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Original Research

Supplementation of Different Level of Corn Silage with Linseed Meal on Performance of Black Head Ogaden Sheep Fed Grass Hay

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Abstract

The experiment was conducted to evaluate the supplementation effect of different level corn silage (CS) with linseed meal (LSM) on performance of black head Ogaden sheep. Twenty five yearling male sheep with a mean initial BW of 14.85±0.31kg were assigned into five treatments in a randomized complete block design. Treatments were grass hay ad libitum + 60 g DM/day LSM alone (T_1) or supplemented with 100 (T_2), 200 (T_3), 300 (T_4) and 400 g DM/day CS (T_5). The experiment contains 90 days feeding and 7 days digestibility trials and carcass evaluation. CP (crude protein) content was 10.0, 8.6, and 30.4% and the NDF content was 76.8, 59.6 and 37.0% DM for grass hay, CS and LSM, respectively. Total DM intake was 575, 637, 695, 765 and 844 g/head/day and was in the order of $T_5 > T_4 > T_3 > T_2 > T_1$ at ($p<0.05$). Total CP intake followed a similar trend to that of total DM intake. The apparent digestibility of CP 72.4% for T_5 was greater ($p<0.05$) as compared to T_1 and T_2. ADG was 50, 65, 70, 80 and 80 g/day for T_1, T_2, T_3, T_4 and T_5, respectively. Among the corn silage supplemented group ADG was lower ($p<0.05$) for T_2 than T_4 and T_5. Hot carcass weight for T_1, T_2, T_3, T_4 and T_5 was 6.03, 7.00, 7.35, 7.97, 8.00 kg respectively and dressing percentage on slaughter BW basis was lower ($p<0.05$) for T_1 as compared to T_3, T_4 and T_5. Marginal rate of return (MRR) was lowest for T_5 (3.64%) and highest for T_2 (22.32%). So considering capital, T_2 with the highest MRR would be recommended as being economical. However, if capital is not the limiting factor, T_4 would be selected since it fetches better net return and is good in inducing better biological performance of animals in terms of ADG and carcass output.

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INTRODUCTION

Small ruminant production is an important agricultural enterprise in Ethiopia and about 25.9 million sheep are estimated to be found in the country, out of which about 73.1 percent are females, about 26.9 percent are males (CSA, 2010). Sheep and goats, are maintained virtually under the traditional subsistence oriented management systems, and constitute an important livestock component in all ecological zones and agricultural systems in the country (CACC, 2003).

According to CSA (2007) the human population in Ethiopia is growing at a rate of 2.5% per annum. Due to the higher demand on the land for the cultivation of food crops, grazing land is rapidly decreasing. Hence, grazing is limited to marginal and over-utilized areas, supplying livestock with low quality feeds. The feed supply is seasonal and shortage of green grass in the dry season is one of the major causes of the drastic decline in livestock performance. As a result, nutritional stress causes low growth rates, poor fertility and high mortality, which is compounded by diseases.

Therefore, it is necessary to look for other alternative source of feedstuff to sustain and improve sheep productivity. In this regard, agro-industrial byproducts could be used as good supplemental source of nutrients. Linseed (*Linumasitatissimum*) meal is one the fuel feed which is a good source of protein more widely available in Ethiopia and around the world (Ørskov *et al.*, 1983; Cheek, 2005; Preston, 2008).

The use of silage as ruminants feed is restricted to institutional farms and certain peri-urban dairy farms, which have large number of dairy stock and substantial hectare of land for feed production. As Adugna (2009) reported, fodder conservation in the form of hay and silage is not common practice in many part of Ethiopia with the exception of the central highland around Addis Ababa. The use of corn silage as sole supplementation or in a mixture with some protein supplement feeds, like linseed meal in the diet of sheep is not so far well evaluated in the country.

In addition to this, the response of Black head Ogaden sheep to these supplements, in feed intake and weight gain were not sufficiently studied and reported. However, silage is one good way of forage conservation during time of plenty and as such forage conservation in a form of silage and using it as supplemental feed in time of feed shortage. In regard of this, any interventions that improve the productivity of sheep and goats should be encouraged in creating wealth and improving the living standard of poor farmers. Therefore, this study was carried out with the objective of assessing the effect of supplementation of different levels of corn silage with linseed meal on fed intake, digestibility, body weight gain and carcass characteristics of Black Head Ogaden sheep fed a basal diet of grass hay.

MATERIALS AND METHODS

Description of Study Area

The experiment was conducted at Haramaya University sheep farm. The University is located 515 km East of Addis Ababa, Ethiopia, at 9°N 42° east. The site is situated at 1950 meters above sea level and has a mean annual rainfall of 790 mm with mean annual temperature of 16 °C (Mishra *et al*., 2004).

Experimental Animals and Management

Twenty five yearling male Black head Ogaden sheep with initial body weight of 14.85±0.31 (Mean ±SD) were purchased from market of Babile woreda. Age of the experimental sheep was determined on the basis of dentition of the sheep and information from the owners. The animals were quarantined for 21 days and during this period they were dewormed by albendazole and dipped with diazinone (acaricide) against internal and external parasites respectively. All animals were also vaccinated against anthrax and ovine pasteurellosis. Before the commencement of the trial the animals were ear tagged for identification purpose. Then the sheep were blocked on the bases of initial body weight in to five blocks and animals in a block were randomly assigned to treatment diet. The experimental animals were used for feeding and digestibility trial that lasts for 90 and 7 days respectively.

