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Effect of Green *Prosopis juliflora* Pods and Noug Seed (*Guizotia obissynica*) Cake Supplementation on Digestibility and Performance of Blackhead Ogaden Sheep Fed Hay as a Basal Diet

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Abstract

This study was conducted to evaluate the effect of supplementation of ground immature Prosopis juliflora pods (PJP), noug seed cake (NSC) and their mixtures at different proportions on feed intake, digestibility, and average daily body weight gain (ADG), feed conversion efficiency (FCE), carcass parameters and economic feasibility of Blackhead Ogaden sheep. Twenty five yearling male sheep with initial BW of 13.82±0.52 kg were blocked in to five blocks based on initial BW and randomly assigned to treatments. Treatments were supplementation of 300 g DM /day of PJP and NSC at proportions of 100, 75, 50, 25, 0% PJP and 0, 25, 50, 75, 100% NSC for T1 (Treatment 1), T2 (Treatment 2), T3 (Treatment 3), T4 (Treatment 4) and T5 (Treatment 5), respectively. Digestibility and feeding trials lasted for 7 and 80 days, respectively followed by carcass evaluation. CP content was 6.2%, 15.5%, and 29.1% and NDF content was 80.9%, 46.7% and 41.3% for hay, PJP and NSC, respectively. Hay and total DM intakes were higher (p<0.05) in T4 and T5 than in T1 which was similar to T3 and T2. Intake of CP increased with increasing level of supplemental NSC. Treatment did not impact DM, OM, NDF and ADF digestibility, but CP digestibility coefficient was low for T1 than T2, T3 and T5 (p<0.05) and T4 had similar (p<0.05) CP digestibility as compared to the other treatments. Animal on T2 and T3 had greater (P<0.05) ADG but T1, T4 and T5 were similar. FCE was in the order of T3 = T2 > T1 = T4 = T5 (p<0.05). Hot carcass weight (HCW) and rib- eye muscle area (REA) were greater for T2 than T1. Based on the biological performance and partial budget analysis, combination of the two supplements in equal proportions was recommended.

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INTRODUCTION

Livestock in Ethiopia are important and integral components of agriculture, which is the backbone of the economy. This sub-sector does not only provide animal protein for ever growing human population, but also contribute in providing export commodities such as live animal, meat, hide and skin to earn foreign exchange to the country (CSA, 2003). Among livestock population of Ethiopia sheep accounts 24.6 million, but productivity level couldn't match with the stock population number, which is estimated to be 10 kg of mutton (FAO, 2000).

Although, there are various and complex constraints which contribute to the reduction of productivity of sheep, the most important limiting factor is feed scarcity. The major feed resources for small ruminants in Ethiopia are forage from natural pasture, crop residues and feed grains or other concentrates (De leuw, 1997). The availability of these feed fluctuates seasonally both in quantity and quality, and animals depend predominantly on high fiber feed that are deficient in nutrients essential for microbial fermentation (Owen and Aboud, 1988). This shows that there is scope for improvement of sheep performance by improving the feeding practices (Kassahun, 2000).

This involves the use of fodder bank, fodder trees, agro-industrial by-products such as, noug seed cake and urea to overcome CP shortages (ILCA, 1990). Supplementation of poor quality roughage feed with suitable energy and protein sources provide an opportunity for smallholder fattening of sheep. Foliage and/or pods of different types of plants such as *Acacia* species and *Prosopis juliflora* can be used as a substitute for concentrate supplement. Sinha (1977) noted that there are some legumes of great potential that have not yet been fully developed or utilized for feed, one is the pods of desert mesquite (*Prosopis juliflora*).

Prosopis juliflora remain green even during the dry season and the pod can be processed and fed to animals. The pod is highly digestible, which is a valid option for animal feed, mainly as a result of its nutritive values and of the economic viability of its production under the semi-arid areas of the world (Shukla *et al.,* 1984). Matured / immature ground *Prosopis juliflora* pod may be fed together with other native fodder species, pastures and agro-industrial by-products. Therefore, the introduction of ground pod of this species may partially offset fodder scarcity during the dry season. But, research result that shows the effects of ground green (immature) *Prosopis juliflora* pods on animal performance appears to be lacking. On the other hand mixing of different ingredients to form a supplement such as noug seed cake and ground immature *Prosopis juliflora* pods may create the complementary role in improving nutrient availability and utilization that will lead to improved animal performances. Therefore, this study was designed to evaluate the effects of different proportion of ground green *Prosopis juliflora* pods and noug seed cake supplementation on digestibility and performance of Black head Ogaden sheep fed hay as a basal diet and to determine the appropriate inclusion levels of ground immature (green) *Prosopis juliflora* pods in the feeding of sheep.

