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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

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Abstract: This study evaluated the feeding value of Lowland Bamboo Leaf Hay (LBLH) as basal diet when offered sole or in mixture with Natural Pasture Grass Hay (NPGH). Thirty local 'Washera' yearling male lambs with initial body weight of 23.8±1.35 kg (mean±SD) were grouped into six blocks of five animals and randomly assigned to five dietary treatments consisting of NPGH and LBLH at a ratio of 100:0 (T1), 75:25 (T2), 50:50 (T3), 25:75 (T4) and 0:100% (T5), respectively. The basal diets were fed *ad libitum* and all animals received 150 g Dry Matter (DM) Noug Seed Meal (NSM)/day. The study consisted of 90 days growth and 7 days digestibility trials. Rumen fluid was sampled at the end for pH and ammonia nitrogen determination. The Crude Protein (CP) level in NPGH, LBLH and NSM were 73, 111 and 322 g/kg DM, respectively. Total DM intake [705, 704, 644, 691 and 649 g/day (SEM = 3.1)] was similar ($p>0.05$) and CP intake [90, 99, 99, 103 and 109 for T1, T2, T3, T4 and T5, respectively (SEM = 0.9)] differ ($p<0.05$) among treatments. Digestibility coefficient of DM was similar among treatments and that of CP was in the order of T1 < T2 = T3 = T4 < T5 ($p<0.001$). Ruminal ammonia concentration was in the order of T5 > T4 > T3 > T2 = T1 ($p<0.05$). Average daily gain [25, 24, 25, 31 and 37 g/day (SEM = 1.1)] and feed conversion efficiency [0.035, 0.034, 0.038, 0.045 and 0.057 for T1, T2, T3, T4 and T5, respectively (SEM = 0.040)] were greater ($p<0.05$) for T5 as compared to T1, T2 and T3 and values for T4 was similar with all other treatments. In conclusion LBLH had a relatively better feeding value as compared to the NPGH used in this study and hence can be a good substitute to hay especially in the dry season when conventional roughages are in short supply and low in CP content.

Key words: Digestibility, grass hay, intake, lowland bamboo, rumen parameters, sheep

INTRODUCTION

The major feed resources in Ethiopia for ruminants are natural pasture and crop residues, which are categorized as poor quality roughage with low intake (Berhanu *et al*., 2009), due to their tough texture, poor digestibility and nutrient deficiency such as Crude Protein (CP) and Metabolizable Energy (ME) and as such do not fulfill the requirements of the animal (Mupangwa *et al*., 2002). Moreover, the importance of natural pasture as source of feed resource is gradually declining as a result of the expansion of crop production, redistribution of grazing lands to the landless and land degradation (Mulat, 1999). On-farm adoptions of chemical treatment of crop residues to improve their nutritive value are also rare because of cost effectiveness and know how. Therefore, identifying feed resources that are locally available and easily accessible to smallholder farmers for use as a basal diet is a timely task. One of these feed resources is lowland bamboo leaf.

Lowland bamboo is widely distributed in East and West Africa. It is multipurpose perennial crop that grows well on poor and shallow soils and in harsh environments, because of its ability to adapt to low rainfall and high efficiency of water uptake (Brias and Tesfaye, 2009). The lowland bamboo species found in Ethiopia (*Oxytenanthera abyssinica*), is a tufted, sympodial plant with a height ranging from 3 to 10 meters and a diameter ranging from 5-10 cm (Brias and Tesfaye, 2009). In the country, the plant is found in dry areas of the north and northwestern regions covering about 440,000 hectare of land in the Benishangul-Gumuz region alone (Kassahun, 2000). The ability of this plant to withstand water stress makes it to be ever green and produce fresh foliage throughout the dry season where other feeds are in short supply (Brias and Tesfaye, 2009).

A recent data (Yeshambel *et al*., unpublished) showed that on average 11.7 tones Dry Matter (DM)/ha of leaf biomass can be harvested from lowland bamboo culm aged one to three years, which is more than the natural pasture biomass yield of 1-3 tones DM/ha in the tropics (Girma *et al*., 2003). An extensive study made by LUSO

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Consult (1997) indicated 3 million tones of leaf DM biomass can be harvested from lowland bamboo in Ethiopia. More yield is expected as its production as a backyard plantation is becoming an emerging practice due to increased awareness about the plant (Brias and Tesfaye, 2009; Mekuriaw *et al*., 2011).

