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Effect of Increasing Levels of Energy and Protein Supplementation on Feed Intake and Body Weight Change of Black Head Somali Sheep Fed on Natural Grass Hay

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Abstract

The experiment was conducted to assess the effect of increasing levels of protein and energy supplements on feed intake and body weight change of Black Head Somali sheep. A randomized complete block design was employed with 5 treatments and 6 blocks. The average initial weight of the yearling experimental sheep was 22.19 ±0.21 kg. The supplement feed was formulated from groundnut cake, brewery dried grain, and wheat bran; taking grass hay as a basal diet. The experimental period lasted for 90 days which was preceded by two weeks of adaptation period. The CP and ME content of grass hay in the study was 9.1% and 8.3 MJ /kg DM, respectively. Higher total CP intake (TCPI) total estimated ME intake (TEMEI) and average daily body weight gain (ADBWG) were recorded (P<0.01) with increasing levels of supplementation. There was a positive and high correlation between intake variables (DMI, EMEI, and CPI) and ADBWG. Marginal rate of return (MRR) was recorded at 11.04, 3.29, 3.42, and -0.317 for T2, T3, T4, and T5, respectively. This indicates that the higher level of energy and protein supplementation has a negative value for MRR. Thus, T4 had a higher net return and was economically viable than the other treatments.

Keywords: Body Weight Gain, CP, Intake, ME, Sheep.

Introduction

Ethiopia has large population of sheep above 30 million head (CSA 2016/17). Sheep holding per household in Ethiopia ranges from 3.7 (Abebe, 2010) to 31.6 (Getachew *et* al. 2010). The annual off-take rate of sheep is estimated to be 33% (EPA, 2002). At the smallholder level, sheep are the major source of food security serving diverse functions *including* as a means of survival, a source of cash income, saving, assets for the poor and the landless, and also serving a socio-cultural function.

Despite their relevance and large population, the productivity of sheep in Ethiopia *i*s very low. The slaughter weight of mature male sheep is 25kg with an average carcass weight of about 10kg, this makes the country the second lowest slaughter weight among the sub-Saharan African countries (FAO, 2009). The low performance of local sheep in terms of live weight, body weight gain, and carcass yield is mainly due to inadequate nutrition *(*Betsha, 2005).

The natural pasture and crop residues, which serve as the main source of feed for livestock in Ethiopia, are characterized by poor nutrient content; low crude protein (CP), and metabolizable energy (ME). The low metabolizable energy and crude protein content of feed has a significant effect on rumen microflora activity and also a comparable negative effect on the digestibility and voluntary feed intake, resulting in poor animal performance (Adugna *et al.*, 2012, Crampton and Harris, 1969). *The* lowest energy density and the minimum CP level required for maintenance of sheep ranges between 8 - 10 MJ/kg and about 8% CP in the DM, respectively. Supplementation of a poor-quality roughage-based diet with energy and protein source feeds improves nitrogen retention and feed utilization (Getenet, 1998, CTA, 1991).

Nutrients feeding below the animals' requirements would restrict growth, and production, and affect their health. On the other side, excess provision of nutrients results in more excretion of nutrients through feces and urine, and the left may be toxic and cause adverse health effects, this all leads to extra costs for the producers (McDonald *et al*, 2010). Ahmed BA (2003) also indicated that adjusting protein and energy levels in the diet of lambs could be important to produce high-quality lamb carcasses more efficiently and economically. Dietary energy and protein level and their interaction are the most important factors for growth, carcass parameters, and productivity of sheep (Haddad *et al*., 2001; Bellof and Pallauf, 2004).

Agro-industrial by-products are supplementary feeds for animals. They have high crude protein content and are good energy sources to supplement small ruminants. The commonly known and commercially available feed supplements are brewery by-products, wheat bran, and oil seed cake (Gizachew A., 2012).

