

Effects of Faba Bean Hull, Noug Seed (*Guizotia Abyssinica*) Cake, Wheat Bran and their Mixtures Supplementation on Biological Performance and Economic Benefits of Farta Sheep Fed Natural Pasture Hay in Ethiopia

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Abstract

The experiment was carried out to evaluate the supplementary effect of Faba bean hull (FBH), noug seed cake (NSC), wheat bran (WB) and their mixtures on biological performance and economic benefits of s in Farta sheep fed grass hay as basal diet. The treatments were grass hay (GH) ad libitum+200g NSC+100 g WB (T1); GH ad libitum +200g NSC+75 g WB+25g FBH (T2); GH ad libitum+200g NSC+50g WB+50g FBH (T3); GH ad libitum+200g NSC+25 g WB+75g FBH (T4) and GH ad libitum+200g NSC+100g FBH (T5). The feeding and digestibility trials were conducted for ninety and seven days, respectively. Data on composition of feeds and feces, dry matter (DM) and nutrient intake, DM and nutrients digestibility, BW changes and feed conversion efficiency (FCE) were collected. The basal DM intakes were 393.32, 393.85, 394.95, 396.04 and 396.98 g/day for T1, T2, T3, T4 and T5, respectively, which were not significant ($P > 0.05$) among treatments. Total intake of DM, organic matter (OM) and CP were not significantly different among treatments ($P > 0.05$). The CP and DM intake of experimental sheep were in the order of $T1 < T2 < T3 < T4 < T5$ though not statistically different ($P > 0.05$). The partial budget analysis showed that sheep offered with relatively the highest level of CP (T4) and (T5) returned a higher net income (296.05 and 304.35ETB/head), respectively. The current experiment reveals that FBH could be an alternative supplement which may substitute WB in the diets of sheep in the highlands of Ethiopia.

Keywords: Agro-Industrial By-Products, Biological Performance, Economic Benefit, Farta Sheep, Nutrient Utilization

1. Introduction

Ethiopia has huge and diversified livestock which contributes enormously to the nation's economy and livelihoods people in the country [1, 2]. In the country, the livestock sub-sector plays vital roles in generating income to farmers, creating job opportunities, ensuring food security, providing services, contributing to asset, social, cultural and

environmental values, and sustain livelihoods. The subsector contributes about 16.5% of the national gross domestic product (GDP) and 35.6% of the agricultural GDP [3]. Regardless of its immense contribution, however, the productivity of livestock per head is usually low mainly because of inadequate year round nutrition, unimproved genetic resources and prevalence of diseases and parasites. Like other livestock species, growth performance of sheep in the country is limited because of poor feeds and feeding. The country is therefore not getting benefit from the sheep and other livestock.

The major feed resources in Ethiopia for ruminants (including sheep) are natural pasture

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and crop residues which are categorized as poor quality roughage with a low intake [4], due to their tough texture, poor digestibility and nutrient deficiency such as crude protein (CP) and metabolisable energy (ME). Concentrate feed resources, are expensive and inaccessible to the majority smallholders in Ethiopia [5, 6]. There are several complementary and alternative strategies that can be pursued in tropical regions with the objective of making low quality feed more useful for production of meat and milk [7]. Thus, the use of other alternative and relatively cheap feed sources such as agricultural and industrial by-products should be investigated. One of which is faba bean hull which is a byproduct of faba bean. Ethiopia is the third main faba bean producing country in the world, next to China and UK, and there are large faba bean varietal diversifications in Ethiopia [8]. The faba bean outer cover (seed coat) is a byproduct called faba bean hull (FBH) is one of the byproducts feeds used for livestock. The FBH constitutes from 12 to 16% of faba bean weight [9]. Newton and Hill (1983) [10] and Hill et al., (2008) [11] indicated that these hulls can be used as a feed for ruminants. It is indicated that FBH hulls contain approximately CP 14.1%, NDF 54.3%, ADF 53.0%, respectively [12]. However, there is limited information on the feeding value of FBH as an alternative supplement in sheep and other ruminant livestock in Ethiopia. This study, therefore, was conducted to evaluate the effect of FBH, NSC, WB and their mixtures supplementation on nutrient utilization, live weight change and economic benefits of Farta sheep based on grass hay.

2. Materials and methods

Description of the study area

The experiment was conducted in Debre Tabor town, which is found in Amhara National Regional State, Ethiopia. The site is situated at 11°40' North latitude and 38°00' East longitudes and at 2650 meter above sea level. The mean annual rainfall is 1570 mm and the mean minimum and maximum annual temperatures are 9.6 and 21.5°C, respectively [13]. The farming system is mainly mixed crop livestock production and the major livestock raised in the study area are cattle, sheep, goats, equines and poultry. The common food crops grown in the study area

include cereals mainly barley and wheat, legumes (faba bean and pea), and potato.

Feeds and feeding management

The basal diet, used in the experiment was mixed sward natural pasture hay which was mixed with clover. The basal diet, grass hay was purchased from farmers around the study area and stored under a shade to maintain its quality. The hay was chopped manually to the size of 4-10 cm so as to improve intake by experimental sheep. The supplements, *i.e.*, NSC, WB and FBH were purchased from local market and stored safely at the study site. The hay was offered *ad libitum* along with free access of water and salt licks to experimental sheep. The concentrate supplements were offered a mixed on iso-nitrogenous basis in 2NSC:1(WB+FBH) ratio and the amount of supplement offered per day was 300 g DM/head at 0800 and 1600 hours in two equal portions daily.

