



## Effect of feeding different proportions of pigeon pea (*Cajanus cajan*) and neem (*Azadirachta indica*) leaves on feed intake, digestibility, body weight gain and carcass characteristics of goats



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### ABSTRACT

A 90-day experimental trial was conducted to investigate the growth performance and carcass parameters of goats supplemented with dry pigeon pea (PP) and neem leaves (NL). Thirty six yearling intact male Gumuz goats with initial mean body weight of  $14.1 \pm 1.5$  kg (means  $\pm$  SD) were allotted through a randomized complete block design to 6 treatments and 6 replicates. The supplement was given at 300 g DM/(animal·d). The experimental treatments were 300 g concentrate mix (CM), 300 g PP, 75 g NL + 225 g PP, 150 g NL + 150 g PP, 225 g NLM and 75 g PP and 300 g NL supplement. Total DM intake and basal feed DM intake were not significantly ( $P > 0.05$ ) affected by supplementary diets. Intake of supplement and apparent DM digestibility were higher ( $P < 0.05$ ) in goats supplemented with 300 g NL. Average daily gain, final body weight and feed conversion efficiency were not different ( $P > 0.05$ ) among treatments. Dressing percentage on the basis of slaughter weight and empty body weight was higher ( $P < 0.05$ ) in goats supplemented with 300 g NL than other treatments, but not differ with goats supplemented with 300 g CM. In conclusion, supplementation of sole NL instead of concentrate mix and PP resulted in similar performance of goats, and all supplements used in this study induced favorable average daily gain and thus can be employed in feeding systems depending on their availability and relative cost.

### 1. Introduction

In developing countries livestock are largely raised on fibrous feeds mainly crop residues and natural pasture. However, these feed resources are deficient in nitrogen, minerals and vitamins which limit intake and digestibility. Evidence suggests that protein supplements are only available at a very high price in developing countries and this has led to the use of non-protein nitrogen sources to improve the nitrogen deficiency in fibrous feeds, thus enhancing their digestibility, intake and nutrient availability through optimization of rumen fermentation (Makkar, 2007). A wide variety of multi-purpose tropical trees grown at the farmers' field can be used as nitrogen sources in supplementary feeds (Ondiek, Tuitoek, Abdulrazak, Bareeba & Fujihara, 2000). The leaves of *Leucaena leucocephala*, *Morus Alba* and *Azadirachta indica* are potential nitrogen supplements (Liu, Yao, B., Yu & Shi, 2001). These tree forages not only provide a cheap source of nitrogen, energy and micro-nutrients but have also many other advantages like their wide spread on-farm availability and easy accessibility to farmers, their

laxative influence on the alimentary system, low degradability of nitrogen in the rumen and provision of variety in the diet.

The replacement of conventional ingredients by tree leaves will make such supplements cheaper than the commercial concentrates (Ondiek et al., 2000). However, the presence of anti-nutritional factors like mimosine in *Leucaena leucocephala*, triterpenoid derivatives (*Azadirachtin*, *nimbidin*) in *Azadirachta indica* and phenolics in most of the leaves limit their use as animal fodder. Tannin concentration in neem leaves is less than in *Leucaena leucocephala* and below the level that will depress feed intake (Niranjan, Udeybir, Singh & Verma, 2008). Farmers usually minimize and overcome these problems by feeding different leaves in mixtures which not only dilutes and reduces the problem of palatability and toxic effects but also extends feed base for animals (Lowry, 1990).

In order to solve the challenges of chronic shortage of feed in terms of availability and quality for improved productivity of farm animals, locally available feed sources have to be exploited and made available to users particularly during dry season. Browse species have received increasing attention as potential livestock forage and re-vegetation of

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disturbed lands, more importantly in arid regions (Ben selam & Nefzaoui, 2000). So far the use of foliage from trees and shrubs in animal nutrition has attracted the attention of many researchers, due to the fact that these plant resources are locally available, perennial source of feeds rich in protein and particularly appropriate for small ruminants. Thus, supplementation with browse leaf seems to be feasible and sustainable feeding system for smallholder farmers. Adjorlolo, Timpong-Jones, Boadu and Adogla-Bessa (2016) reported that the neem plant produces 5 to 50 tones/hectare biomass yield that potentially can help alleviate the challenges of dry season feeding of ruminant livestock in West Africa. Despite its content of bitter principles, there are reports that leaves fed to ruminants result in positive outcomes. Muhammad, Peter, James and Wosilat (2015) and Rahman, Ali, Islam, Ershaduzzaman and Akter (2015) are reported 25.01 and 23.51% value for CP content of neem leaves respectively.

Gowda and Sastry (2000) also pointed out that, neem tree is a drought tolerant plant known to perform well in areas with long dry seasons, even with rainfall as low as 130 mm per annum. In addition, neem tree is often available evergreen throughout the year when pastures and crop residue are depleted. Therefore, proper use of naturally available neem leaves as source of protein in critical periods of the year seems to be of particular benefit to farmers who could not afford and access to other costly protein supplement feeds in the area. However, there are no any literature that compare on supplementary value of sole and mixture of *Azadirachta indica* leaf with pigeon pea leaf and commercial concentrate. Therefore, this study was initiated with the objective of evaluating the feeding values of different proportions of neem tree leaves with pigeon pea leaves and concentrate mixture on the feed intake, digestibility, body weight gain and carcass parameters of goats.

## 2. Materials and methods

### 2.1. Experimental animals and management

The experiment was carried out according to the guidelines of the Ethiopian Animal Experiments Inspectorate, Ministry of livestock and Fisheries with respect to animal experimentation and care of animals under study. Thirty six male intact yearling Gumuz goats with initial body weight of  $14.1 \pm 1.5$  kg (means  $\pm$  standard deviation) were used in the experiment. The animals were quarantined for ten days to get them used to their new environment and to observe their health condition. At the end of the quarantine period, blocked into six block of six animals based on initial live weight and randomly assigned to one of the treatment rations settled.

### 2.2. Experimental feeds

The pigeon pea leaf meal (PPLM) was harvested from less than one year old trees in which 100 kg/ha (1 ha = 10,000 m<sup>2</sup>) of Di ammonium phosphate fertilizer is applied and neem leaf meal (NLM) was mostly from 1 to 3 years old trees. The supplement feed were offered at 300 g DM/ (animal.d). All animals had free access to water and mineralized salt block. Before the experiment starts, samples of supplement ingredients and Rhodes grass hay were analyzed for chemical composition of DM content. Based on the chemical composition the supplement ratios were formulated.

