Effect Of Effective Microorganism Treated Grass Hay Supplementation On Feed Intake, Digestibility And Growth Performance Of Washera Sheep Fed Natural Grass Hay As A Basal Diet

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Abstract- The experiment was carried out to evaluate the effect of Effective Microbes (EM) treated grass hay on feed intake, digestibility, growth performance and economic feasibility of Washera sheep fed on natural grass hay basal diet. Twenty Four growing (8-9 month) intact male Washera sheep with initial body weight of 14.802±1.965kg (mean ± SD) were blocked in to six blocks based on initial body weight and animals within a block randomly assigned to treatment diets. Treatments were adlibitum feeding of grass hay (T1) and grass hay adlibitum supplemented with 5%, 10% and 20% of total dry matter intake Effective Microbes treated hay for T2,T3,and T4, respectively. All sheep were supplemented with 100 g Noug seed cake (NSC) to fulfill maintenance requirement of sheep. Animals were allowed with ad libitum access to water and salt. The experiment consisted of 90 days feeding and 10 days of digestibility trials in that order. Hay contained 6.56% crude protein, 75.42% Neutral Detergent Fiber and 57.45% Acid Detergent Fiber whereas Effective Microorganism (EM) treated hay contained 10.91% crude protein, 60.62% Neutral Detergent Fiber and 42.35% Acid Detergent Fiber. Sheep in T1 consumed significantly ($p<0.0001$) lower total dry matter intake (541.57g/day) compared to T3 and T4 (583.53 and 630.18g/day total dry matter intake, respectively). The crude protein intake ranged 59.88 to 70.38 g/day and was lower for T1. The highest digestibility of dry matter and nutrients were, recorded in sheep fed T3 EM treated hay supplemented group compared to the rest treatments supplemented groups. Average daily gain (ADG) was significantly ($p<0.0001$) higher in supplemented group than the control group and among supplemented groups the highest Average daily gain (ADG) was recorded in sheep fed T3. Similarly, high net return was obtained in T3 with value being 290.56 followed by T4 (82.87ETB/sheep). In conclusion, 10% Effective Microorganism (EM) treated hay used in this study showed significantly highest values in almost all parameters. Therefore, 10% Effective Microorganism (EM) treated hay could be recommended to be used in low quality feeds for improving nutritional value, apparent digestibility and market condition of Washera sheep.

Index Terms- Digestibility, Effective Microorganism, feed treatment, Growth, Intake, Washera Sheep

I. INTRODUCTION

Ethiopia is a home for many livestock species and is believed to have the largest livestock population in Africa. According to Central Statistical Agency data (CSA, 2018) the country is a home for about 60.34 million cattle, 31.30 million sheep, 32.74 million goats 1.42 million camels, 56.06 million poultry, 2.01 million horses, 0.46 million mules and 8.85 million donkeys. From the total cattle population 98.24% are local breeds and the remaining are hybrid and exotic breeds that accounted for about 1.54% and 0.22%, respectively. Sheep production in Ethiopia plays a very important role in contributing to the food security, domestic meat consumption and generating cash income as well as providing continuous service to the economic stability of smallholder farmers (Alemu, 2008). Smallholder farmers depend on sheep for much of their livelihood, often largely than on cattle (ESGPIP, 2009).

Although there exists large number of sheep population in Ethiopia the production and productivity is very low as expressed by annual population growth rate of 1% and off-take rate of 35% (CSA, 2018). Performance of sheep in terms of body weight gain and carcass production is low. The low performance of local sheep is mainly due to inadequate nutrition both in quality and quantity. The limitation in production due to shortage of feeds and poor nutrition is usually profound in areas where high seasonal dynamics in feed sources, fragile ecologies and environments exposed degradation. Moreover, a great majority of feeds are roughages with low feed values. Improving feeds and nutrition through technologies is important to boost the overall productivity, health, and well-being of sheep flocks (Chernet, 2012). In this regard, use of effective microbes (EM) for better utilization of roughages is thus imperative (Safalaoh *et al*., 2001).

The use of EM to small ruminant is very limited in Ethiopia and in particular in the study area. Currently the price of concentrate feeds are high as expressed by (FAO, 2009) therefore, using non-conventional supplements like EM can help to minimize the current towering price of concentrates, through rumen manipulation and efficient utilization of available fibrous feed materials. The lactic acid bacteria, in EM contribute to the fermentation and breakdown of the tough cellulose and lignin materials in the feed. Moreover, the report from this study was expected to narrow down the difference and skeptical out looks towards the use of EM as animal feed in the study area, especially to small ruminant. Thus, the objective of this study was designed to evaluate the effect of effective microbes (EM) treated grass hay supplementation on feed intake, digestibility and growth performance of Washera sheep with assessing its economic feasibility.

