2022 SCIENCELINE

Online Journal of Animal and Feed Research

Volume 12, Issue 4: 222-231; July 30, 2022

ISSN 2228-7701

DOI: https://dx.doi.org/10.51227/ojafr.2022.30

PERFORMANCE OF BLACKHEAD OGADEN SHEEP FED DIFFERENT GRASSES (*Chloris gayana*, *Pennisetum purpureum*, *Panicum maximum* AND *Cynodon dactylon*) BASAL DIETS AND THE SAME CONCENTRATE MIXTURE

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Supporting Information

RESEARCH ARTICLE
PII: S222877012200030-12
Received: May 09, 2022
Revised: July 29, 2022
Accepted: July 30, 2022

ABSTRACT: A study was conducted to determine the effect of feeding Rhodes grass (RG; *Chloris gayana*) as treatment 1 (T1), elephant grass (EG; *Pennisetum purpureum* as T2), guinea grass (GG; *Panicum maximum* as T3) and bermuda grass (BG; *Cynodon dactylon* as T4) supplemented with a similar amount of concentrate mixture (CM; wheat bran (WB) and Noug seed cake (NSC) at 67:33 ratio) on performance and economy of fattening of Blackhead Ogaden sheep. The study consisted of a feeding and digestibility trials of 90 and 7 days long, respectively. Twenty-four intact yearling Blackhead Ogaden sheep with an initial body weight (BW) of 15.83±0.04 kg (mean±SD) were used in a randomized complete block design based on their initial BW with four treatments and six replications. All animals received 300 g dry matter (DM) of CM. Nutrient concentration of RG, EG, GG, BG, NSC and WB were 5.5, 8.8, 7.6, 7.9, 24.3 and 14.0% crude protein (CP), and 83.3, 74.5, 75.4, 81.5, 39.0 and 45% neutral detergent fiber, respectively on DM basis. Intake of DM was 696, 700, 719 and 716 g/day (SEM = 0.004) for T1, T2, T3 and T4, respectively and was lowest for T1 and highest for T3. The CP intake was also lowest for T1 (89 g/day), and similar among the other 3 treatments (99-103 g/day). Digestibility of CP and organic matter were highest for T2, intermediate for T3 and T4 and lowest for T1. Average daily gain was in the order of T2 > T3 = T4 > T1 (27, 63, 50 and 45 g/day (SEM = 13.1) for T1, T2, T3 and T4, respectively); whereas hot carcass weight did not significantly differ among treatments (5.7, 6.4, 6.1 and 6.3 kg (SEM = 0.36) for T1, T2, T3 and T4, respectively). Total return, net income and marginal rate of return were all in the order of T2 > T4 > T3 > T1. Therefore, based on biological performance as well as economic return, sheep fed elephant grass perform better. However, variations in performance and economic return among the four grass species needs to be taken cautiously as part of the difference might have attributed to differences in the stage of maturity of the grasses up on harvest for feeding the lambs.

Keywords: Blackhead Ogaden sheep, Digestibility, Feed intake, Performance, Weight gain.

INTRODUCTION

Sheep contributes to a substantial amount to the farm household income, mutton and non-food products (manure, skin and coarse wool). In addition to many other socioeconomic and cultural functions, they are a source of risk mitigation during crop failures, property security, and monetary saving and investment (Dossa et al., 2008). The productivity of indigenous sheep breed is low as compared to temperate breeds due to limited genetic capacity and diverse environmental factors. Among environmental factors, the main bottleneck for poor animal production in many African and Asian countries is an insufficient supply and low level of feeding due to a severe feedstuff shortage. Ben Salem et al. (2003) reported that there is a wide gap between the requirements and supplies of nutrients for small ruminants in numerous African and Asian countries. Higher animal density in relation to grazing areas, unreliable rainfall, increasing human population, small land holdings, and declining land productivity are all contributing factors to this gap. In addition to scarcity of feed, sheep productivity is constrained by diseases, lack of infrastructure, market information and trained personnel (Chikwanha et al., 2021; Mengistu et al., 2021).

The major feed resources for small ruminants in Ethiopia are forage from natural pastures, crop residues and agro-industrial byproducts (Duguma and Janssens, 2021; Bayissa et al., 2022). The availability of the major feed resources, however, fluctuates seasonally. The scenario holds true in Somali Region where natural pasture and crop residues are the dominant feed resources for small ruminants and feed shortage is faced during dry seasons (Maleko et al., 2018; Habte et al., 2022). Sheep production in Somali Region is constrained not only by the quantity of available feeds but also by the poor quality of the feed resources (Kenfo et al., 2018). Sheep in the area depend predominantly on high fiber feeds that are deficient in nutrients essential for microbial proliferation and nutrient supply to the animal (Xin et al., 2021; Yang et al., 2021). The implications of such poor nutritional values are slow growth rates, poor fertility, and high rates of mortality and consequently reduced production of livestock (Walsh et al., 2011).

