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Evaluation of Nutritive Value of *Albizia gummifera* Foliages as Fodder Source for Livestock in Agrisilvipastoral System

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ABSTRACT

The study was conducted to assess nutritional quality of *Albizia gummifera* (J.F. Gmel) C.A.Sm., a multipurpose tree indigenous to Ethiopia, influenced to altitude and season at hot humid tropical climatic condition. SAS version 9.1 was used for data analysis. *Albizia gummifera* leaf was examined for their chemical components, *in vitro* organic matter digestibility, digestible nutrients and dietary energy values. On DM basis, analytical results ranged between 108 to 308 g CP kg^{-1}, 367 to 396 g NDF kg^{-1}, 283 to 313 g ADF kg^{-1}, 68 to 72 g CT kg^{-1} DM, 379.8 to 430 g IVDMD kg^{-1}, 492.5 to 683.5 g CHO kg^{-1}, 6.1 to 6.9 MJ ME kg^{-1}, 9.4 to 28.3 g DCP kg^{-1} 7.02 to 8.2 g DE kg^{-1} and 400.4 to 460.3 g TDN kg^{-1}. Effects of altitudes and seasons had showed a wide significant variation among many nutritive value parameters studied ($p<0.05$). Significantly higher CP, IVDMD and DCP contents were recorded for the higher altitude region and wet season ($p<0.05$). A negative correlation was observed between CT and CP, IVDMD energy values and TDN. The altitude-season interaction had a significant effect on most of the parameters ($p<0.01$). The nutrient concentrations already suggest that *A. gummifera* have a clear potential for being used as sustainable feed resources in wide locations on top of seasons that can maintain normal rumen microbial metabolism and to supply the quantities and balances of nutrients for different productive states in the tropics.

Key words: Condensed tannin, fodder tree, *in vitro* DM digestibility, nutritive value, digestible nutrients

INTRODUCTION

Inadequate feed supply, both in quality and quantity, is a major constraint to ruminant livestock production in southwest Ethiopia (Yisehak *et al.*, 2010) and Sub-Saharan African countries (Hassan *et al.*, 2007). Local feed resources like leguminous fodder are prime importance for ruminants raise in the tropics particularly low-quality roughages and agricultural crop-residues (Khampa and Wanapat, 2007; Mousa, 2011). Currently small-holder farmers of south west ethiopia in particular (Yisehak *et al.*, 2009, 2011) and many other Sub-Saharan African countries in general are increasingly relying on various potential browse plants underutilized potential feed resources, to supplement their ruminants in especially in dry seasons (Aremu and Onadeko, 2008). During the dry season, feed scarcity period, multipurpose trees like *Albizia gummifera* can provide a green feed throughout the year which may be particularly useful as feed supplements to the typical low-quality diets. *A. gummifera,* a large deciduous leguminous tree, indigenous to Ethiopia which grows in 1500-2300 m above sea level, is becoming sustainable fodder source for herbivore livestock in southwest Ethiopia. It plays a number of very important roles for people and their livestock in Ethiopia. *Albizia gumifera* is the most widespread *Albizia* species in Ethiopia. It is the most appropriate tree for shading *Ensete ventricosum*, banana, various shade loving vegetables and spice crops as well as coffee in plantations up to 2300 m, controls soil erosion, serves as a windbreak, fuel wood and timber and cropland fertility. The tree is known for its fast growth rate, high coppicing and lopping ability, high competition ability with other crops, high biomass productivity and high dry season hardiness. Leaves of *Albizia* are an important component of diets for goats, sheep and cattle and play an important role in the nutrition of grazing animals in areas where few feed alternatives are available (Personal experience). However, there is limited information regarding the effect of altitude and season on potential nutritional quality of foliages of *A. gummifera*. The aim of this study was therefore, to evaluate the effect of altitude and season on the nutritive value parameters of leaves of the *A. gummifera*.