II. Materials and Methods

2.1. Description of the Study Area

The study was conducted in Burie, kebele 03, West Gojam Administrative Zone, Amhara National Regional State, Ethiopia. The geographical location of the study area is 10˚42′29″N latitude and 37˚7′9″E longitude at a distance of 400 km North West of Addis Ababa and 148 km south west of Bahir Dar, the capital of Ethiopia and Amhara National Regional State, respectively. The altitude of the study area is 2604 m.a.s.l (IPMS, 2014). The mean annual rain fall is 1689.4 mm and the mean annual temperature value is 18.5°C (IPMS, 2014).

2.2. Experimental Animal Management

For the feeding experiment, twenty-four growing (8-9 months age) intact male Washera sheep with initial body weight of 14.802 ± 1.965kg (mean ±SD) were purchased from Dangla town. The age of the animal was determined by asking their back ground history and by their dentation. Animals were quarantined for 21 days and they were vaccinated for common diseases of the area (Anthrax, sheep pox and Pasturolosis), injected with oxy tetracycline 20% (0.2 mg/kg) and dewormed with Deoxamine (300 mg/kg) against endoparasites. Each sheep was ear tag for identification purpose and ease of record keeping.

At the end of the quarantine period, sheep were penned individually in a well-ventilated house, which was equipped with feeding and watering troughs. The hay and the supplement feeds were provided in separate containers. Baskets made of bamboo were used for the feeding of hay, while the concentrate and water were offered in plastic bowl. Before the commencement of the actual data collection, animals were acclimatized to experimental diets for 15 days.

2.3. Experimental Diet Preparation

Natural Grass hay was purchased from farmers directly from their farm. The hay was stored properly to keep its quality. Noug seed cake and EM were purchased from the nearby local market called ‘Kuch’ and Bahir Dar Agricultural raw material Center, respectively. Grass hay was hand chopped at 4-5cm length and EM solution was prepared at a ratio of 1:1:18 by volume of stock EM, molasses and chlorine free water, respectively (EMROSA, 2006). The water was warmed to about body temperature and the molasses was stirred until dissolved. After mixing the stock EM with water and molasses, it was poured onto the grass hay slowly in small quantities and thoroughly mixed by hand until it was just moistened throughout so that no moisture comes out of it when squeezed by hand.

To achieve optimum moisture content, 20 litter of EM solution was poured for 60 kg grass hay. The moistened grass hay was then pressed in an air tight sack, with as much air as possible being pressed out before closing it. The filled sack was left in a warm, dark place to ferment for twenty-eight days as per the recommendations of EMROSA (2006). Then untreated grass hay was offered to all animals *adlibitum* as a basal diet by allowing 20% refusal whereas, the EM treated grass hay and NSC were offered twice a day at 8:00 am and 4:00 pm in equal portions. The EM treated grass hay was adjusted every ten days by taking the average total dry matter intake. All animals had free access to water and salt lick. The treatment diets were arranged as presented in Table 1.

Table1

Experimental treatments

Treatment	Basal diet (grass hay)	Supplements
T1	*ad libitum*	100g NSC
T2	*ad libitum*	EM treated grass hay at 5% of TDMI+ 100gNSC
T3	*ad libitum*	EM treated grass hay at 10% of TDMI+ 100gNSC
T4	*ad libitum*	EM treated grass hay at 20% of TDMI+ 100gNSC

EM = effective microbes; TDMI = Total dry matter intake; NSC = Noug seed cake

2.4. Experimental design

A randomized complete block design (RCBD) with four treatments, each replicated six times was used for this experiment. The experimental animals were grouped into six blocks of four animals each based on their initial body weight (IBW) which was determined by taking the averages of two consecutive weighing after overnight fasting of the animals at the end of the quarantine period. Animals in a block were then randomly assigned to one of the four experimental treatment feeds making six animals per treatment.

2.5. Feeding trial

The feeding trial lasted for 90 days. Experimental feeds offered and the corresponding refusals were recorded daily to determine daily feed intake. Daily feed intake was determined as the difference between feed offered and refused. Samples of feeds offered and refusals were taken every day and pooled per feed basis for feed offer and per treatment for the refusal. At the end of the experiment, pooled feed and refusal samples were thoroughly mixed and sub sampled for chemical analysis. The metabolize energy MJ/day intake was estimated from digestible organic matter intake (DOMI) values by using the equation of AFRC (1993).