Bamboo foliages (leaf and twigs) and in few cases stems/culms are important feeds for diverse animal species, particularly ruminants (Keir *et al*., 1997; Sath *et al*., 2008). Halvorson *et al*. (2010) reported that bamboo leaf contain nutrients sufficient for maintenance of adult goats. Higuchi *et al*. (1987) reported that steam-exploded bamboo culm was comparable to that of alfalfa in feeding of ruminants. Conversely, some studies (Smith *et al*., 1991; Greenway, 1999) showed that bamboo leaf are similar in feeding value to low-quality grass hay with a DM digestibility of 30-36% and recommended that bamboo leaf cannot be used as sole source of fodder for ruminants. Similarly, Asaolu *et al*. (2009b) recorded CP content and digestibility of 14.52% and 39.07%, respectively and noted that West African dwarf goats fed sole lowland bamboo leaf had negative nitrogen balance. The *in vitro* dry matter digestibility of lowland bamboo leaf ranged 44-65% (Teklu *et al*., 2010; Yeshambel *et al*., unpublished). Although the high crude protein content (Asaolu *et al*., 2009ab; Eyob, 2010; Teklu *et al*., 2010) of lowland bamboo leaf indicate its potential as a feed, data on the feeding value of the resource is minimal and variable. Therefore, the aim of this study was to evaluate lowland bamboo leaf as a basal diet alone or in mixture with natural pasture grass hay in different proportion on intake, digestibility of nutrients, rumen parameters and body-weight gain of Washera sheep.

MATERIALS AND METHODS

Description of the study area: The experiment was conducted during May-August 2010 at Bahir Dar University, which is located in northwest Ethiopia 564 km from the capital Addis Ababa and at elevation of 1840 meters above sea level and a latitude and longitude of 11°36'N, 37°23'E, respectively. The mean monthly maximum and minimum temperature of Bahir Dar varies from 23-33.5°C and 6.3-16.7°C, respectively. The area is characterized by unimodal rainfall pattern with mean annual rainfall of 1498 mm. Most of the rainfall occurs during summer season between June and September and dry season is from December to April (BoARD, 2006).

Experimental feeds preparation and feeding: The lowland bamboo leaf was collected from Metekel zone of Benishangul-Gumuz Regional State from enclosed area, farmers' backyard and natural forest. The age of culm/stem from which the bamboo leaf harvested was in the range of 1-3 years. The leaf was collected manually in the dry season (February and April, 2010). The leaf was collected by individuals who have experience in determining the age of bamboo culm using record of planting date, culm color (green color of the culm indicates the age of one to three years, whereas presence of white spot because of mosses on the culm indicates age greater than three years). After collection, the leaves were sun dried under shed, thoroughly mixed, packed into sacks and transported to Bahir Dar University and stored under shed. The natural pasture (*Cynodon dactylon* grass species dominant) hay was harvested manually from a school compound in Bahir Dar city, sun dried for three days and stored under shade. Both bamboo leaf and natural pasture grass hay were chopped manually approximately to a size of 3-6 cm. Noug seed meal adequate for the entire feeding period was purchased from oil extracting plant in Bahir Dar city.

The bamboo leaf and natural pasture grass hay were fed as a sole or mixture basal diet *ad libitum* at 30% in excess of daily consumption and weekly offer was adjusted based on the previous seven days average intake. After chopping, the natural pasture grass hay and lowland bamboo leaf hay were separately weighed and thoroughly mixed by hand before putting them in the feed troughs to minimize selection. All animals received 150 g DM/day noug seed (*Guizotia abyssinica*) meal in two equal portions at 0800 and 1600 hrs in a separate feeding trough. Fresh clean water and common salt block were available to the animals all the time throughout the experiment. Lambs were adapted to the respective experimental diets and experiment procedure for 15 days before the commencement of the actual data collection. The feed offer was gradually increased during the adaptation period of 15 days to acclimatize the animal to the feed.

