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Suckling practices and calf performance under intensive smallholder dairy production system in a high potential lowland area in Tanzania

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Abstract

In Tanzania, farmers use different calf rearing practices but the most appropriate practice remains largely unknown. The study was done at Turiani Division – Morogoro rural district to evaluate calf rearing practiced by the smallholder dairy farmers in 7 villages. Data on milk production, growth performance of calves and mortalities indicate a high degree of adoption of standard management practices and keenness of the farmers on this activity. The study showed that, three calf rearing practices were undertaken by the farmers. The first practice was that of allowing a calf to suckle a dam before and after milking. The second practice was that of reserving one teat for a calf to suckle, and the third one was that of reserving two teats for a calf to suckle. These calf rearing practices and sexes were correlated with calf daily gain and weaning weights. No significant differences were shown between female calves suckled one or two teats in terms of daily gains and weaning weights. However, there were significant differences between female calves allowed to suckle one teat and the rest of categories with respect to daily gains and weaning weights. However, since most of the calves were males, this observation may have been contributed by differential treatment by the farmers. The trend of performance by individual groups of calves in different calf rearing practices was the same for both weaning weight and daily gain, indicating that daily gain and weaning weight are correlated positively. However, female calves were much favoured by the practice of reserving one teat for calf suckling but were severely affected by the practice of suckling before and after milking. From this study, it has been shown that, reserving one teat for a calf to suckle was the best practice.

Key words: Calf rearing practices, daily gain, weaning weight

Introduction

Smallholder dairy farming is one of the important sub sectors of the farming system in the household economy of most parts of Tanzania particularly where land is a limiting factor for agriculture (Mdoe, 1985). Land being the limiting factor in this sub sector, only few cattle are kept. Farmers under this sub sector own between 1-10 cows, the size of the farmers' holdings being the main constraint to increased herd size. The importance of this sub sector has been highlighted by Msechu (1988) and Kurwijila (1991).

In order to raise calves, different rearing practice are used depending on one locality to another. In Tanzania, traditional rearing is mainly practised. Irrespective of the rearing method practised; indoors or outdoors, suckling is very important for growth performance of calves. Suckling plays a major role in governing reproductive cycles in female mammals. According to Wettemann *et al.* (1978), the suckling stimulus lengthens the postpartum interval in most mammals. Restricted suckling in particular appears to stimulate the cow's milk production and may increase the total amount of milk produced by the cow. Restricted suckling reduces labour requirements, capital outlay and calf mortality (Preston and Leng, 1987). The majority of smallholder farmers in the tropics allow the calves to suckle their mothers briefly before milking in order to induce let-down milk, and after milking, the calves are allowed to suckle the residual milk in the udder (Chamberlain, 1989; Payne, 1990). The alternative to this is that of allowing a calf to suckle a dam for a short time before milking, then the calf is held by a rope in front of the cow when milking is going on (Payne, 1990). Another practice is to allow the calf to suckle the front or back teats, while the remaining teats are being milked (Payne, 1990). Other practices include allowing the calves to suckle the cows after each milking for a limited period and then until the next milking in cases where herds are normally milked twice daily (Preston, 1984).

The method used for calf rearing has implications with regard to growth and development. For instance, Russell (1972) pointed out that suckled calves usually develop more quickly than those reared by any other method. Different authors and researchers have pointed out the effect of various restricted suckling practices on weight gain by calves. Bastidas *et al.* (1984) and Blunzter *et al.* (1989) have reported that the partial suckling twice daily has been shown to have little effect on calf live weight gain; while Peredes *et al.* (1981) reported that partial suckling has resulted in greater live weight of a calf compared to artificial rearing. It is however, not clear whether these effects are apparent in Tanzania. The study aimed at examining effects of existing calf suckling practices on preweaning growth performance of calves.

