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Effects of Feeding Regime on Intake, Nutrient Utilization, Body Weight Gain and Carcass Traits of Blackhead Ogaden Lambs

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Abstract: A study was conducted with the objective to determine the effects of four feeding regimes on growth and subsequent finishing performance of Blackhead Ogaden (BHO) sheep. Twenty four lambs with mean initial body weight of 17.3±0.52 kg were blocked into four groups of six lambs based on weight. Lambs in each block were randomly assigned to one of the four dietary treatments. During the growth phase, natural grass hay was offered *ad libitum* and a mixture of *Acacia albida* and Cactus pear (*Opuntia ficus-indica*) at the ratio of 2:1, respectively. Acacia- cactus mixture (ACM) was supplemented at the rate of 0.9% (0.9ACM), 1.2% (1.2ACM) and 1.5% (1.5ACM) of lambs body weight. Lambs in control treatment (0ACM) did not receive the supplement. During the finishing phase, roughage composed of natural grass hay and haricot bean hauls at 50:50 ratio and concentrate supplement composed of 69% wheat bran and 31% oil seed meals (Noug and cottonseed cakes at the ratio of 1.1:1) were fed at roughage (R) to concentrate (C) ratios of 60R:40C, 50R:50C, 40R:60C and 30R:70C. The percentage of roughage and concentrate were determined based on ad libitum consumption of individual animal on dry matter (DM) basis. The two feeds were offered to the animals into separate feeding trough. Each of the two feeding regimes lasted for a period of 90 days of feeding and 7 days of digestibility trials. At the end of the finishing phase, all animals were slaughtered for carcass evaluation. Intake of DM and crude protein (CP) was significantly higher ($P<0.05$) for 1.5ACM and 30R:70C than the rest treatment groups during the growth phase and for the overall mean, respectively. Only CP intake showed statistical difference during the finishing phase and was followed a similar trend like that during growth phase. In both phases, treatments did not impact ($P>0.05$) apparent digestibility of nutrients, except CP digestibility, which was higher ($P<0.05$) in 1.5ACM than 0.9ACM and 1.2ACM; for 40R:60C than 60R:40C and 1.5ACM:30R:70C; and 1.2ACM:40R:60C than 0ACM:60R:40C during the growth and the finishing phases and for the overall mean, respectively. Body weight change (BWC), final body weight (FBW) and feed conversion efficiency (FCE) during the growth phase were greater ($P<0.05$) for the supplemented groups than the non-supplemented ones. Among the supplemented groups, 1.5ACM has shown greater ($P<0.05$) performance for these parameters than 0.9ACM, but was similar ($P>0.05$) to 1.2ACM. During the finishing phase, lambs fed 30R:70C diet has shown greater ($P<0.05$) BWC, average daily gain and better FCE than those consumed 60R:40C. Similarly, lambs in 30R:70C displayed better FBW change compared to other treatment groups. Yield of most carcass parameters and rib eye area were superior ($P<0.05$) for lambs fed with 1.5ACM:30R:70C. Therefore, it is concluded that supplementing *Acacia albida* and Cactus pear mixture at the rate of 1.5% during the growth phase and *ad libitum* feeding of roughage and concentrate at the ratio of 30R:70C during the finishing phase is recommended for BHO lambs as better feeding regimes.

Key words: Concentrate · Finishing Phase · Growth Phase · Performance · Roughage · Sheep

INTRODUCTION

Sheep population in Ethiopia is estimated at 26 million head and contributes to the country's economy through foreign currency earnings from export of life animal, meat and leather and leather products and to the livelihood of farmers by providing food (Meat and milk), fiber, wool, skin and manure [1]. Nevertheless, the live

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animal and carcass export from Ethiopia relies much on animals from the traditional pastoralist, agro-pastoralist and smallholder production systems with no or short term feedlot feeding for body conditioning. Because of the poor feeding system and other management problems, sheep from the traditional systems of production rarely achieve a carcass weight of more than 10 kg [2]. These show that meat from sheep obtained from such production system contribute less to the per capita meat consumption (9.94 kg) in Ethiopia per annum [2]. The low carcass yield of sheep obtained from the traditional production system does not only limit availability of meat for local consumption, but also carcass weight, conformation and quality, which all together marginalize the bargaining position of Ethiopia in the meat export trade.

