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Feed intake, digestibility and growth performance of Dorper-Menz cross bred sheep fed local brewery by-product (*atella*) and concentrate mixture at different levels of combination

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Abstract

The aim of this experiment was to evaluate the effect of graded level of local brewery by-product (*atella)* replacement to concentrate mixture on feed intake; digestibility and body weight change of Dorper-Menz crossbred lambs fed hay basal diet. The feeding period of 90 days was preceded by 15 days of acclimatization period. The experimental design was Randomized Complete Block Design (RCBD) with five treatments: T1 [Control, hay *ad libtium*]; T2 [25% *atella* + 75% concentrate mix]; T3 [50% *atella* + 50% concentrate mix]; T4 [75% *atella* + 25% concentrate mix]; and T5 [100% *atella*]. Body weight changes were monitored fortnightly for 112 days. Data on feed intake, body weight change, and digestibility were subjected to Analysis of Variance (ANOVA) using the General Linear Model procedure. Partial budget analysis was performed to evaluate profitability of treatments. The crude protein content of *atella* was above 20% and can be used as a supplement. *Atella* alone or at different level with commercial concentrate mixture has significantly increased body weight gain of crossbred sheep. The positive weight gain results of *atella* supplemented group clearly indicate the potential of *atella*. Based on partial budget analysis, supplementation of dried *atella* could be recommended for fattening Dorper-Menz crossbred male lamb.

Keywords: *Atella, Concentrate, Dorper, Feed intake, Hay, Menz*

1. Introduction

In Ethiopia there are six indigenous sheep breed groups and nine breeds (Solomon, 2008). Among those breeds, Menz sheep is well adapted to the cool highlands of Ethiopia and has slow growth rate. In the past efforts have been made to improve the performance of this breed through selection and cross breeding (Solomon, 2008). These days, pure Dorper rams have been distributed to farmers so as to overcome the slow growth rate of Menz sheep. Currently, selected farmers and small scale private investors are producing 50% Dorper-Menz crosses. Though, sheep feeding with low quality feed resources is a common practice at farmers level in

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Ethiopia, improved feeding of Dorper-Menz crosses seems inevitable. Therefore, looking for local protein sources from the available feed resources is vital and commendable. In this regard, locally available agro-industrial by-products seem proper choice in a country where commercial concentrate is scarce and costly. The traditional agro-industrial brewery by-product (locally called *atella*) is used widely by smallholder livestock farmers in Ethiopia due to its CP content (21-22%) and abundance in most households' localities (Mekasha *et al*., 2003). However, local brewery by-product (*Atella*) as replacement for concentrate mixture in crossbred sheep ration was not well documented. Therefore, the objective of this experiment was to evaluate the effect of graded level replacement of concentrate mixture with local brewery by-product (*atella)* on feed intake, digestibility and performance of 50% Dorper-Menz crossbred lambs fed natural pasture hay basal feed.

2. Materials and methods

2.1. Experimental site

The experiment was conducted at Debre Birhan Agricultural Research Center. Debre Birhan is located in the central highlands of Ethiopia at about 120 km North East of Addis Ababa and 10 km from Debre Birhan town, at an altitude of 2,800 meter above sea level. The geographical location of the area is 09º 35' 45'' to 09º 36' 45'' North latitude and from 39º 29' 40" to 39º 31' 30" East longitude. The mean annual rainfall of the area is 897.8 mm. The mean annual maximum and minimum temperature is 19.9 and 6.5 ºC

2.2. Experimental animals and their management

Twenty five yearlings intact male Dorper with Menz crossbred sheep were obtained from Debre Birhan agricultural research center and identified by using ear tags. The age of animals was determined based on the available records of the research center. Before start of the experiment, sheep were de-wormed with Albendazol bolus and dipping using Diazinol 60% following manufacturer's recommendation. Animals were vaccinated against Anthrax and Pasteurelosis. To fully acquaint sheep with their experimental diets, the actual feeding trial period of 90 consecutive days was preceded by acclimatization period of 15 days. Sheep were kept in door in a well ventilated individual pens equipped with watering and feeding troughs. Animals' were continuously observed for incidence of any ill health and disorders during the experimental period.