MATERIALS AND METHODS

Description of the Study Area

The experiment was carried out at Haramaya University sheep farm. The University is located at an altitude of 1950 meters above sea level between latitude 9^{o} 26$^{"}$ N and longitude 42^{o} 3$^{"}$ E and has a mean annual rainfall of 790 mm and a mean annual temperature of 16 ^{o}C (Mishra *et al*., 2004).

Experimental Animals and Managements

Twenty five yearling Blackhead Ogaden male sheep with initial body weight of 13.92 ± 0.52 (mean ± SD) kg were purchased from the local market. The age of the animals were determined by dentition and quarantined for 21 days, during this period they were de-wormed (drenched) with a broad-spectrum anti-helmentic (Albendazole) against internal and sprayed with acaricides (vetacidin 20% EC) against external parasites, respectively.

Feed Preparation and Feeding

Hay was purchased, chopped and stored in dry environment under shade to maintain quality and used as basal diet throughout the experimental period. Unprocessed immature (green) *Prosopis juliflora* pod was collected during the fruit production season. The pod was sun dried, crushed before added to the grinder to facilitate grinding efficiency of the hammer mill. Pods were ground and stored under dry environmental condition. Mineral lick containing Ca18.8%, P 2.8%, I 0.0068%, Zn 0.17%, Mg 0.09%, Mn 0.084%, Se 0.0004%, Cu 0.005%, Nacl 31.2%, Fe 0.115%, and Co 0.0009% was purchased. Animals were fed individually by weighing their daily allowances feed after removing the previous day's refusal. The hay was fed *ad libitum* by adjusting for 15% refusal to allow *ad libitum* intake. Animals received 300 g DM daily with 0, 25. 50, 75 and 100% proportion of either ground green *Prosopis juliflora* pod or noug seed cake (Table 1). When a mixture of the two supplements was offered to the animals, the supplements were weighed separately and thoroughly mixed before offer. All animal had free access to mineral lick and water.

Experimental Design and Treatments

The experiment was conducted using completely randomized block design (RCBD). At the end of quarantine period, the experimental animals were blocked into five blocks of five animals each based on their initial body weight and animals within a block were randomly assigned to one of the five treatment diets (Table 1). The experimental animals were used for digestibility trial that lasts for 7 days and feeding trial of 80 days respectively.

Table 1. Experimental treatments.

T	Hay	PJP (% of supplement)	NSC (% of supplement)	Supplement amount (g/day/head)
1	*Ad libtum*	100	0	300
2	*Ad libtum*	75	25	300
3	*Ad libtum*	50	50	300
4	*Ad libtum*	25	75	300
5	*Ad libtum*	0	100	300

T= Treatment, PJP = Ground green *Prosopis juliflora* pod; NSC = Noug seed cake

Measurements and Observations

Digestibility Trial

After an adaptation period of 15 days, animals were harnessed with fecal bag to collect feces. After adjustment period of three days to fecal collection bags, feces were collected for seven consecutive days. Each day total fecal output of the animal was collected and weighed, 15% of the fecal output was sub-sampled and stored frozen at -20^{0}C, and pooled over the collection period. Samples of the ort for individual animals during digestibility and feeding trial was separately collected, bulked and pooled over treatment. Feed samples from each feed ingredient were collected for chemical analysis. The digestibility coefficient (DC) of the dry matter and nutrients was calculated as:

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

Feeding Trial

The feeding trial was conducted following the digestibility trial on the same animals. Daily feed offered to the experimental animals and the corresponding refusals of each animal were measured and recorded during the experimental period to determine daily feed intake.