Materials and methods

The study was done at Turiani, Morogoro, a lowland area (altitude 400- 500 m asl, and 1000-1300 mm of rain per annum for the particular site). The mean daily temperature ranges from 15-29°C. The soil is loamy clay with high cation exchange capacity. In rice fields, montmorillonite soils do dominate. The altitude ranges from 300 - 1200 m above sea level with annual rainfall ranging from 1000 - 2000 mm per annum. There are several rivers and streams together with the Nguru Mountains, which create valleys. Main occupation is crop and livestock farming whereby the major cash and food crops are sugar cane, paddy, cassava, maize, bananas, coconuts and pigeon peas. Common livestock are cattle, goats, poultry and pigs.

The households for the study were selected through simple random sampling to get 20 households as a sample size. The sampling frame included the names of the dairy farmers only under the NGO, Foundation for Sustainable Rural Development (SURUDE).

The methods which were employed to collect data are: structured questionnaire, informal interview, use of secondary data and through personal observation, direct participation especially during measuring of heart girth using tape measure.

Data were summarised and edited by adjusting weaning weights and average daily weight gain to correspond with 4 months of weaning age. The adjusted weaning weights and daily weight gain were for the calves, which were weaned below or above four months of age.

Results

Calves were 44% of the total herd with ownership range of 0 – 2. Heifers were 4.2% with ownership range of 0 – 1. Pregnant cows constituted 8% with ownership of 0 – 2. Milking cows were 47.9%, ownership was 1 – 2 and bulls were 4.0% of the total herd with ownership range of < 1. Among the total herd, 35% were supplemented with crop residues, 15% were provided with mineral licks, 25% were supplemented with concentrates and 25% were not supplemented.

The milk yield per cow per day was between 2-10 litres, with average milk yield of 5.3 litres per cow per day (Table 1). Among the total milking cows, 22% were producing 2 – 3 litres per day each, 22% were producing 4 – 5 litres per cow per day, 39% were producing 6 – 7 litres per cow per day and 17% were producing 8 – 10 litres per cow per day. The breeds were crosses of Friesian X Boran and Ayrshire X Boran.

Birth weights were between 25 and 37.5kg and the mean value was32 kg computed for twelve calves. Among these calves, 9 were males with average birth weight of 32.7 kg and female calves were 3 with mean birth weight of 30kg. Weaning weights were between 67 and 95kg with the mean weaning weight value of 81.96kg. The average daily gain ranged between 303 and 536g/day with the mean daily gain of 414g/day. This was computed for 12 calves only. The percentages of calves under different rearing practice are given in Table 2.

Average weaning weight of male calves when suckled before and after milking was 80.54 ±1.97kg. For the treatment of one teat reserved for a male calf, the mean weaning weight was 79.25±3.49 (Table 3).

When female calves were allowed to suckle before and after milking, the mean weaning weight was 74.17±4.8, while where one teat was reserved, mean weaning weight was 99.17 ± 4.8 and where two teats were reserved a mean weaning weight of 89.17±4.8 was recorded (Table 3).

The mean daily gain for a male calf when suckled before and after milking was 402.66±16.92g/day when one teat was reserved for a male calf, the mean daily gain was 390.96±29.98g/day (Table 3). The mean daily gain for female calves when allowed to suckle before and after milking was 347.04

Table 1. Average milk yield per cow per day.

Milk (Litres)	No. of farmers	No. of milking cows	% of total milking herd
2	3	3	13.04
3	2	2	8.70
4	1	3	13.04
5	1	2	8.70
6	6	6	26.10
7	3	3	13.04
8	3	3	13.04
10	1	1	4.35
Total	20	23	100.00

Table 2 Percentages of calves under different calf rearing practices.

Sex	Practice			Total
	S_O	S_1	S_2	
Male	57.14	14.29	4.76	76.19
Female	14.29	4.76	4.76	23.81
Total	71.43	19.05	9.52	100.0

Practices: S_O - Suckling before and after milking; S_1 - One teat reserved for a calf; S_2 - Two teats reserved for a calf.

Table 3. Effect of rearing practice on calf performance.