2.3. Experimental feeds preparation and feeding management

Natural pasture hay (mostly *Andropogon abynicus*) was harvested from Debre Birhan agricultural research center and dry under the shade. Grass hay was chopped in to smaller size (≈ 5 cm) and fed *ad libtium* (allowing ≈ 20% refusal). *Atella* was purchased from local breweries in Debre-Birhan town having similar ingredient (barley, maize, wheat and buckthorn) and fermentation period of seven days. Commercial concentrate mixture was bought from Akaki feed processing plant. Hay and supplement (mixture of concentrate and dried *atella*) were offered separately in two equal portions at 08:00 and 16:00 h daily. Feed offered and corresponding refusal was recorded daily once in the morning before the next feeding throughout the experimental period. Water and salt lick were freely accessed to animals during experimental period. Ingredients of the commercial concentrate mixture are Noug *(Guizotia Abyssinica)* seed cake, wheat bran, graded maize and salt.

2.4. Experimental design and treatment

The experimental design was Randomized Complete Block Design (RCBD). Treatment diets were randomly assigned to each animal within each block in (Table 1). The total daily offer of *atella* with concentrate mixture was 400 g. Treatment 1 was the control, where animals received only hay basal diet *ad libtium*. The remaining treatments involved are *atella* and concentrate mixture at different levels of combination on top of natural pasture hay basal diet.

T1 = Hay *ad libtium* (Control)

T2 = Hay *ad libtium* + 25% *Atella* + 75% Concentrate mixture

T3 = Hay *ad libtium*+ 50% *Atella* + 50% Concentrate mixture

T4 = Hay *ad libtium* + 75% *Atella* +25% Concentrate mixture

T5 = Hay *ad libtium*+ 100% *Atella*

3. Data collection

Feed offer and refusal of each animal were weighed daily to calculate the daily feed intake. Animals were fasted overnight before taking body weight measurement. The initial and final weights were taken twice on two consecutive days and the average of the two was taken as initial and final weights, respectively. Weight gain was calculated as the difference between final and initial body weights. Average daily weight gain was calculated as a weight gain divided by the number of feeding days. Feed conversion efficiency was estimated as a ratio of average daily weight gain per units of dry matter feed consumed daily. Feed intake was recorded daily whereas body weight of animals had been taken every ten days interval (before the morning feeding) with a Salter balance (50 kg capacity of 200 g. precision). At the end of the feeding trial period, animals' were fitted with feces collection bags for digestibility trial and daily feces excretion was collected for seven days. Fecal bags were emptied daily just after the morning meal, and the daily fecal output was weighed and recorded for each animal. Afterwards, the fecal output of each animal was thoroughly mixed and 20% of the voided feces were sampled to make a composite of fecal samples for each animal over the collection period. The fecal samples were stored frozen at -20 ºC until processing for chemical analysis. Apparent DM and nutrients digestibility were determined as the difference between nutrients intake and that recovered in feces expressed as a proportion of nutrient intake (McDonald *et al.*, 2002).

$$DC = \frac{Total\ amount\ of\ nutrient\ in\ feed - Total\ amount\ of\ nutrient\ in\ feces}{Total\ amount\ of\ nutrient\ in\ feed} \times 100$$

3.1. Chemical analysis

Feed and feces sample were analyzed at DBARC. Sample of feed offered, refusals and feces were dried at 65 °C in forced draft oven for about 72 h and ground to pass 1 mm mesh screen size. The ground samples were stored in airtight plastic containers pending chemical analysis. The DM was determined according to the standard methods of association of analytical chemists (AOAC, 1990). Nitrogen was determined by the Kjeldahl procedure. Crude protein was estimated as N × 6.25. Neutral Detergent Fiber (NDF), Acid Detergent Fiber (ADF) and Acid Detergent Lignin (ADL) were analyzed according to the procedures of Van Soest and Robertson (1985). Hemi cellulose and cellulose contents were calculated as NDF minus ADF and ADF minus ADL, respectively.

3.2. Statistical analysis

Data on feed intake, body weight change, and digestibility were subjected to Analysis of Variance (ANOVA) using the General Linear Model (GLM) procedure of SAS (2002). Treatment means were separated using Least Significant Difference (LSD).The model used for this study was $Y_{ij} = \mu + T_i + B_j + e_{ij}$ Where; Y_{ij} = the response variable (feed intake, body weight change, and digestibility); μ = the overall mean; T_i = the treatment effect; B_j = the block effect; e_{ij} = the random error.