Experimental animals and their management

Twenty five yearling intact male Farta sheep were purchased from local market and used for this experiment. The age of the sheep was determined by dentition and information from the owners of the sheep. The sheep were quarantined for 15 days at the site of the experiment in order to let the animals get accustomed to the specific environment and to observe their health situations. The sheep were de-wormed with Albendazol 300 gram/head for endo-and ecto-parasites treatment and vaccinated for ovine pasteurellosis, sheep pox, blackleg and anthrax with 1ml ovine pasteurellosis vaccine, 1ml sheep box vaccine and ½ ml blackleg and anthrax per sheep respectively. The experimental sheep were neck tagged for identification purpose. The experimental sheep were place in individual pen equip with a plastic bucket for concentrates and a feeding through for hay in a well-ventilated experimental barn. Experimental animals were allowed to adapt for 15 days to experimental diets before the commencement of actual data collection.

Experimental design and treatments

The experiment was conducted in a randomized complete block design (RCBD) consisting of five treatments in both the feeding and digestibility trials. The experimental sheep were blocked into five blocks of five animals based on initial body weight, which was determined by two consecutive

weightings after overnight fasting. The experimental treatments were randomly assigned

to each animal in a block. Dietary treatments were explained as follows treatments in table 1.

Table 1. Arrangement of the experimental treatments

Treatments	Basal diet(hay)	Supplement ratio 2NSC:1(WB+FBH)			Total supplement DM
	NPH	NSC (g)	WB9(g)	FBH(g)	(g/h/day)
Treatment1	Ad libitum	200	100	0	300
Treatment2	Ad libitum	200	75	25	300
Treatment3	Ad libitum	200	50	50	300
Treatment4	Ad libitum	200	25	75	300
Treatment5	Ad libitum	200	0	100	300

NPH=Natural pasture hay, FBH=Faba bean Hull, NSC=Noug seed cake and WB=wheat bran

Feeding and growth trial

The daily feeds offered and refused were collected, weighed and recorded for each sheep. Daily feed intake was calculated as the difference between the feed offered and refused. Samples of feed offered were collected per batch while samples of hay refusals were taken from each sheep daily and pooled per treatment over the experimental period and stored in plastic bags. The sheep were offered *ad libitum* hay, at 25% refusal adjustment at every week throughout the experimental period. Sub-samples of feed offer and refusal were taken after thorough mixing for chemical analysis.

Digestibility trial

The digestibility trial was conducted at the end of the feeding trial. In the digestion trial, each sheep was fitted with fecal collection bags for four days of acclimatization period to fecal collection bags prior to total collection of faeces for 7 consecutive days. Faeces voided was weighed and recorded every morning, mixed, 20% of representative samples were taken from each animal and each sample was mixed per treatment and dried by air under shade. The dried fecal samples were ground to pass through 1 mm sieve size and kept in airtight containers for further chemical analysis. Dried and milled samples of feeds, refusals and feces were taken to laboratory for chemical analysis. The apparent digestibility of DM and nutrients were determined using the following equations:

Apparent DM digestibility coefficient= $\frac{\text{DMI}-\text{Faecal DM output}}{\text{DMI}}$

Apparent nutrient digestibility coefficient= $\frac{\text{Nutrient intake}-\text{Faecal nutrient output}}{\text{Nutrient intake}}$

Where: DM=dry matter; DMI=dry matter intake

Body weight change and feed conversion efficiency

Body weight of the animals was taken at the beginning of the feeding trial after overnight fasting and every 10 days during the 90 days of feeding trial. All animals were weighed in the morning hours after overnight fasting (before feed provision) using weighing balance. The average daily body weight (BW) gains were calculated as the difference between final BW and initial BW divided by number of feeding days. The feed conversion efficiency (FCE) of experimental animals was determined by dividing the average daily BW gain to the amount of feed consumed. $\text{FCE}=\frac{\text{Body weight gain in g per day}}{\text{DM intake in g per day}}$

Partial budget analysis

A partial budget analysis was performed to evaluate the economic feasibility of the different feed treatments used in the experiment. According to the procedures of Upton [14], for the determination of the profitability partial budget analysis, purchasing and selling prices of sheep, the total quantity of feed consumed and its purchasing prices were recorded. At the end of the experiment, three experienced sheep dealers were selected from the surrounding area to estimate the selling price of each experimental sheep. In the partial budget analysis, the total return (TR) was determined by the difference between selling and purchasing price of sheep in each treatment before and after the experiment. Total variable costs (TVC) calculated as purchasing prices of total feed cost in Ethiopian Birr (EtB). The net income (NI) was calculated by subtracting total variable cost (TVC) from the total return (TR):

$\text{NI}=\text{TR}-\text{TVC}$

The change in net income (ΔNI) was calculated as the difference between the change in total return

(ΔTR) and the change in total variable cost (ΔTVC) and was calculated as:

$$\Delta NI = \Delta TR - \Delta TVC$$

The marginal rate of return (MRR) measures the increase in net income (NI) associated with each additional unit of expenditure (ΔTVC) was calculated as:

$$MRR = (\Delta NI) / (\Delta TVC)$$

Chemical analysis of feeds and feces

Chemical analysis of the experimental offered and refused feeds, and feces were done by taking the representative samples of feeds offered, refusals and feces. Dry matter was determined after oven drying of sub samples of partially dried samples at 105°C to a constant weight. The organic matter (OM), ash, and nitrogen (N) were analyzed according to the procedures of (AOAC, 1990) [15]. The crude protein (CP) was determined by multiplying the total N by the value of constant 6.25. The neutral detergent fiber (NDF), acid detergent fiber (ADF), and acid detergent lignin

(ADL) were analyzed according to the procedures [16].

