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Growth performance of Adilo sheep fed urea treated wheat straw supplemented with enset(*Enseteventricosum*), atella and their mixtures

Feleke Assefa[1]*, Mengistu Urge[2] andGetachew Animut[2]

[1]Department of Animal and Range Sciences, College of Agriculture, Wolaita Sodo University, Wolaita, Ethiopia.
[2]Department of Animal and Range Sciences, College ofAgriculture, Haramaya University, Addis Ababa, Ethiopia.

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The experiment was carried using twenty-five male intact yearling Adilo sheep with average body weight of 16.5 ± 3.5 kg to determine the effects of ensetventricosum, atella and their mixture supplements to urea treated wheat straw (UTWS) on feed intake, digestibility and body weight gain (ADG). The experiment consisted of ninety days of feeding trial and seven days of digestibility testing. The experimental design was randomized complete block design, and animals were blocked based on their initial body weights. Treatments were UTWS fed ad libitum alone (T_1) or with 300 g/d atella (T_2), 200 atella+100 g/d enset (T_3), 200 enset +100 g/d atella, (T_4) and 300 enset (T5). Results of laboratory analyses for CP (6.4, 18.2 and 7.6%) and NDF contents (72, 51 and 62%) were for UTWS, atella and enset respectively. The result revealed that UTWS intake (333, 356, 353, 349 and 340 (± 0.6) g/d), total DM intake (333, 626, 618, 609 and 595 (± 0.6) g/d), total CP intake (22, 72, 59, 53 and 42 (± 0.1) g/d) for T_1, T_2, T_3, T_4 and T_5, respectively) were greater for those supplemented than non-supplemented sheep and increased (P<0.05) with increasing level of atella in the supplement. The digestibility of DM and CP also lower (P<0.05) for T_1 compared with the other treatments, and CP digestibility for T_2 was greater than other supplemented groups. Sheep fed on supplemented feed achieved greater (P<0.05) ADG (-8.9, 47.8, 34.4, 30 and 24.4 (± 3.35) g for T_1, T_2, T_3, T_4 and T_5, respectively). The value of ADG was greater for T_2 among supplemented groups. Results of this study highlighted that supplementation of UTWS with enset and atella to have a positive effect on feed intake, digestibility and ADG. However, the effect is more profound for atella than supplementation with enset or the two mixtures (T3:14% and T4:11.7%) possibly due to the higher CP content of atella.

Keywords: Atella, digestibility, enset, intake, sheep.

INTRODUCTION

Ethiopia has the largest livestock population in Africa with estimated number of 53.99 million cattle, 25.5 million sheep, 24.06 million goats, 1.91 million horses, 0.35 million mules, 6.75 million donkeys, 0.92 million camels in

*Corresponding author. E-mail:felekeassefa902@gmail.com

the sedentary areas of the Country, and 50.38 million poultry that have a considerable contribution to the national economy and the livelihood of the people (CSA, 2013). Among livestock species, sheep and goats are highly adaptable to a broad range of environments and are closely linked to the social and cultural life of resource poor farmers, serve as a living bank for many farmers, (Workneh, 2000) and provide security in bad years of cropping (Ehui et al., 2000). The short generation interval, ability to give multiple births and their small size make sheep adaptable to smallholder mixed crop-livestock production systems where they contribute up to 22 to 63% to the net cash income (FAO, 2004). The small size of sheep and goats has distinct economic, managerial, and biological advantages. Sheep and goats need small initial investment and correspondingly small risk of loss by individual deaths. For similar reasons, Dinksew and Girma (2000) reported that sheep production is becoming a viable alternative for urban animal production as a means to fulfill parts of home consumption and income needs during severe shortage of cash.

Most of the sheep feeds are derived from natural pasture and crop residues. However, such feed resources may not fulfill the nutritional requirements of animals, particularly in the dry season, due to their inherent low nutrient content and poor quality (Alemayehu, 2006). Feeding such poor nutritional value feeds results in slow growth rates, poor fertility, and high rates of mortality and consequently reduced productivity of sheep (Getahun, 2001).

