Mengistu and Assefa
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RESEARCH

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Supplementation of Mulberry (*Morus indica*) and Vernonia (*V. amygdalina*) leaves as protein source on morphometric measurement, weight change, and carcass characteristics of sheep

Gezahegn Mengistu[1*] and Getnet Assefa[2]

Abstract

Back ground: Protein source supplement such as noug seed cake (NSC) has a greater cost. To overcome the problems associated with the shortage of protein source supplements, there is a need to look for options of protein source feeds preferably cheap, locally available, and easily accessible by farmers. In this regard, browse tree species such as mulberry (*Morus indica*) and *Vernonia amygdalina* represents a valuable option to overcome such problem.

Methods: We evaluated the feed intake, morphometric measurements, weight change, and carcass parameters of 25 male sheep, with initially weighed 20.8 ± 1.7 kg, supplemented for 90 days of experimental period. The treatments (diets) were the replacement of the protein in the NSC with iso-nitrogenous at (0, 25, 50, 75, and 100%) of mulberry and Vernonia mixed leaves meal. The sheep were given a basal diet of Rhodes grass hay, supplemented with 400.0 (D1), 429.8 (D2), 459.5 (D3), 489.3 (D4), and 519.0 (D5) g day^{-1}. The design was randomized complete block design (RCBD) with five animals in each treatment and replication.

Results: The total DM intake (g day^{-1}) was significantly higher in D3 (771.4) than in D1 (722.8) and D5 (642.8) but similar to D2 (754.9) and D4 (759.7). Chest-depth and hip-width were significantly influenced by the diets. The average daily gain of sheep in D1 (87.7), D2 (82.0), D3 (83.4), and D4 (75.2) were significantly higher than in D5 (56.0 g day^{-1}). The hot carcass weight of sheep fed D1 (14.1), D2 (13.7), D3 (12.7), and D4 (12.8) were significantly higher than sheep fed D5 (10.9 kg). Likewise, dressing percentage of sheep for D1 to D4 were higher than D5.

Conclusion: The results of the present investigation confirm that replacement of noug seed cake with mulberry and Vernonia mixed leaves meal up to 75% (25% NSC + 75% mulberry and Vernonia mixed leaves) achieved comparable result with concentrate mix in weight gain and carcass yield.

Keywords: Morphometric measurements, Browse trees, Carcass, Dressing percentage, Protein source

Background

Ethiopia is a frontline country in Africa with a resourceful livestock population. A great diversity of agro-ecological conditions and different production systems found in Ethiopia make the country have a large livestock population suitable for different livestock production (Adugna et al. 2012). The livestock production in Ethiopia contributes considerably to the livelihood of the people and the national economy of the country. For instance, the livestock sector in the country serves as a source of food, income, employment opportunities, draft power, and saving. It also contributed 20% of the total growth domestic

*Correspondence: gezemen19@gmail.com

[1] Teppi Agricultural Research Center, P.O. Box: 34, Teppi, Ethiopia
Full list of author information is available at the end of the article

product (GDP), 40% of agricultural GDP, and 20% of national foreign exchange earnings (Mengistu et al. 2016; Bachewe et al. 2017). Moreover, the need for livestock products is growing rapidly. Compared to the production base year of 2014/15 with an estimated 167 million liters of milk, 1.3 million tons of red meat, and 419 million eggs, the projected demand is expected to be 1490 million liters of milk, 1.9 million tons of red, meat, and 3.9 billion eggs by 2020 (Shapiro et al. 2015).

The production and productivity of sheep in Ethiopia are low, in terms of growth rate, meat production, and reproductive performance (Gizaw et al. 2013). The productivity or output per animal is low and the total production in terms of the number of animals is not increased to satisfy the demand of the ever-increasing population and export market. The total annual meat production that comes from sheep is about 25% with an average lamb carcass weight of 10 kg which is small, compared to the 15.8 kg mean carcass weight of slaughtered animals worldwide (Mueller et al. 2017). The higher carcass weight of 21 kg is observed in Oceania, while the lower in Africa is 14 kg (Stoll-Kleemann and O'Riordan 2015; Skapetas and Kalaitzidou 2017). Sheep productivity in the country is constrained by feed deficit, low genetic potential, and prevailing diseases and parasite infections, and is characterized by input-output systems (Markos 2006; Getahun 2015).

Bonga sheep is one of the well-known Ethiopian local sheep breed types found in humid and sub-humid agro-ecological zones, and geographically distributed in the southwestern part of Ethiopia, particularly in Keffa, Sheka, and Bench Maji zones of Southern Nation, Nationality, and Peoples regional state (SNNPRS) region (Gizaw et al. 2007; Edea 2008). Bonga sheep is an important sheep breed because of its economic value with its meat production, larger body size and better reproductive performances. The farmers in this area are challenged with the scarcity of feed resources particularly feeds of protein source supplements due to the area being located far away from the central parts of the country, where agro-industrial by-products are accessible. Moreover, protein source supplement such as noug seed cake has a greater cost. To overcome the problems associated with the shortage of protein source supplements, there is a need to look for options of protein source feeds preferably cheap, locally available, and easily accessible by farmers.

Consequently, the use of browse multipurpose tree species have great potential and becoming play an important role as protein supplements for ruminants (Haile and Tolemariam 2008; Geta et al. 2014). In this regard, browse tree species such as mulberry (*Morus indica)* and *Vernonia amygdalina* represents a valuable options to overcome such problems considering that; they are locally available, provide considerable nutritional value, with a good ability to produce quality forage (have a high potential as protein forages), and can be grown by farmers (Doran et al. 2007; Kandylis et al. 2009; Yirga et al. 2017). Moreover, mulberry foliage contains protein 15–28% CP (Valdes et al. 2017), and that *Vernonia* contains protein 19–23% CP (Owen and Amakiri 2011; Woyessa et al. 2013; Geta et al. 2014), which could be an alternative replacement to conventional and expensive feed resources. Although studies had been done on mulberry feeding, no desired research has not been carried out on mulberry and *Vernonia* mixed leaves as supplement feed for sheep, and information available for users in the area was scarce. Therefore, this study was carried out to evaluate the effect of replacing noug seed cake with mulberry and *Vernonia* mixed leaves at 50:50 ratio on feed intake, morphometric growth, and carcass characteristics of Bonga sheep maintained on Rhodes (*Chloris gayana*) grass hay as a basal diet.

Materials and methods

About animal care for this experiment

Before the commencement of the experiment, at Teppi Agricultural Research Center, Ethiopia, a committee consisting of Veterinary Medicine, Animal Production, and Animal Nutritionist professionals were organized from the center livestock research process. The committee consider the ethical issues and the physical procedures associated with the housing, feeding, experimentation, and all other routine activities pertaining to ensure the normal welfare of the animals.

