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Research Article

Girawa (*Vernonia amygdalina)* as Supplemental Feed and Its Effects on Weight Gain and Carcass Parameter of Somali Goats Fed Khat (*Catha edulis)* Leftover

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Abstract

The experiment was conducted to determine body weight change, Average daily gain, carcass parameter and Analysis of Partial Budget of Somali goat fed khat leftover, supplemented with graded levels of dried vernonia amygdalina leaf. For this experiment, 24 yearling male goats with a mean initial body weight of 12.57 ± 0.59 kg (means ± SD) were used. The experimental goats were blocked into six blocks of four animals in randomized complete block design depending on initial body weight. The four treatments were assigned randomly to each goat within a block. The experimental goats were accessed a basal diet of khat leftover and supplemented with 100 (T1), 200 (T2), 300 (T3) and 400g (T4) Vernonia amygdalina leaf. The experiment was undertaken for Ninety days of feeding trial followed by carcass evaluation at the end of the experiment. The results of this study showed that level of supplementation significantly ($p < 0.05$) improved average daily weight gain, feed conversion efficiency and had better carcass characteristics. Hot carcass weight (HCW; 5 (T1), 6 (T2), 7 (T3) and 8.25 kg (T4) and dressing percentage on empty body weight basis; 43.29 (T1), 44.48 (T2), 50.34 (T3) and 55.18 (T4) was higher ($p < 0.05$) for T_4 compared to T_1, T2 and T_3. The lower level of supplementation recorded loss of 34 ETB/goat. Goats with higher level of supplementation (T_4) had the highest net income (1626 ETB) as well as the highest marginal ret of (4.1 ETB).

Keywords

Empty Body Weight, Haramaya, Hot Carcass, Offals

1. Introduction

Small ruminants as general and goats specifically are considered as major source of income for smallholder farmers in Sub Saharan Africa: providing a more profitable and less-risky alternative in marginal or densely populated areas where accesses to feed resources are limited [1] Ethiopia, one of the developing Sub-Saharan African countries, has a large livestock population in the continent. Moreover, the country is among the top ten goat producing countries in the world. As per [2], the country owns approximately 30 million goats.

Goats are found under all agro-ecological environments and all livestock production systems being suitable for every production systems [3]. The goat is a hardy and prolific animal with excellent foraging ability. It is adapted to wide climatic conditions and successfully survives in hot, arid and semi-arid zones unsuitable for other livestock species. They are an important nutrient source, particularly for people in

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developing regions. Goat meat is considered as a cheap animal origin quality protein that can be utilized to satisfy the increasing demand for quality food in developing countries. The demand for goat meat has continued to increase dramatically over the last few decades even in developed countries where goat meat consumption is not the norm [4].

Irrespective of their large number in the country and its contributions to household income and to the country's national economy, productivity per unit of animal is low. Insufficient and poor quality feed, particularly during the dry season, is the major constraints to livestock feeding system in the country [5]. The use of concentrates such as oil seed cakes to supplement the poor value roughage feed is not likely to be practical for most smallholder farmers mainly because of insufficient supply and inaccessibility as well as purchasing power will not allow the resource poor farmers to compete for such quality feeds [6].

Therefore, to alleviate the problem of feed availability, use of indigenous non-conventional plants would be regarded as good option. Most non-conventional indigenous plants have high crude protein content, ranging from 10 to more than 25% on dry matter basis. They may be considered as a more dependable feed resource of high quality to develop sustainable feeding systems and in increasing livestock productivity [7]. Their potential to adapt to the natural environment and producing considerable amounts of high protein biomass during the dry season, multi-functionality, life span, and compatibility to the cropping system makes them suitable candidates for further development as feed resources [8]. Thus, there is an extreme need to evaluate the potential and feeding values of indigenous plants, so that they could be used in developing sustainable feeding standards.

Grawa (Vernonia amygdalina) is among multipurpose plants with drought tolerant nature and grows under a range of ecological zones in Africa and produces a lager mass of forage with good protein profile. The results of the study [9] in which substituting *Vernonia amygdalina* leaf meal for brewers' dried grains at 25% and 50% (w/w) show that *Vernonia amygdalina* has good nutrient profile to serve as soure of protein for growing ewes and could support growth performance suggesting further investigation on sole *Vernonia amygdalina* leaves feeding to small ruminants. The results reported [10] also show crude protein value of 223g/kg of DM for vernonia amygidalina leaf indicating the best replacement for costly concentrates. The results of the study [11] revealed that supplementation of *Vernonia amygdalina* have a positive effect on live weight gains of lambs and suggested for more research on higher level of inclusion on animal performances.