Dietary nutrients, particularly energy and protein are the major factors affecting productivity of sheep. The lowest energy density at which sheep does not lose weight is between 8 and 10 MJ ME/kg DM and the minimum protein level required for maintenance is about 8% crude protein (CP) in the DM (NRC, 1985). However, most productive animals such as rapidly growing lambs and lactating ewes need about 11% CP in the DM (NRC, 1985). These energy and protein levels are considerably higher than the average values in crop residues. Crop residues are generally characterized by low digestibility (<500 g DOM/kg DM) due to close association of carbohydrates with lignin. A number of studies (Van Soest, 1988; Zhang et al., 1995) have also proven that crop residues are low in available nutrients and microbial fermentation. These characteristics of straw limit its intake and digestibility.

Although crop residues possess the above nutritional limitations, their nutritive value can be improved through supplementation with grains or agro-industrial by-products (McDonald et al., 2002), or through urea treatment (FAO, 2002). However, the strategy of supplementing crop residues with concentrates and agro-industrial by-products is very expensive and is not affordable for most farmers since concentrate feed resources, especially grains, are highly valued as human food. Moreover, the agro-industrial by-products are concentrated in urban areas and hence their availability is very limited to rural farmers. Therefore, it is imperative to look for alternative locally available and non-conventional feedstuffs as possible supplemental sources of nutrients to enhance the feeding value of crop residues.

In Wolaita Zone, average landholding per household is 0.62 ha(WZFEMD, 2011) and the cropping system is very intensive. In the area, remarkable variation in availability of feed resources between wet and dry seasons are clearly observed. Feed used for stall-fed cattle is obtained mainly from two sources: own farmyard and through purchase. Takele and Habtamu (2006) indicated that traditionally used supplementary feeds were tubers of sweet potato, maize, all *ense*components, pumpkin, sorghum, sugar cane, boiled maize and haricot bean, *atella*and wheat bran.

Non-conventional feedstuffs such as *atella* (traditional brewery residue) and*enset* are important sources of feed supplements for ruminants. Both *atella* and*enset*are the common non-conventional feeds found in WolaitaSoddo area. Because of population pressure and small land size, there is an intense production of *enset*in the study area and hence *enset*and*atella* appear to be the commonly available protein and energy sources of feed in the study area. Therefore, the objective of this study was to determine feed intake, digestibility and body weight gain of Adilo sheep fed urea treated wheat straw supplemented with *enset, atella*and their mixtures.

MATERIALS AND METHODS

Description of the study area

The experiment was conducted at WolaitaSoddo Agricultural, Technical, Vocational, and Educational Training (ATVET) College. The college is located at 380 km south west of Addis Ababa, at an altitude of 1900 m above sea level and 8°50°N and longitude of 37°45°E. longitudes. Annual rainfall in the study area averages 1100 mm and is bimodal, with the short rainy season from March until April and the long rainy season is from June until September or October. The mean monthly temperature is 19°C with minimum and maximum temperatures of 11 and 26°C, respectively.

Experimental animals and their management

Twenty five yearling male Adilo sheep with initial body weight of 16.5 ± 3.5 kg (mean ± SD) were purchased from local market-Boditi town. Physically Adilo sheep is characterized as long fat tailed, large body and, short-haired. The breed is predominantly brown (94.3%), the rest are brown with white patches, black and black with brown patches. Male are short-horned and 18.4% of ewes are horned. Their mature weight reaches to 35 kg. They are reared in southern parts of Ethiopia and their population reaches up to 407,700 (Solomon, 2008).

The animals were quarantined for three weeks on grazing and during this period they were de-wormed with albendazol bolus and sprayed using Diazinol 60% against internal and external parasites, respectively following the manufacturers recommendation. They were also vaccinated against pasteurellosis and anthrax. At the end

Table 1. Experimental treatments.

Treatments	Urea treatedwheat straw	Enset (g DM/d)	Atella (g DM/d)
T_1	*Ad libitum*	0	0
T_2	*Ad libitum*	0	300
T_3	*Ad libitum*	100	200
T_4	*Ad libitum*	200	100
T_5	*Ad libitum*	300	0

of the quarantine period, the animals were offered with urea-treated wheat straw *ad libtium* alone or supplemented with dried *enset*, dried *atella* and their mixtures according to the treatment for 15 days to adapt them to the treatment feeds prior to the beginning of the experiment.