Feeds Preparation and Feeding

The silage was made in a banker silo of the university which was cleaned before ensiling the crop. The crop for the silage (maize) was harvested at 80-90 days after planting, was chopped using a chopper, packed using tractors and finally was covered with strong plastic sheet. The crop was ensiled for 60 days before being used for the experiment. The silage was taken daily from silo and offered to the animal.

Grass hay was purchased and used as basal diet. Linseed meal purchased from Assela edible oil factory. Hay, water and mineralized salt blocks were offered to the animals *ad libitum*.

The basal diet intake was adjusted once every three days to adjust *ad libitum* intake. The animals were offered the supplement in two equal halves at 08:00 and 16:00 hours daily throughout the trial period.

Experimental Design and Treatment

The experiment was arranged in a completely randomized block design (CRBD), with five feeding treatments and five observations (animal) per treatment. Treatments were as supplementation of different levels of corn silage as shown below;

T_1: Grass hay *ad libitum* + 60g DM/head/day linseed meal

T_2: Grass hay *ad libitum* + 60g DM/head/day linseed meal + 100 g DM/head /day corn silage

T_3: Grass hay *ad libitum* + 60g DM/head/day linseed meal + 200 g DM/head /day corn silage

T_4: Grass hay *ad libitum* + 60g DM/head/day linseed meal + 300 g DM/head /day corn silage

T_5: Grass hay *ad libitum* + 60g DM/head/day linseed meal + 400 g DM/head /day corn silage

Measurements

Feeding Trial

The feeding trial lasted 90 days following the adaptation period of 15 days. For each animal; hay, corn silage and linseed meal was offered in a separate feeders, and hay was fed at a level to achieve 20% refusal each day, with increase or decreases within three days offering made on the bases of amount of refusal. The daily feed offered to experimental animals and the corresponding refusals were weighed and recorded throughout the experimental period. Daily feed intake was determined as difference between the amounts of feed offered and refused. This was done for both feeding and digestibility trial. A small amount of sample from the offered feeds was taken once in the middle of each week to make a composite of feed sample during the feeding trial. Refusals for the hay and corn silage was sampled by taking a grab sample from each animal daily for seven consecutive days in week six of the feeding trial, and refusal samples were composited per animal and latter pooled per treatments. Animal were weighed at the beginning of the experiment after overnight fasting and at 10 days interval. Average daily gains (ADG) was calculated as differences between final and initial body weights divided by number of feeding days. Feed conversion efficiency was determined as a ratio of g ADG to g DM intake. The substitution rate of the basal feed with the supplement in the supplemented treatment was calculated using the equation given by (Ponnampalam *et al*., 2004).

Substitution rate = (Basal diet DM intake of T_1 - Basal diet DM intake of the supplement)/Supplement DM intake

Where, T_1 is treatment 1 or the control treatment.

Digestibility Trial

The digestibility trial was conducted after the feeding trial on the same animals. The sheep were accustomed to carrying fecal collection bag for three days. Apparent digestibility was determined by total fecal collected after adjustment period. Fecal output was collected and weighed daily per animal separately for seven days, and a 10% subsample was taken from each animal, frozen at -20^{0}C and composited for subsequent chemical analysis. The samples of feces were partially dried at 60°C for 72 hours in a forced draft oven, ground to pass 1 mm screen and stored in airtight polyethylene bag until analyzed. A daily grab sample of feed offered and refusals from each feed and from each animal respectively were sampled during the 7 days digestibility trial and composited for chemical analysis. Refusal samples were pooled per treatments. The apparent digestibility coefficients of nutrients were calculated by using the following equation.

DC (%) =(Total amount of nutrients in feed – Total amount of nutrient in feces) x 100/ Total amount of nutrients in feed

Carcass Characteristics

At the end of the experiment, all animals were slaughtered for carcass evaluation. The animals were decapitated and blood drained into bucket then weight of blood was measured. Animals were flayed by gentle tearing of the skin from the carcass to ensure that fat and muscle tissue did not adhere on the skin.

The head was separated at its articulation with the atlas and feet cut off at the proximal end of the canon bones, leaving the carpals and tarsal with the carcass. Weights of offal were recorded.

The empty body weight was calculated as gut content deducted from slaughter weight. Total edible offal components (TEOC) were taken as the sum total of abdominal fat, blood, heart, empty gut, liver, kidney, kidney fat, testis, and tongue. Total non-edible offal components (TNEOC) were considered as the sum of head without tongue, gall bladder, lung with trachea, penis. Dressing percentage was calculated as proportion of hot carcass weight to slaughter weight and empty body weight.

The rib-eye muscle was chilled for 12 hours in a refrigerator for proper cutting. Both the right and left halves were cut between the 12^{th} and 13^{th} ribs perpendicular to the backbone to measure the cross-sectional area of the rib-eye muscle traced first on transparency paper then putted on the square paper Each piece of square having an area of 0.25 cm^2 and then the numbers of squares included in that area were counted and multiplied by 0.25 cm^2.

