Performances of Arsi-Bale Sheep Fed on Lentil Straw with Various Levels of Concentrate Supplementation

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የምስር ገለባን ያለገደብ ከተለያየ መጠን የድጎማ መኖ ጋር የአርሲ-ባሌ በጎችን በመመገብ በዕድገታቸውና በስጋ ምርታቸው ላይ በሚያመጣው ለውጥ መሰረት አዋጭ የሆነዉን የድጎማ መኖ መጠን ለመለየት ይህ ሙከራ ተሰርቶ ነበር፡፡ የድጎማ መኖው መጠን 250, 300, 350, 400 እና 450ግራም, በቅደም ተከተል ለተጠኚ 1፣ 2፣ 3 ፣ 4 እና 5 ነበር፡፡በጎቹ በነበራቸው የመነሻ ክብደት ልዩነት መሰረት እያንዳንዳቸው ቡድኖች አምስት በጎች ያሉት በ7 ድግግሞሽ ተጠኝዎቹ ሁሉም ዓይነት የበግ ክብደት ላይ በእኩል ዕድል እንዲያርፉ ተደርጎ ለ84 ቀኖች ሙከራው ተሰራ፡፡ በዚሁ መሰረት በተካሄደው ጥናት 400 እና 450 ግራም የድጎማ መኖ የተሰጣቸው በጎች ያሳዩት የሰውነት ክብደትና የስጋ ምርት ከሌሎቹ የተሻለ ሲሆን ለአንድ ኪ/ግ ክብደት የወጣው የመኖ ዋጋም ዝቅተኛ ነበር፡፡ በመሆኑም የምስር ገለባንና 400-450 ግራም የድጎማ መኖ በማብላት የአርሲ-ባሌ በጎችን ማድለብ አዋጭ ሊሆን ይችላል፡፡

Abstract

This experiment was conducted to evaluate the growth performance and carcass yield of Arsi-Bale sheep fed on lentil straw with concentrate supplementation. The dietary treatments were: lentil straw with concentrate supplement at 250 (T1), 300 (T2), 350 (T3), 400(T4) and 450 (T_5) g lamb/day. Thirty-five yearlings Arsi-Bale lambs with initial body weight of 20.8±1.5 kg (mean ± SE) was randomly allotted to the treatments in randomized complete block design. The concentrate levels had significant ($P< 0.05$) effect on total DM intake with higher value in T3 (791.1), T4 (782.6) and T_5 (826 g) than T_1 (720.2) and T_2 (735g) groups. The highest ($P< 0.001$) average daily live weight gain was attained by lambs in T_4 (78 g) and T_5 (84g). Feed conversion efficiency increased ($P< 0.001$) with increase in the concentrate amount. Lambs supplemented 350, 400 and 450g concentrate had higher ($P< 0.05$) carcass weight (10.6-11.4 kg) than those supplemented 250 and 300g concentrate. The dressing percentage (42%) observed for T_4 and T_5 lambs was higher ($P< 0.05$) than the other groups (37.9-40.1%). The feed cost (birr/kg gain) in T_1 (111) and T_2 (97), were higher ($P< 0.001$) than that of other treatments (67-80 birr/kg gain). It can be concluded that 400-450g of concentrate is the optimum level, for improved feed consumption, live weight gain, FCE, feed cost per unit of live weight gain and carcass yield of Arsi-Bale sheep fed on lentil straw as roughage source.

Keywords: Lentil straw, Concentrate, Arsi-Bale sheep, Carcass

Introduction

Inadequate and poor-quality feeds is among the common production constraints that lower birth weight, growth rate and slaughter body weight of sheep and ultimately affecting profitability of sheep farming. According to Abdi *et al* (2019) report in Ethiopia, most sheep are slaughtered at age of one year with average live weight and hot carcass weight ranging between 18-20 and 8-9 kg, respectively, while the corresponding values adult age were 20-21 kg and 9 kg. However, the sheep can grow faster (attain compensatory growth) if provided with a better diet before attaining their mature live weight. A short-term sheep fattening activity is undertaken in different parts of Ethiopia to improve the low slaughter weight of sheep for marketing.

