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Original Research Article

Feed Intake, Digestibility and Live Weight Change of Lambs Fed Finger Millet (*Eleusine coracana*) Straw Supplemented With Atella, Noug Seed (*Guizotia abyssinica*) Cake and Their Mixtures

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Abstract

Feed intake, digestibility and body weight change of lambs fed finger millet (*Eleusine coracana*) straw basal diet supplemented with atella (traditional brewery residue), noug seed (*Guizotia abyssinica*) cake and mixtures of atella and noug seedcake (NSC) was studied using twenty five yearling male lambs of Ethiopian Highland sheep breed with average initial body weight (BW) of 16.4 ± 1.1 kg (Mean ± SD). The lambs were grouped into five blocks of five animals, and fed with finger millet straw alone (T1), finger millet straw + atella (T2), finger millet straw + mixture of 70% atella: 30% NSC (T3), finger millet straw + mixture of 30% atella: 70% NSC (T4), and finger millet straw + NSC (T5). The supplements were offered at the rate of 300 g/d during the feeding and digestibility trials of 90 and 7 days, respectively. Daily feed intake and body weight change of lambs was measured. Supplementation of atella, NSC and their mixtures increased ($P < 0.05$) the intakes of dry matter (DM) and crude protein (CP) of the total feed. The intake of finger millet straw (393 g/d) DM for lambs in T1 was higher ($P < 0.001$) as compared to finger millet straw intake by lambs in T4 (353.5 g/d) and T5 (337.8 g/d). Lambs in T5 had the highest ($P < 0.05$) CP intake of 101 g/d followed by T4, T3 and T2 with 91, 84 and 73 g/d, respectively. The digestibility of DM, OM and CP, as well as the daily BW gain was higher ($P < 0.05$) for supplemented than for the control (-23.3 g/d). It was concluded that supplementation of lambs with atella alone resulted in lower ($P < 0.05$) daily BW gain of 51 g/d as compared to BW gain of 63 g/d and 60 g/d as a result of supplementation with a mixture of 30% atella: 70% NSC and sole NSC.

Keywords: Body weight gain; lambs; digestibility; *Eleucine coracana* straw; feed intake; *Guizotia abyssinica.*

INTRODUCTION

In Ethiopia, sheep production suffers from feed shortage both in quality and quantity. In mixed agricultural system, sheep production relies on grazing and crop residues. The ever growing human population in most parts of Ethiopia increases pressure on the land for crop production, resulting in less and less land available for grazing, leading to an increase in the utilization of crop residues as animal feed (Mulat et al., 2011).

Dietary nutrients, especially energy and protein are the major factors affecting productivity of sheep. The lowest energy density at which the sheep do not lose weight is between 8 and 10 MJ ME/kg DM and the minimum protein level required for maintenance is about 8% CP in the DM, and the most productive animals such as rapidly growing lambs and lactating ewes need about 11% CP (McDonald et al., 2002). These energy and protein levels are considerably higher than the average values in natural pastures and crop residues.

Crop residues are generally characterized by low digestibility (< 500 g DOM/kg DM), low metabolisable energy (ME) (< 7.5 MJ ME/kg DM), low crude protein (CP) (< 60 g/kg DM) and low content of available minerals and vitamins which is insufficient to provide nutrients beyond maintenance requirements and in most cases even severe weight lose occurs (McDonald et al., 2002).

The performance of sheep can be improved by supplementation with protein and energy sources. There are several complementary and alternative strategies that can be pursued in tropical regions with the objective of making low quality feeds more useful for production of meat and milk. Maximization of livestock productivity in the tropical regions largely depends on the efficiency of utilization of locally available protein sources (Mulat et al., 2011). Concentrate feed resources especially grains are expensive and highly valued as human food. Therefore, it is imperative to look for other cheap and alternative feedstuffs to sustain and improve the ruminant husbandry. Such alternatives should not compete with feedstuffs suitable for monogastric animals and humans, but should exhibit moderate nutrient concentration, and consequently result in improved animal performance.

