
Effect of concentrate supplementation on performances of Ethiopian lowland afar and blackhead Ogaden lambs

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Abstract: The study was conducted to evaluate the effect of increased concentrate supplementation on nutrient intake, growth performance, carcass characteristics, duration of feeding and profitability of Ethiopian Afar and Blackhead Ogaden (BHO) lambs. Forty-eight lambs (24/breed) initially weighing 17.84 ± 1.6 kg were randomly assigned to three dietary treatments (T) in Complete Randomized Design. Each lamb was fed on tef straw *ad libitum* and supplemented with 150, 300, 450 g d⁻¹ of concentrate (containing 19.4% crude protein (CP) and 11.28 MJ ME kg⁻¹DM) in T1, T2 and T3, respectively. Intake and growth trial lasted for 126 days, followed by digestibility trial of 7 days. Dry matter (DM) intake increased ($p < 0.0001$) with increasing concentrate offer in lambs in general, but higher ($p < 0.05$) in Afar than in BHO lambs. Intake of CP peaked at the highest level of supplementation. Increased ($p < 0.0001$) digestibility of DM, CP, neutral detergent fiber (NDF) and acid detergent fiber (ADF) were noted at higher concentrate offer in Afar lambs. Average daily gain of lambs increased ($p < 0.0001$) with increased concentrate, and lambs reached the target weight (25-30kg) for export market relatively within short period of feeding at higher than lower level of concentrate supplementation. Given equal level of concentrate, Afar lambs reached the target weight in less days of feeding than BHO lambs. Increasing concentrate has resulted in increased slaughter weight (SW), hot carcass weight (HCW), dressing percent (DP) and lean-to-fat ratio (LFR) in Afar lambs, while it improved SW, HCW and DP in BHO lambs. This study indicated that increased meat production measured in terms of live weight change and carcass yield in Afar and BHO lambs can be achieved at high concentrate supplementation with profit.

Keywords: Concentrate, Intake, Lambs, Live Weight, Tef Straw

1. Introduction

Although there exist 25.97 million sheep population in Ethiopia [1] the production and productivity is very low [2], as expressed by annual population growth rate of 1% and off-take rate of 35%. The average daily growth rate of indigenous meat sheep is 50 g, while the average carcass yield is 10 kg per animal.

The low performance of local sheep in terms of live weight (BW) gain and carcass yield is mainly due to inadequate nutrition [3] associated with reliance on sole natural pasture, crop residues and/or stubble grazing, which are inherently low in nutrients available being subjected to great seasonal variations[4]. Temporally abundance of forage during short rainy season is followed by long dry periods with feed deficit leading to a cycle of live weight gain and loss of animals. Thus, sheep often takes longer period to attain market weight, lowering its production efficiency. The

present export market (to the Middle East countries) for Ethiopian live sheep and mutton is demanding animals of low land origin, weighing between 25 and 30 kg at yearling age. However, most local lambs slaughtered at this age weigh 18 to 20 kg [5]. Thus, lack of consistent supply of the required animals at younger age has remained a major challenge for mutton and live sheep exporters. Therefore, this study was aimed to evaluate the effect of increased concentrate supplementation on nutrient intake, growth performance, carcass characteristics, duration of feeding and economic benefit of yearling Afar and BHO lambs.

2. Materials and Methods

2.1. Study Site

This experiment was conducted on sheep research station of Debre Zeit Agricultural Research Center, Ethiopia, located at 45 km South East of Addis Ababa, at an altitude of 1900 meter

above sea level (between 8.44°N latitude and 39.02°E longitude). The average maximum and minimum temperature and annual rainfall of the research station were 24.3°C, 8.9°C and 851mm, respectively.

2.2. Animals and Feeding Management

Forty-eight yearling male Afar and Blackhead Ogaden lambs (24/breed) were purchased from local market. All animals were ear-tagged, vaccinated against Sheep pox, Anthrax and Ovine pasteurellosis and treated against ecto- and endo-parasites. After adaptation period of 15 days to the environment, pen management and diets, animals of the respective breed (overall mean live weight=17.84±1.6 kg) were randomly allotted to three dietary treatments (8 lambs per treatment), in Complete Randomized design. All animals were individually penned and fed tef straw *ad libitum* and daily supplemented with 150 g (T1), 300 g (T2) and 450 g (T3) of concentrate, twice daily at 9:00 and 2:00. The concentrate mix, on DM base, was composed of 29% wheat bran, 14% wheat middling, 7% maize grain, 49% noug seed (*Guizotia abyssinica*) cake and 1% common salt, containing 19.4% CP and 11.28 MJ ME kg⁻¹DM. Clean water was freely available for each animal.