Statistical analysis

The data collected on feed intake, body weight change, digestibility and feed conversion efficiency were subjected to analysis of variance (ANOVA) using the General Linear Model procedure of SAS [17]. Differences between treatments means were tested using least significance difference test at alpha 0.05. The statistical model for the analysis of data was:

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

Y_{ij} =observation in the j^{th} block and i^{th} treatment; μ =the overall mean; T_i = the i^{th} treatment effect; B_j =the j^{th} block effect; E_{ij} = random error

3. Results and discussion

Chemical composition of treatment feeds

The chemical composition of the treatment feeds used in the current study is given in table 1.

Table 1. Chemical composition of experimental feeds and refusals

Parameters	DM	OM	ASH	CP	NDF	ADF	ADL
Feed types							
GH	90	87.8	12.20	9.53	65	42.6	9.9
NSC	93	91.4	8.60	30.75	52.42	38.37	5.43
FBH	92	96.7	3.30	13.13	54	41.3	7.6
WB	91	94.5	5.50	12.38	46	28.06	5.3
WBxFBH(3:1)	91	95	5	12.57	52.63	35.52	6.6
WBxFBH(1:1)	91	95.6	4.4	12.75	50	35.79	6.6
WBxFBH(1:3)	91	96	4	12.94	56.63	42.14	7.8
Feed refusals							
Hay(1)	91	93.41	6.59	3.50	75	50.33	9.20
Hay(2)	91	93.41	6.59	3.31	70.79	55.51	10.09
Hay(3)	91	92.31	7.69	3.60	67.91	50.51	9.09
Hay(4)	90	93.33	6.67	3.27	72.00	58.88	10.11
Hay(5)	90	85.71	14.29	3.99	68	48.13	8.11

GH=grass hay; WB=wheat bran; FBH=faba bean hull; DM=dry matter; OM=organic matter; CP=crude protein; NDF=neutral detergent fiber; ADF=acid detergent fiber; ADL=acid detergent lignin.

The dry matter (DM) values of content of hay recorded in the current study is in agreement with previous reports of 91.4, 91.98 and 91.6% DM reported by different authors in Ethiopia [18-20]. However, the current findings lower than 93.99% DM reported by Getnet et al. [21]. The organic matter (OM) of hay in the present study was comparable to the OM values of 88.8, 90.2, 89.47

and 90.23% [19-21], respectively in different parts of Ethiopia. The hay offered to the experimental sheep in the current study contained high CP comparable to the value of 9.2 and 9.89% CP reported by Asmare et al. (2010) [18] and Melese (2011) [19], respectively for Farta sheep, but was higher than the value of 7.13 and 7.12% CP noted by others [20], respectively for Farta and Gumuz

[21] sheep breeds in Ethiopia. The hay used in this study was characterized by relatively high CP content, indicating its good potential to support above 7% CP required satisfying the maintenance requirement of the ruminant animals [22]. Hence, the observed CP content of grass hay in the current study was above that demanded for maintenance requirements of sheep. The higher CP content of hay in the current study might be attributed to species composition of the hay, good environmental condition in which the grasses were grown, curing process during harvesting time, and stage of maturity at which the hay was harvested. The NDF content of hay used in the current study was lower than the previous reports of 69.7, 75.65 and 79.53% reported by Melese [19], respectively, but higher than 58.68% by Yigzaw [20]. The ADF content of hay used in this experiment was lower than 50.12, 47.92 and 52.66% indicated by Asmare et al. [18], Melese [19] Yigzaw et al. [20], respectively, but higher than [19, 20, 18]. The inconsistency of chemical composition of natural pasture hay reported might be due to variations in the environment where the hays produced and stages of harvesting and drying process followed. The DM, OM, CP, ash, ADF and ADL content of the hay refusals were almost similar among all treatments. This might be due to the feeding habits of sheep which selected the most nutritious parts of the grass such as leaves and shoots and left the relatively non-edible parts like stems in similar fashion among treatments. The CP content of hay refusals was relatively similar among the five treatment feeds. However, the hay offered had higher CP but lower NDF and ADF values than the hay refusals.

