The Carcass and Non-Carcass Parameters of Local Sheep Supplemented with Concentrate Mixture, Atella, Faidherbia albida leaf and Sesbania sesban leaf

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Abstract
The experiment was conducted to determine the supplemental value of concentrate mixture of 75% wheat bran and 25% Sesame seed cake (T_1), Atella (T_2), *Faidherbia albida* leaf (T_3) and *Sesbania sesban* leaf (T_4) on carcass and non-carcass parameters using twenty four yearling intact local male sheep with mean initial body weight (IBW) of 18 ±1.55 kg (mean ± SD). Randomized complete block design was used for the experiment and sheep were blocked into six based on IBW. Sheep within block were randomly assigned to treatments. The experiment was conducted for 90 days (feeding trial) after 15 days acclimatization period. The amount of supplements offered were 300 (T_1), 330 (T_2), 360 (T_3) and 280 (T_4) g/day on DM basis, each calculated to supply 73.6 g/day crude protein (CP). The carcass and non-carcass parameters were evaluated at the end of the experiment. Hot carcass weight ranged from 9.75 kg to 11 kg. Most carcass parameters (slaughter weight, empty body weight, hot carcass weight, dressing percentage, rib-eye muscle area, fore-leg, hind-leg, ribs with muscle, sternum and neck) followed similar trends like average daily gain (ADG), in which these parameters were higher in T_1 and lower in T_3; however T_1 and T_3 were similar with T_2 and T_4.
Keywords: dressing percentage**,** edible offals, hot carcass weight, local sheep, non-edible offals, slaughter weight

1. INTRODUCTION
Most investigations in animal nutrition have been conducted on supplementation of poor quality roughages with concentrates (Mekoya, 2008). However, concentrate feeds especially grains and oil seeds are expensive and highly valued as human food (Almaz *et al*., 2012). Thus, maximization of livestock productivity in the tropical regions largely depends on utilization of local protein sources (Seyoum *et al.,* 1996). Hence, supplementary feeds produced on-farm other than commercial concentrates is needed for livestock feeding. In this regard, strategic supplementation of unexploited, cheap, less competitive, and year round and easily accessible protein sources like *Atella*, *Sesbania sesban* and *Faidherbia albida* in place of the highly priced concentrate feeds can be a feasible alternative to mitigate protein deficiency in poor quality feeds during periods of feed scarcity. Therefore, the objective of this study was to compare the effect of supplementation with isonitrogenous levels of concentrate mixture*, Atella*, *F. albida* leaf and *S. sesban* leaf on carcass and non-carcass parameters of local sheep fed hay basal diet.

2. MATERIALS AND METHODS
2.1. Description of Study Area
The study was conducted at Aksum University Shire campus located at a distance of 1087 km North of Addis Ababa. The site is situated at an altitude of 1800 meter above sea level with 14^0 06` to $14^0$ 07`N latitude and 38^0 16' to 38^0 17'E longitude. The average annual rainfall varies between 726 and 1047 mm, and average minimum and maximum temperatures are 20°C and 25°C, respectively.

2.2. Dietary Treatments and Experimental Design
Natural pasture hay was used as a basal diet. The hay was chopped to a length of approximately 4-5 cm. Concentrate mixture was prepared by mixing 75% wheat bran and 25% sesame seed cake. *Atella* (local brewery byproduct) was collected from traditionally "*Tella*" brewing individuals in Shire town, which was prepared mainly from finger millet and small amounts of barely as fermentation catalyst. The wet *Atella* was sun dried for 3-4 consecutive days by thinly spreading on plastic sheets. The leaves of *F. albida* and *S. sesban* were collected by hand stripping and were subjected to air drying under shade for 2-3 days by spreading on plastic sheets.

The amount of concentrate mixture in this experiment was determined to be 300 g on DM basis based on the research findings of Zemichael and Solomon (2009) for Arado sheep. The supplement for the other treatments was on isonitrogenous basis. Samples of treatment feeds were analyzed for dry matter (DM) and crude protein (CP) content before commencement of the experiment to determine the amount of the experimental rations. The DM and CP content obtained from laboratory analysis were 93.47% and 24.53% for concentrate mixture; 93.82% and 22.32% for *Atella*; 94.22% and 20.28% for *F. albida* leaf; and 93.09% and 26.37% for *S. sesban* leaf on DM basis, respectively. Thus, the 300 g concentrate mixture (75% WB to 25% SSC) supplied 73.6 g/day CP on DM basis. To supply the same amount of CP on isonitrogenous basis, 330 g *Atella*, 360 g *F. albida* leaf and 280 g *S. sesban* leaf on DM basis were supplied for sheep in the other treatments daily. The layout of the experimental treatments for the study was:

T_1 = Hay *ad libitum* + 300 g DM concentrate mixture
T_2 = Hay *ad libitum* + 330 g DM sun dried *Atella*
T_3 = Hay *ad libitum* + 360 g DM *Faidherbia albida* leaf
T_4 = Hay *ad libitum* + 280 g DM *Sesbania sesban* leaf

Randomized complete block design was used to conduct the experiment. Sheep were blocked in to six blocks of four sheep each based on their initial body weight (IBW). Sheep within a block were assigned to one of the four dietary treatments randomly.

2.3. Management of Experimental Animals

The experiment was conducted using twenty four yearling intact local male sheep with an average initial body weight of 18 ± 1.55 kg (mean ± SD). The sheep were quarantined for 21 days in the experimental area; and sheep were de-wormed and sprayed against internal and external parasites, respectively. They were also vaccinated against the common diseases prevailing in the area. After 15 days acclimatization period, the feeding trial experiment was conducted for 90 days to determine the carcass and non-carcass parameters. The sheep were offered supplement feeds twice a day at 0800 and 1700 hours.

2.4. Carcass Evaluation

All sheep were allowed to fast overnight before slaughtering, weighed to determine slaughter weight (SW) and slaughtered by severing the jugular vein and carotid arteries with a knife for carcass evaluation. The blood was collected into plastic buckets, weighed and recorded. The esophagus was tied off close to the head to avoid leaking of gut contents. The skin was carefully flayed to avoid attachment of fat and muscle tissues to the skin and then weighed without feet and the feet below fetlock joints were weighed and recorded separately for each sheep. The entire gastro intestinal tract (GIT), except esophagus, was removed with its content and weighed with and without its contents and the weight of the gut content was measured by difference. Non-edible offals (NEOs) such as, skin, feet, spleen, penis and penis fat, lung with trachea and esophagus, bladder and gut contents; and the edible offals (EOs) namely, head, liver with bile, heart, kidney, tail, reticulo-rumen, omasum and abomasum, small and large intestine, blood, total fat (omental, heart and kidney fat), testes and tongue were weighed and recorded separately. Classification of offals in to NEOs and EOs were based on eating habit of the people residing in and around the study area.

The total non-edible offals (TNEOs) and total edible offals (TEOs) were computed as the sum of all NEOs and all EOs, respectively. Empty body weight (EBW) of each sheep was determined by subtracting weight of digesta from slaughter weight. Hot carcass weight (HCW) was computed by excluding contents of thoracic, abdominal and pelvic cavity, head, skin, and the limbs. Dressing percentage (DP) was also calculated as a ratio of HCW to SW, and HCW to EBW.

The cross sectional area of rib-eye muscle (REMA) was traced on transparency paper between the eleventh and twelfth ribs (Galal *et al*., 1979) of the left and right half sides of the carcass after freezing and the area was measured using planimeter. The value for the rib-eye area was taken as the average of the two sides of the ribs.

2.5. Statistical Analysis

The data obtained from carcass and non-carcass parameters were subjected to analysis of variance using the General Linear Model procedure of SAS (2008). Treatment means were separated by using Tukey`s Studentized range test. The model used for data analysis was:

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

Where; Y_{ij} = response variable, μ = overall mean, T_i = treatment effect, B_j = block effect, e_{ij} = random error

3. RESULT AND DISCUSSION

3.1. Carcass Parameters

The values of carcass components of local sheep fed grass hay and supplemented with concentrate mixture, sun dried *Atella* and leafs of *F. albida* and *S. sesban* are given in Table 1. The SW, HCW, DP and REMA differed among treatments and took a similar trend like that of average daily gain (ADG), and as such were greater for T_1 than T_3, but similar among other treatment means. Higher EBW was also observed in T_1 and T_2 compared to T_3, while T_4 was similar with T_2 and T_3. The HCW in this study is slightly in agreement with the values 10.8-12.1 kg reported by Zemichael and Solomon (2009), but higher than 6.1-7.2 kg reported by Neamn (2011) for the supplemented sheep groups.