MATERIALS AND METHODS

Description of the study area: Leaves of *Albizia gummifera* were harvested in two distinct seasons in July, 2008 and February 2009 from two different sites/altitude regions (Sokoru and Dedo) in Jimma zone, southwest Ethiopia. The site 1 located at altitude of 1730 m above sea level. The site 2 located at altitude of 2200 m above sea level. The farming systems, soils and climate of the area/sites are described by GOR (2006).

Data collection and analytical procedure: Leaves were hand harvested from at least 24 different trees of the same species, then sub-sampled and oven dried at 105°C at 16h (AOAC, 2005). The dried samples were ground and analyzed for Dry Matter (DM), Organic Matter (OM), Crude Protein (CP), Crude Ash (CA) and Ether Extract (EE) according to the standard procedures of AOAC (2005). Neutral Detergent Fiber (NDF) and Acid Detergent Fibers (ADF) were determined by the method of Van-Soest *et al.* (1991). Lignin was determined by solubilization of cellulose with H_2SO_4 (Van-Soest and Robertson, 1980). Hemicellulose (%HC) was calculated from the difference between %NDF and %ADF. Determination of total Condensed Tannins (CT) is based on oxidative depolymerization of condensed tannins in butanol-HCl reagent using 2% ferric ammonium sulfate in 2N HCl catalyst (Porter *et al.*, 1985). Metabolizable energy (ME, MJ kg^{-1}) value was estimated from the %IVOMD: ME = 0.016*% IVOMD according to McDonald *et al.* (2002). The two stage *in vitro* technique developed by Tilley and Terry (1963) was used to determine *in vitro* Dry Matter Digestibility (IVDMD) and *in vitro* Organic Matter Digestibility (IVOMD) of the feeds with some slight modifications. The Gross Energy (GE) and Digestible Energy (DE) of feeds were calculated using equations from Hvelpund *et al.* (1995). The total carbohydrate (%CHO) was estimated according to Ranjhnan (2001), total CHO = 100-(%CP + %EE + %Ash+ %lignin). On other hand, the content Total Digestible Nutrient (%TDN) per kg and per kg DM of a feed stuff is calculated as follows: TDN, kg = kg Digestible Crude Protein (DCP) + 2.25 kg Digestible Ether Extracts (DEE) + kg Digestible Carbohydrates (DCHO).

Statistical analyses: Two-ways Analysis of Variance (ANOVA) was carried out to determine the effect of altitude and season on nutritive value parameters and their interaction to altitude and season using General Linear Model (GLM) of SAS (2003). Significance between individual means was identified using the Duncan multiple range test. Mean differences were considered significant at p<0.05. Spearman rho correlation was used to verify the magnitude and direction of relationships between the studied parameters. The statistical model used for analysis of data was:

$$Y_{ijk} = \mu + l_i + pj + m_k + e_{ijk}$$

where, Y_{ijk}: Response variable (nutritional quality), μ: Overall mean effect, l_i: ith altitude effect, p_i: jth effect of season; m_k: kth altitude-season interaction effect and eijk is the random error.

RESULTS

Chemical composition of *A. gummifera*: The proximate and detergent components of foliages of *A. gummifera* are presented in Table 1. The highest contents of CP (214.6 + 22.1 g kg^{-1} DM) and (228.4 + 14.6 g kg^{-1} DM) was determined for HAR and wet season (p<0.05). The altitude-season interaction had also reveal highly significant variation (p<0.01).The highest NDF, ADF and ADL contents were recorded for LAR (p<0.001); though, season had no effect on NDF and ADF (p>0.05), altitude-season interactions showed highly significant variation for NDF and ADF (p<0.001). Altitude, season and altitude-season interactions didn't show statistical variation for CA and OM contents (p>0.05). Moreover, both altitude and altitude-season interactions didn't show significance difference for EE for (p>0.05); on the other hand, seasonal variations showed highly significant difference for EE (p<0.001).