According to abattoirs and live animal exporters, Ethiopian sheep breeds such as Blackhead Ogaden sheep, are the most preferred in the Middle East market. Hence, this breed appears to make one of reasonably high proportion of live sheep exported to the Middle East countries. The preferences for these breeds may have been due to the breeds' lowland background, adaptation of the buyers to the conformation of the animals and the taste of the meat [3]. Nevertheless, available information on body weight gain and carcass yield of Blackhead Ogaden sheep in response to different regimes of feeding is scanty. Some earlier studies [4,5] demonstrated that supplementation of Blackhead Ogaden sheep with agro industrial by-products improved daily body weight gain, dressing percentage and hot carcass weight. However, the studies so far conducted did not produce concrete information with regard to how the manipulation of the feeding regimes of Blackhead Ogaden sheep will improve feed utilization and daily body weight gain to achieve desired carcass weights that is attractive for the export market. Moreover, growth of animals at early age has strong impact on mature body weight and age at which it is achieved [6]. Usually, sheep marginally managed during early age such as during the post weaning growth will achieve mature weight at older age due to slow growth rate and this has a direct impact on quality of the meat produced [7]. Indeed, slow growth rate and exposure to a cycle of weight gain and loss due to fluctuations in annual cycle of feed supply is the main reason for sheep to reach higher body weight at an older age. If animals managed in such manner are slaughtered at younger age, they usually achieve a low body weight that is below the standard demanded on the export market [2]. Thus, proper nutrition at young age is a requirement to allow continuous growth of animals and prepare them for the finishing phase in order to achieve better growth rate and acceptable slaughter and carcass weight. Therefore, the objective of this experiment was to determine the effects of different feeding regimes on intake, digestibility, body weight gain and carcass parameters of Blackhead Ogaden lambs.

MATERIALS AND METHODS

Experimental Animals and Their Management: The experiment was conducted at Haramaya University goat farm (9.0°N latitude and 42.0°E longitude). A total of 24 Blackhead Ogaden lambs with age of 8-10 months, as estimated by dentition and information obtained from the owners, were purchased from Jijiga market. Experimental animals were quarantined for 3 weeks in isolated holding yards at Haramaya University and vaccinated against common infectious diseases in the area (Pasteurellosis and anthrax), de-wormed against internal parasites by albendazol de-wormer and sprayed with acaricides (Vetacidin 20%) against external parasites. Following quarantine, the experimental animals were placed in experimental house partitioned into individual pens (70 X 120 cm) that is equipped with feeding trough and watering bucket. Animals were adapted to the experimental procedures and feeds for 14 days before the commencement of the trials. The experiment consisted growth and finishing phases each with 90 days of feeding and 7 days of digestibility trials. After six months of stall feeding trial, all lambs were slaughtered for carcass parameter studies.

Experimental Feeds: Natural grass hay as a basal diet and dried *Acacia albida* leaves and pods and cactus pear cladodes mixed (ACM) at the ratio of 2:1 as a supplement were used during the 90days of growth phase. Fresh *Acacia albida* leaves and Cactus pear cladodes were collected from plants in Haramaya University campus. Fresh leaves of the Acacia albida were harvested from available trees regardless of the plants age, trimmed with its pods, spread thinly on plastic sheet under shade and turned regularly to ensure uniform drying for safe storage. Likewise, the cactus cladodes were hand chopped into pieces or strips to an approximate size of 5 cm for ease of feeding and drying and spread thinly on plastic sheet under shade and dried.

The same natural pasture hay used during growth phase and haricot bean haulms mixed in the ratio of 50:50 were used as a basal diet during the finishing phase [8, 9].

Haricot bean haulms of different varieties were obtained from the University's crop research and production section. The roughages were separately chopped by hand tool to a length of approximately 5 mm for simplicity of mixing and to reduce selection by animals. The supplement feed comprised wheat bran, noug and cotton cake meals. Concentrate ingredients were mixed at the ratio of 69% wheat bran and 31% of oil seed meals (Noug and cotton meals in 1.1:1 ratio). The roughage and the concentrate feeds were offered in a separate feeder.

Twenty four lambs were blocked into four groups based on initial body weight. Lambs in a block were randomly assigned to one of the four dietary groups making a total of six lambs in each group. Thus, a randomized complete block design (RCBD) was employed. The initial body weights of the experimental animals were determined by two consecutive weighing after overnight withdrawal of feed and the average of the two days were taken. After the completion of the growth experiment, the animals were used for finishing phase with no change of groups.

During the growth phase, the treatments were based on the amount of dried *Acacia albida* leaves and pods and Cactus pear cladodes mixture (ACM) supplement at the ratio of 2:1, respectively. The level of supplement feeding was at the rate of 0ACM (no supplement, control), 0.9ACM (Supplementation with ACM at a rate of 0.9% body weight), 1.2ACM (Supplementation with ACM at a rate of 1.2% body weight)and 1.5ACM (Supplementation with ACM at a rate of 1.5% body weight). Hay was offered *ad libitum* at 20% refusal rate. Treatments during the finishing phase were different proportions of roughage (R) to concentrate (C) ratio, which included 60R:40C, 50R:50C, 40R:60C and 30R:70C. The proportion of roughage to concentrate was determined from animals' *ad libitum* intake on dry matter basis, which was adjusted every four days. In both phases feed was offered in two equal meals.