Table 1. Chemical composition of experimental feed ingredients (g kg⁻¹DM)

	DM	CP	ASH	NDF	ADF	ADL
Tef straw	927	44	109	777	449	50
Maize grain	905	92	22	158	34	0.8
Noug seed cake	916	301	119	365	286	110
Wheat bran	915	140	48	463	95	0.6
Wheat- middling	899	155	50	445	94	21
Salt	970	-	-	-	-	-
Concentrate	906	190	85	375	194	80

Where, DM=Dry Matter; CP = Crude Protein; NDF= Neutral Detergent Fiber; ADF= Acid Detergent Fiber; ADL= Acid Detergent Lignin

Intake and growth trial was undertaken for 126 days. Daily feed offered and refusal were measured and recorded for each animal to determine intake by finding the difference between amount offered and refusal. Samples of feed offered and left over were taken daily and sub-sampled every 15 days for each animal. The live weight of lambs was taken once fortnightly after 16 hour of feed deprivation. At the end of feeding trial, three animals were randomly selected per treatment and transferred to metabolic crate to undertake digestibility trial. Lambs were adapted to fecal bags tied to them for three days followed by data collection for seven days. As true for intake and growth trial, data on feed consumption was taken for each animal. The daily fecal output was measured for each animal, of which 10% was sampled and placed in deep freezer (-21°C) pending chemical analysis. Besides, three animals were selected per treatment, fastened for 12 hours, weighed and slaughtered

for carcass analysis. The carcass was chilled at 4°C for 24 hours followed by deboning it into tissue components. Data on slaughter weight, hot carcass weight, lean meat weight, fat weight and bone weight were taken for each slaughtered animal. Dressing percentage (DP) was calculated as:

$$DP = (HCW/SW)*100.$$

2.3. Sample Analysis

Feeds and fecal samples were analyzed for Dry Matter (DM), Ash, Crude Protein (CP) using the standard procedures[6] and also Acid Detergent Fiber (ADF), Neutral Detergent Fiber (NDF) and Acid Detergent Lignin (ADL) were determined [7].

2.4. Statistics Analysis

Data on feed intake, live weight change, digestibility, feed conversion ratio (g DMI g⁻¹ gain) and carcass parameters were analyzed using the General Linear Models (GLM) procedure of SAS[8] by mathematical model that included the effects of breed, diet and interaction effect of diet and breed. Data on live weight gain of an experimental lamb was computed by finding the difference of the two weighing periods and regressing it over the number of days elapsed. Whenever GLM declares significance, treatment means were separated using LSD. The model used was:

$$Y = \mu + a_i + b_j + (ab)_{ij} + e_{ijk}$$

Where, Y = response variables (Intake, live weight change, digestibility, FCR, carcass parameters); μ = overall mean, a_i = effect of i^{th} diet, b_j = effect of j^{th} breed, $(ab)_{ij}$ = effect of interaction $a*b$ and e_{ijk} = random variation

2.5. Cost-Benefit Analysis

Cost-benefit analysis was done to compare the relative economic importance of the diets. Cost of all variable inputs and buying and selling prices of lambs were recorded to determine the net income of production. The sale value of each finished lamb was estimated at local market bargaining price by averaging estimates of three local sheep traders, while the market values of lambs at export abattoirs were estimated based on the final live weight of lambs. Monetary values of all other variable inputs were considered at the prevailing market price.

3. Results and Discussion

3.1. Nutrient Intake

There was a significant increase ($p < 0.0001$) in total DMI of lambs, while intake of straw reduced ($P < 0.01$) with increase in the concentrate level (Table 2). Total DMI intake was higher ($p = 0.025$) in Afar lambs compared to BHO lambs. Previous studies [9-11] done on Ethiopian highland and lowland Afar and BHO lambs have shown increased feed DM intake as the amount of concentrate increased. It was also reported a decrease in hay intake and an increase in total