The NSC used in the present study had a DM content comparable to the DM contents of 93.2, 92.6 91.3 and 92% DM reported by different authors in Ethiopia for different breeds of sheep [20, 23-25] respectively, reported from different parts of the country. The OM content of NSC in the current study is higher than the value 89.13% OM observed by [20]. The CP content of NSC in this study was lower than the values reported by [20] who reported 34.65% CP for Farta Sheep. However, the current result is comparable to the values of 31.6% CP reported by Seid and Animut [24] for Dorper×Afar F1 sheep, but higher than the value 29.8 and 28.2% CP reported by Girma et al. [23] and Tadesse et al. [25] for Arsi-Bale sheep

and Menz Sheep, respectively. The inconsistency of CP content of NSC obtained in different reports might be attributed to the type of oil extraction method used and variety of the noug seed used [26]. The same author indicated that the chemical composition of oil seed cake vary widely depending on crop species and method of processing. On the other hand, the NDF and ADF content of NSC used in the current study were 52.42 and 38.37%, respectively. These values were higher than the value reported for different findings in the country [25, 20].

The FBH and WB mixture had DM and OM contents were similar within the range of 91 to 92% DM and 94.5 to 96.7% OM, respectively. The CP value of FBH in the current result was relatively comparable to the values of 14.1 and 12.78% CP reported by DOPED [13] and Nigus et al. [27] for feeding of ruminants and Afar Sheep, respectively, but higher than the value of 7.8% CP reported by Gezahegn [28]. The current FBH NDF content was comparable 63.07% NDF content reported by Nigus [27] and lower than 74.1% NDF reported by Gezahegn [28] but, it is higher than 54.3% NDF [13]. These variations might be due to differences in the variety of faba bean and the efficiency of processing methods which may or may not allow inclusion of broken and discarded faba bean. These differences might be also happened due to differences in climatic conditions such as temperature, rainfall and the soil type where the faba bean grown.

The CP content of WB observed in the current study was less than the value of 19.4 and 19.4% CP reported by Lamaro et al. [29] and Mekuriaw and Asmare [30] for Hararghe Highland Sheep and Washera Sheep breeds, respectively. But it was comparable to 13.13% CP reported by Gebeyew et al. [26] for Afar sheep. Although, it was higher than the value of 8.9% CP reported for Bonga sheep [28]. The difference between the results might be due to the variation in the raw material methods of milling and the prolonged storage of WB after milling. The NDF value of the present study of WB was lower than the value of 51.22, 57.2 and 66.5% reported by Nigus [27], Gezahegn [28] and Lamaro et al. respectively [29], but it was higher than 28.7% [30]. The ADF content of WB was higher than 12.95, 11.2, 17.7 and 17.4% ADF reported by different authors [28, 30].

Dry Matter and Nutrient Intakes

The mean values of daily DM and nutrient intake of Farta sheep fed on NPH and supplemented with FBH, WB and NSC and their mixture is presented in table 2. There was no statistical difference ($P>0.05$) in basal DM, total DM, OM, CP and, estimated metabolizable energy (ME) intake among the treatments. Lack of statistical differences among treatments could be attributed to the relative similarity of supplementation of FBH and wheat bran in nutrient content and partly due to the uniform supplementation with noug seed cake. Except CP, the current result agreed with Mulisa et al. [31] who reported that the effect of substitution of pigeon pea leaves meal with neem leaves meal and supplementation of different proportions of PPLM and NLM instead of concentrates mixture was not had significant effect on OM, estimated metabolizable energy, total DM and basal DM intake. Similarly the basal as well as the total DM intake in the present study agreed with the results of Alemu [32] who

reported that when gumuz sheep fed on natural pasture hay supplemented with noug seed cake, wheat bran and their mixtures was no significant difference in the amount of the basal and total DM intake between the supplemented groups. Also Hassen and Ali [33], reported that the effect of different level of molasses inclusion on feed intake, body weight gain and carcass parameters of afar sheep, total dry matter intake (TDMI), organic matter intake (OMI), and digestible organic matter intake (DOMI) did not differ between treatments. In the current result the non-significant difference ($P>0.05$) of CP and ME intake among treatments is in agreement with that of [30] who reported that the nutrient intake, digestibility and growth performance of Washera lambs fed natural pasture hay supplemented with graded levels of *Ficus thonningii* (Chibha) leaves as replacement for concentrate mixture, a non-significant difference was observed in CP and ME intake among treatments.

Table.2. Mean daily dry matter and nutrient intake of Farta sheep fed natural pasture hay basal diet and supplemented faba bean hull, wheat bran and noug seed cake mixtures

Parameters	Treatments					SEM	SL
	T1	T2	T3	T4	T5		
Hay DM intake (g/day)	393.32	393.85	394.95	396.04	396.98	20.8	ns
CM DM intake (g/day)	300	300	300	300	300	-	ns
Total DM intake (g/day)	693.32	693.85	694.95	696.04	696.98	20.8	ns
DM intake (% BW)	3	3	3	3	3	-	ns
DM intake (g/ kg W 0.75)	66.56	66.59	66.85	67.07	67.13	4.6	ns
Nutrient intake (g/d)							
OM intake (g/day)	651.57	654.63	655.21	656.2	660.59	20.2	ns
CP intake (g/day)	125.14	125.49	125.75	125.93	126.22	1	ns
NDF intake (g/day)	146.51 c	172.06bc	173.86bc	198.44ab	228.15a	35.3	**
ADF intake (g/day)	270.05c	284.51bc	291.06abc	294.96ab	308.99 a	17.1	**
ADL intake (g/day)	61.38c	64.40bc	66.28ab	66.61ab	69.47 a	2.8	***
EMEI (MJ/Kg DM)	5.15	5.58	5.66	5.89	6.26	0.86	ns

a, b, c=means within rows having different superscript are significantly different at***= $p<0.001$;**= $P<0.01$, ns =not significant at ($P>0.05$), ADF=acid detergent fiber; BW=body weight; CM=concentrate mixture; CP=crude protein; NDF=neutral detergent fiber; OM=organic matter; SEM=standard error mean; SL=significant level.