3.3. Partial budget analysis

Partial budget analysis was performed using the procedure of Shapiro *et. al*. (1994). Labor cost was assumed to be constant for all treatments. The initial and final market prices of target animals were estimated by traders. The price differences of target animals in each treatment before and after the experiment was considered as gross / total return (TR). The cost of supplementary feeds was computed by multiplying the actual intake for the entire feeding period with the prevailing prices.

The marginal rate of return (MRR) measures the increase in net return (ΔNR) associated with each additional unit of expenditure (ΔTVC) after arranging total variable cost (TVC) in ascending order. MRR = (ΔNR / ΔTVC) × 100

4. Results and discussion

4.1. Chemical composition of treatment feeds

The chemical composition of experimental feeds and refusals is shown in Table 1.

Table 1: Chemical composition of treatment feed (%)

Feed offer (DM base)	DM	OM	CP	NDF	ADF	ADL	Ash
Hay	92	84.39	7.04	61.12	45.65	7.77	7.61
25% *atella* + 75% CM	92	88.41	21.1	35.57	24.18	6.71	6.59
50% *atella* + 50% CM	92	84.41	20.4	45.67	32.68	5.57	6.59
75% *atella* + 25%CM	92	84.41	21.2	50.00	35.16	4.43	6.59
Dried *atella* (100%)	92	84.74	21.3	35.57	43.48	6.66	3.26
Refusal							
T1	91	84.39	5.0	66.84	50.00	8.88	6.61
T2	91	84.21	6.92	78.67	59.34	12.22	6.79
T3	91	85.21	6.4	9.85	52.75	10.00	5.79
T4	91	85.21	6.4	69.85	52.75	10.00	5.79
T5	90	84.21	6.92	78.67	59.34	12.22	6.79

Note: DM = Dry Matter; OM = Organic Matter; CP = Crude Protein; NDF = Neutral Detergent Fiber; ADF = Acid Detergent Fiber; ADL = Acid Detergent Lignin; CM = Concentrate Mixture; T1 = Hay *ad libitum*; T2 = Hay *ad libitum* + 75% CM + 25% *Atella*; T3 = Hay *ad libitum* + 50% CM + 50% *Atella*; T4 = Hay *ad libitum* + 25% CM + 75% *Atella*; and T5 = Hay *ad libitum* + 100% *Atella*.

The CP content of treatment mixture was much higher than hay, whereas the fiber fraction (NDF, ADF and ADL) in treatment mixture was clearly lower than the basal feed. The hay refusals in all treatments had lower CP and higher NDF, ADF and ADL as compared to the hay offered, which was an indication for the selectivity of animals for the better nutritious parts of the plant. The CP content of *atella* found in this study is similar with Solomon (2007), Almaz (2008) and Hagos (2014). According to Lonsdale (1989) feeds that have <12%, 12-20% and >20% CP are classified as low, medium and high protein sources, respectively. Therefore, dried atella in the present study could be categorized among the medium upper limit protein source feed that can serve as a protein supplement for low quality hay and in agreement with Susan (2003).

4.2. Feed and nutrients intake

The mean daily DM and nutrient intake of 50% Dorper-Menz crossbred sheep is presented in Table 2.

Table 2: Daily dry matter and nutrient intakes of 50% Dorper-Menz crossbred sheep supplemented with mixture of concentrate and *atella*

Intake (g/day)	Treatments					SEM	SEL
	T1	T2	T3	T4	T5		
Dry matter							
Hay	624.22	627.75	604.58	603.91	627.75	14.11	NS
Total DM	624.78[a]	991.64[b]	968.50[b]	967.91[b]	991.64[b]	3.06	**

Table 2 (Cont.)

Intake (g/day)	Treatments					SEM	SEL
	T1	T2	T3	T4	T5		
Nutrient intake g/day							
OM	289.82[a]	924.20[b]	923.47[b]	924.15[b]	924.20[b]	6.78	***
CP	51.4[a]	152.0[d]	147.40[d]	135.9[c]	152.0[d]	1.38	***
NDF	541.2[d]	127.52[a]	135.22[b]	392.09	448.32[a]	18.2	***
ADF	577.84[d]	132.97[a]	441.35[b]	458.35[b]	377.97[a]	3.6	**