Dressing percentage, which is an important criterion in carcass merit consideration, is affected by breed, age, sex and plane of nutrition. Values of dressing percentage as empty body weight (DPEBW) bases were higher than dressing percentage as slaughter weight (DPSW) bases, which indicate the influence of digesta on dressing percentage. DPEBW basis in this study was comparable to 53-56.3% (Abebe, 2011), 53-57% (Emebet, 2008) and 55.7-56.4% (Hagos, 2011). On the other hand, lower results of DPEBW (48.6-50% and 47-53%) than the current study were reported by Neamn (2011) and Zemichael and Solomon (2009), respectively.

In the present study, the DPSW bases ranged between 46.0-49.0%, which is in agreement with the 45-45.6% for Arsi-Bale sheep (Abebe, 2011), and the 47.3-48.6% for Tigray highland sheep (Amare, 2007). Relatively lower dressing percentages of 39.5-43.4%, 36-38.4%, 32-38% and 38-39.6% on slaughter weight basis than the present study were reported by Zemichael and Solomon (2009) for Arado sheep, Mulu (2005) for Wogera sheep, Neamn (2011) for local sheep and Gebretinsae (2011) for local sheep, respectively. Generally, the variations in carcass traits in this study and other results of previous studies may be due to variations in age and breed of sheep, and quantity and quality of basal and supplement feeds used for the experiment. In agreement with this, McDonald *et al*. (2010) noted that, nutrition, age, sex, genetics, season and other related factors affect the growth and carcass traits of animals.

REMA is an indicator of muscling and amount of lean meat in the carcass. The REMA in this study is within the range of 6.35-9.25 cm^2 reported by Amare (2007). Comparable results to the present study was also reported by Guesh (2011) (6.7-7.3 cm^2) and Hirut (2008) (7-8.4 cm^2) for Black Head Ogaden sheep and Hararghe Highland sheep, respectively. In contrast, REMA in the current study are lower than the values of 13-19.5, 8.2-10.4, 11.5-12.75 and 8.6-9.5cm^2 reported by Mulu (2005), Emebet (2008), Zemichael and Solomon (2009) and Abebe (2011) for supplemented groups of Wogera sheep, Black Head Ogaden sheep, Arado sheep and Arsi-Bale sheep, respectively; but higher than 4.5-6.5 and 5.7-6.4 cm^2 reported by Neamn (2011) and Hagos (2011) for local sheep and Tigray Highland sheep, respectively. Different previous works showed that supplementation of different protein sources had significant and positive effect on REMA and the differences in REMA reported by various authors may be due to variations in the amount and quality of supplement proteins, and variations in sheep breeds used.

Table 1. Carcass parameters of local sheep fed hay and supplemented with concentrate mixture, *Atella*, *Faidherbia albida* and *Sesbania sesban* leaves.

Carcass	Treatment feeds					
parameters	T_1	T_2	T_3	T_4	SEM	SL
SW (kg)	22.3^{a}	21.9^{ab}	21.2^{b}	21.6^{ab}	0.18	**
ADG (g/day)	50^{a}	45^{ab}	38^{b}	42^{ab}	2.3	*
EBW (kg)	18.4^{a}	17.9^{ab}	17.1^{c}	17.7^{bc}	0.18	**
HCW (kg)	11.0^{a}	10.4^{ab}	9.75^{b}	10.2^{ab}	0.21	**
Dressing percentage:						
SW basis (%)	49.0^{a}	47.6^{ab}	46.0^{b}	46.9^{ab}	0.55	**
EBW basis (%)	59.6^{a}	58.2^{ab}	57.1^{b}	57.4^{ab}	0.59	*
REMA (cm^2)	7.7^{a}	7.3^{ab}	6.9^{b}	7.2^{ab}	0.12	**

$^{a-c}$ mean values in a row having different superscripts differ significantly; ns= not significant; *= significant at $P < 0.05$; **= significant at $P < 0.01$; CM= concentrate mixture (75% wheat bran and 25% sesame seed cake); T_1 = Hay *ad libitum* + 300 g DM/day CM; T_2 = Hay *ad libitum* + 330 g DM/day *Atella*; T_3 = Hay *ad libitum* + 360 g DM/day *F. albida*; T_4 = Hay *ad libitum* +280 g DM/day *S.sesban*

3.1.1. Main carcass components

The main carcass components of local sheep are presented in Table 2. Higher weights of fore-leg, hind-leg and sternum ($P < 0.01$), rib with muscle and neck ($P < 0.05$) were observed for sheep in T_1 compared to sheep in T_3. However, both sheep in T_1 and T_3 were similar ($P > 0.05$) with sheep in T_2 and T_4 for these parameters. Loin weight was similar for all treatments in this study. The higher weights of carcass components in T_1 may be associated with the higher nutrient digestibility and lower fiber fractions in the treatment (Hagos, 2014), which resulted in higher ADG and HCW as compared to T_3.