ME (MJ/d) = 0.0157*DOMI g/kg DM. where: DOMI is digestible OM intake (in gram per kilogram DM)

Where; DOMI was the product of OMI and its digestibility coefficient.

Substitution rate (SR) of the basal feed with the supplements in the supplemented treatment was calculated as:

SR= Basal diet DMI of the control treatment- Basal diet DMI of the supplement treatment

Supplement DMI

Where: DMI= Dry matter intake

Body weight of each animal was measured for two consecutive days at the beginning of the experiment and every 10 days intervals during the 90 days of feeding period after overnight fasting by using portable electronic weighing scale. The average weight of the two consecutive days weighing of the beginning and last dates of the experimental period were taken as the initial and final body weights, respectively. Body weight change was calculated as the difference between final live weight and initial live weight while Average daily body weight gain was computed as body weight change divided by the number of experimental days. Weights recorded at an interval of 10 days were used to show trends of body weight change during the feeding trial period.

2.6. Digestibility trial

The digestibility trial was conducted after the feeding trail with the same animals used for feeding trial. All animals were harnessed with fecal collection bags for the determination of digestibility. The digestibility trail took a total of 10 days with three days of adaptation of carrying the fecal bags. After three days of adaptation, daily total fecal output along with the daily feed offered and refusal were weighed and recorded for seven consecutive days for each animal. Out of the daily total fecal output, 20% was sub-sampled to form a weekly fecal composite sample for each animal and stored at –20ºC. Fecal samples were then thawed, thoroughly mixed, subsampled, dried at 60ºC for 72 hours and ground to pass 1 mm sieve screen and stored pending chemical analysis. Grabs of feed samples from each feed and refusals from each animal were collected each day to make a weekly composite feed sample for each feed and refusal per treatment. The apparent digestibility coefficient of DM and nutrients were calculated as:

$$\text{Apparent Dry Matter Digestibility (\%)} = \frac{\text{Dry matter intake} - \text{Dry matter in faces}}{\text{Dry matter intake}} * 100$$

$$\text{Apparent Nutrient Digestibility (\%)} = \frac{\text{Nutrient intake} - \text{Nutrrient in faces}}{\text{Nutrient intake}} * 100$$

2.7. Chemical analysis

Representative samples of feeds, refusals and faces were taken to Debre Birhan Agricultural Research Center Nutrition Laboratory for chemical analysis. The samples were dried in a forced draft oven at 60ºC for 72 hours and ground to pass through a1mm screen sieve using a mill. The ground sample was stored in an airtight plastic bag pending chemical analysis. Dry matter (DM), ash and CP content of sample of feed offered, refused and feces were analyzed by the method of AOAC (1990). Neutral detergent fiber (NDF), acid detergent fiber (ADF) and acid detergent lignin (ADL) in the samples of feeds that were offered, and from refusals and faces were determined by the method of Van Soest and Robertson (1985). Organic matter (OM) was calculated as ash deducted from hundred.

2.8. Partial Budget Analysis

Partial budget analysis was determined to assess the profitability of the feeding regime. To estimate the economic benefits of supplementation of effective microbes and molasses solution treated grass hay for sheep, the calculations were done according to Upton (1979). Total return (TR) was calculated as the difference between selling and purchasing price of the experimental animals. Net income (NI) was calculated as the amount of money left when total variable cost (TVC); purchasing price of sheep, feed cost and treatment costs are subtracted from total returns (TR);

NI = TR - TVC or NR = TR – TVC

The change in net income *(ΔNI)* will be calculated as the difference between the change in total return (ΔTR) and the change in total variable costs (ΔTVC);

ΔNI= ΔTR-ΔTVC or ΔNR = ΔTR - ΔTVC

The marginal rate of return (MRR) measure the change in net income (ΔNI) associated with each additional unit of expenditure (ΔTVC) and expressed in percentage as;

MRR = (ΔNI) / (ΔTVC) × 100

2.9. Statistical Analysis

The data were analyzed using the General Linear Model (GLM) procedures of the Statistical Analysis Software (SAS, release 9.1, 2008) for analysis of variance (ANOVA). The six blocks per treatment were used to increase the precision of the experiment by reducing the residual error. Treatment means were separated using least significant difference (LSD). Statistical significance was established when probability is ≤ 0.05 level of significance. The model used for analysis was; -

$$Yij = \mu + ti + bj + eij$$

Where:
Yij = Response variable
μ = overall mean
ti = the effect of the i^{th} treatment
bj = the effect of the j^{th} block
eij = Random error