### 2.3. Experimental design and treatments

The thirty six goats were randomly assigned to six feed treatments, based on live weight. The experiment was a randomized complete block design (RCBD) with 6 treatments and 6 replications. The feed tested in the experiment was as follows (in% of DM offered) Table 1.

### 2.4. Chemical analysis

The DM, organic matter (OM), crude protein (CP) and ash were determined according to AOAC (2005). CP content was measured by the Kjeldahl method as N\*6.25. The content of neutral detergent fiber (NDF), acid detergent fiber (ADF) and acid detergent lignin (ADL) were determined according to Van Soest and Robertson (1985).

### 2.5. Feed intake and conversion efficiency

Animals were fed the experimental diets for 90 days in individual pen, and daily feed intake was recorded. Daily feed intake of individual animal was calculated as following: Feed intake (g) = Amount of feed offered (g) – Amount of feed refused (g). The metabolize energy (ME) intake of experimental animals were estimated from its digestible organic matter intake (DOMI) by using the formula, ME (MJ/kg DM) = DOMI  $\times$  0.0157, Where, DOMI = g digestible OM/ kg DM (AFRC, 1993). Feed conversion efficiency was measured using the formula suggested by Gülten, Rad & Kindir, 2000:

$$\text{Feed conversion efficiency} = \frac{\text{Average daily live weight gain (g)}}{\text{Average daily feed intake (g)}}$$

### 2.6. Feed digestibility

The digestibility trial was conducted for seven days after ninety days of experimental feed. Feces was collected and weighted every morning for each animal before giving of feed or water. The daily collected feces from each animal was weighed mixed thoroughly and 20% was sampled and kept in airtight plastic containers and stored at  $-20^{\circ}\text{C}$  up to the completion of the digestibility trial. In, addition, amount of feed offered and refusals was collected, weighted and recorded every morning. At the end of the digestibility trial the fecal sample was thawed, thoroughly mixed and sub samples were taken, weighed and partially dried at  $60^{\circ}\text{C}$  for 72 h. Apparent digestibility percentage of DM, CP, Ash, NDF, ADF and ADL was determined using the following formula (McDonald, Edwards, Greenhalgh & Morgan, 2002):

$$\text{Nutrient digestibility} = \frac{\text{Nutrient intake} - \text{Nutrient excreted in feces}}{\text{Nutrient intake}} * 100.$$

### 2.7. Live weight change and daily gain

Live weight of each animal was taken at every 15 days interval in the morning before provision of feed and water. The live weight change was calculated as difference between final body weight and initial live weights of the bucks. Average daily gain (ADG) was calculated as:

$$\text{ADG (kg/d)} = \frac{\text{Final body weight (Kg)} - \text{Initial live weight (Kg)}}{\text{No. of feeding days}}$$

### 2.8. Carcass parameters

After feed intake, body weight gain and digestibility trial, all goats from each treatment were slaughtered to study the carcass characteristics. Feed was withdrawn overnight and the goats were weighed and recorded as slaughter weight. On slaughtering the blood was collected in a container and weighted. The animals were then suspended with head down. The head was detached from the body and weighed. The skin was flayed and weighted with legs below the fetlock joints. The entire gastro-intestinal tract was removed with contents and weighted, then after removing the gut content. Then the legated to divide into four sections namely esophagus, reticulo-rumen, omasum and abomasum, small and large intestine and was weighted, and then the weight of empty gut was calculated by difference and recorded.

The rip eye area of muscle was traced on the graph paper between

**Table 1**  
Treatment arrangement.

Treatments <sup>1</sup>	Rhodes grass hay	Feed offered, g/d			
		Concentrate Mixture (Wheat bran and Noug seed cake)	Neem Leaf Meal	Pigeon Pea Leaf Meal	Total Supplement
T1	<i>Ad libitum</i>	300	-	-	300
T2	<i>Ad libitum</i>	-	-	300	300
T3	<i>Ad libitum</i>	-	75	225	300
T4	<i>Ad libitum</i>	-	150	150	300
T5	<i>Ad libitum</i>	-	225	75	300
T6	<i>Ad libitum</i>	-	300	-	300

**Table 2**  
Analyzed nutrient profile (%) of experimental feed offered and refused.

Feeds offered	Chemical composition						
	DM	OM	Ash	CP	NDF	ADF	ADL
RGH	91.7	94.9	5.1	7.9	73.6	51.1	4.5
WB	91.6	93.8	6.2	18.6	61.0	17.1	3.6
NSC	93.5	90.0	10.0	32.7	39.4	33.4	8.5
53% WB: 47%NSC	92.3	93.1	6.9	24.6	46.8	20.9	4.4
PPLM	92.7	91.4	8.6	23.0	40.9	29.1	8.9
75% PPLM: 25% NLM	92.6	91.1	8.8	23.7	38.7	28.3	8.3
50% PPLM: 50% NLM	92.7	91.0	9.1	25.0	36.5	27.9	7.9
25% PPLM: 75% NLM	92.7	90.6	9.3	26.0	34.6	25.9	6.3
NLM	92.8	90.5	9.5	28.2	31.8	21.9	4.9
Refusal							
53% WB: 47% NSC	95.0	82.6	17.5	22.8	22.3	19.7	6.9
PPLM	94.4	92.5	7.5	16.7	54.0	39.7	13.7
75% PPLM: 25% NLM	94.3	92.5	7.5	16.3	54.2	39.6	13.4
50% PPLM: 50% NLM	94.3	92.5	7.5	16.0	54.3	39.6	13.3
25% PPLM: 75% NLM	94.3	92.6	7.5	15.9	54.5	39.6	13.2
NLM	94.2	92.6	7.4	15.7	54.8	39.7	13.1
RGH Refusal							
300 gm CM	94.2	88.0	12.1	6.1	78.7	57.2	5.0
100 gm PP	94.2	88.0	12.0	6.1	77.7	49.0	5.0
225 gm PP + 75NL	94.2	88.1	11.9	6.1	79.8	55.5	5.0
150 gm PP + 150NL	94.2	88.0	12.0	6.1	76.9	53.3	5.0
225 gm PP + 25NL	94.1	88.4	11.6	6.3	77.9	52.6	5.0
100 gm NL	94.1	88.1	11.9	6.0	75.0	57.7	5.0