Experimental animals and management: Thirty intact yearling male growing Washera lambs with initial body weight of 23.8±1.35 kg (mean±SD) were purchased from Dangila town where bamboo production and utilization as ruminant feed is common. Age of the animals was determined by their dentition and information obtained from the owners. The experimental animals were neck tagged for identification. Experimental animals were quarantined for 21 days. During this time each animals were treated against internal (albendazol) and external (Ivermectin) parasites and vaccinated against ovine pasteurellosis, sheep pox, blackleg and anthrax based on the recommendation of a veterinarian.

Experimental design and treatments: The experiment consisted of 90 days of growth and 7 days of digestibility trials. There were five treatments in this study. Treatments had different proportions of the two basal diets, i.e. Natural Pasture Grass Hay (NPGH) and Lowland Bamboo Leaf Hay (LBLH) fed *ad libitum* and supplemented with 150 g DM/day Noug Seed Meal (NSM). Therefore, treatments were 100% NPGH (T1), 75 % NPGH + 25% LBLH (T2), 50% NPGH + 50% LBLH (T3), 25% NPGH + 75% LBLH (T4) and 100% LBLH (T5). The design of the experiment was Randomized Complete Block Design (RCBD). At the end of the quarantine period, the lambs were weighed and blocked into six blocks of five animals per block and kept in well ventilated individual pens equipped with watering and feeding troughs. The five treatment diets were randomly assigned to each animal in a block. Thus, there were six animals per treatment.

Feed intake: The amounts of feed offered and refused were recorded daily for each animal and the daily DM intake was calculated by difference. Representative samples of basal feeds offered and refused after thoroughly mixing on daily basis and the noug seed meal per batch were collected and a sub-sample was taken at the end of the experiment for chemical analysis. The metabolize energy (ME; MJ/kg DM) intake of experimental animals was estimated from *in vivo* Digestible Organic Matter Intake (DOMI) values by using the equation of AFRC (1993), as ME (MJ/kg DM) = 0.0157 *DOMI g/kg DM, where DOMI = digestible organic matter intake.

Digestibility: At the end of the growth trial, digestibility trial was conducted using similar dietary treatments and five animals per treatment. For these purpose, five blocks each having five sheep were randomly selected from the total six blocks. The lambs were fitted with faecal collection bags for three days of adaptation followed by a 7 days faeces collection during which daily feed intake and refusal of each animal was recorded. Faeces voided in the bags were weighed individually and recorded daily each morning before feeding. The faeces were then mixed thoroughly and 15% of the daily faecal output was taken and bulked over the experimental period and kept in dip freezer at -20°C. On the last day of the collection period, the composite faecal samples were thawed and thoroughly mixed and a sub-sample was taken. Samples of feed offered and feed refused were also collected every day and sub-sampled at the end of the experiment. The digestibility of DM and nutrients was determined as the difference between nutrients intake and that recovered in faeces expressed as a proportion of nutrient intake.

Rumen fluid was collected on the day of completion of digestibility trial. About 30-40 mL of rumen fluid was collected with a stomach tube at 4 h post feeding. The collected rumen fluid was immediately used for pH readings (pH meter-pHS-3B, China). The portion of the rumen fluid was strained through 2 layers of cheesecloth and transferred into plastic bottles containing 3 to 4 drops of concentrated sulfuric acid and stored at-20°C pending analysis of ruminal ammonia nitrogen.

Body weight change and feed conversion efficiency: The initial body weight of each animal was taken as a mean of two consecutive measurements. The body weight of lambs was measured at 10 days interval in the mornings before the daily feed was offered using spring balance (sensitivity of 100 g). On the day before the weighing date, the feed not consumed until 6:00 pm was removed and weighed. Average daily body weight gain was calculated as the difference between final and the initial body weights of the lambs divided by the number of experimental days. Feed Conversion Efficiency (FCE) of the animal was determined as the proportion of daily weight gain to the total DM intake.

Chemical analysis: Feed, refusal and faecal samples were dried in an oven at 60°C for 72 hrs and ground in a Wiley Mill, to pass a 1 mm sieve screen and kept in air-tight plastic bags pending analysis. DM, OM and Nitrogen (N) were determined according to the procedure of AOAC (1990). Neutral Detergent Fiber (NDF), Acid Detergent Fiber (ADF) and Acid Detergent Lignin (ADL) were analyzed according to the procedure of Van Soest and Robertson (1985). CP was calculated as N*6.25. Hemicellulose and cellulose contents were calculated as NDF minus ADF and ADF minus ADL, respectively. Ammonia nitrogen concentration from rumen fluid was determined following the procedure of ILRI (1997).