Agro-industrial by-products and non-conventional feedstuffs in the diets of ruminants should support growth and lactation, and result in the production of edible food for human beings. Among such feedstuffs, noug seed (*Guizotia abyssinica)* cake and atella (traditionally brewed brewery residue) could be important sources of feeding for ruminant stock. Although these by-products are frequently used for supplementing ruminant feeds, information on the effects of supplementation with sole atella or in combination with noug seedcake (NSC) for lambs fed millet straw basal diet is generally inadequate. Thus, this study investigated feed intake, digestibility, live weight change and feed efficiency of lambs fed finger millet straw basal diet supplemented with atella, NSC and their mixtures.

MATERIALS AND METHODS

Study site, feeds and feeding

The study was conducted at the Chagni Livestock Research Centre, in Awi Zone (Amhara Region, Ethiopia) located 528 km from Addis Ababa at 36°25' E longitude and 10°45' N latitude at an altitude of 1760 m above sea level. The mean annual rainfall and the mean minimum and maximum annual temperatures of the study area, as predicted by PEDB (2008), were 1486 mm and, 21 and 30 °C, respectively. The feeds used in the experiment consisted of a basal diet of *E. coracana* straw and supplements, namely atella and NSC. *Eleucine coracana* straw was chopped to a size of 3-5 cm and offered *ad libitum* whereas atella and NSC were supplemented either sole or mixed at varied proportions to provide sources of energy and protein. The supplements were offered daily in two equal portions at 0800 and 1600 h in separate troughs at the rate of 300 g per head per day. Lambs were adapted to the respective experimental diets for 15 days before the feeding and digestion trials of 90 and 7 days, respectively. All lambs had free access to water and mineral licks all the time. Atella was collected from households who brew traditional local beer on regular bases using the same ingredients (maize, barley, millet and wheat). The wet atella was sun dried by thinly spreading on a canvas using a fork to insure uniform drying and to avoid clumping of the grain. After drying, the total amount of atella required for the experimental period was collected and stored under shade.

Animals, experimental design and treatments

Twenty-five yearling male growing lambs of Ethiopian Highland sheep breed with initial body weight of 15.88 ± 0.91 kg (mean ± SD) were used in a randomised complete block design experiment with five dietary treatments of five lambs each. The five dietary treatments were randomly assigned to animals in the block in such a way that each animal within the block had equal chance of receiving one of the treatment diets. The initial body weight of lambs was determined by weighing the lambs twice after overnight fasting of the lambs at the commencement of the feeding trial. Lambs were de-wormed and sprayed against ecto-parasites and kept in well-ventilated individual pens. The dietary treatments consisted of finger millet straw *ad libitum* (T1); finger millet straw *ad libitum* + 100% atella (T2); finger millet straw *ad libitum* + mixture of 70% atella and 30% NSC (T3); and finger millet straw *ad libitum* + mixture of 30% *atella* and 70% NSC (T4), and finger millet straw *ad libitum* + 100% NSC (T5).

Feed intake, body weight gain and feed conversion efficiency

The amounts of feeds offered were recorded daily and refusal, if any, were collected and weighed every morning before fresh feed was distributed. The amount of feeds consumed during the previous day was determined by subtracting the amount refused from the amount offered on DM basis. Samples of daily feed offered and refused were collected and pooled over experimental period for each feed and animal and stored in plastic bags. Sub-samples of feed offered and refused were taken for each feed and dried at 60 °C for 72 h in a forced draft oven pending chemical analysis. Body weight was taken at weekly intervals for 90 days. Lambs were weighed during morning hours before feeding using a suspended Salter weighing scale (sensitivity of 100 g). The average daily weight change was calculated as the difference between final and initial body weight divided by number of days. Feed conversion efficiency was determined by dividing the daily weight gain by the amount of daily feed intake of each animal.