DM = dry matter; OM = organic matter; CP = crude protein; NDF = neutral detergent fiber; ADF = acid detergent fiber; ADL = acid detergent lignin; RGH = Rhodes grass hay; WB = wheat bran; NSC = Noug seed cake; PPLM = pigeon pea leaves meal; NLM = neem leaves meal.

the 12th and 13th rib of the right half carcass was measured (Khan, Mahr-UN-Nisa & Sarwar, 2003). Total edible products were taken as the sum of total edible offal components and hot carcass weight. Dressing percentage was calculated as proportion of hot carcass weight to slaughter to slaughter weight (SW).

$$\text{Dressing percentage based on SW} = \left( \frac{\text{Hot carcass weight (Kg)}}{\text{Slaughter weight (Kg)}} \right) * 100$$

### 2.9. Partial budget analysis

The partial budget analysis was taken to determine cost benefit (profitability) analysis supplementation of different proportions of dried neem (*Azadirachta indica*) and pigeon pea leaves instead of concentrate mix to supplement in feed of Gumuz goat. The partial budget analysis was calculated from the variable costs and benefits. At the end of the experiment, the selling price of each experimental goat was estimated by three experienced local goat dealers and the average of those three estimation price was taken. The variable costs were calculated from supplementary feed and basal feed costs which are supplied for each experimental goat treatment costs. The cost of neem and pigeon pea leaves was estimated from the cost of daily laborer used to collect the leaves. The total returns (TR) were determined by

calculating the difference between the estimated selling prices and purchasing price of experimental goat. Net return (NR) was calculated as;

$$\text{NR} = \text{TR} - \text{TVC}$$

The change in net return ( $\Delta\text{NR}$ ) was calculated as the difference between change in total return ( $\Delta\text{TR}$ ) and the change in total variable costs ( $\Delta\text{TVC}$ ).

$$\Delta\text{NR} = \Delta\text{TR} - \Delta\text{TVC}$$

### 2.10. Statistical analysis

The data collected on feed intake, digestibility, and body weight gain was subjected to analysis of variance (ANOVA) model for RCBD using Statistical Analysis System Software (SAS version 9.1). When the differences in treatment means was significant at the probability level of  $P < 0.05$ , the means was compared by using Least significant difference (LSD) test.

The statistical model used was:

$$Y_{ij} = \mu + T_i + B_j + E_{ij}$$

Where

$Y_{ij}$  = the dependent variable,

$\mu$  = overall mean,

$T_i$  = effect of treatment, and

$B_j$  = block effect

$e_{ij}$  = random error.

## 3. Results

### 3.1. Chemical composition of treatment feeds

The chemical composition of the feeds used in the present study is specified in Table 2. The CP content of the hay refusals was decreased while the content of NDF, ADF and ADL were increased as compared to the hay offered.

### 3.2. Feed and nutrient intake

The mean values of daily DM and nutrient intake of goats fed on Rhodes grass hay and supplemented with different proportions of dry neem (NL) and pigeon pea (PL) and concentrates mix are presented in Table 3. There was no apparent difference ( $P > 0.05$ ) in organic matter (OM), basal and total DM intake among the treatments. Supplement intake was higher ( $P < 0.05$ ) in groups supplemented with 300 g CM than in groups supplemented with 300 g PP, 225 g PP + 75 g NL and 75 g PP + 225 g NLM, whereas statistically similar in groups supplemented with 150 g NL + 150 g PP and 300 g NL. As indicated Fig. 1, intake of total DM was maintained throughout the feeding trial after 30 days of feeding period. The ash intake was significantly different ( $P < 0.001$ ) among treatments and was lower for goats supplemented with 300 g CM.

**Table 3**

Feed intake of goats fed on Rhodes grass hay and supplemented with different proportions of dry neem and pigeon pea leaves and concentrates mix.

Parameters	300 gm CM	100 gm PP	225 gm PP + 75NL	150 gm PP + 150NL	225 gm PP + 25NL	100 gm NL	SEM	SL
Basal feed DM intake, g/d	305	311	293	288	332	324	9.0	ns
Supplement DM intake, g/d	299 a	265 b	269b	280a,b	257b	279a,b	3.0	*
Total DM intake, g/d	604	577	563	568	590	603	10.9	ns
DM intake,% BW	4	4	4	4	4	4	1.0	ns
OM intake, g/d	583	545	532	537	553	565	9.8	ns
Ash Intake	21b	31 a	30 a	31 a	36a	37 a	1.1	***
EME intake, MJ/ kg DM per d	6	6	6	6	6	7	0.1	ns
CP intake, g/d	101b,c	93d	96c,d	102b,c	105b	116a	1.2	***
NDF intake, g/d	373a	320a,b	297b	291b	309b	307b	7.9	*
ADF intake, g/d	212	229	210	213	221	206	5.4	ns
ADL intake, g/d	24b	32 a	30a	30a	23b	21b	0.8	***
Nutrient intake during digestibility trial, g/d								
DM intake	585	585	569	566	578	579	5.7	ns
OM intake	571	556	542	540	567	549	5.2	ns
CP intake	102c,d	93e	98d	103b,c	107b	115a	1.0	***
NDF intake	399a	375b	347c	342c,d	343c,d	324d	3.7	***
ADF intake	195b,c	239a	209b	211b	210b	188c	3.0	***

CM = concentrate mix; PP = pigeon pea leaves meal; NL = neem leaves meal; SEM = standard error of mean; SL = significant level; RGH = Rhodes grass hay; WB = wheat bran; NSC = Noug seed cake; PPLM = pigeon pea leaves meal; NLM = neem leaves meal; DM = dry matter; BW = body weight; OM = organic matter; EME = estimated metabolizable energy; CP = crude protein; NDF = neutral detergent fiber; ADF = acid detergent fiber; ADL = acid detergent lignin.

<sup>a,b,c,d</sup> Means with different superscripts in a row are significantly different.

\* = ( $P < 0.05$ ).

\*\*\* = ( $P < 0.001$ ); ns = non-significant.