Consequently, this experiment was initiated with the objective of evaluating the effects of including graded level of dried vernonia amygdalina leave on carcass parameter of Somali goats fed Khat leftover.

2. Material and Methods

2.1. Describing the Study Area

The experiment was undertaken at Haramaya, located at east Hararghe zone at 515 km East of Addis Ababa. The area lies at a latitude of 9^{o} 20' North of equator and 42^{o} 03' longitude east of meridian with 1980 m.a.s.l altitude. From [12] reports, the area has a moderate average temperature of 16 ℃, with the mean maximum and minimum annual temperature of 24.02 and 9.73 ℃, respectively. The mean annual rainfall is 780 mm. Khat is well abundant in the area and its leftover covers the main portion of small ruminant feed mainly for barn feeding system.

2.2. Management of Experimental Animals and Feed Preparation

For the study, twenty four male goats with one year age with initial weight of 12.57± 0.59 kg (means ± SD) were purchased from the surrounding local markets of Jigjiga, Babile and Haramaya. The age was considered by dentition and information from the owners. Three weeks of quarantine period was allowed for experimental animals and then weighed and blocked into six blocks of four animals each, basing on their initial body weight. Experimental goats were then randomly assigned to treatments (Table 1) and were fenced individually. Leftover of khat leaves was provided, allowing 20% refusals so as to ensure every animal had *ad libtum* access letting water and mineral licks as free choice. Supplemental feed (*Vernonia amygdalina*) leaf was provided twice a day at 800 and 1600 hour dividing in to equal haves. Leftover of khat was collected from the khat exporting shop at awaday city; and the leaves of Girawa (*Vernonia amygdalina*) were collected from haramaya city surroundings. Both feeds were dried under shade by spreading on plastic sheet then kept for later use.

2.3. Experimental Design and Treatment

A randomized complete block design with four treatments was used to generate data on carcass parameter of the experimental animal. The initial body weight was used as base for blocking experimental animal into six blocks with four animals each. Treatment allocation is shown in the following table:

Table 1. *Experimental treatments.*

Treatments	**Experimental feed**	
	Basal diet	***Supplemental feed/Vernonia* g/d**
T_1	*ad libtum*	*100*

Treatments	Experimental feed	
	Basal diet	***Supplemental feed/Vernonia* g/d**
T_2	*ad libtum*	*200*
T_3	*ad libtum*	300
T_4	*ad libtum*	*400*

2.4. Carcass Parameters Evaluation

At the end of feeding trial, carcass parameters were analyzed. All experimental goats were slaughtered after deprived of feed and water for 12 hours. Immediately before slaughter, the animals were weighed (SBW). The animal was killed by cutting the throat and then slaughtered by severing the head. During slaughtering the blood was collected in a container and weighed. The weight of offal like liver with gall bladder, head, skin and feet, lungs and trachea, heart, spleen, testis, penis, kidneys, abdominal gut, reticulo-rumen, omasum-abomasum, large and small intestine was recorded. Empty body weight (EBW) of experimental animal was determined by deducting the gut content from the slaughter weight. Gut contents was determined by weighing the gut before and after emptying the gut contents. Dressing percentage animal was measured as the proportion of hot carcass weight to slaughter and empty body weights. Hot carcass weight was measured after removal of thoracic, abdominal and pelvic cavities, head, skin with feet and tail of the animal. Rib eye area was traced using plani-meter square paper after cutting the ribs between 12 and 13 ribs. The dressing percentage of the carcass was calculated by the following formula;

$$\text{Dressing percentage/SWB} = \frac{\text{Hot carcass weight}}{\text{Slaughter body weight}} \times 100$$

$$\text{Dressing percentage/EWB} = \frac{\text{Hot carcass weight}}{\text{Empty body weight}} \times 100$$

Where SWB = Slaughter weight basis
EWB = Empty weight basis

2.5. Analysis of Partial Budget

Partial budget analysis was determined to assess the profitability of the feeding regime. Variable cost partial budget was determined as a difference between the feed cost and selling price of goats or feed cost divided by live weight gain. Net income (NI) was calculated as the amount of money left when total variable cost (TVC) were subtracted from total returns (TR); NI = TR-TVC. The change in net income (ΔNI) was determined by calculating the difference between the change in total return (ΔTR) and the change in total variable costs (ΔTVC); ΔNI= ΔTR-ΔTVC. The marginal rate of return (MRR) measure the increase in net income (ΔNI) associated with each additional unit of expenditure (ΔTVC) and expressed in percentage as; MRR= (ΔNI) / (ΔTVC) × 100.

