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Effects of Supplementation with Forage Resources from Natural Pasture on the Growth Performance and Ruminal Fermentation of Grazing Calves in Dry Season.

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Target Audience: Forage Scientists, Ruminant Nutritionists

Abstract

The feeding value of forage resources from the natural pasture as dry season feed supplements for grazing calves was evaluated. Sixteen cross bred calves (White Fulani X N'dama) with initial body weights of 82.5-87.0 kg were grouped into four treatments with four animals per treatment. The treatments consist of sole grazing (SG) in the natural pasture, grazing + hay (G+H), grazing + Leucaena leucocephala leaves (G+LL) and grazing + silage (G+S). The study lasted for 84 days growth trial and 7 days digestibility trial. Rumen fluid was sampled at the end for pH, ammonia nitrogen and volatile fatty acids determination. Average daily gain (2.2, 7.5, 9.5 and 8.5 kg) for SG, G+H, G+LL and G+S, respectively (P < 0.05) among treatments. Ruminal ammonia concentration was in the order of G+LL> G+S> G+H and SG (P < 0.05). The study showed that all the grazing animals that were supplemented increased in weight and had better rumen fermentation, indicating relatively better feeding value. Hence resources from natural pastures, if well managed in form of hay and silage, can be good supplements especially in the dry season when forages in most pastures are in short supply and low in quality.

Keywords: Natural pasture; *Leucaena leucocephala* leaves; hay; silage; rumen parameters.

Description of Problem

Calves are the foundation stock from which the various categories of the adult cattle are obtained. Feeding them adequately could bring about a significant overall improvement in cattle production under the prevailing system. Although, many nutritional studies in Nigeria and elsewhere (1, 2) have recommended the use of various concentrate feeds for calves, the scarcity and high cost of the ingredients for such feeds have limited their use by farmers. Although many of the agro-pastoral farmers in south western part of Nigeria produce some arable crops such as maize, sorghum and cowpea, these are rarely fed to stock as they are usually meant for the household consumption (3). Similarly, the use of chemical treatments in crop residues to improve their nutritive value are rare because of the cost effectiveness and

processing. Therefore, identifying feed resources that are locally available and easily accessible to smallholder farmers for use as a basal diet is imperative. Emphasizing the use of local resources for the management and feeding their livestock will enhance incomes of small-scale farmers.

Herbage availability during the wet season in natural pastures often exceeds animal requirements (4). The unharvested forage loses most of its nutritive value with maturity stage and they become rank. Due to lack of quality forage especially in the dry season, animals feeding on them tend to lose their weight and their productivity are negatively affected.

In order to reduce the limitations of feeds for ruminant animals especially during dry season, there is a need to develop feed conservation strategies. By conserving the excess forages at the right stage of growth when their qualities can meet the animal's requirements, during the period of abundant supply in the natural pasture, so as to make available feeds supply throughout the year.
Ruminants derive substantial part of their nutrients from microbes. These microbes make useful contributions to particle size reduction of forages during digestion (5).

The extent to which forages are digested in the rumen is determined by the chemical and physical nature of the fibre, which in turn depends on the genetic make up of the plant and the environment where it grows (6). Therefore, there is need to study the suitability of processed forage (hay, silage and browse plants) from natural pasture on body weight gain and ruminal fermentation of grazing calves during the dry season.

Materials and Method

Location of study area

This study was carried out at the Cattle Experimental Unit of Teaching and Research Farms Directorate, Federal University of Agriculture, Abeokuta Nigeria. The site lies within the derived savanna agro-ecological zone of South Western Nigeria (latitude: 7◦N, longitude 3.5◦E, average annual rainfall: 1037 mm). Abeokuta has a bimodal rainfall pattern that typically peaks in July and September with a break of two to three weeks in August. Temperatures are fairly uniform with day time values of 28–30 ◦C during the early rainy season of the year (April – June), and late rainy season (July – September) and 30–34 ◦C during the early dry season (October–December) and late dry season (January – March) with the lowest night temperature of around 24 ◦C during the harmattan period between December and February. Relative humidity is high during the rainy season with values between 63 and 96 % as compared to the dry season (55–84%). The temperature of the soil ranges from 24.5 to 31.0 ^{o}C (Source: Agromet Dept., FUNAAB).