Experimental feeds and feed preparation

The different *enset*fractions, that is whole enset, (leaves, pseudostem and corm) of the three local varieties (Gepetanua, Mazia and Nakaka) of 2 years age of maturity were chopped, dried in the shade, mixed and stored in a plastic bag. *Atella*of tellafrom local breweries was collected, spread on a plastic sheet and dried in a shade. The dried *atella* was collected in sacks and properly stored. Two equal sized pits with dimension of 2 x 2 x 2m (length, width and height) were prepared for straw ensiling purpose. A polyethylene sheet lined the floor and the sides of the pit to prevent contact of the straw with soil. A solution of 4 kg of fertilizer grade urea in 80 liters of water was prepared to treat 100 kg DM of wheat straw (MacMillan, 1992; Ibrahim and Schiere, 1989). The straw was treated with a solution prepared on a plastic sheet on the floor, mixed thoroughly and rubbed with hand to ensure proper penetration of the solution. The treated straw was well trampled and compacted batch by batch until filled to the pit capacity. Finally, the pit was sealed with plastic sheet and loaded on top by mass of soil to make it airtight. It was, then, left unopened for twenty-one days. At the end of twenty-one days, the pit was opened and a portion of the straw was taken daily and ventilated overnight to remove residual ammonia before offering to the animals.

Experimental design and treatments

A randomized complete block design was used for the experiment. At the end of the quarantine period, the animals were blocked into five blocks of five animals based on their initial body weight (BW) and animals within the block were randomly assigned to one of the five treatment diets (Table 1). The treatments consisted of urea treated wheat straw fed *ad libitum* alone or supplemented with chopped and dried *enset* or dried *atella* or 1:2 or 2:1 ratio mixtures on as fed basis of the two supplements, respectively to experimental sheep. The supplement was offered in two equal halves at 8 and 16 h daily. All animals had free access to drinking water and salt block.

Feed intake

The feeding trial lasted 90 days following 15 days adaptation period of animals to experimental conditions. Daily feed offered to the experimental animals and the corresponding refusal of each animal was measured and recorded daily during the experimental period to determine feed intake. Samples of feed offered per batch and refusal of each animal collected every day over the experimental period were pooled per treatment and stored in plastic bags pending chemical analysis. Intake of DM and nutrients was determined as a difference of offered and that of refused.

Body weight

The body weight of the animals was taken every ten days after overnight fasting to determine body weight change during the experimental period using suspended balance. Average daily body weight gain was calculated as the difference between final and initial weight divided by the feeding days. The weight taken every ten days was used to show growth pattern.

Digestibility trial

Following the feeding trial, the experimental animals were fitted with feces collection bags. After allowing an adjustment period of three days to the harness, daily total feces excretion per animal was collected for seven days. Each day's fecal output of each animal was weighed and 20% was sub-sampled and stored frozen at –20°C. The daily total fecal excretion per animal collected for seven days was used for the determination of digestibility co-efficient. Sample of feed offered and refusal for individual animal during digestibility trial was separately collected for chemical analysis. The digestibility co-efficient (DC) of nutrients was calculated by using the equation.

Chemical analysis

Samples of feed offered, refusal and feces were dried at 55°C for about 72 h in a forced draft oven and ground to pass 1 mm mesh screen size and used for determination of chemical composition. The nitrogen (N) content in samples of feed offered, refused and feces were determined according to AOAC (1990). The crude protein (CP) content was calculated by multiplying N content with a factor of 6.25. Dry matter (DM), Organic matter (OM) and ash were analyzed according to AOAC (1990). Neutral detergent fibers (NDF), acid detergent fiber (ADF), and acid detergent lignin (ADL) were analyzed based on the method of Van Soest and Robertson (1985).

Data analysis

Data generated on feed intake, digestibility, weight gain and carcass parameters were analyzed using the General Linear Model (GLM) procedure of the SAS (2002). The treatment means were separated using least significant difference (LSD).The model used for data analysis was:

Table 2. Daily feed dry matter and nutrients intake of Adilo sheep fed urea treated wheat straw alone or supplemented with*atella, enset* and their mixtures.