Chemical Analysis

According to Rymer (2000) silage is particularly at risk from loss of volatile substances by oven drying, also drying at too high temperature may also affect the estimation of fiber digestibility. Thus, as silage had high moisture content and freeze dryer was used to dry the sample at vacuum pressure of 770 mm Hg and determine the dry matter (DM) content. All feed offered, refusals and feces were subjected to laboratory analysis for DM, ash and crude protein (CP) content according to AOAC (1990). Neutral detergent fiber (NDF), acid detergent fiber (ADF) and acid detergent lignin (ADL) were analyzed following the procedure of Van Soest and Robertson (1985). The metabolizable energy (ME) value of treatment feeds was estimated from the digestible OM content of the feed using the equation formulated by (McDonald *et al.,* 2002), as

ME (MJ/kg DM/day) = 0.0157 × DOMI,

Where; DOMI = digestible OM intake (g/kg DM)

Statistical Analysis

Data on feed intake, body weight change, digestibility and carcass characteristics were analyzed by employing analysis of variance using the general linear model (GLM) procedure of SAS (1998). Treatment means were separated using the least significant difference. The model used for data analysis was;

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

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

RESULTS AND DISCUSION

Chemical Composition of Feed Stuff

The chemical composition of experimental feed and refusals are shown in Table 1. The DM content of the hay used in the present study was comparable to that reported previously (Getachew, 2005; Simret, 2005; Abebaw, 2007 and Biru, 2008). The dry matter content of a green crop harvested for hay depends on many factors, but mainly ranges about 65-80%, tending to fall as the plant matures (McDonald *et al.*, 2002). The moisture level will then be decreased up on drying the material to preserve it in a form of hay. Generally, the dry matter content of forage in the tropics is high throughout most of the year (Payne and Wilson, 1999).

The 10.03% CP content of hay in this experiment is an indication that the hay was of good quality and is above the 7-7.5% CP required for microbial protein synthesis in the rumen and to support at least the maintenance requirement of ruminants (Van Soest, 1982). The CP content of hay used in this study was higher than the 7.02 and 6.75% reported by Abebe (2006) and Abebaw (2007), respectively, and was comparable with the 9.26% reported by Wondewsen (2010). Differences in the nutritive value of hay including CP content obviously depends on different factors, such as species composition of the harvest the hay is made from, stage of maturity up on harvest and the growing environment (Chrenková, 2006). The NDF and ADF content of hay is reasonably high and values of the current study were comparable to that reported previously (Getachew, 2005; Fentie, 2007; Jemberu, 2008).

Silage is forage preserved under anaerobic conditions, and may contain a high moisture content of 50% to 85% (Collins and Moore, 1995), and the moisture content of the corn silage used in this study was within this noted range. According to Čerešňáková (2006) corn silage has 36.2% DM, 7.86% CP, 44.2% NDF, 23.11% ADF and 95.6% OM, and these values appeared to be comparable to the ones obtained in this study.

In a three years study the DM content of corn silage ranged 28.5-40.5% and averaged 34.7, 33.5 and 31.3% for year 1, 2, and 3, respectively. Utley (1973), which were comparable to the 34.9% DM noted in the current study. However, low DM content (26.5%) was reported for fresh maize silage (Bowden *et al.*, 1980), may be due to the stage of maturity at which the crop for silage was harvested. Similar to the current result Perry and Olson (1975) noted that the CP content of corn silage to be low, usually being less than 10% DM. Generally, DM and nutrient content of silages may vary depending on factors such as species of the crop used, stage of maturity up on harvest, variety and environmental conditions (Payne and Wilson, 1999; Bernard, 2004). Payne and Wilson (1999) noted that different or same forage species in different climatic environments may bring different chemical analysis results, despite the same cutting intervals as the species may be at different stages of growth at different periods within the same season.

The current result showed that linseed meal is rich in CP and less in fiber. Protein and other nutrients content of the linseed meal varies depending on the type of processing method employed. Bell and Keita (1994) noted values of 34.3% CP, 26.68% NDF, and 16.77% ADF for linseed meal which is somewhat comparable to the result of the present study. According to Abebe (2006), linseed cake is nutritionally composed of 26.7% CP, 39.9% NDF, 18.52% ADF and 5.9% ADL, in which the CP level appeared to be somewhat lower than the values obtained in this study.

The DM, Ash, OM, CP, and NDF content of the hay and corn silage refusals were relatively similar to that of the offer. Sheep are intermediate bulk and roughage feeders (Van Soest, 1982) with little ability to select a diet quality better than the average on offer. Thus, from the dietary and refusal chemical analysis value, it appeared that selectivity by animals to be minimal.