Note: [a,b,c,d] Mean values in a row having different superscripts differ significantly; ** p < 0.05, *** = p <0.001; NS = Not Significant; SL = Significance Level; SEM = Standard Error of the Mean; DM = Dry Matter; OM = Organic Matter; CM = Concentrate Mixture; CP = Crude Protein; NDF = Neutral Detergent Fiber; ADF = Acid Detergent Fiber; T1 = Hay *ad libitum*; T2 = Hay *ad libitum* + 75% CM + 25% *Atella*; T3 = Hay *ad libitum* + 50% CM + 50% *Atella*, T4 = Hay *ad libitum* + 25% CM + 75% *Atella* and T5 = Hay *ad libitum* + 100% *Atella.*

The total DM intake of sheep in this study was comparable with 25% Dorper-Menz crossbred sheep[12]. The lowest total DMI of the control group was attributed to the low CP content of hay, because protein have great role to facilitate the rumen microorganisms and increase the DMI. Replacement rate has not influenced the total DMI. Total NDF and ADF intake was in the order of T1 > T5 > T4 > T3 > T2 which appeared to be associated with the level of NDF and ADF in the supplemental diets. Increatment in the replacement rate of *atella* has increased NDF and ADF, but decreased CP intake. The OM and CP intake of feed replaced with sole *atella* was similar to its lowest replacement rate.

4.3. Body weight change

The body weight gain and feed conversion efficiency of 50% Dorper-Menz crossbred sheep fed natural pasture hay basal diet supplemented with different proportion of *atella* and commercial concentrate mix is presented in Table 3.

Table 3: Body weight change of Dorper-Menz crossbred sheep fed *atella* and concentrate at different proportions

Parameters	Treatments					SEM	SL
	T1	T2	T3	T4	T5		
IBW (kg)	27.1	26.32	27.64	28.32	27.16	2.99	NS
FBW(Kg)	26.0[a]	33.46[d]	33.76[d]	32.92[c]	30.96[b]	2.21	***
TBWC (kg)	–1.1[a]	6.43 [d]	6.12 [d]	4.6[c]	3.7[b]	2.5	**
ADG (g)	–11.3[a]	73..2[d]	67.0[d]	51.1[c]	42.22[b]	4.0	**
FCE (gAWG/g DMI)	–0.01[a]	0.07[c]	0.07[c]	0.05[b]	0.04[b]	0.007	***

Note: [a,b,c,d] Mean values in a row having different superscripts differ significantly; NS = Not Significant; ** = p < 0.05; *** = p < 0.001; SL = Significance Level; SEM = Standard Error of the Mean; ADG = Average Daily Gain; FCE = Feed Conversion Efficiency; FBW = Final Body Weight, IBW = Initial Body Weight. TBWC = Total Body Weight Change.

Atella alone or at different level of mixture with commercial concentrate has significantly (p < 0.05) increased the body weight gain of 50% Dorper-Menz crossbred sheep. Weight gain results of *atella* supplemented group clearly indicate the potential of *atella* to be supplement for Dorper-Menz crossbred sheep. When the level of *atella* has increased in the ration there was a decrease in the body weight change. Similar trend has been also observed in final body weight, total body weight change and average daily weight gain. It can be speculated that *atella* might contain rumen undegradable protein and if consumed in higher amount it might not be efficiently utilized by rumen microbes and may resulted in removal of the excess protein through feces (urine) which is in agreement with the findings of Almaz (2008). Body weight loss in the control group is attributed to the poor quality of natural pasture hay (low CP and higher fiber) that could not satisfy the nutrient requirement of growing Dorper-Menz crossbred sheep.