Though indigenous sheep breeds are genetically limited to give enough production, there are indicators for improved productivity through improved husbandry management. For example, as Ayele and Urge (2019) reviewed Ethiopian yearling indigenous sheep breeds fed with various supplementations increased 16 to 126 g live weight per day and gave 7 - 18 kg and 31% -52% carcass weights and dressing percentages, respectively. However, lack of improved sheep production technologies and unwise utilization of available feed resources are also causing for low sheep production and productivity. Decreased community grazing land and increased cropping intensity have created a big gap between feed demand and supply.

There is a need to improve utilization efficiency of available feed resources and to exploit the genetic potential of a sheep at large. Lentil rank 5th among the most important pulses in the world as it's rich in protein for rural poor households inaccessible to animal source foods (FAO, 2014). Lentil cultivation is expected to increase rapidly in the future due to its demand for consumption and agronomic ability to assimilate atmospheric nitrogen (Singh *et al.*, 2011). In Ethiopia the productivity of lentil is 1.19 tons per hectare, which is the highest yield (1.2 t/ha) recorded from the world (Geja, 2019). Thus, the availability of lentil straw is not a problem to use it for sheep feeding. Studies showed that lentil straw contained 7.0, 0.23 and 0.14% of CP, Ca and P, respectively (FAO, 2014).

Lentil straw has better degraded in the rumen of large ruminants and sheep as compared to routinely used cereal straws (Abbeddou *et al*., 2011), however, it has high fiber and low CP contents (Lardy and Atnderson, 2009). Feeding lentil straw by itself is not enough to get the required production from sheep. The animals need be augmented with energy and protein rich concentrates when maintained on lentil straw-based feed. Concentrate supplementation improves the performances of animal on low quality feeds by favoring an ideal environment for rumen microbes and improves fermentation, digestion and absorption (Santra and Karim, 2002). Therefore, this study aimed to compare performances of yearling sheep fed on lentil straw with different levels of concentrate supplementation.

Materials and Methods

Description of the study area

The experiment was conducted at sheep research station of Debre Zeit Agricultural Research Centre, located at 45 km South East of Addis Ababa (08°44'N 38°,58'E; average altitude of 1900 m a.s.l), Ethiopia. The area is known for bimodal rainfall pattern with average annual rainfall of 845 mm and annual minimum and maximum temperature of 10 and 22°C, respectively (Ref). The area is characterized by mixed-crop livestock production system with major crops grown include Tef (*Eragrostis Tef*), wheat, chick pea and lentil.

Experimental animals, diets and design

Thirty-five yearling male Arsi-Bale sheep were purchased from the local market, ear tagged and injected with Ivermectin and Oxyteteracycline for parasite and shipment stress, respectively. The experimental animals were also vaccinated against Sheep Pox and Ovine pasteurellosis. The animals were randomly assigned to 7 groups (blocks) of five animals each using initial body weight taken after overnight fasting at the end of 21 days adaptation period. The average initial body weight of experimental animals was 20.8±1.5 kg (mean ± SE). The lambs were randomly allotted to five dietary treatments with seven lambs per treatment, in randomized complete block design, and managed in individual pen.
The treatments were:

T_1 = 250g as feed-based concentrate feed supplement;

T_2 = 300g as feed base concentrate feed supplement;

T_3 = 350g as feed base concentrate feed supplement;

T_4 = 400g as feed base concentrate feed supplement and

T_5 = 450g as feed base concentrate feed supplement

Concentrate feed was formulated from 39% wheat bran, 40% noug seed cake, 20% ground maize grain and 1% common salt, on DM basis, and contained19.6% CP. All animals were fed lentil straw *ad lib* (at 20% refusal) and concentrate was given in equal portion twice daily at 8 am and 2 pm. Tap water was freely accessed.

Feed intake, growth and feed conversion efficiency

Data on feed offer and refusal were taken daily, and the feed intake was calculated as the difference between feed offered and refused. While live weight was measured at fifteen-days interval after overnight fasting using a movable weighing scale. The average daily body weight gain was calculated as the difference between initial and final live weights divided by the number of experimental days. Feed conversion efficiency (FCE) of the lambs was determined as average daily body weight gain divided by average daily DM intake.

Digestibility trial

Digestibility trial was conducted on three lambs per treatment. Animals were adapted to fecal bags for three days, followed by collection of a done for seven days. The daily fecal output was measured and 10% sampled for each lamb in plastic bags. All samples were freezed at -20°C until used for chemical analysis.

