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Chemical Composition, Anti nutritive Substances and in Situ Digestion Kinetics of Four Ziziphus Specie Leaves use as Fodder for Ruminants in Semi Arid Zone of Nigeria

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Abstract
This study explored the nutritive value of *Ziziphus abyssinica, Ziziphus mauritiana*, *Ziziphus mucronata* and *Ziziphus spinachristi* leaves. Chemical analyses revealed that dry matter (DM) ranged from 937.00 to 981.00 g kg^{-1} DM in *Ziziphus spinachristi* and *Ziziphus abyssinica*, crude protein, whereas, neutral detergent fiber (NDF) was greater in *Ziziphus abyssinica* and *Ziziphus spinachristi* (481.40 g kg^{-1} DM). Acid detergent fiber was higher in *Ziziphus abyssinica* and *Ziziphus spinachristi* (228.30 g kg^{-1} DM), while, acid detergent lignin was greater (119.60 g kg^{-1} DM) in *Ziziphus abyssinica* and *Ziziphus spinachristi*. Organic matter was higher (910.30 g kg^{-1} DM) in *Ziziphus abyssinica* and *Ziziphus spinachristi* had higher (162.40 g kg^{-1} DM) The concentration of total phenolics, tannins, alkaloids and saponin was within safe range. *In situ* DM digestibility was higher (71.29%) for *Ziziphus abyssinica*, DM lag time was shorter (0.20 h) for *Ziziphus spinachristi*, and rate of DM disappearance was lowest (0.014% per h) for *Ziziphus mauritiana* and *Ziziphus spinachristi*. Based on chemical composition and *in situ* digestion kinetics, all the browse forage leaves will be of good supplement for ruminants during the dry season.
Key words: *Ziziphus,* browse, degradability, forages, semi arid

1. Introduction

Browse plants, beside grasses, constitue one of the cheapest sources of feed for ruminants. The diversity and distribution of browse plants in Nigeria have received early attention in studies carried out for the north (Saleem *et al.,* 1979), southwest (Carew *et al.,* 1989) and middle belt (Ibeauchi *et ai.,* 2002). The tree and shrub legume forages are rich in most essential nutrients such as proteins and minerals and tend to be more digestible than grasses and crop residues. They also serve other useful purposes such as the provision of food, drugs, lifewood and building poles and recycling of nutrients.

Feed shortage is the major constraint affecting the development of the country's animal industry (Mohammed Salem, 1985). Browse leaves and pods form a natural part of the diet of goats which meets over 60 percent of the forage requirement and have been used by traditional farmers as sources of forage in Nigeria. There are several types of leguminous and non-leguminous trees used as forage by goats but the predominant genus in southern Borno is *Ziziphus* sp. Feed potential of browse in the diet of herbivores in Nigeria is reflected in report of Saleem *et al.*(1979). Several tree species could be effective sources of providing fodder nutrition during normal as well as scarcity periods (Reddy, 2006). Although there are many advantages of the forages and leguminous crops over tree crops, the leaves of certain trees can be as nutritious as those of fodder legumes (Soliva *et al*., 2005).

Browse plants play a significant role in nutrition of ruminant livestock in tropical regions. Browse species, because of their resistance to heat, drought, salinity, alkalinity, drifting sand, grazing and repeated cutting, are the major feed resources during the dry season (Fagg and Stewart, 1994). Some parts of browse species can be found during the dry season including pods, fruits and leaves. Most trees/shrubs produce their leaves during wet season, thus browse is more available during the spring (August to May) (Palgrave, 1983).The nutritional importance of browse is especially significant for free ranging goats in extensive communal system of production. Goats thrive well in the semi-arid regions of Nigeria due to their ability to feed on different types of plant species, mainly browses and grasses. Goats have a great tendency to change their diet according to seasonal feed availability and growth rate of plants. According to Keay *et al.* (1964) *Zizyphus* is found in some of the northern parts of Nigeria such as Kastina, Bauchi, Borno and Adamawa States. According to N R C (1980), *Zizyphus* is grown in hot tropical regions with less than 600m altitude and rainfall of 350 – 500mm. Jauhari (1960) reported that *Zizyphus* is a drought resistant plant and adaptable to soil need.