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In Ethiopia, even though poor quality and quantity of feed constrained sheep productivity, most sheep are slaughtered at about 12 months of age with body weights (BW) of 18-20 kg. This shows that there is a scope for improvement by improving the feeding and reproductive management practices and health care management (Kassahun, 2000). One of a feeding management practice is improving the nutritive value of low quality feed resources. In crop livestock production system, the strategy used to upgrade the feeding value of animal feed is feed supplementation. These involve the use of fodder banks, fodder trees, by-products such as oil seed cakes and meals, and urea/ molasses licks. Hay from various species of grasses along with appropriate supplementation can also make sheep perform well. Such a feeding strategy can be a feasible approach for agro-pastoral areas so long as awareness is created. In Fafan area of the Somali Regional State, there are an ongoing works on improved forage grass selection and development, including Rhodes grass (*Chloris gayana*), elephant grass (*Pennisetum purpureum*), guinea grass (*Panicum maximum*) and Bermuda grass (*Cynodon dactylon*). However, the potential of these grass species for sheep performance has not been tested in the area. This study was therefore, aimed to determine the effect of feeding Rhodes grass, Elephant grass, Guinea grass, and Bermuda grass hay supplemented with a similar amount of concentrate mixture on intake, digestibility, growth rate and carcass characteristics of Blackhead Ogaden sheep and evaluate the economics of the feeding regime through partial budget analysis.

MATERIALS AND METHODS

Experimental site

The experiment was conducted at Fafan Agricultural Research Center of the Somali Region Pastoral and Agro Pastoral Research Institute (SoRPARI) located in Somali Regional State, Ethiopia. Fafan is located at 9.08^{0}N and 42^{0}21 E and has an elevation 1600-1700 meters above sea level. The area has a mean annual temperature of 21 ^{0}C and an annual rainfall of 750 mm.

Experimental feeds and feeding

The four basal diets used in this experiment were prepared from Rhodes grass (*Chloris gayana*), elephant grass (*Pennisetum purpureum*), guinea grass (*Panicum maximum*) and local grass (*Cynodon dactylon*). All animals were offered the basal diet *ad libitum* at a refusal rate of 20%. Basal feed offered were adjust once every week ensuring a refusal of at least 20% based on previous week's intake of an individual animal. Each animal received a 300 g DM concentrate mixture per day. The concentrate mixture was composed of Noug seed cake (NSC) and wheat bran (WB) at a ratio of 33:67, respectively. Throughout the experiment, all animals had free access to water and mineral licks.

Experimental animals and management

Twenty-four intact yearling Blackhead Ogaden sheep with an initial body weight of 15.83 ±0.04 kg (mean±SD) were purchased from Jigjiga market. The age of the animals was determined by dentition and by asking the owners. The animals were then quarantined for 21 days in order to observe their health condition. During this time, the experimental animals were dewormed and sprayed against internal and external parasite and vaccinated against common diseases of the area, and animals were ear tagged for identification. Following the quarantine period, the animals were kept in individual pens and fed the experimental ration for another fifteen days as an acclimatization period. The animals were used in a feeding trial of 90 days and digestibility trial of 10 days and carcass evaluation at the end. Throughout the experiment, the animals were closely monitored for any signs of illness or disorders.

Animal care

The experiment was carried out in accordance with the European Union directive 2010/63/EU (2010) on the care and use of animals in experimental and scientific purposes.

Experimental design and treatments

The experiment was conducted in a randomized complete block design (RCBD) with four treatments and six replications. The sheep were blocked based on their initial BW into six blocks and animals within each block were randomly assigned to one of the four dietary treatments. The four dietary treatments were the four basal diets used in this study, and all animals received 300 g concentrate mixture (67% WB and 33% NSC). Therefore, treatments were:

T_1: Rhodes grass (*Chloris gayana*) hay *ad libitum* + 300 g DM concentrate mixture

T_2: Elephant grass (*Penniesetum purpureum*) hay *ad libitum* + 300 g DM concentrate mixture

T_3: Guinea grass (*Panicum maximum*) hay *ad libitum* + 300 g DM concentrate mixture

T_4: Bermuda grass (*Cynodon dactylon*) hay *ad libitum* + 300 g DM concentrate mixture

Digestibility trial

The digestibility trial was conducted before the feeding trial. All sheep were kept in individual metabolism cage that was equipped with feeder and waterer. Feces were collected into a fecal collection bag carried by the animal. The animals were adapted to carrying fecal bags for three days, which was follow by total collection of feces for seven consecutive days. During this period, daily feed intake per sheep was recorded. After thorough mixing, twenty percent of the feces

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voided daily was taken and kept in a deep freezer at -20°C. The samples were bulk per animal over the collection period. Samples of feeds refusal were taken daily and the latter was pooled per treatment. The sampled feeds were bulked over the seven days of digestibility trial. At the end of the collection period, sub-samples of feces and feeds were taken and transported in ice box fill with chill ice bags, to laboratory for chemical analysis. The apparent digestibility co-efficient (DC) of nutrients were estimated as:

$$DC = \frac{\text{Total amount of nutrients in feed-nutrients in feces}}{\text{Total amount of nutrients in feed}} \times 100$$

Feeding trial

After the digestibility trial, animals were placed in the feeding trial that lasted 90 days. The amount of feed offered and refusal was recorded daily for each experimental animal to determine daily feed intake of individual animals. Daily feed intake was calculated as a difference between the feed offered and feed refused. Feed samples were taken on batches of feed offered and that of the refusal were taken for each animal daily and pooled per treatment. Feed offer were bulked over the experimental period and sub-samples were taken for chemical composition. Body weights of animals were taken initially and every ten days after overnight fasting to account for differences in gut fill. The average daily body weight gain (ADG) during the experimental period was determined by regressing body weight (BW) of each animal measured at 10 days interval on days of feeding. Feed conversion efficiency (FCE) was calculated as a proportion of ADG to daily feed DM intake.