Study area, feeds preparation, and feeding

The study was performed at Teppi Agricultural Research Center located at 7° 08′ N latitude and 35° 18′ E longitude, Southwest of Ethiopia. The area received a mean annual rainfall of 1630 mm, and an average annual temperature of 23 °C, with a mean minimum and maximum of 15 °C and 30 °C, respectively (Shamil et al. 2017).The basal diet used for this experiment was Rhodes grass hay (*Chloris gayana)* variety of '*Massaba*'. The grass was harvested manually using sickles when it reaches about 50% flowering stage, and sun-dried in the open air for 3 to 4 days until the hay is reached about 15 to 20% moisture content. The hay was chopped manually into short lengths (5–6 cm) to minimize refusals. The browse tree species namely mulberry (*Morus indica)* and Vernonia (*Vernonia amygdalina)* leaves meal were collected from the trees grown in the research center. Fresh green leaves were harvested from the branches manually by leaf peaking method from October to November. The leaves from the bottom to the top of the branches were collected from the standing shrub or trees of mulberry and *Vernonia* to make the feed collected to be representative. After harvesting, the leaves were placed 3 to 4 days under shade for air drying and turned up 4 times a day to attain a uniform drying. The dried mulberry and *Vernonia* leaves were crushed with hand by twisting and stored under the shed until used for the feeding trial to maintain their quality.

Noug seed (*Gizotia abyssinica*) cake (NSC) was purchased from Addis Ababa in the oil processing factory and used as a concentrate protein source. Maize grain was used as an energy source and purchased from the local market and crushed/ground by a local grain miller and stored at the experimental site. Adequate amounts of all the experimental feeds (*Chloris gayana)* grass hay, *Vernonia* leaf meal (VLM), and Mulberry leaf meals (MLM), and the concentrate mix (CM)) were prepared once before the start of the experiment. The grass hay was offered *adlibtum* and the supplements were given twice daily in equal portions at 8:00 am and 16:00 pm to each experimental lamb (Sebsibe and Tadesse 2011). Before feeding the animal, every morning extra feed from the previous day was collected and weighed.

Animals' management and experimental design

A total of 25 intact yearling male Bonga lambs with similar ages and an initial body weight (mean ± SD) 20.8 ± 1.7 kg were purchased from Yeki local market. Immediately, the animals were ear-tagged, vaccinated with Ovine Pasteurellosis, and quarantined for three weeks before the start of the experiment. For internal parasite treatment, albendazole (150 mg/head) was given to all experimental animals. Then, the sheep were housed in well-ventilated individual pens consisting of separated feeding troughs for hay and supplemental diets, and watering troughs. The experiment was layout out in randomized complete block design (RCBD) with five replications. The experimental animals were assigned randomly in each block using the initial body weight of lambs. Before the actual data collection, the lambs were fed individually the experimental diets for 2 weeks of adaptation periods followed by 90 days of feeding periods. Throughout the experimental period, drinking water and salt block were available freely to all animals.

Feed laboratory analysis and experimental diets

The basal diet (Rhodes grass hay), and the supplemental diet which consisted of noug seed cake, mulberry, Vernonia, and Maize grain were analyzed before the start of the feeding trial (Table 1). The feed samples was dried at 105 °C overnight in a forced draft oven for DM determination, while the ash content was determined by igniting the feed samples using a muffle furnace at 550 °C for 3 h. The DM, ash, and organic matter contents of the feed samples were determined following the procedure of AOAC (1990). The N contents of the sample were determined by the micro-Kejldhal method (AOAC, 1990) and the amount of N (nitrogen) multiplied by 6.25 to estimate the crude protein (CP). Whereas, the neutral detergent fiber (NDF), acid detergent fiber (ADF), and acid detergent lignin (ADL) were determined according to the procedure of Van Soest et al. (1991).

The crude protein (CP) value of *Chloris gayana* grass hay was slightly above the threshold level (7% CP). The CP contents of noug seed cake (NSC), and ground maize grain were 32.4 and 8.3%, respectively. The CP concentration of the dried mulberry leaves (DML) and dried *Vernonia* leaves (DVL) were 18.5 and 22.5%, respectively. *Vernonia* leaves had higher NDF content (lower soluble carbohydrate content) than dried mulberry leaves. The formulated experimental diets in this study had 15.8–19.8% CP and were classified as medium protein feed sources.

The proportion of feed ingredients of concentrate mixture for supplement in the control treatment was in equal proportion of 49.5% NSC, 49.5% ground maize grain, and 1% common salt and set at 400 g head/ day^{-1} based on the recommendation for Horro lambs (Solomon et al. 1991).

The dried mulberry and *Vernonia* leaves were mixed together in a one-to-one ratio in such a way to replace NSC (noug seed cake) in different proportion. The treatments (supplemental diets) had prepared in an iso-nitrogenous manner with the control diet. The amounts of the supplement were fixed to supply 64.2 g CP which falls between 60 and 65 g/CP/head day^{-1} recommended by the National Research Council for growing sheep weighing 20–30 kg and gaining 100 g/head day^{-1} (Britain & Bureaux, 1980). The dietary treatments consisted five levels of mixed dried mulberry and *Vernonia* leaves meal *replaced NSC* as protein sources at: control (0), 25, 50, 75, and 100% proportions. The amount of the supplemental diets were: 400.0, 429.8, 459.5, 489.3, and 519.0 g/day head^{-1} on the DM basis for D1, D2, D3, D4, and D5, respectively. The experimental diets were composed of ground maize grain (GMG), noug seed cake (NSC), mulberry leave meal (MLM), Vernonia leaf mea (VLM), and common salt (Table 1). The basal diet was offered *adlibtum* based on the fact that by adjusting 15–20% of refusal.

Measurements

Morphometric measurements

Different morphological traits such as height at wither, body length, chest depth, hip-width, and heart girth were measured using a tape meter before the beginning of the feeding trial and at the end feeding experiment. Wither

Table 1 Experimental feed ingredients chemical compositions and the formulated treatment diets