Experimental diets

During late rainy season when the available natural forages were high in both quantity and quality, forage samples were harvested. After harvesting, the

forages were sorted out and the proportion of each plant species in the composite were weighed and recorded as follows: *Hyparrhenia rufa* (2.06 %), *Panicum maximum* (6.21 %), *Andropogon tectorum* (11.24 %), *Cynodon nlemfuensis* (2.12 %), *Andropogon gayanus,* (17.82 %), *Pennisetum pedicellatum,* (2.11 %), *Pennisetum purpureum,* (23.11 %), and the legumes components were *Calopogonium mucunoides,* (7.45 %), *Mucuna pruriens* (9.13 %) and *Tephrosia bracteolata* (18.75 %). The forages harvested from the natural pasture were divided into two portions and were conserved as hay and silage. The conserved forages were then stored to serve as supplements to grazing calves during the dry season. Leaves of *Leucaena leucocephala* were harvested fresh on a daily basis during the late dry season and were fed to the animals in a cut-and-carry system. However, during the dry season, forage from the natural pasture (*Pennisetum purpureum, Andropogon gayanus, A.tectorum, Panicum maximum, Sorghum almum* and legumes *Stylosanthes hamata, Calopogonum mucunoide, Centrosema molle*) *that were* readily consumed by calves were harvested and analysed for their chemical composition.

Animals and management

Sixteen crossbred calves (White Fulani x N'dama) aged between 9-12 months, with an average live weight of 83.8 kg were used in a 84-day experimental period which was preceded by an adaptation period of 12 days to get adjusted to the environment. The animals were thereafter, distributed into four groups based on their initial body weight. Each group consisted of four comparable animals which were then randomly assigned to one of the four dietary treatments in a completely randomized design which were: sole grazing, grazing + hay, grazing +silage and grazing + *L. leucocephala* leaves. They were dewormed with 1 ml/10 kg body weight of *albendazole* and treated with ivomec against *ectoparasites* at 0.5 ml/10 kg body weight. The animals were housed individually in well ventilated, thoroughly washed and disinfected pens. The diets were fed to the calves at 3 % BW/day on dry matter basis at 07.30 to 11.00 hr everyday while water was provided *ad libitum*. After this, the animals were released for grazing until 16.00 hr.

Feed intake and weight gain measurements

The growth of animals in response to the experimental treatments were monitored by taking initial weights of individual animals at the commencement of the trial and followed by individual weighing on a weekly basis prior to feeding, to determine weekly weight changes. Quantities of feeds offered daily per animal and quantities refusals were weighed and recorded every morning to compute the daily feed intake.

Rumen sampling

Rumen fluid samples (30 ml on average) were taken from three calves per treatment at the end of the feeding trial, 3

h after the morning meal, by using a flexible stomach tube according to the method described by (7). The rumen liquid was strained through two layers of cheese cloth and its pH was determined with a pH meter. 1 ml of orthophosphoric acid solution (5% v/v) was added to 5 ml of liquid, mixed and immediately stored frozen at -20^{o}C for subsequent determination of volatile fatty acids analysis, ammonia concentration and microbial contents. Ammonia concentration and microbial contents were determined as described by (8).

Volatile fatty acids (VFAs) measurements

Frozen rumen liquid samples were thawed in the refrigerator overnight. After thawing, the samples per treatment were bulked by sampling time, centrifuged at 10, 000 × g for 15 min at 4^{o}C. 5 ml of supernatant was left to stand on ice for 30 min after addition of 1 ml of 5% *m*-phosphoric acid and then centrifuged at 10,000 × *g* for 10 min. The mixture was then analysed for VFAs by gas chromatography according to the method described by (9).