Faeces collection

At the end of the feeding trial, lambs were adapted to carrying faecal collection bags for 3 days, which was followed by total faeces collection for a period of 7 successive days for each animal. Total faeces voided was collected and weighed every morning before feeding and 20% of the total faeces were sampled; composite samples per lamb were stored in airtight plastic bags in deep freezer at -20 °C pending chemical analysis.

Laboratory analysis

The composite samples of feeds offered and refused, and faeces were thoroughly mixed for each lamb and sub-samples dried in an oven at 60 °C for 72 h, ground (Wiley mill, UK) to pass a 1 mm sieve screen and kept in air-tight plastic bags. The analysis of DM, N, OM and total ash contents of the samples was done according to AOAC (1990) and crude protein (CP) was estimated as N × 6.25. The analysis of NDF, ADF, ADF-ash and ADL was done according to

Goering and Van Soest (1970). The apparent digestibility coefficients for DM, OM, CP, NDF and ADF of the basal diet and total feed were determined as the proportion of DM and/or the respective nutrient intakes not recovered in the faeces (McDonald et al., 2002). The metabolizable energy (ME) content of treatment feeds was estimated from the digestible organic matter (DOM) contents of the feeds using the equation of McDonald et al. (2002) as: ME (MJ/kg DM) = 0.016DOM, where, DOM = g digestible organic matter/kg DM.

Table 1. Chemical composition of finger millet straw (FMS) and supplements

Chemical composition	Finger millet straw (FMS) and/or supplement feeds				
	FMS (T1)	ATL (T2)	ATL: NSC (70:30%) (T3)	ATL: NSC (30:70%) (T4)	NSC (T5)
DM (%)	92.5	93.8	94	94.8	95.5
Ash (%DM)	7.9	3.6	5.8	7.6	7.9
OM (%DM)	92.1	96.4	94.2	92.3	92.1
CP (%DM)	3.6	21.2	25.1	27.4	30.9
NDF (%DM)	73.2	34.7	35.6	38.0	40.2
ADF (%DM)	45.8	21.4	25.5	29.5	33.1
ADL (%DM)	7.6	7.3	8.1	10.9	12.1
IVOMD (%DM)	57.0	73.4	72.0	70.0	70.0
Hemicellulose (%DM)	27.3	12.9	10.2	8.4	7.0
Cellulose (%DM)	38.2	14.6	17.4	18.7	21.1
EME (MJ/kg DM)	9.0	11.8	11.5	11.2	11.1

FMS = Finger millet straw; ATL= atella; ADF = acid detergent fiber; ADL= acid detergent lignin; CP = crude protein; DM= dry matter; EME = estimated metabolizable energy; MJ = mega joule; NDF = neutral detergent fiber; NSC = noug seedcake; OM = organic matter

Statistical analysis

Data from feeding and digestion trials were subjected to analysis of variance (ANOVA) using the General Linear Model (GLM) procedure of SAS (2007). Treatment means were separated using Duncan's Multiple Range Test. The model used for treatments was: Yij = $\mu + \alpha i + \beta j + eij$, where Yij = the observation in ith treatment and jth block, μ = Over all mean, αi = the ith treatment effect, βi = the jth block effect and eij = the random error.

RESULTS

Chemical composition of treatment feeds

The chemical components of feeds used in the feeding and digestion trials are given in Table 1. While the CP content of finger millet straw used as a basal feed was 3.6%, the supplements, namely, atella and noug seedcake had 21.2 and 30.9% CP, respectively. The mixtures of the two supplement sources at 70% atella: 30% NSC, and at 30% atella*:* 70% NSC resulted in 25.1 and 27.4% CP, respectively. The CP content of the mixture supplement at 30% atella: 70%

Table 2. Daily dry matter and nutrient intakes of local lambs fed finger millet straw alone or supplemented with mixtures of atella and noug seedcake at different proportions

