Weight Change, Carcass Characteristic and Economic Benefit of Yearling Hararghe Highland Rams Fed Diet Containing Concentrate Mixtures and Sugarcane Bagasse or Rice Husk Treated with Trichoderma viride and Effective Microorganisms

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Research Article

Keywords: Biological treatment, feed conversion efficiency, carcass, sheep, profitability

Posted Date: April 13th, 2022

DOI: https://doi.org/10.21203/rs.3.rs-1532936/v1

Abstract

A study was conducted to evaluate body weight change, carcass characteristics and economic benefit of Hararghe highland sheep fed biological treated Rice husk (RH) or sugarcane bagasse (SCB) in total mixed diet. Thirty six sheep with initial weight of 18±1.8kg (mean±SD) were used. A randomized complete block design (RCBD) in 2x3 factorial arrangements consisting two feeds (SCB and RH) and three biological treatments (Control, Trichoderma viride (Tv) and effective microorganism (EM)) was employed. The study period lasted for 90 days of fattening. The total mixed diet was fed adlibitum at a rate of 20% refusal. The result indicated that sheep fed diet contained RH as roughage source had significantly ($p<0.05$) higher carcass weight, dressing percentage, rib eye muscle area, total non carcass fat and total edible offal components than sheep fed SCB diet. Sheep fed diet contained biological treated feed had significantly ($p<0.05$) higher hot carcass weight and dressing percentage while other parameters were not affected by treatments. There was no significant difference between diets based on roughage based on Tv and EM treated. Profitability analysis indicated that fattening sheep with diet based on RH and biological treated by-products displayed greater profitability than SCB and untreated. It is concluded that fattening of sheep with Rice husk (RH) and sugarcane bagasse treated with Trichoderma viride and effective microorganism (EM) yield more carcass and fetch better profit, but optimum inclusion levels need other investigation particularly for sugarcane bagasse (SCB).

1. Introduction

Sheep in Ethiopia are the second most important species with estimated number of about 30.5 millions (CSA, 2017) and mainly kept for meat productions (Ewnetu et al., 2006). The annual national mutton production of the country is estimated at about 77 thousand metric tons with 30% off take (Amha, 2008) and 10.1 kg average carcass weight which is the second lowest amongst sub-Saharan Africa countries (FAO, 2009). Although, Ethiopia has high genetic diversity, their productivity is low mainly because of inadequate year round nutrition, in terms of both quality and quantity (Alemu, 2008). Livestock in general and sheep in particular are getting their feed from natural pasture and crop residues, which are characterized by low nutrient content, low digestibility and low voluntary intake (Adugna, 2007).

Shortage of animal feed attracts the attention of many researchers for efficient utilization of lignocellulose by-products. In Ethiopia, there are about 35 million tons of lignocelulose agricultural by-products produced annually (CSA, 2013). Currently about 4 million tons of sugarcane bagasse (Esayas et al., 2018) and 27,200 tons of rice husk (CSA, 2016) are annually produced. Crop cultivation also generates huge amount of fibrous crop residues such as cereal straws, pulse straw and oil crop straws, which are usually fed to ruminants. The primary factors limit the utilization of lignocellulose are low nutrient content, low digestibility and low voluntary intake. Their low digestibility are generally due to the high fibrous contents consisting of mainly 32–40% cellulose, 14–36% hemicelluloses and 10–18% lignin on DM basis (Mussatto and Teixeira, 2010). It is important to improve nutritive value of fibrous feed for ruminants through overcoming their inherent barriers to rumen microbial fermentation (Sarnklong et al., 2010); this can be done physical, chemical and biological methods and their combinations (Preston, 2003).

Biological treatment employs microorganisms and their enzymatic machineries to break down lignin and alter lignocelulose structures. The use of fungi and/or their enzymes that metabolize lignocelluloses is a potential biological treatment to improve the nutritional value of legnocelulose agro-industrial by-products (Jalc, 2002). Most research reports indicated that feeding biologically treated roughage were increased feed intake, improved digestibility and feed conversion efficiency as compared to untreated roughage (Belew et al., 2003; Fouda, 2008; Abdel-Azim et al., 2011; El-Bordeny et al., 2015). However, few studies were done on the effect of biological treatment on animal performance in Ethiopia (Mulgeta, 2015; Tibebu, 2019). Therefore, this study was aimed at evaluating the effects of biological treatments with *Trichoderma viride* and effective microorganism (EM) treated sugarcane bagasse (SCB) and rice husk (RH) with concentrate mixture on growth performance, carcass characteristics and economic benefit of yearling Hararghe highland rams.

