ORIGINAL ARTICLE

Forage yield and replacing concentrate supplements with oat and vetch mixed forage on the performance of sheep fed Desho grass (*Pennisetum pedicellatum)* based diets

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ABSTRACT

Smallholder farmers are often challenged by lack of access and affordability of concentrate supplements for fattening small ruminants. An on-farm feeding experiment was conducted using 32 yearling rams (weighing 21.1±2.3 kg), to evaluate the effect of replacing a concentrate supplement with a home-grown oat-vetch mixed forage on the performance of lambs fed Desho grass basal feed *adlibitum*. In addition experimental forage yield was determined. The sheep were blocked into four groups according to their weight, and randomly assigned to one of the four treatments. The four treatments were hay + 302.6 g/h/d/ concentrate (T1); hay + 106.7 g oat-vetch and 204.7 g concentrate (T2); hay + 204 goat-vetch hay and 106 g concentrate (T3) and hay + 302 g oat-vetch hay (T4). The actual feeding experiment lasted 75 days. Feed intake was measured daily and body weight gain fortnightly. Dry matter (DM) yields of the oat-vetch mixture ranged from 6.4 to 7.1 ton/ha and the Desho grass from 10.2 to 11.8 ton/ha. Feed intake decreased ($P<0.05$) with increasing level of supplementation of oat-vetch mixed supplement. Mean daily intake of DM per animal decreased from 742 g for the groups fed on sole concentrate supplement to 691 g for the groups fed on sole oat-vetch supplement. The consumption of all other nutrients showed similar pattern to that of dry matter intake. The groups fed on 67% concentrate plus 33% oat-vetch mixture had higher ($P<0.05$) average daily body weight gain (130 g) and feed conversion efficiency (0.17) compared with the others. On the other hand, higher ($P<0.05$) marginal rate of economic return was observed for groups fed on 33% concentrate plus 678% oat-vetch mixture (229%), followed by those fed 67% concentrate plus 33% oat-vetch (147%). In conclusion, homegrown oat-vetch mixed forage could substitute a considerable proportion of concentrate supplement required for intensive sheep fattening with reduction in production costs and optimizing income for smallholders.

Keywords: Concentrate, Desho grass, Oat-vetch mixture hay, Replacement value, Weight gain.

INTRODUCTION

Ethiopia has a large small ruminant population, with an estimated number of 30.7 million sheep and 30.2 million goats (CSA, 2017) that are widely adapted to different agro ecological zones. Sheep and goat production serve as a source of meat and immediate cash income for smallholders. However, the shortage of good quality feed for year-round production has remained the major constraint to boosting small ruminant production for local and export markets (Lemecha et al., 2013; Shapiro et al., 2015). Feed scarcity is mainly associated with the continual conversion of grazing lands into arable lands to meet the food demands of the increasing human population (Mekasha et al., 2014).

The current scenario in the highlands necessitates a shift in small ruminant production practice from grazing based to an intensive cut-and-carry feeding system. Connected to this, efforts have been initiated to promote cultivated forages under the smallholder system, especially the integration of cultivated forages with natural resource management practices. Desho grass is one such forage which has been playing an important role in stabilizing soil bunds/terraces constructed in enclosures and arable lands, as well as providing much needed good quality basal feed for small ruminants (Asmare et al., 2016). However, animals feeding on such grass-based diets need supplementation with energy and protein source feeds to obtain optimal weight gain within a reasonable time. Concentrate supplements are often inaccessible to smallholder farmers and, where they are accessible, the purchasing power of the farmers is limited. Consequently, homegrown feed supplements offer good alternatives to concentrates both in terms of accessibility and economic feasibility. A mixture of grass and legume forages, such as oats and vetch, could serve such a function. Oat and vetch forages can be grown easily in a wide range of agro-ecologies and harvested within 90 days of planting with a potential for multiple cuts. This study was conducted to explore the potential of oat and vetch mixture forage as a supplement to enhance the performance of local sheep fed a basal diet of Desho grass.