2.6. Statistical Analysis

SAS software package (SAS, 1998) was used for analysis of variance (ANOVA) and Least significant difference (LSD) test was used to separate the difference between treatments means. The following ANOVA model was used for the data analysis:

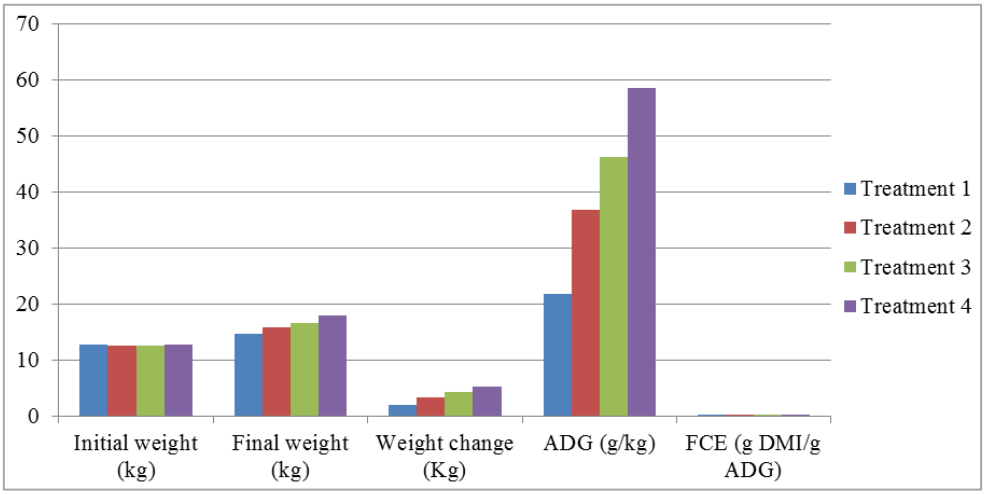
$$Y_{ij} = \mu + T_i + B_j + E_{ij}$$

Where;
Y_{ij} = Response variable
μ = Overall mean
T_i = Treatment effect
B_j = Block effect
E_{ij} = Random error

3. Results and Discussion

3.1. Live Weight Gain

The effect of including graded levels of dried *Vernonia amygdalina* leaf on weight changes and daily gain of experimental animals were shown in Figure 1. Though the initial body weight was similar among treatments (P>0.05), final body weight, body weight change and Average Daily Gain as well as Feed Conversion Efficiency was lowest for T_1 compared to other treatments. Final body weight and Feed Conversion Efficiency was increased with the increasing level of *Vernonia amygdalina*, whereas body change and Average Daily Gain was greater ($P < 0.05$) for T4 than T1 and T2 and values for T3 were statistically similar with T4 ($P > 0.05$).



ADG = average daily gain; FBW =final body weight; FCE = feed conversion efficiency; IBW = initial body weight

Figure 1. *Body weight gain of experimental goat khat leftover and graded level of supplemental feed.*

The increase in weight gain following the increments in level of supplementation for current study was agreed with the reports of [11] that reveal greater growth rates of lambs with higher levels of inclusion rate of fresh *vernonia amaygdalina* leaf. The reports of [9] also showed that there was a progressive effect on average weight gain and feed/gain ratio with higher supplementation. The reported BW gain of 13-40.7 g/day in Menz sheep fed teff straw and supplemented with multipurpose tree or their mixtures which [13] was more or less comparable to the current study. Furthermore, the reports of [14] (36- 53 g/d), for goats fed grass hay as a basal diet and supplemented with concentrate mixture of 200 g DM/d was also agree with the current study. Similarly, [15] reported average daily weight gain of 16.5-38.73 g/day for Somali goats supplemented with different levels of khat leftover to sorghum stover. On the other hand, average daily weight gain of 41-80 g/d of goats fed natural grass as a basal diet and supplemented with tree leaves reported by [16].