Carcass evaluation

At the end of the feeding trial four animals were kept in fasting overnight then slaughtered for carcass evaluation. Hot carcass weight and non-offal components were measured immediately after slaughter. The carcasses were chilled at 4˚C for 24 hours for proper cutting and weighing and then the rib-eye muscle was measured. Cold carcass was cut between the 12^{th} and 13^{th} ribs perpendicular to the backbone to measure the area of the rib-eye muscle. The transparency paper was placed on the area of rib-eye muscle first then sketch by pencil and the area again sketched from transparency paper on 0.25 cm^2 gridded paper. The number of squares counted in the area was multiplied by 0.25 cm^2 and the value taken as rib eye muscle area. Dressing percentage was calculated on the basis of slaughter body weight: Hot carcass weight /Slaughter body weight X 100

Feed cost analysis

Feed cost per unit live weight gain was determined dividing feed cost by body weight gain of the respective treatment.

Laboratory analysis of samples

Laboratory analysis of experimental feeds for dry matter, Ash, Nitrogen, Neutral detergent fiber, acid detergent fiber and acid detergent lignin contents were determined using AOAC official methods (AOAC, 2005). DM for feed offered and refusal samples was determined by oven drying of the samples at 105 ^{0}C to constant weigh. Nitrogen was determined using kjeldhal`s procedure then N was multiplied by 6.25 to find crude protein content. The fiber analysis for NDF, ADF and ADL was done according to (Van Soest *et al.*, 1994).

Data analysis

Data was analyzed using SAS software program (SAS, 2003). Mean comparison was done using Duncan's multiple range test and significant differences between the treatment groups were declared at $P<0.05$. The model fitted to calculate the different parameters were:

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

Where: Y_{ij} = Response variables, μ = Over all mean, a_i = i^{th} concentrate level effect, B_j= j^{th} body weight effect, E_{ij} = Effect of the ij^{th} random error

Results and Discussion

Nutrient composition of feeds

Results of chemical analysis of experimental feed ingredients and refusals are presented in Table 1. The dry matter (DM) and crude protein (CP) content of offered lentil straw was 91 and 7.38%, respectively. The contents of neutral detergent fiber (NDF), acid detergent fiber (ADF) and acid detergent lignin (ADL) of lentil straw was 63.94, 59.45 and 14.61%, respectively. As reported by FAO (2014), the DM, CP, NDF, ADF and ADL content of lentil straw was 92.1, 7.0, 60.6, 39.8 and 9.7%, respectively. The DM, CP and NDF contents of the present lentil straw were similar, while ADF and ADL contents were higher compared to that of previous report.

Roughages with crude protein content greater than 7% DM can satisfy the requirements of rumen microorganisms (Lopez *et al.*, 2005). However, the minimum protein level required for sheep maintenance is about 8% (Gatenby, 2002). The chemical analysis result of the previous and the present data showed that lentil straw alone cannot satisfy the nutrient requirement of sheep for production, indicating that supplementation of energy and protein rich concentrate is required. In line with this, Santra and Karim (2002) stated that concentrate supplementation improves sheep productivity by providing ideal environment for rumen microbes for fermentation, and nutrient digestion and absorption.

Table 1. Nutrient composition of experimental feed ingredients and lentil straw refusals

Sample	DM	CP	NDF	ADF	ADL
Lentil straw offered	91	7.4	63.9	59.4	14.6
Noug cake	92.1	32.9	36.7	27.1	12.9
Wheat bran	89.3	11.7	44.8	11.7	2.6
Maize	89.0	9.5	37.6	12.5	3.7
Lentil refusal:					
T_1	89.4	7.4	66.2	61.0	16.7
T_2	89.4	8.9	73.1	63.5	16.9
T_3	89.7	8.3	75.0	60.9	15.9
T_4	89.4	8.3	64.6	56.2	15.3
T_5	89.6	8.01	67.9	57.26	16.09

DM = dry matter; CP = crude protein; NDF = neutral detergent fiber; ADF = acid detergent fiber

The result of chemical analysis showed that Noug seed cake contained 92.09% DM, 32.9% CP, 36.75% NDF, 27.06 % ADF and 12.90 % ADL. The value of DM, CP, NDF, ADF, and ADL in wheat bran was 89.34, 11.6, 44.76%, 11.74 and 2.62%, while for maize 88.99, 9.51, 37.58, 12.49, and 3.72%, respectively. And the corresponding values for concentrate mix was 16, 46.76, 17.96 and 5.32%, respectively. The DM content of lentil refusals was similar among the treatments, while less CP content was observed in T_1 left over. The reason could be due to high selection since concentrate supplement (250g) was not enough to meet sheep nutrient requirement. The content of NDF, ADF and ADL of lentil refusal was relatively low in T_4. The observed differences in feed nutrient analysis results between the present and previous studies might be due to difference in environment, methods of trashing, storing facilities, time and method, soil type and lentil variety.