Over the past few years, a number of agro-industries like flour milling, oil extracting, and brewery factories have been expanding in different parts of Ethiopia. Recently, there has been the production of around 1, 872, 368 tons of wheat bran, 102 319 tons of brewery grain (spent grain) and 202, 134 tons of oil milling by-products per year in dry matter base (FAO, 2018).

However, most agro-industrial by-products are not efficiently utilized based on their dietary energy and protein level. This is due to a lack of enough information on the optimum level of energy and protein supplementation and their interaction effect from different agro-industrial by-product sources. Therefore, to fill the gap and increase the profitability of sheep fattening by evaluating the optimum level of dietary energy and protein sources from the existing feed resources is very important

Thus, the objectives of the current study were:

- To investigate the effects of increasing levels of energy and protein supplementation on feed intake and body weight gain of Blackhead Somali sheep, and

- To determine the economically optimum level of protein and energy supplementation for Blackhead Somali sheep based on a mixture of agro-industrial by-products

Material and Methods

Study Site

The experiment was conducted at Haramaya University (HU) Sheep Farm. The University is located on the eastern escarpment of the Rift Valley about 515 km East of Addis Ababa, at the latitude of 9°26'N, the longitude of 42°03'Eand the altitude of 1950 meters above sea level. The mean annual rainfall of the study area is 790 mm with mean annual temperatures of 16.0 ºC (Mishra et *al*., 2004).

Experimental Animals and Their Management

Thirty intact yearling males of Blackhead Somali sheep were used. The ages of the experimental sheep were determined using dentation techniques. The feeding trial was conducted for 90 continuous days. adaptation with experimental diets and management conditions was done before the actual feeding trial for two weeks. The animals were vaccinated against common diseases, and treated against external and internal parasites before the commencement of the actual experiment. The animals were housed and fed in individual pens. Grass hay was used as basal feed and fed *ad libitum* and they have had free access to water and mineral licks.

Experimental Feeds and Feeding

Natural grass hay obtained from HU-campus was used as a basal diet. It was chopped, weighed, and offered *ad libitum* two times a day at 8:30 AM and 4:30 PM after they finished the concentrate supplement. Refusals of hay were collected and weighed every morning before new feed was offered to the animals.

Treatment diets were formulated from, groundnut cake, brewery-dried grain, and wheat bran. Treatment Feeds were formulated in such a way that sheep can get CP percent from 20% CP to 35 % CP with a variation of 5% Cp within the treatment. The ME content of treatment feeds also ranges from 1.6 MJ to 4.6 MJ with a variation of 1MJ among treatments. Treatment feed was offered two times a day in two equal meals at 8:00 AM and 4:00 PM, before the provision of the basal feed. Samples of hay offered and refused were collected daily and bulked over 90 experimental days. Samples of the concentrate diet were taken immediately after mixing and formulating the different treatments, bulked, and sub-sampled at the end of the experiment. Sub-samples from hay offered refused, and treatment feeds were used for chemical analysis.

Table 1: Chemical composition of the experimental diets

Variables	Treatments				
	T1	**T_2**	**T3**	**T4**	**T5**
DM (%)	93.3	87.5	87.5	87	88.5
Ash (%DM)	8.9	4.7	6	4.7	5
OM (%DM)	91.2	95	94	95.4	95
CP (%DM)	9.1	20	23.5	28.5	32.4
NDF (%DM)	71.1	31.1	34.2	35.1	33.8
ADF (%DM)	49.3	29.4	30.6	29.4	32.4
EME (MJ/kg DM)	8.3	9.6	11.5	12.5	13.8
Hemicelluloses	21.8	1.7	3.6	5.7	1.4

DM = dry matter, OM = organic matter, CP = crude protein, Ash = ash, NDF = neutral detergent fiber, ADF = acid detergent fiber, EME= estimated metabolizable energy; MJ= mega joule T1= grass hay; T2=concentrate feed for treatment two; T3 concentrate feed for treatment three; T4= concentrate feed for treatment four; T5= concentrate feed for treatment five.