Table 1: Chemical Composition of treatment diets and refusals

Feed offered	DM (%)	Ash (% DM)	CP (% DM)	NDF (% DM)	ADF (% DM)	ADL (% DM)
Grass hay	92.87	9.76	10.03	76.83	46.58	8.53
Corn silage	34.9	5.73	8.58	59.58	37.83	7.49
Linseed meal	92.11	8.12	30.40	37.00	11.08	5.47
Corn Silage Refusal						
T_3	36.5	5.92	8.28	64.74	41.93	7.98
T_4	36	6.89	8.13	63.74	40.90	7.63
T_5	35	6.49	8.28	60.47	37.42	9.90
Grass Hay Refusal						
T_1	92.82	10.14	9.578	77.26	47.53	9.69
T_2	92.91	9.98	9.581	76.75	49.03	9.70
T_3	92.42	10.51	9.99	77.79	47.53	8.51
T_4	92.55	10.63	8.286	77.61	46.46	8.63
T_5	91.99	10.21	8.7	77.20	49.98	10.48

ADF = acid detergent fiber; ADL = acid detergent lignin; CP = crude protein; DM = dry matter; NDF = Neutral detergent fiber; T_1 = Grass hay *ad libitum* + 60 g DM/day linseed meal; T_2 = Grass hay *ad libitum* + 60 g DM/day linseed meal + 100 g DM/day corn silage; T_3 = Grass hay *ad libitum* + 60 g DM/day linseed meal + 200 g DM/day corn silage; T_4 = Grass hay *ad libitum* + 60 g DM/day linseed meal + 300 g DM/day corn silage; T_5 = Grass hay *ad libitum* + 60 g DM/day linseed meal + 400 g DM/day corn silage

Dry Mater and Nutrient Intake

Hay DM intake was significantly higher (p<0.05) in corn silage non-supplemented sheep than those supplemented with corn silage (Table 2). This is due to the positive substitution of the hay with corn silage, in part associated with the limited capacity of the gut to consume more hay as the corn silage is low in DM content. Feed intake varies among breeds independently of body weight, and also water content or the free water on forage may affect the total quantity of feed consumed (Payne, 1969).

Many factors affect feed consumption by animals, including test, odor, physical texture, and chemical composition of the diet may alter feed intake (Pond and Pond, 2000). Generally, the hay although was good in terms of crude protein was high in NDF content, which is a major factor in limiting voluntary intake (Waldo, 1986). However, Oba and Allen (1999) proposed that cows fed more degradable NDF consume additional digestible NDF, because the NDF fraction is more readily degraded, thus leaving the rumen at a greater rate and facilitating greater DM and NDF intake. Greater intake of hay DM for non-supplemented, than concentrate supplemented animals has been noted before (Bimrew, 2008).

Total DM intake was greater (p<0.05) for the corn silage supplemented than non-supplemented sheep, and was in the order of T_5> T_4> T_3> T_2> T_1. This was due to increasing level of corn silage intake with increase in the supplemental level of corn silage. Forbes (2007) noted that there is positive relationship between the DM content of silage and its intake by ruminants. The total DM intake in this study was similar to that reported for Adilo sheep fed grass hay alone and supplemented with 125, 250, 375 g/head/day mixtures of sweet potato tuber and haricot bean screenings (Biru, 2008).

Intake of total OM and CP as well as ME followed a similar trend to that of total DM intake, and as such increased with increasing level of corn silage supplementation. The higher level of energy in corn silage than the hay was apparent from greater differences in ME intake among treatments in this study. On the other hand, despite the lower CP level in corn silage than the hay used in the current study, intake of CP increased with rise in the level of supplemental corn silage, indicating that improvements in total DM intake to be a major factor to greater intake of nutrients by sheep in this study. The total DM intake as a percent of body weight was within the expected range of 2 - 4% (Susan, 2010) and was in the order of T5 > T_4 = T_3> T_2 = T_1 (p<0.05). The results obtained were higher than the values of 2.75 - 3.00% BW intake for Arsi-bale sheep fed grass hay basal diet supplemented with concentrate mixed with *Sesbaniasasban* (Wondewsen, 2010) and lower than the 3.3 - 4.3% BW intake reported by another study (Biru, 2008).

Apparent Dry Matter and Nutrient Digestibility

The apparent digestibility of DM, OM, CP and NDF were greater (p<0.05) for the highest level of corn silage supplemented group as compared to T_1 and T_2, and values for T_3 and T_4 were statistically similar (p>0.05) with all other treatments except for CP digestibility where values for T_1 was less than that of T_3 and T_4 (Table 3). These indicated that the apparent digestibility of nutrient was highly improved when corn silage was used at higher proportions. Digestibility in ruminants is affected by dietary quality (Thomas *et al.,* 1976), quantity (Brown, 1966), physical form (Balch and Campling, 1962), particle size (Forbes, 1986), and passage rate (Van Soest, 1982) of feeds. Particle breakdown is one of the main factors influencing digestion of feed (Welch, 1982) and this depends heavily upon feed types (Wilson *et al*., 1989; Kwak *et al*., 1996). Maize silage has high digestibility and high amount of water soluble carbohydrate characteristics (Bolsen, 1994). Plant cell content is almost completely digestible, while the availability of plant cell walls varies depending on their composition and structure (Buxton and Mertens, 1995), as such may be the reason for improvement in DM and nutrient digestibility with greater amount of corn silage supplementation.