Feed intake

The effect of concentrate levels on the average daily feed DM intake of experimental animals is presented in Table 2. Increasing concentrate level had no effect ($p > 0.05$) on lentil straw intake, however, it increased ($P \leq 0.05$) total feed DM intake, which indicated that concentrate feeding had no replacement effect on lentil straw intake. Numerically, the highest lentil straw intake was recorded for T_1 group. Concentrate consumption increased ($P \leq 0.001$) with its level of offer. Lambs assigned in T3 T_4 and T5, consumed significantly ($P<0.05$) more feed DM compared to lambs in T1 and T_2 groups. The higher DM intake of lambs' observer at higher concentrate level could be due to improved rumen fermentation and lentil straw digestibility with increased supplementation.

Table 2. Average daily dry matter intake of Arsi-Bale sheep as affected by concentrate levels

Treatment	Lentil straw intake	concentrate intake	TDMI
T_1	494.8^a	225.4^e	720.2^c
T_2	465.3^a	270.4^d	735.8^c
T_3	475.6^a	315.5^c	791.1^{ab}
T_4	422.0^a	360.6^b	782.6^{ab}
T_5	420.7^a	405.6^a	826.3^a
Grand mean	456.6	314.1	770.7
P-value	0.1991	<.0001	0.0464
Significance	ns	***	*

Note: TDMI=total dry matter intake; ns=non-significant (($p > 0.05$); *= significant($P<0.05$); ***=significant($P<0.001$)

Lentil straw was dry, steamy and contained high proportion of fiber and lignin, which limited palatability, fermentation and digestion. In line with this, Lardy and Anderson (2009) described that lentil straw has high fiber content like most of other crop residues. The overall mean daily DMI of lamb in this experiment (770.70±64.34g) was lower than DMI of 920g/day (Getahun, 2015), but within the range of 704-843g (Getahun *et al.*, 2020) reported for the same sheep breed.

Digestibility of experimental feeds

Table 3 shows the effect of concentrate levels on dry matter, CP and fiber digestibility. The experimental feed DM digestibility (DMD) was differed ($P \leq 0.05$) among the treatments. Experimental feed digestibility in T_3, T_4 and T_5 groups was higher than in T1 and T2 lambs. Numerically, the NDF, ADF and ADL (fibers) digestibility in experimental sheep was better at T_3 groups. As reported by Abebe and Yoseph (2015), Arsi-Bale sheep fed on urea treated barley straw and 400g concentrate showed DMD of 77%, which is higher than the present result. Hirut *et al* (2011) reported DMD of 56% for Hararghe Highland Sheep fed on a basal diet of urea treated maize Stover with 350g concentrate. These differences could be due to sheep breed and feed used.

Table 3. Digestibility (%DM) feeds in Arsi-Bale sheep as affected by concentrate levels

Parameters	Treatment means					Grand mean	*P*-value	Significance
	T_1	T_2	T_3	T_4	T_5			
DM	59^{c}	63^{bc}	69^{a}	66^{ab}	66^{ab}	65	0.0125	*
CP	60	63	64	71	71	66	0.0947	ns
NDF	49	54	58	56	53	54	0.2333	ns
ADF	52	52	55	54	54	53	0.9721	ns
ADL	8	12	28	27	17	21	0.1843	ns

DM =dry matter, CP=crude protein, NDF = neutral detergent fiber, ADF = acid detergent, ADL = acid detergent Fiber; ns=non-significant ((p> 0.05); *= significant(P<0.05)

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Body weight change and feed conversion efficiency

