Effects of supplementation of sole or mixtures of selected multipurpose trees (MPTs) on feed intake, live weight and scrotal circumference gain in Menz sheep fed a basal diet of tef (*Eragrostis tef*) straw.

Solomon Melaku† and Kurt J. Peters

Humboldt University, Department of Animal Breeding in the Tropics and Subtropics, Philippstraße 13, Haus 9, 10115 Berlin. †Fax 030-2093 6370;
e- mail : meraf42@hotmail.com

Abstract

Fifty four Menz rams were fed tef straw *ad libitum* and supplemented with sole or mixtures of MPTs at a daily rate of 0.9 % of live weight on dry matter (DM) basis, in a feeding trial that lasted for 124 days. Treatments consisted of supplementation with *Sesbania sesban* 1198; *Sesbania sesban* 15019; *Leucaena pallida* 14203; *Acacia angustissima* 15132; *S. sesban* 1198 + *L. pallida* 14203 (2:1); *S. sesban* 15019 + *L. pallida* 14203 (2:1); *S. sesban* 1198 + *A. angustissima* 15132 (2:1); *S. sesban* 15019 + *A. angustissima* 15132 (2:1) and wheat bran (control).

Rams supplemented with sole and mixtures of MPTs had significantly higher daily intakes of basal feed DM, total DM, ADF ($P< 0.01$), OM ($P<0.05$), and N ($P<0.001$) than those supplemented with wheat bran. However, the significant differences in intake were reflected in significantly higher ($P< 0.05$) final live weight, daily live weight and scrotal circumference gains only in those supplemented with mixtures of MPTs than the control feed. Mixtures of MPTs also promoted significantly higher daily intakes of supplement and total DM, ADF ($P< 0.05$), OM ($P<0.01$), and N ($P<0.001$) than sole MPTs and this subsequently resulted in significantly higher daily live weight ($P<0.001$) and scrotal circumference ($P<0.05$) gains as well as final live weight ($P<0.01$). It was concluded that supplementation with MPTs than with a conventional by-product supplement such as wheat bran significantly improved intake of tef straw, and moreover, supplementation with mixtures than sole MPTs enhanced feed intake and animal performance, and the mixture strategy was particularly important for wider utilization of *A. angustissima* 15132 as secondary plant metabolites contained in it reduced palatability and were also detrimental to the survival of sheep.

Keywords: MPT, tef straw, feed intake, live weight, scrotum circumference.

Introduction

Inadequacy and inconsistency of feed supply is a major bottleneck to efficient animal production in tropical farming systems. Tropical feeds are usually fibrous in nature and deficient in nitrogen, sulfur and phosphorus (Goodchild and McMeniman, 1994; Abdulrazak et al., 1997), and therefore, low levels of animal production and reproductive performance are attainable by exclusively feeding animals on tropical fibrous feeds. To this end, there is a strong need to identify and use renewable resources that can correct nutrient deficiencies in animals in a sustainable manner. In this regard, multipurpose trees (MPTs) offer an attractive alternative in animal feeding by virtue of their high nitrogen content as well as integration in tropical farming systems (Siaw et al., 1993).

However, secondary plant metabolites, which are widely spread in the MPTs may have adverse effects on feed intake, digestibility and animal metabolism (Kumar and Singh, 1984) and recently, mortality was reported in sheep supplemented with *A. angustissima* 15132 without gradual adaptation (Odenyo et al.,1997). In range areas, browsing animals dilute deleterious effects of secondary plant metabolites by feeding on mixtures of plant species (Le Houerou, 1981; Dicko and Sikena, 1992). Such a strategy may also improve the efficiency of nutrients utilization. Therefore, this experiment was conducted with the objective of evaluating the effects of supplementation with sole or mixtures of selected MPTs on feed intake, daily live weight and scrotal circumference gains in Menz rams offered a basal feed of tef straw.

Materials and methods

Study site, animals and management

The research was conducted at the International Livestock Research Institute‘s (ILRI) Debre Zeit Research Station in the central highlands of Ethiopia. Fifty four yearling Menz rams were used in a feeding trial designed to last 126 days. Initial and final live weights of experimental animals were determined as a mean of weights taken on two consecutive days. Fortnightly live weights were taken to determine daily live weight gain. All body weight measurements were made after withholding of feed and water for 14 - 15 hours. Monthly scrotal circumference measurements were made by using a metal scrotum measuring tape, at the point of greatest paired testicular diameter, with the testes hanging loosely in the scrotum.