The total DM intake as percent of body weight of the experimental sheep was 3% while intake per metabolic body weight of experimental sheep varied from 66.56 to 67.13 % although the results were not statistically significant ($P>0.05$). The total DM intake expressed as percent of body weight obtained from the current study was in agreement with that of Hassen and Ali [33] the value of which is in the range of the recommended dry matter intake of ruminants (2-6%) by ARC [35]. The NDF and ADF intakes of sheep were

significantly different ($P<0.01$) among treatments and in the order of $T5>T4>T3>T2>T1$. The current result were comparable to those of Getnet et al. [21], who reported that the effect of replacing hay with soybean or groundnut straw as basal diet on feed intake, nutrient utilization, body weight gain, and carcass characteristics of gumuz sheep, the nutrient intake were significant difference ($P<0.01$). Whereas, significantly higher ($P<0.001$) ADL intake was observed between treatments in the order of $T5>T4>T3>T2>T1$. The

current result was comparable with that reported by Mekuriaw, Y. and Asmare [30] in Washera lambs supplemented with different levels of ficus leaves and concentrate mixture.

The trends in DM intake over the feeding trial period for Farta sheep fed natural pasture hay and supplemented with the ratio of 2NSC:1(WB+FBH) concentrate is presented in Fig 1. As the Figure illustrates the total DM intake

of experimental sheep in the current study continued slightly increasing trend throughout the experimental period. The trend is similar between treatments in total DM intake throughout the experimental period. This associated with similar increment in live body weight of experimental animals among treatments. This might be the daily nutrient intake can satisfy equally the daily nutrient requirement of the experimental sheep.

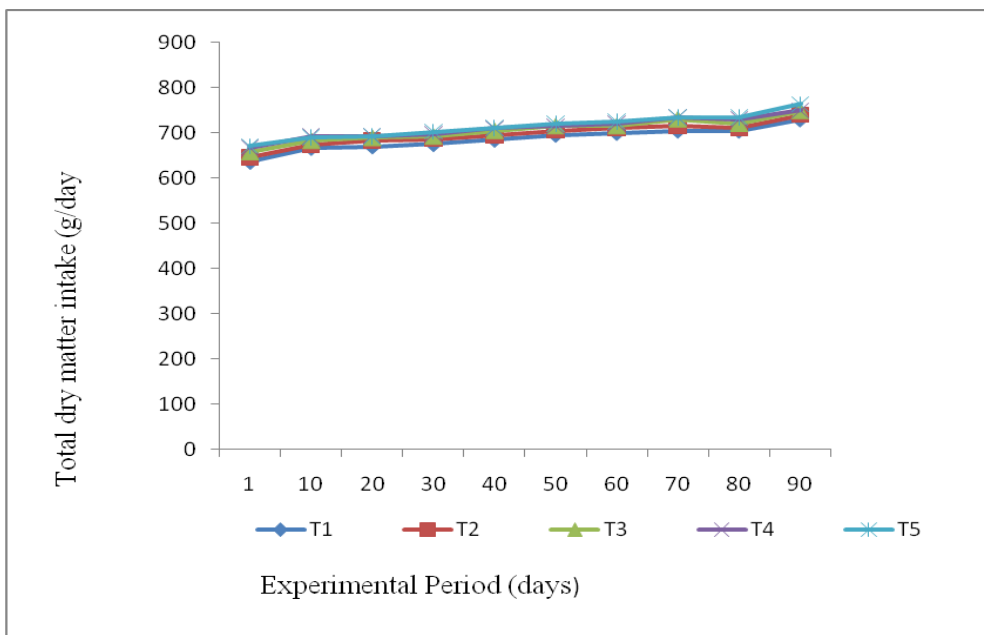


Figure 1. Trends in dry matter intake over the experimental period for Farta sheep fed natural pasture hay and supplemented with faba bean hull wheat bran and noug seed cake mixture

Dry Matter and Nutrient Digestibility

The DM and nutrient digestibility of Farta sheep fed natural pasture hay basal diet and supplemented with mixtures of faba bean hull, wheat bran and noug seed cake is presented in table 3. The digestibility of DM and nutrients were not significantly different ($P>0.05$) among treatments. The non-significant difference among treatments might be due to the similarities of the nutrient composition of the supplement feeds. The current result was comparable with the report of Nigus [27], when 45 g NSC as maintenance requirement and FBH and wheat bran mixture indifferent proportions used as supplemented diets with the exception of digestibility of CP, the digestibility of DM and other nutrients were not significantly affected by treatments, while differences among the substituted group in CP digestibility were not significant. In the current

study the apparent digestibility of CP and OM also comparable with the reports of Alemu [32], who reported that the apparent digestibility of CP and OM were no different among the supplemented groups. Yigzaw, et al. [20] reported also supplementation of different levels of lentil hull and noug seed cake mixtures to Farta sheep fed on natural pasture hay as basal diet showed no significance difference among supplemented treatments for DM, OM and CP digestibility. McDonald et al. [7] noted that the OM digestibility of young pasture grass to range from 45 to 85%, and the values noted in the current study are within this range. Lack of statistical differences in DM and nutrient digestibility among treatments could be attributed to the relative similarity of the FBH and wheat bran supplementation in nutrient content.