Rearing practice	Sex	Daily gain (kg)	Weaning weight (kg)
Before and After milking	Male	402.66 ± 16.92^a	80.54 ± 1.97^a
One teat reserved	Male	390.96 ± 29.98^a	79.25 ± 3.49^a
Before and After milking	Female	347.04 ± 41.31^a	74.17 ± 4.82^a
One teat reserved	Female	555.04 ± 41.31^b	99.17 ± 4.82^b
Two teats reserved	Female	477.04 ± 41.31^{ab}	89.17 ± 4.82^{ab}

^{a,b} means in the same column followed by the same superscript are not significantly different (P<0.05).

$\pm$ 41.31, while when one teat reserved for suckling, the mean daily gain was 555.04$\pm$41.31g/day and 477.04 $\pm$ 41.31/day when two teats were reserved for suckling (Table 3).

About 14.3% of the total calves were given maize bran and legumes, 9.5% were supplemented with maize bran, cotton seed cake and minerals, 23.8% were supplemented with maize bran only, and 14.3% calves were given maize bran and grasses. Approximately 38.1% of the total calves were not supplemented. However, supplementation was not consistent. Most of the calf houses had timber off-cut walls (60%), thatched with grass (70%) with stone floors (75%). The calves were attended mainly by women and children (70%).

Discussion

According to the study results, the average calf birth weight was 32.0kg. The value obtained is within the range reported by other authors. Arthur *et al.* (1996) reported birth weights of different breeds to be 36.4kg for Ayrshire, 46.4kg for Brown Swiss, 32.2kg for Guernsey, 42.9kg for Holstein and 24.7kg for Jersey.

It has also been showed that male calves are born heavier (about 2 kg) than female calves (Arthur *et al.*,1996). The reasons for this phenomenon are that, genetically male calves are born with more muscle cell numbers than female calves. Also, with purebred and crossbred calves, the males tend to be carried a day or two longer than the females, and this is reflected in the greater birth weight of the male (Arthur *et al.*, 1996). In these earlier studies , it was further argued that parity, which is closely related to maternal age, has an effect on calf birth weight, and it is well known that heifers have calves that are 1 – 4kg lighter than cows. The possible reasons are the restricted and small size of the pelvis together with small size of uterus (maternal environment), which restricts the foetal size so that parturition becomes possible. Generally there is an increasing calf birth weight with increasing weight of the dam, but beyond the third parity, by which time the dam is fully grown, there is no increase in calf weight.

Maternal nutrition during pregnancy has also an influence on birth weight. Severe underfeeding of cows result into light calves, and is more pronounced in late pregnancy (Arthur *et al.*, 1996).

The study showed that the calf average daily gain was 414g/day, which was almost similar to that which was reported by Russell (1972) and Alvarez *et al.* (1980) of 450g/day and 464g/day, respectively. However, Peredes *et al.* (1981), Velazco *et al.* (1982) and Gonzalez *et al.* (1984) reported daily gains of 862g, 770g and 598g, respectively. In relation to the calf performance in terms of growth rate, the calf under restricted suckling suckles the residual milk, which has a higher butterfat content and hence more energetic. This is supported by Reaves and Henderson (1963), Russell (1972) and Peredes *et al.* (1981) who reported that calves on a nurse-cow would make their greatest growth than those, which are artificially reared. Further, *Bos indicus* cattle and their crosses tend to hold back milk during milking releasing that milk when the calf suckles, so, eventually a calf develops more quickly (Russell, 1972).

The study showed that most farmers weaned their calves at age of 4 months. This was contrary to what was pointed out by Fishwick (1962), that calves are conventionally weaned at 8 weeks. However, early or late weaning age will depend on the health status of the calf and dam, growth rate of the calf, availability of supplements to the calves and time of starting supplementing the calves.

Three calf-rearing practices were observed to be used by the smallholder dairy farmers at Turiani Division. One practice was that of allowing calves to suckle before and after milking, which was also reported by Chamberlain (1989) and Payne (1990). The second practice was similar to that which was reported by Sanh (1994), of reserving one teat for a calf to suckle. The third practice was also reported by Payne (1990), which was that of reserving two teats for a calf to suckle.