The effect of concentrate levels on body weight change and feed conversion efficiency (FCE) of lambs is presented in Table 4. The initial body weight of experimental animals was similar ($P \geq 0.05$) between the dietary groups. Average final body weight (FW) and daily body weight gain of the animals were higher ($P \leq 0.01$) for lambs in T_4 and T_5 than for $T_{1,}$ T_2 and T_3. Effect of concentrate level was significant ($P \leq 0.01$) on FCE. The lambs in T_4 and T_5 showed superior feed efficiency (0.10) than the other groups. The ADG (84g) of lambs in T5 (450 g) was in the rage (80-90g) reported by Getahun *et al.* (2020) for Arsi-Bale yearling sheep fed on grass hay, sugarcane top silage or hay with 350 concentrate supplements. Ayele and Urge (2019) reviewed that most of the indigenous sheep at yearling age consumed various types of supplement feed attained 18 - 26kg live weight and gained 16 - 126 g/day. Specifically, Arsi-Bale sheep that fed on grass hay *ad lib*, and concentrate at 2% of initial body weight gained 69-104g live weight daily. In this current study the lambs supplemented with 450g concentrate (T_5) attained the highest body weight (28kg), showing that there is a potential to find better live weight at yearling age on various feeding strategies.

Table 4. Average body weight change of Arsi-Bale sheep as affected by different concentrate levels supplement

Parameter	Treatment means					Grand mean	*P*-value	Significance
	T	T	T	T	T			
IBW (kg)	20.6	21.1	20.7	20.6	20.6	20.7	0.8998	ns
FW (kg)	23.6^{c}	25.7^{b}	26.6^{b}	26.9^{ab}	28.0^{a}	26.2	0.0021	**
TWG (kg)	3.7^{c}	4.4^{c}	5.9^{b}	6.8^{ab}	7.4^{a}	5.6	0.0001	***
ADG (g)	43.1^{c}	50.8^{c}	67.3^{b}	78.2^{ab}	84.8^{a}	64.5	0.0001	***
FCE	0.06^{c}	0.07^{bc}	0.08^{ab}	0.10^{a}	0.10^{a}	0.08	0.0001	***

Note: IBW = Average initial body weight; FW = Final body weight; ADWG = Average daily body weight gain; FCE =feed conversion efficiency; ns=non-significant ((p> 0.05); **= significant(P<0.01); ***=significant(P<0.001)

Abdi *et al* (2019) report that most of the indigenous sheep can attained 18-20 kg live weight at their yearling age and 20-21kg at adult age. According to Hirut *et al* (2011), Arsi-Bale sheep fed on urea treated barley straw and 400g concentrate gained 74.82 g live weight daily, which is less than the present finding on similar concentrate level. The trend of body weight across the feeding period is indicated in Figure 1. Lambs allocated to T_1 had the lowest body weight after the first 30 days of feeding, while lambs in T_4 and T5 had consistently increased body weight throughout experimental period.

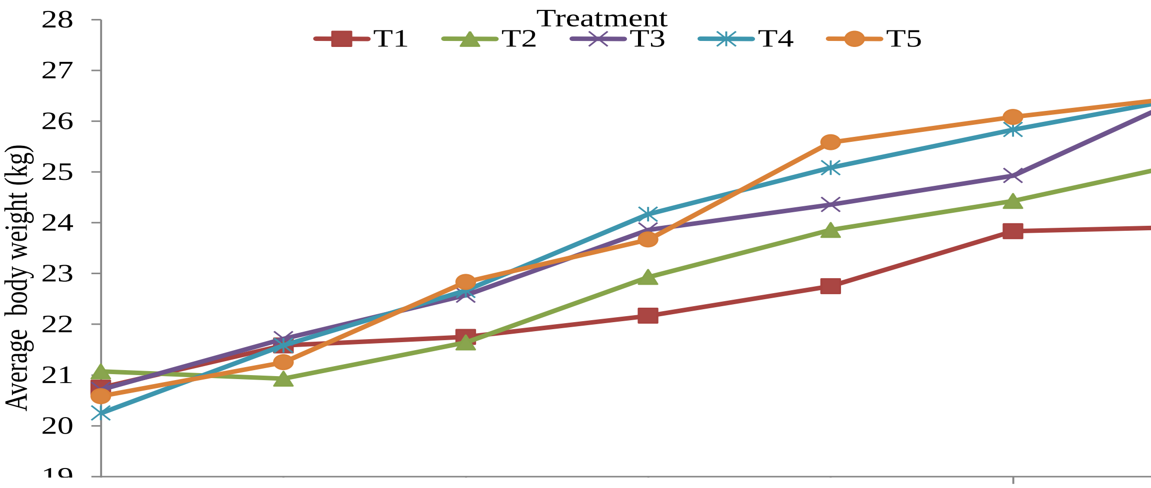

Figure 1. Trends of experimental animals' body weight change as affected by concentrate levels