The de facto reference method to determine rumen degradability of feed components is the *in situ* nylon bag technique (NBT). However, the NBT is very labourious, time-consuming, and incubation and analyses of the feed residues often last several weeks. Other disadvantages are the need for ruminally cannulated animals, the limited number of practically possible incubation times, particle losses from bags and microbial contamination of incubation residues (De Boever, 2002). Nowadays, the nylon bag technique (Meherez and Orskov, 1977) is the standard technique in feed evaluation systems (Tamminga *et al*., 1994; Thomas, 2004). Nevertheless, some drawbacks have been pointed out (Mould, 2003) and a particular importance has been given to the excessive loss of particulate material that might lead to the disappearance of undegraded material from the nylon bags. In this way, the technique might be inappropriate for feedstuffs with high proportions of soluble materials (starch, sugars) and/or high proportions of small particles (Cone *et al*., 1999). The objective of the study was to evaluate the feed potential of browse (*Ziziphus* sp.) for nutrient and utilization as supplementary feed for ruminants in the semi arid.

2. Materials and Methods

2.1 Harvesting and preparation of tree leaves

Leaves of *Ziziphus abysinica, Ziziphus mauritiana*, *Ziziphus mucronata* and *Ziziphus spinachristi* were collected from Gwoza local Government Area of Borno State, Nigeria in May 2009. The collected leaves were dried separately in forced air oven at 55^0C, ground to pass a 2 mm sieve in Willey mill and saved in polythene bags for further analysis.

2.2 Chemical analysis

Dry matter (DM) content was determined by drying the sample at 105^oC in forced air oven till the constant weight. Ash content was measured after igniting sample in a muffle furnace at 550^oC for 4 hours (h). Crude protein (CP) was determined by Kjeldahl method (Anon., 1995). Neutral detergent fiber (NDF), acid detergent fiber (ADF) and acid detergent lignin (ADL) were determined by methods of Van Soest *et al*., (1991) without the use of alpha amylase but with use of sodium sulfite. Following the wet digestion (nitric acid and perchloric acid), the P was determined by the spectrophotometer (U 1100, Hitachi), while the flame photometer (Jenway PFP7) was used to estimate Na and K concentration. Some anti-nutritional constituents that were determined in the browses include Phytate estimated as phytic acid using the method prescribed by Maga (1982),while hydrogencyanide (HCN) was determined by the Knowels and Watkins distillation method as described by Pearson (1976). Saponins and total condensed tannin were determined as reported by (Babayemi *et al*., 2004a) and (Polshettiwar *et al*., 2007). Finally, phenolics were determined using Folin Ciocalteu metho as described by Makkar (2000). All chemical analyses were done in triplicate.

2.3 In situ trial

An *in sacco* trial was conducted to examine the digestion kinetics of leaves of selected tree species. Nylon bags measuring 10×23 cm with an average pore size of 50μm were used to determine digestibility, rate of disappearance, lag time and extent of digestion of DM and NDF. A mature ruminally cannulated bull (350±10kg) was used to study *In sacco* digestion kinetics of tree leaves. The bull was fed corn bran, cowpea husk and salt lick as supplements daily and concentrate along with leaves of these trees to meet the nutritional requirements for 22 days. Initial 10 days were adjustment phase whereas following 12 days were for data collection. For each time point, there were 3 bags. Ground samples were weighed (5 g on DM basis) into nylon bags. The bags were manually pushed deep into the liquid phase of the ventral sac of rumen and incubated for 0, 3, 6, 12, 24, 36, 48, 72 and 96 h. The bags were placed in the rumen in a reverse sequence. All bags were removed at the same time to reduce variation associated with the washing procedure. After removal from the rumen, the bags were washed in running tap water until the rinse was clear. These bags were dried in forced air oven at 60^oC for 48 h. The bags were weighed and the residues were transferred into bottles and stored for analysis. Digestibility was calculated at 48 h of incubation. Rate of disappearance was determined by subtracting the indigestible residue i.e. the 96 h residue from the amount in the bag at each point and then regressing the natural log (ln) of that value against time. Extent of digestion was determined at 96 h of incubation. The rumen degradation parameters of DM were calculated using the equations of Ørskov and McDonald (1979):