MATERIALS AND METHODS

Description of the study area

This study was conducted in the Damot Gale district of Southern Ethiopia located at 6° 53′ 0" and 7° 6′ 30" N, and 37° 46′ 0" and 37° 58′ 40" E at an altitude of 1501 to 2950 meters above sea level (Admasu *et al.*, 2019). The area receives mean annual precipitation of 1151 mm and the mean monthly temperature of the Sodo Zuria district ranged from 19 °C to 23 °C with an average temperature of 20.5 °C (NMA, 2020). The farming system in the area is mixed crop-livestock system. The area experiences high population pressure with an average land holding of 0.5 ha/hh. Farmers often raise and fatten sheep by tethering around the homestead for home consumption and cash income. .

Forage production

As part of a forage technology scaling intervention, oats (*Avena sativa* L) and vetch (*Vicia sativa* L) mixed seed (at a ratio of 2:1 by weight) and desho grass splits were distributed to 16 volunteer farmers who allocated an average of 0.2 ha of land in Wadara Gale and Boloso Sore sub-districts. Planting of forages were done on plots of volunteer farmers. The forages were planted during the main rainy season on August 8 and 9, 2017. Desho grass splits were planted on terraces and farmlands with plant and row spacing of 0.1 and 0.5 m, respectively. Diammonium phosphate fertilizer was applied to the oat-vetch mixture at a rate of 100 kg/ha at the time of planting. The oat-vetch mixture was harvested after 90 days of planting, when the vetch attained around 50% flowering. Before the total harvest, representative samples were collected, using 1×1 m quadrat, from three random spots per plot for yield estimation. The weight of oat and vetch in each sample was recorded to determine the relative proportion. Harvesting of desho grass was done at the commencement of the feed adaptation period. The representative samples were stored in cotton bags and air dried to avoid mold formation prior to oven drying. The air-dried samples were kept in an oven at 105^{0}C for approximately 12 h until a constant weight is obtained.

Animal management

A total of 32 yearling Adilo rams (with an average initial body weight of 21.1±2.3 kg) were purchased from Wolaita market based on physical appearance, information from the owner and dental examination. They were ear-tagged, vaccinated for common diseases in the area and treated against ecto- and endo-parasites and allowed an adaptation period of 15 days. At the end of adaptation period the sheep were divided into 4 groups each with 8 sheep. Each group was further sub-divided into 4 groups each with 2 sheep. Each group of 2 sheep was randomly distributed to farmers who had grown oat-vetch forage which was used as a supplement. Finally each group was randomly assigned to the 4 treatment diets in Randomized Complete Block Design (Table 1). Animals were managed uniformly among the farmers in order to minimize variability as much possible. Desho grass was used as a basal diet and offered *ad libitum*. The sheep in each treatment group were tethered and fed separately while in barns and or outdoors. Individual feeding troughs were used to offer both the basal feed and the refusals. The animals were tethered outside under shade from 8:00 AM to 4:00 PM, and housed in barns during the night time.

Experimental feed preparation and feeding

A total of 16 farmers who developed their own forage were selected in advance to participate in the feeding experiment based on good forage management and their proximity to each other. Oat-vetch mixed forage was harvested, made into hay, chopped at about 5 cm length and stored in clean sacks. Desho grass was harvested daily starting after three months of planting to be fed green. Desho grass was chopped at about 10 cm length before being offered to the experimental animals. Samples of offered desho grass were collected every two weeks to determine their dry matter content. The basal feed (desho grass) was offered *ad libitum* and the supplemental forage (oat-vetch) was fed in the form of hay as per the experimental design indicated in Table 1. A concentrate mix was prepared from wheat bran and noug *(Gizotia abyssinica)* seed cake at a ratio of 2:1 (wheat bran to noug cake) and salt was added at 0.5% of the concentrate mix.