According to the results it has been shown that, the practice of reserving one teat for a calf to suckle resulted into better performance than the practice of reserving two teats to suckle. This is contrary to the expectations, because one could expect a calf that is exposed to two teats reserved for suckling to perform better than a calf exposed to one teat reserved for suckling. The possible reason for this unexpected performance is probably due to the small number of farmers practicing this system and possibly being necessitated by very low yielding cows.

Restricted suckling is a good calf rearing system in the tropics where the environmental and hygienic conditions favour a variety of diseases. The system is easy to use by smallholder farmers. The three calf suckling practices have shown no much significant difference with respect to calf performance, so farmers have a flexibility in using these practices.

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Fermentation characteristics and nutrient composition of ensiled *Calliandra calorthyrsus, gliricidia sepium* and *Leucaena leucocephala* browses and maize fodder

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Abstract

The studies were conducted in laboratory silos to determine the fermentation characteristics and chemical composition of *Calliandra calorthyrsus*, *Gliricidia sepium* and *Leucaena leucocephala* when ensiled and maize fodder. The browses and maize fodder were ensiled in triplicate 2 kg lots in polythene bags which acted as silos and allowed to ferment for 30 days. Maize silage fermented well with lactic acid and pH levels of 4.98% dry matter and 3.86, respectively. The browse silages had similar and low levels of butyric acid ranging from 0.04 to 0.10% dry matter indicating minimum undesirable butyric acid fermentation. However, the browse silages had lower ($P \leq 0.05$) lactic acid levels ranging from 0.94 to 2.81% dry matter and higher ($P \leq 0.05$) pH levels ranging from 5.08 to 5.38 than maize silage. Maize silage had non protein nitrogen levels elevated ($P \leq 0.05$) and crude protein and neutral detergent fibre levels remained unaffected ($P > 0.05$), while acid detergent fibre, neutral detergent fibre nitrogen, acid detergent fibre nitrogen and acid detergent lignin levels were depressed ($P \leq 0.05$). Of the browse silages, *Gliricidia* silage fermented best on account of its higher ($P \leq 0.05$) lactic acid level (2.81% dry matter) and both its crude protein, non protein nitrogen levels, fibre-nitrogen and acid detergent lignin fractions were depressed ($P \leq 0.05$). *Calliandra* silage fermentation was the poorest ($P \leq 0.05$) with a very low lactic acid level of 0.94% dry matter but did not affect ($P > 0.05$) non protein nitrogen level. Its neutral detergent fibre, acid detergent fibre, acid detergent fibre nitrogen and acid detergent lignin were higher ($P \leq 0.05$) while neutral detergent fibre nitrogen was lower ($P \leq 0.05$). *Leucaena* silage also had inadequate fermentation with lower ($P \leq 0.05$) lactic acid level of 1.86% dry matter than either *Gliricidia* or maize silages.

Key words: Chemical composition, fibres, silages, silos

Introduction

Supplementing grass fodder with legume tree fodder improves the overall nitrogen (N) content of the diet, dry matter intake (DMI) and utilization resulting in higher livestock production (Reynolds and Adeoye, 1986; Malamusha *et al.*, 1993; Muinga, 1993; Nguyen, 1998; Nguluve and Muir, 1999; Maarsdorp *et al.*, 1999). However, tree foliage contain anti-nutritional factors whose effects need to be ameliorated if greater utilisation of these forages is to be realised. The most prevalent of these factors are tannins and phenolics (Lowry, 1990; Bareeba and Aluma, 2000). Methods for alleviation of the effects of anti-nutritional factors in tree foliage include supplementation, dilution, detoxication, feeding in combination with other fodders, wilting, heating and drying (Lowry, 1990; Topps, 1992).