Table 2: Dry matter and nutrient intake of Black head Ogaden sheep fed hay and supplemented with different level of corn silage with linseed meal

Intake (g/day)	Treatment					SEM
	T_1	T_2	T_3	T_4	T_5	
Hay DM	515.25^{a}	477.45^{b}	455.11^{bc}	437.59^{c}	427.15^{c}	10.42
Corn silage DM	0.00^{e}	100^{d}	180.14^{c}	267.35^{b}	357.00^{a}	2.33
Linseed meal DM	60	60	60	60	60	-
Total DM	575.25^{e}	637.45^{d}	695.25^{c}	764.94^{b}	844.16^{a}	11.46
Total DM (g/kg $BW^{0.75}$)	61.81^{c}	65.70^{c}	71.47^{b}	74.90^{b}	83.36^{a}	1.39
Total DM (% BW)	2.94^{c}	3.08^{c}	3.35^{b}	3.45^{b}	3.86^{a}	0.05
Total ME (MJ/kg DM/day)	5.94^{e}	7.11^{d}	8.07^{c}	8.86^{b}	10.23^{a}	0.20
Total OM	519.86^{e}	579.59^{d}	635.49^{c}	701.89^{b}	777.00^{a}	10.37
Total CP	69.86^{e}	74.58^{d}	79.23^{c}	84.96^{b}	91.59^{a}	1.13
Total NDF	387.46^{d}	447.95^{c}	484.50^{bc}	517.68^{ab}	563.08^{a}	14.61
Total ADF	246.62^{d}	253.69^{cd}	263.65^{bc}	277.27^{b}	294.80^{a}	5.07
Substitution rate	0.00^{c}	0.08^{bc}	0.13^{ab}	0.18^{a}	0.22^{a}	0.020

$^{a-e}$ means with different superscripts in a row differ significantly (P < 0.05); ADF = acid detergent fiber; ADL = acid detergent lignin; BW = body weight; CP = crude protein; DM = dry matter; ME = Metabolizable energy; NDF = Neutral detergent fiber; OM = organic matter; SEM = standard error mean; T_1 = Grass hay *ad libitum* + 60 g DM/day linseed meal; T_2 = Grass hay *ad libitum* + 60 g DM/day linseed meal + 100 g DM/day corn silage; T_3 = Grass hay *ad libitum* + 60 g DM/day linseed meal + 200 g DM/day corn silage; T_4 = Grass hay *ad libitum* + 60 g DM/day linseed meal + 300 g DM/day corn silage; T_5 = Grass hay *ad libitum* + 60 g DM/day linseed meal + 400 g DM/day corn silage

Table 3: Apparent Digestibility Coefficient of Black head Ogaden sheep fed hay and supplemented with different level of corn silage with linseed meal

Digestibility (%)	Treatment					SEM
	T_1	T_2	T_3	T_4	T_5	
DM	72.88^{b}	75.57^{b}	77.49^{ab}	78.04^{ab}	81.16^{a}	1.65
OM	73.16^{b}	75.87^{b}	77.66^{ab}	78.25^{ab}	81.48^{a}	1.64
CP	55.31^{c}	63.31^{bc}	66.86^{ab}	68.37^{ab}	72.44^{a}	2.85
NDF	70.56^{b}	71.34^{b}	73.90^{ab}	74.06^{ab}	78.09^{a}	2.02
ADF	69.21^{b}	73.42^{ab}	74.59^{ab}	74.74^{ab}	78.22^{a}	2.14

$^{a-c}$means with different superscripts in a row differ significantly (P < 0.05); ADF = acid detergent fiber; CP = crude protein; DM = dry matter; NDF = Neutral detergent fiber; OM = organic matter; SEM = standard error mean; T_1 = Grass hay *ad libitum* + 60 g DM/day linseed meal; T_2 = Grass hay *ad libitum* + 60 g DM/day linseed meal + 100 g DM/day corn silage; T_3 = Grass hay *ad libitum* + 60 g DM/day linseed meal + 200 g DM/day corn silage; T_4 = Grass hay *ad libitum* + 60 g DM/day linseed meal + 300 g DM/day corn silage; T_5 = Grass hay *ad libitum* + 60 g DM/day linseed meal + 400 g DM/day corn silage

The percentage digestible DM of feeds of less than 55% is poor quality and will not maintain live weight, whereas feeds exceeding 65% digestibility are generally considered to be of high quality (David, 2007). Thus, values in this study for percentage digestible DM of treatment diets were more than 70%, indicating that the diet was above the maintenance requirement of the animals. This may be presumably due to the relatively good quality of the hay used in this study and partly due to the supplemented dietary linseed meal to all animals in the study which might have improved nutrient supply to ruminal microbes and consequently DM and nutrient digestibility. Although the digestibility of silage was not determined separately in this study, improvements in total DM and nutrient intakes as well as digestibility with silage addition to hay might indicate the good quality or digestibility of the silage. However, silage digestibility may vary on different factors.

Body Weight Change and Feed Conversion Efficiency

The initial body weight (BW), final BW, BW change, average daily BW gain (ADG) and feed conversion efficiency (FCE) of the experimental sheep fed hay and supplemented with different level of corn silage is shown in Table 4. Initial BW was similar (p>0.05) among treatments. Change in BW and ADG was greater (p<0.05) for corn silage supplemented group than the non-supplemented one. Among the corn silage supplemented group BW change and ADG was higher (p<0.05) for T_4 and T_5, and values for T_3 was similar (p>0.05) with other corn silage supplemented groups. FCE on the other hand was greater (p<0.05) for T_4 than T_1, but differences among other treatments were not significant. Differences in BW change and ADG appeared to be consistent with variation in intake and apparent digestibility of DM and nutrients in this study.