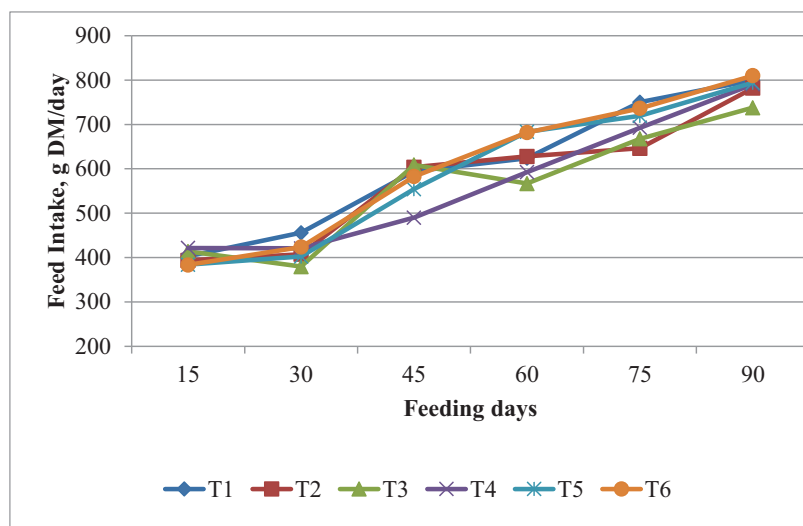
Highly significant ( $P < 0.001$ ) impacts were recorded due to supplementary inclusion on crude protein intake values. It is noticeable that crude protein intake of goats supplemented 300 g NL and 25 g PP + 225 g NL was highest than goats supplemented 225 g PP + 75 g NLM and 150 g PP + 150 g NL. Moreover, the CP intake of groups supplemented 300 g NL was higher ( $P < 0.001$ ) than groups supplemented 300 g CM, 150 g PP + 150 g NL and 75 g PP + 225 gm NL. The CP intake was 16.7, 16.2, 17.1, 18.1, 17.9 and 19.3% of the total DM intake in goats supplemented 300 g (CM), 300 g PP, 75 g NL + 225 g PP, 150 g NL + 150 g PP, 225 g NLM and 75 g PP and 300 g NL, respectively. The estimated ME intake was non-significant ( $P > 0.05$ ) among the treatments. Significant ( $P < 0.05$ ) difference in NDF intake was observed among groups and it was higher ( $P < 0.05$ ) in groups supplemented 300 g CM than other supplementary groups, whereas statistically similar with groups supplemented 300 g PP.

There were significant main effects ( $P < 0.001$ ) in the value of ADL intake due to supplementary inclusion. Goats supplemented 300 gm PP, 225 gm + 75 gm NL and 150 gm PP + 150 gm NL had highest ADL intake values than goats supplemented 300 gm CM, 75 gm PP + 225 gm NL and 300 gm NL (300 gm PP = 225 gm + 75 gm NL = 150 gm

PP + 150 gm NL > 300 gm CM = 75 gm PP + 225 gm NL = 300 gm NL). In contrary to the result of NDF and ADL intake, ADF intake was non-significant ( $P > 0.05$ ) among groups.

### 3.3. Dry matter and nutrients digestibility

The apparent DM and nutrients digestibility percentages of experimental feeds are shown in Table 4. Apparent DM digestibility recorded was highest in groups supplemented 300 gm NL ( $P < 0.05$ ) than other groups, though statically similar with groups supplemented 225 gm PP + 75 gm NL. The apparent CP digestibility in groups supplemented 300 gm CM and 300 gm NL was higher ( $P < 0.001$ ) than 300 gm PP and 75 gm PP + 225 gm NL. Moreover, apparent CP digestibility was higher ( $P < 0.001$ ) for goats supplemented 300 gm NL as compared to goats 300 gm CM, 225 gm PP + 75 gm NL and 150 gm PP + 150 gm NL. The apparent NDF digestibility values in groups supplemented 300 gm NL was higher ( $P < 0.05$ ) than groups supplemented 300 gm PP, 225 gm PP + 75 gm NL and 75 gm PP + 225 gm NL, though similar with groups supplemented 300 gm NL and 150 gm PP + 150 gm NL. Contrary to the NDF digestibility, apparent ADF digestibility was non-



**Fig. 1.** Trends in total DM intake of goats fed on Rhodes grass hay and supplemented with different proportions of dry neem and pigeon pea leaves and concentrates mix.

RGH = Rhodes grass hay; WB = wheat bran; NSC = Noug seed cake; PPLM = pigeon pea leaves meal; NLM = neem leaves meal; T1 (control) = RGH *ad libitum* + 300 g/(animal·d) 53%: 47% WB: NSC; T2 = RGH *ad libitum* + 300 g/(animal·d) PPLM; T3 = RGH *ad libitum* + 300 g/(animal·d) 75%: 25% PPLM: NLM; T4 = RGH *ad libitum* + 300 g/(animal·d) 50%: 50% PPLM: NLM; T5 = RGH *ad libitum* + 300 g/(animal·d) 25%: 75% PPLM: NLM; T6 = RGH *ad libitum* + 300 g/(animal·d) NLM.

**Table 4**

Nutrient apparent digestibility (%) in goats fed on Rhodes grass hay and supplemented with different proportions of dry neem and pigeon pea leaves and concentrates mix.

Parameters	Treatments						SEM	SL
	300 gm CM	100 gm PP	225 gm PP + 75NL	150 gm PP + 150NL	225 gm PP + 25NL	100 gm NL		
DM digestibility	67 b	65b	67a,b	65b	63b	75a	1.2	*
OM digestibility	69	66	70	68	65	77	1.1	ns
CP digestibility	71b	67c	71b,c	70b,c	67c	77a	0.7	**
NDF digestibility	65a,b	60b	60 b	63a,b	60b	67a	0.8	*
ADF digestibility	62	60	60	62	60	63	1.4	ns

CM = concentrate mix; PP = pigeon pea leaves meal; NL = neem leaves meal; SEM = standard error of mean; SL = significant level;

<sup>a,b,c</sup> Means with different superscripts in a row are significantly differ.

\* = ( $P < 0.05$ ); \*\*\* = ( $P < 0.001$ ); DM = dry matter; OM = organic matter; CP = crude protein; NDF = neutral detergent fiber; ADF = acid detergent fiber.

significant among treatments ( $P < 0.05$ ).

### 3.4. Body weight gain

Mean values of initial and final body weight (BW), daily BW gain and feed conversion efficiency (FCE) of the experimental animals are indicated in Table 5. The result indicated that the effect of supplement was not significant on average daily and final BW gain, final BW, FCE and protein conversion efficiency (PCE) of experimental animals ( $P > 0.05$ ). The trend of weight changes across the feeding days (Fig. 2) revealed that all goats up to the 15th days showed BW gain almost in a similar manner. After the 45th days, all supplemented goats showed a steady growth rate throughout the experimental period, except goats supplemented 300 gm PP.