In vitro* digestible drymatter and dietary energy density of *A. gummifera: Altitude differences showed significant variation for IVDMD content of *A. gummifera* (p<0.05) (Table 1). Highest IVDMD values 405.2±3.4 and 402.1±3.9 g IVDMD kg^{-1} DM were recorded for HAR and wet season, respectively (p<0.05). Similarly, altitude-season interaction had a significance difference for IVDMD (p<0.05). Both altitude and season had a significant effect on ME value (p<0.05). However, both factors and their interaction had no significant effect on total carbohydrate content (p>0.05). Both altitude and season and their interaction effects have sowed significant variation for the contents DCHO (p<0.05) where the highest DCHO values were recorded for HAR, 403.7±3.4 g kg^{-1}, as well as wet season, 402.0±3.9 g kg^{-1} DM. Though, altitude and altitude-season interaction had no significant effect on DEE content (p>0.05), season has shown highly significant difference for the DEE contents (p<0.001). Season along with season-altitude interaction has resulted significant differences in the value of DCP (p<0.05). Although seasonal variation had no significant difference on contents of GE, DE and TDN, altitude and altitude-season interaction has resulted significant variation for values GE, DE and TDN (p<0.05).

Correlation between variables: Positive or negative correlation coefficients were determined between variables (Table 2). The relations between variables were either significant or non-significant; However, the correlation coefficients were either strong (absolute r value close to 1) or weak (absolute r value close 0) or no correlation (r value exactly 0). CP was negatively correlated with NDF, ADF, ADL, CT and total CHO (p<0.01). The relation between cell wall fractions (NDF, ADF, ADL) and IVDMD, most of dietary energy density and digestible nutrients was found to be negative(p<0.05). The correlation between IDMD and ME and DCHO was highly significant, positive and strong (r = 1.0, p<0.001). Highly significant and strong correlation was obtained between DE and TDN(r = 1.0; p<0.0001). There was no correlation between CA and IVDMD, ME and DCHO (r = 0.00; p>0.05).

Table 1: Effect of altitude and season and altitude-season interactions on the average values of nutritive value parameters of *A. gummifera* leaves

	Altitude			Season			Altitude-season interaction	
Parameters	LAR	HAR	p-value	Dry	Wet	p-value	Overall, mean	p-value
CA g kg^{-1}	83.3±1.4	90.4±5.7	ns	86.5±3.8	87.2±4.6	ns	86.9±3.0	ns
OM g kg^{-1}	909.6±1.8	915.3±5.7	ns	912.0±3.9	912.5±4.6	ns	912.5±3.0	ns
CP g kg^{-1}	182±10.0	214.6±22.1	*	162.7±15.0	228.4±14.6	*	198.3±12.3	**
EE g kg^{-1}	29.0±3.7	27.2±3.3	ns	33.8±2.8	35.1±3.3	***	28.1±2.4	ns
NDF g kg^{-1}	285.3±2.4	272.3±3.2	***	376.8±3.1	381.2±3.7	ns	378.8±2.4	***
ADF g kg^{-1}	255.3±1.8	243.0±3.6	***	295.5±3.3	303.4±3.0	ns	299.2±2.3	***
ADL g kg^{-1}	116.7±0.0	111.9±1.5	***	113.2±1.5	115.6±0.9	**	114.3±0.9	**
Hemi g kg^{-1}	30.04±0.6	29.3±2.3	ns	27.8±2.4	31.3±0.9	ns	29.7±1.2	ns
CT g kg^{-1}	71.3±0.3	69.08±0.3	***	70.1±0.4	70.3±0.5	ns	70.2±0.3	*
IVDMD g kg^{-1}	394.9±2.0	405.2±3.4	**	397.6±1.1	402.1±3.9	*	400.1±2.2	*
ME,MJ kg^{-1}	6.5±0.0	6.3±0.1	**	6.3±0.0	6.5±0.1	*	6.4±0.0	*
CHO g kg^{-1}	589.0±11.5	556.0±20.8	ns	548±12.4	601.4±19.1	ns	572.5±12.1	**
DCHO g kg^{-1}	396.3±2.0	403.7±3.4	**	397.5±1.1	402.0±3.9	*	400.0±2.2	*
DEE g kg^{-1}	2.7±0.4	2.5±0.3	ns	3.1±0.3	2.1±0.3	***	2.6±0.2	ns
DCP g kg^{-1}	16.6±0.9	19.7±2.1	ns	14.8±1.5	20.9±1.4	*	18.1±1.1	***
GE, MJ kg^{-1}	12.2±0.3	13.14±0.6	*	12.2±0.3	13.2±0.5	ns	12.7±0.3	***
DE, MJ kg^{-1}	7.3±0.1	7.6±0.1	**	7.3±0.1	7.6±0.1	ns	7.4±0.1	**
TDN g kg^{-1}	417.5±2.7	430.4±4.8	**	420.1±2.6	427.8±5.0	ns	424.0±3.0	**