Parameter	Treatments					
	T1	T2	T3	T4	T5	SEM
DMI (g/d)						
UTWS	333^e	356^a	353^b	349^c	340^d	0.6
Supplement	---	270^a	266^b	260^c	255^d	0.0
Total	333^e	626^a	618^b	609^c	595^d	0.6
Total OMI	296^e	560^a	555^b	548^c	537^d	0.5
Total CPI (g/d)	22^e	72^a	59^b	53^c	42^d	0.1
Total CP (g/kgW$^{0.75}$/d)	2.8^e	9.7^a	8.1^b	7.3^c	5.6^d	0.25
Total NDFI (g/d)	240^e	392^d	400^c	405^a	402^b	0.6
Total ADFI (g/d)	170^e	248^c	245^d	261^a	255^b	0.3

^{a,b,c,d,e}Means in the same row with different superscripts differ significantly (P<0.05); SEM: standard error of mean ; DMI: dry matter intake; OMI: organic matter intake; CPI: crude protein intake; NDFI: neutral detergent fibre intake; ADFI: acid detergent fiber intake; UTWS= urea treated wheat straw; T1= UTWS *ad libitum*; T2 = UTWS *ad libitum* + 300 g/d*atella*; T3 = UTWS *ad libitum* + 200 g/d*atella*+ 100 g/d *enset*; T4 = UTWS *ad libitum* + 100 g/d *atella*+ 200 g/d *ense*t; T5 = UTWS *ad libitum* + 300 g/d*enset.*

$$Y_{ij} = \mu + \alpha_i + \beta_j + e_{ij}$$

Where: Y_{ij}= response variable, μ = overall mean effect, α_i = treatment effect, β_j = block effect, e_{ij} = residual error.

RESULTS AND DISCUSSION

Feed intake

The mean daily DM and nutrient intake of Adilo sheep fed urea treated wheat straw alone or supplemented with*atella, enset* and their mixtures is presented in Table 2. The intake of urea treated wheat straw for non-supplemented sheep was lower than that of supplemented sheep (P<0.05). However, in comparison to their body weight, the total dry matter intake of the basal diet for all treatments appeared to be low. Similar low intake of the basal feed of urea treated wheat straw was observed in the experiment conducted by Yenesew (2010) which was as low as 52.8 g/day in sheep supplemented with mixture of groundnut cake and wheat bran. The urea treated wheat straw intake in the supplemented treatments increased with increasing level of *atella*, suggesting that intake of the straw to be a function of the level of CP supplemented. For instance Van Soest (1982) indicated that dietary protein supplementation improves intake by increasing the supply of nitrogen to the rumen bacteria. This has a positive effect of increasing bacteria population and efficiency, thus enabling them to increase the rate of breakdown of the digesta and consequently feed intake.

Total DM, OM and CP intakes were greater (P< 0.05) for the supplemented than non-supplemented sheep. Among the supplemented treatments, total DM, OM and CP intakes increased with increasing level of *atella* in the supplement. Total DM intake as percent of body weight in the present study (2.05 to 3.86%) was within the range of the recommended value of 2 to 4% of body weight for tropical sheep/goats (Susan, 2003). The higher DM intake with *atella* supplementation in the current study was similar to the result reported by Yoseph et al. (2002) that supplementation with *atella* improved total DM and OM intake without affecting the intake of the basal diet hay. Similar result was also reported by Almaz (2008) who noted that sheep supplemented with soleor higher proportion of*atella* in the concentrate mix consumed higher total DM intake. The variation in total DMI among the treatments in this study might be due to the increased level of CP in the supplement. Consistent to the current results, DMI and growth rate in Alpine and Nubian goats increased as the level of protein in the diet increased (Potchoiba, 1990). This result agrees with Bonsi et al. (1996) that noted increased DM intake with supplementation. The current result in DM intake was also consistent with theresult of Matiwos (2007) in which high protein diet supplementation improved DM intake.

In line with this, an increase in DM intake when low N-fibrous diets were supplemented with protein has been reported (Kempton and Leng, 1979; Yilala, 1987). Similarly, Biru (2008) reported higher total DM intake of Adilo sheep fed different proportion of sweet potato and haricot bean screening as compared to the non-supplemented group, which was attributed to the increased level of CP intake. Similar trend was also observed in the study of Wondwosen (2008) when goats were fed with grass hay supplemented by oil seed cake.

As opposed to the total DM intake, the NDF and ADF intake were higher (P<0.05) for treatments containing 100 and 66% of *enset* than the other two supplemented treatments. This is may be related to the higher level of NDF and ADF in *enset* than *atella*. Although total DM intake of those sheep supplemented with *enset* was

Table 3. Digestibility coefficient of DM, OM, CP, NDF and ADF in Adilo sheep fed urea treated wheat straw alone or supplemented with *atella, enset* and their mixtures.