Chemical analyses

The hay, silage, *L. leucocephala* leaves and forages from the natural pastures were weighed fresh at the time of collection, and then oven dried at 65 ^{o}C to constant weight to determine DM content. The dried samples were ground with hammer mill through a 1-mm sieve and stored for subsequent chemical analyses. Parameters analysed according to the standard methods of (10) included ash, crude protein, ether extract, while fibre parameter, neutral detergent fibre (NDF), acid detergent fibre and acid detergent lignin (ADL) were determined with (11) procedure. Cellulose was taken as the difference between ADF and lignin while hemicellulose was taken as the difference between NDF and ADF.

Statistical analyses

The experimental data were analysed as a completely randomized design according to the following linear model:

$$\gamma_{ij} = \mu + T_i + \epsilon_{ij}$$

Where μ is the population mean, T_i is the processed forages from natural pasture treatment effect and ϵij is the residual error. The statistical analyses were carried out using (12). Significant differences were accepted if $P \leq 0.05$.

Results and Discussion

Chemical composition of the diets

Table 1 shows the chemical composition of the hay, silage, *Leucaena leucocephala* leaves and forage samples from the natural pasture. The CP content ranged from 59 g/kg DM in natural pasture forages to 171 g/kg in *Leucaena leucocephala* leaves and was higher ($P < 0.05$) in *Leucaena leucocephala* leaves than other treatments. The mean NDF content was 607 g/kg DM ranging from 560 g/kg DM in *Leucaena leucocephala* leaves to 705 g/kg DM in natural pasture forages ($P < 0.05$).

The CP content of the natural pasture hay in this study was higher than the value of 73 g/kg DM recorded by (13) for natural pasture grass hay in Ethiopia. The variation in CP contents of natural

pasture hay in this study could be due to its combination with grasses and legumes.

Moreover, it has been noted that CP value of 8 % is required to satisfy maintenance requirement of ruminant animals (14). Hence the observed CP content of the natural pasture in the current study may not be sufficient to satisfy the demand for rumen microbial synthesis.

Table 1: Chemical composition (g/Kg DM) of hay, *L. leucocephala* leaves, silage and forage samples from the natural pasture.

	DM	C P	NDF	ADF	ADL	Hem	Cellulose	ME* ($MJKg^{1}$)
Hay	905^{a}	92^{b}	589^{b}	436	$175a^{b}$	153	262	125^{c}
L. leucocephala	316^{d}	171^{a}	560^{b}	381	116^{c}	179	266	133^{a}
Silage	336^{c}	108^{b}	574^{b}	363	128^{bc}	211	236	129^{b}
Natural pasture	870^{a}	59^{c}	705^{a}	440	184^{a}	265	256	123^{c}
±SEM	84.72	14.2	18.60	9.89	7.07	9.61	3.20	1.13

$^{a, b,\cdots}$: Means in each column with the different letters are significant ($P<0.05$). SEM- Standard Error of Means.

*Calculated according to De Boever *et al.* (1997)

DM: Dry matter; CP: Crude protein; NFE: Nitrogen free extract; NDF: Neutral detergent fibre; ADF: Acid detergent fibre; ADL: Acid detergent lignin; Hem: Hemicellulose; ME:- Metabolizable energy.

Natural pasture composition during the dry season: (*Pennisetum purpureum, Andropogon gayanus, A.tectorum, Panicum maximum, Sorghum almum, Stylosanthes hamata, Calopogonum mucunoide, Centrosema molle*)

However, the mean CP contents of hay, silage and *Leucaena leucocephala* leaves (supplementary diets) were all above minimum level necessary to provide sufficient nitrogen required by rumen microorganisms to support optimum activity.