Parameters	Treatments					SEM	SL
	T1	T2	T3	T4	T5		
Dry matter intake							
Finger millet straw (g/d)	393^{a}	380.4^{a}	373.8^{ab}	353.5^{bc}	337.8^{c}	11.46	**
Supplement (g/d)	0.00	281.6^{d}	282.0^{c}	284.4^{b}	286.6^{a}	0	***
Total DM (g/d)	393^{c}	661.9^{a}	655.9^{a}	637.9^{ab}	624.4^{b}	11.46	***
Total DM (g/kg $W^{0.75}$)	51.2^{d}	74.2^{a}	72.4^{ab}	69.7^{bc}	68.5^{c}	1.49	***
Total DM (% BW)	2.6^{d}	3.6^{a}	3.5^{ab}	3.33^{bc}	3.28^{c}	0.08	***
Nutrient intake (g/d)							
Total OM	362.0^{d}	621.9^{a}	610.1^{ab}	588.2^{bc}	575.1^{c}	10.56	***
Total CP	14.1^{e}	73.3^{d}	84.3^{c}	90.7^{b}	100.6^{a}	0.4	***
Total NDF	287.5^{b}	376.0^{a}	373.9^{a}	365.5^{a}	362.3^{a}	8.39	***
Total ADF	180.0^{c}	236.0^{b}	243.0^{ab}	245.9^{ab}	249.7^{a}	5.2	***
Total ADL	29.9^{d}	49.7^{c}	51.2^{c}	57.9^{b}	60.3^{a}	0.87	***
EME (MJ/d)	3.6^{c}	6.8^{a}	6.7^{a}	6.4^{b}	6.3^{b}	0.1	***
Substitution rate	-	0.045^{c}	0.068^{bc}	0.139^{ab}	0.19^{a}	0.094	*

a, b, c, = means with different superscripts in a row are significantly different. * = ($P < 0.05$); ** = ($P < 0.01$); *** = ($P < 0.001$); ADF = acid detergent fiber; ADL = acid detergent lignin; CP = crude protein; DM = dry matter; NDF = neutral detergent fiber, OM = organic matter; SEM = standard error of mean; SL = significance level; T1 = control (finger millet straw sole); T2 = finger millet straw + 300 g atella; T3 = finger millet straw + 300 g (70% atella: 30% NSC); T4 = finger millet straw + 300 g (70% NSC: 30% atella); T5 = finger millet straw + 300 g NSC

NSC was higher than that of mixtures at 70% atella: 30% NSC. The results showed that NSC had high NDF and ADF contents than atella and their mixtures.

Dry matter and nutrient intake

The mean daily DM and nutrient intake of lambs fed finger millet straw alone or supplemented with sole atella and noug seedcake as well as their mixtures is presented in Table 2. The total daily DM intake was higher ($P < 0.001$) for 100% and 70% atella supplemented lambs than for unsupplemented and 100% NSC supplemented ones. Lambs supplemented with lower proportion of atella: NSC mixture (T4) and sole NSC (T5) had also higher ($P < 0.001$) total DMI as compared to unsupplemented ones (T1). Supplementation improved the total DMI by 68.4, 67.6, 63.0, and 58.9% over unsupplemented group for T2, T3, T4 and T5, respectively. The CP intake of lambs increased ($P < 0.001$) in the order of T5>T4>T3>T2>T1. Supplementation of finger millet straw with atella, NSC and their mixtures increased ($P < 0.001$) OM, CP, NDF and ADF intakes as compared to the control. Higher ($P < 0.001$) ADF intake was recorded in NSC supplemented (T5) lambs than atella supplemented group (T2).