Table 1. Treatments, proportion of the diets and the amount of feeds offered to the experimental animals

Treatments and proportion	Basal diet	Supplement (g DM /Day)	
	Desho grass	Oat-Vetch	Concentrate
Desho Grass + 100 % Concentrate* (T1)	ad libitum	0	302.6
Desho Grass + 67 % concentrate + 33% Oat-vetch (T2)	ad libitum	106.7	204.7
Desho Grass + 33% Concentrate + 67% Oat-vetch (T3)	ad libitum	204.7	106.7
Desho Grass + 100 % Oat-Vetch (T4)	ad libitum	302.6	0

*Concentrate is made of wheat bran and noug seed cake mixture in 2:1 proportion.

During the feeding trial, the supplements were offered after animals received their morning basal feed. For the treatments which included both oat-vetch hay and concentrate supplement, the oat-vetch hay was given first followed by the concentrate mix. For the treatment group receiving oat-vetch hay supplement alone, about 8 g salt (measured using a sensitive balance and packed in a rolled small paper bag) was dissolved in half a glass of water and sprayed over the top of the daily hay offering. Water was made freely available.

Daily feed offered and refusals were measured using a sensitive balance and sub samples (100 g) of the offered and refusals were collected throughout the feeding period for immediate DM determination. The remaining parts of the samples were bulked from which representative samples were taken for chemical analysis at the end of the feeding experiment. Intake was determined by calculating the difference between feed offered and refusals.

Weight gain and feed conversion efficiency

Initial animal body weight was taken at the start of the actual feeding experiment. Thereafter weight was measured every 15 days before the morning feed. The final weight measurement was taken at the end of the feeding experiment. The average daily weight gain was calculated by dividing the difference between the final and initial body weight over the number of feeding days. Feed conversion efficiency (FCE) was calculated by dividing the average daily weight gain by the average daily feed intake, measured in grams.

Chemical analysis

The analyses were conducted in the nutrition laboratory of the International Livestock Research Institute (ILRI). Dried samples were ground to pass through a 1mm sieve. Near Infrared Spectroscopy (NIRS) was used to analyze the samples. The NIRS machine used equations calibrated and validated by the conventional wet chemistry analysis (AOAC, 1990). The NIRS instrument used was a FOSS Forage Analyzer 5000 with software package WinISI II. Predicted nutritional variables were nitrogen (N) (Crude protein = N*6.25), neutral detergent fibre (NDF), acid detergent fibre (ADF), acid detergent lignin (ADL), *in vitro* organic matter digestibility (IVOMD). Metabolisable energy (ME) was estimated from digestible energy (DE) which in turn was estimated from the IVOMD (NRC, 2001): $DE = (0.01*(OM/100)*(IVOMD+12.9)*4.4) - 0.3$; $ME\ (MCal/kg) = 0.82*DE$.

Partial budget analysis

Information on all costs of production including medication, animal and feed purchase costs was collected. Sheep price estimation was made together with two sheep traders and one farmer representative who has experience of sheep marketing. Information on the market price of local grass hay and fresh Desho grass was obtained from survey work and the weekly forage price data in the district forage market. The cost of hay in the local market and information obtained from oat-vetch producer farmers (who did not participate in the feeding experiment) was considered to estimate the cost of oat-vetch mixture hay. Economic analysis was conducted using the procedure recommended by CIMMYT (1988). Dominance analysis was carried out by first listing the treatments in order of increasing costs that vary. Marginal rate of return was computed by dividing the marginal net benefit (i.e., the change in net benefits) with the marginal cost (i.e., the change in costs) multiplied by one hundred and expressed as a percentage.

Statistical data analysis

Measured parameters of the experiment were subjected to analysis of variance (ANOVA) using the general linear model (GLM) of SAS 9.2 version (SAS, 2007). Mean comparisons were made using Duncan's multiple range test at a 5% probability. The model statement for the growth and digestion trial was:

$Y_{ij} = \mu + F_i + B_j + €_{ij}$ Where Y_{ij} = response variable, μ = over all mean, F_i = effect of feed (treatment effect), Bj = block effect, $€_{ij}$ = random error.