Chemical analysis

The sample of feed offered, refusal and feces were analyzed for DM, ash and nitrogen, neutral detergent fiber (NDF), acid detergent fiber (ADF), acid detergent lignin (ADL) and crude protein. The dry matter (DM), ash and nitrogen contents of the samples were analyzed following the methods of AOAC (2005). The nitrogen contents were determined using the micro-Kjeldahl method (AOAC, 2005) and the CP content was estimated by multiplying the N content by 6.25. The neutral detergent fibre (NDF), acid detergent fibre (ADF), and acid detergent lignin (ADL) were analyzed according to Van Soest et al. (1991).

Carcass parameters

At the end of the feeding trial, all the sheep was fasted overnight, weighed and slaughtered. On slaughtering, the animals were killed by severing the jugular vein and the carotid artery with knife. Blood, skin, head, tongue, hot carcass, liver with gall bladder, heart, kidneys, lung with trachea, tail, testis, penis, spleen, fat (omental, intestinal and kidney), feet, gut fill, total and empty gut were recorded. Empty body weight (EBW) was calculated as the difference between slaughter weight (SW) and gut content. Total edible offal components (TEOC) was taken as the sum total weight of blood, heart, liver with gall bladder, empty gut, kidney, tongue, tail, testis and fat (omental, intestinal and kidney). Total non-edible offal components (TNEOC) were considered as the sum of the weight of head without tongue, lung with trachea, skin, penis, spleen, feet and gut content. Dressing percentage was calculated as proportion of hot carcass weight (HCW) to SW and EBW. Regarding the rib eye muscle area (REA), both the right and left halves were cut between the 11^{th} and 12^{th} ribs perpendicular to the backbone to measure the cross-section of the rib-eye muscle. The rib-eye muscles were traced first on transparency paper then on graph paper and the area was measured by using mechanical polar planimeter.

Partial budget analysis

Partial budget analysis was performed to evaluate the profitability of feeding the sheep with a basal diet of hay prepared from the different grasses supplemented with same level of concentrate mix. It was done by considering the main cost components of sheep price and feed prices. Before slaughtering, three experienced animal dealers estimated the selling price of each experimental sheep. The difference in sale and purchase price was considered as total return (TR) in the analysis. The calculation was done according to Upton (1979). Net return (NR) was calculated as NR= TR-TVC (total variable cost). Marginal rate of return (MRR) was determined as MRR= NR/ TVC.

Data analysis

The data were subjected to analysis of variance (ANOVA) using the general linear model procedures of SAS (2011). Tukey test was used for mean separation that was found to be statistically different at the 5% significant level. The statistical model used for the analysis of data was: $Y_{ij} = \mu + T_i + B_j + E_{ij}$

Where, Y_{ij}= the response variable, μ= overall mean, T_i = treatment effect), B_j = block effect, E_{ij}= random error

RESULTS AND DISCUSSION

Chemical analysis of the experimental feeds

The result of chemical analysis of feeds used in the study is shown in Table 1. The CP content of the hay used in this study ranged 5.5% for Rhodes grass to 8.9% for elephant grass. While the CP content of Bermuda, elephant and guinea grass was above 7.5%, the content of Rhodes grass was far below the 7% level required to support the maintenance

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requirements of sheep and for normal microbial function (Bonsi et al., 1996; Ftiwi and Tadess, 2018). Thus, the basal feeds in this study might have a nutritional potential to satisfy the maintenance requirement of the animals except for Rhodes grass.

Information on Feedipedia (2015) indicated range of CP content of 4.4-16.6% for Rhodes grass, 5.5-15.1% for elephant grass, 2.4-5.8 for guinea grass and 6.3-14.7% for Bermuda grass. It appears that the protein content of guinea grass reported in this study is higher than the ranges of values reported. On the other hand, the CP content of the hay from the other three grasses was within the reported ranges. From the same source, the NDF and ADF contents ranges 70.5-80.8 and 37-50% for Rhodes grass hay, 55-75% and 33-50% for elephant grass hay, 69-79% and 37-54% for guinea grass hay and 69-79% and 28-44% for Bermuda grass hay, respectively.

The NDF and ADF content of the hay used in this experiment were relatively high. The NDF and ADF contents of the hay used in the present study were indicators of the fact that the hay was prepared from grasses harvested at a relatively matured stage. Advance in maturity of plants was reported to be associated with low CP and high cell wall content (McDonald et al., 2002).