III. Results and Discussion

3.1. Chemical Composition of Treatment Feeds

The chemical composition of the treatment feeds and hay refusals are given in Table 2. The CP value recorded for hay used in the current study was lower and indicates 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 (7%) required for microbial function (Van Soest, 1994). The CP content of hay refusals showed relatively similar among the four treatment feeds. However, the hay offered had higher CP but lower NDF, ADF and ADL values than the hay refusals. This may be due to the fact that experimental sheep selected more edible portions of the basal diet and left the fibrous parts of the grass which has higher structural constituents (NDF, ADF and ADL) fractions.

Table2

Chemical composition (% for DM and %DM for others) of experimental feeds and hay refusals

Feeds	DM	OM	CP	NDF	ADF	ADL
Hay	92.00	91.83	6.56	75.42	57.45	14.42
EMTH	67.68	93.61	10.91	60.62	42.35	12.40
NSC	93.00	92.77	30.91	52.4	35.05	8.46
EM treated hay refusals						
T2	63.92	93.87	4.56	65.44	49.39	13.4
T3	64.17	93.70	5.66	64.44	46.67	13.27
T4	66.03	93.74	5.19	64.44	46.67	13.27
Hay refusals						
T1	91.00	92.62	4.5	78.45	66.16	14.57
T2	90.00	92.55	3.81	77.77	63.83	14.43
T3	94	92.78	3.66	77.26	61.55	14.43
T4	93.00	92.70	3.81	76.52	60.17	14.47

DM= dry matter; OM= organic matter; CP= crude protein; ADF= acid detergent fiber; NDF= neutral detergent fiber; ADL= acid detergent lignin; EMTH= Effective Microbes treated hay; NSC= Noug Seed Cake; T1= grass hay+100g NSC; T2= grass hay+ 5%EMTH+100g NSC; T3= hay+10% EMTH+100gNSC; T4= grass hay +20%EMTH+100 g NSC.

The CP content of hay used in the current study was relatively comparable to the CP content of 6.04%, 6.23%, 6.56% and 6.8%, reported by Michael *et al.* (2017), Birhanu (2013), Simret (2005) and Abadi *et al.* (2014), respectively and lower than the CP content of 7.01%, 7.2% and 7.2% reported by Berhanu *et al*. (2014), Desta *et al*. (2017) and Lemma *et al.* (2018), respectively, but higher than the CP contents of 3.56%, 3.73%, 3.75% and 4.2% reported by Fentie (2007), Berhan and Asnakew (2015), Asnakew (2005) and Mulu (2005), respectively. The differences in CP content of hay among the various studies could be due to the factors like the species composition of the hay, environmental factors in which the hay was grown, and stage of maturity at which the hay was harvested (Chrenkova *et al.,* 2006; Dereje, 2015).

Neutral detergent fiber content above 55% was reported to limit DM intake and hence directly interfere with the productivity of animals (Van Soest, 1985). In this regard, the NDF value (75.42%) of hay in the current study was found to be high and it was comparable to 73.48% and 76.5% NDF for natural pasture hay previously reported by Amde (2015) and Michaele *et al.* (2017), respectively. But it was lower than 79.4% and 80.87% reported by Shashie *et al.* (2017) and Awoke (2015), respectively for natural pasture hay and it was higher than, 70.67 and 71.8% reported by Asnakew (2005) and Getachew (2005), respectively.

The CP and OM content of EM treated hay in the current study was higher but NDF, ADF and ADL components were low compared to the untreated hay. This difference might be due to the fermentation effect of plant cell wall components by effective microbes and the synthesis of microbial protein. Similarly, EM treated hay refusals were found to contain lower CP and higher fiber (NDF, ADF and ADL) fractions. In the current study, it was clearly observed that effective microbes improve the crude protein content of low quality grass hay. The current result agree with the results of Mulugeta (2015) who reported treating crop residue by EM resulted a decrease in NDF and ADF content but slightly increase the CP content.