2. Materials And Methods

2.1. Study site

The experiment was conducted at Haramaya University goat farm. Haramaya University is located at 9^o 26'N latitude and 42^{o}3' E longitude. The site is situated at about 1980 meters above sea level (m.a.s.l.) and located at 520 km east from the capital city, Addis Ababa. The mean annual rainfall of the study area is about 870 mm with a range of 560–1260 mm and the mean maximum and minimum temperatures are 23.4^{o}C and 8.25^{o}C, respectively (Mishra et al., 2004).

2.2. Treatment preparation, experiment design and layout

*Trichoderma viride (*Tv.*)* was obtained from plant protection section of the school of plant sciences of Haramaya University, Ethiopia. The sample of Tvkept under 4^{o}C was taken and grown on petridish to activate the microorganisms. Three days old slant culture samples of Tvwas inoculated on petridish (9 cm) containing 25ml potato dextrose agar (PDA) for seven days. The seven days old culture was used to inoculate plastic bottle containing the following substances per one liter of distilled water: 4% molasses, 0.4% urea, 0.2% KH_2PO4 and 0.03% $MgSO4(7H_2O)$ per one liter of water and the inoculate was kept for seven days under room temperature. The Rice husk and sugarcane bagasse were inoculated by the solution to prepare spawn. Then the untreated sugarcane bagasse and rice husk were moistened at 55% and inoculated with 10% of the respective spawn fungi of SCB and RH (Abdel-Azim et al., 2011). The treatment was made on clean room padded with plastic sheet chemically disinfected by Dettol and Formalin. After the spawn and feeds were mixed, it was covered by plastic sheet and left for 21 days to ferment; then the treated materials were opened and placed under the sun for 8 h/days to about 10% and packed and stored until used in the feeding trials.

Adequate quantities of an inert form of EM (EM-1) packed in plastic bottles was obtained from Weljijie PLC (Debrezeit). Molasses was added and mixed with EM at equal proportion in order to initiate multiplication and metabolism activities of the microorganism. The mixture of EM and molasses was diluted with chlorine free water at a ratio of 18:1 per liter, respectively (Higa and Wididana, 2007). After stirring, the solution was stored in 200 liters capacity barrel for seven days to activate the EM solution. Then the EM solution was uniformly sprayed on to the sugarcane bagasse and Rice husk at a proportion of one liter EM to one kg dry matter feed, thoroughly mixed and packed in an airtight plastic bag of 100 kg capacity and stored in a large barrel of 200 to 250 kg capacity, covered with plastic sheet and kept at room temperature for 21 days for feeding.

Six experimental ration were prepared from concentrate feed mixture (CFM) and the two roughages (Rice husk and Sugarcane bagasse). The treatments had 50:50 ratios of the roughages to concentrate as shown in Table 1.The treatments were randomly allocated to thirty six yearlings Hararghe highland rams housed individually in a Randomized Complete Block Design (RCBD), thus each treatment were replicated six times. The rations were offered as a total mixed diet *ad libitum* at a rate of 20% refusal adjusted at interval of four days based on previous day's intake of the individual animal. The daily offer was given in two meals at 8:00 AM and 2:00 PM. The amount of feed offer and refusal was recorded daily for each animal to determine daily intake of the individual animal as a difference between the two. Feed samples were taken on batches of feed prepared, but that of the refusal were taken for each animal daily, recorded, and pooled per animal. Feed offer and refusal samples were bulked across the experimental period and sub-samples were taken for determination of chemical composition.