Treatments, feeding management and laboratory analysis

The MPT supplements were harvested from the trees grown at the Debre Zeit Research Station. The fresh leaves were dried under shade, packed in sacks and stored for later use. The daily quantity of chopped tef straw required was taken from stacks and thoroughly mixed before weighing.

Treatments (Table 1) consisted of either supplementation with single or mixtures of MPTs at the level of 0. 9 % of LW on DM basis.

Table 1. Treatment feeds used in the experiment

Treatment	Basal feed	Supplement	Form of Supplement
1	Tef straw	*Sesbania sesban* 1198*	Sole
2	Tef straw	*Sesbania sesban* 15019	Sole
3	Tef straw	*Leucaena pallida* 14203	Sole
4	Tef straw	*Acacia angustissima* 15132	Sole
5	Tef straw	*Sesbania sesban* 1198 + *Leucaena pallida* 14203, (2 : 1)	Mixture
6	Tef straw	*Sesbania sesban* 15019 + *Leucaena pallida* 14203, (2: 1)	Mixture
7	Tef straw	*Sesbania sesban* 1198 + Acacia angustissima 15132, (2 : 1)	Mixture
8	Tef straw	*Sesbania sesban* 15019 + *Acacia angustissima* 15132, (2 : 1)	Mixture
9	Tef straw	Wheat bran	Control

*Numbers after the MPTs are ILRI (International Livestock Research Institute) MPT accession numbers.

Experimental animals were gradually adapted to *A. angustissima* 15132 as a sole supplement by feeding 50 g DM for the first week, and this was raised by 25 g DM per week for two subsequent weeks, and by 50 g DM per week thereafter until the maximum DM offer of 0.9 % of live weight was achieved. Tef straw, water and mineral licks were offered *ad libitum*. Daily weights of feed offered and refused were recorded for each animal. Refusals from previous day's offer were removed every morning before offering supplement and basal feeds at 08:00 h and 10:00 h respectively.

Samples of batches of feed offered and refusals per animal were taken for analysis of chemical composition. Feed DM, OM, N were determined according to AOAC, (1986) procedures. NDF and ADF were determined by the method of Goering and Van Soest, (1970). Soluble phenolics and condensed tannins were assayed according to Reed et al., (1985).

Experimental design and statistical analysis

A randomized block design was used, and the sheep were blocked by initial weight (15.66 ± 0.32 kg) into 6 blocks of nine animals and randomly assigned within each block to one of the nine treatments giving six animals per treatment. Data on daily feed intake, daily live weight and scrotal circumference gain were analyzed by the general linear models (GLM) procedure in SAS version 6.12 (1996). Daily live weight and scrotal circumference gains were calculated by regressing live weight and scrotal circumference on time. Treatment means were separated by the Duncan's Multiple Range Test.

Results and discussion

Chemical composition of treatment feeds

The chemical composition of the treatment feeds is given in Table 2. The CP in all the MPTs and their mixtures ranged between 21.6 - 27.8 %, and this was higher than in wheat bran. The OM and fiber in the MPTs ranged between 88.4 - 93.1 % and 20.4 - 33.8 % respectively. The chemical composition of the MPTs compares well with a good quality alfalfa that has to contain 20 % CP, less than 40% and 20 % NDF and ADF respectively. However, higher content of cell wall constituents and NDF -N may make *A.*

angustissima 15132 and *L. pallida* 14203 less desirable supplements to low quality feeds than both accessions of *S. sesban*.

OM and fiber were relatively higher in wheat bran than in the MPTs. Despite high NDF content, the ADF and ADL content in wheat bran were relatively lower than in sole or mixtures of MPTs. Thus, wheat bran appears to supply more digestible nutrients than the MPTs, as feed digestibility and ADF content are inversely related (McDonald et al., 1995).