The CP content of NSC used in the current study was similar with the value 30.57% reported by Lemma *et al.* (2018) but higher than the values 28.2% and 29.12% reported by Gezu *et al.* (2017) and Birhanu (2013), respectively. But lower than the values 34.65% and 36.2% reported by Dessie *et al.* (2019) and Shashie *et al.* (2017). The variation in CP contents of NSC in different studies might be due to the difference in variety of Noug seed, soil and the agro-ecology where the crop grown and the effectiveness of the oil extraction factories during the processing (Abadi, 2014). The NDF value of NSC in the current study was slightly comparable to 56.84% reported by Abadi (2014) but higher than the values 40.78% and 41.3% reported by Dessie *et al.* (2019) and Worknesh and Getachew (2018), respectively.

3.2. Dry Matter and Nutrient Intakes

The mean daily total DM and nutrient intakes for Washera sheep are presented in Table 3. In the current study basal dry matter intake was none significantly different (P>0.05) among treatment groups. But there was, highly significant difference (p<0.0001) in total dry matter intake among treatments with the highest value (630.18 g/day/animal) recorded for T4 and the least values (541.57) and (553.30 g/sheep/day) were recorded for T1 and T2, respectively. Generally, total daily DM intake showed an increasing trend with increasing the level of EM treated grass hay from T1 to T4

Table3

Daily dry matter and nutrient intake of Washera sheep fed natural pasture hay supplemented with EM treated hay at different proportions.

Parameters			Treatments			
Dry matter intake	T1	T2	T3	T4	SEM	p value
Hay (g/d)	441.57	425.39	425.34	416.70	19.002	0.0824
EMTH (g/d)	0^{d}	27.914^{c}	58.199^{b}	113.479^{a}	7.17	<0.0001
NSC (g/d)	100	100	100	100	-	-
Total DMI (g/d)	541.57^{c}	553.30^{c}	583.53^{b}	630.18^{a}	21.98	<0.0001
DMI (%BW)	3.51^{a}	3.34^{a}	2.90^{b}	3.32^{a}	0.29	0.0106
DMI (g/kg BW$^{0.75}$)	69.56^{a}	67.27^{a}	61.41^{b}	69.13^{a}	4.17	0.0107
Nutrient intake (g/d)						
ME (MJ/d)	4.69^{c}	5.5^{b}	7.22^{a}	7.1^{a}	0.25	<0.0001

OM	498.26^{c}	509.53^{c}	537.84^{b}	581.65^{a}	20.27	<0.0001
CP	59.88^{c}	61.86^{c}	65.16^{b}	70.63^{a}	1.66	<0.0001
NDF	385.43^{c}	390.15^{c}	408.47^{b}	435.47^{a}	15.89	0.0002
ADF	288.73^{c}	291.26^{bc}	304.06^{b}	322.50^{a}	11.95	<0.0007
Substitution rate	-	0.58^{a}	0.28^{b}	0.22^{b}	0.19	0.0003

^{abcd} means with different superscripts in a row are significantly different at P< 0.05. SEM=standard error of mean; OM= organic matter; CP= crude protein; ADF= acid detergent fiber; NDF= neutral detergent fiber; EMTH=Effective microbes Treated Hay; NSC= Noug Seed Cake: T1= grass hay + 100g NSC; T2=grass hay+5% EMTH+100gNSC; T3= grass hay+10% EMTH +100g NSC; T4= grass hay +20% EMTH +100g NSC.

This trend is in line with the report of Deribe *et al.* (2017) who reported that the total DM intake of animals was increased with increasing level of Effective Microorganism (EM). In contrast to the current finding, Chernet (2012) reported that there was a fall in total DM intake as EM-Bokash inclusion in the diets increased from 1 to 5%. Higher total DM intake in the supplemented groups is related to the favourable rumen environment, such as microbial growth, production of fiber degrading enzymes, which could have been resulted in enhanced fermentation, rate of break down and rate of digestion of the feed and resulted in a greater DM intake (McDonald *et al.*, 2010).

The least total DM intake recorded for the sheep kept on natural grass hay (T1) was probably due to the low colonization of microorganisms in the rumen and the retention of fiber contents in the rumen for long time which is likely depressing both feed intake and digestibility. One of the factors that affect forage and concentrate intake and digestibility is the microbial density in the rumen. Effective fiber colonization of microbes in the rumen reduces the retention time of fiber components due to production of fiber degrading Enzymes (Walker, 2007; Seo *et al*., 2010).