Carcass characteristics

The effect of concentrate levels on carcass yield is presented in Table 5. The slaughter weight (SW), carcass yield and dressing percentage (DP) of finishing ram lambs varied among the treatments (*P*< 0.05). Experimental lambs in T_3, T_4 and T_5 had higher SW than in T_1 group Carcass weights of lambs in T_3, T_4 and T_5 were higher *(P≤ 0.05)* than that of lambs in T_1 and T_2 categories. The carcass yield (9-11kg) observed in this study was within the range 7-18kg reported for indigenous sheep breeds (Ayele and Urge,2019). According to Abdi *et al* (2019), most indigenous sheep slaughtered at one year of age has average carcass weight between 8-9 kg.

The lowest dressing percentage (37.9%) was recorded for lambs in T_2, while the highest (42.02%; P≥0.05) in T_4 and T_5 groups. Different studies showed that dressing percentage of yearling indigenous sheep breeds fed with various supplementations ranged 31%-52% and specifically, the DP of Arsi-Bale sheep fed on urea treated barley straw with 300-400g concentrate supplement was 36-38% (Ayele and Urge,2019).The slaughter weight and carcass weight of yearling weight of Arsi-Bale ram lambs grazing natural pasture were 12 and 5kg, respectively (Kefyalew *et al.*, 2013), indicating that the productivity of sheep is impaired by insufficient nutrition. The current and previous reports also showed that yearling sheep attain best slaughter weight and carcass yield at higher than lower levels of supplementation.

Table 5. Carcass characteristic of Arsi-Bale sheep as affected by different concentrate levels

Parameters	Treatment					Grand mean	*P*-value	Sig
	T	T	T	T	T			
SW (kg)	23.4^{b}	25^{ab}	26.5^{a}	26.5^{a}	27.3^{a}	25.7	0.0380	*
HCW (kg)	9.4^{b}	9.5^{b}	10.6^{a}	11.1^{a}	11.4^{a}	10.4	0.0199	*
CCW (kg)	9.2^{c}	9.5^{b}	10.7^{a}	10.9^{a}	11.0^{a}	10.3	0.0323	*
DP (%)	40.1^{b}	37.9^{c}	40.1^{b}	42.0^{a}	41.7^{a}	40.4	0.0540	*
REA (cm^2)	17.2	16.4	16.6	16.6	16.6	16.7	0.9940	ns

HCW= Hot carcass weight, CCW= cold carcass weight, CP=Dressing percentage, REA= Rib eye area; ns=non-significant ((*p*> 0.05); *= significant(*P*<0.05)

The areas of rib-eye muscles were not statistically (*P*>0.05) different among the treatments. The higher rib-eye area (16.4-17.2 cm^2) observed in the present experiment was higher than that (5.6-9.5cm^2) reported by Abebe *et al* (2010) Otonie *et al* (2012)] reported that rib-eye areas of the *longissimus dorsi* muscle varies with breed and management, and directly related to the amount of muscle in the carcass.

Non-carcass components of Arsi-Bale sheep as affected by concentrate levels are show in Table 6. The concentrate level had no significant (*P*>0.05) effect on the weight of non-carcass components, except on uro-genital tract. The heaver (*P*≤

0.01) uro-genital tract was recorded in T_4 animal group. The skin weights of for Arsi-Bale sheep in the current study, were higher than the skin weight reported for the same breed (Kefyalew *et al*., 2013), but lower than 2.7kg skin weight reported for Menze sheep supplemented with 352g concentrate supplement (Wude *et al*.,2019). These differences in skin weight of local sheep breeds could be because of the feed type and breed differences. The head, heart and liver weight of sheep in this study was almost similar with previous reports for yearling Arsi-Bale sheep raised on natural pasture grazing (Kefyalew *et al*., 2013).