Statistical analysis: Data obtained were subjected to Analysis of Variance (ANOVA) using the general linear model procedure of SAS version 9.1.3 (SAS, 2002). Differences among treatment means were tested using Least Significant Difference (LSD). The model for data analysis was $Y_{ij} = \mu + t_i + b_j + e_{ijk}$, where, Y_{ij} is the response variable, μ the overall mean, t_i the treatment effect, b_j the block effect and e_{ijk} is random error.

RESULTS

Chemical composition of basal feeds: The nutrient content of LBLH tends to be higher than NPGH and its inclusion increased CP content of the diet and decreased NDF, ADF and ADL (Table 1). The supplemental noug seed meal was totally consumed by the animals. But looking on the chemical composition of the hay refusals for the different treatments, it appears that there was little selectivity by the animals against both hay types.

Dry matter and nutrient intake: Total DM intake as g/day and % body weight was similar (p>0.05) among

Table 1: Chemical composition of experimental feeds

Diet offered	Chemical composition (g/kg for DM and g/kg DM for others) DM	OM	CP	NDF	ADF	ADL	C	HC
T1	919	891	73	797	547	100	447	250
T2	911	866	89	787	540	97	443	247
T3	916	854	92	779	536	94	442	229
T4	922	836	93	774	516	90	426	268
T5	914	815	111	770	507	83	424	272
NSM	913	908	322	358	273	61	197	85
Refusal								
T1	918	907	67	807	559	103	456	248
T2	930	886	85	834	556	99	457	278
T3	925	865	76	814	568	98	470	246
T4	929	844	82	800	566	101	465	234
T5	930	829	97	804	555	89	466	249

ADF = Acid Detergent Fiber; ADL = Acid Detergent Lignin; C = Cellulose; CP = Crude Protein; DM = Dry Matter; HC = Hemicelluloses; LBLH = Lowland Bamboo Leaf Hay; NDF = Neutral Detergent Fiber; NSM = Noug Seed Meal; NPGH = Natural Pasture Grass Hay; OM = Organic Matter; T1 = 100% NPGH *ad libitum* + 150 g DM NSM/day; T2 = 75% NPGH + 25% LBLH *ad libitum* + 150 g DM NSM/day; T3 = 50% NPGH + 50% LBLH *ad libitum* + 150 g DM NSM/day; T4 = 25% NPGH + 75% LBLH *ad libitum* + 150 g DM NSM/day; T5 = 100% LBLH *ad libitum* + 150 g DM NSM/day

Table 2: Daily dry matter and nutrient intake of Washera lambs fed mixtures of lowland bamboo leaf hay and natural pasture grass hay at different proportion

Intake	Treatments T1	T2	T3	T4	T5	SEM	SL
DM intake							
Basal diet (g/day)	554.9	553.7	494.0	540.7	499.1	3.12	ns
NSM (g/day)	150.0	150.0	150.0	150.0	150.0	-	-
Total (g/day)	704.9	703.7	644.0	690.7	649.1	3.12	ns
Total (%BW)	3.6	3.6	3.8	3.7	3.9	0.21	ns
OM intake (g/day)	627.5[a]	606.6[ab]	548.7[bc]	581.3[abc]	532.8[c]	2.98	*
CP intake (g/day)	90.0[c]	98.9[b]	98.9[b]	102.8[b]	108.9[a]	0.94	***
NDF intake (g/day)	494.0	477.8	430.5	461.6	422.5	2.79	ns
ADF intake (g/day)	342.2[a]	333.4[ab]	291.8[c]	299.9[bc]	267.9[c]	2.36	**
ME (MJ/day)[1]	6.4[a]	6.2[ab]	5.8[b]	5.6[b]	5.2[b]	0.31	**

[a-c]Means within rows having different superscript are significantly different at *p<0.05; **p<0.01; ***p<0.001; LBLH = Lowland Bamboo Leaf Hay; NPGH = Natural Pasture Grass Hay; ns = not significant; NSM = Noug Seed Meal; SEM = Standard Error of the Mean; SL = Significance Level; T1 = 100% NPGH *ad libitum* + 150 g DM NSM/day; T2 = 75% NPGH + 25% LBLH *ad libitum* + 150 g DM NSM/day; T3 = 50% NPGH + 50% LBLH *ad libitum* + 150 g DM NSM/day; T4 = 25% NPGH + 75% LBLH *ad libitum* + 150 g DM NSM/day; T5 = 100% LBLH *ad libitum* + 150 g DM NSM/day.