Experimental Design and Treatment

A randomized complete block design was employed with the initial weight of the sheep as a blocking factor. The experiment consisted of five treatments and six blocks, sheep in a block were randomly assigned to each of the dietary treatments. The treatments were formulated using Double Pearson's square method (Ensimiger, 2002). The levels of CP and ME were based on the recommendations of Paul *et al*. (2003) for sheep gaining 50 to 100 g/d. The expectation was to provide a 5% variation in Cp and MJ, ME per treatment; however, there is a slight difference in

CP and ME variations between the actual and the planned treatments.

Actual treatments were:

Treatment 1: grass hay (control) fed ad libitum
Treatment 2: grass hay ad libitum+ 169.4 g DM per day concentrate mix consisting of 20 % CP and 1.70 MJ, ME
Treatment 3: grass hay ad libitum + 227 g DM per day concentrate mix consisting of 23.5 % CP and 2.6 MJ, ME
Treatment 4: grass hay ad libitum + 281 g DM per day concentrate mix consisting of 28.5 % CP and 3.6 MJ, ME
Treatment 5: grass hay ad libitum+ 343.6 g DM per day concentrate mix consisting of 32.4 % CP and 4.8 MJ, ME

Economic Analysis

Economic analysis was done by partial budget analysis based on the method developed by Ehui and Rey (1992). Net income (total revenue – total variable cost) and marginal rate of return (change in net income divided by change in total variable costs) normally expressed in terms of percentage, were determined. Input data were collected (total concentrate and hay consumed in kg/sheep and initial body weight of sheep together with their prices per kg) to estimate the cost incurred and output data on body weight change (final body weight –initial body weight) in terms of prices per kg body weight were used to calculate the total revenue.

Statistical Analysis

Data on feed intake, body weight change, and carcass composition were subjected to statistical analysis of variances (ANOVA) using the General Linear Model Procedure of Statistical Analysis System (1998) version 8. Duncan's Multiple Range test (DMRT) was used for mean separation. Regression analysis between feed intake, body weight gain, and levels of CP and ME intake were undertaken (Minitab, 2007). Correlation analysis between body weight change and carcass yield components, level of CP and ME supplementation, body weight, and carcass components were also computed using the Pearson method.

Model for the Experiment

$Y_{ij} = \mu + Ti_i + Bj + E_{ij}$

Where:
Y_{ij} = the response variable/observation in j^{th} block and i^{th} treatment
μ = the overall mean
$T_{i.}$ = The treatment effect/ the effect of i^{th} level of feeding
Bj = the block effect/ the effect j^{th} body weight
E_{ij} = the random error

Results and Discussion

A proper understanding of animal feed intake and nutrient requirements is very important for controlling the overfeeding or underfeeding of the animal and through that making efficient utilization of feeds. As a result, finding the optimum level of energy and protein intake for the fattening of sheep is important.

Dry Matter and Nutrient Intake

The dry matter and nutrient intake of the current study are given in Table 2. In this study, the average daily DMI of the basal diet was higher (P<0.01) for the control than the supplemented treatment. The low nutrient content of the basal feed compared to the other treatments is expected to provide less amount of nutrients that do not satisfy the nutrient requirement of the animal. Hence, the animals could meet their nutrient requirement only through the intake of relatively more GH than the supplemented groups, which had an alternative nutrient source from the concentrate they consumed. Total DMI was higher in the supplemented rams as compared to the control group (P<0.01). Moreover, there was also a difference (P<001) in TDM intake between the supplemented groups due to the increasing levels of supplementation. Accordingly, rams in T5 had the highest (p<0.01) total DMI as compared to rams in the other treatments. This indicates that there is a substitution effect of concentrate supplementation over the basal feed grass hay, when the level of supplementation increases the DM intake of Grass hay decreases but the total DM intake of the sheep increases. Ponnampalam *et al., (*2004) also reported that the type and amount of supplementation can affect the substitution rate of the basal feed and generally substitution rate increases with increasing levels of supplementation.