The CP content of Noug seed cake (NSC) used in this study was relatively high, although many other reports noted values greater than 33% (Dessie et al., 2019; Mamo et al., 2021). It is obvious that NSC is a good source of protein that could be used to supplement low quality roughages. The amount and quality of NDF in a diet can either enhance or limit intake. At lower NDF concentrations (7.5%-35.5%), DM intakes increased with increasing dietary NDF concentration, but DM intakes decreased sharply as NDF concentration increased over the range of 22.2%–45.8% in high-producing animals (Harper and McNeill, 2015). Thus, the level of NDF in NSC observed in the present study is expected to have little negative impact on consumption and/or digestibility of the diets by the animals.

Wheat bran is one of the major agro-industrial by-products commonly used in the feeding of livestock. The CP content of wheat bran noted in this study was within the range of 13.4-21% reported before (Feedipedia, 2015). The NDF, ADF and ash values of wheat bran used in this study were also within the reported range of values. On average wheat bran contains 18.9 MJ/kg DM gross energy (Feedipedia, 2015), and is a good supplemental energy for ruminants. Though, the chemical analysis may not give full information regarding availability of the nutrients present in the feedstuffs to animals, it is a good indicator about the quality of the feedstuffs. Thus, based on the chemical analysis results, NSC and WB are good sources of nutrients. Feeds that contain 20% or more CP are classified as protein supplements that NSC qualifies (Kellems and Church, 2002).

Table 1 –Chemical composition of the experimental feeds (%DM)

Feed offered	DM (%)	CP	NDF	ADF	ADL	Ash
Rhodes grass	91.5	5.50	83.3	49.9	10.6	9.64
Elephant grass	91.4	8.88	74.5	41.5	8.5	14.9
Guinea grass	90.6	7.56	75.4	44.2	10.6	11.1
Bermuda grass	91.5	7.90	81.5	49.3	11.4	9.3
NSC	92.5	38.75	24.3	15.5	4.2	7.56
WB	90.3	14.25	45.1	12.5	4.1	4.75

ADF = acid detergent fiber; ADL = acid detergent lignin; CP = crude protein; DM = dry matter; NDF = neutral detergent fiber; NSC=Noug seed cake; WB=wheat bran.

Dry matter and nutrients intake

The DM and nutrient intakes of Blackhead Ogaden sheep during the feeding trial are presented in Table 2. The supplemental concentrate mixtures supplied to the animals were entirely consumed. Therefore, any difference among treatments in the intake of DM and nutrients was a result of variations in the intake and nutrient content of grass hays made from the four grass species.

Hay DM intake differed among treatments ($P<0.05$) and was in the order of Guinea grass hay > Bermuda grass hay > Elephant grass hay > Rhodes grass hay. Consequently, total DM intake took a similar trend like that of hay DM intake, values being in the order of T3 > T4 > T2 > T1 ($P<0.05$). However, numerical differences in hay and total DM intake was not so high, indicating that differences observed in the chemical composition of the hay was either not big enough to result to a wider impact on intake of DM or the supplement might have played in supplying sufficient additional nutrients to balance nutrient deficiencies in the hay so as to bring comparable level of hay or total DM intake. McDonald et al. (2002) indicated feed intake to be maximized if the feed provides all nutrients required by rumen microbes and by the tissue of the animal. Therefore, the higher hay and total DM intake in treatments with concentrate mixture (combinations of the two supplements WB and NSC) could as well be due to the better nutrient balance supplied to the animals when supplemented to the grass hay.

Although, there were statistical variations among treatments in the total OM intake ($P<0.05$), numerical variations on the total OM intake among treatments were not very high which was consistent with the total DM intake. Intake of total crude protein was lowest for T1 ($P<0.05$) as compared to the other treatments that had a similar level of crude protein intake ($P>0.05$). Differences in CP intake among treatments appears to be in line with the low level of CP of Rhodes grass noted in this study as compared to the other grass species used in this experiment.

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Intake of NDF and ADF varied among treatments (*P*<0.05) and was in the order of T4 > T1 > T3 > T2. This appears to be in line with differences in the NDF and ADF content of the hays from the four grass species. Generally, the NDF contents of the hays from the four grass species used in this study was high, which might imply that intake of basal diet may be limited since a major factor regulating forage intake is NDF content, as it is the major component limiting rumen fill and directly correlated with rumination or chewing time (Gebreegziabher, 2016). However, the supplement might have played a role in reducing the negative effect of high NDF content of the hays on intake. According to Roche et al. (2008), dietary fiber content, its digestibility and rate of degradation in the rumen are the most important forage characteristics that determine DMI. Therefore, the neutral detergent fiber (NDF), which is a measure cell wall content, determines the rate of digestion and has negative correlation with the rate at which the feed is digested (McDonald et al., 2002).

Previous studies (Solomon et al., 2004a; Solomon et al., 2004b) indicated that supplementation of protein rich feed to poor quality basal diets improved total DM intake, and intake of some nutrients. In general, Martinez et al. (2022) and Ali (2019) indicated that supplementation to low quality feeds increase feed intake because the supplements stimulate the rumen microbial function and thereby reduce digesta retention time. Riveros (1992) indicated that intake of elephant grass (*Pennisetum purupureum*) by sheep was improved by supplemental concentrated mix. Dietary deficiency of nutrients, especially CP for rumen microbes was noted to reduce voluntary feed intake (Cheeke, 1999).