Table 6. Non-carcass characteristic of Arsi-Bale sheep as affected by concentrate levels

Parameters	Treatment					Grand mean	P-value	Sig.
	T_1	T_2	T_3	T_4	T_5			
Skin (kg)	2.1	2.2	2.3	2.4	2.4	2.3	0.7418	ns
Leg (kg)	0.6	0.6	0.6	0.6	0.6	0.6	0.8918	ns
Head (kg)	1.7	1.2	1.6	1.9	1.9	1.7	0.2867	ns
FGIT (kg)	6.4	7.7	7.2	6.7	6.9	7.0	0.3073	ns
EGIT (kg)	1.7	3.2	2.0	1.9	1.9	2.1	0.4787	ns
Kidney (g)	65	72	75	70	72	71	0.2337	ns
Kidney fat	45	42	50	58	58	51	0.8020	ns
Lung*(g)	327	335	372	335	347	343	0.3719	ns
Heart (g)	97	102	110	102	100	102	0.7362	ns
Liver (g)	327	360	427	382	198	339	0.0798	ns
Spleen (g)	30	42.5	50	35	50	41	0.1692	ns
UGT(g)	297^b	317^b	347^b	350^b	412^a	300	0.0018	**
Tail fat (g)	378.3	329.0	568.0	442.3	740.5	492	0.0669	ns

FGIT = full gastrointestinal truck; EGIT = empty gastrointestinal truck*= Lung with trachea; UGT = Uro-genital track (bladder, penis, urethra and testicles); ns=non-significant ((p> 0.05); **= significant(P<0.01)

Analysis of feed cost

The cost of experimental feeds and feed cost per unit body weight gain are presented in Table 7. Feed cost per kg body weight gain was lower in T_3, T_4 and T_5 than in T_1 and T_2 groups. The highest P<0.001) feed cost per kg live weight gain (111birr/kg gain) was recorded from T_1 lambs. This study showed that supplementation can improve body weight gain and reduce feed cost required to produce a unit amount of live weight. In line with the current study, Abebe and Yoseph (2015) reported that concentrate supplementation was profitable, while feeding hay alone led to economic loss. Arsi-Bale sheep fed on urea treated barley straw and supplemented with 200g concentrate had higher feed costs per unit live weight gain than the group supplemented with 400 g concentrate, (Hirut *et al.*, (2021). Proper supplementation of concentrate is useful to meet the nutrient demand of sheep and improve performances (Umberger, 2009).

Table 7. Feed cost per weight gain as affected by concentrates levels (Birr/lamb/84 days)

Treatment	Feed ingredients' cost				Total feed cost	Cost per kg gain
	Lentil straw	Noug cake	Wheat bran	Maize		
T_1	236.5[a]	69.6[e]	59.4[e]	30.4[e]	396[c]	111.4[a]
T_2	222.4[a]	83.5[d]	71.3[d]	36.5[d]	413.7[c]	97.4[ab]
T_3	227.3[a]	97.4[c]	83.1[c]	42.6[c]	450.5[b]	80.4[bc]
T_4	201.7[a]	111.4[b]	95[b]	48.7[b]	456.8[ab]	69.8[c]
T_5	201.1[a]	125.3[a]	106.9[a]	54.8[a]	488.1[a]	67.9[c]
G mean	218	97	82.8	42.4	440.5	85
P-value	0.1991	<.0001	<.0001	<.0001	<.0001	<.0001
Sig.	ns	***	***	***	***	***

Note: ns=non-significant ((p> 0.05); ***= significant(P<0.001); *P*-value=probability value; Sig.=significance

Conclusion

Meat sheep production on pasture grazing or grass hay-based diet is preferred in many aspects. However, the low availability and high price of grass hay limit its use in sheep fattening. There is a need to look for alternative roughage source such as lentil straw with appropriate concentrate supplementation for a short-term sheep fattening operation. This study has revealed that higher levels (400-450 g) concentrate supplementation improved feed consumption, growth performances, feed conversion efficiency and carcass weight and reduced feed cost per live weight gain in Arsi-Bale sheep fed lentil straw *ad libitum*. Based on the present finding, it can be concluded that 400 to 450g/day concentrate is optimum level of supplementation for Arsi-Bale sheep fed on lentil straw.

Acknowledgment

The authors are grateful to the Ethiopian Institute of Agricultural Research for the financial support to conduct this experiment.

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