Table 1
Ingredients (%) and chemical composition (%DM basis) of the experimental Treatments

Ingredients (%)	Treatments					
	Rice husk(RH)			Sugarcane Bagasse(SCB)		
	U	EM	Tv	U	EM	Tv
Untreated RH	50	-	-	-	-	-
EM treated RH	-	50	-	-	-	-
Tv treated RH	-	-	50		-	-
Untreated SCB	-	-	-	50	-	-
EM treated SCB	-	-	-	-	50	-
Tv treated SCB			-	-		50
Maize	11	11	11	11	11	11
Wheat bran	11	11	11	11	11	11
Noug seed cake	23.5	23.5	23.5	23.5	23.5	23.5
Molasses	3	3	3	3	3	3
Salt	1	1	1	1	1	1
Pre.mix	0.5	0.5	0.5	0.5	0.5	0.5
Chemical composition of diet (% DM basis)						
DM	89.6	66.6	89.5	89.8	61.1	89.6
OM	85.8	85.1	84.6	92.5	91.5	90.5
CP	13.7	13.8	15.6	11.4	11.9	13.2
NDF	50.3	45.7	43.7	60.2	57.6	55.7
ADF	30	25.8	24	38.1	35.6	35.7
ADL	9.7	9.5	8.8	10.2	9.6	9.3
ME MJ/kg DM	10.59	11.37	12.05	10.4	11.2	11.14

U = Untreated; EM = effective microorganism; Tv = Trichoderma viride; DM = Dry matter; OM = Organic matter; CP = Crude protein; NDF = Neutral detergent fiber; ADF = Acid detergent fiber; ADL = Acid detergent lignin; ME = metabolizable energy;premix contained: 500000IU vitamin A, 100000IU vitamin D3,100mg vitamin E,190g Ca,90g Mg, 50g Na, 2g Mn, 3g Fe, 0.3g Cu,3gZn, 0.1g Co and 1 mg Se

2.3. Animals and management

A total of thirty six yearling intact Hararghe highland sheep were purchased from Chelenko and Kulubi markets. The animals were transported to Haramaya University and quarantined for 3weeks, at the end of which the animals were treated against internal parasites and ear-tagged for ease of identification. The lambs were placed in an individual pen furnished with feeding and watering equipments. After overnight feed withdrawal, animals were weighed for two consecutive days and the mean weights were taken as an initial body weight. Clean tap water was provided in a bucket twice daily and feed was offered in feeding trough.

2.4. Growth trial

The fattening study lasted for 90 days. The amount of total mixed ration (TMR) offered and refused were recorded daily throughout the study period using digital balance having a sensitivity of 0.02 kg. Animals were weighed at an interval of 10 days after overnight feed withdrawal and before the daily feed was offered using hanging scale graduated in 0.2 kg interval. Total weight gain (TWG) was calculated as the difference between final and initial weights. Average daily weight gain (ADG) was determined by regressing body weight against time. Feed conversion efficiency (FCE) of the animal was determined as the proportion of daily weight gain to the daily DM intake.

2.5. Laboratory analysis of feeds

Chemical analysis of samples was done in Haramaya University Animal nutrition laboratory. Representative samples of feeds and refusals were dried at 60°C for 72 hours. The dried samples were ground using laboratory mill to pass through 1 mm screen and stored for subsequent analyses of dry matter (DM), crude protein (CP), ash (AOAC, 1990), acid detergent fiber (ADF), neutral detergent fiber (NDF) and acid detergent lignin (ADL) (Van Soest and Robertson, 1985). The CP was calculated as N*6.25.

2.6. Carcass evaluation

At the end of the feeding trial, all the sheep were fasted overnight, weighed and slaughtered. The animals were killed by severing their jugular vein and carotid artery with knife. During slaughtering process, data were carefully recorded on total edible offal components (TEOC) that include the sum of weight of blood, heart, liver with gall bladder, tail, kidneys, empty gut and fat (omental, intestinal and kidney); and total non-edible offal components (TNEOC) as the sum of the weight of head, lung with trachea, skin, spleen, penis, testis, gut content and feet. The empty body weight (EBW) was calculated as the difference between slaughter weight (SW) and gut content. Dressing percentage was calculated as HCW divided by SWB and/or HCW divided by EBW. Both the right and left rib-eye area (REA) were cut between the 12th and 13th ribs perpendicular to the backbone to measure the cross section of the rib-eye muscle. The rib-eye muscle was traced first on transparency paper then the left and right REM area were traced onto a square paper which was placed on the transparency and the area of the squares (0.25 cm^2 each) that fell within the traced area was counted and those partially fell outside was estimated and the average of the two sides was taken as the REM area.