Table 2: Daily dry matter and nutrient intake of Black Head Somali Sheep fed on a basal diet of GH and supplemented with increasing levels of energy and protein

Feed Intake	**Treatments**						
	T1	**T2**	**T3**	**T4**	**T5**	**SL**	**SEM**
GH DMI (g/d)	710.8^{a}	615^{b}	602.1^{b}	606.5^{b}	619.9^{b}	**	10.84
Supplement DMI (g/d)	-	169.4	227	281.8	343.6	na	
TDMI (supp + GH) (g/d)	710.8^{d}	784.8^{c}	829^{bc}	888.3^{b}	963.5^{a}	**	10.79
TDMI (g/kg $W^{0.75}$)	67.4^{c}	69.5^{bc}	71.2^{bc}	77.7^{ab}	82.9^{a}	**	2.2
TDMI (% BW)	3.1^{c}	3.1^{c}	3.3^{bc}	3.5 ^{ab}	3.7^{a}	**	0.07
OMI (GH) (g/d)	662.1^{a}	561.4^{b}	549.4^{b}	553.6^{b}	564.7^{b}	**	9.96
OMI (Supp) (g/d)	-	161.7	213	268.7	326.7	-	-
Total OMI (g/d)	662.1^{d}	723.1^{cd}	762.4^{bc}	822.3^{b}	891.4^{a}	**	10.21
CPI (GH) (g/d)	71.6^{a}	64.5^{ab}	60.5^{b}	61.8^{b}	64^{ab}	*	1.15
CPI (Supplement) (g/d)	-	33.9	53.3	80.4	111	na	
Total CPI(g/d)	71.6^{e}	96.4^{d}	113.3^{c}	142^{b}	173 ^{a}	**	1.1
EME I, GH (MJ/d)	6.1	5.3	5.2	5.3	5.4	ns	0.2
EMEI, supp (MJ/d)	-	1.7	2.6	3.6	5	na	
Total EMEI (MJ/d)	6.1^{e}	7 ^{d}	7.8^{c}	8.8^{b}	10.4^{a}	**	0.09
Hemi cellulose intake	156.9^{a}	132.1^{b}	131.2^{b}	131.3^{b}	134.1^{b}	**	2.32
Substitution effect	-	0.56	0.48	0.37	0.26		

*Means within the same row and with different letter supper script differ significantly; *= (P<0.05); ** = (P<0.01) ns = not significant; na= not applicable; DMI= dry matter intake; TDMI= total dry matter* intake*; GH= grass hay; SEM= standard error of mean; OMI= organic matter intake; CPI= crude protein intake; NDF= neutral detergent fiber; ADF= acid detergent fiber; EMEI= estimated metabolizable energy intake; MJ= mega Joule; SL= significant level; Supp= supplement.*

The total DM intake observed in the current study for the supplemented group as compared to the control was higher, this could be due to the better nutritive value of the concentrate feeds, which might have increased the activity of the rumen microorganism and increased the passage rate of the feed. The current finding indicates that the voluntary feed intake of the sheep was increased continuously up to 36% concentrate inclusion this is in agreement with the finding of Asmare *et al*, (2010) that indicates the voluntary feed intake of an animal will increase up to 75% inclusion rate of concentrate feed.

Total CP and ME intake in the present study was different (P<0.01) among the various levels of supplementation and between the supplemented and control groups. Both CP and ME intakes increased (P<0.01) with the increasing level of supplementation. Increased CP intake with increasing levels of concentrate supplementation is due to increased levels of CP and ME content across the different treatment feeds

Body Weight Change

Body weight change, feed conversion ratio, and efficiency of Black Head Somali sheep in the current study are presented in Table 3. In the present study Sheep consuming only grass hay achieved positive body weight. This may be due to the good nutritional quality of the basal diet, which indicates that the grass has more Cp and ME content than the minimum maintenance requirement for sheep. McDonald *et al*, (2002) indicated that the lowest energy density at which the sheep do not lose weight ranges between 8 to 10 MJ ME/kg DM, and the minimum crude protein level required for maintenance is about 8%/kg DM.