### 3.5. Carcass characteristics

Values recorded on the effects of supplementation of neem and pigeon pea leaf at different proportions on carcass parameters of goats presented in Table 6. No significant ( $P < 0.05$ ) impacts were noticed on slaughter weight, hot carcass weight, empty body weight (EBW) and rib-eye areas during the experimental period due to supplementation of neem and pigeon pea browse leaves at different proportions and concentrates mixture. Dressing percentage on the basis of SW and EBW was higher ( $P < 0.05$ ) in group supplemented 300 g NL than others groups but, similar with group supplemented 300 gm CM. These results suggested that supplementation of sole NL had higher dressing percentage than sole PP and mixture of NL and PP. However, supplementation of sole NL and concentrate mixture similarly influence the dressing percentage of goats.

#### 3.5.1. Edible and edible offal's

The edible and non-edible non-carcass component of goats fed different proportions of dry neem and pigeon pea leaves and concentrates mix presented in Table 7. In this study, except for stomach fat, tail and bladder no significant difference ( $P > 0.05$ ) was observed among treatments. In this study, group supplemented 300 gm NL had higher ( $P$

$< 0.01$ ) tail weight than other groups. The result of current study showed that a total edible product (hot carcass weight + total edible offals component) was not apparently different ( $P > 0.05$ ) among treatments.

#### 3.5.2. Proportion of different carcass parameters

The proportion of different carcass parameters goats fed different proportions of dry neem and pigeon pea leaves and concentrates mix presented in Table 7. The result of this study showed that gut fill to slaughter weight (GF: SW), total edible offal components to total non-edible components (TEOC: TNEOC), total edible offal components to empty body weight (TEOC: EBW) and total non-edible components to empty body weight (TNEOC: EBW) was not significantly different among treatments.

### 3.6. Partial budget analysis

The partial budget analysis of Gumuz goats fed on Rhodes grass hay and supplemented with different proportions of dry neem and pigeon pea leaves and concentrates mix presented Table 8. The partial budget analysis was performed to evaluate the economic advantages of use of locally available neem tree with pigeon pea leaf meals at different proportions instead of commercial concentrate mixture. The result of this study indicated that higher total return (11.5 \$/goat) was obtained from the goat supplemented 300 gm NL. As it's indicated from the partial budget analysis, groups supplemented 300 gm NL returned a higher net income (8.6 \$/goat) as compared to the other groups. The result of current study revealed that total variable cost was decreased as the level of NL increased across the treatment among the non-conventional supplemented groups. Generally, as this study based on the net profit, supplementation of 300 gm NL per head of goats, outweighs other treatments and is recommended. However, all supplements used in this study induced positive net profit and thus can be employed in feeding systems depending on their availability and relative cost.

**Table 5**

Body weight parameters of goats fed on Rhodes grass hay and supplemented with different proportions of dry neem and pigeon pea leaves and concentrates mix.

Parameters	300 gm CM	100 gm PP	225 gm PP + 75NL	150 gm PP + 150NL	225 gm PP + 25NL	100 gm NL	SEM	SL
Initial body weight, kg	14.0	14.3	14.3	14.2	14.0	13.9	0.3	ns
Final body weight, kg	17.6	16.6	117.7	17.4	16.1	17.8	0.3	ns
BW Change, Kg	3.6	2.2	3.4	3.2	2.1	3.9	0.3	ns
Daily BW gain, g/d	40.1	24.9	37.9	35.8	22.8	43.5	3.9	ns
FCE, g DBWG/g DDMI	0.06	0.04	0.07	0.07	0.03	0.08	0.01	ns
PCE, g DBWG/g DCPI	0.34	0.26	0.39	0.35	0.19	0.37	0.04	ns

CM = concentrate mix; PP = pigeon pea leaves meal; NL = neem leaves meal; SEM = standard error of mean; SL = significant level; ns = non-significant; BW = body weight; FCE = Feed conversion efficiency; DBWG = Daily body weight gain; DDMI = Daily dry matter intake; PCE = Protein conversion efficiency; DCPI = Daily crude protein intake.



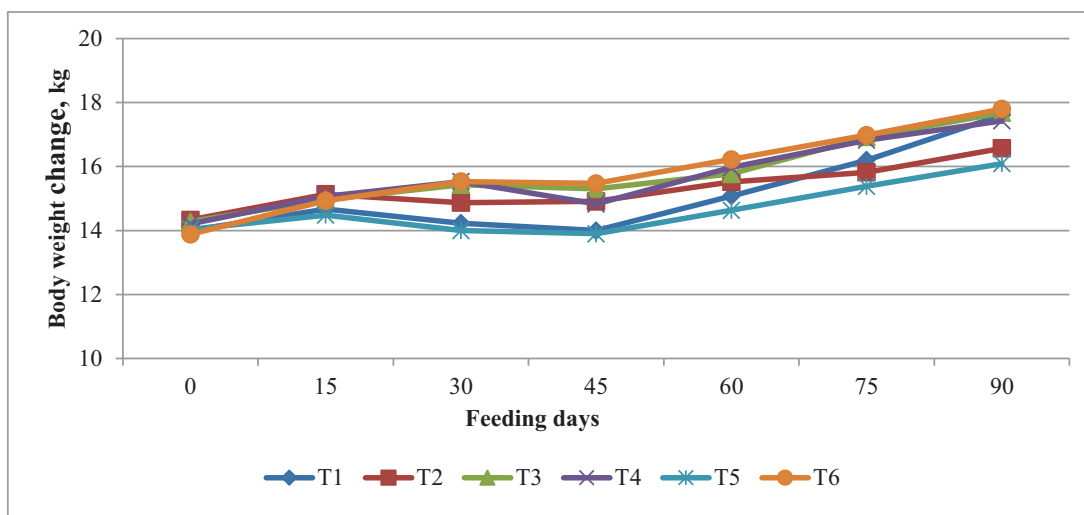


Fig. 2. Trends in body weight change of goats fed on Rhodes grass hay and supplemented with different proportions of dry neem and pigeon pea leaves and concentrates mix.

RGH = Rhodes grass hay; WB = wheat bran; NSC= Noug seed cake; PPLM= pigeon pea leaves meal; NLM= neem leaves meal; T1 (control) = RGH *ad libitum* + 300 g/(animal·d) 53%: 47% WB: NSC; T2 = RGH *ad libitum* + 300 g/(animal·d) PPLM; T3 = RGH *ad libitum* + 300 g/(animal·d) 75%: 25% PPLM: NLM; T4 = RGH *ad libitum* + 300 g/(animal·d) 50%: 50% PPLM: NLM; T5 = RGH *ad libitum* + 300 g/(animal·d) 25%: 75% PPLM: NLM; T6 = RGH *ad libitum* + 300 g/(animal·d) NLM.