$P=a + b\ (1-e^{-ct})$, Where:

P = Potential degradability after time ‘t’
a = Water Soluble Fraction (zero hour)
b = Insoluble but degradable fraction after time ‘t’
c = Rate of degradation of slowly degradable fraction b
t = Incubation length i.e. 3, 6, 12, 24, 36, 48, 72, 84 and 96 hours
e = exponential

The effective ruminal degradability of DM (EDDM) were calculated according to Ørskov and McDonald (1979): EDDM = $b \times (c/(c + k))$ where: $k = 0.06h^{-1}$ for EDDM

2.4 Statistical analysis

The data collected regarding digestibility, lag time, rate of digestion and extent of digestibility were analyzed for variance analysis in completely randomized design and means were compared using computer software Anon., (1999).

3. Results

3.1 Chemical composition of the browse leaves

The chemical composition of the browse forage leaves determined in this study is presented in Table 1. Dry matter content ranged from 937.00 g kg^{-1} DM in *Ziziphus spinachristi* to 981.00 g kg^{-1} DM in *Ziziphus abyssinica* on DM basis. On the average the dry matter content of the browse leaves in this study was 961.32 g kg^{-1} DM. Generally, the examined plant leaves had high crude protein values. The mean content of this nutrient was 153.65 g kg^{-1} DM ranging from a low value of 140.80 g kg^{-1} DM in *Ziziphus mauritiana* to 162.40 g kg^{-1} DM in *Ziziphus spinachristi.* The highest neutral detergent fibre content of 575.40 g kg^{-1} DM was recorded in *Ziziphus mucronata* while *Ziziphus abyssinica* and *Ziziphus spinachristi* had the lowest value of 481.40 g kg^{-1} DM. The acid detergent fibre levels in the experimental leaves ranged from 205.90 g kg^{-1} DM in *Ziziphus mauritiana* to 228.30 g kg^{-1} DM in *Ziziphus abyssinica* and *Ziziphus spinachristi*. The least lignin content of 108.60 g kg^{-1} DM in the browse forages was recorded in *Ziziphus mucronata* while *Ziziphus abyssinica* and *Ziziphus spinachristi* had the highest value of 119.30 g kg^{-1} DM. Ash content of the browse forages range from 70.60 g kg^{-1} DM in *Ziziphus abyssinica* to 231.60 g kg^{-1} DM in *Ziziphus mucronata* Values obtained for organic matter content of the browse forages ranged from 785.30 in *Ziziphus spinachristi* to 910.30 g kg^{-1} DM in *Ziziphus abyssinica* with a mean of 838.05 g kg^{-1} DM.

3.2 Anti-nutritional factor levels of semi-arid browse forages

The result of anti-nutritional constituents in the browse forage leaves is shown in Table 2. Total condensed tannin varied from 0.12 mg g^{-1} DM in *Ziziphus abyssinica* to 0.38 mg/g^{-1} DM in *Ziziphus mauritiana*. A range of 0.33 mg g^{-1} DM in *Ziziphus abyssinica* to 0.52 mg g^{-1}DM in *Ziziphus mucronata* was obtained for phenolic. Saponin content of the experimental leaves range from 1.92 mg g^{-1} DM in *Ziziphus mucronata* to 2.33 mg g^{-1} DM in *Ziziphus spinachristi*. Oxalate in the browses used ranged from 5.04 mg g^{-1} DM in *Ziziphus mauritiana* to 8.96 mg g^{-1} DM in *Ziziphus mucronata*. The highest value of 4.08 mg g^{-1} DM was obtained in *Ziziphus mauritiana* while *Ziziphus spinachristi* had the lowest value of 2.97 mg g^{-1} DM for Phytic acid in the browses studied. The hydrogen cyanide and Fluoroacetate are generally low in all the browse samples studied. The result showed no significant difference among the browse forages.