The contents of neutral detergent fibre (NDF) in natural pasture during the dry season were above the recommended threshold level (550-600 g/kg DM) for healthy rumen function (15) and also for better feed intake and digestibility (16). McDonald *et al*. (17) noted that feeds that contain high proportion of ADF have low availability of nutrients due to the negative correlation between ADF and feed digestibility. For improved intake and production of finishing ruminants, fibre content of feed should not exceed 150-200 g/kg DM (18). Therefore, the basal diets in the present experiment reflected typical characteristics of tropical forages. Van Soest *et al.* 11 noted that such type of roughage diets can limit feed intake and digestibility.

Effect on growth parameters

Table 2 showed the growth performance of grazing calves supplemented with different feed resources from the natural pasture. The total weight gain of the grazing calves supplemented with feed resources from the natural pasture were significantly higher ($P < 0.05$) than the calves that were grazing alone. Growth rate for grazing calves supplemented with *L. leucocephala* leaves and silage were significantly higher ($P < 0.05$) than that of calves supplemented with hay, which was significantly higher than the calves that are grazing alone. Differences among treatment means in average weight gain in this study might mainly be due to differences in CP contents, digestibility and ruminal NH_3-N concentration among dietary treatments.

The higher rate of live weight gain on supplemented calves is apparently attributed to a higher digestibility. The lowest average weight gain and growth rate recorded for calves grazing alone in the natural pasture without any form of supplementation may be attributed to lowered CP content of the forages during the sampling period. The lower CP content recorded for natural pasture may be largely due to moisture stress experienced by the forages during the dry season and build up of lignocellulosic fibre structure of the plants diluting the nitrogen (19). Moreover, the lower weight gain might also be due to reduced voluntary forage intake (which will reduce intake of most nutrients) and utilization due to higher fibre levels and reduced digestion due to lower crude protein contents of the forage on the range.

The highest weight gain on calves supplemented with *L. leucocephala* leaves was also similar to the report by (20) in goats fed *L. leucocephala* leaves. This could be as a result of increased intake of protein by the calves. Mpairwe *et al.* (21) indicated that a dietary CP content of 11 % was ideal for normal weight gain by ruminant animals. Higher CP content of *L. leucocephala* leaves which is often associated with high dry matter intake may have resulted in faster rates of passage of digesta through the gastro-intestinal tract (20).

Effect on rumen fermentation

Values for pH, ammonia and volatile fatty acids in rumen fluid are shown in Table 3. There was significant ($P < 0.05$) difference in rumen pH among the treatment groups. The level of rumen ammonia nitrogen (NH_3- N) concentration was impacted by treatment ($P < 0.05$). Calves that consumed *L. leucocephala* leaves as a supplementary diet recorded the highest rumen ammonia nitrogen followed by the ones supplemented with silage and hay, while the unsupplemented sole grazing had the lowest rumen NH_3-N concentration. The total volatile fatty acid increased significantly ($P < 0.05$) from 56.37 mol L^{-1} in calves without supplementation to 77.00 mol L^{-1} for calves supplemented with *L. leucocephala* leaves. Normally, ruminant animals depend on cellulolytic bacteria to digest cellulose, but these bacteria cannot resist the low ruminal pH

and an increase in pH gradient leads to anion toxicity (22). The lowest ruminal pH recorded for calves without supplementation, could be the reason for lowest number of bacterial available that should be responsible for the digestion of cellulose in unsupplemented calves.

Table 2: Body weight parameters of grazing calves fed different forage resources from natural pasture.