DM and CP intake in growing Somali goats with increased amount of peanut cake and wheat bran mixture [3]. However, non-significant ($p>0.05$) increase in DM intake with an increase in concentrate level was reported in Afar rams fed on tef straw [12], and Washera lambs fed on urea treated rice straw [13]. Contrary to the present result, decreased DMI in fat-tailed Chall lambs was noted with increased concentrate part of a ration [14]. In the present study, increased intake of dietary CP ($p<0.0001$) was noted with increased concentrate

level, while intake of NDF ($p=0.1682$) and ADF ($p=0.2882$) reduced. This could be due to the reduction ($p<0.01$) in the straw intake inherently low in protein, but high in fiber fractions. In this study, no interaction effect ($p>0.05$) of breed and diet was observed in nutrient consumption. The increased in DM intake of lambs at higher level of concentrate could be linked to the fact that energy requirements of lambs were met. Animals consume feed mainly to satisfy their desire for energy [7].

Table 2. Nutrient intake of experimental animals (g per lamb d⁻¹)

		DM		CP		NDF		ADF	
		Straw	Total	Straw	Total	Straw	Total	Straw	Total
Diet	T1	466.7a	602.6c	21.3a	47.2c	361.9a	412.8	208.5a	234.9
	T2	422.3ab	694.1b	18.8b	70.5b	329.5ab	431.4	189.9ab	242.7
	T3	383.5b	789.4a	17.1b	94.2a	298.8b	451.0	174.5b	253.2
	SEM	18.03	18.03	0.8	0.8	14.49	14	8.37	8.08
Afar	T1	486.6a	622.5c	22.3a	48.2c	377.2a	428.1b	217.0a	243.4b
	T2	438.8ab	710.6b	19.3b	71.0b	344.5ab	446.4ab	200.2ab	252.9ab
	T3	417.6b	824.0a	18.5b	95.7a	326.1b	478.5a	189.4b	268.2a
	SEM	18.59	18.59	0.84	1.13	14.42	14.42	8.3	8.3
BHO	T1	446.8a	582.7b	20.3a	46.2c	346.6a	397.7	199.9	226.3
	T2	405.8ab	677.6a	18.4ab	70.0b	314.4ab	416.4	179.6	232.4
	T3	349.4b	754.7a	15.8b	92.8a	271.5b	423.4	159.6	238.2
	SEM	31.12	31.12	1.37	1.37	24.18	24.18	13.97	13.97
Mean	Afar	447.7a	719.1a	20.0a	71.6a	349.2a	451.0a	202.2a	254.9a
	BHO	400.7b	671.7b	18.2b	69.7b	310.8b	412.5b	179.7b	232.3b
Effect, p-value	SEM	14.72	14.72	0.65	0.65	11.43	11.43	6.6	6.6
	Diet	0.0061	<.0001	0.0013	<.0001	0.0078	0.1682	0.0142	0.2882
	Breed	0.0262	0.025	0.0453	0.0381	0.0194	0.0189	0.0178	0.0174
	Diet*Breed	0.7737	0.760	0.7353	0.685	0.7857	0.779	0.8539	0.8489

Means in the same column with different letters are different ($P<0.05$); SEM=standard error of mean; T1=Tef straw +150 g per lamb d⁻¹ concentrate; T2=Tef straw + 300 g per lamb d⁻¹ concentrate; T3=Tef straw + 450 g per lamb d⁻¹ concentrate.

3.2. Apparent Digestibility

Table 3. Apparent digestibility values (g kg⁻¹DM) of nutrients in lambs fed experimental diets.

	Treat.	DM	CP	NDF	ADF
Diet	T1	589.2b	426.3c	580.5	507.7
	T2	619.8ab	592.6b	559.9	475.9
	T3	665.2a	704.3a	593.9	515.9
	SEM	16.9	19.0	19.0	23.0
Afar	T1	537.2b	380.7b	526.1b	442.8b
	T2	654.5a	652.6a	596.7ab	520.8ab
	T3	683.4a	711.8a	628.9a	547.3a
	SEM	23.0	22.9	27.9	33.8
BH	T1	641.2	472.0b	634.9a	572.5a
	T2	585.1	532.6b	523.1b	430.9b
	T3	647.0	696.8a	558.9ab	484.4ab
	SEM	24.3	30.3	27.8	32.8
Mean	Afar	625.1	581.7	583.9	503.7
	BHO	624.5	567.2	572.3	495.9
Sig.	Diet	*	***	NS	NS
	Breed	NS	NS	NS	NS
	Diet x Breed	**	**	*	*