The amount of feed offered and refused by each animal was weighed and recorded each morning using sensitive balance. Daily feed intake for each animal was calculated as the difference between daily feed offer and leftover. Representative samples of feeds were taken from each feed at offer and leftover samples were taken from each animal, pooled per treatment and sub-sampled for chemical analysis. The body weight of each experimental animal was measured at the beginning of the experiment and at 10 days intervals during the experimental period. Body weight was measured after overnight feed withdrawal to account for differences in gut fill. Average daily body weight gain was calculated as a difference between final and initial body weight of the lambs divided by the number of experimental days. Feed conversion efficiency of the animal was determined as the proportion of daily body weight gain to the total daily dry matter intake (DM) intake.

At the end of feeding trial of the growth and finishing phases, digestibility trial was conducted using all animals in the respective treatments. Lambs were fitted with fecal collection bags and placed in individual metabolic cages. Animals were adapted to carrying of the bags and the cage for three days and total feces collection was done for seven days. Feces output per animal was weighed and recorded each morning before feeding. The feces were mixed thoroughly and 10% was taken and bulked across the seven days and kept in dip freezer at -20ºC. At the end of the collection period, the composite fecal samples were thawed and thoroughly mixed and sub samples were taken. Samples of feed offered and refusal were also collected every day and sub sampled at the end of the experiment. The digestibility of DM and nutrients was determined as the difference between nutrients intake and that recovered in feces expressed as a proportion of nutrients intake.

The experimental animals were fasted overnight and slaughter body weights (SBW) were taken before slaughtering of the animals. Weights of empty body weight (EBW); slaughter weight minus gut content), non-carcass components and their percentage to EBW, hot carcass weight (HCW) and cold carcass weight (CCW) were recorded. Dressing percentage (DP) of hot and cold carcass weights was calculated as a percentage of SBW and EBW. Total usable product (TUP) was taken as the sum total weight of HCW, total edible offal component (TECO) and skin. The dressed carcasses were chilled for about 24 hours at 4 °C and weighed to provide CCW. Thereafter, each carcass was split into two equal halves by cutting through the vertebral column. Both sides were weighed and the left side was dissected into lean, fat and bone components. Cooling shrinkage was calculated as the percentage of the differences between HCW and CCW divided by HCW. The rib-eye muscle area of each animal was determined by tracing the cross sectional area of the 12^{th} and 13^{th} ribs after cutting perpendicular to the back bone. The left and right rib-eye area was traced on a transparent waterproof paper and the area was calculated by counting the squares on graph paper and multiplying with their area after the rib eye area was transferred to graph paper. The mean of the right and left cross sectional area were taken as rib-eye area.

Chemical Analysis: Samples of feed offered, refusals and feces were dried in an oven at 60°C for 72 h and milled in ground mill to pass 1mm sieve screen and kept in air tight plastic bags pending analysis. DM, organic matter (OM) and Nitrogen (N) were determined according to the procedures of AOAC [10]. The crude protein (CP) content was estimated as N X 6.25. Neutral detergent fiber (NDF), Acid detergent fiber (ADF) and Acid detergent lignin (ADL) were analyzed according to the procedures of Van Soest and Robertson [11].

Statistical Analysis: The data for each phase separately and the entire experiment data (both phases together) were subjected to Analysis of Variance (ANOVA) using the general linear model procedure of SAS [12]. Treatment means were separated using Tukey HSD (Tukey honestly significant difference) test. The model for data analysis was $Y_{ij} = \mu + T_i + B_i + E_{ij.}$ Where, Y_{ij} is the response variable; μ is the overall mean; $T_{i =}$ the treatment effect; Bi is the block effect and Eij is the random error.

RESULTS

Chemical Composition of Feeds: The CP content of the natural pasture hay is at the borderline of minimum CP needed for maintenance requirements of ruminant animals while NDF and ADF were high (Table 1). *Acacia albida* has high CP content while cactus pear cladode was characterized by its low CP content.

Dry Matter and Nutrient Intake: Dry matter (DM) and nutrient intakes are presented in Table 2. Hay dry matter intake during the growth phase is lower (P<0.05) in groups supplemented with mixture of *Acacia albida* leaves and cactus pear cladodes. Hay consumption at the higher level of the foliage mix supplement was significantly lower than at other levels, but total DMI was higher for this group than all other treatments indicating a gradual substitution of the foliage to natural pasture hay. Regardless of the ratio of roughage to concentrate, total DM intake during the finishing phase remained the same among the treatments.

Dry matter intake for the combined data (Entire experiment period) was significantly higher (P<0.05) for groups that consumed 1.2ACM and 1.5ACM during the growth phase and 40R:60C and 30R:70C during the finishing phase compared to the rest groups (P<0.05). Crude protein intake during the growth, finishing and for the entire period demonstrated a similar trend with DM intake and increased with increasing level of the foliage mixture supplement or concentrate proportion (P<0.05). Organic matter (OM) intake during the growth phase showed a similar trend to that of CP intake, but significant difference was not observed during the finishing phase. Its intake in the entire period increased with the increased level of foliage supplement and concentrate proportion. Intake of ADF during the growth phase and NDF and ADF during the finishing and entire period was higher (P<0.05) for groups consumed 0ACM/60R:40C than other treatment groups. Intake of estimated metabolizable energy (ME) increased with increasing level of foliage and concentrate supplement and its value during growth, finishing phases and entire period has shown more or less similar trend, but was generally lower for 0ACM/60R:40C than 1.5ACM/30R:70C group.