Table 2 – Daily dry matter and nutrient intakes of Blackhead Ogaden sheep fed Rhodes grass, elephant grass, guinea grass and bermuda grass hay supplemented with concentrate mix

Feed offered \ Treatments	T1	T2	T3	T4	SEM
Hay DM	396^{d}	400^{c}	419^{a}	416^{b}	0.003
Supplement DM	300	300	300	300	-
Total DM	696^{d}	700^{c}	719^{a}	716^{b}	0.004
Total OM	641^{c}	624^{d}	656^{b}	660^{a}	0.003
Total CP	89^{b}	103^{a}	99^{a}	100^{a}	0.019
Total NDF	444^{b}	413^{d}	431^{c}	453^{a}	0.021
Total ADF	238^{b}	207^{d}	226^{c}	245^{a}	0.011

$^{a-d}$Means with different superscripts in a row are significantly different (P<0.05); SEM=standard error of the mean; ADF = acid detergent fiber; CP = crude protein; DM = dry matter; NDF = neutral detergent fiber; OM = organic matter; CM = concentrate mixture (67% wheat bran + 33% noug seed cake); T1 = Rhodes grass hay ad libitum + 300 g DM of CM; T2 = Elephant grass hay ad libitum + 300 g DM of CM; T3 = Guinea grass hay ad libitum + 300 g DM of CM; T4 = Bermuda grass hay ad libitum + 300 g DM of CM

Dry matter and nutrient digestibility

The apparent digestibility coefficients of DM and nutrients for Blackhead Ogaden sheep fed hay of the four grass species supplemented with a similar 300 g DM amount of concentrate mixture is shown in Table 3. In the current study, treatments had a significant effect on DM, OM, CP, NDF and ADF digestibility. This is presumably due to the slight variations in the chemical composition of the different species of grasses used in the current study. This is also an indicative that improvements in digestibility of roughage diets due to supplementation with concentrate feed (McDonald et al., 2002) might not bring the different roughages to a similar level of digestibility, which is a sign of the presence of additive effect in digestibility when roughages are mixed with protein rich concentrates.

The utilization of nutrients contained in feeds is determined by the amount of dry matter intake and digestibility. A primary consideration concerning DM intake is digestibility. Digestibility of feedstuff is affected by many factors such as stage of maturity of the crop, botanical composition, dry matter intake, processing and chemical treatment and dietary supplements. Ammerman et al. (1972) found that nitrogen intake was a major factor influencing the intake and digestibility of low quality roughages by ruminants. Similarly, Banamana et al. (1990) indicated that increasing CP in concentrates increased the digestibility of DM. Therefore, the lower DM digestibility of T1 as compared to the other treatments might be associated to the lower CP level in Rhodes grass as compared to the other three grass species used in this study. This slightly lower level of digestibility for T1 was reflected in lower intake of T1 diet as compared to the other treatments.

The apparent digestibility of CP in this study was in the order of T2 > T3 = T4 > T1 (P<0.05). This appears to be consistent with variations in the CP content of the four grass species used in this study and was also in line with differences in CP intake among treatments. This might suggest the possible additive effect of the grass hays when supplemented with concentrate mixture in the digestibility of the total diet. Generally, the digestibility of the different nutrients in this study followed a similar trend to that of CP intake. McDonald et al. (2002) remarked that concentrate feed rich in protein promotes high microbial population which in turn facilitates rumen fermentation. According to Robert (2011), the amount of protein in a feed affects its digestibility. As the level of protein in the feed increased, the apparent protein digestibility would be improved. If protein rich feeds are added to balance low protein roughages, the activities of microorganisms are increased and nutrient digestibility consequently be improved (Ranjihan, 2001). Supplementation of low quality roughage with moderate levels of protein source has been known to stimulate higher digestibility and therefore, improved feed intake (Fonseca et al., 2001; Sawal et al., 2004). Furthermore, ARC (1980) indicated that digestibility is much reduced when a ration has too little protein.

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Table 3 – Apparent digestibility coefficients of dry matter and nutrients of Blackhead Ogaden sheep fed Rhodes grass, elephant grass, guinea grass and bermuda grass hay supplemented with concentrate mix

Digestibility coefficient (%) / Treatments	T1	T2	T3	T4	SEM
DM	66.8^{b}	68.1^{a}	67.9^{a}	67.9^{a}	0.078
OM	66.2^{c}	66.8^{a}	66.4^{b}	66.4^{b}	0.001
CP	67.9^{c}	70.4^{a}	68.4^{b}	68.3^{b}	0.007
NDF	65.4^{c}	68.5^{a}	66.8^{b}	66.4^{bc}	0.008
ADF	64.5^{d}	67.5^{a}	66.4^{b}	65.2^{c}	0.039
DM	66.8^{b}	68.1^{a}	67.9^{a}	67.9^{a}	0.078