Initial body weights of each animal were determined by taking mean of two consecutive weights after overnight fasting at the beginning of the feeding trial. Body weights of the animals were measured after over-night fasting at 10 days interval. Average daily gain (ADG) was calculated as the difference between the final and initial body weights divided by the number of days of feeding. Feed conversion efficiency (ADG: DM intake) was also determined.

Carcass Evaluation

Carcass parameters were measured at the end of the feeding trial. Animals were fasted overnight then weighed to take slaughter weight and slaughtered. During slaughtering, the blood was collected in a container and weighed. Empty body weights of each animal were determined deducting the gut content from the slaughter weight. The rib-eye muscle area was determined by tracing the cross sectional area of the eleventh and twelfth ribs after cutting perpendicular to the back bone. The mean of the right and left cross sectional area was taken as a rib-eye muscle area.

Chemical Analysis

Chemical analysis was done at Haramaya University Animal Nutrition Laboratory. Samples of feed offered and refused as well as feces were subjected to laboratory analysis for DM, CP and ash determination following the procedure of AOAC (1990). Neutral detergent fiber (NDF), acid detergent fiber (ADF) & acid detergent lignin (ADL) were determined according to the procedures of Van Soest and Robertson (1985).

Partial Budget Analysis

Partial budget analysis involved calculation of the variable cost of experimental animal, feeds and benefits gained from the result. The purchasing prices of the feeds and animals and selling price of animals were used for partial budget analysis. The difference between selling and purchasing price in each experimental treatment were used to determine the total return (TR). The net income (NI) was calculated as the amount of money left when total variable costs (TVC) are subtracted from the total returns (NI = TR –TVC).

Statistical Analysis

Analysis of variance using the general linear model procedure of SAS (1998) was used to analyze the data. Treatment means were separated by least significant difference (LSD). The model used for data analysis was: $Y_{ij} = \mu + T_i + \beta_j + e_{ij}$

Where;

Y_{ij} = Response variable
μ = Overall mean
T_i = Treatment effect
β_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 2. The CP content of the hay used in this study is 6.23% and the NDF and ADF content of hay are relatively high. These values indicate that the basal feed has a poor nutritional potential and may fail to support the maintenance requirements of sheep as it contains CP below the minimum level of (7%) required for microbial function (Van Soest, 1994). Although hay intake without supplementation was not measured in this study, the high NDF content of the hay 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 (Cheeke, 1999).

The low CP and high NDF contents of the hay used in this study could be attributed to the maturity of mixed sward from which the hay was prepared. 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 ground immature *Prosopis juliflora* pods (PJP) is slightly similar with the 16.5% CP reported by Vimal and Tyagi (1986). Other studies reported value in the range of 18.6-25% CP **(**Mahgoub *et al.,* 2004; Koech *et al.,* 2010), which is greater than the results of the current study. Lower values of 13.9% has also been reported (Andrew, 1992) for ripped *Prosopis juliflora* pods. Such variation in CP content of the pods of *Prosopis juliflora* may be attributed to the differences in soil nutrient contents of the area and the maturity stage of the pods.

Table 2: Chemical compositions of experimental feeds.

Feed Offered	DM (%)	CP (% DM)	NDF (% DM)	ADF (% DM)	ADL (% DM)	Ash (% DM)
Hay	93.20	6.23	80.87	53.48	10.55	8.86
PJP	92.64	15.48	46.71	33.11	9.17	6.17
NSC	93.22	29.12	41.33	33.17	7.38	8.21
Refusal						
Hay T1	93.48	2.90	83.11	53.71	11.23	7.63
Hay T2	92.80	4.35	83.65	54.04	11.32	7.40
Hay T3	93.55	3.77	83.24	54.50	11.20	7.35
Hay T4	93.48	4.65	79.15	53.22	11.15	7.62
Hay T5	93.70	3.20	81.40	56.51	14.34	7.74

ADF = acid detergent fiber; ADL = acid detergent lignin; CP = crude protein; DM = dry matter; NDF = neutral detergent fiber; OM = organic matter; PJP = *Prosopis juliflora* pods; NSC=Noug seed cake; T1 = hay *ad libtum* + 100% *Prosopis juliflora* pod (300 g DM); T2 = hay *ad libtum* + 75% *Prosopis juliflora* pod + 25% Noug seed cake; T3 = hay *ad libtum* + 50% *Prosopis juliflora* pod + 50% Noug seed cake; T4 = hay *ad libtum* + 25% *Prosopis juliflora* pod + 75% Noug seed cake; T5 = hay *ad libtum* + 100% Noug seed cake.