Dry matter and nutrient digestibility

Supplementation with sole atella and/or with mixture of 70% atella: 30% NSC resulted in higher ($P < 0.001$) DM, OM and CP digestibility than those supplemented with sole NSC (Table 3). The digestibility of DM increased by 57.1, 59.9, 50.8 and 44.8% in response to supplementation for T2, T3, T4 and T5, respectively, over the unsupplemented diet. The digestible DM, OM, CP, NDF and ADF intakes were

Table 3. Dry matter and nutrient digestibility by local lambs fed finger millet straw alone or supplemented with mixtures of atella and noug seedcake at different proportions

Parameters	Treatments					SEM	SL
	T1	T2	T3	T4	T5		
Digestibility (%)							
DM	42^{c}	66^{a}	67^{a}	63^{ab}	61^{b}	2.52	***
OM	44^{c}	69^{a}	69^{a}	65^{ab}	64^{b}	2.53	***
CP	33^{c}	69^{a}	69^{a}	65^{ab}	63^{b}	2.49	***
NDF	45^{b}	61^{a}	62^{a}	58^{a}	58^{a}	3.16	***
ADF	27^{b}	48^{a}	51^{a}	47^{a}	47^{a}	4.37	***
Digestible nutrient intake (g/d)							
DM	165.0^{c}	436.9^{a}	439.5^{a}	401.9^{ab}	380.9^{b}	22.9	***
OM	159.3^{d}	429.1^{a}	420.9^{ab}	382.3^{bc}	368.1^{c}	24.6	***
CP	4.5^{c}	51.1^{b}	58.3^{a}	59.0^{a}	62.8^{a}	2.24	***
NDF	129.4^{b}	229.4^{a}	231.8^{a}	211.9^{a}	210.1^{a}	16.7	***
ADF	48.6^{b}	113.3^{a}	123.9^{a}	115.6^{a}	117.4^{a}	12.6	***

a, b, c,= means with different superscripts in a row are significantly different. *** = ($P < 0.001$); ADF = acid detergent fiber; ADL= acid detergent lignin; CP= crude protein; DM =dry matter; NDF = neutral detergent fiber; OM = organic matter; SEM = standard error of mean; SL= significance level; T1= control (finger millet straw sole), T2 = finger millet straw + 300 g atella, T3 = finger millet straw + 300 g (70% atella: 30% NSC), T4 = finger millet straw + 300g (70% NSC: 30% atella), T5 = finger millet straw + 300g NSC.

Table 4. Body weight change of local lambs fed finger millet straw alone or supplemented with mixtures of *atella* and noug seedcake at different proportions

Body weight changes	Treatments					SL	SEM
	T1	T_2	T_3	T_4	T_5		
Initial BW (kg)	16.3	16.3	16.4	16.4	16.4	ns	0.08
Daily AWG (g/d)	-23.3^{c}	51.1^{b}	56.7^{ab}	63.3^{a}	60^{a}	***	1.52
Final BW (kg)	14.2^{c}	20.9^{b}	21.5^{ab}	22.1^{a}	21.8^{a}	***	0.3
FCE (g AWG/g DMI)	-0.06^{c}	0.08^{b}	0.09^{ab}	0.11^{a}	0.1^{a}	***	0.0028

$^{a, b, c}$, Means within the same row not bearing a common superscript differ significantly; *** ($P < 0.001$); ns = not significant; SEM = standard error of mean; T1 = control (finger millet straw sole); T2 = finger millet straw +300 g atella; T3 = finger millet straw + 300 g (70% atella: 30% NSC); T4 = finger millet straw +300 g (70% NSC: 30% atella); T5 = finger millet straw + 300 g NSC; FCE = feed conversion efficiency.

higher ($P < 0.001$) for supplemented than unsupplemented sheep, whereas among supplemented groups, sole atella and 70% atella: 30% NSC supplemented groups had the highest ($P < 0.001$) digestible DM and OM intakes. The digestibility of CP was higher ($P < 0.05$) for 100% atella, and 70% atella: 30% NSC supplemented groups.