3.3 Dry matter Disappearance

The results of the study showed significant difference (P<0.05) among browse forages from the incubated leaves (0 - 96 hrs) is shown in Table 5. There was an increasing disappearance of DM from the incubated leaves over time. This was generally moderately in all plant leaves. At 48 hours of incubation over 40% of the dry matter in most of the leaves had been degraded. Most of the plant leaves were 70% degraded at 96 hours of incubation except *Ziziphus abyssinica* with 71.29% degraded at 96 hours.

3.4 Dry matter (DM) degradation characteristic

Degradation characteristics for dry matter in the different browse leaves incubated in the rumen of bulls are presented in Table 6. Significant differences (P<0.05) were observed between the leaves in all the degradation characteristics except for rate of DM degradation ‘c’. Soluble dry matter fraction 'a' was observed to be more in *Ziziphus mauritiana* (17.11%) with the least value being in *Ziziphus abyssinica* (8.01%). The insoluble but degradable DM fraction ‘b’ was observed to be highest in *Ziziphus mucronata* with a value of 75.81% and lowest in *Ziziphus abyssinica* with 65.19%. It was observed in this study that although relatively close, the potentially degradable DM ‘a+b’ value was more in *Ziziphus mucronata* (91.92%) while *Ziziphus mauritiana* with a value of 73.20% had the least. The rate of DM degradation ‘c’ per hour of the potentially degradable portion showed no significant difference (P>0.05) among the browse forages. Values for effective degradability (ED) of DM at 0.12-outflow rate were found to be generally low with the highest value in *Ziziphus abyssinica* with 29.50 whereas *Ziziphus spinachristi* had the least value of 22.60.

4. Discussion

4.1 Chemical composition

The high CP content of browse species is well documented and is one of the main distinctive characteristic of browse compared to most grasses. Norton (1998) reported a range of CP contents from 12 to 30% for tropical tree legumes, and Le Houerou (1980) gave a mean of 12.5% in West African browse species with about 17% for leguminous species. Generally, the CP content in browse has been shown to be above the minimum level required (7%) for microbial activities in the rumen (Norton, 1998). Le Houerou (1980) also noted that all browse species are able at all their phenological stages to meet the energy requirements of livestock at maintenance level and often well above, and thus West African browse are considered to be excellent fodder, with very few exceptions. The difference in CP content between species can be explained by inherent characteristics of each species related to the ability to extract and accumulate nutrients from soil and/or to fix atmospheric nitrogen, which is the case for legumes plants. The other factors causing variation in the chemical composition of browse forages include soil type (location), the plant part (leaf, stem, pod), age of leaf and season. With regard to the location, some authors have reported that browse plants in the Sahelian zone are higher in N compared to plants in the humid zone (Rittner and Reed, 1992). Younger leaves are richer in N than mature leaves, which however contain more N than the latter. With regard to the fibre content, Rittner and Reed (1992) reported similar mean for NDF and lignin contents across different ecological zones as follows 40.1% and 11.7% in the Sahelian zone, 45.7% and 10.5% in the sub-humid zone and 43.6% and 9.3% in the humid zone respectively. Fall (1993) found a range of 31 to 57% for NDF and 19 to 43% for ADF. The values of the present study were generally higher and fall within the range reported by Njidda *et al.* (2008) and this can limit feed intake (Meissner *et al.,*1991). This species also had a high lignin content. Lignin is a component of the cell wall, and deposited as part of the cell wall-thickening process (Boudet, 1998). Lignin is in general higher in browse than in herbaceous plants. The content varies according to species, age and the plant parts. Positive correlations were reported between contents of lignin and soluble or insoluble proanthocyanidins (Rittner and Reed, 1992). Reed (1986) also found a negative correlation between the content of NDF and soluble phenolics, while the correlation with insoluble proanthocyanidins was positive. The browse forages had moderate to high content of fibre. This is a positive attribute of the browse forages since the voluntary DM intake and digestibility are dependent on the cell wall constituents (fibre), especially the NDF and lignin (Bakshi and Wadhwa 2004).