Feed ingredients	Chemical compositions (%) of feed ingredients						
	DM	OM	Ash	CP	NDF	ADF	ADL
Rhodes grass hay (RGH)	93.1	90.3	7.9	9.7	74.8	46.8	6.4
Mulberry leaf meal	92.1	83.3	18.5	16.7	28.6	26.6	7.4
Vernonia leaf meal	91.0	87.6	22.5	12.5	46.0	26.0	4.9
Ground maize grain	87.6	94.3	8.3	5.8	15.3	4.2	2.0
Noug seed cake	92.3	90.9	32.4	9.0	31.6	22.7	6.1
Experimental diets	**Chemical compositions (%) of diets**						
	DM	**OM**	**Ash**	**CP**	**NDF**	**ADF**	**ADL**
100% concentrate mix [D1]	89.9	94.2	19.8	5.8	23.5	13.5	3.6
75% NSC + 25% (MLM + VLM) [D2]	89.8	92.2	18.9	7.8	24.9	14.7	6.4
50% NSC + 50% (MLM + VLM) [D3]	89.9	90.6	17.9	9.4	26.2	15.9	5.6
25% NSC + 75% (MLM + VLM) [D4]	90.1	90.3	16.7	9.7	27.3	16.9	7.3
100% (MLM + VLM) [D5]	90.0	89.5	15.8	10.5	28.3	17.8	8.1
Basal diets, and Supplement (g day^{-1}) DM basis							**Total (g day^{-1})**
Experimental diets	**RGH**	**GMG**	**NSC**	**MLM**	**VLM**	**Salt**	
100% concentrate mix [D1]	*adlib*	198.0	198.0	0.0	0.0	4.0	400.0
75% NSC + 25% (MLM + VLM) [D2]	*adlib*	198.0	148.5	43.5	35.8	4.0	429.8
50% NSC + 50% (MLM + VLM) [D3]	*adlib*	198.0	99.0	87.0	71.5	4.0	459.5
25% NSC + 75% (MLM + VLM) [D4]	*adlib*	198.0	49.5	130.5	107.3	4.0	489.3
100% (MLM + VLM) [D5]	*adlib*	198.0	0.0	174.0	143.0	4.0	519.0

D diet, *RGH* Rhodes grass hay, *GMG* ground maize grain, *NSC* noug seed cake, *MLM* mulberry leave meal, *VLM Vernonia* leave meal, *g* gram, *d* day, *DM* dry matter, *OM* organic matter, *CP* crude protein, *NDF* neutral detergent fiber, *ADF* acid detergent fiber, *ADL* acid detergent lignin

height (WH) was measured from the ground to the highest point of withers between the shoulders using meter. Body length (BL) is measured from the base of the ear to the base of the tail. Chest depth (CD) is the linear measurement just behind the chest. Hip width (HW) is the distance between the tips of the hip and is an indicator of the muscularity of live weight. Heart girth (HG) is measured the body circumference just behind the forelegs (Yami and Merkel 2008).

Feed intake

The feed offered and the refusals of hay and supplemental diets were weighed and recorded daily for each experimental animal during the 90 days of the experiment periods to determine daily feed intake. The dry matter (DM) intake was computed as the difference between the amount of feed offered and refused on DM basis. Similarly, nutrient intake was calculated as the difference between the nutrient content of feed offered and nutrient content in feed refusals on DM basis. The estimated metabolizable energy (EME) intake of experimental animals was estimated from its digestible organic matter intake (DOMI) by using the formula, EME (MJ/kg DM) = DOMI × 0.0157 (Alderman et al. 1993).

Body weight and feed conversion ratio

During 90-day of feeding periods, the lambs were weighted once every 10 days intervals to adjust the quantity of feed offered during the trial. During live weight measurement, the experimental animal fasted overnight before each weighing (Getahun 2015). Average daily body weight gain was calculated as the difference between final body weight and initial body weight divided by the number of feeding days. Feed conversion ratio (FCR) is the determined Kg of feed consumed per kg of weight gain during the entire experimental period (Kashan et al. 2005).

Carcass evaluation

At the end of the feeding trial, the animals were slaughtered after fasting for approximately 16 h for carcass evaluation. The pre-slaughter procedures followed by good animal care and welfare were carried out with well-trained persons. Slaughter body weight (SBW) was taken immediately before slaughter. Then, the animals were killed by severing the jugular vein and the carotid artery with a knife. Following the slaughtering, bleeding, and skinning, the fore legs, and the hind legs were trimmed off at the carpal and tarsal joints and weighted. Internal organs (kidneys, heart, liver spleen, and lungs) and fat deposits such as heart fat, kidney fat and abdominal fat, testicles and genital organ, gut contents, and empty gastro intestinal track were separated. The hot carcass was separated and weighed within about 45 min, and hung by hook (Sebsibe 2008). Empty body weight (EBW) was calculated by subtracting slaughter weight to gut content. The rib-eye area was determined by cutting perpendicular to the backbone between the 12th and 13th ribs and measuring the cross-sectional area of the rib-eye muscle area (Williams 2002). The left and right sides of the rib-eye area were traced first onto a transparent paper then by counting the number of squares lying on the traced picture on the square paper and multiplied by the area of the single square. The rib-eye area measurement was determined by taking the average of the two sides. The dressing percentage was calculated as a proportion of hot carcass weight (HCW) to slaughter body weight and empty body weight bases.

The weight of edible offal components (EOCs) including heart, liver, kidney, tongue, reticulo-rumen, omasum, abomasum, small and large intestine, fat (kidney, heart, abdominal), and tail were taken and recorded separately. The total edible offal components (TEOCs) were calculated as the total sum of the edible offal components. The non-edible offal components (NEOCs), namely, blood, head (without tongue), skin, lung with trachea, spleen, bladder, gut contents, testicles, tests, and feet with hooves were weighed and recorded. The total non-edible offal components (TNEOCs) were calculated as the total sum of the non-edible offal components.

Data analysis

The data were subjected to analysis of variance (ANOVA) using the general linear model procedures of the statistical analysis system (SAS 2011). Duncan's multiple range tests were used for means separation that was found to be statistically different ($P<0.05$) of significant level. The statistical model used for the analysis of data was;

$\mathbf{Y_{ij}=\mu+T_i + B_j+E_{ij}}$, Where: Y_{ij} = Response variable, μ = Overall mean, T_i = Treatment effect, B_i = Block effect, and E_{ij} = Random error.

The strength and relationship of between carcass parameters and dry matter intake was indicated by Pearson correlation coefficient and it was computed using the following formula:

$r=\frac{n(\sum xy)-(\sum x)(\sum y)}{\sqrt{[n\sum x^2-(\sum x)^2][n\sum y^2-(\sum y)^2]}}$ Where: r = Pearson coefficient, n = number of the pairs of stock; $\sum xy$ = sum of product of the paired variables; $\sum x$ = sum of the x value; $\sum y$ = sum of the y value; $\sum x^2$ = sum of the squared x value; $\sum y^2$ = sum of the squared y value.

Results

Feed intake

The mean daily DM intake of feeds, total DM, and nutrient intakes of Bonga growing lambs during 90-days of an experimental period are presented in Table 2. The lambs allotted in diets (D1 and D2) consumed all quantities of supplements (without refusal) during the entire experimental period. Significant differences ($P<0.01$) were observed among treatments in daily hay DM and total DM intakes. The intake of sheep for Rhodes grass hay dry matter was significantly different ($P<0.01$). Accordingly, the animals grouped in D2 fed the highest basal diet (325.9 g day^{-1}) whereas the lambs in D5 consumed the lowest value (228.1 g/day). The differences ($P<0.01$) in basal diet intake of lambs are described as D1 = D3 = D2 > D4 > D5. Total dry matter intake (TDMI) of sheep receiving diets (1, 2, 3, and 4) were significantly higher ($P<0.01$) than D5. Similarly, the total OM intake of sheep receiving D1, D2, D3, and D4 were higher ($P<0.01$) than D5.