[1]Estimated Metabolizable Energy (ME) = 0.0157 x Digestible Organic Matter Intake (DOMI) (AFRC, 1993)

treatments (Table 2). Intake of NDF was also similar among treatments. Intake of OM and ADF appeared to decrease with increasing level of LBLH. Total CP intake was highest for T5, lowest for T1 and intermediate for the other treatments (p<0.001). The estimated ME intake was greater (p<0.05) for animal fed the sole NPGH as compared to animals in T3, T4 and T5, whereas values for T2 were similar (p>0.05) with other treatments.

Nutrient digestibility: Apparent digestion coefficients of DM, OM, NDF and ADF were not statistically different (p>0.05) among the treatments (Table 3). Differences in CP digestibility was consistent with that of CP intake and was in the order of T1 < T2 = T3 = T4 < T5 (p<0.05).

Rumen parameters: No significant (p>0.05) difference was observed in rumen pH among the treatment groups

Table 3: Apparent nutrients digestibility coefficient in Washera lambs fed mixtures of lowland bamboo leaf hay and natural pasture grass hay at different proportion

Digest. coeff.	Treatments T1	T2	T3	T4	T5	SEM	SL
DM	0.56	0.55	0.60	0.56	0.59	0.87	ns
OM	0.60	0.58	0.64	0.60	0.63	0.83	ns
CP	0.56[c]	0.69[b]	0.71[b]	0.73[b]	0.80[a]	0.95	***
NDF	0.53	0.52	0.57	0.54	0.56	0.90	ns
ADF	0.51	0.44	0.50	0.47	0.46	0.96	ns

[a-c]Means within rows with different superscripts are significantly different at *** = p<0.001; ADF = Acid Detergent Fiber; CP = Crude Protein; DM = Dry Matter; LBLH= Lowland Bamboo Leaf Hay; NDF = Neutral Detergent Fiber; NPGH = Natural Pasture Grass Hay; ns = not significant; NSM = Noug Seed Meal; OM = Organic Matter; SEM = Standard Error of the Mean; SL = Significance Level; T1 = 100% NPGH *ad libitum* + 150 g DM NSM/day; T2 = 75% NPGH + 25% LBLH *ad libitum* + 150 g DM NSM/day; T3 = 50% NPGH + 50% LBLH *ad libitum* + 150 g DM NSM/day; T4 = 25% NPGH + 75% LBLH *ad libitum* + 150 g DM NSM/day; T5 = 100% LBLH *ad libitum* + 150 g DM NSM/day. Digest. Coeff. = Digestibility Coefficient

Table 4: Mean rumen parameters of Washera sheep fed mixtures of lowland bamboo leaf hay and natural pasture grass hay at different proportion

Rumen parameters	Treatments T1	T2	T3	T4	T5	SEM	SL
Rumen pH	5.15	5.33	4.27	5.06	4.80	0.54	ns
NH_3-N (mg/l)	52.10[d]	52.50[d]	60.20[c]	67.70[b]	81.20[a]	1.01	***

[a-d]Means within rows with different superscripts are significantly different at *** = p<0.001; LBLH = Lowland Bamboo Leaf Hay; NPGH = Natural Pasture Grass Hay; ns = not significant; NSM = Noug Seed Meal; SEM = Standard Error of the Mean; SL = Significance Level; T1 = 100% NPGH *ad libitum* + 150 g DM NSM/day; T2 = 75% NPGH + 25% LBLH *ad libitum* + 150 g DM NSM/day; T3 = 50% NPGH + 50% LBLH *ad libitum* + 150 g DM NSM/day; T4 = 25% NPGH + 75% LBLH *ad libitum* + 150 g DM NSM/day; T5 = 100% LBLH *ad libitum* + 150 g DM NSM/day

Table 5: Body weight parameters and feed conversion efficiency of Washera lambs fed mixtures of lowland bamboo leaf hay and natural pasture grass hay at different proportion

