ maize silages made in laboratory silos

Nutrient	Browse /maize silages			
	Calliandra	*Gliricidia*	*Leuceana*	SE
Organic Matter	92.66^{a}	92.65^{b}	93.36^{a}	0.18
Crude Protein	10.42^{b}	10.87^{a}	11.06^{a}	0.21
NPN(% Total N)	21.43^{c}	41.05^{a}	29.08^{b}	1.33
Calcium	0.20^{b}	0.18^{b}	0.19^{a}	0.002
Phosphorus	0.16^{b}	0.14^{b}	0.18^{a}	0.01
NDF	62.59^{a}	56.96^{c}	61.49^{b}	0.52
ADF	47.12^{a}	40.21^{c}	43.59^{b}	0.56
NDFN	41.56^{a}	27.91^{c}	47.21^{b}	0.87
ADFN	35.09^{a}	16.69^{b}	20.53^{b}	1.13
Lignin	10.02^{a}	4.66^{c}	7.24^{b}	0.46

^{abc} Values followed by different superscripts in the same row are significantly different ($P < 0.05$)

TABLE 7. Browse level effect on nutrient composition of the browse/maize silages made in laboratory silos

Nutrient composition	Broswe level						
	0	10	20	30	40	50	SE
Organic Matter	93.04^{abc}	93.21^{a}	92.40^{a}	92.49^{a}	92.82^{abc}	93.40^{a}	0.28
Crude Protein	6.25^{f}	8.42^{e}	9.76^{d}	12.03^{c}	13.29^{b}	14.96^{a}	0.32
NPN(%Total N)	38.19^{a}	30.99^{b}	28.24^{b}	27.44^{b}	29.48^{b}	28.79^{b}	2.04
Calcium	0.19^{b}	0.19^{b}	0.19^{b}	0.19^{b}	0.19^{b}	0.20^{a}	0.003
Phosphorus	0.2^{ab}	0.12^{c}	0.17^{ab}	0.15^{bc}	0.15^{bc}	0.14^{bc}	0.02
NDF	64.86^{a}	60.70^{b}	60.54^{b}	59.62^{bc}	57.74^{c}	58.61^{bc}	0.80
ADF	41.41^{c}	39.94^{c}	42.23^{c}	45.05^{b}	45.23^{b}	47.97^{a}	0.86
NDFN(% Total N)	44.14^{a}	19.54^{d}	24.02^{c}	25.87^{bc}	29.18^{b}	27.43^{b}	1.33
ADFN(% Total N)	25.00^{a}	12.32^{b}	22.78^{a}	26.13^{a}	26.16^{a}	25.55^{a}	1.72
Lignin	3.52^{c}	4.45^{c}	5.54^{c}	9.08^{b}	10.01^{ab}	11.38^{a}	0.71

^{abcdef} Values followed by different superscript in the same row are significantly different ($P < 0.05$)

TABLE 8. Nutrient composition of *Calliandra*/maize silages made in laboratory silos

Nutrient composition	Level of browse						
	0	10	20	30	40	50	SE
Organic matter	93.04^{a}	94.00^{a}	91.70^{ab}	91.87^{ab}	92.26^{ab}	93.09^{a}	0.48
Crude Protein	6.25^{d}	7.68^{d}	9.35^{c}	12.82^{ab}	12.34^{b}	14.10^{a}	0.55
NPN(%) Total N)	38.19^{a}	25.74^{b}	15.89^{c}	17.42^{bc}	16.87^{bc}	14.49^{c}	3.53
Calcium	0.19^{b}	0.19^{b}	0.19^{b}	0.19^{b}	0.20^{a}	0.21^{a}	0.004
Phosphorus	0.19	0.14	0.16	0.15	0.16	0.17	0.03
NDF	64.86	61.46	62.71	61.73	61.53	63.23	1.38
ADF	41.41^{d}	38.55^{d}	44.66^{cd}	49.81^{b}	50.76^{b}	57.51^{a}	1.49
NDFN(% Total N)	44.14^{a}	29.81^{c}	38.88^{ab}	41.71^{a}	47.43^{a}	47.03^{a}	2.31
ADFN(% Total N)	25.00^{b}	28.13^{b}	35.15^{a}	42.51^{a}	38.35^{a}	41.40^{a}	2.98
Lignin	3.52^{b}	4.49^{b}	6.92^{b}	13.90^{a}	14.57^{a}	16.69^{a}	1.23

^{abcd} Values with different superscripts in the same row are significantly different ($P \leq 0.05$)

TABLE 9. Nutrient composition of *Gliricidia*/ maize silages made in laboratory silos