Greater ADG in supplemented group could therefore, be associated with more digestible energy and other protein intakes with greater levels of corn silage supplementation, which is in line with previous reports (Matiwos, 2007; Beauchemin *et al.,* 1995; Guru *et al.,* 2008).

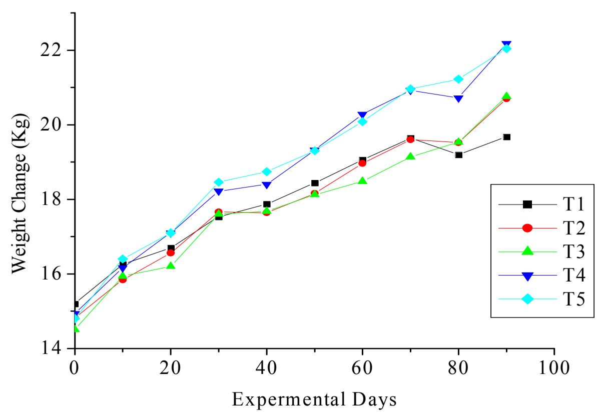
The overall ADG observed in this study was 73.94 g/day, which was comparable with the 70.4 g/day ADG reported for Wogera sheep supplemented with brewer dried grain at 200 g and 300 g DM/day (Mulu, 2005). Fentie (2007) also reported ADG value of 82.4 g/day for Farta sheep supplemented with noug seed cake, wheat bran and their mixture which is similar to the ADG noted for T_4 and T_5. On the contrary, the current result was lower than that observed by Wendewsen (2010) that reported ADG of 96 and 84 g/day when Arsi- bale sheep fed grass hay basal diet was supplemented with 67% concentrate mix and 33% *Sesbaniasusban*, and 33% concentrate mix with 67% *Sesbaniasusban*, respectively. Average daily weight gains of corn silage supplemented sheep in this study were higher than the 62.9 g/day value noted by Bonsi *et al.,* (1996). Comparing value for FCE in the current study with other studies involving supplementation showed that it was higher than the results of Jemberu (2008). Comparisons of results in this and previous studies generally suggest that corn silage may support somewhat comparable level ADG to that of conventional concentrates when supplemented to hay basal diet.

Table 4: Body weight gain and feed conversion efficiency of Black head Ogaden sheep fed hay and supplemented with different level of corn silage with linseed meal

Parameters	Treatments					
	T_1	T_2	T_3	T_4	T_5	SEM
Initial body weight (kg)	15.20	14.82	14.50	14.94	14.80	0.76
Final body weight (kg)	19.69^b	20.70^{ab}	20.76^{ab}	22.18^a	22.04^a	0.52
Body weight change (kg)	4.49^c	5.88^b	6.26^{ab}	7.24^a	7.24^a	0.49
ADG (g/day)	49.87^c	65.33^b	69.55^{ab}	80.44^a	80.44^a	5.47
FCE (g ADG/ g feed)	0.086^b	0.102^{ab}	0.100^{ab}	0.105^a	0.095^{ab}	0.008

$^{a-c}$ means with different superscripts in a row differ significantly (P < 0.05); ADG = average daily gain; FCE = feed conversion efficiency; SEM = standard error mean; T_1 = Grass hay *ad libitum* + 60 g DM/day linseed meal; T_2 = Grass hay *ad libitum* + 60 g DM/day linseed meal + 100 g DM/day corn silage; T_3 = Grass hay *ad libitum* + 60 g DM/day linseed meal + 200 g DM/day corn silage; T_4 = Grass hay *ad libitum* + 60 g DM/day linseed meal + 300 g DM/day corn silage; T_5 = Grass hay *ad libitum* + 60 g DM/day linseed meal + 400 g DM/day corn silage

Trends in body weight change in the current study are shown in Figure 1. Overall there was an increase in body weight with increasing days of feeding. However, it seemed that animal supplemented corn silage show consistent increase in body weight than non-supplemented group over the entire feeding trial. Moreover, T_4 and T_5 show more weight change after day twenty than all other treatment groups. However, T_1 showed a decline in body weight since day seventy.



T_1 = Grass hay *ad libitum* + 60 g DM/day linseed meal; T_2 = Grass hay *ad libitum* + 60 g DM/day linseed meal + 100 g DM/day corn silage; T_3 = Grass hay *ad libitum* + 60 g DM/day linseed meal + 200 g DM/day corn silage; T_4 = Grass hay *ad libitum* + 60 g DM/day linseed meal + 300 g DM/day corn silage; T_5 = Grass hay *ad libitum* + 60 g DM/day linseed meal + 400 g DM/day corn silage

Figure 1: Trends in body weight change of black head Ogaden sheep fed hay basal diet and supplemented with different level corn silage with linseed meal

Carcass Components

Slaughter BW was significantly higher (p<0.05) for T_4 than T_1 and T_2, and T3 was not significantly different from other treatments (Table 5). Empty BW, hot carcass weight (HCW) and dressing percentage on slaughter BW basis was lower (p<0.05) for T_1 as compared to T_3, T_4 and T_5, and T_2 is similar (p<0.05) among each other.