The NDF contents in ground immature *P. juliflora* pod used in this study is lower than 51.8% reported for the matured *P. juliflora* pod (Koech *et al*., 2010). The immature *P. juliflora* pod also contained 6.17% ash, which is higher than the 4% and slightly similar with the 5.2% ash reported for the matured *P. juliflora* pod by Mahgoub *et al*. (2004) and Koech *et al*. (2010), respectively. The CP and mineral contents of *P. juliflora* pod used in this study are satisfactorily high and warrant consideration of its use as supplement to low quality feed (Abdurezak *et al*., 2006).

The CP content of noug seed cake (NSC) used in this study although high, it is slightly less than many other reports with values of greater than 33% (Beyene, 1976; Alemu, 1981; Amaha, 1990). It is obvious that NSC is a good source of protein that could be used to supplement low quality roughages (Beyene, 1976). The NDF content of 70% in a feed was thought to be enough to limit DM intake and digestibility (Beyene, 1976). The NDF values ranging from 35 to 42% noted to have a relatively little impact on intake and digestibility of DM (Alemu, 1981). 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.

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 results of the chemical analysis, feeds used in the present study can be classified as high, medium and low based on their chemical contents. Based on the CP content, NSC is classified as high protein sources, the immature *P. juliflora* pod as medium quality feed, and the hay as of poor quality feed. Feeds that contain 20% or more CP are classified as protein supplements (Kellems and Church, 2002). With the CP content of 15.48% and low crude fiber, which was reported to be 2.6% (Mahgoub *et al.,* 2004) in ground mature *P. juliflora* pod, can be classified as a medium quality feed.

Dry Matter and Nutrients Intake

The DM and nutrient intakes of Blackhead Ogaden sheep during the feeding trial are presented in Table 3. Hay and total DM intakes are the least (p<0.05) when *P. juliflora* pod constitute the whole supplement, followed by the combination of the two supplements at equal level (T3) and as of T2 supplement. The treatment with 100% noug seed cake (NSC) and mixture feed supplemented (T4) group appeared to impart more hay and total DM intake. Total DM intake expressed in percent or metabolic body weight showed opposite trend, which appeared to be mainly due to the differences in body weight or average daily body weight gain of animals among treatments. McDonald *et al.* (2002) and Pond *et al*. (1995) indicated that, feed intake will 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 combinations of the two supplements or as sole NSC could be due to the better nutrient balance supplied to the animals when the supplements are offered in mixture or sole NSC than the sole *P. juliflora* pods. Ground *P. juliflora* pods are generally rich in sugars, mineral, vitamin and essential amino acids (Andrew, 1992 and Pasiecznick *et al.,* 2001).

Andrew (1992) indicated that, intake of elephant grass (*Pennisetum prupureum*) by sheep was improved by supplemental ground *Prosopis juliflora* pods. The ground *Prosopis juliflora* pods combined with a good protein supplement like NSC can enhance DM intake.

Dietary deficiency of nutrients, especially CP for rumen microbes will reduce voluntary feed intake (Cheeke, 1999). For adequate microbial protein synthesis in the rumen and maintenance, sheep require a minimum of 7% DM dietary CP (Gatenby, 2002). Crude protein intake in the current study increased with increasing level of supplemental NSC, obviously due to the higher CP content in NSC than *Prosopis juliflora* pods. The CP intake of the experimental animals follow similar trend of DM intake, indicating that the combination of the two supplements might support better supply of nutrients than sole *P. juliflora* pod offered to animals and same to sole NSC offered ones. The positive gain in body weight of sheep in this study obviously indicates that the animals were getting nutrients above their maintenance requirements.