4. Discussion

The CP content of the hay and supplements refusals was decreased while the content of NDF, ADF and ADL were increased as compared to the hay and supplements offered in the present experiment might be due to selectivity by animals for nutritious parts of the hay, although there was an attempt to decrease selectivity by chopping in this study. The intake of DM was maintained throughout the feeding trial and this response might be associated with increment in body weight and consequent increase in intake to satisfy nutrient requirement of the animal. Findings from this feeding trial agree with reports of Schoenian (2003) who findings reveal that stresses of pregnancy, lactation and growth increase the DM intake to satisfy nutrient requirements of the animals.

The CP and ash intake increment were consistent with the increment of NL level in the supplementary diet and this might be attributed to the higher CP and ash content of NL used in this experiment (Table 2). The average CP intake in terms of metabolic body weight (11.4 g/kgW<sup>0.75</sup>) was above the minimum requirements for maintenance of 4.15 g CP/kgW<sup>0.75</sup> (NRC, 1981). The estimated daily ME intake 5.7 to 6.5MJ ME in this study was within the range of the maintenance requirements of 3.25 to 6.47 MJ for goats (Devendra & Burns, 1983). The differences of NDF intake among treatments slightly consistent with NDF content of the supplements. The difference in ADL intake among the treatments was slightly consistent with the ADL content of supplemental diets.

The result of the current study showed that DM digestibility was

adversely influenced by the lignin concentration in the experimental diet. Digestibility of a feed is determined largely by chemical composition of the feed (Khan et al., 2003). In sole NL supplementation higher CP intake results could have created a better environment by providing more nitrogen for rumen microorganisms which was make higher digestibility of DM for this treatment (Yinnesu & Nurfeta, 2012). The significant improvement in CP and DM digestibility with sole NL supplement diet might be due to the higher CP content of the NL, since high CP intake is usually associated with better CP digestibility (McDonald et al., 2002).

The statistical difference of dry matter and nutrient digestibility among the treatments were not significantly affect the daily body weight change and final body weight gain of goats and this might be associated with inefficient utilization of nitrogen for growth and the high CP intake might be excreted through urine due to the combination of the two diets at this ratio which might be influence activity of rumen microorganisms (Bruh, 2008). The numerical differences in daily body weight gain among the treatments might be due to the differences in daily DM, and CP intake as well as DM and CP digestibility between treatment groups. Despite neem leaves superior in nutritional quality, weight gain trends do not follow the increasing proportion of neem leaves in supplementary feed and this might be associated with due to the combination of the two diets at that ratio which might be not apt for the activity of rumen microorganisms.

The absence of BW loss across the treatments in the current study could be attributed to supplementation increased intake and

Table 6

Carcass characteristics of goats fed on Rhodes grass hay and supplemented with different proportions of dry neem and pigeon pea leaves and concentrates mix.

Carcass parameters	300 gm CM	100 gm PP	225 gm PP + 75NL	150 gm PP + 150NL	225 gm PP + 25NL	100 gm NL	SEM	S. L
Slaughter weight, kg	17	16	17	17	15	17	0.3	ns
Empty body weight, kg	15	15	16	16	14	16	0.3	ns
Hot carcass weight, kg	7	6	7	6.6	6.1	8	0.2	ns
<b>Dressing percentage</b>								
Percent slaughter weight	41 <sup>a,b</sup>	39 <sup>b,c</sup>	38 <sup>c</sup>	39 <sup>b,c</sup>	40 <sup>b,c</sup>	44 <sup>a</sup>	0.6	*
Percent empty BW	50 <sup>a,b</sup>	47 <sup>b</sup>	48 <sup>b</sup>	48 <sup>b</sup>	48 <sup>b</sup>	53 <sup>a</sup>	0.6	*
Rib-eye area, cm <sup>2</sup>	9	10	10	9	8	11	0.3	ns

CM= concentrate mix; PP= pigeon pea leaves meal; NL = neem leaves meal; SEM = standard error of mean; SL = significant level; ns = non-significant.

<sup>a,b,c</sup> Means with different superscripts in rows are significantly differ.

\* = (P < 0.05); ns = non-significant (P > 0.05).

**Table 7**

Non-carcass components (g) and proportions of different carcass parameters (%) of goats fed on Rhodes grass hay and supplemented with different proportions of dry neem and pigeon pea leaves and concentrates mix.

Parameters	300 gm CM	100 gm PP	225 gm PP + 75NL	150 gm PP + 150NL	225 gm PP + 25NL	100 gm NL	SEM	S.L
Blood	733	744	786	763	742	846	20.2	ns
Tongue	43	46	48	47	51	52	1.9	ns
Kidneys	67	61	69	69	68	64	1.6	ns
Heart	76	78	79	82	77	81	1.5	ns
Liver with gall bladder	409	373	395	392	393	419	11.3	ns
Testis	120	104	135	119	102	129	6.1	ns
Tail	28 <sup>b</sup>	23 <sup>b</sup>	24 <sup>b</sup>	24 <sup>b</sup>	21 <sup>b</sup>	36 <sup>a</sup>	1.2	**
Rumen-Reticulum	438	447	442	456	411	500	12.8	ns
Omasum-Abomasum	125	130	140	141	124	133	3.4	ns
SI and LI	563	610	615	564	590	580	14.3	ns
Total of Fat Deposits	240	284	259	278	196	240	8.3	ns
TEOC, kg	3	3	3	3	3	3	0.1	ns
Head without tongue	1154	1195	1159	1220	1073	1133	21.5	ns
Skin + Feet	1752	1513	1850	1767	1633	1833	46.1	ns
Lungs with trachea	260	257	231	254	271	257	7.2	ns
Spleen	54	43	46	54	42	49	1.8	ns
Esophagus	36	37	35	37	32	36	1.0	ns
Penis	23	19	24	20	20	20	0.9	ns
Gut fill	2874	2879	3313	3223	2642	2870	1.4	ns
TNEOC, kg	6	6	7	7	6	6	124.5	ns
TEP, kg	10	10	10	10	9	11	0.2	ns
GF:SW	17	18	19	18	17	16	0.7	ns
TEOC:TNEOC	20	21	22	21	22	21	1.4	ns
TEOC:EBW	46	50	45	45	48	49	0.2	ns
TNEOC:EBW	45	45	49	47	46	43	1.2	ns

CM = concentrate mix; PP = pigeon pea leaves meal; NL = neem leaves meal; SEM = standard error of mean; SL = significant level; ns = non-significant.