$^{a-d}$Means with different superscripts in a row are significantly different (P<0.05); SEM=standard error of the mean; ADF = acid detergent fiber; CP = crude protein; DM = dry matter; NDF = neutral detergent fiber; OM = organic matter; CM = concentrate mixture (67% wheat bran + 33% noug seed cake); T1 = Rhodes grass hay ad libitum + 300 g DM of CM; T2 = Elephant grass hay ad libitum + 300 g DM of CM; T3 = Guinea grass hay ad libitum + 300 g DM of CM; T4 = Bermuda grass hay ad libitum + 300 g DM of CM

Body weight gain and feed conversion efficiency

The initial and final body weights, daily live weight change and feed conversion efficiency of the experimental sheep are presented in Table 4. Sheep fed Rhodes grass hay basal diet had the lowest and those fed elephant grass hay basal diet had the highest final body weights. Body weight change, daily body weight gain (ADG) and feed conversion efficiency followed a similar trend like that of final body weight and were in the order of T2 > T3 = T4 > T1 (P<0.05). Feeding the four species of grass hay supplemented with a concentrate mixture made of noug seed cake and wheat bran resulted to positive ADG in this study. The positive gain in body weight of sheep in this study obviously indicates that the animals were getting nutrients above their maintenance requirements partly due to the supplemental regime employed in this study. Previous studies (Solomon et al., 2004a; Solomon et al., 2004b) indicated that supplementation of protein rich feed to poor quality basal diets improved body weight gains.

Growth and hence body weight gain is a consequence of the level of feed intake and the concentrations of nutrients in the diet. AS such animal performance is the product of nutrient concentration, intake, digestibility, and metabolic efficiency of absorbed nutrients. Since all animals were supplemented similar amount of the same concentrate mixture, any variation in the growth rate of sheep among treatments will unquestionably be a consequence of the variation in the chemical composition of the basal diets and their subsequent effect on intake, digestibility and nutrient supply. Therefore, differences in ADG among treatments in the current study was in line with differences in CP content, DM and CP intake and digestibility of DM and nutrients observed in the current study. Therefore, differences in chemical composition especially of the protein content of hays can lead to a significant effect on the overall productivity of growing animals. This variation could be associated with between species variation of may be a result of management and utilization such as growing condition and harvesting time and conservation practice.

Table 4 – Body weight, average daily gain and feed conversion efficiency of Blackhead Ogaden sheep fed Rhodes grass, elephant grass, guinea grass and bermuda grass hay supplemented with concentrate mix

Parameters / Treatments	T1	T2	T3	T4	SEM
Initial BW (Kg)	16.13	16.08	15.7	15.4	1.67
Final BW(Kg)	18.55^{c}	21.73^{a}	20.23^{b}	19.43^{bc}	1.79
BW change (Kg)	2.42^{c}	5.65^{a}	4.53^{b}	4.03^{b}	1.39
ADG (g/day)	26.85^{c}	62.78^{a}	50.37^{b}	44.82^{b}	13.11
FCE (g ADG/g DMI)	0.035^{c}	0.081^{a}	0.063^{b}	0.056^{b}	0.273

$^{a-c}$Means with different superscripts in a row are significantly different (P<0.05); SEM = standard error of the mean; ADG = average daily body weight gain; BW = body weight; FCE = feed conversion efficiency; DMI = dry matter intake; CM = concentrate mixture (67% wheat bran + 33% noug seed cake); T1 = Rhodes grass hay ad libitum + 300 g DM of CM; T2 = Elephant grass hay ad libitum + 300 g DM of CM; T3 = Guinea grass hay ad libitum + 300 g DM of CM; T4 = Bermuda grass hay ad libitum + 300 g DM of CM

Carcass

Carcass components

Empty BW was lowest (P<0.05) for T1 highest for T2 and intermediate for the other two treatments (Table 5). The trend in variation among treatments in empty body weight is consistent with that of differences in final body weight among treatments. Although hot carcass weight was slightly lower for T1 as compared to the other treatments, differences were not significant (P>0.05). Similarly, dressing percentage and rib eye area did not differ (P>0.05) among treatments. This happens despite significant differences among treatments in DM and CP intake and digestibility as well as variations among treatments in body weight gain and empty body weight. The reason for such observation is not apparent although numerical differences in aspects like intake and digestibility on DM and nutrients were not high.

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Table 5 – Carcass parameters, dressing percentage and rib eye muscle area of Blackhead Ogaden sheep fed Rhodes grass, elephant grass, guinea grass and bermuda grass hay supplemented with concentrate mix					
Parameters / Treatments	T1	T2	T3	T4	SEM
Slaughter BW (kg)	18.54[c]	21.73[a]	20.23[b]	19.43[bc]	1.79
Empty BW (kg)	13.04[c]	15.72[a]	14.69[b]	14.70[b]	1.28
HCW (kg)	5.66	6.38	6.07	6.29	0.36
Dressing percentage (% Slaughter BW)	30.07	29.43	29.97	32.38	4.24
Rib eye area (cm^2)	9.51	12.64	11.15	9.67	6.00