4.2 Secondary metabolites

Tannins are phenolic plant secondary compounds and are widely distributed through the plant kingdom, especially legumes and browses which affect animal performance in many countries (Min *et al*., 2003). The level of CT is lower than the range of 60 to100 g Kg^{-1} DM considered to depress feed intake and growth (Barry and Duncan, 1984) but within the range 0.41 to 0.81 mg g^{-1} DM reported by Njidda *et al.* (2008) for semi arid browse forages. Feeding tannin containing plant can decrease ruminal protein degradation, promote microbial crude protein (CP) synthesis (Cardozo *et al.,* 2004), and prevent excessive ruminal gas formation which can lead to bloat (Wina *et al.,* 2004). However, in ruminants, dietary condensed tannins of 2 to 3% have been shown to have beneficial effects because they reduce the protein degradation in the rumen by the formation of a protein-tannin complex (Barry, 1987) and increasing absorption of amino acids in the small intestine (Barry and McNabb, 1999). Phenolic compounds are the largest single group of secondary plant compounds (SPCs), and total phenolics in plants can reach up to 40% of the dry matter (Reed 1986; Tanner *et al*., 1990). In grasses, the major phenolic is lignin that is bound to all plant cell walls, and is a significant limiting factor in their digestion in the rumen (Minson, 1990). Lignin is also a limiting factor in the digestion of legumes, but is bound largely to the vascular tissue (Wilson 1993), with often high concentrations of other free and bound phenolic compounds (phenolic acids, coumarins and flavonoids) in floral, leaf and seed tissues (McLeod, 1974). Oxalate content in this present study was low. It has been reported that 20g/kg oxalate can be lethal to chicken (Acamovic *et al*., 2004). Oxalate has been shown to deplete the calcium reserve, but these browse species were found to contain reasonable amount of calcium, magnesium and phosphorus. Saponins are group of compounds containing an a-glycone moiety linked to carbohydrates. Many plant species consumed by livestock contain saponins. Feedstuffs containing saponin have been shown to be defaunating agents (Teferedegne, 2000) and capable of reducing methane production (Hu *et al.,* 2005). Cheeke (1971) reported that saponins have effect on erythrocyte haemolysis, reduction of blood and liver cholesterol, depression of growth rate, bloat (ruminant), inhibition of smooth muscle activity, enzyme inhibition and reduction in nutrient absorption. Saponins have been reported to alter cell wall permeability and therefore to produce some toxic effects when ingested (Belmar *et al*.,1999). Phytic acid is a phosphoric acid derivative of myo-inositol. It constitutes an important component of forage plants with the ability to chelate essential minerals including calcium, magnesium, iron, zinc and molybdenum (Iqbal *et al*., 2005). The resulting chelates resist breakdown in the digestive tract and become unavailable thus inducing dietary deficiency of these elements (NRC 2001; Iqbal *et al*., 2005). Most of the phosphorus in plants is organically bound to phytic acid (Maga, 1982). The HCN contents of the browse species examined were equally low. The lethal dose of HCN for cattle and sheep is 2.0 to 4.0 mg per kg body weight. The lethal dose for cyanogens would be 10 to 20 times greater because the HCN comprised 5 to 10% of their molecular weight (Conn, 1979). However, the quantity of HCN produced by most of these species is too low to pose major animal health problems (Kumar and D'Mello, 1998).