Values are least square Mean±SEM, ns: Non-significant; *Means are significant at $p<0.05$; **Means are significant at $p<0.01$; ***Means are significant at $p<0.001$, CA: Crude ash contents, OM: Orgaric matter, CP: Crude protein, EE: Ether extract, DCP: Digestiable crude protein, TDN: Total digestable nutrients, NDF: Neutral detergent fiber, ADF: Acid detergent fiber, CT: Condensed tannin, IVDMD: *In vitro* drymatter digestable, CHO: Total carbohydrater, DE: Digestiable energy, ADL: Acid detergent ligin, DCHO: digestiable carbohydrate, DEE: Digestiable ethanol extract, GE: Gross energy

Table 2: Descriptive values for nutritional parameters of *A.gummifera* at different altitudes and seasons ((MJ/kg: ME,GE and DE; g/kg DM rest of parametres)

Altitude	Season		CA	CP	EE	NDF	ADF	ADL	Hemi	CT	IVDMD	ME	CHO	DCHO	DEE	DCP	GE	DE	TDN
LAR	Dry	Mean	84.7	174.3	36.4	382.9	303.4	116.6	29.5	70.7	397.9	6.4	587.9	397.8	3.4	15.9	12.4	7.4	421.4
		Min.	80.5	110.0	23.0	376.4	298.0	115.9	26.0	69.0	397.6	6.4	550.3	397.5	2.1	9.9	10.4	7.2	412.4
		Max.	98.4	206.0	45.0	396.0	313.0	120.1	33.0	71.6	399.6	6.4	667.6	399.5	4.2	18.9	13.4	7.5	425.9
		SEM	2.8	20.0	3.9	4.1	3.1	0.7	1.2	0.5	0.3	0.0	22.7	0.3	0.4	1.9	0.6	0.1	2.5
	Wet	Mean	81.9	189.7	21.6	387.7	307.2	116.7	30.6	71.9	391.8	6.3	590.1	391.8	2.0	17.3	12.1	7.3	413.5
		Min.	80.4	177.0	15.0	376.4	298.0	115.9	28.4	71.6	379.8	6.1	551.5	379.7	1.3	16.2	11.6	7.0	400.4
		Max.	83.5	206.0	45.0	390.0	309.0	120.0	31.0	72.0	397.6	6.4	602.7	397.5	4.2	18.9	13.4	7.5	425.9
		SEM	0.4	4.0	4.7	2.3	1.8	0.7	0.4	0.1	3.6	0.1	7.9	3.6	0.5	0.4	0.3	0.1	4.3
	Combined	Mean	83.3	182.0	29.0	385.3	305.3	116.7	30.0	71.3	394.9	6.3	589.0	394.8	2.7	16.6	12.2	7.3	417.5
		Min.	80.4	110.0	15.0	376.4	298.0	115.9	26.0	69.0	379.8	6.1	550.3	379.7	1.3	9.9	10.4	7.0	400.4
		Max.	98.4	206.0	45.0	396.0	313.0	120.1	33.0	72.0	399.6	6.4	667.6	399.5	4.2	18.9	13.4	7.5	425.9
		SEM	1.4	10.0	3.7	2.4	1.8	0.5	0.6	0.3	2.0	0.0	11.4	2.0	0.4	0.9	0.3	0.0	2.6
HAR	Dry	Mean	88.6	148.8	30.6	379.2	303.4	114.3	25.8	69.4	397.2	6.4	617.6	397.2	2.8	13.5	11.5	7.3	417.1