The total dry matter intake (TDMI) in the present study ranged from 2.8 to 3.2% BW and was not significantly different ($P>0.05$) among experimental diets. The quantity of nutrient intake by sheep under the different experimental diets was also observed. The total crude protein intakes for sheep receiving Diets (1, 2, 3, and 4) were significantly ($P<0.001$) higher than for sheep receiving diet 5. Sheep who received diets 2, 3, and 4 statistically ($P<0.05$) show a higher DM intake per unit of metabolic body weight ($g/kgW^{0.75}/day$) than sheep in D5, but similar to D1.

The total NDF intake of lambs in D5 was significantly lower ($P<0.05$) than in the rest of the supplemental diets. The ADF intake of Lambs in D3 was the highest ($P<0.01$) whereas lambs in D5 showed the lowest ADF intake followed by D1. Statistically similar ADF intake was recorded between lambs in D2 and D4. The ADF intakes among the diets were nearly consistent with the total DM intake. Similarly, there were significant differences ($P<0.001$) among supplemental diets in ADL intake.

The highest ADL intake was observed for sheep received diet (D4) and whereas sheep received D1

Table 2 Mean daily dry matter and nutrient intakes of Bonga lambs fed on Rhodes grass hay basal diet and supplemented with mulberry and *Vernonia* mixed leaves meal

Intake (g/day)	Treatments (diets)					SEM	F-value	SL
	D1	D2	D3	D4	D5			
Hay DM	322.8^{ab}	325.9^{a}	323.3^{ab}	294.1^{b}	228.1^{c}	9.41	3.73	**
Supplement DM	400	429.8	448.1	465.6	414.7	–		–
TDMI	722.8^{b}	755.7^{ab}	771.4^{a}	759.7^{ab}	642.8^{c}	13.34	15.25	**
TDMI (%BW)	2.9	3.1	3.2	3.1	2.8	0.12	1.03	Ns
TDMI (g/kgW$^{0.75}$/day)	64.8^{ab}	68.2^{a}	70.6^{a}	69.5^{a}	60.9^{b}	2.24	3.03	*
TDNI								
OM	668.3^{a}	689.1^{a}	697.9^{a}	686.1^{a}	577.1^{b}	12.06	17.02	**
CP	104.7^{ab}	106.8^{a}	105.8^{a}	100.9^{b}	88.2^{c}	1.48	45.3	***
EME (MJ/Kg DM)	10.0^{a}	10.2^{a}	9.9^{a}	10.2^{a}	8.3^{b}	0.25	10.4	***
Ash	54.5^{c}	64.9^{b}	73.5^{a}	73.7^{a}	65.7^{b}	1.32	35.2	***
NDF	335.5^{a}	350.1^{a}	359.3^{a}	347.3^{a}	288.1^{b}	8.05	10.5	**
ADF	204.9^{b}	215.3^{ab}	222.6^{a}	216.4^{ab}	180.6^{c}	5.03	15.9	**
ADL	35.1^{c}	48.3^{b}	45.8^{b}	52.8^{a}	48.2^{b}	0.92	51.94	***

^{a,b,c} Mean values with different superscripts within a row are significantly different at *= (p < 0.05); ** =(p < 0.01) and *** =(p < 0.001); *DM* dry matter, *OM* organic matter, *CP* crude protein, *EME* estimated metabolizable energy, *NDF* neutral detergent fiber, *ADF* acid detergent fiber, *ADL* acid detergent lignin, *TDMI* total dry matter intake, *TDNI* total digestible nutrient intake, *SEM* standard error of the mean, *SL* significant level, nonsignificant, *D1* Rhodes grass hay *adlibtum* + 100% concentrate mix, *D2* Rhodes grass hay *adlibtum* + 75% Noug Seed Cake (NSC) and 25% Mulberry and *Vernonia* mixed leaves meal, *D3* Rhodes grass hay *adlibtum* + 50% NSC and 50% Mulberry and *Vernonia* mixed leaves meal, *D4* Rhodes grass hay *adlibtum* + 25% NSC and 75% Mulberry and *Vernonia* mixed leaves meal, *D5* Rhodes grass hay *adlibtum* + 100% Mulberry and *Vernonia* mixed leaves meal

showed the lowest ADL intake. The result of this study showed that increasing the substitution level of dried mulberry and *Vernonia* mixed leaves meal for NSC up to 75% significantly increase the TDMI of the sheep as compared to the control group. However, the intake of basal diet for sheep in diets (2, 3, and 4) were not significantly different from the intake in diet (D1), but higher than in D5. Feed intake is negatively influenced by the quantity of indigestible fractions such as NDF, ADF, and ADL contents of the roughages that make depressed voluntary intake and digestibility. The estimated metabolisable energy (EME) intake in the current study is significantly different (P < 0.001). Sheep in diets (1, 2, 3, and 4) consumed significantly (P < 0.001) more ME compared with diet 5 (sole mulberry and *Vernonia* leaves mixture). The value of EME was consistent with that of apparent digestibility of organic matter intake.

Morphometric measurements after the end of feeding trial

The morphological measurements of sheep at the end of the experimental period are indicated in Table 3. The experimental diets had no significant effect (P > 0.05) on height at wither, body length, and heart girth, likewise

Table 3 Morphometric measurements of experimental animals supplemented with dried mulberry and *Vernonia* mixed leaves meal replacing protein source

Parameters	Treatments (diets)					SEM	F-value	SL
	D1	D2	D3	D4	D5			
Height at withers (cm)	65.8	63.2	64.4	63.2	62.4	1.02	1.57	Ns
Body length(cm)	78	77.1	78.8	77.6	73.2	1.49	2.12	Ns
Chest depth (cm)	33.6^{a}	32.4^{abc}	33.2^{ab}	31.0^{bc}	30.8^{c}	0.74	2.91	**
Hip width (cm)	14.4^{a}	13.8^{ab}	14.6^{a}	13.2^{bc}	12.8^{c}	0.32	5.44	**
Heart girth (cm)	72.4	69.6	73.4	69.4	68	1.47	2.34	Ns

^{a,b} Mean values within a row with different superscripts are significantly different at **=(p < 0.01); *SEM* standard error of means, *SL* significant level, *ns* non-significant, *D1* Rhodes grass hay *adlibtum* + 100% concentrate mix, *D2* Rhodes grass hay *adlibtum* + 75% Noug Seed Cake (NSC) and 25% Mulberry and *Vernonia* mixed leaves meal, *D3* Rhodes grass hay *adlibtum* + 50% NSC and 50% Mulberry and *Vernonia* mixed leaves meal, *D4* Rhodes grass hay *adlibtum* + 25% NSC and 75% Mulberry and *Vernonia* mixed leaves meal, *D5* Rhodes grass hay *adlibtum* + 100% Mulberry and *Vernonia* mixed leaves meal