Nutrient composition	Level of browse						
	0	10	20	30	40	50	SE
Organic matter	93.04^{a}	92.52^{b}	92.39^{a}	92.47^{a}	92.35^{a}	93.15^{a}	0.48
Crude protein	6.25^{d}	8.82^{bc}	9.96^{b}	11.37^{b}	13.86^{a}	14.97^{a}	0.55
NPN(%) Total N)	38.19	37.12	40.53	42.82	44.96	42.69	3.53
Calcium	0.19	0.20	0.20	0.20	0.19	0.12	0.004
Phosphorus	0.21^{a}	0.10^{b}	0.17^{b}	0.13^{b}	0.10^{b}	0.15^{b}	0.03
NDF	64.86^{a}	58.58^{b}	56.96^{b}	54.22^{bc}	54.10^{bc}	53.01^{cd}	1.38
ADF	41.41	39.06	39.74	40.58	39.07	41.37	1.49
NDFN (%Total N)	44.14^{a}	25.02^{b}	26.72^{b}	21.50^{b}	24.97^{b}	25.09^{b}	2.31
ADFN (%Total N)	25.00^{a}	18.13^{a}	20.81^{a}	10.94^{b}	12.18^{b}	13.06^{b}	2.98
Lignin	3.52^{c}	3.45^{c}	4.18^{b}	4.99^{b}	5.46^{ab}	6.34^{a}	1.23

^{abcd} Values with different superscripts in the same row are significantly different ($P \leq 0.05$)

TABLE 10. Nutrient composition of Leucaena/maize silages made in laboratory silos

Nutrient composition	Levels of browse						
	0	10	20	30	40	50	SE
Organic matter	93.04	93.09	93.11	93.13	93.85	93.96	0.48
Crude protein	6.25 ^{e}	8.77 ^{d}	9.97 ^{d}	11.89 ^{c}	13.66 ^{b}	15.80 ^{a}	0.55
NPN (% Total N)	38.19 ^{a}	30.10 ^{a}	28.30 ^{b}	22.07 ^{b}	26.60 ^{b}	29.21 ^{b}	3.53
Calcium	0.19	0.19	0.19	0.19	0.19	0.2	0.004
Phosphorus	0.21 ^{a}	0.18 ^{b}	0.17 ^{b}	0.16 ^{b}	0.20 ^{a}	0.15 ^{b}	0.004
NDF	64.86 ^{a}	62.05 ^{a}	61.95 ^{a}	62.89 ^{a}	57.59 ^{b}	59.60 ^{b}	1.38
ADF	41.41	42.22	42.28	44.77	45.84	45.02	1.49
NDFN(%Total N)	44.14 ^{b}	38.47 ^{bc}	41.53 ^{b}	52.78 ^{a}	53.67 ^{a}	52.65 ^{a}	2.31
ADFN(% Total N)	25.0 ^{a}	10.69 ^{b}	12.37 ^{b}	24.95 ^{a}	27.95 ^{a}	22.20 ^{a}	2.98
Lignin	3.52 ^{c}	4.96 ^{b}	5.52 ^{b}	8.36 ^{ab}	9.99 ^{a}	11.10 ^{a}	1.23

^{abcde} Values with different superscripts in a row are significantly different ($P \leq 0.05$).

(Table 8). This is further supported by the lactic acid levels, which declined significantly after the 20% level of browse addition (Table 1). Nutrient composition of *Gliricidia*/maize silages show that CP of *Gliricidia*/maize silages increased significantly with addition of browse but the levels of NPN remained similar (Table 9). The NDF levels of the silages with the browse were significantly lower, however they were more or less the same between the browse silages. The ADF levels were not affected by browse addition. However, both NDFN and ADFN levels increased significantly with browse addition. The level of ADL was not affected by browse addition. Fermentation in *Gliricidia*/maize silages was as good as in the maize silage as evidenced by the similar lactic acid and pH levels that were optimal (Table 3). The advantage of *Gliricidia*/maize browse addition is therefore, the increase of CP content, which can reach the level of 14.97% with the 50% levels of browse addition. Nutrient composition of *Leucaena*/maize silages show that CP levels of *Leucaena*/maize silages could be increased up to 15.8% by the 50% level of browse addition (Table 10). However, there could be no further advantage of additional browse after the 30% level. Instead, fibre N (NDFN and ADFN) which is less available and ADL,, which impedes digestion, are higher with the 30% level of browse addition.

The results obtained in the study reveal that 20% browse/maize mixture (DM basis) would produce silage that is well fermented. It would give silage that is 9 to 12% CP with lower fibre, fibre N and ADL levels than in the browses alone. *Gliricidia*/maize silages showed the best fermentation and nutrient patterns with a high CP content coupled with available N as NPN and low fibre N, fibre and ADL fractions.

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