		Min.	75.5	108.0	23.0	368.0	289.0	108.0	5.0	69.0	388.0	6.2	518.0	387.9	2.1	9.7	10.2	7.0	402.8
		Max.	120.1	206.0	41.0	396.0	313.0	115.9	33.0	70.0	403.0	6.4	683.5	402.9	3.8	18.9	13.3	7.6	430.2
		SEM	8.1	23.4	4.1	6.9	5.9	1.6	5.3	0.2	2.5	0.0	33.3	2.5	0.4	2.2	0.7	0.1	5.1
	Wet	Mean	91.6	261.6	24.8	367.4	285.6	110.1	31.9	68.9	410.9	6.6	511.9	410.8	2.3	24.0	14.3	7.8	440.0
		Min.	68.4	206.0	13.0	367.0	283.0	105.0	29.0	68.0	401.0	6.4	492.5	400.9	1.1	18.9	13.3	7.5	427.9
		Max.	130.0	308.0	39.0	368.0	289.0	119.7	34.0	70.0	430.0	6.9	548.2	429.9	3.6	28.3	15.3	8.1	460.3
		SEM	8.4	19.7	4.9	0.2	1.2	2.1	1.0	0.4	4.4	0.1	7.5	4.4	0.5	1.8	0.4	0.1	4.9
	Combined	Mean	90.4	214.6	27.2	372.3	293.0	111.9	29.3	69.1	405.2	6.5	556.0	405.1	2.5	19.7	13.1	7.6	430.4
		Min.	68.4	108.0	13.0	367.0	283.0	105.0	5.0	68.0	388.0	6.2	492.5	387.9	1.1	9.7	10.2	7.0	402.8
		Max.	130.0	308.0	41.0	396.0	313.0	119.7	34.0	70.0	430.0	6.9	683.5	429.9	3.8	28.3	15.3	8.1	460.3
		SEM	5.7	22.1	3.3	3.2	3.6	1.5	2.3	0.3	3.4	0.1	20.8	3.4	0.3	2.1	0.5	0.1	4.8
	Grand mean	Mean	86.9	198.3	28.1	378.8	299.1	114.3	29.7	70.2	400.1	6.4	572.5	400.0	2.6	18.1	12.7	7.4	424.0
		Min.	68.4	108.0	13.0	367.0	283.0	105.0	5.0	68.0	379.8	6.1	492.5	379.7	1.1	9.7	10.2	7.0	400.4
		Max.	130.0	308.0	45.0	396.0	313.0	120.1	34.0	72.0	430.0	6.9	683.5	429.9	4.2	28.3	15.3	8.1	460.3
		SEM	3.0	12.3	2.4	2.4	2.3	0.9	1.2	0.3	2.2	0.0	12.1	2.2	0.2	1.1	0.3	0.1	3.0
		p	ns	ns	ns	**	**	**	**	ns	**	ns	***	*	*	ns	ns	*	*

NS: Non-significant; * Means are significant at p<0.05; ** Means are significant at p<0.01; ***Means are significant at p<0.001, CA: Crude ash contents, OM: orgaric matter, CP: Crude protein, EE: Ether extract, DCP: Digestiable crude protein, TDN: Total digestable nutrients, NDF: Neutral detergent fiber, ADF: Acid detergent fiber, CT: Condensed tannin, IVDMD: *In vitro* dry matter digestable, CHO: Total carbohydrater, DE: Digestiable energy, ADL: Acid detergent ligin, DCHO: Digestiable carbohydrate, DEE: Digestiable ethanol extract, GE: Gross energy