[a-d]Means with different superscripts in a row are significantly different (P<0.05); SEM=standard error of the mean; ADF = acid detergent fiber; CP = crude protein; DM = dry matter; NDF = neutral detergent fiber; OM = organic matter; CM = concentrate mixture (67% wheat bran + 33% noug seed cake); T1 = Rhodes grass hay ad libitum + 300 g DM of CM; T2 = elephant grass hay ad libitum + 300 g DM of CM; T3 = guinea grass hay ad libitum + 300 g DM of CM; T4 = Bermuda grass hay ad libitum + 300 g DM of CM

Non carcass parameters (edible and non-edible offals)

Non carcass parameters of Blackhead Ogaden sheep fed Rhodes grass, elephant grass, guinea grass and bermuda grass hay supplemented with concentrate mix is shown in Table 6. All edible offal components except empty gut were significantly affected by treatment (P<0.05). For all of the edible offals where significant effect of treatment was noted, the highest value was observed for sheep fed the basal diet of Elephant grass and the lowest value was for animal fed the basal diet of Rhodes grass, while values for the other two treatments were intermediate. Consequently, the weight of total edible offal components was in the order of T2 > T3 > T4 > T1 (P< 0.05).

It appears that differences in body weight change or ADG observed among treatments in this study to be more reflected in the weight of edible offals than in the weight of hot carcass component. This might be attributed to the young age of the animals used in this study, which might have drained nutrients towards the development of organs associated with nutrient metabolism and utilization. Moreover, the growth of certain edible carcass components might be positively associated with nutrient intake. Kidney, kidney fat, and abdominal fat were also significantly higher (P<0.001) for sheep in T_2 compared to other supplemented groups associated with the relatively more DM and nutrient intakes. The higher amount of visceral fat in accordance to DM and nutrient intake in this study substantiates that animals supplied with better nutrient can store more fat in the viscera. This is in agreement with the view of Khan et al. (2009) who stated that animals fed on poor feed that could not fulfill their maintenance requirement loses weight since body reserves are used up and vice versa. Hagos and Melaku (2009) also reported relatively lower TEO which were 2.8 kg for the un-supplemented and 4.32 kg for 350g DM/day supplemented group. Generally, supplementation affects positively the weights of visceral and other edible offal component.

All of the non-edible offals and the total non-edible offal components were significantly different among treatments (Table 6). Gut contents was greater for Rhodes grass fed sheep as compared to the other treatments, a reflection of the lower digestibility and greater ruminal retention time of Rhodes grass possibly associated with the lower CP content of Rhodes grass as compared to other grass species used in the current study. This resulted to consequent higher total non-edible offal components for T1 as compared to T2 and numerical differences as compared to T3 and T4. Other non-edible offal components were relatively greater for T2 as compared to other treatments.

Table 6 – Non carcass components of Blackhead Ogaden sheep fed Rhodes grass, elephant grass, guinea grass and bermuda grass hay supplemented with concentrate mix						
Parameters (g) / Treatments		T1	T2	T3	T4	SEM
Edible offal	Empty gut	1686.2[a]	1545.0[b]	1654.0[ab]	1662.0[ab]	27.84
	Heart	51.0[c]	79.0[a]	74.0[ab]	68.0[b]	2.63
	Liver with bile	195.0[c]	298.2[a]	278.0 [b]	272.2[b]	9.05
	Kidney	61.0[c]	90.4[a]	78.0[b]	76.0[b]	2.72
	Kidney fat	30.0[c]	112.0[a]	98.0[b]	94.0[b]	7.37
	Tail	680.40[d]	1026.0[a]	894.2[b]	773.9[c]	2.45
	Abdominal fat	58.0[d]	142.0[a]	121.2[b]	92.0[c]	7.30
	Tongue	72.0[b]	86.0[a]	76.6[b]	74.0[b]	1.92
	Testis	112.0[c]	220.4[a]	220.0[a]	172.0[b]	4.63
	Blood	852.0 [d]	1118.0[a]	1100.0[b]	946.0[c]	4.18
	TEO	3758.20[c]	4704.0[a]	4579.0[b]	4318.2[c]	21.13
Non-edible offal	Skin with feet	1742.0[b]	1878.0[a]	1790.0[b]	1774.0[b]	17.84
	LTE	230.0[c]	258.0[a]	252.0[ab]	246.0[b]	2.90
	Spleen	28.3[c]	44.2[a]	38.3[b]	36.2[b]	1.51
	Head without tongue	826.0[b]	910.0[a]	904.0[a]	820.0[b]	11.64
	Penis	112.0[c]	156.0[a]	149.2[ab]	144.0[b]	4.02
	Gut fill	5120.1[a]	3986.0[c]	4810.0[b]	4986.0[ab]	82.93
	TNEO	8082.1[a]	7212.0[b]	7938.0[a]	7987.0[a]	104.83

[a-d] Means with different superscripts in a row are significantly different (P<0.05); SEM=standard error of the mean; TEOC = total edible offal; TNEO = total nonedible offal; LTE = lung, trachea and esophagus; CM = concentrate mixture (67% wheat bran + 33% noug seed cake); T1 = Rhodes grass hay ad libtum + 300 g DM of CM; T2 = Elephant grass hay ad libtum + 300 g DM of CM; T3 = Guinea grass hay ad libtum + 300 g DM of CM; T4 = Bermuda grass hay ad libtum + 300 g DM of CM