Table 4. 2. Chemical composition of treatment feeds

	Chemical composition									
	DM	OM	ASH	CP	NDF	NDF-N	ADF	ADL	SP	CT
S. sesban 1198	91.78	884.7	115.3	231.2	204.4	5.3	134.1	27.2	14.9	31.4
S. sesban 15019	911.4	886.2	113.8	220.6	200.3	5.4	139.7	28.2	17.6	63.3
L. pallida 14203	918.8	911.2	88.8	216.2	298.2	13.8	158.1	60.5	23.6	86.4
*A.angustissima*15132	913.6	931.3	68.7	278.7	338.2	17.9	161.3	56.0	32.3	27.5
SS 1198 + *LP* 14203	918.4	896.6	103.4	230.0	244.9	8.6	140.9	34.5	19.5	58.2
SS 15019 + *LP* 14203	914.8	897.8	102.2	218.1	236.8	7.8	145.9	46.9	22.1	58.4
SS 1198 + *AA* 15132	916.6	894.0	106.0	233.1	246.2	8.0	141.6	37.5	22.1	40.9
SS 15019 + *AA* 15132	912.6	898.0	102.0	222.5	237.5	7.5	146.5	44.1	23.6	56.6
WHEAT BRAN	873.1	940.1	59.9	165.0	469.0	6.6	127.0	25.7	10.7	5.6
TEFF STRAW	909.3	910.5	89.5	45.0	728.9	2.8	412.4	41.0	9.6	5.5

DM = dry matter (g kg $^{-1}$); OM = organic matter (g kg $^{-1}$DM); CP = crude protein (g kg^{-1} DM); NDF = neutral detergent fiber (g kg^{-1} DM); NDF-N = neutral detergent fiber bound nitrogen (% NDF); ADF = acid detergent fiber (g kg^{-1}DM); ADL = acid detergent lignin (g kg $^{-1}$DM) ; SP = soluble phenolics (% DM); CT = condensed tannins (Abs g $^{-1}$ NDF); IVDMD = *In vitro* dry matter digestibility (%)

A. angustissima 15132 contained the highest level of soluble phenolics. Soluble phenolics are easily hydrolysed in the rumen and may cause toxicity in animals (Lowry et al., 1996). Therefore, the soluble phenolics in *A. angustissima* 15132 could have caused the aversive reactions observed in animals supplemented with it. Indeed, the mortality observed in one ram that consistently consumed the total offer of *A. angustissima* 15132 for 3 - 4 days could be attributed to an acute lethal toxicity of its soluble phenolics. The highest level of condensed tannins was assayed in *L. pallida* 14203. Condensed tannins complex with feed, microbial and endogenous proteins and make them indigestible at normal rumen pH

(Kumar and Vaithiyanathan,1990). Tannin - protein complexes are liable to break at lower pH in the intestine (Kumar and Singh, 1984) and therefore, at reasonable levels, condensed tannins may protect feed protein from ruminal fermentation and make them available as by pass protein in the intestine (Kumar and Vaithiyanathan,1990). However, higher levels such as that assayed in *L. pallida* 14203 may reduce feed intake and digestibility, and therefore, lessen the MPT's role as a supplement compared to *S. sesban* 1198 and *S. sesban* 15019, which contain low and medium levels of condensed tannins respectively.

Feed and nutrients intake

Feed and nutrients intake are given in Table 4. 3. Sole MPTs promoted significantly higher ($P< 0.05$) intake of the basal feed DM than wheat bran, but supplement DM intake was significantly higher ($P < 0.01$) in wheat bran than in sole MPTs supplemented animals, and this evened out differences in the total feed DM intake between treatments supplemented with the sole MPTs or wheat bran.

Supplementation with mixtures of MPTs than wheat bran resulted in significantly higher basal, total feed DM ($P < 0.001$), and OM ($P < 0.01$) intakes. Supplementation with mixtures than sole MPTs also resulted in significantly higher supplement, total DM ($P < 0.001$), OM ($P < 0.01$) and ADF ($P < 0.05$) intakes. The difference in the intake of basal DM was higher in animals supplemented with mixtures than sole MPTs, although statistically not significant ($P < 0.09$). Animals supplemented with sole and / or mixtures of MPTs had significantly higher ($P < 0.01$) N intakes than those supplemented with wheat bran.

The superior daily feed intake observed with the supplementation of mixtures of MPTs is in agreement with the hypotheses of this study and confirmed the remarks of Madsen et al., (1997), which states that mixtures of feeds maximize benefits drawn from each component. Therefore, the higher daily feed intake in animals supplemented with mixtures of MPTs could be due to balanced nutrients supply at ruminal and intestinal levels.