Live weight gain and feed conversion efficiency

The average daily body weight gain of lambs supplemented with atella, noug seedcake and their mixtures is given Table 4. Unsupplemented lambs had lower ($P < 0.001$) daily body weight gain than the supplemented ones. The higher ($P < 0.001$) average daily BW gain of 51, 57, 63 and 60 g/d/sheep was recorded for lambs in T2, T3, T4 and T5 as compared to non-supplemented groups, respectively, and the body weight gain tended to increase for the higher CP intakes. Atella (T2) supplemented group had lower ($P < 0.001$) daily body weight gain, and final body weight as compared to T4 and T5. The feed conversion efficiency (FCE) was improved ($P < 0.001$) for supplemented groups relative to the unsupplemented ones. Feed conversion efficiency was higher ($P < 0.001$) for T4 and T5 as compared to T2.

Correlation between nutrient intake and digestibility

The correlation between nutrient intake and digestibility of feeds is presented in Table 5. Dry matter intake was positively correlated ($P < 0.01$) with OM, CP, NDF and ADF intake, and digestibility. The CP intake was positively correlated ($P < 0.01$) with intake of DM, ADF and NDF, and digestibility of ADF and NDF. Similarly, CP digestibility was positively correlated ($P < 0.01$) with DM and OM intake and digestibility. But, CP digestibility was negatively correlated ($P < 0.05$) with intake of ADF and NDF. The NDF and ADF intake was negatively correlated ($P < 0.01$) with the digestibility of DM, OM and CP; whereas ADF digestibility was positively correlated with the digestibility of DM, NDF, OM and CP ($P < 0.01$). However, there was a weak ($P < 0.05$) correlation between CP intake and DMD, OMD and CPD.

Table 5. Correlation between nutrients intake and digestibility in local lambs fed finger millet straw alone or supplemented with sole atella or noug seedcake or their mixtures at different proportions

	DMI	OMI	CPI	NDFI	ADFI	DMD	OMD	CPD	NDFD
DMI	1								
OMI	0.98**	1							
CPI	0.43*	0.28 ^{ns}	1						
NDFI	0.97**	0.94**	0.49*	1					
ADFI	0.78**	0.70**	0.78*	0.88**	1				
DMD	0.82**	0.81**	0.3 ^{ns}	-0.74**	-0.59**	1			
OMD	0.83**	0.83**	0.29 ^{ns}	-0.76**	-0.59**	0.99**	1		
CPD	0.75**	0.77**	0.23 ^{ns}	-0.66**	-0.47**	0.91**	0.92**	1	
NDFD	0.82**	0.81**	0.39*	0.79**	0.68**	0.93**	0.94**	0.83**	1
ADFD	0.80**	0.81**	0.49*	0.79**	0.74**	0.93**	0.92**	0.82**	0.96**

** = ($P < 0.01$); * = ($P < 0.05$); DMI = dry matter intake; DMD = dry mater digestibility, OMI = organic matter intake, OMI = organic matter intake, OMD = organic matter digestibility, CPI = crude protein intake; CPD = crude protein digestibility; NDFI = neutral detergent fiber intake; NDFD = neutral detergent fiber digestibility; ADFI = acid detergent fiber intake; ADFD = acid detergent fiber digestibility.

Abbreviations used in the text:

ADF	Acid detergent fiber
ADL	Acid detergent lignin
ATL	Atella
CP	Crude protein
CPD	Crude protein digestibility
DM	Dry matter
DMD	Dry matter digestibility
DMI	Dry matter intake
DOM	Dingestible organic matter
EME	Estimated metabolisable energy
ME	Metabolizable energy
NDF	Neutral detergent fiber
NSC	Noug seedcake
OM	Organic matter
OMD	Organic matter digestibility
OMI	Organic matter intake

DISCUSSION

The finger millet straw used in this experiment could be characterized by its low CP (3.6%) and 9.0 MJ EME/kg DM, and high NDF (73.2%), ADF (45.8%) and ADL (7.6%) contents, which were consistent with the values reported by Seyoum and Zinash (1998) for tropical crop residues. The OM content of 96.4% of atella in this experiment was in line with the result of 96.8% (Yoseph, 1999). The NDF content of NSC in this study was comparable with the value of 39.7% (Mulat et al., 2011), whereas the NDF content of atella in this study was lower than the results of 54% (Demeke, 2007). According to Lonsdale (1989), feeds that have < 120, 120 - 200 and > 200 g CP/kg DM and < 9, 9 - 12 and > 12 MJ ME/kg DM are classified as low, medium and high protein and energy sources, respectively.