In the current study Metabolizable energy intake of sheep under supplemented groups showed significantly (p<0.0001) higher values than the control group but with similar values for T3 and T4. The ME intake of sheep in the current study indicated higher values required for maintenance (3.7-4.1 MJ/day/sheep) estimated for a 20 kg lamb (ARC, 1980). The current result was similar with the results of Worku *et al*. (2016) who reported presence of significant difference through supplementation of 5% EM-Bokash compared to the unsupplemented group. The ME intake values (4.6-7.2 MJ/day) in the current study were within the range of 4.3-7.8 MJ/day/animal for Washera sheep fed urea treated finger millet straw and supplemented with non-conventional feeds (Melese *et al*., 2014).

On the other hand, significantly (P<0.0001) higher intake values of OM, CP, NDF and ADF were observed in T4, compared to the rest of the treatments. The higher microbes contend in the supplemented feeds compared to the basal diet might be result higher microbial protein synthesis in the supplemented groups. According to Ranjhan (1997), the average daily protein and energy requirement for maintenance of the sheep weighing 30 kg was reported to be 36 g and 4.017 MJ ME, respectively. This indicated that both the supplemented and control sheep in this study had CP intake beyond their maintenance requirement above which protein being used for body weight gain purposes. Significant differences were also observed in OM, CP and NDF intake among the supplemented groups with the highest value recorded for T4.

Total DM intake values expressed as percent of body weight in this study fall in the range of 2.90 to 3.51% as expressed in (Table 3). T3 had significantly (p <0.05) lower dry matter intake as percent of body weight than the other treatment groups. The lower dry matter intake as percent of body weight in T3 might be due to higher feed conversion efficiency and which in turn results in higher body weight gain. The total DM intake as percent of body weight of this trial was comparable with the values 2.8 to 3.1% BW reported by Wondwosen *et al.* (2013) for Washera sheep fed natural pasture hay supplemented with 300g concentrate mix with *Sesbania sesban* at different proportions. On the other hand, total DM intake as percent of body weight of the current study was lower than the values of 3.3 to 3.9% BW reported by Melese *et al.* (2014) for the same breed fed urea treated finger millet and supplemented with non-conventional feeds. The differences in Total DM intake values as percent body weight are arising from the variation in the nutrient composition, feed intake and body weight of the animals. The total DM intake in the present study was in the range of the recommended dry matter intake (2-4%) for sheep and goat (Susan, 2009).

The total DM intake per unit of metabolic body weight in the present study ranged between 61.41g to 69.56 g/kg $BW^{0.75}$. Sheep under T3 consumed significantly (P<0.05) lower DM per unit of metabolic body weight as compared to the other supplemented groups. The variation might be due to the high body weight gain of the experimental sheep in T_3 (Table 5) and the efficient utilization of feeds per unit of their metabolic body weight. The total DM intake per unit of metabolic body weight of this trial was comparable with the values 56.10-65.59g/kg $BW^{0.75}$ for Washera sheep fed urea treated rice straw and supplemented with graded level of concentrate mix (Abebe, 2017). But lower than the values 76.2-88.9 g/kg $BW^{0.75}$ reported by Mesganaw (2014) on total DM intake per unit of metabolic body weight for the same breed.

In the current study, substitution rate of natural pasture hay with supplement of EM treated hay was observed at the rate of 0.22, 0.28 and 0.58 for T4, T3 and T2, respectively. Generally, it has been known that amount of supplement can affect substitution rate.

3.3. Dry Matter and Nutrient Digestibility

The apparent digestibility of dry matter and nutrients for the experimental animals are given in Table 4. The apparent digestibility of DM, OM, CP, NDF and ADF were highly significantly (p<0.0001) higher in T3 than the rest treatment groups but no difference (p>0.05) was noted between T1 and T2 in DM, CP and NDF digestibility and between T2 and T4 in CP and NDF digestibility. On the other hand, there were highly significant (p<0.0001) difference between T1 and T2 in OM and ADF digestibility and between T2 and T4 in DM, OM and ADF digestibility. There were also highly significant (p<0.0001) difference among T3 and T4 in DM, OM, CP, NDF and ADF digestibility with the highest digestibility value recorded for T3.

The digestibility improvement observed in T3 as compared to the rest of the treatment groups might be due to optimum microbial supplementation level and efficient production of fiber degrading enzymes by effective microorganisms. On the other hand, the low level of DM digestibility observed in T2 might be due to the low level of microorganism supplementation to degrade plant cell wall components whereas the moderate digestibility improvement observed in T4 might be due to higher by pass rate (i.e. high nutrient balance). Addition of effective microbes on feeds increased microbial population in the rumen to support optimum ruminal activity and balance nutrient intake and nutrient lose through faces (Jalc, 2002).