Table 4. 3. Least squares means of daily feed and nutrients intake of Menz rams

Treatment (n = 6)	DM intake (g/day)			OM, nitrogen, NDF and ADF intake (g kg^{-1} DM day $^{-1}$)				F: G (g DM g^{-1} wt gain)
	Basal	Sup.	Total	OM	N	NDF	ADF	
1 *S. sesban* 1198	444.2 ^{abc}	160.0 ^{ab}	604.2 ^{ab}	546.0 ^{bc}	9.1 ^{b}	356.5 ^{b}	204.6 ^{abc}	23.8 ^{b}
2 *S. sesban* 15019	451.2 ^{abc}	161.8 ^{ab}	613.0 ^{ab}	554.2 ^{abc}	9.0 ^{b}	361.3 ^{ab}	208.7 ^{abc}	22.7 ^{b}
3 *L. pallida* 14203	461.0 ^{ab}	161.6 ^{ab}	622.5 ^{a}	567.0 ^{abc}	8.9 ^{b}	384.2 ^{ab}	215.6 ^{a}	29.6 ^{b}
4 *A. angustissima* 15132	436.5 ^{bc}	102.1 ^{c}	538.6 ^{c}	492.5 ^{d}	7.7 ^{c}	352.7 ^{b}	196.5 ^{bc}	46.1 ^{a}
5 *SS 1198* + *LP* 14203	483.7 ^{a}	169.8 ^{a}	653.5 ^{a}	592.7 ^{a}	9.7 ^{a}	394.2 ^{a}	223.4 ^{a}	20.1 ^{b}
6 *SS 15019* + *LP* 14203	459.3 ^{ab}	161.2 ^{ab}	620.5 ^{a}	562.9 ^{abc}	8.9 ^{b}	373.0 ^{ab}	212.9 ^{ab}	22.2 ^{b}
7 *SS 1198* + *AA* 15132	453.6 ^{abc}	162.0 ^{ab}	615.5 ^{ab}	557.8 ^{abc}	9.3 ^{ab}	370.5 ^{ab}	210.0 ^{ab}	23.9 ^{b}
8 *SS 15019* + *AA* 15132	465.8 ^{ab}	163.7 ^{ab}	629.5 ^{a}	571.1 ^{ab}	9.2 ^{ab}	378.4 ^{ab}	216.1 ^{a}	21.2 ^{b}
9 Wheat bran (control)	414.2 ^{c}	156.3 ^{b}	570.5 ^{bc}	524.0 ^{cd}	7.1 ^{d}	375.3 ^{ab}	190.7 ^{c}	29.2 ^{b}
SEM†	13.6	3.5	15.1	13.8	0.18	10.2	5.8	3.6
Significance level								
Treatment	*	***	***	***	***	ns	**	***
Sole vs. control	*	**	ns	ns	***		*	ns
Mixtures vs. control	***	*	***	**	***		***	ns
Sole vs. mixtures	ns	***	***	**	***		*	***
Rest vs. control	**	ns	**	*	***		**	ns

^{abc} = means with different superscripts in a column are significantly different , (P < 0.05); ns = not significant; * = P < 0.05; ** = P < 0.01; *** = P < 0.001; DM = dry matter; OM = organic matter; NDF = neutral detergent fiber; ADF = acid detergent fiber; N = number; Sup. = supplement; SEM = standard error of mean;F : G = feed gain ratio; † SEM is calculated for n = 6; n = number.

The daily supplement DM intake of sole and mixture of MPTs was 26 % of daily total DM intake except for *A. angustissima* 15132. The level of supplement intake was in line with the objective of the experiment and the recommendations made by Preston (1995). However, voluntary intake of *A. angustissima* 15132 was 18.95 % of daily total DM intake in rams supplemented with *A. angustissima* 15132, and a quarter of the daily offer was refused. Refusals were observed after daily offer exceeded 100 gram. Therefore, limitation in voluntary intake of the MPT may be an adaptive mechanism through which sheep avoided toxicity, by relating post - ingestive experiences (Baumont et al., 2000) with toxic secondary plant metabolites contained in the MPT.

The significantly higher daily intake of basal DM in animals supplemented with sole or mixtures of MPTs than wheat bran is concurrent with higher nitrogen intake. Higher nitrogen intake usually improves concentration of rumen ammonia nitrogen and this creates conducive ruminal environment for cellulolytic microorganisms to effectively ferment plant fiber (Ørskov, 1982)

Live weight and scrotum circumference gain

Data on live weight and scrotal circumference are given in Table 4. 4. Mixtures of MPTs promoted significantly higher live weight gain than wheat bran ($P < 0.05$) or sole MPTs ($P< 0.001$), and significantly higher final live weight than wheat bran ($P < 0.05$) or sole MPTs ($P < 0.01$).