Ensiling could also be used to alleviate the effects of anti-nutritional factors in tree forages. The silo environment of temperature, moisture, acidity and fermentation affects the chemical composition of the stored material (Weiss *et al.*, 1986; Charmley and Veira, 1990; Tamminga *et al.*, 1991). Therefore, the ensiling effect could in part negate the effects of anti-nutritional factors in legume tree forages.

Many farmers have adopted zero grazing of dairy cattle and practice fodder preservation by ensiling. Ensiling grass fodder with browses would improve the feeding value of the fodder. In the investigations reported here in, *Calliandra, Gliricidia* and *Leucaena* forages were ensiled to determine the fermentation pattern and nutrient composition of the resulting silages.

Materials and methods

Calliandra, Gliricidia and *Leucaena* leaves (leaf and petiole) and maize fodder at milk stage were ensiled in triplicate 2 kg lots in polythene bags which acted as silos. The materials were chopped to 3 to 5 cm to facilitate packing. The experimental treatments were arranged in a completely randomised experimental design. The dry matter (DM) of the materials at ensiling were; 38.70, 24.40, 24.20 and 25.00% for *Calliandra, Gliricidia, Leucaena* and maize, respectively. Oven dried samples of the unfermented materials were then ground through 1mm sieve and stored in air tight sample bottles for chemical analysis. The ensiled materials were allowed to ferment for 30 days. 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 silage were used for determination of the volatile fatty acids, pH and ammonia nitrogen (NH_3-N). The water extracts were prepared by shaking 100g of the silages in 800ml of water in a 1000ml flask for two hours on a mechanical shaker (Burrell Wrist-action shaker at the speed of 5). After shaking water was added to the mark. The extracts were filtered through two layers of cheese cloth. The pH of the water extracts was determined using a pH meter. Lactic, butyric and acetic acids were determined by fractional distillation and titration using standard procedures in the Department of Animal Science, Makerere University. Ammonia nitrogen (NH_3-N) was determined by distillation into boric acid and titration. Dry matter 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 thereafter analysed for organic matter (OM) crude protein (CP), calcium (Ca) and phosphorus (P) according to AOAC (1990) and carbon (C) according to Walkley and Black (1934). Non protein nitrogen (NPN) was determined by the trichloro acetic acid method according to Gaines (1977). Neutral detergent fibre (NDF), acid detergent fibre (ADF) and acid detergent lignin (ADL) were determined according to procedures of Van Soest and Robertson (1985). Neutral detergent fibre nitrogen (ADFN) and acid detergent fibre nitrogen(ADFN) were obtained by determining N (Kjeldahl) in the NDF and ADF residues, respectively.

Statistical analysis

The data were subjecred to analysis of variation using the General Linear Model (GLM) procedure of Statistical Analytical Systems (SAS) Institute Inc. (1999). Where significant differences were obtained means were compared using LSD at a probability level of 5%.

Results and discussion

Fodder materials ensiled

The chemical composition of unfermented browses and maize is shown in Table 2. The values obtained for CP content of the browses are comparable with those reported elsewhere for the browse leaves and edible stem (Jones *et al.*, 1992; Flores *et al.*, 1992; Topps, 1992; Kaitho, 1997).

Fermentation pattern

The fermentation characteristics of the silages are presented in Table 1. Fermented *Calliandra* had the highest DM content than either *Gliricidia, Leucaena* or maize silages as was the case with the unfermented forms. Lactic acid and acidity which are measures of the desirable lactic acid fermentation (Vetter and Kendall, 1978; Mahanna, 1998) were highest ($P \leq 0.05$) in maize silage. A lactic acid level of 3 to 13% DM would be ideal (Bareeba,1977; Mahanna, 1998). Of the browses, *Gliricidia* fermented best as it had higher ($P \leq 0.05$) lactic acid concentration than either *Leucaena* or *Calliandra*. However, all the browse silages had similar ($P>0.05$) but higher pH levels compared to maize fodder silage. A low pH (3.86) observed in maize fodder silage is indicative of better silage and consistent with earlier findings that a pH level of 4.2 or less is desirable for good silage (Mahanna, 1998). The higher pH values in the browse silages can be accounted for by the lower ($P \leq 0.05$) levels of lactic acid. Levels of NH_3-N were higher ($P< 0.05$) in maize silage compared to the browse silage. Levels of NH_3-N were lower ($P \leq 0.05$) in *Calliandra* than in *Gliricidia* and *Leucaena* which suggests that CP in *Calliandra* was not readily fermented or broken down. This was possibly due to higher levels of tannin and lignin in *Calliandra*.