Body weight change, average daily body weight gain, and final body weight of sheep supplemented with different levels of energy and protein were higher (P<0.01) than the control group. There were also differences (P<0.01) between the supplemented groups. Average body weight gain was increased parallel with the increased level of energy and protein supplement. The average daily body weight gain obtained in the current study receiving different ME and Cp level treatments ranged from 60.4 – 95.6 g/d. This is greater than the average daily body weight gain reported by Shashe *et al*. (2017), which indicates that Blackhead Ogden sheep feed on hay and concentrate mix in a feedlot finishing has ADG of 49.2 g/d. This difference might be due to the parallel increment in ME and Cp intake in the current study.

Table 1: Body weight change, feed conversion ratio, and efficiency of blackhead Somali sheep fed GH and supplemented with increasing levels of energy and protein

Body Weight Parameters	Treatments						
	T1	**T2**	**T3**	**T4**	**T5**	**SL**	**SEM**
Initial body weight (kg)	22.4	22.4	21.9	22.1	22.3	ns	0.24
ADBWG (g)	18.9^{d}	60.4^{c}	68.4^{b}	79.4^{b}	95.6^{a}	**	5.87
Final body weight (kg)	24.1^{c}	28.7^{b}	28.7^{b}	29.2^{ab}	30.8^{a}	*	0.42
Total gain (kg)	1.95^{c}	6.31^{b}	6.8^{ab}	7.12^{ab}	8.56^{a}	**	0.29
FCR (g DMI/ g ADBWG)	37.9^{a}	11.3^{b}	11.3^{b}	11.3^{b}	10.2^{b}	**	0.73
FCE (g WG/ g DMI)	0.03^{b}	0.09^{a}	0.09^{a}	0.09^{a}	0.1^{a}	**	0.004

*Means within the same row with different superscript letters differ significantly; * = (P<0.05); ** = (P<0.01); ns = not significant); SEM = Standard error of mean. FCR = feed conversion ratio; FCE = feed conversion efficiency; DMI = dry matter intake; ADBWG = average daily body weight gain, WG=weight gain*

The higher final body weight and average daily gain observed for the supplemented group in the present experiment can be explained by the higher DM and nutrient intake (higher CP and ME) in the supplemented group than the control treatment, which allows more microbial population growth and therefore promotes digestion and making nutrient available to increase weight gain in the current experiment. In addition, the dietary concentrate to roughage ratio in the current study was 0-35.7% which exerted a positive effect on the performance of DMI, ADBWG, and total WG, this finding is in line with HonggjinLiuin *et* al, (2019) which indicate that inclusion of dietary concentrate level from 0- 60%b has a positive effect on DMI and Total weight gain and they concluded that, increases dietary concentrate level improved the growth performance but the optimum level of concentrate to roughage ratio for Taliban Sheep were at 45% of concentrate diet.

Feed conversion efficiency was higher for the supplemented rams (P<0.01) than for the control. However, there was no significant difference (P>0.05) within the different levels of supplementation. The non-significance difference between supplemented groups in FCE may be because of the parallel increasing levels of protein and energy supplements.

Correlation Between Dry Mater Intake, Nutrient Intake, and Body Weight Change in Black Head Somali Sheep

The result of the correlation analysis for the current experiment is given in Table 4. The correlation analysis result of the present study indicated that average daily body weight gain was highly and positively correlated with DM, ME, and CP intake. Similarly, CP intake and ME were positively correlated with TDMI (P<0.01). Total DMI was also positively correlated (P<0.01) with daily body weight gain. This explains that high levels of CP and ME-supplemented groups have higher TDMI and recorded higher body weight gain.

Table 4: Correlation between EMEI, CPI and ADBWG

	EMEI	**CPI**	**ADBWG**
EMEI	1		
CPI	0.75	1	
ADBWG	0.88**	0.91**	1
DMI	0.98**	0.97**	0.87**

*** = (P<0.01); EMEI= Estimated metabolizable energy intake; CPI = crud protein intake; DBWG = daily body weight gain; DMI=dry matter intake*

A positive and high correlation between protein and ADG might indicate that the experimental animals were in a growing stage so they utilized the CP intake efficiently for gain.