<sup>a,b,c</sup> Means with different superscripts in rows are significantly differ.

\*\* = ( $P < 0.01$ ); \*\*\* = ( $P < 0.001$ ); ns = non-significant; SI = small intestine; LI = large intestine; TEOC = total edible offals component; TNEOC = total non-edible offals component; TEP = total edible products; GF = gut fill; SW = slaughter weight; TEOC = total edible offal components; TNEOC = total non-edible offal components; EBW = empty body weight.

digestibility of DM and CP that promotes average daily BW gain (Gizachew, 2013 and Freweini, 2014; Yinnesu & Nurfeta, 2012). For the first few days after the start of the experiment BW by all experimental animals was increase in similar manner and this could be due to the residual effect of energy reserve in the form of glycogen and body fat in the first phase of the experimental period, which was probably high and due to restricted movement that saved energy wastage (Bruh, 2008). In

effect, animals can survive with lower nutrients and slight body growth. Since energy requirement of an animal is influenced by muscular activity (NRC, 1981).

The weight of liver was not affected by treatment diets in the current study, which could be an indicative of low level of anti-nutritional compounds in the leaves used in the current study that could otherwise have demanded the liver to grow to undertake detoxification process

**Table 8**

Partial budget analysis of Gumuz goats fed on Rhodes grass hay and supplemented with different proportions of dry neem and pigeon pea leaves and concentrates mix.

Parameters	Treatments					
	300 gm CM	100 gm PP	225 gm PP + 75NL	150 gm PP + 150NL	225 gm PP + 25NL	100 gm NL
Purchase price of goat (\$/goat)	18.5	18.5	18.5	18.5	18.5	18.5
Rhodes hay consumed (kg/goat)	27.5	28.1	26.4	25.9	29.9	29.2
Dried neem leaves consumed (kg/goat)	–	–	6.1	12.6	17.4	25.1
Dried pigeon pea leaves consumed (kg/goat)	–	23.9	18.2	12.6	5.8	–
Wheat bran consumed (kg/goat)	16.9	–	–	–	–	–
Noug seed cake consumed (kg/goat)	11.1	–	–	–	–	–
Total supplement consumed (kg/goat)	26.9	23.9	24.3	25.2	23.2	25.1
Total feed consumed (kg/goat)	57.2	54.8	53.3	53.8	56.0	57.2
Cost of Rhodes grass hay(\$/goat)	0.05	0.06	0.05	0.05	0.06	0.06
Cost for dry neem leaves(\$/goat)	–	–	0.33	0.69	0.95	1.37
Cost for dry pigeon pea leaves (\$/goat)	–	2.60	1.99	1.38	0.63	–
Cost of Wheat bran (\$/goat)	2.46	–	–	–	–	–
Cost of Noug seed cake (\$/goat)	2.01	–	–	–	–	–
Total variable cost (\$/goat) (TVC)	5.98	4.14	3.76	3.48	3.21	2.96
Gross income (R) (\$/goat)	27.49	27.27	31.02	27.56	23.64	30.00
Total return (TR) (\$/goat)	9.38	8.80	11.82	9.09	5.16	11.53
Net return (NR) (\$/goat)	3.41	4.67	8.07	5.62	1.95	8.57
Change in total return ( $\Delta$ TR)	–	–0.58	2.44	–0.29	–4.22	2.15
Change in total variable cost ( $\Delta$ TVC)	–	–1.84	–2.22	–2.49	–2.76	–3.01
Change in net return ( $\Delta$ NR)	–	1.26	4.66	2.20	1.46	5.16

ETB = Ethiopian birr;  $\Delta$ NI = change in net income;  $\Delta$ TVC = change of total variable cost; NR = net return; TR = total return; NLM = neem leaf meal; PPLM = pigeon pea leaf meal; WB = wheat bran; NSC = nougseed cake; RGH = Rhodes grass hay; gm = gram.

(Ahamefule et al., 2006; Assefa., Kijora, Kehaliew, Bediye & Peters, 2008 and Freweini, 2014). Increased weights of internal organs such as liver are commonly used as evidence of toxicity or presence of anti-nutritional factors in the diet (Ahamefule et al., 2006). Ermias (2008) showed that supplementation did not increase the TEOC: EBW and TNEOC: EBW in Arsi-Bale sheep fed faba bean haulms and supplemented with linseed meal, barley bran and their mixtures, which agrees with the current study.

There was no loss of price/goats in all treatments and this might be due to the weight gain exhibited by experimental animals during the experimental period. The difference in total return followed the same trend with weight gain of the animals and this shows that goats which had higher weight gain had a better potential to be sold at higher price to earn higher gross income. Group supplemented 300 gm NL returned a higher net income and this mainly due to numerically higher weight gain obtained, feed conversion efficiency and higher selling price of animals by this treatment than other treatments group and lower cost of neem leaves as compared to pigeon pea leaves and concentrate mix. Supplementation of 300 gm NL was economically more feasible and more profitable because total feed cost and cost of supplement decreased by 50.4 and 69.4% respectively and net profit was increased by 151.3% as compared to group supplemented 300 gm CM.

## 5. Conclusion

From the aforementioned results and discussion, body weight and carcass parameters values in the current finding outlined that, neem leaf as sole supplement is comparable to the supplementary value of concentrate mixture and pigeon pea to improve goat performance. This implies, neem leaf can substitute the feeding value of improved tree legumes (pigeon pea) and protein rich conventional feeds (concentrate mixture). Correspondingly based on partial budget analysis, supplementation of sole neem leaf instead of concentrate mix and pigeon pea displayed reduction of feed cost and increase of net return. Likewise, NL and PP mixture at different levels can also replace the highly valued commercial concentrate feeds because of their similar performance effects on goats. Generally, all supplements used in this study induced favorable average daily gain and positive net return and thus can be employed in feeding systems of goat depending on their availability and relative cost.

## Declaration of Competing Interest

We declare that we have no personal relationships with other people or organizations that can inappropriately influence our work, there is no professional or other personal interest of any nature or kind in any product, service and/or company that could be construed as influencing the content of this paper.