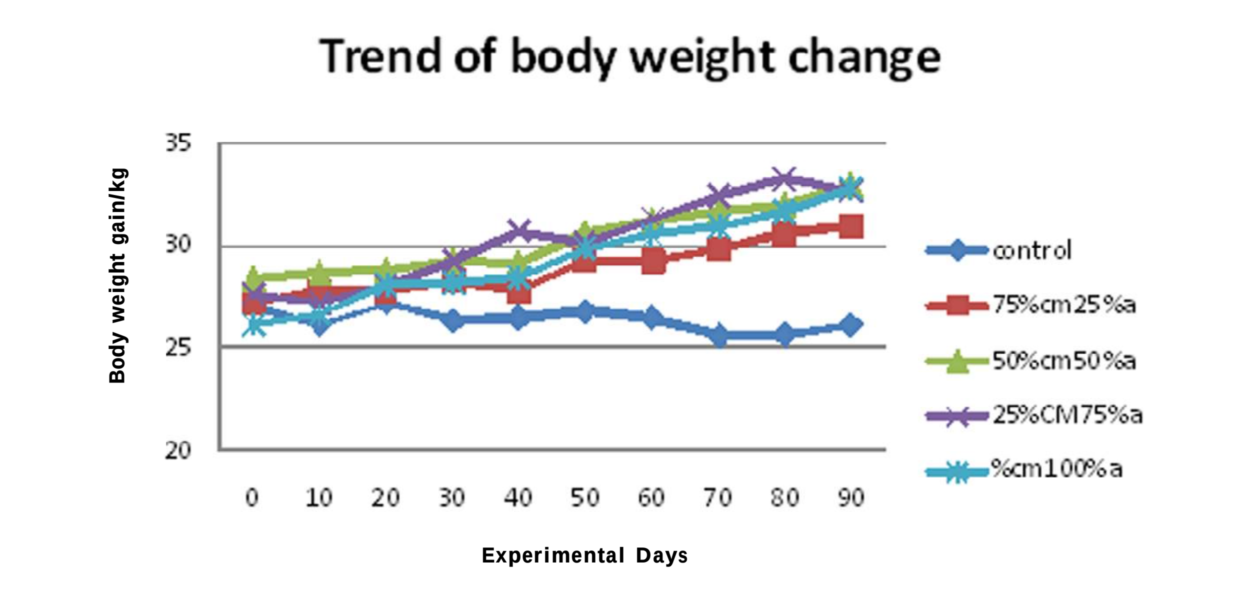

Figure 1: Trends in body weight gain of Dorper-Menz crossbred sheep fed mixture of *atella* and concentrate

4.4. Nutrient digestibility

Apparent DM and nutrient digestibility and correlation of intake, digestibility and BWG is presented in Tables 4 and 5.

Table 4: Nutrient digestibility of Dorper-Menz crossbred sheep fed mixtures of *atella* and concentrate

Digestibility	Treatments					SEM	SL
	T1	T2	T3	T4	T5		
DM	0.73	0.77	0.77	0.74	0.77	6.15	NS
OM	0.65	0.66	0.66	0.70	0.65	6.48	NS
CP	0.51^a	0.66^b	0.60^b	0.66^b	0.62^b	0.065	**
NDF	0.55^a	0.68^b	0.65^b	0.65^b	0.60^b	1.26	**
ADF	0.46^a	0.60^b	0.58^b	0.63^b	0.59^b	0.54	**

Note: ^{a,b} Mean values in a row having different superscripts differ significantly; NS = Not Significant; ** = $p < 0.001$; ADF = Acid Detergent Fiber; CM = Concentrate Mixture; CP = Crude Protein; DM = Dry Matter; NDF = Neutral Detergent Fiber; OM = Organic Matter; SL = Significance Level; SEM = Standard Error of the Mean; T1 = Hay *ad libitum*; T2 = Hay *ad libitum* + 75% CM + 25% *Atella*; T3 = Hay *ad libitum* + 50% CM + 50% *Atella*, T4 = Hay *ad libitum* + 25% CM + 75% *Atella* and T5 = Hay *ad libitum* +100% *Atella.*

Average daily gain is strongly and positively correlated ($p < 0.001$) with DMI, OMI, ADFI, ADFD and CPD. The increase in nutrient intake would create a favorable ruminal environment for microorganism in the rumen to increase digestibility and passage rate of the digesta with a subsequent increase in the overall DMI and improves body weight gain. Total DMI is negatively correlated with NDFI and positively correlated ($p < 0.001$) with CPI, CPD, ADFI and NDFD.

Table 5: The correlation between feed intake, digestibility and body weight gain of Dorper-Menz crossbred sheep fed mixtures of *atella* and concentrate

	DMI	DMD	CPI	CPD	OMI	OMD	NDFI	NDFD	ADFI
DMI	1.00								
DMD	0.202	1.00							
CPI	0.96***	0.141	1.00						
CPD	0.76***	0.076	0.93***	1.00					
OMI	0.97***	0.180	0.979***	0.92***	1.00				
OMD	0.226	0.99***	0.155	0.095	0.197	1.00			
NDFI	–0.176	–0.196	–0.036	–0.08	–0.17	–0.22	1.00		
NDFD	0.69**	0.25	0.703	0.61**	0.63**	0.26	0.19	1.00	
ADFI	0.92***	0.205	0.979***	0.91***	0.95***	0.217	0.041	0.69**	1.00
ADFD	0.82***	0.32	0.89***	0.86***	0.88***	0.31	0.018	0.620**	0.91***

Note: *** = $p < 0.001$; ** = $p < 0.05$; ADG = Average Daily Body weight Gain; CPD = Crude Protein Digestibility; CPI = Crude Protein Intake; DMD = Dry Matter Digestibility; DMI = Dry Matter Intake; OMI = Organic Matter Intake; OMD = Organic Matter Digestibility; NDFI = Neutral Detergent Fiber Intake; NDFD = Neutral Detergent Fiber Digestibility; ADF = Acid Detergent Fiber; ADFD = Acid Detergent Fiber Digestibility.