DISCUSSION

Proximate composition: Crude ash content, the mineral level in a feed and large amount of silica (Verma, 2006) of *A. gummifera* in the present study has ranged between 68.4 and 130 g kg^{-1} DM (Table 3). Typical ash content of forages and feeds are in the range of 80 to 100 g kg^{-1} DM, so the combined values in the present study, 99.2 g CA kg^{-1} DM, falls within in that range (Topps, 1993). Whereas the CP content calculated for the leaves of *A. gummifera* in both altitudes and seasons are much higher than the minimum CP level (70 g CP kg^{-1} DM = 45.5 g DCP kg^{-1}) required for optimum functioning of rumen (McDonald *et al.,* 2002) and for adequate intake of forages Ranjhnan (2001). Ranjhnan (2001) have indicated that intake of forages is limited when their CP content is less than 100 g kg^{-1} DM. Voluntary feed intake also rapidly falls if CP content of forage is below 62 g kg^{-1} (Nasrullah *et al.*, 2003). The optimum concentration level of rumen bacteria is reached at a CP level in the diet of 130g CP kg^{-1} (= 85 g DCP kg^{-1}). The minimum CP content required for lactation and growth of cattle is 150 g kg^{-1} DM (Norton, 2000) therefore, the foliages of *A. gummifera* appeared to have sufficient N content to meet animal nitrogen requirement on assumption that they were adequately degraded and were non-toxic to rumen microbes and host animals. These values thus indicate that *A. gummifera* foliages can serve as protein supplement when animals are based only on crop residues and pasture grazing. The CP levels of the foliages correlated positively with many desired plant components like *in vitro* digestible DM and ME energy($r = 0.71$; $p<0.001$) can be good indicator of feed value potentials of *A. gummifera*. All these components decline to deficient levels at about the same time and CP serves as a reliable measure of overall nutritional quality of a feed (Ramirez *et al.*, 2002). Tolera *et al.* (1999) also suggested that due to low CP and high lignocellulosic cell wall contents, it is justifiable to elevate alternative sources of protein if a nutritional constraint to animal production is to be alleviated. However, the advantage of *A. gummifera* is having higher protein value compared to tropical grasses. Therefore, they could serve as potential protein supplements to enhance the intake and utilization of fibrous crop residues for ruminant diets. This also shows that there are indeed possibilities of improving farmers feed resource base and other farm objectives from local resources available in study area. The results of the present study also agreed with Getachew *et al.* (2000) in that browse forages are better used as protein supplement than poor quality roughages such as hay, straws and stover. EE content of *A. gummifera* samples ranged between 13 to 45 g kg^{-1} DM. Total diets do not contain EE more than 100 g kg^{-1} is acceptable (Preston, 1995). Ruminant diets should be limited to about 40 g EE kg^{-1} DM (Campbell *et al.*, 2006). Thus, EE values of *A. gummifera* are also acceptable for livestock feeding in the tropics.

Detergent fiber fractions: The threshold level of NDF in tropical grasses beyond which DM intake of cattle is affected is 600 g NDF kg^{-1} (Meissner *et al.*, 1991) suggesting that the *A. gummifera* leaves have acceptable NDF values (below 600 g NDF kg^{-1} DM) and also indicating that the *A. gummifera* are very high in feeding value in terms of lower NDF content. Tree forages with a low NDF content (200-350 g kg^{-1}) are usually of high digestibility (Norton, 1994). The digestibility of plant material in the rumen is related to the proportion and lignification of cell walls (Van-Soest, 1994). In contrast, high contents of cell wall and lignin are typical of tropical forages (Van-Soest *et al.*, 1991) which have serious implications on the digestibility of forages. NDF actually determines the rate of digestion because it is inversely correlated to digestibility