Table 4 Growth performances of Bonga lambs fed on Rhodes grass hay basal diet and supplemented with dried mulberry and *Vernonia* mixed leaves meal replacing protein source

Parameters	Treatments (diets)					SEM	F-value	SL
	D1	D2	D3	D4	D5			
IBW (Kg)	20.84	20.98	20.83	20.95	20.94	0.28	0.05	Ns
FBW (Kg)	28.74	28.36	28.34	27.72	25.98	0.67	2.81	ns
BWC (Kg)	7.90^{a}	7.38^{a}	7.51^{a}	6.77^{a}	5.04^{b}	0.49	5.26	**
ADG (g/d/head)	87.7^{a}	82.0^{a}	83.4^{a}	75.2^{a}	56.0^{b}	5.45	5.76	**
FCR ((TDMI/BWG(Kg))	0.09	0.11	0.11	0.11	0.13	0.001	2.24	ns
PCE (ADG/daily CPI)	0.79	0.73	0.75	0.69	0.58	0.05	2.05	ns

[a,b] Mean values within a row with different superscripts are significantly different at **=(p < 0.01); *SEM* standard error of means, *SL* significant level, *ns* non-significant, *IBW* initial body weight, *FBC* final body weight, *BWC* body weight change, *ADG* average daily gain, *FCR* feed conversion ratio, *TDMI* total dry matter intake (kg), *BWG* body weight gain (kg), *PCE* protein conversion efficiency, *D1* Rhodes grass hay *adlibtum* + 100% concentrate mix, *D2* Rhodes grass hay *adlibtum* + 75% Noug Seed Cake (NSC) and 25% Mulberry and *Vernonia* mixed leaves meal, *D3* Rhodes grass hay *adlibtum* + 50% NSC and 50% Mulberry and *Vernonia* mixed leaves meal, *D4* Rhodes grass hay *adlibtum* + 25% NSC and 75% Mulberry and *Vernonia* mixed leaves meal, *D5* Rhodes grass hay *adlibtum* + 100% Mulberry and *Vernonia* mixed leaves meal

Table 5 Carcass parameters of Bonga lambs fed on Rhodes grass hay basal diet and supplemented with mulberry and *Vernonia* mixed leaves meal as a protein source

Parameters	Treatments (diets)					SEM	F-value	SL
	D1	D2	D3	D4	D5			
Slaughter body weight (kg)	29.1	28.7	28.2	28.5	26.4	0.65	2.68	ns
Empty body weight(kg)	25.3^{a}	24.9^{a}	24.1^{a}	24.3^{a}	21.6^{b}	0.6	5.45	**
Hot carcass weight (kg)	14.1^{a}	13.5^{a}	12.7^{a}	12.8^{a}	10.6^{b}	0.45	9.92	**
DPSBW (%)	48.3^{a}	46.9^{ab}	44.7^{b}	45.0^{b}	39.9^{c}	0.83	19.39	***
DPEBW (%)	55.7^{a}	54.3^{a}	52.5^{a}	52.3^{a}	48.8^{b}	0.98	8.82	***
REMA (cm^2)	12.8^{a}	13.6^{a}	12.0^{a}	12.4^{a}	9.0^{b}	0.64	7.48	***

[a,b,c] Mean values with different superscripts within a row are significantly different at **=(p < 0.01); ***= (P < 0.001); *SEM* standard error of means, *SL* Significant level, *ns* non-significant, *DPSBW* dressing percentage on Slaughter body weight basis, *DPEBW* dressing percentage on empty body weight basis, *REMA* rib-eye muscle area, *D1* Rhodes grass hay *adlibtum* + 100% concentrate mix, *D2* Rhodes grass hay *adlibtum* + 75% Noug Seed Cake (NSC) and 25% Mulberry and *Vernonia* mixed leaves meal, *D3* Rhodes grass hay *adlibtum* + 50% NSC and 50% Mulberry and *Vernonia* mixed leaves meal, *D4* Rhodes grass hay *adlibtum* + 25% NSC and 75% Mulberry and *Vernonia* mixed leaves meal, *D5* Rhodes grass hay *adlibtum* + 100% Mulberry and *Vernonia* mixed leaves meal

chest depth and hip-width were significantly ($P < 0.05$) affected by the feeding diets. Sheep maintained in the control group (D1) statistically achieved similar to sheep allotted to diet 2 and 3, but significantly higher chest depth as compared to sheep maintained on sole mixed leaves meal (D5). Sheep kept on diets containing different proportions of mixed leaves meal D2, D3 and D4 showed statistically similar chest depth. The lambs fed diets (D1, D2, and D3) had scored statistically similar hip-width whereas greater than lambs supplemented D4 and D5.

Body weight and feed conversion ration

Mean values of initial body weight, final body weight, body weight change, average daily gain, feed conversion ratio (FCR), and protein conversion efficiencies (PCE) of experimental animals are shown in (Table 4). Although there was no significant difference ($P > 0.05$) in the final body weight (FBW), we observed an increase in the final body weight of animals in each experimental diet. There were significant differences ($P < 0.01$) among treatments on body weight changes (BWC) and average daily weight gain (ADG). Thus, sheep in diets 2, 3, and 4 had higher ($P < 0.05$) body weight changes than sheep who received diet 5, but sheep allotted in diets 1, 2, 3, and 4 had statistically ($P > 0.01$) attained similar BWC and ADG. The values for ADG observed in the current study are ranged from 56.0 to 87.7 g day^{-1}. The feed conversion ratio (FCR) and protein conversion efficiency (PCE) of experimental animals were similar ($P > 0.05$) among the dietary treatments.