Parameters	Grazing + hay	Grazing+ *L.leucocephala*	Grazing + silage	Sole grazing	±SEM
Initial Average weight (kg)	85.0	82.5	87.0	80.84	1.16
Final Average live weight (kg)	92.5	92.0	95.5	83.04	1.19
Average weight gain (kg)	7.5[a]	9.5[a]	8.5[a]	2.20[b]	0.75
Metabolic weight gain ($g/kgW^{0.75}$)	29.0[ab]	34.7[a]	31.9[a]	4.60[c]	1.40
Growth rate (g/d)	89.3[b]	113[a]	101[a]	26.2[c]	4.76
Supplementary intake (g/d)	451	543	441	0.0	38.41
Metabolic intake($g/kgW^{0.75}$)	97.9[b]	113[a]	96.3[b]	0.0	13.57

[a, b,...]: Means in each column with the different letters are significant (P<0.05). SEM- Standard Error of Means
Natural pasture composition during the dry season: (*Pennisetum purpureum, Andropogon gayanus, A.tectorum, Panicum maximum, Sorghum almum, Stylosanthes hamata, Calopogonum mucunoide, Centrosema molle*)

The low ruminal pH observed for unsupplemented calves in this study might be due to lower CP contents of the forages that were available during the dry season.

The mean concentration of NH_3-N for calves that were supplemented appeared to be sufficient to meet the N requirements of the rumen microbial population since it lies within the range 50-70 mg NH_3-N/L rumen liquor reported for normal microbial activity (13). For maximum nutrient utilization, however, 150-200 mg/L rumen fluid is essential (23), which was reached in the present study for grazing calves that where supplemented with *L. leucocephala* leaves. This is possible probably due to the high level of total CP intake. In this study, NH_3-N concentration was higher in calves that were supplemented, which obviously is related to the ingestion of relatively more degradable crude protein. Similarly, (24) recorded increased tendency of NH_3-N in the rumen fluid as the quantity of nitrogen in the diet increases. However, the NH_3-N content in this study was lower than the value of 412 mg/L for *L. leucocephala* leaves fed to goats (25). The differences could be attributed to environmental condition, stage of maturity at harvest, post harvesting

handling that was carried out and different species of animals used.

The mean ruminal ammonia concentration of the animals that were only grazing the natural pasture during the dry season was lower than that of the animals that were supplemented. The obvious reason for this could be as a result of large differences in CP contents of the supplemented and the unsupplemented calves. This could have been explained that microbial growth efficiency is higher in the rumen of calves that were supplemented compared with the unsupplemented ones.

Reliable evidence exists in ammonia as an essential nutrient for the growth of cellulolytic micro-organisms in the rumen (26). The requirements for these nutrients by cellulolytic micro-organisms which were supplemented can be expected to be high because of the combination of high cell wall content, a high cell wall digestibility and a low retention time in the rumen (27).

Table 3: Rumen fermentation characteristics of grazing calves with or without supplementation from forage resources from natural pasture

Parameters	Treatments				SEM
	Grazing + Hay	Grazing + *L. leucocephala*	Grazing + Silage	Sole grazing*	
pH	5.68^{ab}	6.51^{a}	6.08^{ab}	5.30^{b}	0.17
NH_3-N (mg/l)	65.30^{c}	167^{a}	82.10^{b}	42.30^{d}	14.21
Total VFA (mM/L)	67.80^{c}	77.00^{a}	70.40^{b}	56.37^{d}	2.26

$^{a, b,\ldots}$: Means in each column with the different letters are significant (P<0.05). SEM- Standard Error of Means.

VFA: Volatile fatty acids; NH_3-N: Ammonia nitrogen

*Natural pasture composition during the dry season: (*Pennisetum purpureum, Andropogon gayanus, A.tectorum, Panicum maximum, Sorghum almum, Stylosanthes hamata, Calopogonum mucunoide, Centrosema molle*)

The highest level of rumen ammonia recorded for *L. leucocephala* leaves can be interpreted as supporting the viewpoint of (28) that the value of tree foliage is mainly to provide nutrients for the rumen microbial fermentation.

Lower value of rumen ammonia for forages from natural pasture during the dry season may be due to the fact that, the forages have become matured which lower the CP content, increased fibre components, which would have led to lower intake and digestibility by the grazing calves.