The trend in live weight change of goats over the experimental period is given in Figure 1. The weight gain of the experimental animals increased through time in all the treatments with more prominent increase for medium and highest level supplemented animals. Live weight change of goats over the experimental period showed similar trend with the total DM intake of goats from reports of [10].

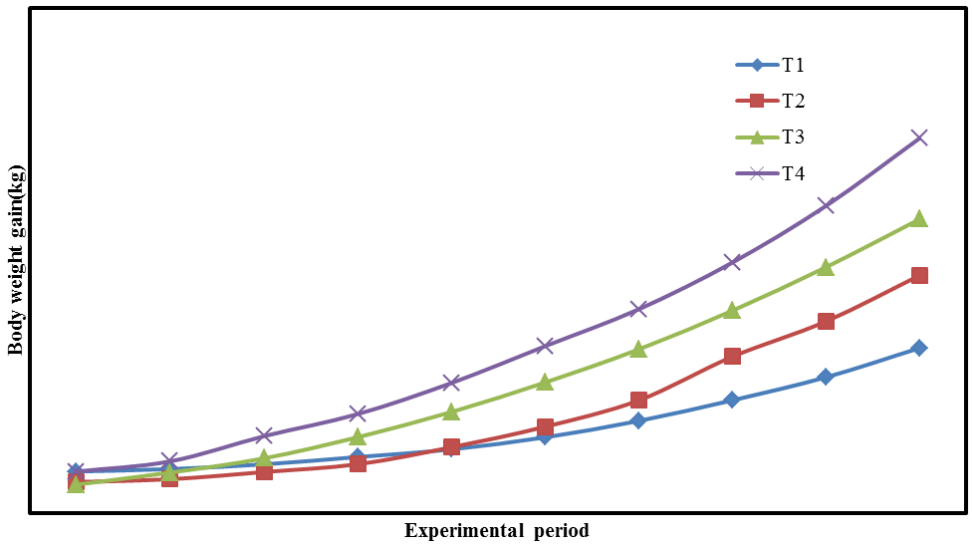


Figure 2. *Trends in body weight changes across the experimental period.*

T_1 = Basal diet +100g supplemental feed; T_2 = Basal diet +200g supplemental feed; T_3 = Basal diet +300g supplemental feed; T_4 = Basal diet +400g supplemental feed.

3.2. Carcass Parameter

Mean values of slaughter weight (SW), empty body weight (EBW), hot carcass weight (HCW), dressing percentage and rib-eye area (REA) of experimental animal are shown in Table 2. The mean slaughter weight was significantly (P< 0.05) different among treatments. It increased as the level of supplementation increases.

Table 2. *Carcass parameters of experimental goats fed khat leftover and different levels of supplemental feed.*

Parameter	Treatments				SEM
	T_1	T_2	T_3	T_4	
Slaughter wt (kg)	14.12^{c}	15.25^{bc}	16^{b}	17.21^{a}	0.27
1. Empty body wt (kg)	2. 11.55^{b}	3. 13.49^{b}	4. 13.89^{b}	5. 14.95^{a}	6. 0.28
7. Hot carcass wt (kg)	8. 5^{c}	9. 6^{bc}	10. 7^{b}	11. 8.25^{a}	12. 0.24
13. Dressing percentage (%)	14.	15.	16.	17.	18.
19. Slaughter BW basis	20. 35.71^{c}	21. 39.34^{b}	22. 43.19^{b}	23. 47.94^{a}	24. 1.04
25. Empty BW basis	26. 43.29^{b}	27. 44.48^{b}	28. 50.34^{b}	29. 55.18^{a}	30. 0.85
Rib-eye area (cm^2)	7.49^{b}	8.22^{b}	8.65^{b}	10.03^{a}	0.24

^{a,b,c}Means with different superscripts in rows are significantly different ($p<0.05$); BW = body weight SEM; standard error mean; T_1 = basal diet +100g supplemental feed; T_2 = Basal diet +200g supplemental feed; T_3 = Basal diet +300g supplemental feed; T_4 = Basal diet +400g supplemental feed.