RESULTS AND DISCUSSION

Experimental forage yield and chemical composition

The average fresh and dry matter yield of the oat-vetch mixture and Desho grass is shown in Table 2. Dry matter yields of the oat-vetch mixture ranged from 6.4 to 7.1 ton/ha and the Desho grass from 10.2 to 11.8 ton/ha. The yield of the forages was similar between the two sites. The proportion of oats and vetch in the mixed forage was close to 1:1 on a DM basis. The yield and quality of the oat-vetch supplement and Desho grass basal diet were generally in line with expectations based on previous studies (Bezabih et al. 2016; Asmare 2016).

Table 2. Mean fresh and dry matter yield (ton/ha) of oat-vetch mixed forage and Desho grass in Wandara Gale and Boloso Sore sub-districts harvested during the feeding period.

Variable	Districts	
	Wandara Gale	Wandara Boloso
Oat-vetch fresh yield (ton/ha)	29.86 ± 11.08	30.9 ± 8.85
Oat-vetch dry matter (DM) percent	21.99 ± 2.26	22.47 ± 1.25
Oat-vetch dry matter yield (ton/ha)	6.36 ± 1.62	7.1 ± 1.88
Desho fresh yield (ton/ha)	45.89 ± 13.92	54.31 ± 17.83
Desho dry matter percent	22.15 ± 2.18	21.7 ± 2.09
Desho dry matter yield (ton/ha)	10.22 ± 3.57	11.77 ± 3.85
Oat proportion (%)	51.05 ± 13.24	56.11 ± 8.17
Vetch proportion (%)	48.95 ± 13.24	43.89 ± 8.17

The chemical composition of the forages produced and concentrate supplements used in the experiment are shown in Table 3. There was considerable variation in the chemical composition of the basal diet and the supplements. Compared to Desho grass, the oat-vetch forage contained 55% and 16% higher CP and ME, respectively. Wheat bran contained approximately double the CP content of Desho grass, and similarly the ME content was higher by greater than 50%. Noug cake had the lowest OM content, but the CP content was more than double that of wheat bran. While both wheat bran and noug cake had similar NDF content, they differed considerably in ADF and ADL contents.

The mean CP content of desho grass in the current study is in agreement with result obtained from highland (8.17%) and midland (9.55%) area (Asmare, 2016), harvested at 3 months of age. The CP content in the current study is greater than the CP content (6.5%) of the same species reported by Waziri et al. (2013). The mean energy content (8.22 MJ/kg) of desho grass used in the current experiment was greater than another finding reported by Asmare (2016) in both highland (6.69 MJ) and midland (6.82 MJ) areas at three month cutting age. This result indicates that desho grass can satisfy the energy requirement (6.4MJ/kg DM) of growing male sheep with 20 kg live body weight and 150 gram mean daily gain, but require protein supplement to satisfy the metabolisable protein requirement (61-76 g) of the same class of animal (Mc Donald *et al.*, 2010). The mean CP content of oat-vetch hay (13.29 %) was lower than CP content of the same mixed forage species reported (15%) by Bezabih *et al.* (2016). The CP content of oat-vetch used in the current feeding experiment was above the minimum level of 7.5 % required for optimum rumen function (Van Soest, 1982) and is sufficient enough to satisfy the nutrient requirement of sheep when supplemented to desho grass.