2.7. Partial budget analysis

The profitability analysis was performed to evaluate the profitability of feeding sugarcane bagasse (SCB) and rice husk (RH) treated with EM and Tv incorporated into the concentrate mixture containing maize, noug seed cake, molasses and salt to Hararghe highland sheep. The analysis was performed considering the main input costs such as sheep price, feed price and labor expenses. The average price was taken as purchasing price of sheep for all treatments. The cost of feed treatements was estimated and added on feed cost. The selling price of each animal was estimated by three experienced individuals involved in sheep trading in the area. The difference in average selling and purchase price of each animal was taken as total return (TR). The calculations for the following economic parameters were done according to Upton (1979) as follows:

NR = TR-TVC; MRR=ΔNR/ΔTVC; Where NR = net return; TR = total return; TVC = total variable cost; MRR = marginal rate of return.

2.8. Statistical data analysis

The results of weight changes and carcass characteristics for respective treatment diets of sheep were analyzed using SAS software 9.1.3 (SAS, 2008). Where there is significant difference between means, the mean separation was made adjusted Tukey honestly significant difference test.The model employed for the analysis was: Model: yijkl = μ + ai + bj + cl + b*cij + εijkl; Where:Yijkl = the dependent variables, μ = overall mean, ai = The i^{th} block, bj = The j^{th} feed type, cl = The l^{th} treatment method, c*b feed type = The jl^{th} interaction (between feed type and treatment method), εijkl = random error.

3. Results

3.1. Nutrient composition of experimental diet

Diet containing rice husk had higher CP as compared to sugarcane bagasse (Table 1). The value of CP tends to increase for the diet made from EM and Tv treated feed as compared to untreated. The fiber components (ADF and NDF) were higher for diet contained sugarcane bagasse as compared to the diet formulated from Rice husk. Inclusion of biological treated sugarcane bagasse and rice husks tends to decrease the NDF and ADF, while the CP and Ash content increased.

3.2. Weight gain and feed conversion efficiency

Sheep fed diet containing RH had significantly ($p < 0.05$) higher final body weight, total body weight gain, average daily gain and feed conversion efficiency as compared to sheep fed diet containing SCB (Table 2). Biological treatments also had an effect on growth performance of animals. Final body weight, total weight gain and average daily gain were significantly highest in animals fed biological treated feed as compared to untreated diet. However, there was no significant difference observed between EM and Tv.

Table 2
Growth parameters of Hararghe highland sheep fed diet containing Rice husk or sugarcane bagasse treated with *Trichoderma viride* and effective microbes

Parameters	Feed (F)			Treatments (T)				*p-value*		
	RH	SCB	SEM	U	EM	Tv.	SEM	F	T	F x T
IBW (kg)	18.1	18.1	0.52	18.1	18	18.2	0.64	0.98	0.99	0.99
FBW (kg)	27.6^{a}	22.9^{b}	0.54	23.8^{b}	26.2^{a}	25.8^{ab}	0.66	< 0.0001	0.04	0.49
TWG(kg)	9.5^{a}	4.7^{b}	0.28	5.7^{b}	8.1^{a}	7.6^{a}	0.34	< 0.0001	< 0.0001	0.1
ADG (g/d)	105.9^{a}	52.7^{b}	3.1	62.9^{b}	90.4^{a}	84.5^{a}	3.8	< 0.0001	< 0.0001	0.1
DMI (g/h/d)	986.5^{a}	679.6^{b}	22.3	748.5^{b}	890.7^{a}	856.9^{a}	27.3	< 0.0001	0.0025	0.004
FCE	0.107^{a}	0.076^{b}	0.003	0.080^{b}	0.100^{a}	0.096^{ab}	0.004	< 0.0001	0.001	0.25

$^{a-b}$*Meansof each parameter with different superscripts within the same column are significantly different at P < 0.05; SEM = Standard Error Mean. Where RH = Rice husk, SCB = Sugarcane bagasse, U = Untreated; EM = effective microorganism, Tv = Trichoderma viride, IBW = Initial body weigt, FBW = Final body weight, TWG = Total weight gain,ADG = Average daily gain, DMI = Dry matter intake, FCE = Feed conversion efficiency*(g DG/g DDMI).