Treatments	Treatments T1	T2	T3	T4	T5	SEM	SL
IBW (kg)	23.9	24.1	23.5	24.1	23.6	0.49	ns
FBW (kg)	26.2	26.3	25.8	26.9	26.8	0.52	ns
BWC (kg)	2.2[b]	2.2[b]	2.2[b]	2.8[ab]	3.3[a]	0.33	**
ADG (g/day)	25.2[b]	24.2[b]	24.8[b]	31.3[ab]	36.7[a]	1.08	*
FCE (g gain/g fed)	0.035[b]	0.034[b]	0.038[b]	0.045[ab]	0.057[a]	0.04	**

[a,b]Means within rows with different superscripts are significantly different at * = p<0.05; ** = p<0.01; ADG = Average Daily Gain; BWC = Body Weight Change; FBW = Final Body Weight; FCE = Feed Conversion Efficiency; IBW = Initial Body Weight; ns = not significant; NSM = Noug Seed Meal; SEM = Standard Error of the Mean; SL = Significance Level; T1 = 100% NPGH *ad libitum* + 150 g DM NSM/day; T2 = 75% NPGH + 25% LBLH *ad libitum* + 150 g DM NSM/day; T3 = 50% NPGH + 50% LBLH *ad libitum* + 150 g DM NSM/day; T4 = 25% NPGH + 75% LBLH *ad libitum* + 150 g DM NSM/day; T5 = 100% LBLH *ad libitum* + 150 g DM NSM/day

(Table 4). The level of rumen ammonia nitrogen (NH_3-N) concentration was impacted by treatment (p<0.001). Groups that consumed sole LBLH (T5) as a basal diet recorded the highest rumen ammonia nitrogen followed by T4 and T3, while T1 (100% NPGH) and T2 (25% LBLH) had the lowest rumen NH_3-N concentration.

Body weight change: Initial and final body weights were not affected (p>0.05) by treatment (Table 5). Treatments varied in Average Daily Body Weight Gain (ADG), total body weight change and Feed Conversion Efficiency (FCE) of lambs. Basal diet consisting sole LBLH (T5) resulted in higher (p<0.05) total weight gain, ADG as well as FCE of sheep than T1, T2 and T3, while values for T4 was similar (p>0.05) with all other treatments.

DISCUSSION

Chemical compositions of treatment feeds: The nutrient content of NPGH, LBLH and their mixtures is comparable, although it appeared that LBLH had relatively higher CP. The CP content of NPGH in this study was higher than the value reported earlier (Bishaw and Melaku, 2008), but lower than the value of 92 g/kg DM (Asmare *et al*., 2010). The differences in CP content of NPGH used in various studies can be attributed to environmental condition, stage of maturity at harvest, drying procedures and storage management. The CP content of lowland bamboo leaf used in the present study was lower than values reported in previous studies (Asaolu *et al*., 2009ab; Eyob, 2010; Teklu *et al*., 2010). The fiber contents of LBLH used in this study were similar to the value reported by Eyob (2010) but, higher than that reported by Asaolu *et al*. (2009a) and Teklu *et al*. (2010). The OM content of LBLH in the present study was similar with that reported by Eyob (2010), but lower than the value recorded by Asaolu *et al*. (2009a) for lowland bamboo and by Denbeshu (2010) for highland bamboo. The difference in nutrient composition of bamboo species among studies could be explained by age and season at which the plant was harvested (Embaye *et al*., 2005).

It has been noted that CP value of 8% is required to satisfy maintenance requirement of ruminant animals (Norton, 2003). Hence, the observed CP content of the NPGH in the current study may not be sufficient to satisfy the demand for rumen microbial synthesis. However, the mean CP content of the treatments with mixture of the two basal diets and sole LBLH as basal diet were all above the minimum level necessary to provide sufficient nitrogen required by rumen microorganisms to support optimum activity. The content of detergent fibers in both NPGH and LBLH were above the recommended threshold level (550-600 g/kg DM) for healthy rumen function (Meissner *et al*., 1991) and better feed intake and digestibility (Van Soest, 1994). McDonald *et al*. (2002) 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, fiber content of feed should not exceed 150-200 g/kg DM (Buxton, 1996). Therefore, the basal diets in the present experiment reflected typical characteristics of tropical forages. Van Soest *et al.* (1991) noted that such type of roughage diets can limit feed intake and digestibility.