Means in the same column with different letters are statistically different ($P<0.05$); SEM=standard error of mean; Sig.=significance; NS=not significant; *= $p<0.01$; **= $p<0.001$; ***= $p<0.0001$

Table 3 presents the apparent digestibility values of nutrients. Dry matter digestibility was improved ($p<0.01$) by

13% (589 vs. 665 g kg⁻¹DM) in lambs in general, and by 27% (537 vs. 683 g kg⁻¹ DM) in Afar lambs, implying increased feed utilization efficiency at higher concentrate supplementation. Similarly, the digestibility values of CP, NDF and ADF were increased significantly ($p<0.001$) with increased concentrate in Afar lambs. Earlier studies [12] on Afar lambs fed tef straw at various concentrate level (150-350 g per lamb d⁻¹) has shown comparable DM digestibility (670-680 g kg⁻¹DM), but higher in digestibility of CP (720-830 g kg⁻¹DM), NDF (610-680 g kg⁻¹DM) and ADF (560-650 g kg⁻¹DM) than the present results. Moreover, there was no significant difference ($p>0.05$) between the Afar and BHO lambs in nutrient digestibility.

3.3. Live Weight Change, Feed Conversion Ratio (FCR)

The live weight change and FCR were indicated in Table 4. The final live weights of lambs increased ($p<0.0001$) with increased concentrate level, and within the range of 25 to 30kg currently required by export market. The ADG of lambs was highest ($p<0.0001$) at the highest concentrate offer, increasing from 36.95 to 79.36 g d⁻¹ in Afar lambs and from 33.48 to 65.19 g d⁻¹ in black head Ogaden lambs. However, supplementation beyond 300 g per day for BHO lamb did not improve growth remarkably ($p>0.05$), which may not be economical. Although non-significant ($p=0.1455$), Afar lambs gained relatively better live weight than BHO lambs.

Moreover, Afar lambs reached the minimum live weight in demand (25 kg) for export market at about 70 days of feeding compared to BHO lambs that took 112 days. Afar rams maintained on tef straw and supplemented 250 g d⁻¹ of concentrate with CP and ME content comparable to the present diet gained 67.1 g d⁻¹ of live weight, but reduced to 63 g d⁻¹ at 350 g d⁻¹ concentrate feeding [12]. Moreover, it was reported that intact Afar rams fed on urea treated tef straw supplemented with wheat bran achieved ADG of 65.6 g [11]. The present increase in the growth of lambs could

be attributed to substantial improvement in feed DM intake, digestibility and feed conversion ratios. As shown in the growth curve (figure1), lambs appeared to approach market weight in shorter feeding period at higher than lower concentrate feeding. Feed conversion ratios increased in all lambs (pooled) (p=0.0005), in Afar lambs (p=0.0313) and BHO lambs (p=0.0022) with increased concentrate level. This study further indicated that high amount of protein and energy-rich concentrate is important to achieve better performances of Afar and BHO lambs.