Table 2. Main carcass components of local sheep fed hay and supplemented with concentrate mixture, *Atella, Faidherbia albida* and *Sesbania sesban* leaves

Carcass parameters (kg)	Treatment feeds T_1	T_2	T_3	T_4	SEM	SL
Fore-leg	1.70^{a}	1.61^{ab}	1.47^{b}	1.59^{ab}	0.039	**
Hind-leg	2.09^{a}	1.96^{ab}	1.85^{b}	1.96^{ab}	0.037	**
Ribs with muscle	1.65^{a}	1.56^{ab}	1.45^{b}	1.54^{ab}	0.044	*
Sternum (Brisket)	0.50^{a}	0.47^{a}	0.39^{b}	0.46^{ab}	0.019	**
Neck	0.81^{a}	0.7^{ab}	0.62^{b}	0.71^{ab}	0.034	*
Loin	1.46	1.42	1.28	1.4	0.048	ns

[a, b] = mean values in a row having different superscripts differ significantly; ns= not significant; *= significant at P < 0.05; **= significant at P < 0.01; ***= significant at P < 0.001; SEM = Standard Error of Means; CM= concentrate mixture (75% wheat bran and 25% sesame seed cake); T_1 = Hay *ad libitum* + 300 g DM/day CM; T_2 = Hay *ad libitum* + 330 g DM/day *Atella*; T_3 = Hay *ad libitum* + 360 g DM/day *F. albida*; T_4 = Hay *ad libitum* +280 g DM/day *S.sesban*

3.2. Non-Carcass Parameters

3.2.1. Edible offal components

The edible offal components of local sheep are presented in Table 3. In the present study, higher (P < 0.01) weights of liver and visceral fat were observed in sheep supplemented with T_1 than sheep in T_3. The increase in liver weight of sheep groups in T_1 may be related with the storage of reserve substances such as glycogen as described by Lawrence and Amedeo (1989). Similarly, the higher weight of visceral fat in T_1 may also be due to higher digestible OM and CP intake, and higher OM and CP digestibility, which promoted higher internal fat deposition in different organs (omentum, kidney and heart) in T_1 compared to T_3 (Hagos, 2014).

Higher weights of testes (P < 0.05), omasum and abomasum, and small and large intestines (P < 0.001) were observed in T_1 than T_3, but was similar (P > 0.05) with T_2. The tail weight in T_1, T_2 and T_3 was higher (P < 0.001) compared to T_4. Total edible offals (TEOs) were higher in sheep supplemented with T_1 than T_3; this may be associated with the heavier weights of omasum and abomasum, small and large intestines, liver and visceral fat in T_1. However, there was lack of differences (P > 0.05) in the weights of reticulo-rumen between T_1 and T_3, and among T_2, T_3 and T_4; and in testes weight among T_1, T_2 and T_4 as well as among T_2, T_3 and T_4. Similar weights of TEOs were also observed between T_1 and T_2, and among T_2, T_3 and T_4. Although significant difference were observed in the weight of total edible offals, non significant differences (P > 0.05) of total edible offals as a percent of slaughter weight were observed among the treatments. Results of the present study also indicate that, the weights of head, tongue, blood, heart, testes and kidney were not different (P>0.05) among the treatments. This was in harmony with the findings of Mulu (2005) who reported, the weights of offal components rich in bone and/or offal components with a low metabolic activity (like head, feet and lungs) varied slightly with diet, as these organs are early maturing parts.

Table 3. Edible offal components of local sheep fed hay and supplemented with concentrate mixture, *Atella, Faidherbia albida* and *Sesbania sesban* leaves