3.3 Carcass components

Sheep fed dite contained RH had higher (p < 0.05) SBW, EBW, HCW, dressing percentage(DP) and rib- eye area as compared to sheep fed dite containing SCB(Table 3). Biological treatment had an effect on carcass components of animals. Sheep fed dite containing treated EM and Tv had significantly higher SBW, HCW and dressing percentage (DP) than sheep fed diet based on untreated roughages. However, there were no significant differences between EM and Tv in carcass parameters.

Table 3

Carcass components of Hararghe highland sheep fed dietcontainingRice husk or sugarcane bagasse treated with *Trichoderma viride* and effective microbes

	Feed(F)			**Treatments(T)**				***p-value***		
Carcass parameter	RH	SCB	SEM	U	EM	Tv	SEM	F	T	F x T
Slaughter body weight(kg)	27.6^a	22.8^b	0.54	23.8^b	26.2^a	25.8^a	0.66	< 0.0001	0.04	0.5
Empty body weight (kg)	22.8^a	19.1^b	0.50	19.8	21.7	21.4	0.55	< 0.0001	0.06	0.2
Hot carcass weight (kg)	12.4^a	9.1^b	0.32	9.7^b	11.4^a	11.1^a	0.4	< 0.0001	0.01	0.5
Dressing percentage										
SBW basis	44.6^a	39.9^b	0.62	40.5^b	43.4^a	43.0^a	0.76	< 0.0001	0.02	0.6
EBW basis	54.5^a	47.6^b	0.9	49.0	52.5	51.9	1.1	< 0.0001	0.07	0.6
REM area(cm^2)	9.92^a	7.48^b	0.29	8.23	9.12	8.74	0.36	< 0.0001	0.22	0.6

$^{a-b}$*Means in a in a row under the same heading with different subscript letter differ significantly (p < 0.05); RH = Rice husk; SCB = Sugarcane bagasse; U = Untreated; EM = Effective microbes; Tv = Trichoderma viride; SEM = pooled standard error of mean; SBW = slaughter body weight basis; EBW = empty body weight basis; HCW = Hot carcass weight; DP = Dressing percentage; REMA = Rib eye muscle area.*

3.3. Non carcass edible components

Weight of blood, heart and tongue were similar (p > 0.05) for feed type and biological treatment (Table 4). However, liver with gall bladder, kidney and empty gut weights were significantly higher for sheep consumed ration contained RH. Similarly, heart fat and omentum and mesentric fat were significantly higher for the sheep consumed RH diet. Weight of total non carcass fat (TNCF) was significantly lower for sheep received SCB diet. Total edible offal (TEO) was significantly higher in RH group than SCB ones. Biological treatments had no significant effect on individual carcass components but total edible offal (TEO) was significantly (p < 0.05) higher for feed treated with *Trichoderma viride* (Tv).

Table 4
Edible offal components of Hararghe highland sheep fed with diet containingRice husk or sugarcane bagasse treated with *Trichoderma viride* and effective microbes

	Feed(F)			Treatments(T)				*p.value*		
Parameters	RH	SCB	SEM	U	EM	Tv	SEM	F	T	FxT
Blood(kg)	0.92	0.84	0.036	0.88	0.92	0.84	0.044	0.08	0.46	0.92
Liver + gall bladder (kg)	0.36^a	0.26^b	0.011	0.3	0.3	0.33	0.014	< 0.0001	0.062	0.35
Heart(kg)	0.07	0.07	0.002	0.07	0.07	0.07	0.003	0.24	0.26	0.88
Kidney(kg)	0.07^a	0.06^b	0.002	0.06	0.06	0.07	0.003	< 0.0001	0.07	0.57
Tail(kg)	1.06^a	0.56^b	0.043	0.67^b	0.95^a	0.81^{ab}	0.008	< 0.0001	0.0032	0.32
Empty gut(kg)	1.31^a	1.16^b	0.03	1.2	1.22	1.28	0.04	0.001	0.32	0.16
Tongue(kg)	0.05	0.05	0.004	0.05	0.05	0.06	0.005	0.94	0.45	0.87
Omenetal & M.fat	0.32^a	0.20^b	0.018	0.26	0.23	0.28	0.023	< 0.0001	0.17	0.01
Heart&kidney fat(kg)	0.11^a	0.084^b	0.007	0.10	0.09	0.10	0.008	0.008	0.5	0.01
TNCF(kg)	0.42^a	0.28^b	0.02	0.35	0.32	0.38	0.026	< 0.0001	0.18	0.03
TEO(kg)	4.7^a	3.6^b	0.12	3.86^b	4.16^{ab}	4.46^a	0.15	< 0.0001	0.023	0.3

$^{a-b}$Meansin a row with different subscript letter differ significantly ($p < 0.05$). RH = Rice husk; SCB = Sugarcane bagasse; U = Untreated; EM = Effective microbes; TV = Trichoderma viride; SEM = pooled standard error of mean;TNCF = Total non carcass fat; TEO = Total edible offal.