Previous studies (Kaitho *et al*., 1997; Solomon *et al*., 2004a; Solomon *et al*., 2004b; Zewdu *et al*., 2006) indicated that, the supplementation of protein rich feed to poor quality basal diets improved total DM intake, and intake of some nutrients and body weight gains. Research study conducted by ILRI on nutritional value of *Prosopis juliflora* pods (green on the tree, ripe on the tree and ripe fall on to the ground) in Kenya also showed that the pods have good nutritional values for feeding animals (ILRI, 2006). In general, Inoue *et al.* (1994) reported that concentrate supplementation to low quality feeds increase feed intake because the supplements stimulate the rumen microbial function and thereby reduce digesta retention time.

Table 3: Daily dry matter and nutrient intakes of Black Head Ogaden sheep fed grass hay and supplemented with ground immature *Prosopis juliflora* pods, noug seed cake and their mixtures.

Intake (g/day)	Treatments					SEM
	T_1	T_2	T_3	T_4	T_5	
Hay DM	430.63^b	439.52^b	439.04^b	457.98^a	457.36^a	2.82
Supplement DM	300.00	300.00	300.00	300.00	300.00	-
Total DM	730.63^b	739.52^b	739.04^b	757.98^a	757.36^a	2.82
Total DM (g/kg $BW^{0.75}$)	86.66^a	76.57^b	75.02^b	83.18^a	82.11^a	1.44
Total DM (% BW)	4.25^a	3.60^{bc}	3.52^c	3.99^a	3.92^{ab}	0.09
Total OM	681.38^{ab}	682.76^{ab}	674.90^b	687.19^{ab}	693.64^a	2.25
Supplement CP	46.46^e	56.68^d	67.14^c	77.14^b	87.36^a	0.03
Total CP	75.33^d	101.47^c	109.31^b	109.99^b	132.43^a	3.93
Total NDF	494.93^a	491.57^a	479.07^b	498.64^a	491.28^a	1.83
Total ADF	333.97^b	334.47^b	328.92^b	344.44^a	344.51^a	1.53

$^{a-e}$Means with different superscripts in a row are significantly different ($P<0.05$); SEM=standard error of the mean; ADF = acid detergent fiber; BW = body weight; CP = crude protein; DM = dry matter; NDF = neutral detergent fiber; OM = organic matter; T1 = hay *ad libtum* + 100% *Prosopis juliflora* pod (300 g DM); T2 = hay *ad libtum* + 75% *Prosopis juliflora* pod + 25% Noug seed cake; T3 = hay *ad libtum* + 50% *Prosopis juliflora* pod + 50% Noug seed cake; T4 = hay *ad libtum* + 25% *Prosopis juliflora* pod + 75% Noug seed cake; T5 = hay *ad libtum* + 100% Noug seed cake.

Dry Matter and Nutrient Digestibility

The apparent digestibility coefficients of DM and nutrients for Blackhead Ogaden sheep fed hay as a basal diet and supplemented with ground immature *P. juliflora* pod, NSC and their mixtures at different proportion are given in Table 4. In the current study treatment did not have significant effect on DM, OM, NDF and ADF digestibility. This indicated that the two supplemental diets have similar effect on the digestibility of DM and nutrients. CP digestibility is low for T1 than T2, T3 and T5 ($p<0.05$) and T4 had similar ($p>0.05$) CP digestibility as compared to the other treatments.

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 OM, ADF, NDF and DM.

The increased digestibility of CP in the NSC and its mixture supplemented treatments compared to sole ground green *P. juliflora* pod supplemented group could be due to the higher supply of dietary CP received by treatment group and possibly associated to the better profile of nutrients supplied by the combination of the two dietary supplements.

McDonald *et al*. (2002) remarked that concentrate feed rich in protein promotes high microbial population which in turn facilitates rumen fermentation. Ranjhan (1997) also noted that the level of protein influences the digestibility of feed. 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 microorganism is increased and nutrient digestibility consequently be improved (Ranjihan, 1997). However, in this study digestibility of CP did not follow a similar trend with that of CP intake. This may be attributed to differences in the nature of CP contents found in supplemental diets. Supplementation of low quality roughage with moderate levels of protein source has been known to stimulate higher digestibility and therefore, improved feed intake (Silva *et al*., 1989; Ferrell *et al*., 1999; Fonseca *et al*., 2001). McDonald *et al*. (2002) pointed out that digestibility of the feed may be reduced by deficiency or excess of nutrients or other constituents. Furthermore, ARC (1980) indicated that digestibility is much reduced when a ration has too little protein as compared to the amount of readily digested carbohydrates. All these indicate that the protein and/or nutrients supplied by the different combination of supplements employed in this study were enough to induce more or less similar effect on the digestibility of DM and nutrients.