Carcass characteristics of experimental animals

The mean values of carcass parameters of Bonga lambs fed on Rhodes grass hay basal diet and supplemented with mulberry and *Vernonia* mixed leaves meal are given in Table 5. Dressing percentage as a proportion of slaughter body weight basis (DPSBW) and dressing percentage as proportion of empty body weight basis (DPEBW)

Table 6 Edible offal components of Bonga lambs supplemented with dried mulberry and *Vernonia* mixed leaves meal at different levels fed with Rhodes grass hay basal diet

Offal components (g)	Treatments (diets)					SEM	F-value	SL
	D1	D2	D3	D4	D5			
Heart	136	134	122	124	138	7.85	1.45	ns
Liver	476	462	474	482	498	14.53	0.82	ns
Kidney	86	92	84	84	86	2.86	2.34	ns
Tongue	78	74	72	66	76	6.2	0.54	ns
Reticulo-rumen	700	738	730	712	682	37.49	0.36	ns
Abomasum	164	196	194	150	196	17.01	1.61	ns
Omasum	106	118	108	107	108	17.77	0.77	ns
Small intestine	760	656	728	656	710	42.26	1.17	ns
Large intestine	576[a]	526[ab]	440[bc]	440[bc]	404[c]	37.15	3.67	*
Tail	726	584	564	628	538	70.74	1.09	ns
Heart fat	50	50	34	38	34	8	1.38	ns
Kidney fat	102	82	84	90	64	9.73	2.01	ns
Abdominal fat	272	222	258	256	202	0.06	0.82	ns
TEOC (kg)	4.23	3.93	3.89	3.83	3.73	0.12	2.62	ns

[a,b,c] Mean values with different superscripts within a row are significantly different at *=(p < 0.05); ***= (P < 0.001); *SEM* standard error of means, *SL* significant level, *ns* non-significant, *D1* Rhodes grass hay *adlibtum* + 100% concentrate mix, *D2* Rhodes grass hay *adlibtum* + 75% Noug Seed Cake (NSC) and 25% Mulberry and *Vernonia* mixed leaves meal, *D3* Rhodes grass hay *adlibtum* + 50% NSC and 50% Mulberry and *Vernonia* mixed leaves meal, *D4* Rhodes grass hay *adlibtum* + 25% NSC and 75% Mulberry and *Vernonia* mixed leaves meal, *D5* Rhodes grass hay *adlibtum* + 100% Mulberry and *Vernonia* mixed leaves meal

values of the sheep in diets (1, 2, 3 and 4) were significantly (P < 0.001) higher than sheep fed diet 5, showed similar trends to EBW and HCW. The mean DPEBW for sheep showed statistically different (P < 0.001) with D1 = D2 = D3 = D4 > D5. The dressing percentage of Bonga sheep fed on Rhodes grass hay as a basal diet and substitution of NSC of concentrate mix with dried mulberry and *Vernonia* mixed leaves meal in the current study were 39.9–48.3% and 48.8–55.7% on slaughter and empty body weight basis, respectively.

Edible and non-edible offal components

The edible offal components of Bonga sheep fed dried mulberry and *Vernonia* leaves mixture as substitution for noug seed cake of concentrate mix supplement to Rhodes grass hay basal diet during a 90-days of feeding trial are given in Table 6. The present study showed that most edible offal components and total edible offal were not affected (P > 0.05) by the experimental diets.

The non-edible offal components of Bonga lamb fed the experimental diets are given in Table 7. There were insignificant differences (P > 0.05) among treatments in terms of weight for most of the non-edible offal components, except head, skin, gut contents, and total non-edible offal components, which had significant differences (P < 0.05) among the experimental diets. The gut contents of the present study ranged from 3.84 to 4.83 kg.

Relative proportion of carcass parameters

The relative proportion of different carcass parameters of the experimental animals are indicated in Table 8. The result revealed that gut content to slaughter body weight (GC: SBW) recorded in D5 significantly (P < 0.001) higher than in the rest of the treatments. The proportions of total edible offal components to total non-edible offal components (TEOC: TNEOC) and total non-edible offal components to empty body weight (TNEOF: EBW) were significantly different among treatments.

Correlation between feed intake and carcass parameters

Table 9 shows the relationship between dry matter intake (DMI) and carcass parametres of Bonga sheep kept on the experimental diets. Daily dry matter intake was positively correlated (P < 0.05) with empty body weight (EBW), slaughter body weight (SBW), hot carcass weight (HCW), dressing percentage on slaughter body weight (DSBW), dressing percentage on empty body weight basis (SEBW), whereas total non-edible offal components (TNEOC) showed weak positive relationship. The present study result revealed that, SBW had significantly (P < 0.01) strong positive association with EBW (r = 0.97), HCW (r = 0.98), DSBW (r = 0.99) and REMA (r = 0.90). Similarly, empty body weight (EBW) had a strong positive association (P < 0.01) with HCW(r = 0.94), DSBW (r = 0.94) and REMA (r = 0.82). Hot carcass weight

Table 7 Non-edible offal components of Bonga lambs supplemented with dried mulberry and *Vernonia* mixed leaves meal at different levels fed with Rhodes grass hay basal diet

Non-edible offals	Treatments (diets)					SEM	F-value	SL
	D1	D2	D3	D4	D5			
Blood (kg)	1.35	1.34	1.32	1.43	1.37	0.03	1.51	ns
Head (kg)	1.51^{b}	1.59^{ab}	1.69^{a}	1.66^{a}	1.49^{a}	0.03	5.41	**
Skin (kg)	2.38^{bc}	2.55^{ab}	2.39^{bc}	2.71^{a}	2.16^{c}	0.08	6.04	**
Feet (g)	666	662	654	668	514	56.18	1.41	ns
Tests (g)	306	312	288	329	318	14.66	1.08	ns
Penis (g)	50	60	50.6	61	40	5.24	2.4	ns
Lung with trachea (g)	404	422	452	442	450	45.09	0.21	ns
Spleen (g)	46	52	52	56	52	6.22	0.33	ns
Gut contents (Kg)	3.84^{b}	3.88^{b}	4.19^{b}	4.16^{b}	4.83^{a}	0.18	4.77	**
Bladder (g)	20	20	18	32	18	4.03	2.13	ns
TNEOC (Kg)	10.57^{b}	10.88^{ab}	11.10^{a}	11.58^{a}	11.24^{a}	0.45	2.95	*

^{a,b,c} Mean values with different superscripts in a row are significant different at **= (p < 0.01); *SEM* standard error of the mean, *SL* significant level, *ns* non-significant, *NEOC* non-edible offal components, *TNEOC* total non-edible offal components, *D1* Rhodes grass hay *adlibtum* + 100% concentrate mix, *D2* Rhodes grass hay *adlibtum* + 75% Noug Seed Cake (NSC) and 25% Mulberry and *Vernonia* mixed leaves meal, *D3* Rhodes grass hay *adlibtum* + 50% NSC and 50% Mulberry and *Vernonia* mixed leaves meal, *D4* Rhodes grass hay *adlibtum* + 25% NSC and 75% Mulberry and *Vernonia* mixed leaves meal, *D5* Rhodes grass hay adlibtum + 100% Mulberry and Vernonia mixed leaves meal

Table 8 Proportion of different carcass parameters of Bonga lambs fed on Rhodes grass hay basal diet and supplemented with dried mulberry and *Vernonia* mixed leaves meal

Parameters (%)	Treatments (diets)					SEM	F-value	SL
	D1	D2	D3	D4	D5			
GC: SBW	13.2^{b}	13.5^{b}	14.9^{b}	14.6^{b}	18.3^{a}	0.68	11.95	***
TEOC: TNEOC	40.1^{a}	37.1^{ab}	35.0^{bc}	33.2^{bc}	32.3^{c}	1.34	5.37	*
TEOC: EBW	16.8	16	15.8	15.6	17.3	0.48	2.16	ns
TNEOF: EBW	41.8^{c}	43.7^{bc}	46.1^{bc}	47.5^{b}	52.1^{a}	1.39	10.71	**