The low ($P \leq 0.05$) lactic acid levels and high ($P \leq 0.05$) pH in *Calliandra* silages suggests that *Calliandra* silage did not ferment well. Visual observation indicated that *Calliandra* silage had greater mold damage than either *Gliricidia* or *Leucaena* silages. Although *Calliandra* material had high DM (38.70%) it should have fermented well as DM content of 30-35% is optimum for desirable lactic acid fermentation of ensiled forages. The poor fermentation of *Calliandra* can be attributed to its high content of tannins and lignin. Tannins and lignin in fodder are capable of adsorbing or binding microbial enzymes, nitrogen and carbohydrates (Zahedifar, 1977; Fahey *et al.*, 1980; Hill *et al.*, 1987; Navas-Camancho *et.al.*, 1993; Moya-Rodriguez *et al.*,2002). This possibility would suggest that anti-nutritional factors, tannins and lignin, affected fermentation in *Calliandra* through their binding effect of microbial enzymes, nitrogen and carbohydrates.

The fermentation characteristics therefore, showed that fermentation was good in maize silage. This must have been on account of the readily fermentable carbohydrates in the maize grains. However, all the silages had similar ($P>0.05$) levels of butyric acid which were low indicating minimum undesirable butyric acid fermentation which occurs in spoiled silages (Vetter and Kendall, 1978; Edwards and McDonald, 1978; Mahanna,1998). A butyric acid concentration of more than 0.2% DM would be undesirable (Bareeba, 1977; Mahanna, 1998). Of the browse silages, *Gliricidia* fermented best. However, all the browse silages did not keep well on account of their low lactic acid and high pH levels. This could be overcome by addition of a readily fermentable carbohydrate source, such as molasses.

Table 1. Fermentation characteristic of the maize and browse silages.

	Maize	*Calliandra*	*Gliricidia*	*Leucaena*	LSD
DM(%)	25.91^{b}	35.55^{a}	23.46^{c}	24.38^{bc}	2.39
Acetic Acid(% DM)	2.69^{a}	0.52^{c}	0.85^{bc}	1.73^{ab}	0.99
Butyric Acid(% DM)	0.09	0.09	0.04	0.10	0.13
Lactic Acid(% DM)	4.98^{a}	0.94^{d}	2.81^{b}	1.86^{c}	0.68
PH	3.86^{b}	5.38^{a}	5.08^{a}	5.30^{a}	0.78
NH_3-N(% Total N)	10.28^{a}	1.27^{c}	5.57^{b}	7.33^{b}	0.08
DM losses (%)	9.27	8.29	9.65	2.06	8.41

Values having different superscripts in a row are significantly ($P \leq 0.01$) different.

Nutrient composition

The chemical composition (% DM) of fermented (F) and unfermented (U) maize and browses is presented in Table 2. *Calliandra* had the highest OM and fermentation had no effect on OM composition. *Leucaena* had the highest ($P \leq 0.05$) CP content of 25.59% and maize had the lowest of 7.30%. Fermentation elevated ($P \leq 0.05$) CP concentration in *Gliricidia*. This is possible as the C:N ratio narrowed from 13.93 to 11.76 in unfermented and fermented *Gliricidia*, respectively. The narrowed C:N ratio indicated loss of oganic matter in the course of fermentation which could have resulted in increased %CP or concentration in the silage. Maize silage had the highest ($P \leq 0.05$) NPN content and *Calliandra* had the lowest ($P \leq 0.05$) level of NPN. Fermentation raised ($P \leq 0.05$) NPN content in maize and *Gliricidia* silages but, it did not ($P > 0.05$) affect the NPN content in *Calliandra* silage. It reduced ($P \leq 0.05$) it in *Leucaena* silage. Both *Calliandra* and *Leucaena* had high levels of fibre (NDF and ADF) and lignin and much of the N was fibre-bound as NDFN or ADFN (Table 2).