Table 3. Mean dry matter and nutrient digestibility by Farta sheep fed natural pasture hay basal diet and supplemented with faba bean hull, wheat bran noug seed cake and their mixtures

Parameters	Treatments					SEM	SL
	T1	T2	T3	T4	T5		
Apparent digestibility							
DM	46.44	51.70	52.50	54.84	57.06	9.20	ns
OM	49.26	54.32	55.06	57.28	60.50	8.70	ns
CP	71.40	71.72	72.24	74.50	75.28	5.50	ns
NDF	34.66	35.62	39.56	44.80	50.44	11.40	ns
ADF	13.22	14.34	20.70	28.02	33.72	14.80	ns
	Digestible nutrient intake (g/d)						
DDMI	331.31	347.35	352.56	368.89	383.73	59.70	ns
DOMI	327.82	355.58	360.55	374.99	399.01	54.90	ns
DCPI	89.39	90.31	91.13	93.65	95.16	6.70	ns
DNDFI	151.48	165.34	176.74	215.74	241.79	50.50	ns
DADFI	35.66	58.30	58.78	85.69	94.87	34.80	ns

DM=dry matter; OM=organic matter; CP=crude protein; NDF=neutral detergent fiber; ADF=acid detergent fiber; DDMI=digestible dry matter intake; DOMI=digestible organic matter intake; DCPI=digestible crude protein intake; DNDFI=digestible neutral detergent fiber intake; DADFI=digestible acid detergent fiber intake; SEM=standard error mean; SL=significance level.

Body Weight Change and Feed Conversion Efficiency

The average daily gain and feed efficiency of Farta sheep fed natural pasture hay basal diet and supplemented with mixtures of FBH, WB and NSC are presented in table 4. The current result indicated that the effect of supplement had no significant effect ($P>0.05$) on average daily body weight gain, final body weight and feed conversion efficiency of experimental sheep. The absence of significant difference among treatments in daily live weight gain reflected that the substituting supplements were comparable in their potential to supply nutrients for improving the weight gains of the sheep. The current result is comparable to the result of Nigus [27] who

reported that substitution effect of faba bean hull to wheat bran on body weight change and carcass characteristics of Afar sheep fed hay as basal diet, the daily live weight gain, final body weight, body weight change and feed conversion efficiency (FCE) were no significant difference among the substituted treatments. Similarly, it was comparable to the reports of Mulisa et al. [31] who stated that effect of feeding different proportions of pigeon pea and neem leaves on feed intake, digestibility, body weight gain and carcass characteristics of gumuz goats, the daily live weight gain, final body weight, body weight change and feed conversion efficiency (FCE) were no significant difference among treatments.

Table 4. Body weight change, feed conversion efficiency of Farta sheep fed on natural hay and noug seed cake and substituted with different proportions of faba bean hull and wheat bran

Body weight change	Treatments					SEM	SL
	T1	T2	T3	T4	T5		
Initial BW (kg)	16.66	16.40	16.86	16.34	16.72	2.13	ns
Final BW (kg)	22.98	23.00	23.52	23.56	24.24	2.29	ns
BWC (kg)	6.32	6.60	6.66	7.22	7.52	1.25	ns
ADG (g/day)	70.90	74.40	75.60	77.80	80.20	14.25	ns
FCE (ADG/g DMI)	0.09	0.10	0.11	0.11	0.12	0.03	ns

ns=not significant at ($P>0.05$); ADG=average daily gain; BW=body weight; FCE: feed conversion efficiency; SEM=standard error of means; SL=significant level.

The final body weight and feed conversion efficiency in the current results were comparable to those of Asmare et al. [36] for Washera sheep fed on natural pasture hay and desho grass hay mixture and supplemented with noug seed cake

and wheat bran in 50:50 ratio the final body weight and feed conversion efficiency were not statistically significant. On the other side, the results of the current study was comparable to the results Gezahegn (2018) [28] who reported 81.1

g/day from Bonga sheep fed on natural grass hay basal diet supplemented with concentrate (300 g/d DM).

Mean daily body weight gain of sheep obtained from this study was higher than the results of Nigus [27] who reported that the mean daily gain of Afar sheep fed grass hay and noug seed cake and substituted with different proportions of FBH and WB ranged between 63.96 and 64.67 g/day. The general trends in body weight changes of Farta sheep fed on natural pasture hay with supplementation of concentrate mixture is shown in Fig. 2. The figure show that in the current study, the daily body weight gain increased as the experimental period increased. The study shows that supplementation of FBH and WB bran improves performance of animals. The result of the current study is supported by the findings of Tekliye et al. [37] indicated that supplementation with *Sesbania sesban* leaves improved average

daily gain and feed conversion efficiency of Farta sheep. Similarly Alemu [32] reported that supplementing Gumuz sheep fed natural hay as basal diet with different proportions of Noug seed cake and wheat bran mixtures improved total DM intake, digestibility of nutrients and digestible nutrient intake which resulted in improving weight gain performance and carcass characteristics. The current result feed conversion efficiency was higher than the observed results (0.09) of Nigus [27] for Afar sheep. However, the current result was comparable with that reported that the feed conversion efficiency in the supplemented treatment (0.12) by Alemu [32] in Gumuz sheep. These results may presumably be due to higher nutrient concentration of the substitute supplement feed, which have higher digestibility values result in higher final body weight gain, average daily gain and feed conversion efficiency.