Nutrients	Treatments					
	T1	T2	T3	T4	T5	SEM
DM	0.59^{b}	0.73^{a}	0.72^{a}	0.71^{a}	0.71^{a}	0.006
OM	0.65^{b}	0.77^{a}	0.76^{a}	0.76^{a}	0.76^{a}	0.005
CP	0.44^{c}	0.67^{a}	0.64^{b}	0.64^{b}	0.63^{b}	0.008
NDF	0.68^{b}	0.78^{a}	0.78^{a}	0.78^{a}	0.78^{a}	0.006
ADF	0.48^{c}	0.65^{ab}	0.64^{b}	0.67^{a}	0.66^{ab}	0.008

[a,b,c]Means in the same row with different superscripts differ significantly (P<0.05); SEM: standarderror of mean; DM: dry matter; CP: crude protein; OM: organic matter; NDF: neutral detergent fibre; ADF: acid detergent fiber; T1= UTWS *ad libitum*; T2 = UTWS *ad libitum* + 300 g/d*atella*; T3 = UTWS *ad libitum*+ 200 g/d*atella*+ 100 g/d *enset*; T4 = UTWS *ad libitum* + 100 g/d *atella*+ 200 g/d *ense*t; T5 = UTWS *ad libitum* + 300 g/d*enset.*

Table 4. Body weight change of Adilo sheep fed urea treated wheat straw alone or supplemented with*atella, enset* and their mixtures.

Parameter	Treatments					
	T1	T2	T3	T4	T5	SEM
IBW (kg)	16.2	16.2	16.5	16.1	16.4	0.73
FBW (kg)	15.4^{b}	20.5^{a}	19.6^{a}	18.8^{a}	18.6^{a}	0.82
WC (kg)	-0.8^{c}	4.3^{a}	3.1^{b}	2.7^{b}	2.2^{b}	0.30
ADG (g)	-8.9^{c}	47.8^{a}	34.4^{b}	30.0^{b}	24.4^{b}	3.35
FCE (gain/feed)	0.026^{c}	0.076^{a}	0.055^{b}	0.049^{b}	0.041^{b}	0.0065

[a,b,c]Means with different superscripts in the same row are significantly different (P<0.05); SEM: standard error of mean; IBW: initial body weight; FBW: final body weight; WC: weight change; ADG: average daily body weight gain; FCE: feed conversion efficiency T1= UTWS *ad libitum*; T2 = UTWS *ad libitum* + 300 g/d*atella*; T3 = UTWS *ad libitum*+ 200 g/d*atella*+ 100 g/d *enset*; T4 = UTWS *ad libitum* + 100 g/d *atella*+ 200 g/d *ense*t; T5 = UTWS *ad libitum* + 300 g/d*enset.*

lower than that of *atella* supplemented, *enset*supplementation improved intake as compared with the control groups.

Digestibility

There was greater (P<0.05) apparent digestibility of DM, OM, CP, NDF and ADF for the supplemented than non-supplemented sheep (Table 3). Similar to the current study, supplementation of urea treated barley straw with vetch and alfalfa hay improved the apparent digestibility of DM of the diet substantially as compared to the non-supplemented ones (Dawit, 2007).

Digestibility of nutrients among supplemented sheep was not different (P>0.05) from each other, except for CP and ADF. Digestibility of CP was greater (P<0.05) for 100% *atella* supplemented sheep as compared to other supplemented groups. The greater CP digestibility of sole*atella* supplemented group could be due to higher intake of dietary protein, since CP digestibility is associated with higher CP intake (McDonald et al.,2002). Yoseph et al. (2002) observed higher nitrogen digestibility in sheep supplemented with *atella* compared with faba bean, field pea, and rough pea hulls. *Atella* in addition of being protein supplement (Lonsdale, 1989), it may contain soluble carbohydrate, which would enhance microbial assimilation of ammonia in the rumen (Yosephet al., 2003).