Partial Budget Analysis

The partial budget analysis of the current experiment is given in Table 5. The result of the partial budget analysis indicated that the T4 level of concentrate supplementation returned a higher profit margin than the rest of the supplemented groups and control treatments. The treatments were in increasing trend of protein and energy supplement and also increasing level of concentrate intake in dry matter. the net return also increased from the control group (T1) up to T4 and decreased for T5. On the other hand, the sheep fed on the control diet (T1) had a lower net return (-220 ETB) compared with the highest net return level of the supplement (T4) group (2395.6ETB/head). On the contrary, the net return from the high level of supplementation (T5) gets lower than the T4, however, the total body weight gain of T5 was greater than T5. This might be due to the proportion of GNC increasing with increasing levels of ME and CP in the diet and T5 consumed a higher kg of GNC nearly 26 kg during the experiment period. Since the cost of GNC is more than 22.00ETB/kg as compared to 5.5, 10, and about 10 ETB for hay, BDG, and WB, respectively, therefore the high cost of GNC turned down the profitability of the treatment with higher level of CP and ME supplementation.

Table 5: Partial budget analysis of experimental feeds

Parameters	**Treatments**				
	T1	**T2**	**T3**	**T4**	**T5**
Purchase price of rams (ETB/head)	1780	1780	1450	1580	1730
Total hay consumed (kg/head)	68.8	59.6	58.3	58.7	60
Total mixed concentrate consumed (kg/head)	0	19.5	23.1	29.2	34.8
GNC consumed (kg/head)	0	2.29	6.3	14.6	25.6
BDG consumed (kg/head)	0	12	5	4.9	3.6
WB consumed (kg/head)	0	5.2	11.7	9.8	5.7
Total cost for GH	430	372.5	364.4	366.9	375
Total cost for GNC	0	51.53	141.75	328.5	576
Total cost for BDG	0	120	50	49	36
Total cost for WB	0	52	117	98	57
Total feed cost	430	596.15	673.15	824.4	1044
Total cost	2210	2376.15	2123.15	2404.4	2774
Selling price (ETB/head)	2000	4000	4000	4800	5100
Gross return (ETB/head)	220	2220	2550	3220	3370
Net return (ETB/head)	-210	1623.85	1876.85	2395.6	2326
Δ NR	-	1833.85	253	518.75	-69.6
Δ TVC	-	166.15	77	151.25	219.6
MRR (Ratio)	-	11.03732	3.285714	3.423	-0.317
MRR (%)	-	1103.732	328.5714	342.98	-31.694

**The current market cost for the feed ingredients were 22.5, 10, 10, and 5.5* ETB *for GNC, WB, BDG, and Hay respectively.*

The marginal rate of return (MRR) for the current experiment by the current feed ingredient and the market cost was 11.04, 3.29, 3.42, and -0.317 for T2, T3, T4, and T5, respectively. This means that 1 ETB on feed additional cost increment for T2 compared to the control treatment resulted in an 11.04 Birr return. Similar to T2, T3 and T4 had also positive returns. T4 has the highest and optimum return in the current experiment. An additional 1 ETB increment in T4 compared with T3 resulted in a 3.29 ETB return. But T5 has resulted in a negative return compared to T4, for each ETB increment in T5 there was a loss of 0.317 ETB compared to T4.

The net return of T4 was higher than the net return of T2, T3, and T5. The difference in the net return was due to the difference in the feed ingredient or proportion of the three feeds in each treatment, which can be affected by the difference in body weight gain and feed cost for the different feed ingredients. The proportion of GNC inclusion increases from T2 to T5 in an increasing trend. The current market cost of GNC is more than two times the cost of DBG and WB. The high inclusion rate of GNC in the treatments tends to decrease the net return of T5 than T4.