Table 1: Chemical composition of ingredients and experimental diets used during growth and finishing phases (DM as %, others %DM)

	Chemical composition					
Parameters	DM	OM	CP	NDF	ADF	ADL
Growth phase						
Natural pasture hay	90.7	90.0	7.8	67.6	33.2	21.5
Acacia albida	91.2	89.8	12.0	52.5	32.0	9.80
Cactus cladodes	90.3	82.0	5.99	23.3	15.0	2.40
2Acacia:1Cactus	90.7	84.7	11.0	35.7	21.5	4.20
Finishing phase						
Natural pasture hay	90.7	90.0	7.8	67.6	33.2	21.5
Haricot bean haulms	91.3	90.1	6.7	62.1	38.9	7.00
Wheat bran	89.2	85.9	17.7	39.5	11.6	2.10
CSM	91.8	80.8	28.0	34.9	30.9	7.70
NSM	91.0	89.2	40.0	41.9	15.2	8.30
Concentrate mixture	90.5	85.0	18.5	39.1	17.4	6.70

DM= Dry matter; OM= Organic matter; CP= Crude protein; NDF= Neutral detergent fiber; ADF= Acid detergent fiber; ADL= Acid detergent lignin; CSM= cotton seed meal; NSM= noug seed meal.

Table 2: Dry matter and nutrients intake of blackhead Ogaden sheep during different phases of feeding regimes

Intake (g/day)	Dietary treatments* 0ACM	0.9ACM	1.2ACM	1.5ACM	SEM	p-value
Growth phase						
DM						
Hay	708[a]	570[b]	558[b]	489[c]	14.9	0.0001
Supplement	0.0[d]	157[c]	252[b]	342[a]	5.36	0.0001
Total	708[b]	727[ab]	810[ab]	831[a]	15.3	0.0002
OM	636[d]	667[c]	738[b]	794[a]	0.01	0.0001
CP	55.1[c]	61.7[b]	71.2[a]	77.0[a]	1.41	0.0002
NDF	480	454	486	478	10.9	0.220
ADF	325[a]	278[b]	282[b]	259[b]	1.30	0.0001
ME (MJ/day)	4.80[b]	5.50[b]	6.40[ab]	7.90[a]	1.10	0.0002
Finishing phase	60R:40C	50R:50C	40R:60C	30R:70C		
DM						
Roughage	370[a]	300[b]	238[c]	181[d]	2.58	0.0001
Concentrate	247[d]	301[c]	356[b]	423[a]	8.32	0.0001
Total	617	601	594	605	8.19	0.3160
OM	525	528	534	542	7.46	0.2212
CP	83.2[c]	90.4[bc]	97.6[b]	109[a]	1.84	0.0001
NDF	337[a]	312[b]	292[c]	284[C]	2.24	0.0001
ADF	293[a]	253[b]	217[c]	191[c]	3.56	0.0001
ME (MJ/day)	9.20[b]	9.31[b]	10.31[ab]	11.4[a]	1.03	0.0002
Entire period						
DM						
Roughage	538[a]	435[b]	397[c]	336[d]	7.13	0.0001
Supplement	123[d]	228[c]	301[b]	381[a]	4.67	0.0001
Total	662[b]	664[b]	702[a]	718[a]	9.95	0.0001
OM	580[d]	597[c]	636[b]	668[a]	4.53	0.0001
CP	69.0[d]	76.0[c]	84.0[b]	92.0[a]	1.29	0.0021
NDF	408[a]	383[b]	389[b]	381[b]	5.91	0.0001
ADF	309[a]	264[b]	250[c]	225[d]	3.68	0.0001
ME (MJ/day)	7.01[b]	7.40[ab]	8.40[ab]	9.60[a]	1.56	0.0001

*Means in a row with different superscripts are significant at p<0.05; SEM= standard error mean; DM= Dry matter; OM= Organic matter; CP= Crude protein; NDF= Neutral detergent fiber; ADF= Acid detergent fiber; ME=Metabolizable energy; *Growth phase treatments are based on Acacia albida and Cactus pear cladodes mixture (ACM) supplementation at a ratio of 2 to 1, respectively; 0ACM= no supplement, control; 0.9ACM= supplementation at a rate of 0.9% body weight; 1.2ACM=1.2% body weight; 1.5ACM=1.5% body weight and finishing phase treatments are based on roughage (R) to concentrate (C) ratio: 60R:40C (60% roughage and 40% concentrate feeding); 50R:50C; 40R:60C; 30R:70C.*

Table 3: Apparent dry matter and nutrients digestibility coefficient of Blackhead Ogaden sheep during different feeding regimes