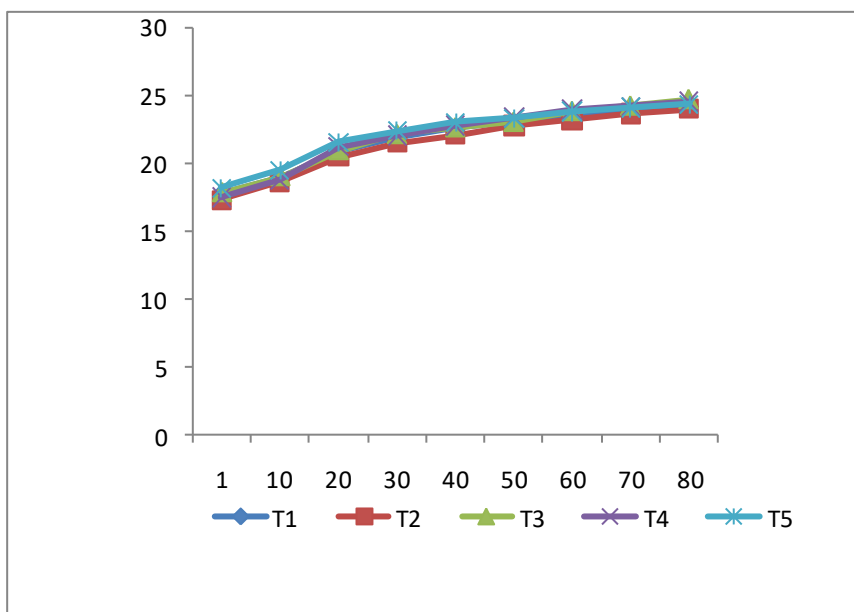


Figure 2. Trends in body weight changes of Farta sheep fed natural pasture hay and supplemented with different proportions of faba bean hull and wheat bran and noug seed cake mixture

Correlation between Nutrients Intake, Digestibility and Daily Body Weight Gain of Farta sheep

Results of correlation between and among some parameters of intake, digestibility and daily body weight changes are presented in table 5. The result of the present study indicated that dry matter intake (DMI) was positively correlated ($p < 0.01$) with the intake and digestibility of OM, CP, NDF and ADF. As the total dry matter intake increased

the other nutrient intake also increase. This agreed with the results reported by asmare et al. [36]. Positive correlation of DM intake ($P < 0.01$) with OM, CP, NDF and ADF intake and CP digestibility observed by Alemu [32] in gumuz sheep fed natural pasture hay with mixtures of wheat bran and noug seed (*Guizotia abyssinica*) cake agrees with the current finding. In the current study OMI was positively correlated ($p < 0.01$) with the intake and digestibility of CP,

NDF, and ADF. In this study, CP intake was positively correlated ($P<0.01$) with intake of DM, OM, NDF, and ADF, digestibility of DM, OM and CP. The results of the present study were in accordance with the results reported by [36]. The result of the correlation analysis indicated that daily body weight gain was positively ($P<0.01$) correlated with DM, OM, CP, NDF, and ADF intake and digestibility which is in agreement with previous results obtained from the feeding trial conducted with Washera sheep [34, 36]. Similarly,

alemu [32] also reported that body weight gain (ADG) was positively correlated with DM, OM and CP intake and CP digestibility. As many research results made the evident thus far, the effect of increased digestibility on improving feed intake depends on the quality of roughage feed used. The correlation analysis result indicated that provision of FBH and WB as a supplement in small ruminant feeding is a promising feed in terms of nutrient utilization and animal performance.

Table 5. Correlation between nutrient intake, digestibility and body weight change in Farta sheep fed natural pasture hay and supplemented with faba bean hull, wheat bran and noug seed cake mixture

	DMI	DMD	OMI	OMD	CPI	CPD	NDFI	NDFD	ADFI	ADFD	ADG
DMI	1										
DMD	0.89**	1									
OMI	0.90**	0.89**	1								
OMD	0.90**	0.96**	0.89**	1							
CPI	0.93**	0.94**	0.87**	0.93**	1						
CPD	0.90**	0.92**	0.76**	0.90**	0.95**	1					
NDFI	0.82**	0.56**	0.57**	0.58**	0.55**	0.58*	1				
NDFD	0.83**	0.58**	0.59**	0.56**	0.54**	0.61**	0.37*	1			
ADFI	0.76**	0.54**	0.65**	0.54**	0.55**	0.59**	0.49*	0.24*	1		
ADFD	0.80**	0.53**	0.55**	0.54**	0.61**	0.61**	0.42*	0.51*	0.09*	1	
ADG	0.95**	0.86**	0.96**	0.83**	0.97**	0.85**	0.27*	0.76**	0.34*	0.78**	1

*= $(p<0.05)$; **= $(p<0.01)$, DMI=Dry matter intake; OMI=Organic matter intake; CPI=Crude protein intake; NDFI=Neutral detergent fiber intake; ADFI=Acid detergent fiber intake; DMD=Dry matter digestibility; OMD=Organic matter digestibility; CPD=Crude protein digestibility; NDFD=Neutral detergent fiber digestibility; ADFD=Acid detergent fiber digestibility; ADG=Average daily gain.