Table 4. 4. Least squares means for live weight and scrotal circumference of Menz rams

	Treatments (n = 6)	Initial live weight (kg)	LWG (g day $^{-1}$)	Final live weight (kg)	ISC (cm)	SCG (mm day $^{-1}$)	FSC (cm)
1	*S. sesban* 1198	15.6 [a]	33.4 [ab]	19.7 [ab]	19.7 [a]	0.36 [abc]	24.1 [ab]
2	*S. sesban* 15019	15.6 [a]	35.7 [ab]	20.2 [ab]	19.7 [a]	0.41 [abc]	25.2 [a]
3	*L. pallida* 14203	15.9 [a]	27.8 [b]	19.5 [b]	20.5 [a]	0.28 [cd]	24.3 [ab]
4	*A. angustissima* 15132	15.6 [a]	13.0 [c]	17.6 [c]	19.7 [a]	0.21 [d]	22.4 [b]
5	*SS 1198* + *LP* 14203	15.8 [a]	40.7 [a]	21.2 [a]	19.2 [a]	0.46 [a]	25.1 [a]
6	*SS 15019* + *LP* 14203	15.5 [a]	34.7 [ab]	20.2 [ab]	20.2 [a]	0.40 [abc]	25.8 [a]
7	*SS 1198* + *AA* 15132	15.7 [a]	33.7 [ab]	20.2 [ab]	19.4 [a]	0.39 [abc]	24.3 [ab]
8	*SS 15019* + *AA* 15132	15.6 [a]	38.4 [ab]	20.5 [ab]	18.6 [a]	0.43 [ab]	24.2 [ab]
9	Wheat bran (control)	15.6 [a]	29.2 [b]	19.3 [b]	19.8 [a]	0.29 [bcd]	23.9 [ab]
	SEM†	0.13	3.3	0.50	0.63	0.04	0.67
	Significance level						
	Treatment	ns	***	**	ns	**	ns
	1& 2 vs. 3 & 4		***	**		**	
	Sole vs. control		ns	ns		ns	
	Mixtures vs. control		*	*		**	
	Sole vs. mixtures		***	**		**	
	Rest vs. control		ns	ns		ns	

[abc] = means with different superscripts in a column are significantly different, ($P < 0.05$); ns = not significant; * = $P < 0.05$; ** = $P < 0.01$; *** = $P < 0.001$; SEM† = standard error of mean; LWG = live weight gain; SCG = scrotum circumference gain; ISC = initial scrotum circumference; FSC = final scrotum circumference; n = number; SEM† calculated for n = 6.

Rams on mixtures than sole MPTs required significantly lower ($P< 0.001$) feed DM per unit of daily live weight gain. Similarly, daily scrotal circumference gain was significantly higher ($P < 0.01$) in rams on mixtures of MPTs than those on sole MPTs or wheat bran. Significantly higher daily live weight and scrotal circumference gain ($P < 0.05$) was observed in rams supplemented with the mixture of *S. sesban* 1198 and *L. pallida* 14203 than those supplemented with sole *L. pallida* 14203. Supplementation with the mixture of both accessions of *S. sesban* and *A.*

angustissima 15132 than sole *A. angustissima* 15132 also resulted in significantly higher ($P < 0.05$) daily live weight and scrotal circumference gains.

The correlation between scrotal circumference and live weight was significant ($R^2 = 0.57$, $P < 0.001$) and in agreement with similar studies (Kaitho, 1997; Rege et al., 2000).

The rate of daily live weight and scrotal circumference gain were similar with the results of other studies (Bonsi et al., 1994; Kaitho,1997). The differences between treatments were direct reflections of differences in feed intake. Improved live weight and scrotal circumference gain with mixtures than sole MPTs or wheat bran may be a result of balanced supply and efficient utilization of nutrients for live weight and scrotal circumference gain. Moreover, mixtures of MPTs may improve ram reproductive performance as strong correlations were reported between scrotal circumference, volume, concentration and motility of semen in Menz rams (Rege et al., 2000).

Conclusion

The results indicated that MPTs improved basal feed and nutrient intakes better than conventional by- product supplements like wheat bran. Supplementation with mixtures of MPTs proved to be superior than sole MPTs in daily feed intake, live weight and scrotal circumference gains, which suggests that mixing the MPTs might have diluted the different secondary plant metabolites contained in sole MPTs, and thus reduced their negative effects on feed intake and animal performance.

Moreover, supplementation of *A. angustissima* 15132 in a mixture with *S. sesban* 1198 and *S. sesban* 15019 has the potential to alleviate limitations set by secondary plant metabolites for extensive utilization of *A. angustissima* 15132 as a sole supplement.