Maize fermented best followed by *Gliricidia, Leucaena* and *Calliandra*. The increase in NPN in the fermented materials followed similar trends. Increase in NPN due to fermentation in silage is expected particularly in low DM silages (Mahanna, 1998; Weiss *et al.*, 1986; Charmley and Veira, 1990). Increase in NPN, however, as a source of readily available N could augument rumenal degradation of fibre by the rumen bacteria and increase the amount of energy derivable from the diet by ruminant farm animals.

Increase in NPN in silages is due to solubilisation of protein through proteolysis and deamination (Cushnahan and Gordon, 1995). Much of the N in unfermented *Calliandra* was fibre-bound either as NDFN or ADFN such that it may not have solubilised readily. Also, the binding effect of N by tannins and lignin in *Calliandra* could have inhibited solubilisation of the N in *Calliandra*. Hence, the low levels of NPN in *Calliandra* silages.

Calcium content differed ($P \leq 0.05$) by fermentation in *Gliricidia* silages only while phosphorus content was not affected. The results in Table 2 show that fermentation elevated ($P \leq 0.05$) NDF levels in *Calliandra* and *Leucaena* silages but it did not affect ($P > 0.05$) the NDF levels for maize and *Gliricidia* silages . The ADF levels were lowered ($P \leq 0.05$) by fermentation in maize and were not affected ($P > 0.05$) in *Leucaena.* Weiss *et al.* (1986) observed that fibre constituents are not affected by normal fermentation with the exception of losses in hemicellulose. According to Weiss *et al.* (1986) NDF and cellulose remain fairly constant among silages and fresh herbage although ADF and lignin may be elevated. Results in this study however, show that fermentation elevated ($P \leq 0.05$) both NDF and ADF levels in *Calliandra* and significantly lowered ($P \leq 0.05$) ADF levels in maize and *Gliricidia*.

Table 2. Chemcal composition (%DM) of fermented and unfermented maize and browses.

	Maize		Calliandra		Gliricidia		Leucaena		SE
	U*	F	U	F	U	F	U	F	
Organic Matter	93.68^{b**}	93.58^{b}	94.54^{a}	94.73^{a}	91.68^{c}	91.67^{c}	94.03^{b}	93.16^{b}	0.21
Crude Protein	7.56^{c}	7.03^{e}	18.18^{d}	19.18^{d}	20.68^{c}	23.38^{b}	25.89^{a}	25.29^{a}	0.31
NPN(% Total N)	27.25^{e}	37.96^{a}	9.26^{e}	11.15^{e}	12.18^{e}	31.97^{b}	18.82^{d}	13.62^{e}	2.51
C:N Ratio	37.54^{a}	35.09^{a}	14.65^{b}	14.62^{b}	13.93^{b}	11.76^{c}	10.14^{c}	10.41^{c}	1.23
Calcium	0.15^{e}	0.20^{e}	0.94^{c}	0.91^{c}	1.31^{a}	1.16^{b}	0.60^{d}	0.61^{d}	0.02
Phosphorus	0.24	0.23	0.14	0.14	0.20	0.22	0.24	0.23	0.01
NDF	71.44^{b}	70.51^{b}	70.63^{b}	77.00^{a}	58.13^{d}	55.70^{d}	62.40^{c}	75.55^{a}	0.94
ADF	37.56^{cd}	32.95^{e}	58.67^{b}	66.08^{a}	38.22^{cd}	32.76^{e}	41.63^{c}	45.01^{c}	1.19
NDFN(% Total N	64.95^{d}	42.47^{e}	90.27^{a}	78.16^{bc}	86.92^{ab}	59.74^{d}	80.97^{b}	79.92^{b}	2.63
ADFN(%Total N)	37.75^{c}	14.24^{d}	60.15^{b}	68.08^{a}	40.22^{c}	13.47^{d}	44.29^{c}	42.59^{c}	1.45
ADL	9.06^{a}	4.40^{h}	29.74^{b}	34.46^{a}	19.18^{e}	12.15^{f}	23.83^{d}	27.06^{c}	0.79

*U = Unfermented; F = fermented.