^{a,b,c} Mean values with different superscripts within a row are significantly different at*=(p < 0.05);**=(p < 0.01) and ***= (P < 0.001); *GC* gut contents, *SBW* slaughter body weight, *TEOC* total edible offal components, *TNEOC* total non-edible offal components, *EBW* empty body weight, *SEM* standard error of the mean, *SL* significant level, *ns* non-significant, *D1* Rhodes grass hay *adlibtum* + 100% concentrate mix, *D2* Rhodes grass hay *adlibtum* + 75% Noug Seed Cake (NSC) and 25% Mulberry and *Vernonia* mixed leaves meal, *D3* Rhodes grass hay *adlibtum* + 50% NSC and 50% Mulberry and *Vernonia* mixed leaves meal, *D4* Rhodes grass hay *adlibtum* + 25% NSC and 75% Mulberry and *Vernonia* mixed leaves meal, *D5* Rhodes grass hay *adlibtum* + 100% Mulberry and *Vernonia* mixed leaves meal

Table 9 Correlation coefficient between dry matter intake and carcass parameters on Bonga lambs fed on Rhodes grass hay basal diet and supplemented with mulberry and *Vernonia* mixed leaves meal

	DMI	SBW	EBW	HCW	DSBW	DEBW	REMA	TEOC
SBW	0.76^{ns}							
EBW	0.87*	0.97**						
HCW	0.84*	0.98**	0.94**					
DSBW	0.68*	0.99**	0.94**	0.99**				
DEBW	0.47*	0.92*	0.82*	0.96*	0.95*			
REMA	0.72^{ns}	0.90*	0.88*	0.92*	0.91*	0.85^{ns}		
TEOC	0.32^{ns}	0.83^{ns}	0.74^{ns}	0.89*	0.89*	0.93**	0.72^{ns}	
TNEOC	0.13*	-0.5^{ns}	-0.33^{ns}	-0.61^{ns}	-0.60^{ns}	-0.78^{ns}	-0.55^{ns}	-0.81^{ns}

DMI dry matter intake, *SBW* slaughter body weight, *EBW* empty body weight, *HCW* hot carcass weight, *DSBW* dressing percentage slaughter body weight basis, *DEBW* dressing percentage empty body weight basis, *REMA* rib eye muscle area, *TEOC* total edible offal components, *TNEOC* total non-edible offal components, *ns* non-significant, significantly different at *=(p < 0.05); **= (P < 0.01)

(HCW), DSBW (r = 0.99) and REMA (r = 0.96) followed the same strong positive (P > 0.01) correlation. Total edible offal components (TNEOC) showed negative correlation with SBW, EBW, HCW, DSBW, DEBT, REMA and TEOC.

Discussion

The basal diet intake decreased with increasing the substitution levels of dried mulberry and *Vernonia* mixed leaves meal in diets (D4 and D5) probably due to the bulkiness of the mixed leaves meal contributing to the gut fills. On the other hand, the supplemental diets containing NSC had reduced rumen retention time by increasing the out-flow rate and stimulating the intake than sole mulberry and *Vernonia* mixed leaves meal. Moreover, an increased in DM and OM intake in sheep fed on mulberry and *Vernonia* mixed leaves meal substitution up to 75% agrees with the finding of Kedir (2011) that noted greater DM and OM intakes in diets comprising *Vernonia* supplement in growing Somali goats fed *Catha edulis* leftover. The total dry matter intake of sheep in the present study ranged from 642.8 to 771.4 g day^{-1} and higher than 480–498 g day^{-1} DM intake reported by Mulat (2006) for local lambs fed finger millet straw basal diet and different levels of concentrate supplements, and comparable to 671.7–754.3 g/day reported by Wegi (2016) for Arsi-bale sheep fed *Faba bean* straws with concentrate, but lower than 681.6–809.3 g/day reported by Animut and Adem (2014) for Dorper x Afar F1sheep fed rhodes grass hay supplemented with alfalfa, lablab and *Leucaena leucocephala* and concentrate mixtures. The observed variations in dry matter intakes could be attributed to animal factor, body weight, environmental conditions, diet composition and quality (Mc Donald et al. 2002). Moreover, the physical and chemical characteristics of the feed can positively or negatively affect the intake.

The feed intakes were slightly higher than (2.8–3%) reported by Wegi (2016) for Arsi-Bale sheep fed *Faba bean* straws with 300 g/day concentrate mix (noug seed cake and wheat bran) and lower than 3.25–4.29% BW reported by (Yulistiani et al. 2015). The total CP intake in this experiment ranged from 88.2 to 106.8 g/day were within the range of 81.1–126.9 g day^{-1} for 300 g day^{-1} concentrate supplemented for Arsi-Bale sheep fed *Faba bean* haulms as basal diet (Negewo et al. 2018). The variation in CP intake observed might be due to the differences in hay and supplement intakes. The EME intake (8.3–10.2 MJ/day) in this experiment was higher than (6.2–8.5 MJ/day) for the maintenance and growth requirements of sheep with 20–30 kg live weight (ARC 1980). This difference might be due to variations in breed, feed, and other factors.

The results of this study indicated that the replacement of mulberry and *Vernonia* mixed leaves meal for NSC didn't significantly affect the final body weight of growing Bonga lambs. This result agrees with the report of Yulistiani et al. (2015) who found that supplementation with mulberry as concentrate replacer had no significant effect on the final weight of Pelibuey male lambs. The differences in body weight change and daily body weight gain among treatments in the current study could be due to the differences in the amount of daily DM intake and digestibility of the feed intake (McDonald et al. 2011). The level of intake and digestibility of experimental diets could determine the animals' performances (Guimarães et al. 2014).

Sheep maintained in sole leaves meal had a lower total body weight change than sheep in D1 had the highest ADG. The variation in ADG might be resulted from sheep supplementation with NSC that had better DM and OM intake and nutrient digestibility than in D5. Furthermore, this difference might also be resulted from the relatively higher by-pass protein content in NSC than mulberry and *Vernonia* leaves mixture. Alemu and Merkel (2008) in their study on evaluation of supplement feed indicated that feeds such as oilseed cakes have a large proportion of the protein bypasses to the small intestine without being solubilized in the reticulo-rumen and this improves the use of dietary protein more efficiently. The above authors also agreed that crude protein from forage legumes has intermediate rumen solubility. The values for ADG observed in the current study are ranged from 56.0 to 87.7 g day^{-1} and higher than the values of 51.9–70.7 g/day/head reported by Gebru et al. (2017) who did substitution of concentrate mix with dried mulberry leaves in the diets of Abergelle sheep and higher than (52–67 g day^{-1}) for dried mulberry leaf supplementation for local sheep in Wollo area reported by Yirga et al. (2017). On contrary, the ADG observed in this study was lower than 93.8 g day^{-1} reported by Woyessa et al. (2013) or Horro sheep supplemented with 450 g day^{-1} ground *Vernonia* leaves and ground sorghum grain mixtures. The insignificant variation in feed conversion efficiency, indicating similarity in age of the experimental animals, breed, and condition in which the animal was kept. This is in agreement with the finding of Woyessa et al. (2013) for Horro sheep supplemented with different levels of ground *Vernonia* leaves and ground sorghum grain mixtures and Gebru et al. (2017) for substitution of concentrate mix with dried mulberry leaves for Abergelle sheep.