Partial Budget Analysis

The partial budget analysis result of Farta sheep fed natural pasture hay alone and supplemented with mixtures of faba bean hull and wheat bran at different proportions and noug seed cake for maintenance requirement is presented in table 6. The partial budget analysis was performed to evaluate the economic advantages of the feeding regime.

The result of the partial budget analysis indicated that the total return obtained in this trial was 696, 701, 714, 724 and 731 ETB/head for the sheep fed on T1, T2, T3, T4 and T5 diets, respectively. The result of this study indicated that higher total return (731 ETB/head) was obtained from the

sheep supplemented with sole FBH (T5); followed by, T4, T3, T2 and T1 in decreasing order. The net income was 276, 278.5, 288.75, 269.05 and 304.35 ETB/head for T1, T2, T3, T4 and T5 respectively. This result indicated that there was no loss of Birr/head in all treatments. This was due to the weight gain exhibited by experimental animals in all treatment diets during the experimental period. In this study, difference in total return followed the same trend with weight gain of the animals. This shows that the sheep which had higher weight gain had a better potential to be sold at higher price to earn higher gross income.

Table 6. Partial budget analysis of farta sheep fed natural pasture hay basal diet and supplemented with faba bean hull, wheat bran, noug seed cake and their mixtures

Variables	Treatments				
	T1	T2	T3	T4	T5
Purchase price of sheep (ETB/head)	1079	1079	1079	1079	1079
Hay consumed (Kg/head)	35.4	35.45	35.55	35.64	35.73
WB and FBH mixture consumed (Kg/head)	9	9	9	9	9
NSC Consumed for maintenance (Kg/head)	18	18	18	18	18
Total feed consumed (Kg/head)	62.4	62.45	62.55	62.64	62.73
Cost of hay (ETB/head)	177	177.25	177.75	178.2	178.65
Cost of supplement (ETB/head)	72	74.25	76.5	78.75	81
Cost of NSC (ETB/head)	171	171	171	171	171
Total feed cost (ETB/head) (TVC)	420	422.5	425.25	427.95	430.65
Gross income (Sell price) (ETB/head)	1775	1780	1793	1803	1814
Total return (TR) ETB/head)	696	701	714	724	735
Net income (NI) ETB/head	276	278.5	288.75	296.05	304.35
Change in net income (Δ NI)	-	2.5	12.75	20.05	28.35
Change in total variable cost (Δ TVC)	-	2.5	5.25	7.95	10.65
MRR= Δ NI / Δ TVC	-	1	2.4	2.5	2.7

ETB=Ethiopian birr; NSC=noug seed cake; TR=total return; Δ NR= change in net return; Δ TVC=change in total variable cost; MRR=marginal rate of return.

As it's indicated from the partial budget analysis in Table 5 sheep fed on 100 g of FBH and 200 g NSC mixture in T5 returned a higher net income (304.35 ETB/head) as compared to the other treatments. This was mainly due to slightly higher weight gain obtained, feed conversion efficiency and higher selling price of animals by this treatment than other treatments. The changes in net income from the treatments were 2.5, 12.75, 20.05 and 28.35 ETB/head. The change in net income was higher in T5 followed by in the order of T4>T3>T2. The marginal rate of return in T2, T3, T4, and T5 were 1, 2.4, 2.5, and 2.7, respectively. This indicates that to attain required BW by supplement feeding, each additional unit of 1 ETB increment per sheep to purchase supplement feed resulted in a profit of 1, 2.4, 2.5 and 2.7 ETB for T2, T3, T4 and T5, respectively. The economic profitability in the current study indicated that supplementation of 100 g FBH and 200 g NSC (T5) was slightly profitable and economically beneficial than the other treatment feeds. Generally, as this study based on the net profit, T5 relatively higher than other treatments and is recommended. However, all supplements used in this study induced positive net profit and thus can be employed in feeding systems depending on their availability and relative cost.

4. Conclusions

In the current study, it was concluded that sheep supplemented with FBH, WB and NSC mixtures at a ratio of 200 g NSC+25gWB+75 g FBH (T4) and 200 g NSC+0 g WB+100 g FBH were economically feasible and profitable. Thus, it is recommended that supplementation of hay with 300 g/day concentrate mixture of FBH, WB and NSC at a ratio of 200 g NSC+ 25 g WB+75 g FBH (T4) and 200 g NSC+0 g WB+100 g FBH (T5) is biologically efficient and potentially profitable in feeding of yearling Farta sheep. The result of this study indicated that CP content of faba bean hull completely comparable with WB and has favorable response in terms of sheep body weight improvement and marginal rate of return (MRR). Therefore, FBH can be used as alternative supplement in areas where wheat bran is not accessible. In order to verify the finding of the current study at producers' level, undertaking on farm trials using the treatment used in this study is worthwhile.

Declaration of Competing Interest

All authors declare that they have no conflict of interest.

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