The DM digestibility of the urea treated wheat straw in the present study was higher than the 58.5% reported by Getahun (2006) and the 47 to 54% noted by Yenesew (2010), but was similar to other reports (Firewet al., 2005). The relatively lower nutrient digestibility observed in the non-supplemented treatment might be due to the high level of intake of NDF and ADF from the urea treated wheat straw than in supplemented treatments, since the primary chemical components of feed that determine the rate of digestion are NDF and ADF (MacDonald et al., 2002). In addition, it might be due to the lower CP content of the urea treated wheat straw as compared to other supplements. The digestibilities of DM and OM in sheep fed *enset*supplement alone were slightly lower than reports ofAjebuet al. (2008b). The CP digestibility of this same treatment was higher (62.8%) than the value reported by Ajebuet al. (2008b).

Body weight gain

Mean initial and final body weight, average daily gain (ADG) and feed conversion efficiency (FCE) are presented in Table 4. Supplemented sheep gained more (P<0.05) body weight and had a greater FCE compared

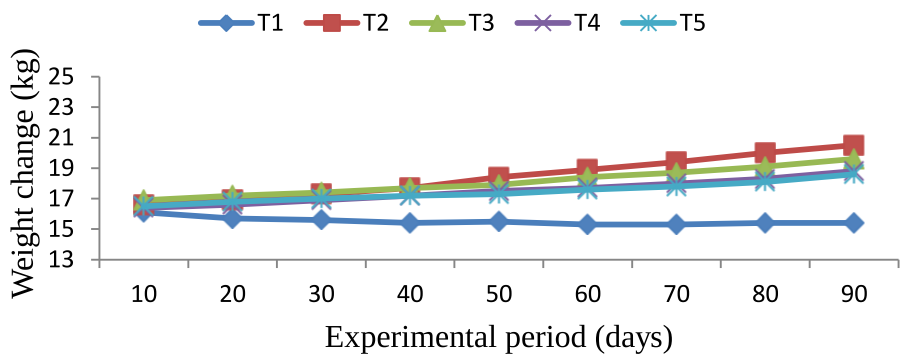


Figure 1. Change in live weight in Adilo sheep fed urea treated wheat straw alone or supplemented with *atella, enset* and their mixtures.

with non-supplemented ones. In this study, supplementation promoted higher intake of urea treated wheat straw. Thus, greater body weight gains in the supplemented group might be related to more nutrient supply from both the supplement and the basal diet.

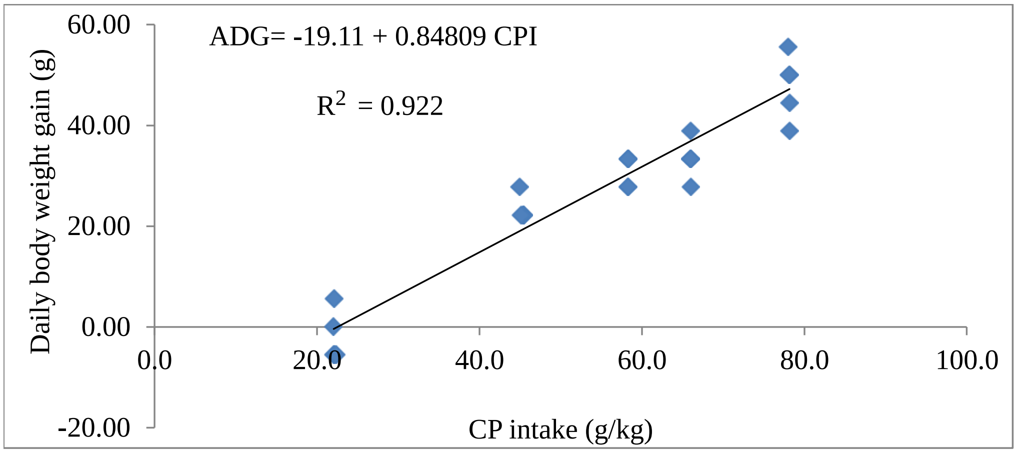
Nitrogen deficiency below the requirement of rumen bacteria could impact animal performance (McDonald et al.,2002), which may occur when the CP content of the forage is below 8% (Van Soest, 1994). Because of low nitrogen, high cell wall and slow digestion, animals kept on sole straw or hay diet may not be able to maintain their nitrogen balance and growing animals could lose body weight (Kaitho, 1997). In this study, the possible increment in CP content and digestibility of wheat straw as the result of ammoniation was unable to help provide sufficient nutrients to at least support the maintenance requirement of the animals. Similar to this observation, Hadjipanayiotouet al. (1993) stated that even if animals depend on urea treated crop residues perform better than those on untreated crop residues, animals continued to be on negative nutrient balance. Likewise, Abebe (2008) reported that sheep fed only urea treated rice straw lost 4.3 g body weight per day. Contrary to this study, sheep fed with sole urea treated wheat straw consumed greater (566 g/day) and gained body weight of 10.7 g/day (Getahun, 2006). Firewet al. (2005) also recorded positive weight gain of 14 g/day in sheep fed urea treated wheat straw. This may indicate that body weight lose in the present experiment is both due to low CP content of the basal diet as well as the low total DM intake.