Table 3: Correlation coefficient for nutritive value parameters of *A. gummifera*

	DM	TA	CP	EE	NDF	ADF	ADL	CT	IVOMD	ME	CHO	DCHO	DEE	DCP	GE	DE	TDN
DM	1	0.22	0.23	0.34	-0.22	-0.15	0.41**	0.52***	-0.03	-0.03	-0.38	-0.03	0.34	0.23	0.29	0.13	0.12
TA		1	-0.14	0.42***	-0.21	-0.19	0.36	0.03	0.00	0.00	-0.21	0.00	0.42***	-0.14	-0.02	-0.01	0.02
CP			1	-0.14	-0.70*	-0.87*	-0.52**	-0.22	0.62*	0.62*	-0.92*	0.62*	-0.14	1.00*	0.96*	0.86*	0.81*
EE				1	-0.30	-0.18	0.40**	0.33	-0.12	-0.12	-0.19	-0.12	1.00	-0.14	0.11	-0.01	0.03
NDF					1	0.88*	0.33	0.32	-0.59*	-0.59*	0.80*	-0.59***	-0.30	-0.70*	-0.79*	-0.75*	-0.75*
ADF						1	0.49**	0.38	-0.68*	-0.68*	0.93*	-0.68*	-0.18	-0.87*	-0.93*	-0.88*	-0.86*
ADL							1	0.69*	-0.48***	-0.48***	0.29	-0.48***	0.40***	-0.52**	-0.44**	-0.50***	-0.48**
CT								1	-0.60*	-0.60*	0.10	-0.60*	0.33	-0.22	-0.19	-0.45**	-0.47**
IVOMD									1	1.00*	-0.58*	1.00*	-0.12	0.62*	0.67*	0.92*	0.94*
ME										1	-0.58*	1.00*	-0.12	0.62*	0.67*	0.92*	0.94*
CHO											1	-0.58*	-0.19	-0.92*	-0.96*	-0.83*	-0.80*
DCHO												1	-0.12	0.62*	0.67*	0.92/	0.94*
DEE													1	-0.14	0.11	-0.01	0.03
DCP														1	0.96	0.86	0.81*
GE															1	0.90	0.87*
DE																1	1.00*
TDN																	1

*Significant at p<0.05, **Significant at p<0.01, ***Significant at p<0.001. CA: Crude ash contents, OM: Orgaric matter, CP: Crude protein, EE: Ether extract, DCP: Digestiable crude protein, TDN: Total digestable nutrients, NDF: Neutral detergent fiber, ADF: Acid detergent fiber, CT: Condensed tannin, IVDMD: *In vitro* dry matter digestable, CHO: Total carbohydrater, DE: Digestiable energy, ADL: Acid detergent ligin, DCHO: digestiable carbohydrate, DEE: Digestiable ethanol extract, GE: Gross energy

(McDonald *et al.*, 2002). High ADL content can limit the voluntary feed intake, digestibility and nutrient utilization of ruminant animals (Khanal and Subba, 2001). Moreover, lignin as a percentage of lingo-cellulose is highly correlated with the digestibility of cell wall fraction (Van-Soest *et al.*, 1991). In the present study, hemicellulose contents (range 5.0-34.0 g kg^{-1} DM) of the mixtures were very low compared to those of most tropical grasses (319 to 354 g kg^{-1} DM), respectively (Moore and Jung, 2001) suggesting that lower cell wall contents will result higher digestibility coefficients for *A. gummifera* species.

Condensed tannin: The effect of tannins can be either adverse or beneficial for animals, depending on the concentration and chemical structure (Makkar, 2003; Min *et al.*, 2003). Barry and Manley (1984) explained that forage containing more than 50 g CT kg^{-1} DM is considered tannin-rich forages. Higher tannin levels become highly detrimental (Barry and Manley, 1984) as they reduce digestibility of fiber in the rumen (Reed *et al.*, 1985) by inhibiting the activity of bacteria (Chesson *et al.*,1982) and anaerobic fungi (Akin and Rigsby, 1985) high levels also lead to reduced intake (Leng, 1997). The negatively significant correlation ($p<0.01$) between CT and IVDMD, ME, DCHO, DE and TDN might be due to the fact that tannins can potentially bind to proteins by preventing proteins from microbial digestion that in turn will result in low ME, digestible of DM and digestible nutrients.