4.3 DM disappearance from browse forage leaves incubated in the rumen of bulls

The disappearance of dry matter from the browse plant leaves in this study was observed to be moderate and well above 40% of their reported potential degradability values after 48hrs incubation. According to Ehargava and Ørskov (1987) high degradability values after 48hrs of incubation imply high digestibility since degradability values at this time are regarded as being equivalent to digestibility. Kimambo and Muya (1991) confirms this fact that degradability values at 48hrs of incubation are the most important as this period is closer to the mean retention time of 48hrs for fibrous feeds in ruminants. Thus McDowell (1972) considered such high degradability values to be adequate for high performance of animal on pastures. The resultants effect of this high degradation values after 48hrs of incubation was the almost complete disappearance of dry matter by 96hrs of incubation for most of the browse forage leaves.

4.4 In situ dry matter digestion kinetics

The rapidly degradable fraction 'a' was generally low across the leaves studied. This is possibly an indication of high level lignifications in most of the leaves or may have, according to Adogla-Bessa and Owen (1995) and Dzowela *et al.* (1995), resulted from the accumulation of soluble carbohydrates due to later stages of maturity. The 'a' fraction of dry matter in 75% of the studied browse leaves were below the values reported by Larbi *et al.*

(1998) for some tropical browse forages. The slowly degradable or insoluble but 'fermentable dry matter fraction 'b' differed between the investigated leaves and mostly high. *Pterocarpus erinceus* was richest in insoluble but fermentable dry matter content' with 82.65%. This observation may probably be due to it cell wall content (Wilson, 1994). Potentially degradable 'a+b' dry matter in the browse leaves was high, above 50%. However, according to Singh and Makkar (1992) the statistical variations may be associated with their fibrous components such as the structural polysaccharides, which vary in their degradation among forages. The highest value 91.92 for this parameter recorded in *Ziziphus mauritiana* may have been due to its high content of slowly degradable fraction. The significantly low rate of degradation recorded in *Maerua angolensis* and most of the browse forages under study may be alluded to the observations of Cheng *et al*. (1984) that dry matter degradation characteristics may be due to the cell wall configuration of their polysaccharides and their effect on microbial attachment -and colonization of digest particles. The effective degradability of dry matter in the investigated shrub and tree leaves at a rumen out flow rate of 0.12 varied significantly ($P < 0.001$). The effective degradability of dry matter in the investigated shrub and tree leaves at a rumen out flow rate of 0.12 varied significantly ($P < 0.001$). According to Mupangwa (2003) variations in effective degradability of dry matter in forages closely corresponds with the proportion of potentially degradable dry matter and level of NDF Llamas-Lamas and Combs (1990) have observed forages with low fibre to have high effective dry matter degradability compared to those with high fibre content.

5. Conclusion

Selected tree leaves by virtue of having high CP, shorter lag time and faster digestion rate are compatible to concentrates. The browse forages have high level of P and hence no need for P supplementation when fed to ruminants.

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Table 1. Chemical composition of the browse forages (Ziziphus) species (g kg^{-1} DM).

Browse Forages	DM	CP	NDF	ADF	ADL	Ash	OM
Ziziphus abyssinica	981.00^{a}	157.00^{b}	481.40^{c}	228.30^{a}	119.60^{a}	70.60^{d}	910.30^{a}
Ziziphus mauritiana	973.00^{a}	140.80^{d}	488.30^{b}	205.90^{c}	115.80^{b}	139.40^{c}	833.30^{b}
Ziziphus mucronata	954.30^{b}	154.40^{c}	575.40^{a}	211.80^{b}	108.60^{c}	231.60^{a}	823.30^{c}
Ziziphus spinachisti	937.00^{c}	162.40^{a}	481.40^{c}	228.30^{a}	119.60^{a}	151.60^{b}	785.30^{d}
MEAN	**961.32**	**153.65**	**506.625**	**218.575**	**115.9**	**148.3**	**838.05**
SEM	**1.23**	**1.06**	**2.11**	**1.13**	**0.98**	**0.73**	**2.12**

a,b,c,d=mean values along the same column with different superscripts are significantly different (P<0.05); DM=Dry matter; CP= Crude protein;NDF=Neutral detergent fibre; ADF=Acid detergent fibre; ADL=Acid detergent lignin;OM=Organic matter and SEM=Standard error of means.