The higher DMI of lambs supplemented with 100% and 70% atella was probably due to the low fiber content in atella, which might be attributed to fermentable protein, which might have enhanced the efficiency of rumen micro-organisms resulting in improved feed intake. The higher NDF and ADF contents of NSC might be the major factors contributing to reduced intakes of the basal diet by reducing rate of passage. As the total DM intake increased the other nutrients intake were also increased. Supplementation of finger millet straw with atella, NSC and their mixtures resulted in the substitution of the basal diet at the rate of 0.045, 0.068, 0.14 and 0.19, which resulted in a decreased intake of finger millet straw by 3.2%, 4.9%, 10% and 14% for T2, T3, T4 and T5, respectively. This CP and OM intake increment in supplemented lambs could be attributed to increased total DMI and higher CP and OM content of atella, NSC and their mixtures. The improved growth performance of lambs in T5 might be associated with increased CP intake.

The total DM and CP digestibility of T1 in the present study was comparable with values reported by Mulat et al. (2011) in lambs fed finger millet straw basal diet supplemented with different protein sources. Atella used in this experiment had the highest digestibility as compared to NSC, which could be attributed to the higher fiber (ADF and ADL) contents in NSC, indicating the potential of atella to improve the digestibility of the basal diet. The lower apparent digestibility of nutrients in NSC supplemented groups compared with the other supplemented treatments could be associated with the higher CP excretion in the faeces due to the higher fiber content.

The body weight (BW) gain obtained in this study was higher than the value 22.7 g/d BW gain reported by Mulat et al. (2011) when lambs fed finger millet straw basal diet were supplemented with 24% NSC. The higher daily BW gain in the present study might be due to the high CP intake of lambs100.6 g/d than 47.8 g/d reported by Mulat et al. (2011). All lambs supplemented with atella, noug seedcake and their mixtures obtained CP above their maintenance requirements, while the lambs fed with finger millet straw alone could not get the amount of CP needed to meet their maintenance requirements with consequent loss of BW of the control lambs. A weight loss of 24.9 g/d in lambs fed sole finger millet straw had been reported by Mulat et al. (2011), which could be due to low protein and energy intake than required for the maintenance of the lambs and due to higher NDF, ADF and ADL contents of finger millet straw. The lower body weight gain of atella supplemented group (T2) could be due to the lower CP content of atella, and consequently lower digestible CP intakes of the lambs as compared to other supplemented treatments. The similarity in daily body weight gain among supplemented lambs reflected that the supplements were comparable in their potential to supply nutrients for improving the weight gains of sheep. The improved feed conversion efficiency (FCE) seemed to be related to higher nutrient concentration of the supplements and the consequent increase in BW gain. This showed that NSC and its mixture in higher proportion with atella have greater potential in effectively supplying the required nutrients for the sheep. Comparable to the previous studies (Pond et al., 1995), the FCE was significantly higher ($P < 0.001$) in lambs with high daily body weight gain. Therefore, supplementation improved feed conversion efficiency due to enhanced daily body weight gain.

CONCLUSIONS

Supplementation of local sheep with atella, NSC and their mixtures at the rate of 300 g/d resulted in improved nutrient intake and digestibility, and body weight gain. The improvement in the body weight gain ranged from 51.1-63.3 g/d as compared to sheep in control treatment that lost body weight at the rate of -23.3 g/d. The impact of supplementation was relatively more pronounced for sheep supplemented with higher proportion of NSC: atella supplementation.

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