Edible offals	Treatments T_1	T_2	T_3	T_4	SEM	SL
Head (Kg)	1.12	1.10	1.12	1.11	0.020	ns
Blood (g)	707.5	705.0	701.7	702.5	10.90	ns
Tongue(g)	105.0	104.2	102.2	105.8	1.77	ns
Heart (g)	90.8	91.7	80.8	89.2	4.01	ns
Kidney (g)	52.7	53.3	51.7	52.5	1.43	ns
Testes (g)	352.5^{a}	341.7^{ab}	310.0^{b}	343.3^{ab}	9.22	*
Liver + Bile (g)	334.2^{a}	322.5^{ab}	307.5^{c}	315.0^{bc}	3.59	***
Visceral fat (g)	232.3^{a}	215.8^{a}	178.8^{c}	197.2^{b}	4.34	***
Ret-Rum (g)	434.2^{a}	411.7^{b}	421.7^{ab}	406.7^{b}	3.81	***
Oma-Abo (g)	252.5^{a}	242.5^{a}	220.0^{b}	240.8^{a}	4.40	***
SI and LI (g)	535.8^{a}	523.3^{ab}	510.8^{bc}	502.5^{c}	4.48	***
Tail (g)	464.2^{a}	458.3^{a}	448.3^{a}	427.5^{b}	4.37	***
TEOs (Kg)	4.68^{a}	4.57^{ab}	4.45^{b}	4.50^{b}	0.037	**
TEOs (% SW)	21.1	21.0	21.1	20.9	0.21	ns

[a, b] mean values in a row having different superscripts differ significantly; ns= not significant; *= significant at P < 0.05; **= significant at P < 0.01; ***= significant at P < 0.001; SEM= standard error of mean; SL= significance level; Ret-Rum = reticulo-rumen; Oma-Abo = Omasum and Abomasum; CM= concentrate mixture

(75% wheat bran and 25% sesame seed cake); T_1 = Hay *ad libitum* + 300 g DM/day CM; T_2 = Hay *ad libitum* + 330 g DM/day *Atella*; T_3 = Hay *ad libitum* + 360 g DM/day *F. albida*; T_4 = Hay *ad libitum* +280 g DM/day *S.sesban*

3.2.2. Non-edible offal components

The non-edible offal components of local sheep are presented in Table 4. All non-edible offal components were not significant (P > 0.05), except weight of skin, gut contents and total non-edible offals (TNEOs). The skin weight of T_1 and T_2 were higher than T_4; and similarity was observed between T_1 and T_2, T_2 and T_3, and T_3 and T_4. The difference in skin weight may be due to the better subcutaneous layer fat deposition of sheep supplemented with concentrate mixture and *Atella*. Higher weights of TNEOs were also observed in T_2 followed by T_1 and T_3; and the lowest was recorded for T_4.

Table 4. Non-edible offal components of local sheep fed hay and supplemented with concentrate mixture, *Atella, Faidherbia albida* and *Sesbania sesban* leaves

	Treatment feeds					
Non edible offals	T_1	T_2	T_3	T_4	SEM	SL
Skin (kg)	1.78[a]	1.73[ab]	1.60[bc]	1.48[c]	0.031	***
Penis and penis fat (g)	47.5	45.4	42.5	42.7	1.56	ns
Feet (g)	419.2	420.0	415.8	421.2	7.61	ns
LTE (g)	485.0	479.2	441.7	461.7	19.59	ns
Spleen (g)	64.5	63.2	60.7	63.8	2.59	ns
Bladder (g)	28.8	28.3	26.3	28.2	1.07	ns
Gut content (kg)	3.88[b]	3.99[a]	3.98[ab]	3.89[b]	0.023	**
TNEOs (kg)	6.71[ab]	6.76[a]	6.56[bc]	6.4[c]	0.047	***
TNEOs (% SW)	30.34	31.04	31.07	29.71	0.379	ns

[a, b] mean values in a row having different superscripts differ significantly; ns=not significant; **= significant at P < 0.01; ***= significant at P < 0.001; LTE =lung + trachea + esophagus; CM= concentrate mixture (75% wheat bran and 25% sesame seed cake); T_1 = Hay *ad libitum* + 300 g DM/day CM; T_2 = Hay *ad libitum* + 330 g DM/day *Atella*; T_3 = Hay *ad libitum* + 360 g DM/day *F. albida*; T_4 = Hay *ad libitum* +280 g DM/day *S.sesban*

4. CONCLUSION

Most carcass parameters (slaughter weight, empty body weight, hot carcass weight, dressing percentage, rib-eye muscle area, fore-leg, hind-leg, ribs with muscle, sternum and neck) were higher for sheep supplemented with concentrate mixture and lower for sheep supplemented with *F. albida* leaf; however sheep supplemented with concentrate mixture and *F. albida* leaf show similar results of carcass and non-carcass parameters with those supplemented with *Atella* and *S. sesban* leaf. Thus, it is recommended that, small holder sheep producers can use *Atella* and *S. sesban* in place of the highly valued commercial concentrate feeds. Similarly, the feeding values of *Atella* and *S. sesban* can be replaced by *F. albida* leaf because of their similar effects on the carcass and non-carcass parameters of local sheep.

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