Dressing percentage on empty BW basis was significantly different (p<0.05) for T_1 and T_5 only. Rib eye muscle area was in the order of T_3 = T_4 = T_5> T_2 = T_1 (p<0.05).

The increase in slaughter body weight with supplementation is also reported by Mulu (2005). Empty BW is a function of live weight (Fehr *et al.,* 1976), and as such trends in empty BW appeared to be similar to that of final or slaughter BW. The dressing percentage of many tropical sheep breeds is low and within the range of 40 - 50% (Payne and Wilson, 1999), which is in line with the results of the current study. The degree of muscling as being indicated by rib eye muscle area in the current study was improved by corn silage supplementation except for T_2 as can be expected, although Saikia *et al*. (1996) reported that rib-eye muscle area was not affected in male goats supplemented with low, medium and high energy feeds in contrast to the present study.

Table 5: Carcass characteristics of Black head Ogaden sheep fed hay and supplemented with different level of corn silage with linseed meal

Parameters	Treatment					
	T_1	T_2	T_3	T_4	T_5	SEM
SBW (kg)	19.34^c	20.40^{bc}	20.84^{abc}	22.08^a	21.50^{ab}	0.65
EBW (kg)	13.89^b	15.18^{ab}	15.69^a	16.63^a	16.50^a	0.60
HCW (kg)	6.03^b	7.00^{ab}	7.35^a	7.97^a	8.00^a	0.42
Dressing percentage (%)						
EBW basis	43.24^b	46.08^{ab}	46.86^{ab}	47.24^{ab}	48.35^a	0.19
SBW basis	31.06^b	34.28^{ab}	35.23^a	35.53^a	37.06^a	1.12
REMA (cm^2)	7.40^b	7.11^b	8.24^a	8.06^a	8.00^a	0.30

$^{a-c}$ means with different superscripts in a row differ significantly (p<0.05); EBW = Empty body weight; HCW = hot carcass weight; REMA = Rib eye muscle area; SBW = Slaughter body weight; SEM = standard error mean; T_1 = Grass hay *ad libitum* + 60 g DM/day linseed meal; T_2 = Grass hay *ad libitum* + 60 g DM/day linseed meal + 100 g DM/day corn silage; T_3 = Grass hay *ad libitum* + 60 g DM/day linseed meal + 200 g DM/day corn silage; T_4 = Grass hay *ad libitum* + 60 g DM/day linseed meal + 300 g DM/day corn silage; T_5 = Grass hay *ad libitum* + 60 g DM/day linseed meal + 400 g DM/day corn silage

Non - Carcass Parameters

There was significantly higher (p<0.05) abdominal fat, blood, kidney fat and total edible offal (TEO) for T_4 and T_5 (p<0.05) than non-supplemented sheep (Table 6). There were no significant difference (p<0.05) in heart, liver, tests and tongue weights among treatments. The blood of the animals was noted to account for 3.5% of live weight (Payne and Wilson, 1999), which appeared to be slightly higher than the values in this study of 2.80, 3.05, 3.3, 3.05 and 3.03% BW for T_1, T_2, T_3, T_4 and T_5, respectively. The heavier weight of TEO component in the supplemented sheep indicated that supplementation has a positive effect on the weight of such non-carcass components or may be due to individual differences. In the present study skin and total non edible offal (NEO) components were higher (p<0.05) for T_5 than T_1 (Table 7). Generally most NEO components were not impacted by treatment, and it appeared that supplementation of corn silage may not have notable effect on NEO components.

Table 6: Edible offal components of Black head Ogaden sheep fed hay and supplemented with different level of corn silage with linseed meal

Parameters (g)	Treatments					
	T_1	T_2	T_3	T_4	T_5	SEM
Abdominal fat	24.80^c	34.40^{bc}	58.40^{ab}	73.94^a	75.20^a	8.87
Blood	541.80^b	622.40^{ab}	688.20^a	674.06^a	652.40^a	33.32
Heart	74.16	88.60	73.40	71.46	78.00	6.03
Empty gut	1091.86^b	1234.00^{ab}	1176.60^{ab}	1324.40^a	1237.60^{ab}	80.34
Kidney	46.00^c	53.80^{ab}	49.80^{bc}	49.30^{bc}	55.80^a	1.68
Kidney fat	21.00^c	32.60^{abc}	30.20^{bc}	41.20^{ab}	46.20^a	4.24
Liver	241.16	249.20	264.60	278.96	263.80	16.96
Testis	151.00	170.80	148.00	144.34	162.60	16.07
Tongue	49.87	46.80	47.60	51.28	49.20	2.26
TEO	2241.70^b	2532.60^a	2536.80^a	2708.90^a	2620.80^a	122.09

$^{a-c}$ means with different superscripts in a row differ significantly (P < 0.05); SEM = standard error mean; TEO = total edible offal; T_1 = Grass hay *ad libitum* + 60 g DM/day linseed meal; T_2 = Grass hay *ad libitum* + 60 g DM/day linseed meal + 100 g DM/day corn silage; T_3 = Grass hay *ad libitum* + 60 g DM/day linseed meal + 200 g DM/day corn silage; T_4 = Grass hay *ad libitum* + 60 g DM/day linseed meal + 300 g DM/day corn silage; T_5 = Grass hay *ad libitum* + 60 g DM/day linseed meal + 400 g DM/day corn silage