Feed intake and body weight gain

This study present the first dataset on the potential of homegrown annual oat-vetch mixed forage as a substitute of concentrate feeds in sheep fattening diets.Intake of Desho grass (the basal diet) was lower ($P<0.05$) for sole oat-vetch than for sole concentrate, 67 % concentrate and 33 % Oat-vetch and 33 % concentrate 67% oat-vetch mixture, with the later treatment combinations showing similar ($P > 0.05$) levels of Desho grass intake (Table 4). The highest ($P < 0.05$) daily total DM, OM, CP and ME intakes were observed in sheep supplemented with sole concentrate and 67% concentrate and 33% oat-vetch mixture, with a decreasing trend as the proportion of oat-vetch in the supplement increased from 0 to 100%. When the DM intake was expressed in terms of metabolic body weight, the highest ($P<0.05$) total DM intake was observed in the sheep fed sole concentrate supplement. Conversely, intakes of ADF increased with increasing levels of oat-vetch mixture in the diet. As a result, sheep fed the sole oat-vetch mixture had the highest ADF intake (P<0.05) followed by 33 concentrate and 67 % oat-vetch mixture, 67% concentrate and 33% oat-vetch mixture and sole concentrate supplement. In the present study the highest dry matter intake was observed in sheep supplemented with concentrate only and in sheep supplemented with a high proportion of concentrate and a low proportion of oat-vetch mixed forage. This appears to be a direct reflection of the nutritional balance for microbial growth and fermentation in the rumen which improves the rate of fibre degradation and passage of ingesta in the digestive tract. On the other hand, the lowest basal diet intake observed in sheep supplemented with oat-vetch hay alone may be attributed to higher rumen fill and more time spent on rumination. Intake of ME and CP followed the same trend as the dry matter, decreasing with increasing levels of oat-vetch mixed hay in the supplement.

Table 3: Nutrient composition (percent) of experimental feed ingredients on dry matter bases used for the feeding trial

Feed type	DM (%)	Ash	CP	NDF	ADF	ADL	IVOMD	ME (MJ/Kg)
Desho grass forage	25.83	14.8	8.53	67.1	38.2	3.93	59.1	8.22
Oat-vetch mixture forage	86.89	9.55	13.3	61.7	35.8	3.71	60.8	9.50
Wheat bran	89.33	1.30	17.4	47.6	8.61	0.25	77.3	12.4
Noug seed cake	89.53	17.23	36.8	45.8	17.6	6.77	60.7	8.17
Concentrate mix	89.4	6.61	24.7	46.9	11.6	2.43	71.7	10.9

DM, dry matter; CP, crude protein; NDF, neutral detergent fiber; ADF, acid detergent fiber; ADL, acid detergent lignin; IVOMD, in vitro organic matter digestibility; ME, metabolizable energy, MJ, mega joule

Table 4. Daily dry matter (DM) and nutrient intake of sheep fed different supplement treatment diets under Desho grass basal diet

Feed parameter	Treatments				SEM	CV	SL
	100 C	67 C + 33 O-V	33 C + 67 O-V	100 O-V			
Oat-vetch DM intake (g day $^{-1}$)	0.00	92^{c}	184^{b}	256^{a}	3.98	2.99	-
Desho grass DM intake (g day $^{-1}$)	440^{b}	441^{a}	440^{ab}	435^{c}	0.93	0.21	*
Concentrate DM intake	303^{a}	205^{b}	107^{c}	0.00	0	0	-
Total DM intake (g day $^{-1}$)	742^{a}	737^{a}	731^{b}	691^{c}	3.96	0.55	**
DMI (% BW)	2.95^{a}	2.85^{c}	2.91^{b}	2.84^{c}	0.02	0.56	**
DMI per kg $W^{0.75}$	66.1^{a}	64.2^{c}	65.2^{b}	63.0^{d}	0.36	0.55	**
OM intake (g day $^{-1}$)	666^{a}	655^{b}	641^{c}	602^{d}	3.18	0.50	**
CP intake (g day $^{-1}$)	112^{a}	100^{b}	87.9^{c}	71.1^{d}	1.04	1.06	**
NDF intake (g day $^{-1}$)	446^{c}	455^{b}	450^{b}	461^{a}	2.18	0.48	**
ADF intake (g day $^{-1}$)	200^{d}	223^{c}	244^{b}	258^{a}	1.27	0.55	**
ME (MJ day $^{-1}$)	7.00^{a}	6.94^{b}	6.68^{c}	6.44^{d}	0.03	0.51	**