3.4. Non-edible offal components

The result sows that significantly higher weight of head without tongue, testicles, spleen, esophagus, penis with fat, skin with legs and gut content observed for sheep fed RH based diet as compared to SCB (Table 5). However, there was no significant difference in lung with trachea between the groups. Generally, total non-edible offal (TNEO) was significantly higher in RH group than SCB one. Weight of testicles, spleen, esophagus, skin with legs and gut content are similar for sheep fed with biologically treated roughage based ration. Likewise, significantly higher value of head without tongue and penis with fat were recorded for the feed treated with EM and lung with trachea for feed treated with Tv.

Table 5
None edible offal components of Hararghe highland sheep fed with diet containingRice husk or sugarcane bagasse treated with *Trichoderma viride* and effective microbes

	Feed(F)			**Treatments(T)**				***p.value***		
Parameters	RH	SCB	SEM	U	EM	Tv.	SEM	F	T	FxT
Head	1.60^{a}	1.35^{b}	0.03	1.38^{b}	1.56^{a}	1.46^{ab}	0.037	< 0.0001	0.01	0.36
Testicles(kg)	0.30^{a}	0.25^{b}	0.03	0.27	0.28	0.28	0.015	0.003	0.9	0.52
Penis with fat(kg)	0.17^{a}	0.10^{b}	0.008	0.13^{ab}	0.15^{a}	0.12^{b}	0.01	< 0.0001	0.04	0.12
Spleen(kg)	0.03^{a}	0.02^{b}	0.0015	0.03	0.03	0.03	0.002	0.0003	0.3	0.072
Lung + trachea(kg)	0.25	0.24	0.01	0.22^{b}	0.24^{b}	0.27^{a}	0.013	0.49	0.03	0.05
Esophagus(kg)	0.03^{b}	0.04^{a}	0.004	0.03	0.04	0.04	0.005	0.03	0.2	0.27
Skin with legs(kg)	3.84^{a}	3.10^{b}	0.095	3.26	3.63	3.51	0.11	< 0.0001	0.09	0.88
Gut content(kg)	4.86^{a}	3.87^{b}	0.15	4.03	4.68	4.37	0.18	0.005	0.45	0.49
TNEO(kg)	11.08^{a}	8.80^{b}	0.23	9.14	10.61	10.03	0.28	< 0.0001	0.09	0.33

$^{a-b}$Meansin a row with different subscript letter differ significantly (p < 0.05); RH = Rice husk; SCB = Sugarcane bagasse; U = Untreated; EM = Effective microbes; TV = Trichoderma viride; SEM pooled standard error of mean; TNEOC = Total non edible offal components.

3.5. Partial budget analysis

Based on total variable cost (TVC), purchasing and selling price of sheep, the highest net return obtained from sheep fed diet containing RH and biological treated by-productsas as compared to sheep fed untreated roughage based diet (Table 6). The differences in the net return among sheep feddiet containing RH and biological treated by-productsis mainly due to higher body weight gain and good body conditions which has contributed to increased selling price.