There was a significant difference (P<0.05) between levels of supplementation in EBW and hot carcass weight (Figure 2). Slaughter weight and hot carcass weight in the present study was greater for higher level of supplementation (T4) than the others and values for T1 was lower, whereas T2 and T3 were statistically similar (P >0.05). Similarly, empty body weight was higher for high level of supplementation (T4), however there was no significant difference (P >0.05) among the rest groups.

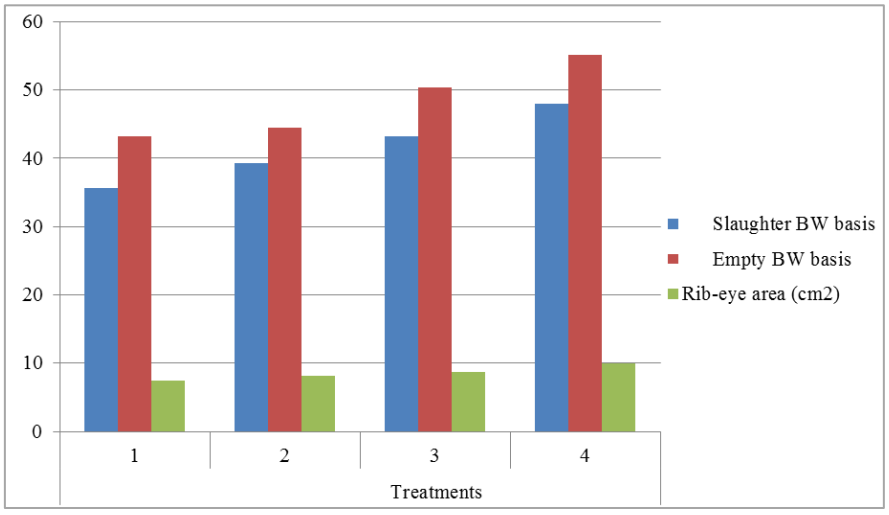


Figure 3. *Slaughter weight, empty body weight and hot carcass weight of experimental goats.*

Dressing percentage on slaughter and empty BW weight basis and rib-eye muscle area were greater for the highest level of supplemented goats compared to other treatments, which illustrated that supplementation had a progressive effect on dressing percentage and rib-eye muscle area.

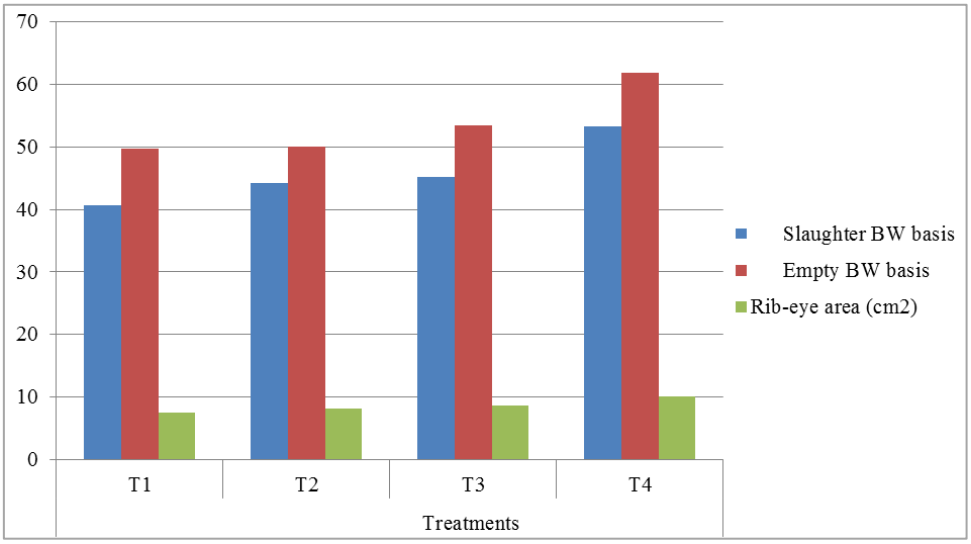


Figure 4. *Dressing percentage on slaughter and empty body weight basis and rib-eye muscle area.*

Lack of significance difference in dressing percentage between T2 and T3 in the present study even if they have significance difference in average daily gain may be due to variation of gut content. There was reports that indicate ingesta constitute a significant portion of the body weight even if the animals might be fasted long hours [17]. Dressing percentage observed in current study was agreed with the results reported on fattening Ethiopian sheep [18] and [19]. Also reports of the study [20], reveals the highest dressing percentage in supplemented goats as compared to those fed hay alone. The observed low dressing percentage on slaughter body weight in low level supplemented goats might be related to high gut fill that reduced the dressing percentage. Moreover, supplementation showed relatively higher eye muscle area, which is a reflection of an increase of lean.