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Partial budget analysis

The partial budget analysis of the experiment is given in Table 7. Despite a similar purchasing price of sheep used for the different treatments, estimated selling price of lambs vary among treatments. This appears to be consistent with variations in the live weight gain, feed conversion efficiency and consequently difference in body weight and body conditions of sheep. Total return, net income and marginal rate of return were all in the order T2 > T4 > T3 > T1. Therefore, based on biological performance as well as economic return (net income and marginal rate of return), sheep fed elephant grass perform better. However, variations in performance and economic return among the four grass species needs to be translated cautiously as part of the difference might have attributed to differences in the stage of maturity of the grasses up on harvest for feeding the lambs. Thus, further work is needed to substantiate the results by synchronizing harvesting of the grasses at a similar stage of maturity.

Table 7 – Partial budget analysis of Blackhead Ogaden sheep fed Rhodes grass, elephant grass, guinea grass and bermuda grass hay supplemented with concentrate mix

Parameters \ Treatments	T1	T2	T3	T4
Purchasing price of sheep (ETB/head)	550	550	550	550
Estimated selling price of sheep (ETB/head)	1610	1830	1700	1715
Total cost of hay (kg/head)	142.45	144.0	151.1	130.8
Total cost of supplement	121.5	121.5	121.5	121.5
Total feed cost VC (ETB)	263.95	265.5	272.6	252.3
Total variable cost	813.95	815.5	822.6	802.3
Total return (TR)	1060	1280	1150	1165
Net income (NI)	246.05	464.50	327.40	362.7
MRR	0.30	0.57	0.40	0.45

ETB = Ethiopian birr; ΔNI = change in net income; ΔTR = change in total return; ΔTVC = change in total variable cost; MRR = marginal rate of return; CM = concentrate mixture (67% wheat bran + 33% noug seed cake); T1 = Rhodes grass hay ad libtum + 300 g DM CM; T2 = elephant grass hay ad libtum + 300 g DM of CM; T3 = guinea grass hay ad libtum + 300 g DM of CM; T4 = Bermuda grass hay ad libtum + 300 g DM of CM

CONCLUSION

The crude protein (CP) and neutral detergent fiber (NDF) contents of Rhodes grass, elephant grass, Guinea grass and Bermuda grass were 5.5 and 83.3, 8.8 and 74.5, 7.6 and 75.4, and 7.9 and 81.5, respectively indicating that Rhodes grass CP content was below the limit to support maintenance requirement of ruminants. Noug seed cake had 39% CP and 24% NDF, and that of wheat bran contained 14.0% CP and 45.1% NDF. Hay DM intake differed among treatments (P<0.05) and was in the order of Guinea grass hay (419 g/day) > Bermuda grass hay (416 g/day) > Elephant grass hay (400 g/day) > Rhodes grass hay (396 g/day). Total DM intake was 696, 700, 719 and 716 g/day (SEM = 0.004) for T1, T2, T3 and T4, respectively and followed a similar trend like that of hay DM intake being lowest for T1 and highest for T3. The CP intake was also lowest for T1 (89 g/day), and similar among the other 3 treatments (99-103 g/day). Intake of NDF and ADF vary among treatments (P<0.05) and was in the order of T4 > T1 > T3 > T2 (NDF intake: 444, 413, 431 and 453 (SEM = 0.02); ADF intake: 238, 207, 226 and 245 (SEM = 0.01 for T1, T2, T3, T4, respectively).

The apparent digestibility of organic matter (OM) and CP in this study was in the order of T2 > T3 = T4 > T1 (P< 0.05) (OM digestibility: 66.2, 66.8, 66.4 and 66.4 (SEM = 0.001); CP digestibility: 67.9, 70.4, 68.4 and 68.3 (SEM = 0.007 for T1, T2, T3, T4, respectively). Average daily gain was in the order of T2 > T3 = T4 > T1 (27, 63, 50 and 45 g/ day (SEM = 13.1) for T1, T2, T3 and T4, respectively); whereas hot carcass weight did not significantly differ among treatments (5.7, 6.4, 6.1 and 6.3 kg (SEM = 0.36) for T1, T2, T3 and T4, respectively).

Partial budget analysis result showed that net return in the current study to be 1060, 1280, 1150 and 1165 ETB, indicating that net return was in the order of T2 > T4 > T3 > T1. The difference in the net return among treatments was due to the difference in feed cost and selling price of the animals. Therefore, based on biological performance as well as economic return, sheep fed elephant grass perform better. However, variations in performance and economic return among the four grass species needs to be translated cautiously as part of the difference might have attributed to differences in the stage of maturity of the grasses up on harvest for feeding the lambs. In addition, further work is needed to substantiate the results by synchronizing harvesting of the grasses used in the current study at a similar stage of maturity.

DECLARATIONS

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Authors' contribution

I contributed on data collection, analysis and the write up of the manuscript.

Conflict of interests

The authors have not declared any conflict of interests.

Acknowledgements

The authors are grateful for Jigjiga University and Haramaya University.

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