Parameters	Dietary treatments* 0ACM	0.9ACM	1.2ACM	1.5ACM	SEM	p-value
Growth phase						
DM	0.58	0.64	0.66	0.72	0.05	0.337
OM	0.65	0.67	0.71	0.75	0.04	0.304
CP	0.60[b]	0.70[ab]	0.71[ab]	0.77[a]	0.04	0.013
NDF	0.62	0.58	0.60	0.63	0.03	0.623
ADF	0.49	0.50	0.47	0.52	0.04	0.623
Finishing phase	60R:40C	50R:50C	40R:60C	30R:70C		
DM	0.63	0.61	0.62	0.65	0.42	0.962
OM	0.67	0.66	0.66	0.68	0.01	0.153
CP	0.59[c]	0.63[b]	0.68[a]	0.69[a]	0.01	0.0001
NDF	0.64	0.62	0.62	0.61	0.01	0.050
ADF	0.66	0.67	0.66	0.68	0.01	0.270

*Means in a row with different superscripts are significant at P<0.05; SEM= standard error of mean; DM= Dry matter; OM=Organic matter; CP= Crude protein; NDF= Neutral detergent fiber; ADF= Acid detergent fiber; *Growth phase treatments are based on Acacia albida and Cactus pear cladodes mixture (ACM) supplementation at a ratio of 2 to 1, respectively; 0ACM= no supplement, control; 0.9ACM= supplementation at a rate of 0.9% body weight; 1.2ACM=1.2% body weight; 1.5ACM=1.5% body weight and finishing phase treatments are based on roughage (R) to concentrate (C) ratio: 60R:40C (60% roughage and 40% concentrate feeding); 50R:50C; 40R:60C; 30R:70C*

Table 4: Body weight change and feed conversion efficiency of blackhead Ogaden sheep during different phases of feeding regimes

	Dietary treatments*					
Parameters	0ACM	0.9ACM	1.2ACM	1.5ACM	SEM	P-value
Growth phase						
IBW (kg)	16.9	17.0	17.6	17.5	0.59	0.085
FBW (kg)	18.5[c]	21.2[b]	22.9[ab]	23.6[a]	0.36	0.0001
BWC (kg)	1.54[c]	4.21[b]	5.26[ab]	6.10[a]	0.39	0.0001
ADG (kg)	17.1[d]	46.79[c]	58.5[b]	67.8[a]	4.44	0.0001
FCE (g ADG/g DMI	0.03[c]	0.05[b]	0.06[ab]	0.07[a]	0.02	0.0001
Finishing phase	60R:40C	50R:50C	40R:60C	30R:70C		
IBW (kg)	18.8[d]	21.9[c]	23.3[b]	24.1[a]	0.43	0.0001
FBW(kg)	25.2[d]	29.0[c]	31.5[b]	32.5[a]	0.19	0.0001
BWC (kg)	6.4[b]	7.1[ab]	8.2[ab]	8.4[a]	0.48	0.037
ADG (kg)	71.1[b]	78.9[ab]	91.0[ab]	93.0[a]	5.17	0.037
FCE (g ADG/g DMI	0.115[b]	0.135[ab]	0.154[a]	0.155[a]	0.02	0.0001
Entire period						
BWC (kg)	7.9[c]	11.3[b]	13.5[a]	14.5[a]	0.33	0.0001
ADG (kg)	44.3[c]	64.1[b]	74.7[a]	80.4[a]	1.86	0.0001
FCE (g ADG/g DMI	0.0725[c]	0.925[b]	0.107[a]	0.113[a]	0.02	0.0001

*Means in a row with different superscripts are significant at p<0.05; SEM= standard error of mean; IBW= Initial body weight; FBW= Final body weight; BWC= body weight change; ADG=Average daily gain; FCE= Feed conversion efficiency; *Growth phase treatments are based on Acacia albida and Cactus pear cladodes mixture (ACM) supplementation at a ratio of 2 to 1, respectively; 0ACM= no supplement, control; 0.9ACM= supplementation at a rate of 0.9% body weight; 1.2ACM=1.2% body weight; 1.5ACM=1.5% body weight and finishing phase treatments are based on roughage (R) to concentrate (C) ratio: 60R:40C (60% roughage and 40% concentrate feeding); 50R:50C; 40R:60C; 30R:70C.*

Nutrient Digestibility: Apparent digestibility coefficients of DM and nutrients, except CP did not differ (P>0.05) among the treatments in both phases (Table 3). Increased level of supplement during the growth phase improved CP digestibility and value was higher (P<0.05) for 1.5ACM group compared to 0ACM with no difference between the rest treatment comparison. In the finishing phase, CP digestibility was lower (P<0.05) for 60R:40C than the rest treatments and that for 50R:50Cwas lower (P<0.05) than the higher levels of supplementation.