Therefore, from the current feed ingredient, the optimum point from an economic point of view was T4.

Rams fed on the higher level of supplementation (T5) have better body weight gain than T5 but have lower MRR. This might be due to the higher amount of GNC consumption. Even though rams in the higher level of concentrate supplementation had recorded higher performance in body weight gain, it was not found to be economically feasible compared to rams supplemented with the T4 level of supplement. this indicates that T4 was more profitable and economically feasible than the other Treatments and control groups.

The current study suggested that supplementation of sheep fed on GH 281 g DM per day concentrate mixture (consisting of GNC, WB, and DBG) that provides 28.5 % CP and 3.6 MJ, ME is potentially more profitable and economically beneficial than the other level of supplements and the control group with current market price of the feeds used.

Conclusion

The present study was carried out to assess the impact of increasing the level of energy and protein supplementation on feed intake, and growth performance and to determine the economically feasible level of energy and protein supplementation for fattening of Blackhead Somali sheep fed on native grass hay basal diet. Experimental animals fed on grass hay only have positive daily body weight gain. This indicates that the grass hay offered in this experiment had better nutritive value which gives more nutrients than the maintenance requirement. This is because of the harvesting time and drying method of the grass. Therefore, grass harvested from November to December around Harmaya University and dried under a shed without leaching has better feeding value. Higher ($P<0.01$) average daily body weight gain (95.64) was recorded in sheep supplemented with the highest level of ME and CP than the other treatments. Heavier lean meat weight and higher Rib eye muscle area ($P<0.01$) were observed at high levels of energy and protein supplementation.

Control treatments had significantly lower ($P<0.01$) dressing percentage than the supplemented treatments with no significant difference ($P>0.05$) among the supplemented groups. Dry matter intake was positively and significantly ($P<0.01$) correlated with EMEI and CPI. Correlation analysis of hot carcass, rib-eye muscle area, lean, and fat showed significant ($P<0.01$) and positive association with body weight parameters

Supplementing with increasing levels of dietary energy and protein level from the current feed ingredients (Wheat bran, Ground nut cake, and Brewery dried grain) has a parallel positive effect on Feed intake, body weight gain, and different carcass parameters. Hence grass hay only is not enough to gain the expected sheep fishing parameters, supplementing with agro-industrial by-products with an appropriate ration formulation guide will help to increase the fattening efficiency of sheep

The result of the current study suggested that supplementation of sheep fed on GH 281 g DM per day concentrate mixture (consisting of GNC, WB, and DBG) that provides 28.5 % CP and 3.6 MJ, ME is potentially more profitable and economically beneficial than the other level of supplements and the control group with current market price of the feed ingredient currently used.

Recommendation

Thus, from this study, it could be recommended that treatment four with the supplementary level of 281 g DM per day concentrate mixture (consisting of GNC, WB, and DBG) that provides 28.5 % CP and 3.6 MJ, ME is potentially more profitable and it could provide a higher economic return to the urban and peri-urban feedlot sheep producers, who have access to agro-industrial by-products feeds. The output of the present study could be used as an alternative feeding package for small ruminant production in the country. This study could also serve as a benchmark for further studies on the effect of different levels of energy and protein supplements on small ruminant's productive performances. Since the biologically optimum level was higher than the recommended level in the current experiment, further studies on alternative feed ingredients in place of GNC, which was solely responsible for the high cost at a high level of supplementation is recommended. The following could be areas for further research work.

- Based on the results of the present study, further researches are recommended by using more detailed levels of energy and protein supplementation (different proportions of energy and protein) by using different feed sources for supplement and basal diets.

- The effect of different levels of energy and protein mixes at the different physiological statuses of Black Head Somali sheep should be considered.
- Studies on the supplementation of different CP levels and ME at different ages in the current and other indigenous sheep breeds are recommended.

Contribution by Authors

Equal contribution. All authors declared that 'written informed' consent was obtained from the approved parties for the publication of this article and accompanying images.

Conflict of Interests

There is no conflict of interest.

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