***In vitro* digestible DM, digestible nutrients and dietary energy:** The IVDMD values in the present study were found to be slightly higher than IVDMD values reported by Mokonnen *et al.* (2009) for multipurpose fodder tree and shrub species in central highlands of Ethiopia. Mokonnin *et al.* (2009) IVDMD values presented in Table 1 were possibly associated with the low level of NDF, ADF and ADL. In reality when IVDMD falls below 550 g kg^{-1}, physical limitations on the rate of eating, rate of digestion and passage through the gastrointestinal tract is restricted and live weight loss is inevitable (SCA, 1990). A feed contain 600-700, 400-600 and less than 400 g DDM kg^{-1} is considered as moderate, low and very low digestibility (Naseri, 2004). It has been reported that cell wall component, NDF, ADF and lignin, were negatively correlated with IVDMD in tree leaves (Kundu and Sharma, 1988; Perveen, 1998). The negative correlation between IVDMD, NDF, ADF and ADL in the present study inline with those of Van-Soest (1978) who reported poor relationship of NDF, ADF and ADL with digestibility. Lichtenberg and Hemken (1985) also reported that per unit increase in lignin often resulted in a three to four unit decrease in DM digestibility. In general, variations in chemical composition, IVDMD, digestible nutrients and energy density among foliages of *A. gummifera* species due to altitude may be partly due to variation in soil chemical nutrients as well as seasonal influences that control accumulation of plant nutrients.

Digestible Energy (DE) is approximately equivalent to Total Digestible Nutrients (TDN) in the present study agrees with similar reports of Martens (2006). All feeds (apart from those with a very high fat or oil content) having GE content 18 MJ kg^{-1} DM is considered to be good source of energy (Naseri, 2004; Saricicek and Kilic, 2011).

Interaction effect of altitude and season on nutritional quality of *A. gummifera*: There was a significant interaction ($p<0.05$) between altitude and season in both study districts for the most of parameters measured for nutritional quality. The possible reason for the presence of interaction between altitudes and season could be partly due to presence of differences soil nutrients and seasonal influences of nutritional parameters (Yisehak *et al.*, 2009; Terefe *et al.*, 2010). This can also point out that evaluation of a feed staff from various locations and seasons can be a good indicator for linking nutritional quality and environmental factors. Accordingly, this part of the study requires further investigation.

CONCLUSION

In the present study, the high CP content of foliages of the *A. gummifera* indicating that suitability for protein supplementation to herbivore livestock fed low quality roughages. Because of generally high protein content, browse intake improves digestibility of low-quality feeds and leads to an overall increase in intake of digestible dry matter. Intake of browse, especially over critical periods such as the dry season, also results in increased survival and productivity of livestock. Thus, based on analysis of chemical parameters and IVDMD, in general the foliage of *A. gummifera* has potential to be used as sources of fodder with a proper feeding management scheme. The *A. gummifera* had also moderate to high IVDMD, digestible nutrients, total carbohydrates as well as ME. This demonstrates the high nutritive value of the browse forage when used in livestock feeding.

The *A. gummifera* had a CT concentration ranging from 68 to 72 g kg^{-1} DM. However, over 50 g CT kg^{-1} DM was set as limit for effective anti-nutritional effects, suggesting that CT of *A. gummifera* had adverse effect on feeding value. Therefore, *A. gummifera* leaves should be supplemental with Polyethylene Glycol (PEG) or other alkali, since the possible detrimental effect of CT in plant leaves could be reduced by applying these tannin deactivating substances on daily rations of livestock.

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