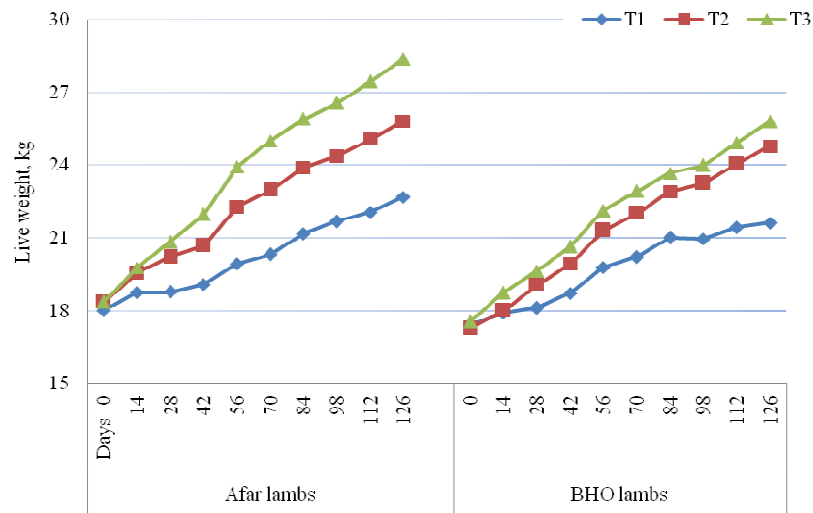


Figure 1. Trend in the liveweight of lambs during growth trial

Table 4. Live weight change and feed conversion ratios of experimental lambs

		Initial(kg)	Final(kg)	LWC(kg)	ADG(g)	DMI(g d ⁻¹)	FCR(g DMI g ⁻¹ gain)
Diet	T1	17.71	22.15c	4.43c	35.22c	602.6 ^c	17.11b
	T2	17.82	25.29b	7.46b	59.27b	694.1 ^b	11.71a
	T3	17.97	27.08a	9.10a	72.27a	789.4 ^a	10.92a
	SEM	0.41	0.51	0.41	3.29	18.03	1.7
	P-value	0.9113	<.0001	<.0001	<.0001	<.0001	0.0005
Afar	T1	18.03	22.68c	4.65c	36.95c	622.5c	16.85b
	T2	18.37	25.81b	7.43b	59.03b	710.6b	12.04a
	T3	18.37	28.37a	10.00a	79.36a	824.0a	10.38a
	SEM	0.5	0.67	0.64	5.09	18.59	3.043
	P-value	0.8554	<.0001	<.0001	<.0001	<.0001	0.0313
BHO	T1	17.4	21.62b	4.21b	33.48b	582.7b	17.40b
	T2	17.28	24.78a	7.50a	59.50a	677.6a	11.39a
	T3	17.57	25.78a	8.21a	65.19a	754.7a	11.58a
	SEM	0.65	0.78	0.52	4.15	31.12	1.49
	P-value	0.9552	0.0043	<.0001	<.0001	0.001	0.0022
Mean	Afar	18.26	25.62a	7.36	58.44	719.1a	12.3
	BHO	17.41	24.06b	6.64	52.73	671.7b	12.74
	sem	0.33	0.42	0.33	2.69	14.72	1.42
	p-value	0.0871	0.0138	0.1455	0.1455	0.025	0.7128

Where, Means in the same column with different letters are statistically different (p<0.05); sem=standard error of mean; LWC= Live Weight Change; d=day; T1=Tef straw + 150 g per lamb d⁻¹ concentrate; T2=Tef straw + 300 g per lamb d⁻¹ concentrate; T3=Tef straw + 450 g per lamb d⁻¹ concentrate; BHO= Blackhead ogaden lambs

3.4. Carcass Parameters

Results of carcass analysis are shown in Table 5. Disregarding breed difference, an increase in the level of

concentrate improved SW (p=0.0003) of lambs by about 29% (19.5 vs. 25.2 kg), HCW (p<.0001) by 50% (7.6 vs. 11.4 kg), DP (p<.0001) by 16.8% (38.7 vs. 45.2kg) and lean-to-bone ratio by 47.4% (1.9 vs. 2.8). Increasing

concentrate feeding in Afar lambs increased SW from 20.7 to 26.2 kg, HCW from 8.5 to 12 kg, DP from 41 to 45.8 and LFR from 2.2 to 2.4. Moreover, higher level of concentrate increased the SW, HCW and DP in both breeds. Similarly, higher concentrate feeding increased HCW and DP of Afar lambs [9], whereas, increased SW and HCW, but unimproved DP were reported for growing Afar lambs supplemented up to 350 g d⁻¹ of wheat bran, noug seed (*Guizotia abyssinica*) cake and sesame seed cake mixture [12]. Also, it was [13] reported that improved SW, but no change in HCW and DP of Washera lambs fed urea treated rice straw and supplemented up to 400 g d⁻¹ concentrate. In present study, higher concentrate level did not affect LFR in overall lambs and in BHO lambs, but increased ($p<0.05$) LFR in Afar lambs. However, increasing the slaughter weight of BHO lambs from 18.3 (T1) to 24.1kg (T3) changed LFR from 2.1 to 1.6 indicating favored fat tissue accretion. Diet had a significant effect ($p=0.0173$) on lean-to-bone ratio of lambs. In general, the response of Afar lambs to SW, HCW, DP, LFR and LBR was higher than that observed for BHO lambs. The observed increase in SW, DP and HCW upon increasing concentrate feeding suggest an increase in the available nutrient for absorption and/or improved feed utilization efficiency. Supporting the present work, increasing concentrate portion of a ration have been reported to improve the carcass traits of lambs [14-16].