Body Weight Change: Initial body weight during the finishing phase is different (P<0.05) between the treatments because of differences observed during the growth phase (Table 4). During the growth phase, Average Daily Gain (ADG) increased (P<0.05) with increasing level of foliage supplementation. Feed conversion efficiency (FCE) was also higher for supplemented compared to the non-supplemented ones. Among the supplemented groups, lambs supplemented with 1.5ACM recorded significantly greater (P<0.05) FCE than those supplemented with 0.9ACM, but was similar (P>0.05) with 1.2ACM. During the finishing phase, lambs fed with 30R:70C diet has higher (P<0.05) ADG and better FCE than those fed 60R:40C. For the entire experimental period, body weight change, ADG and FCE had shown a similar trend and was higher for 1.2ACM/40R:60C and 1.5ACM/30R:70C than 0ACM/60R:40C and 0.9ACM/50R:50C. Group 0.9ACM/50R:50C also has significantly higher values for these parameters than the 0ACM/60R:40C.

Slaughter Measures: Most of the slaughter measures are lower in 0ACM/60R:40C than the other treatment groups (Table 5). However, chilling lose was significantly higher for 0ACM/60R:40C than 1.2ACM/40R:60C and 1.5ACM/30R:70C groups. Group 0ACM/60R:40C display smaller hot and cold carcass weight than the rest and 0.9ACM/50R:50C recorded lower values for these parameters than 1.5ACM/30R:70C. Dressing percentage is higher in 1.5ACM/30R:70C than the 0ACM/60R:40C group. Total usable product is higher in 1.2ACM/40R:60C and 1.5ACM/30R:70C than the other groups.

Rib-eye muscle area showed increasing trend with increasing foliage supplementation and concentrate proportion and significantly higher in 1.2ACM/40R:60C and 1.5ACM/30R:70C than 0ACM/60R:40C.

Table 5: Effect of different feeding regimes on slaughter parameters of blackhead Ogaden sheep

	Dietary treatments*					
Parameters	0ACM/60R:40C	0.9ACM/50R:50C	1.2ACM/40R:60C	1.5ACM/30R:70C	SEM	p-value
SBW(kg)	24.4^{c}	28.2^{b}	30.5^{ab}	31.5^{a}	0.58	0.0001
EBW(kg)	19.6^{c}	23.4^{b}	26.1^{ab}	27.3^{a}	0.64	0.0001
HCW(kg)	9.0^{c}	11.8^{b}	13.4^{ab}	15.0^{a}	0.60	0.0001
CCW(kg)	8.50^{c}	11.2^{b}	12.9^{ab}	14.5^{a}	0.55	0.0001
LH(kg)	4.80^{c}	5.80^{b}	6.70^{ab}	7.50^{a}	0.30	0.0001
Chilling loss	5.70^{a}	5.10^{ab}	3.70^{bc}	3.33^{c}	0.01	0.0001
HDP(%SBW)	38.0^{c}	41.4^{b}	43.2^{ab}	48.2^{a}	1.43	0.0002
HDP(%EBW)	44.7^{b}	50.0^{ab}	51.3^{ab}	55.1^{a}	1.46	0.001
CDP(%SBW)	36.3^{c}	40.0^{bc}	42.8^{ab}	46.6^{a}	1.33	0.0001
CDP(%EBW)	45.0^{b}	48.1^{b}	49.8^{ab}	53.3^{a}	1.31	0.003
TUP (kg)	16.3^{c}	19.3^{b}	22.2^{a}	22.6^{a}	0.62	0.0001
Tail (kg)	1.03^{b}	1.26^{ab}	1.37^{ab}	1.40^{a}	0.76	0.016
REMA(cm^{2})	9.12^{b}	10.4^{ab}	11.2^{a}	12.6^{a}	0.41	0.0002

*Means in a row with different superscript are significant at $p<0.05$; SBW= Slaughter body weight; HCW= hot carcass weight; CCW = Cold carcass weight; EBW= Empty body weight; LH= Left half carcass; CDP=Cold dressing percentage; TUP= Total usable product; REMA = Rib-eye muscle area; *Growth phase treatments are based on Acacia albida and Cactus pear cladodes mixture (ACM) supplementation at a ratio of 2 to 1, respectively; 0ACM= no supplement, control; 0.9ACM= supplementation at a rate of 0.9% body weight; 1.2ACM=1.2% body weight; 1.5ACM=1.5% body weight and finishing phase treatments are based on roughage (R) to concentrate (C) ratio: 60R:40C (60% roughage and 40% concentrate feeding); 50R:50C; 40R:60C; 30R:70C*

DISCUSSION

Growth Phase: The hay contains the minimum (7%) CP needed to support acceptable ruminal microbial activity and the maintenance requirement of the host ruminant [13]. The CP content of *A. albida* was within the range of 12-18% reported by previous worker [14]. Cactus pear cladodes contains low CP than hay and the value obtained in the present study is comparable to that reported in earlier studies [15]. Fiber fractions content was higher for the natural pasture hay than *A. albida* and Cactus pear cladodes (Table 1). The fiber fractions content of *A. albida* is comparable to values of 560 g/kg NDF and 336g/kg ADF reported by [16].