Table4

Apparent digestibility of dry matter and digestible nutrient intakes of Washera sheep fed natural pasture hay and supplemented with Effective Microbes treated hay at different proportions

	Treatments					
Digestibility (%)	T1	T2	T3	T4	SEM	P value
DM	51.81^{c}	57.63^{c}	79.77^{a}	68.15^{b}	7.69	<0.0001
OM	59.97^{d}	69.38^{c}	85.49^{a}	77.78^{b}	5.71	<0.0001
CP	82.39^{c}	83.79^{bc}	90.55^{a}	84.74^{b}	1.65	<0.0001
NDF	50.17^{c}	57.70^{bc}	82.68^{a}	65.83^{b}	8.42	<0.0001
ADF	44.49^{d}	57.82^{c}	83.26^{a}	71.97^{b}	8.08	<0.0001
Digestible Nutrient intake (g/day)						
DM	280.59^{d}	318.87^{c}	465.48^{a}	426.73^{b}	14.02	<0.0001
OM	298.81^{c}	353.52^{b}	459.80^{a}	452.41^{b}	15.94	<0.0001
CP	49.33^{c}	51.83^{b}	59^{a}	59.63^{a}	1.41	<0.0001
NDF	193.37^{d}	225.12^{c}	337.72^{a}	286.67^{b}	9.82	<0.0001
ADF	128.46^{d}	168.41^{c}	253.16^{a}	232.10^{b}	7.55	<0.0001

^{abcd} means with different superscripts in a row are significantly different (P<0.05; DM= dry matter; OM= organic matter; CP= crude protein; ADF= acid detergent fiber; NDF= neutral detergent fiber; ADL= acid detergent lignin; EMTH= Effective Microbes treated hay; NSC= Noug Seed Cake; T1= grass hay+100g NSC; T2= grass hay+ 5%EMTH+100g NSC; T3= hay+10% EMTH+100gNSC; T4= hay +20%EMTH+100 g NSC.

The low digestibility of DM observed in T1 might be related to the low CP, high NDF and ADF content of hay. It was noted that feeds with DM digestibility less than 55% is considered as poor quality and will not maintain body weight, whereas feeds having DM digestibility exceeding 65% is categorized as high quality (David, 2007). Hence, based on the results of current study, supplementation of sheep with effective microbes treated hay at the level of 10% had high potential to improve the digestibility of nutrients and dry matter by producing optimum level fiber degrading enzymes in the rumen. Similar to the present study, Samsudin *et al.* (2013) reported improved digestibility of DM, OM, CP, NDF and ADF than the control group with EM treated rice straw supplementations. But the current study disagreed with the work of Chernet (2012), who reported absence of significant differences in the digestibility of DM and CP content by inclusion of EM treated wheat bran and solution into the concentrate feeds.

3.4. Body Weight Change and Feed Conversion Efficiency

Mean initial body weight, final body weight (FBW) average daily gain and feed conversion efficiency (FCE) are presented in Table 5. Initial body weight was similar among all treatments (P>0.05). Supplemented groups, which offered 10% (T3) and 20% (T4) EM treated hay, had significantly higher (p<0.0001) FBW as compared to unsupplemented sheep but none significant difference (p>0.05) was observed between T1 and T2, T2 and T4, and T3 and T4. All supplemented groups had significantly higher BWC and ADG as compared to the control group. There was significant variation among supplemented groups in BWC and ADG with the highest value was recorded for T3 and the lowest value was recorded for T2.

due to the higher total DM intake and microbial protein synthesis in the rumen as compared to the control group. Among the supplemented treatments, significantly lower (P<0.001) records of BWC and ADG were observed in T2 which might be due to the lower microbial protein synthesis in T2 compared to T3 and T4. Body weight gain of (6.61 g/d) for T_1 animals indicated that a small amount of NSC supplementation resulted in alleviating the possible body weight loss of the animals. The result of the current experiment agrees with previous studies of Worku *et al.* (2016) in which supplementation of probiotics improved final body weight (FBW), BWC and ADG.