The ruminal ammonia content of calves supplemented with hay from natural pasture, was higher than the value reported by (13) for natural pasture grass hay. This could be because of higher CP content of hay in this study compared with 73 g/kg DM from natural pasture for grass hay. The differences in CP and

ammonia concentration of hay used compared with others, might be because it was the combination of both grasses and legumes, which enhanced it quality.

Total VFA concentration was significantly affected by different dietary treatments. Total VFA concentrations of calves supplemented with *L. leucocephala* leaves and silage were in normal concentration of 70 to 130 mM/L, (29) while hay and sole grazing were lower ($P < 0.05$). The higher VFA measured in the rumen liquor of the calves that were supplemented compared with those without supplementation may also be explained if lysis of microbial cells and degradation of the cells is lower with unsupplemented calves.

Additional live weight gain of the calves and growth of micro-organisms in grazing calves supplemented may be because the supplemented diets have released considerable quantities of iso-butyrate and iso-valerate into the rumen fluid (30).

The increased animal production was the result of a better balance of nutrients absorbed by the supplemented calves and the overall efficiency of feed utilization improved because of the reduction in heat production (27).

Effect on rumen microbes

Table 4 shows the rumen microorganism population. There was significant differences between the treatments ($P<0.05$). Grazing calves that were supplemented (with hay, silage and *L. leucocephala* leaves) recorded higher number of microorganisms that were responsible for digestion of forages than calves that were grazing on natural pasture alone. Supplementation of forage resources from natural pasture has resulted in increased number of bacteria population while the sole grazing decreased. At pH below 6.0, the cellulolytic bacteria are inhibited and feed intake depressed (22). Most ruminal bacteria prefer pH near neutrality for growth (31), this could be the reason that calves supplemented with *L. leucocephala* leaves with pH near neutral recorded the highest number of microorganisms that were available for digestion. The predominant ruminal bacteria are particularly sensitive to low pH. Also, calves that were supplemented with *L. leucocephala* leaves, had pH value that fell between 6.5 to 7.0, which is required for maximum microbial growth (31).

Table 4: Influence of different forage resources from natural pasture on ruminal bacteria and total bacteria population in grazing.

Treatments	Bacteria isolated	Total viable count x 10^{10} -----(Cfuml^{-1})-----
Grazing + Hay	*Bacillus caseus,* *Pseudomonas auregunosa,* *Protues vulgaris,* *Escherichia coli,* *Micrococcus acidiophilus* *Bacillus subtilis,* *Streptococcus aureus,*	6.9a
Grazing + *L. Leucocephala*	*Staphylococcus aureus,* *Pseudomonas putida,* *Pseudomonas gellucidum,* *Streptococcus faecalis,* *Protues morganic* *Aerobacter aerogenes,*	7.5a
Grazing +Silage	*Pseudomonas fragic,* *Streptococcus faecum,* *Streptococcus aureus,* *Bacillus macerans,* *Bacillus funns,* *Micrococcus luteus,*	7.4[a]
Sole grazing*	*Bacillus sublicus,* *Micrococcus acidiophilus,* *Protues vulgaris,* *Pseudomonas aureginosa,*	4.3b
±SEM		0.21

[a, b,...]: Means in each column with the different letters are significant (P<0.05). SEM- Standard Error of Means.

*Natural pasture composition during the dry season: (*Pennisetum purpureum, Andropogon gayanus, A.tectorum, Panicum maximum, Sorghum almum, Stylosanthes hamata, Calopogonum mucunoide, Centrosema molle*).

Conclusion and Application

It was concluded that

1. Processed forages from natural pasture compared with forages during the dry season from the natural pasture, contained relatively high CP with greater digestibility which improved average weight gain and rumen NH_3-N concentration.

2. Processed forage resources from the natural pasture, could be utilized as supplements for ruminant animals grazing, especially in the dry season when most of the conventional roughages are in short supply and low in CP content.