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## Ethical Statements

This manuscript or a very similar manuscript has not been published, nor is under consideration by any other journal.

## References

- Adjorlolo, L. K., Timpong-Jones, E. C., Boadu, S., & Adogla-Bessa, T. (2016). Potential contribution of neem (*Azadirachta indica*) leaves to dry season feeding of ruminants in west africa. *Livestock Research for Rural Development*, 28 Article#75.
- Ahamefule, F. O., Eduok, G. O., Usman, A., Amaefule, K. U., Obua, B. E., & Oguike, S. A. (2006). Blood biochemistry and haematology of weaned rabbits fed sundried, ensiled and fermented cassava peel based diets. *Pakistan Journal of Nutrition*, 5(3), 248–253.
- AFRC (Agricultural and Food Research Council). Energy and protein requirements of ruminants. 1993, CAB International, Wallingford.
- AOAC. (2005). *Official methods of analysis* (18th edition). Washington, DC: Association of Official Analytical Chemists.
- Assefa, F. (2014). *Intake, digestibility, body weight change and carcass characteristics of Hararghe Highland goats fed a basal diet of urea treated sorghum stover supplemented with dried leaves of Erythrina burana, Casimiroa edulis, concentrate mix and their mixtures*. Haramaya University.
- Assefa, G., Kijora, C., Kehaliew, A., Bediye, Seyoum, & Peters, K. J. (2008). Evaluation of tagasaste (*Chamaecytisus palmensis*) forage as a substitute for concentrate in diets of sheep. *Livestock Science*, 114, 296–304.
- Ben selam, H., & Nefzaoui, A. (2000). Growth performance of sheep fed on mixed diets. In C. Agola Bounnejmate, & K. Mossi (Eds.). *Production and utilization of multi-purpose fodder shrubs and trees in west asia, north africa and the sahel* Aleppo, Syria: ICARDA ILRI, Nairobi, Kenya.
- Delil, G. (2013). *izaecho, w. Comparative performance evaluation of yearling arsi-bale sheep fed urea treated maize stover or grass hay basal diet alone or with concentrate mix* [MSc Thesis]. Haramaya University.
- Devendra, C., & Burns, M. (1983). *Feeding and nutrition. Goat production in the tropics*. London UK: CAB (Commonwealth Agriculture Bureau) 56–115.
- Gowda, S. K., & Sastry, V. R. B. (2000). (*Azadirachta indica*) seed cake in animal feeding-scope and limitations: Review. *Asian-Australasian Journal of Animal Science*, 13(5), 720–728.
- Gülten, K., Rad, F., & Kindir, M. (2000). Growth performance and feed conversion efficiency of siberian sturgeon juveniles (*Acipenser baeri*) reared in concentrate ways. *Turkey Journal of Veterinary and Animal Science*, 24, 435–442.
- Khan, M. A., Mahr-UN-NISA, & Sarwar, M. (2003). Review techniques measuring digestibility for the nutritional evaluation of feeds. *International Journal of Agriculture and Biology*, 5(1), 91–94.
- Liu, J. X., Yao, Jun, Yan, B., Yu, J. Q., & Shi, Z. Q. (2001). Effects of mulberry leaves to replace rapeseed meal on performance of sheep feeding on ammoniated rice straw diet. *Small Ruminant Research*, 39, 131–136.
- Lowry, J. B. (1990). Toxic factors and problems: methods of alleviating them in animals. *In Shrubs and Tree Fodders for Farm Animals* (Ed. Devendra, C.), 76–88 Ottawa, Ontario, Canada: IDRC.
- Makkar, H. P. S. (2007). *Feed supplementation block technology past, present and future. Feed supplementation blocks. urea-molasses multi nutrient blocks: Simple and effective feed supplement technology for ruminant agriculture, vol. 164*, FAO animal production and health paper 1e12.
- McDonald, P., Edwards, R. A., Greenhalgh, J. F. D., & Morgan, C. A. (2002). *Animal nutrition 6th edition*. Edinburgh, Great Britain: Pearson Educational Limited.
- Muhamma, Mahmud, d, Peter, Shaba, James, Gana, & Wosilat, Abdulsalam (2015). Growth performance of growing quails (*Coturnix japonica*) fed graded levels of neem. *International Journal of Applied Research*, 1(2), 04–07.
- Niranjan, P., Udeybir, S., Singh, J., & Verma, D. N. (2008). Mineral and anti-nutritional factors of common tree leaves. *Indian Veterinary Journal*, 85, 1067–1069.
- NRC (National Research Council). (1981). *Nutrient requirements of goats. no. 15*. Washington, D.C., U.S.A.: National Academy of Sciences vii + 91 pp.
- Ondiek, J. O., Tuitoek, J. K., Abdulrazak, S. A., Bareeba, F. B., & Fujihara, T. (2000). Use of leucaena leucocephala and gliricidia sepium nitrogen sources in supplementary concentrates for dairy goats offered rhodes grass. *Asian-Australian Journal of Animal Science*, 13, 1249–1254.
- Rahma, Zillun, r, Ali, Yousef, Islam, Azharul, Ershaduzzaman, Talukder, & Akter, Sumona (2015). Effect of feeding tree forages on productive performances on growing sheep. *Asian Journal of Medicinal and Biological Research*, 1(3), 648–653. <https://doi.org/10.3329/ajmbr.v1i3.26489>.
- Schoenian, S. (2003). *An introduction to feeding small ruminants*. Western Maryland Research and Education Center, Maryland Cooperative Extension.
- Tekletsadi, E. (2008). *rmiak, s. The effect of supplementation with barley bran, linseed meal and their mixtures on the performance of Arsi-Bale sheep fed a basal diet of faba bean haulms* [MSc Thesis]. Haramaya University.
- Van Soest, P. J., & Robertson, J. B. (1985). *Analysis of forages and fibre foods. a laboratory manual for animal science 613*. Ithaca, New York: Department of Animal Science. Cornell University.
- Weldemaria, B. (2008). *rum, h. Supplementation with dried foliage of selected indigenous browses: Effects on feed intake, digestibility, and body weight gain and carcass characteristics of Abergelle goats offered hay*. [MSc Thesis]. Haramaya University.
- Yinnesu, A., & Nurfeta, A. (2012). Effects of supplementing erythrina brucei leaf as a substitute for cotton seed meal on growth performance and carcass characteristics of sidama goats fed basal diet of natural grass hay. *Trop. Anim Health Prod*, 44, 445–451.