3.3. None Carcass Offals

Non-carcass components of experimental goats fed khat leftover and supplemented with graded levels of dried *Vernonia amygdalina* leaf are presented in tables 3 and 4. Total non-edible offal was lower for T1 and similar among other treatments. Weight of Abdominal fat, heart, liver, small and large intestine, omasum-abomasum, reticulo-rumen and skin recorded in this study were significantly varied ($P<0.05$) among higher level supplemented goats. The increase in liver weight with increasing supplementation level might be comes from the storage of reserve substances such as glycogen as described by [21].

Table 3. *The weight of edible offal of experimental goat fed khat leftover and with graded level of supplemental feed.*

Parameters	**Treatments**				**SEM**
	T_1	**T_2**	**T_3**	**T_4**	
Blood	458.33^{b}	543.17^{a}	500.17^{a}	517.33^{a}	10.30
31. Heart	32. 90.50^{b}	33. 120.83^{b}	34. 137.50^{a}	35. 113.33^{b}	36. 3.17
37. Head	38. 923.33	39. 1005.83	40. 1004.17	41. 1005.83	42. 12.64
43. Liver	44. 242.50^{b}	45. 274.17^{ab}	46. 282.50^{b}	47. 296.67^{a}	48. 6.28
49. Kidney	50. 171.67	51. 166.67	52. 158.33	53. 169.17	54. 2.42
55. Kidney fat	56. 133.83^{b}	57. 135.83^{b}	58. 116.67^{c}	59. 162.83^{a}	60. 3.86
61. Reticulo-Rumen	62. 431.67^{bc}	63. 418.33^{c}	64. 467.50^{a}	65. 452.50^{ab}	66. 5.13
67. Omasum–Abomasums	68. 256.67^{a}	69. 235.83^{b}	70. 285.00^{a}	71. 238.33^{b}	72. 4.69
73. Small and Large intestine	74. 375.00^{c}	75. 393.33^{bc}	76. 418.33^{a}	77. 403.33^{b}	78. 4.21
79. Genital fat	80. 75.83	81. 79.17	82. 77.50	83. 70.83	84. 1.27

Parameters	Treatments				SEM
	T_1	T_2	T_3	T_4	
85. Abdominal fat	86. 260.00^{ab}	87. 265.83^{a}	88. 233.33^{c}	89. 245.83^{bc}	90. 3.22
91. Tests	92. 151.67^{b}	93. 190.83^{a}	94. 176.67^{a}	95. 189.17^{a}	96. 3.85
97. Tongue	98. 56.67	99. 54.83	100. 68.33	101. 68.33	102. 1.57
Total edible offal	3627.67^{b}	3884.67^{ab}	3926.00^{a}	3933.50^{a}	31.83

^{a,b,c}Means with different superscripts in rows are significantly different SEM =standard error mean; T_1 = basal diet +100g supplemental feed; T_2 = Basal diet +200g supplemental feed; T_3 = Basal diet +300g supplemental feed; T_4 = Basal diet +400g supplemental feed.

The reports on dietary energy intakes and protein concentration on intakes and visceral organ mass lambs show that high protein diets of the calculated National Research Council requirements resulted in greater weights of internal organs like small intestine, kidney and liver compared to normal protein diets in lambs [22]. But there was not significant differences in head, genital fat, bladder, spleen and lungs and trachea and penis with varying levels of supplemental feed. The similar results reported with the current study for goats results on different diets that had no significant effect on most of the non-edible offal components [23]. Similarly, there was reports[24]that the weights of bone rich offal components and/ or with a low metabolic activity (head, feet and lungs) varied slightly in diet, indicating that these organs are early maturing parts less affected by diet in growing animals. Moreover, in the current study the value of total non-edible offal component was significantly different and was lowest (p>0.05) for groups supplemented with the lowest level of supplementation.