The values of SBW ranged from 26.4 to 29.1 kg which was higher than the value of 22.83–23.77 kg reported by Gebru et al. (2017) for substitution of concentrate mix with dried mulberry leaves for Abergelle sheep. The values of EBW and HCW of sheep in diets (1, 2, 3 and 4) were significantly higher than in sheep kept on diet 5 could be associated with higher daily weight gain obtained for sheep fed NSC with different levels as compared to sheep fed on sole mixed leaves meal. The hot carcass weight in this study was within the range of 10.6 to 14.1 kg. The dressing percentage values reported in this study were higher than the values for Washera sheep which had 31–40% and 46–52% on slaughter and empty body weight basis reported Gizachew (2012). The values of REMA (cm^2) in the current study showed significant differences ($P < 0.001$) among the treatments and the values ranged from 9.0 to 13.6 cm^2. Accordingly, the rib-eye muscle area scored for sheep fed noug seed cake containing different substitution levels with dried mulberry and *Vernonia* mixed leaves meal had better muscle than the animals supplemented with sole mixed leaves meal. The result showed a consistent trend with empty body weight and hot carcass weight. Irshad et al. (2013) suggested that the rib-eye area is affected by the weight and muscularity of the live animals and carcass weight.

The present result revealed that treatments had no significant effect ($P > 0.05$) on slaughter body weight (SBW) and the result was consistent with that of final body weight. This might be due to similar feed conversion efficiency. The mean values of DPEBW were higher than DPSBW. This is an indication of the effect of gut contents on dressing percentages and the prediction of carcass weight on an empty weight basis seems to be appropriate.

Offal components referred to as varieties of meat consisting of internal and external organs categorized as edible and non-edible offal based on tradition, beliefs, cultures, and differences in preference of the people from one locality to the other (Sebsibe 2008). In Ethiopia, religion and beliefs have considerable effects on the consumption of meat and meat products (Seleshe et al. 2014). Sheep allotted in diet 1 had the highest ($P < 0.05$) large intestine weight whereas sheep in diet 5 had the lowest weight (g). This might be due to a higher intake of dry matter that would result in a more developed gastrointestinal tract (Sen et al. 2011). Sheep kept in diet 4 showed the highest skin weight, but were statistically similar to diet 2. The relatively higher skin weight obtained in sheep fed D2 and D4 might be associated with their numerically higher metabolizable energy intakes, in each treatment (10.2 MJ day $^{-1}$) and which might have resulted in better subcutaneous layer fat deposition in these groups. According to the result of Gizachew (2012), skin could be affected by diet, where a high level of concentrate feeding resulted in heavier skin weight. In contrast with the above author, a diet containing 25% NSC resulted in higher skin weight than the control. Sheep in D5 had higher ($P < 0.05$) gut contents as compared to sheep belong to other treatments and this might be due to more feed retention time in the rumen and also reflected in low digestibility of fiber from mulberry and *Vernonia* leaves (Van Soest 1994). Contrary to the report of Gizachew (2012), the weight of total non-edible offal components in the present study was affected by the diet. Accordingly, sheep fed D5 showed higher ($P < 0.05$) TNEOC than sheep in D1 might be due to the higher (4.83 kg) gut contents in D5 the other treatments.

The proportion of total edible offal components to empty body weight (TEOC: EBW) of the present study ranged 15.6–17.3% which was higher than 12–15% in Priangan Javanese fat tailed rams (Baihaqi and Herman 2012). Similarly, the proportion of total non-edible offal components to edible empty body weight (TNEOF: EBW) ranged 41.9–53.7% which was higher than 30–32% in Priangan Javanese fat tailed rams (Baihaqi and Herman 2012). The variation could be due to breed difference and diet offered to the animals (Wachira et al. 2002).

Slaughter body weight, and rib-eye muscle area were showed strong positive correlation. On the contrary, total edible offal components showed weak positive relationship. The result of this study is in agreement with the result of (Hailu et al. 2011) who reported positive correlations between dry matter intake and with most of carcass parameters of Washera sheep fed on urea treated rice straw supplemented with graded levels of concentrate mix. The current study is in agreement with the result of (Hagos and Melaku 2009) reported that positive correlation between rib-eye area, hot carcass weight, dressing percentage, with slaughter body weight of afar rams fed teff (*Eragrostics tef)* straw supplemented with graded levels of concentrate mixtures.

Conclusion

This study indicated that supplementing of mulberry and *Vernonia* mixed leaves meal by replacing noug seed cake at 25, 50 and 75% proportions for sheep diet resulted statistically similar performance in terms of body gain and carcass parameters compared to the control (concentrate mix) diet. This study also highlights the positive potential of dried mulberry and Vernonia leaves mixture as a supplement to ruminants on a basal diet of fibrous feed. Therefore, considering the availability in the local conditions, ease of accessibility, and profitability; using such browse trees in areas where they are easily available as an option of supplement regime in ruminant animals feeding is give more advantage than compared to conventional concentrates and agro-industrial by products. Thus, supplementing of mulberry and *Vernonia* mixed leaves up to 75% achieved comparable result with concentrate mix in weight gain and carcass yield. Moreover, studies on the effects of these tree leaves meal on carcass quality, advanced evaluation for anti-nutritional factors, identifying best time of using browse trees for high biomass yield, effective conservation methods, and level of inclusion with other basal diets and available concentrate feeds would be of priority areas to be addressed in the future.

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Author contributions
GM: Deign the methodology, collection of the data, analysis and wrote the manuscript. GA: analysis the data, review and edit the final manuscript. All authors read and approved the final manuscript.

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Availability of data and materials
The data set used /analyzed during the current study is available from the corresponding author on reasonable request.

Declarations

Ethics approval and consent to participate
The participants were Informed and agreed before participation in the study.

Consent for publication
Not applicable.

Competing interests
The authors declared that they have no competing interest.

Author details
[1]Teppi Agricultural Research Center, P.O. Box: 34, Teppi, Ethiopia. [2]Ethiopian Institute of Agricultural Research, P.O. Box: 2003, Addis Ababa, Ethiopia.

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