In the present study, lower hay intake by groups supplemented with foliage diet(Table 2) is an attribute of substitution of supplement foliage for hay indicating better palatability of the foliage. In the absence of supplementation, lambs consume as much hay as they could until factors such as gut fill limit further intake in order to satisfy their nutrient requirement. Decreased basal diet intake when the supplement source constitutes foliage of better palatability and nutritive values than hay also has been reported in earlier studies [16, 17]. Lower basal diet intake in sheep supplemented with concentrate partially substituted with multi-purpose tree foliage or ground prosopis pod were also reported by [18] and [19], respectively. Improvement in total DM intake in the foliage supplemented lambs could be attributed to better supply of CP compared to sole hay, which enhanced the proliferation of rumen microbes enabling more efficient digestion of the fiber components, which in turn lead to higher intake [20]. On the other hand, the low total DM intake in the non-supplemented lambs could be attributed to the gut fill due to the retarded fermentation in the rumen arising from limited nutrients for rumen microorganisms.

The high CP and OM intake by supplemented lambs in the present study is in accordance with [17] who noted increased CP intake in sheep when Moringa leaf is supplemented to a basal grass hay. [18] also observed improved intake of CP and OM in sheep supplemented with legume foliage to a basal diet of grass hay. Higher intake of CP and OM with increasing level of foliage supplementation is due to the lower fiber and higher CP content of the supplement that increase N supply to the rumen microorganisms as compared to the basal diet [13]. Average CP intake of the supplemented treatments was about 11.5% of the total DM intake. Therefore, the significant improvement in intake and digestion of most nutrients in the supplemented groups can be justified by the relatively better intake and digestibility of CP. The estimated metabolizable energy (ME) intake by the lambs in all treatments was above the maintenance requirement (3.7-4.1 MJ/day) estimated for 20kg lamb [21]. Among the supplemented lambs, the relatively higher ME intake for sheep in 1.5ACM/30R:70C might be due to the significant differences in OM intake.

Apparent CP digestibility was improved at the higher level of foliage supplementation and higher proportion of concentrate in the diet (Table 3). This is consistent with [17] who reported linear increase in CP digestibility with increasing levels of *Moringa stenopetala* leaves supplementation in sheep fed a basal diet of Rhodes grass, respectively. This could be explained by the fact that increasing CP intake linearly increases CP digestibility, enhance microbial population and facilitates rumen fermentation [22, 23]. Improvement in digestibility of CP also could be associated with the supply of more readily available energy from cactus cladodes, which could have contributed to increased microbial synthesis and consequently improve microbial digestion and hence digestibility. Digestibility of NDF and ADF was not impacted by foliage supplementation. Concomitant with the current study, [24] reported that increasing CP content of the diet through supplementation increased CP digestibility, but had little effect on the digestibility of other nutrients. [25] also reported that digestibility of DM, NDF and ADF failed to improve in steers fed Orchard grass hay diet supplemented with alfalfa at different intake levels.

As shown in Table 3, differences in ADG among treatments are in accordance with differences in intake of nutrients. In accordance with the present result, [26] observed 16% increase in body weight of growing lambs when supplemented with *Acacia saligna*. Likewise, improved growth performance of sheep supplemented with different levels of dried foliage of *Gliricdia sepium,* Sesbania sesban and *A. angusstissima* mixed with pearl millet stover [27] and *A. albida* [28] were reported. The ADG of lambs fed higher level of *A. albida* leaves and pods in the current experiment was comparable to the value (66.2g/day) reported by [29] in indigenous sheep fed a basal diet of Rhodes grass hay supplemented with concentrate. Although growth rate is not comparable due to the potential of the breed used, Mousa [14] reported body weight gain of 186.3g/day in lambs fed 40% *A. saligna* as a substitute for concentrate mixture as compared to those fed 20% *A. saligna* and the control diets. Studies indicated that up to 40% of acacia foliage can be used in the total diet of conventional feed ingredients safely without any adverse effect in animals health and performance [30]. In the present study *A. albida* consumption was only about 27% of the total diet. The growth performance of lambs at higher level of foliages supplementation is comparable with results of studies evaluated animal growth under concentrate supplementation [14]. This indicates the potential that multipurpose tree foliages can play as a supplement to poor quality feeds in the tropics, where animal feed is scarce and of low quality. This also shows the possibility of replacing portion of concentrate supplements with tree leaves for economical production of lambs under small holder production system.

High fiber content and low CP digestibility are known to be associated with low intake of metabolizable energy and may cause weight loss in animals fed with only roughage feeds of poor quality [31]. Nevertheless, lambs fed natural grass hay alone in the present study gained 17g/day. This is an attribute of the relatively better CP content of the grass which supplied the minimum CP required for ruminal microbial synthesis. In this regard, there are inconsistencies among literature in that some reported positive gain [18, 19] while others noted no change in body weight [32] for animals consumed sole hay diet. The inconsistency arise due to variability in the type and quality of nutrients, particularly CP contents of the roughage feeds used as a basal diet.