Table 4: Apparent digestibility coefficients of dry matter and nutrients of Black Head Ogaden sheep fed grass hay and supplemented with ground immature *Prosopis juliflora* pods, noug seed cake and their mixtures.

Digestibility coefficient (g)	Treatments					SEM
	T_1	T_2	T_3	T_4	T_5	
DM	0.666	0.668	0.668	0.670	0.682	0.008
OM	0.647	0.638	0.646	0.642	0.660	0.009
CP	0.620^{b}	0.663^{a}	0.669^{a}	0.631^{ab}	0.664^{a}	0.009
NDF	0.659	0.653	0.660	0.667	0.677	0.008
ADF	0.687	0.672	0.687	0.680	0.697	0.005

$^{a-b}$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; T1 = hay *ad libtum* + 100% *Prosopis juliflora* pod (300 g DM); T2 = hay *ad libtum* + 75% *Prosopis juliflora* pod + 25% Noug seed cake; T3 = hay *ad libtum* + 50% *Prosopis juliflora* pod + 50% Noug seed cake; T4 = hay *ad libtum* + 25% *Prosopis juliflora* pod + 75% Noug seed cake; T5 = hay *ad libtum* + 100% Noug seed cake.

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 5. Animals on T2 and T3 had greater (p>0.05) final body weight (BW) and average daily BW gain (ADG) than animals supplemented with the sole crushed immature *P. juliflora* pod. Values for final BW and ADG for T4 and T5 are not different from other treatments. Feed conversion efficiency (FCE) also differed among treatments (p<0.05) and was in the order of T3 = T2 > T1 = T4 = T5. Animals supplemented with sole NSC had statistically similar (p>0.05) performance to the ones supplemented with sole ground immature *P. juliflora* pods.

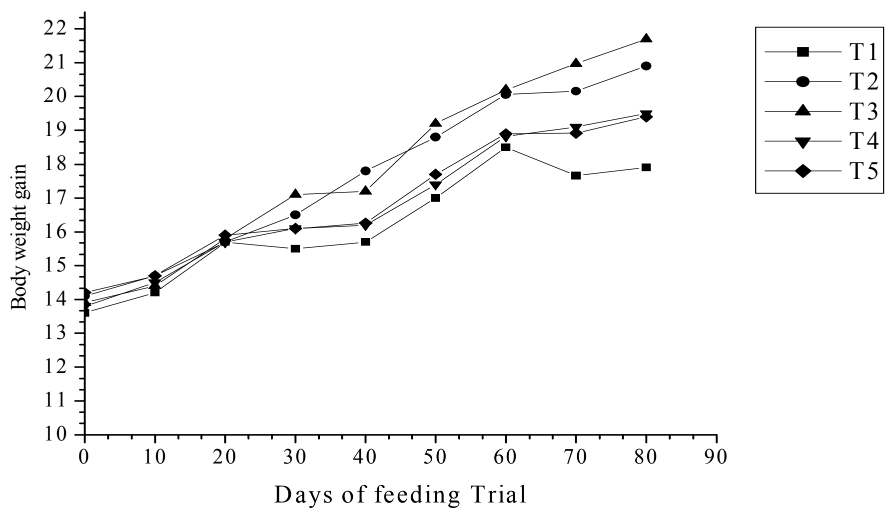
Animal performance is the product of nutrient concentration, intake, digestibility, and metabolic efficiency of absorbed nutrients. Differences in animal performance among treatments in this study are inconsistent with differences in total DM intake. According to Andrew (1992), sheep fed replacement of sorghum flour with dry ground mature *Prosopis juliflora* pods flour increased live weight gain up to 45% replacement but not at 60% replacement, and sheep fed on replacement of sugarcane molasses with matured *Prosopis juliflora* pods flour at 0, 15, 30, 45 and 60% were most effective in terms of live weight gain at the 30 and 45% levels. In this study up to 50% replacement of immature *Prosopis juliflora* pods to NSC appeared to impart positive response in terms of ADG and FCE, although 100% replacement appeared to be possible without significant effect on animal performance. According to FARM-Africa (2008), the overall performance of goats grazing pasture supplemented only with ground mature *Prosopis juliflora* pods was low, whereas goats supplemented with 1:1 mixture of ground mature *Prosopis juliflora* pods and corn, showed considerably better performance. This is in line with the better performance noted for T3 in this study. This may indicate that ground mature or immature *Prosopis juliflora* pod flour appeared to have a better impact on animal performance when supplemented along with other concentrates. This is in line with the report by Mahgoub *et al.* (2004) indicated that *Prosopis juliflora* pods when fed in mixed rations improve nutrient supply and palatability of the diet.