Nutrient intake: Mean total DM intake as percent body weight in the present study lies within the range of 3-4% reported by Eyob (2010) for sheep and the 2-6% recommendation by ARC (1980) and Susan (2003), but lower than 4.4-5.3% recorded by Estifanos and Melaku (2009). Lack of statistical differences in DM intake among treatments could be attributed to the relative similarity of the basal diets in nutrient content and partly due to the uniform supplementation with noug seed meal. Consequently all treatment diets had CP level above 8% and nitrogen deficiency, which is a factor to cause intake reduction (Van Soest, 1994), might not have been a problem. NDF concentration of forage is a good predictor of voluntary DM intake by sheep (Van Soest, 1965). In the present experiment, variation in total NDF intake and digestibility of NDF among treatments were non-significant ($p>0.05$). Thus, its effect in influencing feed intake is expected to be similar across the treatments. Similar lack of difference in feed intake of sheep fed dwarf bamboo and Bahia grass was reported by Yayota *et al.* (2009). In contrary to the present finding, Asaolu *et al.* (2009b) reported significant differences in DM intake of goats fed with lowland bamboo leaf in mixture with *Moringa oleifera* at a proportion similar to that used in the present experiment and the lowest intake was recorded in a group fed with the sole lowland bamboo leaf. The present finding is not also in accordance with that of Eyob (2010) who reported decreased total DM intake with increasing level of lowland bamboo leaf hay in the diet. The variation between the results of the experiments is attributed to the differences in nutrient content of the diet substituted by bamboo. *Moringa oleifera*, for example consists 27.9% NDF as compared to 68.8% in bamboo leaf, while the CP content of *Moringa oleifera* is relatively higher than bamboo leaf (Asaolu *et al.*, 2009b).

The high CP intake by group fed on sole LBLH and its mixture with NPGH in the present study is similar to that obtained by Asaolu *et al.* (2010) and Eyob (2010), who reported increased CP intake when bamboo leaf is substituted with ground nut hay and tef straw, respectively. The high CP intake is due to the presence of relatively higher level of CP in LBLH than the NPGH. The estimated ME intake by the lambs in all treatments was above the maintenance requirement range of 3.7-4.1 MJ/day estimated for a 20 kg lamb (ARC, 1980). Lower ME intake with increased level of LBLH in the diet is in agreement with the finding of Yayota *et al.* (2003) who reported that beef cows grazed on native pasture dominated with Nezasa dwarf bamboo (*Pleioblastus chino var. viridis*) had lower ME intake than those on improved grass pasture. The relatively higher ME intake for sole NPGH group is due to the higher OM intake as compared to the rest treatments.

Nutrient digestibility: Although inclusion of LBLH significantly improved CP digestibility as compared to sole NPGH, digestibility was not significantly increased with increasing level of LBLH (T2, T3 and T4). Concomitant with the current study, Asaolu *et al.* (2010) reported that mixture of groundnut hay and bamboo leaf at 50:50 ratio (%DM basis) increased CP digestibility and intake compared to the sole groundnut hay. This could be explained by the fact that feed rich in protein content promotes high microbial population and facilitates rumen fermentation (McDonald *et al.*, 2002). Subba and Singh (2000) noted that high content of available protein of bamboo leaf make it comparable feed resource with *Grewia tiliafolia* and *Ficus roxburghii* tree fodders in livestock feeding. Previous studies (Asaolu *et al.*, 2009b; Eyob, 2010; Denbeshu, 2010) noted decreased CP digestibility as the level of lowland or highland bamboo leaf in substitution for *Moringa oleifera* and concentrate increased, presumably due to the better nutritive value of the latter feed items. Contrary to the current result, Yayota *et al.* (2003) noted that beef cows grazed dwarf bamboo dominated pasture recorded lower DM, CP and NDF digestibility compared to groups grazed on improved grass pasture. Asaolu *et al.* (2010) reported that substitution of groundnut hay by bamboo leaf at 50:50 ratio significantly decreased DM digestibility coefficient in goats contrary to what has been noted in this study. Groundnut hay contained lower NDF than bamboo leaf, which could be the reason for reduction in digestibility when bamboo replaced groundnut hay (Asaolu *et al.*, 2010).