*Means along row with different subscripts (a, b, c, d) are significantly different at P <0.05; ** (P<0.01) and *(P<0.05). 100 C, 100% concentrate; 67 C + 33 O-V, 67% concentrate+33% oat-vetch hay; 33 C + 67 O-V, 33% concentrate + 67% oat-vetch mixture hay; 100 O-V, 100% oat-vetch mixture hay; SEM, standard error of mean; CV, coefficient of variation; SL, significance level; CP, crude protein; NDF, neutral detergent fiber; ADF, acid detergent fiber; DMI, dry matter intake; OM, organic matter; ME, metabolizable energy*

The initial body weight of the experimental sheep was similar across the treatments. However, significant differences (P<0.05) were observed in final body weight, average daily body weight gain and feed conversion efficiency due to the treatments (Table 5). Sheep fed the 67 % concentrate and 33 % oat-vetch mixture diet had the highest (P<0.05) final body weight (30.7 kg), average daily weight gain (130 g/d), and feed conversion efficiency (0.17), while sole oat-vetch supplement showed the lowest.

Table 5. Weight gain and feed conversion efficiency in sheep fed different proportion of concentrate and oat-vetch mixture under green Desho grass as basal diet

Descriptions	Treatments				SEM	CV	SL
	100 C	67 C + 33 O-V	33 C + 67 O-V	100 O-V			
Initial weight (kg)	21.1[a]	21.0[a]	20.99[a]	21.2[a]	0.43	2.02	NS
Final weight (kg)	29.3[b]	30.7[a]	29.21[b]	27.5[c]	1.16	3.97	*
Average daily gain (g)	109[b]	130[a]	110[b]	86.2[c]	0.02	14.9	*
FCE	0.16[b]	0.17[a]	0.15[b]	0.12[c]	0.02	14.7	*

*Mean along rows with different superscript letters (a,b,c) are significantly different at *(P<0.05) 100 C, 100% concentrate; 67 C + 33 O-V, 67% concentrate + 33% oat-vetch mixture hay;* 33 C + 67 O-V , *33% concentrate + 67% oat-vetch mixture hay;* 100 O-V, *100% oat-vetch mixture hay; FCE= feed conversion efficiency; and NS, not-significance*

The highest body weight gain was recorded for 67% concentrate and 33 % oat-vetch mixture diet, and the lowest daily gain for sole oat-vetch mixture, which are in line with the DM, CP and ME intakes observed for these diets. In a similar manner to the intakes, the average daily weight gain achieved in the current study were on the high side compared to several published reports for different breeds. For instance, for the Washera and Horro sheep breeds, a daily body weight gain ranging from 43 to 91g were reported when the sheep were fed native grass hay supplemented with different energy and protein source feeds (Likawent, 2012; Firisa *et al*., 2013;Asmare, 2016; Ayele *et al*., 2017). On the other hand, the mean daily weight gain in the current study was close to that observed for the Bonga and Doyogena sheep (Bezabih *et al*., 2016; Tadesse*et al*., 2014). It is known that the genetic potential of the breeds, the quality of the feed ingested the level of processing prior to feeding and the management practice and health of animals all contribute to the variation in daily weight gain (Gemiyo et al., 2014; Gizaw et al., 2014). In the present study, the fact that all experimental animals were tethered all the time and fed indoors might have reduced the energy utilized during activity/grazing and increased the partitioning of energy and nutrients towards weight gain. As Desho grass was used as a basal diet in this trial, and the grass was chopped prior to feeding, it appears that it has served as a good basal feed.