Table 5. Carcass parameters of lambs fed test diets

	Treat	SW	HCW	DP	LFR	LBR
Diet	T1	19.5b	7.6b	38.7b	2.2	1.9b
	T2	24.0a	10.7a	44.4a	1.7	2.8a
	T3	25.2a	11.4a	45.2a	2.0	2.7a
	sem	0.71	0.34	0.69	2.00	0.20
Afar lambs	T1	20.7b	8.5b	40.9b	2.2ab	1.9
	T2	24.9a	11.5a	46.0a	1.6b	3.0
	T3	26.2a	12.0a	45.8a	2.4a	2.7
	sem	1.06	0.49	0.53	0.20	0.35
BHO lambs	T1	18.3b	6.7b	36.4b	2.1	1.9b
	T2	23.1a	9.9a	42.8a	1.8	2.6a
	T3	24.1a	10.8a	44.7a	1.6	2.7a
	SEM	0.95	0.48	1.27	0.21	0.20
Mean	Afar	23.9a	10.6a	44.2a	2.1	2.5
	BHO	21.8b	9.1b	41.3b	1.9	2.4
	Diet	0.0003	<.0001	<.0001	0.1342	0.0173
P-value	Breed	0.0257	0.0023	0.0031	0.2605	0.6100
	Diet x Breed	0.9696	0.8499	0.2543	0.0613	0.8074

Where, Means in the same column with different letters are statistically different ($P<0.05$); sem =standard error of mean; SW=Slaughter weight ;HCW=hot carcass weight; DP(Dressing%) =(HCW/SW)*100; LFR=lean-to-fat ratio; LBR= lean-to-bone ratio; T=Tef straw+150 g per lamb d⁻¹ concentrate;T2=Tef straw+300 g per lamb d⁻¹ concentrate; T3=Tef straw+450 g/lamb d⁻¹ concentrate.

Table 6. Cost-profit analysis of the diets fed to lambs (ETB/lamb)

	Afar lambs			BHO lambs		
	T1	T2	T3	T1	T2	T3
Variables	n=8	n=8	n=8	n=8	n=8	n=7
Input costs						
Straw	83	75	72	77	70	60
Concentrate	37	75	112	37	75	111
Feed cost	121	150	183	114	144	171
Lambs	271	276	276	261	259	264
Labour cost	63	63	63	63	63	63
Vet.service	5	5	5	5	5	5
Transport fee	17	17	17	17	17	17
Total cost (1)	476	510	544	460	488	520
Income variables						
*Sale at export abattoir(2)	543	617	679	517	593	617
Net return 1(2-1)	67	107	135	58	105	97
Net return over T1	-	40	68	-	47	40
Sale at Gate(3)	588	694	746	514	604	660
Net return 2(3-1)	112	184	203	54	116	140
Net return over T1	-	72	91	-	62	86

*estimated at 23 birr kg⁻¹ live weight. Market values of feed ingredients (ETB kg⁻¹): Wheat bran=1.76; Wheat middling=2; Noug seed cake=3; Maize grain=2.30; Salt=0.90); ETB (Ethiopian birr), 18 ETB =1 USD; N= number of lambs.

3.5. Cost-Benefit Analysis

With increased level of concentrate, feed cost increased from 120 to 183 ETB in Afar lamb and from 114 to 171 ETB in BHO lambs (Table 6). The total cost of production (considering all variable costs) in Afar lamb elevated from 476 (T1) to 544 (T2) and from 460(T1) to 519(T2) ETB in BHO lamb, which was mainly contributed by high cost of concentrate and its increased consumption. The net return from sale of lambs at bargaining price of export abattoirs, was positive and increased with increasing concentrate level. Similarly, selling at local market indicated a positive net return per lamb, and increased along with increasing concentrate. This could be due to improved growth and body condition of lambs, favoring their sale values, which was well reflected in Afar lambs than in BHO lambs. Generally, the highest reduction in cost of production was achieved on days lambs attained minimum target weight for marketing. Under the present feeding regime, relatively Afar lambs appeared to grow faster than BHO lambs and profitable at lower cost of feeding.

4. Conclusion

Up-grading yearling Afar and BHO lambs to meet the export market demand was achieved with the present feeding regimes. Supplementation of up to 450 and 300 g d⁻¹ of concentrate containing 19.4% CP and 11.28 MJ ME kg⁻¹ DM appeared optimal to finish yearling Afar and BHO lambs, respectively. This study has indicated that meat production in terms of live weight change and carcass yield from Afar and BHO lambs can be considerably improved with economic benefit at higher than lower concentrate supplementation.

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