Table 4. *The weight of non-edible offals of experimental goat fed khat leftover and supplemented with graded level of supplemental feed.*

Treatments					
Non-edible offal	**T_1**	**T_2**	**T_3**	**T_4**	**SEM**
Skin with feet	1230.67^{c}	1281.83^{bc}	1350.00^{b}	1280.00^{a}	17.88
Lungs and trachea	228.33	217.50	231.67	220.82	2.55
Spleen	48.33	46.17	52.50	50.83	0.77
Penis	49.33	47.50	52.67	51.32	0.63
Bladder	57.50	56.00	60.50	58.33	0.64
Gut content	2486.64^{b}	2410.8^{a}	2212.2^{a}	2126.7^{a}	96.14
Total non-edible offal	4100.80^{b}	4059.80^{a}	3859.54^{a}	3788.00^{a}	96.88

^{a,b,c}Means with different superscripts in rows are significantly different (p >0.05); SEM = standard error mean; T_1 = basal diet +100g supplemental feed; T_2 = Basal diet +200g supplemental feed; T_3 = Basal diet +300g supplemental feed; T_4 = Basal diet +400g supplemental feed.

3.4 Partial Budget Analysis

The analysis for partial budget was conducted to assess the economic profit for overall feeding trial. According to partial budget analysis, total return increased with the increasing level of supplementation quantitatively, 650, 1250, 1538, and 2702 respectively (Table 5). Goats supplemented with higher level of *Vernonia amygdalina* leaf (T4) had higher net income followed by T_3 and T2.

The present result suggested that increasing level of supplementation was potentially more profitable than lower level of supplementation. The higher returns seen as a following increment in the level of supplementation in the current result was attributed to the higher growth rates and final BW of higher level supplemented goats than that lower level supplementation. Therefore, according to the results of

current study, diets with the highest proportion of *Vernonia amygdalina* leave could be recommended based on animal performance responses and economic feedback.

Table 5. *Partial budget analysis of experimental animals fed basal diet and with graded level of supplemental feed.*

Variables	Treatments			
	T_1	T_2	T_3	T_4
Purchasing price of goats (ETB/head)	2800.00	2800.00	2800.00	2800.00
Cost for khat leftover (ETB/goat)	504	478.8	340.2	296
Cost for suppl. (ETB/Goat)	180	360	540	720
Total feed cost /TVC (ETB)	684	838.8	880.2	1080
Gross income (sell price)	3450	4050	4338	5502
TR (ETB)	650	1250	1538	2702
NI (ETB)	-34	411.2	654	1626
ΔNI (ETB)	0.00	445.2	691.8	1656
ΔVC(ETB)	0.00	154.8	196.2	396
MRR (ΔNI /ΔVC)	0.00	2.9	3.5	4.2

ETB = Ethiopian Birr; MRR = marginal rate of return; Suppl. = supplement; TVC = total variable cost; TR = total return; NI =Net income; △NI = change in net income; ΔVC = change in variable cost; T_2 = Basal diet +200g supplemental feed; T_3 = Basal diet +300g supplemental feed; T_4 = Basal diet +400g supplemental feed.

4. Conclusions

The current study showed that supplementation of graded level of dried *Vernonia amygdalina* leaf have positive progressive on live weight gain and carcass parameters of Somali goats fed khat leftover as basal diet. Hot carcass weights, dressing percentage on SW basis and rib-eye muscle area were generally greater for the high level supplemented group as compared to the lower level of supplementation, which clearly illustrate that, supplementation had a positive effect on hot carcass, dressing percentage (slaughter weight basis) and rib-eye muscle area. Goats supplemented with 400g (T_4) had the highest net income (1626 ETB) as well as the highest marginal ret of (4.1 ETB*)* whereas goats with lowest level of supplementation showed loss34 ETB per animal. *Venonia amygdalina* have a potential to supplement animals fed low quality roughage with no adverse effects on animal performance up to 400gDM/day inclusion and was found to be economical for small holder farmer, thus is recommended to be used as an alternative supplement fibrous diets.

Abbreviations

ADG Average daily gain
EBW Empty Body Weight
ETB Ethiopian Birr
FBW Final body weight
FCE Feed conversion efficiency
HCW Hot Carcass weight
IBW Initial body weight
SBW Slaughter Body Weight

Conflicts of Interest

The author declares no conflicts of Interest**.**

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