Table 6
Economic return of Hararghe highland sheep fed diet containing Rice husk or sugarcane bagasse treated with *Trichoderma viride* and effective microbes

	Rice husk(RH)			**Sugarcane bagasse(SCB)**		
Variables	U	EM	Tv	U	EM	Tv
Purchase price of sheep(ETB)	820.00	820.00	820.00	820.00	820.00	820.00
Total feed intake(kg)	84.8	86.61	94.67	49.92	73.71	59.57
Feed cost(ETB)	393.38	445.08	486.5	206.62	341.94	276.34
labor cost per animal(ETB)	52	52	52	52	52	52
Total variable cost(ETB)	445.38	497.08	538.5	258.62	393.94	328.34
Selling price of sheep	1684	1837.33	1913.33	1209.33	1509.33	1392
Total return(TR) (ETB)	864	1017.33	1093.33	389.33	689.33	572
Net return(NR) (ETB)	418.62	520.25	554.83	130.71	295.39	243.66
Change in net return(ΔNR)	-	101.63	136.21	-	164.68	112.95
Change in total variable cost(ΔTVC)	-	51.7	93.12	-	135.32	69.72
Marginal rate of return(MRR)	-	1.96	1.46	-	1.22	1.62

U = Untreated; EM = Effective microbes; TV = *Trichoderma viride;* ETB = Ethiopia Birr, Maize = 550birr/Quntal, Wheat bran = 430 birr / Quntal, Noug cake = 750 birr / Quntal, Rice husk = 300 birr / Quntal, Sugarcane bagasse = 200 birr / Quntal, Molasses 2 birr /lit., Salt = 5 birr /kg, Premix = 50 birr /kg, EM = 20 birr /lit, Tv = 20 birr /lit

4. Discussion

4.1. Chemical composition

In the current study, the variation of experimental ration in chemical composition is due to variation in feed chemical composition and biological treatments. The result of the present study was similar with earlier study that showed decreased OM, NDF and ADF and increased CP and ash (Mahrous et al., 2009; Omer et al., 2012). The tendency of decrease in NDF and ADF of diet containing biologically treated RH and SCB might be due to the utilization of NDF and ADF during the incubation period by Tv and EM for their growth, because microorganisms are capable to decompose the gro-industrial by-products. The observed increase in CP content of diet containing Tv treated RH and SCB might be related to the release of water soluble sugar from polysaccharide, which had led to faster growth which in turn results in higher CP contents (Omer et al., 2012).

4.2. Weight gain and feed conversion efficiency

The current study shows that body weight change recorded for sheep fed RH diet (9.5kg) is higher than body weight change of sheep fed SCB diet (4.7kg). The greater weight of sheep fed RH based diet as compared to SCB diet can be ascribed to the increased DM and protein intakes. The result of the present study is comparable with that reported for Arsi-Bale sheep fed a basal diet of hay and supplemented with 300g DM of sole or mixture of linseed meal and wheat bran (Abebe et al., 2010). It is also similar with the value reported for the same breed at maximum level of supplementation (Hirut et al., 2011; Dirba et al., 2015; Kefyalew et al., 2015). Sheep fed with diet containing biological treated roughage were more efficient than those fed total mixed ration based on untreated ration. In agreement with the result of this study, Founda (2008) reported that incorporating biological treated sugarcane bagasse in a complete diet increased live weight and feed conversion efficiency. Likewise, El-Bordeny et al.(2015) reported that animal fed with biological treated(*Trichoderma viride* and *Trichoderma reesei*) rice straw showed higher total gain and average daily gain and recorded better feed conversion as compared to the control group. Moreover, Gado et al. (2006) reported that goats fed with biological treated sugarcane bagasse had higher dry matter intake and average body weight gain. In contrary to the present study, the average daily gain of rabbit fed with diet based on SCB treated with brown rot fungi (*Trichoderma reessei F-418*) was less than the rabbit consumed diet based on untreated SCB (El-Banna et al., 2010b).

4.3. Carcass component

The higher carcass weight recorded for RH and biological treated diet might be attributed to higher feed intake and greater nutrient digestibility, which promoted weight gain and tissue developments. In agreement to this result, Ebrahimi et al. (2007) reported that well formulated ration with 14.5% crude protein could be improved feed intake, live weight gain, hot carcass weight and overall performance of sheep. The carcass weight (12.4kg) observed for RH diet in the present study was comparable with the value(12.1kg) reported for Ethiopian highland ram lambs fed two varieties of maize silage or stover forms and supplemented with wheat bran and noug seed cake(Tesfaye et al., 2019). However, the value (9.1kg) recorded for SCB diet is within the range of value (5.2kg-9.1kg) reported for the same breed consumed different basal diet supplemented with different levels of concentrate (Hirut et al., 2011; Tagaynesh, 2014; Driba et al., 2015; Kefyalew et al., 2015)