References

1. Moss, R.J. (1993). Rearing heifers in the subtropics and tropics. Nutrient requirements and supplementation. *Tropical Grasslands* 27: 238-249.
2. Little, D.A., Wassink, G.J., Riley, J.A. Agyemang, K., Badjie, B. and Dwinder, R.H. (1994). Feed supplementation of village-based N'Dama calves. *Tropical Agriculture* (Trinidad) 71: 219-222.
3. Okoruwa, V.O. (1994). *The Economics of Agro-pastoral Production Systems in the derived Savanna of Oyo State Nigeria.* PhD Thesis University of Ibadan, Nigeria. 237pp.
4. Crowder, L.V. and Chedda, H.R. (1982). *Tropical Grassland Husbandry*. Longman Inc., New York.562pp.
5. Bowman, J.G.P. and Firkin, J.L. (1996). In situ particle size reduction as affected by forages species and grinding mesh size. *Journal of Animal Science,* 73: 439-446.
6. Osuji, P.D., Fernandez-Rivera, S. and Odenyo, A. (1995). Improving fibre utilization and protein supply in animals fed poor quality roughages. In: ILRI Nutrition Research and Plans. In: Wallace, R. J. and Lahlou-Kassi, A. (eds). Rumen Ecology Research Planning. Proceedings of a workshop held at ILRI, Addis Ababa, Ethiopia. 13-18 March, 1995. ILRI (International Livestock Research Institute), Nairobi, Kenya. P. 1.
7. Babayemi, O.J. and Bamikole, M.A. (2006). Effects of Tephrosia candida DC leaf and its Mixtures with Guinea Grass on in vitro Fermentation Changes as Feed for Ruminants in Nigeria. *Pakistan Journal of Nutrition,* 5, 14- 18.
8. Lanyansunya, T.P., H. Wang, H., Kariuki, S., Mukisira, E., Abdulrasak, S., Kibitok, N. and Ondiek, J. (2007). The potential of *Commelina benghalensis* as forage for ruminants. *Animal Feed Science and Technology,* 144:185-195.
9. Erwin, E.S., Marco, G.J. and Emery, E.M. (1961). Volatile fatty acid analyses of blood and rumen fluid by gas chromatography. *Journal of Dairy Science,* 44, 1768-1771.
10. AOAC (2000). Official Methods of Analysis. Association of Official Analytical Chemists. EUA.
11. Van Soest, P.J., Robertson, J.B. and Lewis, B.A. (1991). Methods for dietary fibre, neutral detergent fibre and non-starch polysaccharides in relation to

animal nutrition. *Journal of Dairy Science,* 74:3583–3597.