Rumen parameters: The optimum rumen pH for microbial protein synthesis is >5.7 (Stewart, 1977) and the range should be between 6.7 and 7 for optimum cellulolysis (Mould and Orskov, 1983). Inhibitory effects of rumen pH on cellulolysis at pH values <6.1 was recorded (Mould and Orskov, 1983). Based on these findings, the rumen pH measured in animals of all treatments in the present experiment fall within the inhibitory range for fibre digestion. But fiber digestion in this study appeared to be not much impacted by the feeding regimen. The low ruminal pH observed in this study might be due to the time of sampling ruminal fluid which was close to the feeding time. On the other hand, Morris (1988) noted the existence of low pH resistant fibrolyitc rumen microbes. Furthermore, Russell and Wilson (1996) reported that fibrolyitc enzymes appear to maintain activities at lower pH values. Therefore, absence of inhibitory effects of low pH on fiber digestion in the present study might be due to the adaptive characteristics of the microbes in the rumen of sheep and their enzyme.

The mean concentration of NH_3-N 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 (Satter and Slyter, 1974), except T5 which has higher value. For maximum nutrient utilization, however, 150-200 mg/L rumen fluid is essential (Perdok and Leng, 1989), which was not reached in the present study, probably due to the low level of total CP intake. In this study, NH_3-N increased with increasing level of LBLH, which obviously is related to the ingestion of relatively more degradable crude protein. Similarly, Corona *et al*. (2011) recorded increased tendency of NH_3-N in the rumen fluid as the quantity of nitrogen in the diet increases. However, NH_3-N value in the present study is relatively lower as compared to that of Sahoo *et al*. (2010) who determined NH_3-N concentration of different bamboo cultivars using *in vitro* techniques. This could be attributed to the bamboo varietal/cultivar differences.

Body weight change and feed conversion efficiency: Differences among treatment means in ADG in this study might mainly be due to differences in CP intake, CP digestibility and ruminal NH_3-N concentration among dietary treatments. Thus, nitrogen retention might have been increased with increasing level of LBLH in the diets in the current study. This was supported by Asaolu *et al*. (2010) who noted greater nitrogen retention value for 50:50% combinations of lowland bamboo and groundnut hay than sole ground nut hay fed goats. Similarly, Holstein heifers fed higher level of fresh bamboo shoot shell as supplement to ammonia treated straw basal diet had higher body weight gain (Liu *et al*., 2000). The highest ADG recorded at higher level of LBLH inclusion (T4 and T5) in this study is higher than the ADG value of 14.4 g for other breed of sheep fed the highest level of LBLH supplementation (Eyob, 2010). However, reduced body weight of Sidama sheep fed increasing level of highland bamboo leaf as replacement for concentrate mixture was reported by Denbeshu (2010). The ADG of Washera sheep fed higher level of LBLH in the current experiment was comparable to the same sheep breed fed urea treated rice straw as basal diet and supplemented with 200-400 g DM/day of noug seed cake, wheat bran and brewery dried grain mixture (Hailu *et al*., 2011), but lower than the values reported by Taye (2009) for Washera sheep fed different combinations/mixtures of Napier grass (*Pennisetum purpureum*) and Sesbania (*Sesbania sesban*). Lose in body weight in Washera sheep fed LBLH as a sole basal diet was not observed. However, the same sheep breed fed with sole urea treated rice straw (Hailu *et al*., 2011), sole finger millet straw (Alem *et al*., 2011) and sole Rhodes grass hay (Gebru, 2010) as basal diet lost weight. Although positive gains in body weight in LBLH fed animals could in part be due to the added NSM, looking on the chemical composition of LBLH lose in body weight might not have been occurred if it was fed alone, indicating its better feeding value. The improved FCE for sheep fed with higher proportion of LBLH in the current study might presumably be due to higher CP concentration and intake.

Conclusion: Lowland bamboo leaf and natural pasture grass hay used in the present experiment are comparable in most of their chemical constituents, but lowland bamboo leaf hay contain relatively high CP with greater digestibility, which improved ADG, FCE and rumen NH_3-N concentration indicating that lowland bamboo leaf could be used as an alternative fibrous feed source to medium quality grass hay. Therefore, it can be concluded that lowland bamboo leaf hay can be utilized as basal diet for ruminants, especially in the dry season when most of the conventional roughages are in short supply and low in CP content.

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