The higher dressing percentage expressed as percentage of full and empty body weight, in RH diet could be an attribute of the higher hot carcass weight compared to SCB. Biological treatment also increases dressing percentage from 40.5 to 43.4% these could be attributed to higher feed intake and nutrient digestibility consequently improve the live weight of animals. The finding of the current study is within a range (36.7–45.2%) reported for other indigenous sheep breeds supplemented with different diets (Jemal et al., 2005; Getnet et al., 2008; Takele and Getachew, 2011)

Rib-eye muscle area is an indirect measurement of body musculature and amount of lean meat in the carcass (Wolf et al., 1980). The Rib-eye muscle area (9.92 cm^2) observed for sheep fed RH diet is higher than the value reported for Hararghe highland sheep (3.7–8.4 cm^2) consumed different concentrate level and basal diet(Hirut et al., 2011;Driba *et al*., 2015; Kefyalew et al., 2015;). The Rib eye muscle area is positively correlated with slaughter weight (Park et al., 2002), which can be impacted by nutrition. Thus, the high protein and energy content of RH promote muscle tissue development and live weight gain. On contrary to this result, Ríos-Rincón et al. (2014) reported that rib eye muscle area was not significantly affected with different diet consisting of different proportion of protein and energy.

4.4. Non-carcass components

The feeds the animals consume not only affect the mass of live body weight and carcass but also the mass of viscera organs (Lawrence and Fowler, 2002). In the present study, higher value of liver with gallbladder, kidney, empty gut, total non-carcass fat and total edible non-carcass components were recorded for sheep fed diet containing RH as compared to sheep fed diet containing SCB. This might be due to high energy and protein content of the RH based diet. Archimede et al. (2008) stated that the amount of fat deposit is highly correlated with plane of nutrition or energy content of the diet and appropriate dietary energy to protein combinations. On the other hand, the higher liver weight for this group might be related to the storage of reserve substances such as glycogen as described by Lawrence and Fowler (2002).

Higher proportions of total edible offals were obtained from sheep fed RH diet and Tv treated diet. The TEO recorded (3.6–4.7%) was higher than the value obtained by Tsehay (2012) in Hararghe highland sheep (2.7–3.2%) fed a basal diet of natural pasture hay and supplemented with graded levels of onion leaves as a substitute for wheat bran in concentrate mixture. But, it falls within a range (2.22 kg–4.19 kg) reported by other authors (Hirut et al., 2011;Driba et al., 2015).The total non edible offal (8.80-11.08kg) recorded for this study was slightly higher than value (8.09kg-9.43) reported for the same breed (Hirut et al., 2011, Dirba et al., 2015).The high net return obtained from sheep fed diet contained biological treated RH or SCB is due to the greater body weight gain, good body condition as result of higher nutrient intake as compared to sheep fed diet contained untreated RH or SCB.

5. Conclusion

The result in the present study showed that sheep fed with diet containing RH performed better in body weight change, carcass yield and profitability. Likewise, live weight changes, carcass yield and profitability were highest for sheep fed diet consisting biological treated feed. Hence, it can be concluded that total mixed ration consisting Rice husk (RH) and sugarcane bagasse treated with *Trichoderma viride* and effective microorganism (EM) can be considered as an alternative ration for fattening of sheep.

Declarations

Author contributions

RB contributed in designing study, feed formulation, conducting Animal trial, laboratory analysis, statistical analysis and manuscript writing. MU contributed in designing study, coordinating Animal trial and manuscript writing. TN contributed in designing study and manuscript review. GA contributed in designing study and manuscript review. All authors read and approved the final manuscript.

Acknowledgements

The authors would like to acknowledge Haramaya University for supplementary budget, research facilities and allowing access to laboratory facilities. Mizan Teppi University also greatlyacknowledgedfor providing study leave and paying salary.

Competing of interest

The authors declare no competing interest

Availability of data and material

Data used and analyzed for this study available from the corresponding author on reasonable request

Ethical approval and consent to participate

Animal care and ethical issue were careful evaluated and approved the experiment (1956ET-12/2017) by Haramaya University, College of Agriculture and Environmental Science ethics Committee. Directive 2010/63/EU of the European Union guidelines (2010) concerning the treatment and use of animals in research and development purposes were employed.

Funding

No funding was obtained for this study

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