The negative correlation of fiber component NDF with feed intake is in agreement with Van Soest (1965). The non significant ($p > 0.05$) difference in apparent digestibility of CP among the treatments confirmed the comparable quality of atella with that of concentrate mixture. Feeds rich in protein promote high microbial population which in turn facilitates rumen fermentation and the fermentative activity is usually responsible for the increased digestibility McDonald *et.al*. (2002). Therefore, the current finding is in agreement with Mekonnen *et al.* (2014) denoting that lambs with higher growth potential has higher nutritional needs.

5. Partial budget analysis

Economic analysis of the experiment is computed and described for each treatment (Table 6).

Table 6: Partial budget analysis and marginal rate of return of Dorper-Menz crossbred sheep fed mixtures of *atella* and concentrate

Particulars	Units	Treatments				
		T1	T2	T3	T4	T5
Purchasing price	Birr/head	804.16	788.66	869.98	941.3	744.8
Total weight gain	kg/head	–1.02	3.81	4.6	6.12	6.43
Average daily gain	g/head	–11.3	42.22	51.10	68.00	73.60
Hay consumed in 90 days	kg/head	81.00	81.00	81.00	81.00	81.00
Atella consumed in 90 days	kg/head	0.00	36	27.00	18.00	9.00
Concentrate consumed in 90 days	kg/head	0.00	0.00	9.00	18.00	27.00

Table 6 (Cont.)

Particulars	Units	Treatments				
		T1	T2	T3	T4	T5
Hay cost in 90 days	Birr/head	243.00	243.00	243.00	243.00	243.00
Atella cost in 90 days	Birr/head	0.00	59.76	44.72	29.88	15.00
Concentrate cost in 90 days	Birr/head	0.00	0.00	45.00	90.00	135.00
Total feed cost	Birr/head	243.00	302.76	332.72	362.88	393.00
Medication cost	Birr/head	4.00	4.00	4.00	4.00	4.00
Total variable Cost	Birr/head	1051.6	1095.42	1205.70	1308.8	1141.8
Total Gross Return (GR)	Birr/head	1083.3	1450.32	1516.68	1533.3	1376.6
Net Return(NR)	Birr/head	31.7	354.58	310.98	225.12	234.8
Change of Gross return (ΔGR)		-	367.72	140.088	16.62	–73.00
Change of variable cost (ΔTVC)		-	43.82	63.90	103.1	46.38
Change of net return (ΔNR)			322.40	76.78	–84	–119.78
Marginal ret return (MRR)%		-	735	120.3	D	D

Note: D = Negative value marginal ret of return. T1 = Hay *ad libtium*, T2 = 25% *atella* + 75% concentrate mix, T3 = Hay *ad libtium* + 50% *atella* + 50% concentrate mix, T4 = Hay *ad libtium* + 75% *atella* +25% concentrate mix, and T5 = Hay *ad libtium* + 100% *atella*.

The major cost that determined profitability of sheep feeding was the initial price of animals and the feed cost. Sheep received T5 (*atella* alone) returned higher net income followed by sheep fed T4 (75 % *atella* + 25% CM). The differences in total return, net return and marginal ret of return among treatments is mainly associated with the differences in selling price of the sheep, differences in intake and cost of feed. The marginal rate of return analysis reveals what farmers can expect to gain on the average in return for their investment. Considering the net return and MRR, sheep supplemented with dried *atella* is economically profitable and in agreement with the recommendation of Hagos (2014).

6. Conclusion

Result of this study shows that traditional brewery by-product (*atella*) can be used as a protein source. Based on partial budget analysis, different levels of *atella* with concentrate mixture could be recommended as profitable supplement for 50% Dorper-Menz crossbred male lamb fattening. *Atella* may lose some volatile nutrients during drying process and further research is needed to compare wet *atella* with dried one.

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