In this study, growth rate in the first 30 days appeared to be similar among treatments and differences were apparent then after (Figure 1). She ep on sole *P. juliflora* pods supplementation lost body weight towards the last 20 days of the experimental period. Pasiecznik *et al*. (2001) also noted that animals on *P. juliflora* pods for a long period lost body weight which may be due to the regression of rumen bacterial cellulase activity with time by high sugar content of the pods. Mahgoub *et al*. (2004) also indicated that sheep fed on diets with increasing amount of Ghaf (*Prosopis cinerarian*) at 0, 15, 30 and 45% for long period demonstrated sudden drop in feed intake when the Ghaf approaches 45%.

Table 5: Body weight, average daily gain and feed conversion efficiency of Black Head Ogaden sheep fed grass hay and supplemented with ground immature *Prosopis juliflora* pods, noug seed cake and their mixtures.

Parameters	**Treatments**					**SEM**
	T_1	T_2	T_3	T_4	T_5	
Initial BW (kg)	13.6	14.1	13.9	13.8	14.2	1.25
Final BW (kg)	17.5^b	20.8^a	20.9^a	19.5^{ab}	19.4^{ab}	1.02
BW change (kg)	3.9^b	6.7^a	7.0^a	5.7^{ab}	5.2^{ab}	0.76
ADG (g/day)	48.75^b	83.75^a	87.75^a	70.75^{ab}	65.00^{ab}	4.75
FCE (g gain/feed)	0.024^b	0.028^a	0.029^a	0.026^b	0.026^b	0.002

a-b 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; T1 = hay *ad libtum* + 100% *Prosopis juliflora* pod (300 g DM); T2 = hay *ad libtum* + 75% *Prosopis juliflora* pod + 25% Noug seed cake; T3 = hay *ad libtum* + 50% *Prosopis juliflora* pod + 50% Noug seed cake; T4 = hay *ad libtum* + 25% *Prosopis juliflora* pod + 75% Noug seed cake; T5 = hay *ad libtum* + 100% Noug seed cake.



T1 = hay *ad libtum* + 100% *Prosopis juliflora* pod (300 g DM); T2 = hay *ad libtum* + 75% *Prosopis juliflora* pod + 25% Noug seed cake; T3 = hay *ad libtum* + 50% *Prosopis juliflora* pod + 50% Noug seed cake; T4 = hay *ad libtum* + 25% *Prosopis juliflora* pod + 75% Noug seed cake; T5 = hay *ad libtum* + 100% Noug seed cake.

Figure 1: Trends of body weight change of Black Head Ogaden sheep fed grass hay and supplemented with ground immature *Prosopis juliflora* pods, noug seed cake and their mixtures.

Carcass Components

Empty BW was lower (*p*<0.05) for T1 than the other four treatments that were similar (*p*>0.05) amongst each other (Table 6). The higher EBW in the mixture and sole NSC supplemented sheep might be partly due to the lower proportion of gut content in these treatments than T1. Hot carcass weight (HCW) and rib eye muscle area (REA) which is used as a measure of carcass leanness were greater for T2 than the sole crushed immature *P. juliflora* pod supplemented group, and the rest of treatments were similar to each other. Dressing percentage both on slaughter and empty BW basis was not affected by treatment. Differences in HCW and REA observed among treatments in this study are somewhat in line with the results of DM intake and growth performance noted in this study. The treatment with sole ground immature *P. juliflora* pods supplementation had the least CP intake that might have lead to the lower HCW and REA.