Table 7: Non edible Offal of Black head Ogaden sheep fed hay and supplemented with different level of corn silage with linseed meal

Parameters (g)	Treatments					
	T_1	T_2	T_3	T_4	T_5	SEM
Feet	412.32	409.40	393.80	429.48	370.40	22.10
Gall bladder	12.62	14.20	11.40	10.96	13.80	1.84
Head without tongue	1214.30	1226.80	1136.20	1147.92	1203.60	44.27
Lung with trachea	221.24^{ab}	219.60^b	244.60^{ab}	236.00^{ab}	254.80^a	11.85
Penis	32.00	41.00	40.20	35.30	41.00	3.45
Skin	1585.50^c	1718.80b^c	1880.00^{abc}	1919.40^{ab}	2098.40^a	121.64
Total NEO	3478.30^b	3629.80^{ab}	3706.20^{ab}	3779.10^{ab}	3982.00^a	767.57

$^{a-c}$ means with different superscripts in a row differ significantly (P < 0.05); NEO = Non edible offal; SEM = standard error mean; T_1 = Grass hay *ad libitum* + 60 g DM/day linseed meal; T_2 = Grass hay *ad libitum* + 60 g DM/day linseed meal + 100 g DM/day corn silage; T_3 = Grass hay *ad libitum* + 60 g DM/day linseed meal + 200 g DM/day corn silage; T_4 = Grass hay *ad libitum* + 60 g DM/day linseed meal + 300 g DM/day corn silage; T_5 = Grass hay *ad libitum* + 60 g DM/day linseed meal + 400 g DM/day corn silage

Partial Budget Analysis

Partial budget analysis of the present study is shown in Table 8. Total return increased with increasing level of corn silage supplementation and was 81, 101, 114, 134 and 146 ETB/ sheep for sheep in T_1, T_2, T_3, T_4, and T_5, respectively. Sheep supplemented with 300 g corn silage (T_4) had higher net return (33.37 ETB/head) followed by T_3 and T_5 and the least net return was for corn silage non supplemented sheep. However, in the present finding no loss of net return in T_1 was observed, which might be due to the supplemental linseed meal and quality hay that resulted in weight gain. Marginal rate of return (MRR) values indicated that each additional unit of one ETB per sheep cost increment resulted in additional 0.22, 0.08, 0.14 and 0.036 ETB benefit for T_2, T_3, T_4 and T_5 respectively.

Table 8: Partial Budget Analysis of Black head Ogaden sheep fed hay and supplemented with different level of corn silage with linseed meal

Variables	Treatment				
	T_1	T_2	T_3	T_4	T_5
Purchase price of sheep (ETB/head)	259	262	254	250	247
Corn silage consumed (kg/sheep)	0.00	25.65	46.45	68.94	92.06
Linseed meal consumed (kg /sheep)	5.85	5.85	5.85	5.85	5.85
Hay consumed (kg/sheep)	49.94	46.05	44.10	42.40	41.39
Total Feed consumed (kg/sheep)	55.79	77.55	96.39	117.19	139.30
Cost of hay (ETB/sheep)	36.95	34.07	32.64	31.38	30.63
Cost of corn silage (ETB/sheep)	0.00	19.23	34.83	51.70	69.04
Cost of linseed meal (ETB/sheep)	17.55	17.55	17.55	17.55	17.55
Total feed cost (ETB/sheep) or (TVC)	54.50	70.85	85.02	100.63	117.22
Gross income (Sell price) (ETB/sheep)	340	363	368	384	393
Total return (TR) (ETB/sheep)	81	101	114	134	146
Net return (income) (TR) (ETB/sheep)	26.5	30.15	28.98	33.37	28.78
Change of net income (∆NI)	0.00	3.65	2.48	6.87	2.28
Change of total variable cost (∆TVC)	0.00	16.35	30.52	46.13	62.72
MRR (%)	-	22.32	8.13	14.89	3.64

ETB = Ethiopian Birr; MRR = marginal ret of return; NI = net income; TR = total return; TVC = total variable cost; T_1 = Grass hay *ad libitum* + 60 g DM/day linseed meal; T_2 = Grass hay *ad libitum* + 60 g DM/day linseed meal + 100 g DM/day corn silage; T_3 = Grass hay *ad libitum* + 60 g DM/day linseed meal + 200 g DM/day corn silage; T_4 = Grass hay *ad libitum* + 60 g DM/day linseed meal + 300 g DM/day corn silage; T_5 = Grass hay *ad libitum* + 60 g DM/day linseed meal + 400 g DM/day corn silage

CONCLUSION

Considering capital, the ration containing 100g corn silage with the 22.32% MRR would be recommended as being economically acceptable as compared to the other supplemented treatments. However, if capital is not the limiting factor, the ration containing 300g corn silage would be selected since it fetches better net return and is also good in inducing better biological performance of animals in terms of ADG and carcass output.

Conflict of Interest

Conflict of interest none declared.

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