References

Abdulrazak SA, Muinga RW, Thorpe W, Orskov ER (1997) Supplementation with *Gliricidia sepium* and *Leucaena leucocephala o*n voluntary food intake, digestibility, rumen fermentation and live weight of crossbred steers offered *Zea mays* stover. Livestock Production Science. 49: 53 - 62

A.O.A.C (1984) Association of official analytical chemists. Official methods of analysis, AOAC, Washington DC, USA

Baumont R, Prache S, Meuret M, and Morand-Fehr P, (2000) How forage characteristics influence behavior and intake in small ruminants: a review. Livestock Prod. Sci. 64: 15 -28

Bonsi MLK, Osuji PO, Nsahlai IV, Tuah AK (1994) Graded levels of *Sesbania sesban*, and *Leucaena leucocephala* as supplements to tef straw given to Ethiopian Menz sheep. Anim. Prod. 59: 235-244

Dicko MS, and Sikena LK, (1992) Feeding behavior and quantitative and qualitative intake of browse by domestic ruminants. In : A. Speedy and Pugliese, (Eds.). Legume Trees and Other Fodder Trees as Protein Sources for Livestock. FAO Animal Production and Health Paper No.102. Food and Agriculture Organization (FAO). Rome

Goering HK, Van Soest PJ (1970) Forage Fiber Analysis. Agric. Handbook No. 379. Agric. Res. Serv., USDA., Washington, DC, pp 1 - 20

Goodchild AV, McMeniman NP (1994) Intake and digestibility of low quality roughages when supplemented with leguminous browse. J. Agric. Sci. (Camb.) 122:151 - 160

Kaitho RJ (1997) Nutritive value of browses as protein supplement(s) to poor quality roughages. Ph.D Thesis. Wageningen agricultural University. The Netherlands

Kumar R, Singh M (1984) Tannins: their adverse role in ruminant nutrition. Journal of Agricultural and Food Chemistry 32: 447-453

Kumar R, Vaithiyanathan S (1990) Occurrence, nutritional significance and effect on animal productivity of tannins in tree leaves. Anim. Feed Sci and Technol. 30: 21 - 28

Le Houerou HN (1981) Browse in northern Africa: In: H. N. Le Houerou (ed.), Browse in Africa. The Current State of Knowledge. International Symposium on Browse in Africa, Addis Ababa, 8-12 April 1980. ILCA (International Livestock Center for Africa), Addis Ababa, Ethiopia, pp.55-82

Lowry BJ, McSweeney S, Palmer B (1996) Changing perceptions of the effect of plant phenolics on nutrient supply in the ruminant. Aust. J. Agric. Res. 47: 830 – 842

Madsen J, Hvelplund T, Weisbjerg MR (1997) Appropriate methods for the evaluation of tropical feeds for ruminants , Animal Feed Science And Technology. 69: 53-66

Mcdonald P, Greenhalgh JFD, Edwards RA, Morgan CA (1995) Animal Nutrition, 5th Edition, Longmanns, London

Odenyo AA, Osuji PO, Karanfil O, Adinew B (1997) Microbiological evaluation of *Acacia angustissima* as a protein supplement for sheep. Animal Feed Science and Technology. 65: 99-112

Ørskov ER (1982) Protein Nutrition in Ruminants. In Academic Press, London

Preston TR (1995) Tropical Animal Feeding. a manual for research workers. FAO Animal Production and Health Paper No. 126. Food and Agriculture Organization (FAO). Rome

Reed JD, Horvath PJ, Allen MS, Van Soest PJ (1985) Gravimetric determination of soluble phenolics including tannins from leaves by precipitation with trivalent ytterbium. J. of the Sci. of Food and Agric. 36: 255 -261

Rege JEO, Toe F, Mukasa - Mugerwa E, Tembely, Anindo D, Baker RL, Lahlou - Kassi (2000) Reproductive characteristics of Ethiopian highland sheep. II. Genetic parameters of semen characteristics and their relationships with testicular measurements in ram lambs. Small Rum. Res. 37: 173 - 187

SAS (1996) Statistical analysis System institute. Procedures Guide For Personal Computers. Version 6 .12 , SAS Institute, Cary, NC, USA

Siaw DEKA, Osuji PO, Nsahlai IV (1993) Evaluation of multipurpose trees germplasm: the use of gas production and rumen degradation characteristics. J. Agric. Sci.(Camb.) 120: 319 - 330