Table 6: Carcass parameters, dressing percentage and rib eye muscle area of Black Head Ogaden sheep fed grass hay and supplemented with ground immature *Prosopis juliflora* pods, noug seed cake and their mixtures.

Parameter	**Treatments**					**SEM**
	T_1	T_2	T_3	T_4	T_5	
Slaughter BW (kg)	17.75^b	21.63^a	21.40^a	19.83^{ab}	19.63^{ab}	1.30
Empty BW (kg)	13.58^b	17.61^a	17.19^a	16.61^a	16.37^a	1.01
HCW (kg)	7.13^b	9.13^a	8.63^{ab}	8.13^{ab}	8.13^{ab}	0.66
Dressing percentage (%)						
Empty BW basis	52.15	51.90	50.56	48.75	49.68	2.42
Slaughter BW basis	39.93	42.45	40.36	41.68	41.39	2.84
Rib eye area (cm^2)	6.00^b	9.40^a	9.40^a	8.00^a	8.60^a	0.72

a-bMeans with different superscripts in a row are significantly different (P<0.05); SEM=standard error of the mean; BW = body weight; HCW = hot carcass weight; T1 = hay *ad libtum* + 100% *Prosopis juliflora* pod (300 g DM); T2 = hay *ad libtum* + 75% *Prosopis juliflora* pod + 25% Noug seed cake; T3 = hay *ad libtum* + 50% *Prosopis juliflora* pod + 50% Noug seed cake; T4 = hay *ad libtum* + 25% *Prosopis juliflora* pod + 75% Noug seed cake; T5 = hay *ad libtum* + 100% Noug seed cake.

Partial Budget Analysis

Partial budget analysis of the experiment is given in Table 7. Based on the total variable costs, purchasing and selling prices of sheep, the highest total income is gained from sheep supplemented with 50% NSC and 50% ground immature *Prosopis juliflora* pods (T3). These values are directly related with the live weight gain, body conditions of sheep and the prices of experimental feeds. The best net income is gained in T3 followed by T5. The change in net income is also highest for T3. The value of MRR in the present study is found to be positive for all the treatments and highest for T2 followed by T3. As can be observed from the results of feed intake, digestibility, body weight change and feed conversion efficiency in the present study, and based on most of the parameters (net income, total rate of return and marginal rate of return) considered in partial budget analysis, combination of the two supplements in equal proportions as in T3 appeared to be recommendable.

Table 7: Partial budget analysis of Black Head Ogaden sheep fed grass hay and supplemented with ground immature *Prosopis juliflora* pods, noug seed cake and their mixtures.

Variables (ETB)	**Treatments**				
	T_1	T_2	T_3	T_4	T_5
Purchasing price of sheep	1280	1280	1280	1280	1280
Price of consumed hay	470.63	471.59	460.34	491.40	490.74
Price of supplement	291.60	264.44	237.29	210.13	182.97
Total variable cost (TVC)	762.23	736.03	697.63	701.53	673.71
∆TVC	0	26.20	64.60	60.70	88.52
Gross income	2260	2600	2810	2520	2610
Total rate of return (TRR)	980	1320	1530	1240	1330
∆TRR	0	340	550	260	350
Net income (NI)	217.77	583.97	832.37	538.47	656.29
∆NI	0	313.80	485.40	199.30	261.48
MRR (%)	0	1197.70	751.39	327.84	294.85

ETB = Ethiopian birr; ∆NI = change in net income; ∆TR = change in total return; ∆TVC = change in total variable cost; MRR = marginal rate of return; T1 = hay *ad libtum* + 100% *Prosopis juliflora* pod (300 g DM); T2 = hay *ad libtum* + 75% *Prosopis juliflora* pod + 25% Noug seed cake; T3 = hay *ad libtum* + 50% *Prosopis juliflora* pod + 50% Noug seed cake; T4 = hay *ad libtum* + 25% *Prosopis juliflora* pod + 75% Noug seed cake; T5 = hay *ad libtum* + 100% Noug seed cake.

CONCLUSION

Based on the biological performance and based on most of the parameters (net income, total rate of return and marginal rate of return) considered in partial budget analysis, combinations of the two supplements in equal proportions as in T3 appeared to be recommendable in this study.

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