Table5

Body weight gain of Washera sheep fed natural pasture hay supplemented with EM treated hay at different levels

Parameter	Treatment T1	T2	T3	T4	SEM	P value
IBW (kg)	14.92	14.63	14.75	14.92	1.965	0.99
FBW (kg)	15.51[c]	16.74[bc]	20.29[a]	18.97[ab]	1.99	0.0021
BWC (kg)	0.59[d]	2.11[c]	5.54[a]	4.06[b]	0.78	<0.0001
ADG (g/d)	6.61[d]	23.48[c]	61.56[a]	45.06[b]	8.70	<0.0001
FCE(gADG /gDMI)	0.013[d]	0.043[c]	0.11[a]	0.07[b]	0.015	<0.0001

[abcd] means with different superscripts in a row are significantly different (P<0.05); T1= grass hay+100g NSC; T2= grass hay+ 5%EMTH+100g NSC; T3= hay+10% EMTH+100gNSC; T4= hay +20%EMTH+100 g NSC. IBW = initial body; FBW = final body weight; BWC=body weight change; ADG, average daily gain; FCE = feed conversion efficiency

Feed conversion efficiency values showed significant (P<0.0001) difference among treatment groups and was in the order of T3>T4 > T2>T1 (FCE). The highest value in sheep fed T3, diets which have higher digestibility values result in higher final body weight gain, average daily gain and feed conversion efficiency. On the other hand, the lowest FCE for the control group might be due to low level of microbes in the rumen which in turn resulted low level of fiber degrading enzymes and depressed digestibility and absorption of nutrients. The low feed intake contributed to the low body weight gain which consequently might have affected FCE.

Partial budget analysis of Washera sheep fed natural pasture hay and supplemented with Effective Microbes treated hay at different proportions is given in Table 6. The total return was in the order of T3>T4>T2>T1 and the least total income was gained from unsupplemented group (T1). These values were directly related with the weight gain of sheep but not with prices of experimental feeds. The net return 290.56, 82.87, 78.99 and 19 ETB/sheep were obtained from sheep fed T3, T4, T2 and T1, respectively. The gross financial margins 898.05, 1350.37 and 155.29 ETB/sheep were obtained from sheep fed T2, T3 and T4, respectively.

3.5. Partial Budget Analysis

Table 61

Partial budget analysis of Washera sheep fed natural pasture hay and supplemented Effective microbes treated hay at different proportions

Variables	Treatment T1	T2	T3	T4
Sheep purchasing price(ETB/head	1188	1188	1188	1188
Total Grass hay consumed (kg/head)	39.74	38.29	38.28	37.5
Total EM and molasses solution treated hay consumed (kg/head)	-	2.51	5.24	10.22
Total NSC consumed (kg/head)	9	9	9	9
Feed cost				
Cost for grass hay/kg (ETB)	4.50	4.50	4.50	4.50
Total cost for grass hay (ETB/head)	178	172.31	172.26	168.75
Cost for NSC/kg	10	10	10	10
Total cost for NSC/(ETB/head)	90	90	90	90
Cost for EM treated hay/kg (ETB	-	4.93	4.93	4.93
Total Cost for EM treated (ETB /head)	-	12.37	25.83	50.38
Total feed cost (ETB/head)	268	274.68	288.11	309.13
Gross income (ETB/head)	1475	1541.67	1766.67	1580.0
Total return (ETB/head)	287	353.67	578.67	392
Net return (ETB/head)	19	78.99	290.56	82.87

Δ NR	-	59.99	271.56	63.87
ΔTVC	-	6.68	20.11	41.13
MRR (%)		898.05	1350.37	155.29

MRR= marginal rate of return; ETB= Ethiopian Birr; ΔNR= change in net return; ΔTVC= change in total variable cost; T1 : grass hay + 100g; T2= grass hay+100 g NSC +5% EMTH; T3=EMTH +100 g NSC+10%EMTH; T4= : hay +100 g NSC+20%EMTH

IV. Conclusions

Sheep fed T3 diet showed significant improvement in, DM and nutrient digestibility, FCE and body weight gain over the other treatment feed supplemented groups. Relatively, the highest net return and change in net return were obtained in T_3 (290.56ETB/sheep and 271.56ETB/sheep, respectively). While the highest change in total variable cost (ΔTVC) was recorded in T_4 (41.13ETB/ sheep) and the lowest in T2 (6.68 ETB/sheep). Supplementing of EM treated hay to the basal diet grass hay improved total DM and nutrient intakes, digestibility and feed conversion efficiency as compared to sheep in control group. EM treated hay supplemented at 10% of total diet (daily dry matter intake) resulted in highest weight gain and profit compared to 5% and 20% EM treated hay supplemented groups. Therefore, supplementing a 10% of EM treated hay could be used in low quality feeds for improving nutritional value, apparent digestibility and market condition of Washera sheep.

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