Table 2. Anti-nutritional factors of the browse forages (Ziziphus) species (mg g^{-1} DM)

Browse Forages	TCT	PHE	SAP	OXA	PHY	HCN	FLU
Ziziphus abyssinica	0.12^{d}	0.33^{c}	2.17^{b}	5.37^{b}	3.67^{b}	0.03	0.0006
Ziziphus mauritiana	0.38^{b}	0.34^{lc}	2.23^{b}	5.04^{b}	4.08^{a}	0.07	0.0010
Ziziphus mucronata	0.21^{c}	0.52^{a}	1.92^{c}	8.96^{a}	3.51^{b}	0.05	0.0004
Ziziphus spinachisti	0.41^{a}	0.49^{b}	2.33^{a}	8.30^{a}	2.97^{c}	0.03	0.0011
MEAN	**0.2125**	**0.42**	**2.1625**	**6.9175**	**3.5575**	**0.045**	**0.000675**
SEM	**0.08**	**0.06**	**0.67**	**0.72**	**0.33**	**0.070NS**	**0.0002**

a,b,c,d=mean values along the same column with different superscripts are significantly different (P<0.05); TCT=Total condenced tannin; PHE=Phenolics; SAP=Saponin; OXA=Oxalate; PHY=Phytate: HCN=Hydrogen cyanide; FLU; Floroacetate; SEM=Standard error of means.

Table 3. Dry Matter Disappearance of the Ziziphus species semi-arid browses (% DM)

Browse forages	**0**	**3**	**6**	**12**	**24**	**48**	**72**	**96**
Ziziphus abyssinica	8.01^{a}	10.36^{a}	20.55^{a}	30.21^{a}	40.17^{a}	49.41^{c}	59.59^{b}	71.29
Ziziphus mauritiana	7.29^{b}	9.98^{a}	20.14^{a}	31.28^{a}	39.53^{a}	51.13^{b}	61.29^{a}	70.31
Ziziphus mucronata	5.21^{d}	6.64^{b}	17.78^{b}	28.25^{b}	38.61^{ab}	59.00^{a}	61.05^{a}	70.29
Ziziphus spinachisti	6.33^{c}	7.38^{b}	17.41^{b}	27.90^{b}	37.86^{ic}	49.37^{c}	59.48^{b}	70.65
MEAN	**6.7**	**8.59**	**18.97**	**29.41**	**39.0425**	**2.2275**	**60.3525**	**70.635**
SEM	**0.2'**	**0.84**	**1.16**	**1.24**	**1.11**	**0.97**	**1.33**	**2.76**

Table 4. Degradation characteristics and Effective degradability of DM of browse forages incubated in the rumen of bulls

Browse Forages	**a**	**b**	**a+b**	**c**	**Lag T**	**ED**
Ziziphus abyssinica	8.01^{d}	65.19^{b}	73.20^{c}	0.025	0.90^{b}	29.50^{a}
Ziziphus mauritiana	17.11^{a}	69.68^{b}	86.79^{d}	0.014	1.20^{a}	25.70^{b}
Ziziphus mucronata	16.11^{b}	75.81^{a}	91.92^{d}	0.012	0.90^{b}	23.90^{c}
Ziziphus spinachisti	14.34^{c}	74.51^{a}	88.85^{b}	0.014	0.20^{c}	22.60^{d}
MEAN	**13.8925**	**37.58**	**85.19**	**0.0162**	**0.8**	**4.25**
SEM	**0.98**	**1.16**	**2.16**	**0.008**	**0.02**	**0.98**