12. SAS (1999). *Users Guide* Statistics, SAS Institute, Cary, North Carolina, USA. Pg. 923.
13. Yeshambel M., Mengistu, U. and Getachew, A. (2012). Intake, Digestibility, Live Weight Changes and Rumen Parameters of Washera Sheep Fed Mixtures of Lowland Bamboo (*Oxytenanthera abyssinica*) Leaves and Natural Pasture Grass Hay at Different Ratios. *Pakistan Journal of Nutrition*, 11 (4): 322-331.
14. Norton, B.W. (2003). The nutritive value of tree legumes. Available at http://www.fao.org/ag/AGP/AGPC/doc/Publicat/Guttshel/x5556e0j.htm. pp 1-10
15. Meissner, H.H., Koster, H.H., Nieuwoudt, S.H. and Coertze, R.J. (1991). Effect of energy supplementation on intake and digestion of early and mid season ryegrass and panicum/smuts finger hay and on *in sacco* disappearance of various forage species. S. *Africa Journal of Animal Science,* 21:33-42.
16. Van Soest, P.J. (1994). *Nutritional Ecology of the Ruminant* (2nd edition). Comstock Publishing Associates/Cornell University Press, Ithaca, NY, USA.
17. McDonald, P., Edwards, R.A., Greenhalgh, J.F.D. and Morgan, C.A.(2002). *Animal nutrition* (6th Edition). Prentice Hall, USA.
18. Buxton, D.R. (1996). Quality-related characteristics of forages as influenced by plant environment and agronomic factors. *Animal Feed Science and Technology*, 59: 37-49.
19. Anele U.Y., Arigbede, O.M., Südekum, K.H., Ani, A.O., Jolaosho, A.O., Olanite, J.A., Adeosun, A.I., Dele, P.A., Ike, K.A. and Akinola. O.B. (2009). Seasonal chemical composition, *in vitro* fermentation and *in sacco* dry matter degradation of four indigenous multipurpose tree species in Nigeria. *Animal Feed Science and Technology* doi:10.1016/j.anifeedsci.2009.07.007 (Netherlands)
20. Mtenga, L.A. and Shoo, R.A. (1990). Growth rate, feed intake and feed utilization of Small East African goats supplemented with *Leucaena leucocephala*. *Small Ruminant Research*. 3:9–18.
21. Mpairwe, D. R., Sab2ti, E.N. and Mugerwa, J.S. (1998). Effect of dried Gliricidia sepium leaf supplement on feed intake, digestibility and nitrogen retention in sheep fed dried KW4 elephant grass (Pennisetum purpureum) ad libitum. *Agroforestry System.* Volume 41, Number 2, 139-150.
22. Russell, J.B. and Wilson, D.B. (1996). Why are ruminal cellulolytic bacteria unable to digest cellulose at low pH?

Journal of Dairy Science, 79:1503-1509.

23. Perdok, H.B. and Leng, R.A. (1989). Rumen ammonia requirements for efficient digestion and intake of straw by cattle. In: Nolan, J.V., Leng, R.A., Demeyer, D.E., Penumbul (Eds.), Protozoa and fungus in ruminant digestion. Armidale, Australia, pp: 291-293.
24. Corona, J.S.S., Duarte, J.I.S., Ortiz, M.M. and Perez, E.C. (2011). Oat hay apparent digestibility, rumen ammonia nitrogen and bun in goats supplemented with fermented molasses-poultry litter. *J. Anim. Vet. Adv.*, 10: 808-812.
25. Nguyen Thi Hong Nhan. (1998). Effect of *Sesbania grandiflora, Leucaena leucocephala, Hibiscus rosa-sinensis* and *Ceiba pentadra* on intake, digestion and rumen environment of growing goats. *Livestock Research for Rural Development*. Volume 10, Number 3.
26. Mir, P. S., Mir, Z. and Robertson, J.A. (1986). Effect of branched-chain amino acids or fatty acid supplementation on in vitro digestibility of barley straw or alfalfa hay. Can. *Journal of Animal Science,* 66:151-156.
27. Perdok, H.B. and Leng, R.A. (1990). Effect of supplementation with protein meal on the growth of cattle given a basal diet of untreated ammoniated rice straw. Asian-Aus. *Journal of Animal Science,* 3 (No. 4) 269-279.
28. Leng R.A. (1997). *Tree foliage in ruminant nutrition.* FAO Animal Production and Health Paper No. 139, FAO; Rome.
29. France, J. and Siddons, R.C. (1993). Volatile fatty acid production. In: Quantilitive Aspects Ruminant Digestion and Metabolisim (Eds., J.M. Forbes and J. Frace). C.A.B. International, Willingford, UK.
30. Ndlovu L.R. and Buchanan-Smith, J.G. (1985). Utilisation of poor quality roughage by sheep. Effect of alfalfa supplementation on ruminal parameters, fibre digestion and rate of passage from the rumen. *Canadian Journal of Animal Science* 65: 693-703.
31. Khampa, S. and Wanapat, M. (2006). Influences of Energy Sources and Levels Supplementation on Ruminal Fermentation and Microbial Protein Synthesis in Dairy Steers. *Pakistan Journal of Nutrition* 5 (4): 294-300. ISSN 1680-5194