Economic feasibility of the supplements

Total variable cost, gross return, net benefit and marginal rate of return are indicated in Table 6. The mean purchasing and selling prices were 38 and 43 Ethiopian Birr (ETB) per kg of live weight, respectively. According to the results of the partial budget analysis, the highest net benefit was obtained from the use of 67% concentrate plus 33% oat-vetch supplement (ETB 418/head), followed by 33 % concentrate plus 67% oat-vetch supplements (ETB 380/head), sole concentrate supplement (ETB 329/head) and sole oat-vetch supplement (ETB 328/head). It was observed that sole concentrate supplement had the highest variable cost but lower net benefit than 67% concentrate and 33% oat-vetch and 33% concentrate and 67% oat-vetch, and thus was dominated. According to dominance analysis, sole concentrate supplement and sole oat-vetch supplements were dominated by other treatments, hence, eliminated from further economic analysis. Based on the marginal analysis, 33 % concentrate and 67% oat-vetch and 67 concentrate and 33% oat-vetch supplements were superior to other treatments. A dominance analysis is carried out by first listing the treatments in order of increasing cots that vary. Any treatment that has net benefits that are less than or equal to those of a treatment with lower costs that vary is dominated. The analysis showed that the marginal rate of return for changing from sole oat-vetch to 33% concentrate and 67% oat-vetch was 229% and from 33% concentrate and 67% oat-vetch to 67% concentrate and 33% oat-vetch mixture were 147%.

Table 6. Partial budget analysis in sheep fed different proportion of concentrate and oat vetch mixture hay under Desho grass basal diet

Description	Treatments			
	100 C	67 C + 33 O-V	33 C + 67 O-V	100 O-V
Initial weight (kg)	21.1	21.0	20.9	21.2
Final weight (kg)	29.3	30.7	29.2	27.5
Cost of oat-vetch (ETB)	0.00	17.1	34.1	48.6
Cost of concentrate (ETB)	128	86.3	45.0	0.00
Variable feed cost (total) (ETB)	128	103	79.1	48.6
Animal purchase cost (ETB)	801	799	798	806
Total variable cost (A) (ETB)	928	903	877	854
Animal selling price (B) (ETB)	1258	1321	1256	1182
Net income (C) = (B-A) (ETB)	329	418	379	328
Change in total variable cost (TVC)	25.6	26.1	22.5	0.00
Change in net benefit (NB)	-88.5	38.4	51.5	0.00
MRR (%) = (ΔNR/ΔTVC) *100	D	147	229	D

MRR, marginal rate of return; NR, net return; TVC, total variable cost; D, dominated, 100 C *, 100% concentrate mix;* 67 C + 33 O-V, *67% concentrate mix + 33% oat-vetch mixture hay;* 33 C + 67 O-V, *33% concentrate mix + 67% oat-vetch mixture hay;* 100 O-V, *100% oat-vetch mixture hay.*

For smallholder farmers to adopt different supplementation strategies, economic feasibility and accessibility are the main driving factors. In the present study, although total replacement of concentrate supplements with home-grown oat-vetch hay resulted in lower rates of body weight gain and net economic return than partial replacements, the fact that the hay can be easily accessed by the producer would still make it a viable alternative for farmers to use. Under the current price scenario, the higher net benefit would be obtained from the 67 % concentrate and 33% oat-vetch mixture followed by 33 % concentrate and 67% oat-vetch diet. The marginal rate of return obtained from 33 % concentrate and 67% oat-vetch (228.89 %^{MRR}) and 67 % concentrate and 33% oat-vetch mixture (147.24 %^{MRR}) implies that for 1.0 Birr investment in sheep production, the producer can get Birr 2.29 and 1.47, respectively, an achievement that is above the minimum acceptable rate of return (CIMMYT, 1988). A key finding from this analysis is that, when conditions allow, replacing a considerable portion of the concentrate demands with good quality home-grown forages can result in higher economic benefit for smallholders.

CONCLUSIONS

Supplementation of locally available basal diets with energy and protein rich feeds is important to achieve optimum growth performance and economic returns during small ruminant fattening. The current study demonstrated that under smallholder farmer conditions, it would be biologically efficient and economically feasible to replace concentrate supplement with a mixture of farm grown forages. Oat-vetch mixed forage hay can effectively replace 67% of the concentrate demand in intensive sheep fattening practices. Therefore, on-farm forage production (either rain-fed or through irrigation) should improve the availability of supplemental feeds that can boost productivity and profitability by reducing demand for expensive and less accessible concentrate feeds.

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