**Values having different superscripts in a row are significantly ($P \leq 0.05$) different.

A similar trend was observed for ADL where fermentation elevated ($P \leq 0.05$) levels of ADL in *Calliandra* and *Leucaena* but, lowered ($P \leq 0.05$) it in maize and *Gliricidia*.

Maize and *Gliricidia* silages exhibited greater fermentation as indicated by their higher levels of NH_3-N and or lactic acid. Reports cited by Zahedifar (1997) indicate that during steam treatment of lignocellulosic materials, formation of organic acids, principally acetic acid, occurs. This leads to acid hydrolysis of cell wall components. Solubilisation of hemicellulose and depolymerisation of lignin are the most important changes that occur during the process. Therefore, the observed lowered levels of ADL in maize and *Gliricidia* silages could have been as a result of depolymerisation under the moist and acidic conditions in the silage. The chemical nature of lignin differs by source. Therefore, maize and *Gliricidia* lignin could have been more susceptible to the silo conditions than *Calliandra* and *Leucaena* lignin. Hence, the lower levels of ADL observed in maize and *Gliricidia* silages in this study. The results on the fibre constituents therefore, present fermented *Gliricidia* as a more utilizable browse than either *Calliandra* or *Leucaena* and comparable to maize silage.

Levels of NDFN were highest ($P \leq 0.05$) in *Calliandra* and *Leucaena* silages followed by *Gliricidia*. A similar trend was observed for ADFN levels. The results also show that while fermentation reduced ($P \leq 0.05$) NDFN in all the silages, it did not affect NDFN in *Leucaena* silage. While fermentation lowered ($P \leq 0.05$) ADFN in maize and *Gliricidia*, silages it elevated ($P \leq 0.05$) it in *Calliandra* silage and it did not affect ($P > 0.05$) it in *Leucaena* silage. According to Weiss *et al.* (1986) ensiling solubilizes cell wall protein or NDF amino acids preferentially over NPN components associated with NDF fraction. However, normal ensiling would have little effect on concentration of amino acids insoluble in acid detergent or ADFN. Hence, the observed reduction in NDFN in the silages except in *Leucaena* silage where it remained unaffected. However, there was a reduction in ADFN in maize and *Gliricidia* silages and it was elevated in *Calliandra* silage and unaffected in *Leucaena* silage.

Calliandra and *Leucaena* silages had higher levels of ADL than either maize or *Gliricidia* silages (Table 2). Also, *Calliandra* and *Leucaena* browses are known to contain high levels of tannins (Lowry, 1990; Bareeba and Aluma, 2000). Therefore, the tannins and lignin in the ADF fraction could have adsorbed and held the N in *Calliandra* and *Leucaena* silages. In heat damaged silages much of the N is held as ADFN (Weiss *et al.*, 1986). Hence, the elevated levels of ADFN in *Calliandra* silage as well as the unaffected levels of ADFN in *Leucaena* silages.

The results are therefore interpreted to mean that ensiling affects the chemical and nutrient composition of the browses; *Calliandra, Gliricidia* and *Leucaena.* and could ameliorate the effects of their anti-nutritional factors, particularly in *Glricidia*. However, in *Calliandra* and *Leucaena*, the anti-nutritional factors, tannins and lignin appear to negatively affect fermentation through their binding action on microbial enzymes, N and carbohydrates. This would affect the quality and utilization of silages containing either *Calliandra* or *Leucaena*.

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