Finishing Phase: The CP content of hay used in the finishing phase is similar to that of growth phase, since the source is the same (Table 1). The CP composition of haricot bean haulm was relatively lower than hay. Low CP concentration in haricot bean haulm is attributed to let harvesting of the crop after much of the leaves have been shattered. As expected, the CP content of the concentrate mixture is well above required to satisfy the nitrogen demand for proper functioning of rumen microorganisms and it is a good complement to the low quality roughage used.

As shown in Table 2, absence of difference in total dry matter intake regardless of roughage to concentrate ration indicate the voluntarily intake of the two diets did not hampered as a result of increased or decreased quantity of the other. This in line with earlier study [33] who did not observed difference in total DM intake when lambs consumed diet varying in roughage to concentrate ratios. Other researchers who evaluate effect of increasing level of concentrate supplementation in sheep diet did not also found difference in total dry matter intake [34]. The increase in CP and the decrease in NDF and ADF intake with increasing concentrate proportion is due to the inherently low protein and high fiber fractions content of the roughage as compared to the concentrate.

The high apparent digestibility of CP in groups with 50% concentrate in the diet and above is (Table 3) related to the intake level of this nutrient. At higher intake of proteinous concentrate, CP intake was high and digestibility varies accordingly. Earlier studies [23, 35] also showed that increasing level of CP in the total ration improved CP intake and enhanced CP digestibility in sheep. Similarly, [36] observed better apparent CP digestibility in Granadina goats consumed 30 to 70% roughage to concentrate ratio than other treatment groups. However, unlike the previous studies that reported improved fiber fraction digestibility with increasing CP intake [5], significant change in fiber digestion did not occur in the present study. This may be attributed to the sufficiency of the lowest proportion of the concentrate, such as 60R:40C in the present study, to bring equal improvement in fiber digestion as do higher level of concentrate proportion in the diet.

The higher average daily gain at highest level of concentrate proportion in the diet (Table 4) might mainly be due to the higher CP intake and feed conversion efficiency occurred for this group than the others. In line with this, [37] observed that increasing roughage proportion decreased live weight gain of lambs fed diets with varying level of roughage to concentrate ratios. Other researchers also noted improved body weight gain and feed conversion efficiency in lambs consumed higher level of concentrate than low [5].

Similar to intake and growth parameters, carcass yield and chilling loss values (Table 5) are better at higher level of concentrate in the diet. Hot carcass weight obtained in groups fed with 50% or above concentrate proportion in the diet ranged 11.8 to 15 kg, which is a significant improvement as compared to results reported in previous studies. Hot carcass weight of Black head Ogaden sheep finished in feedlot in three months were reported to range 8.0 to 10.6 kg [9], 7.1 to 9.1 kg [4] and 6.7 to 10.8 kg [5] when fed with different roughage sources and supplemented with graded levels of concentrate. This imply that carcass yield of the current sheep breed could be improved by manipulating the feeding system and better supplementation strategy. Higher carcass weight with high level of concentrate in the diet also was reported for different breeds [38, 39]. The higher dressing percentage of groups with high concentrate diet (30R:70C) could be attributed to differences in carcass weight. This is in agreement with the findings of [40] who reported that higher dressing percentage in lambs consumed low forage diet than medium, high and control groups. The average values for dressing on the basis of slaughter body weight in the present study is comparable with the results reported by [4], but higher than the value reported by [5]. The values of dressing percentage on the basis of EBW was higher than that on SBW basis, implying the effect of digesta, which was on average about 4.19% in the present study. This is confirmed by [41] who reported that digesta contribute 4 to 14% of fasted live weight in sheep and goats fasted for about 24 hours before slaughter.

Chilling loss had shown a decreasing trend with increased proportion of concentrate and the mean value obtained for the present study (4.5%) was comparable to the result reported by [42] in Santa Ines ewes and higher than that of [43] in Corriedale and Ile de France and Corriedale cross lambs and Rocha *et al.* [44] in Santa Ines lambs. Lower chilling loss for lambs consumed ration with higher proportion of concentrate could be occurred as a result of high fat deposition in the carcass, thus resulting in smaller losses by dehydration during chilling. High proportion of concentrate had significant and positive effect on the rib-eye muscle area indicating higher amount of carcass muscle. Similar result also was reported in Blackhead Ogaden sheep [4].

CONCLUSION AND RECOMMENDATION

- Under small holder and pastoral production systems, animals' growth is influenced by scarce feed resource. Animals marketed from this system do not meet the standard weight for export of live animal or carcass and this is a real problem to Ethiopian export abattoirs.
- The present study demonstrated that improving early age nutrition by using locally available feed source followed by high concentrate finishing diet can significantly improve live and carcass weight.
- Thus, we recommend producers, personnel and institution in charge of the extension system and policy makers to consider stratified sheep finishing practice in order to alleviate the problem of marketing young and underweight lambs, which are less needed in export market.

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