Although ADG tend to decline with decreasing level of *atella* in the supplemented group, only sheep supplemented with *atella* alone had significantly($P<0.05$) higher ADG than other supplemented group. However, these values were lower than that reported by Ajebu (2010) in which sheep supplemented with 373 g/day *atella*gained 58 g/day and that of Almaz (2008) who noted 51 g/day ADG for sheep supplemented with 300 g/day *atella.* Body weight gain of *enset* supplemented sheep in this study was lower thanthe 36.5 g/day recorded by Ajebuet al. (2008a) in sheep fed on wheat straw and *Desmodiumintortum* hay supplemented with 250 g DM/day whole *enset*fractions.

The highest ($P<0.05$) FCE was recorded for sheep supplemented with *atella* alone as compared to other treatment groups. The FCE (0.08) of sheep fed finger millet basal diet supplemented by 300 g *atella* (Almaz, 2008) was similar to the result of the current study. Sheep fed urea treated wheat straw alone (control) recorded the lowest FCE (-0.026) due to the negative weight gain. The increased feed conversion efficiency for sole *atella*supplemented group could be partly contributed by the observed higher apparent CP digestibility and intake that probably supplied more protein for tissue synthesis and hence lead to increased ADG, which in part apparent from the high positive coefficient of determination observed between CP intake and ADG (Figure 2). As indicated by Pond et al. (1995), the improved feed conversion efficiency may also be due to the relatively higher nutrient composition of the supplements and the consequent increase in body weight gain showing that diets that promote a high rate of gain will usually result in a greater efficiency than diets that do not allow rapid gain, since the rapidly gaining animals utilize less of the total feed intake for maintenance and more of it for live weight gain (Table 4).

The trend in live weight change of sheep over the experimental period is given in Figure 1. The live weight of the experimental animals in all the supplemented treatments increased through time with more prominent increase in animals supplemented with *atella*. Animals in the control however lost weight at a rate of 8.9 g/day indicating that the basal diet may not able to maintain their body weight.

Regression analysis clearly indicated a paramount contribution of CP intake to daily live weight change as explained by higher coefficient of determination (R^2 = 0.922, $P< 0.001$). The daily live weight gain of sheep was contributed much by increased intake of crude protein. Similar result was reported by Biru (2008) in which sweet



R^2 = Coefficient of determination

Figure 2. Regression of daily body weight gain (ADG) on crude protein intake (CPI) of Adilo sheep fed urea treated wheat straw alone or supplemented with *enset, atella* and their mixtures.

Table 5. The correlation between feed intake, digestibility and body weight gain of Adilo sheep fed urea treated wheat straw alone or supplemented with *enset, atella* and their mixtures.

	DMD	OMD	CPD	DMI	OMI	CPI	ADG
DDM	1						
OMD	0.99***	1					
CPD	0.94***	0.93***	1				
DMI	0.96***	0.96***	0.88***	1			
OMI	0.95***	0.96***	0.88***	0.99***	1		
CPI	0.84***	0.83***	0.84***	0.87***	0.85***	1	
ADG	0.86***	0.85***	0.84***	0.88***	0.87***	0.96***	1

*** (P<0.001); DMD = dry matter digestibility; OMD = organic matter digestibility; CPD = crude protein digestibility; DMI = dry matter intake; OMI = organic matter intake; CPI = crude protein intake; ADG = average daily gain.

potato tuber and haricot bean showed increased ADG with increase in CP intakeinAdilo sheep.Dawit (2007) and Almaz (2008) have also reported that the daily weight gain of sheep have increased as the level of CP intake increased. The regression analysis also reflected that the body weight loss in the non-supplemented sheep is largely associated with its low CP content, in addition to low DM intake.

Correlation between nutrients intake, digestibility and daily weight gain

Pearson correlation values among nutrient intake, digestibility and body weight gain is presented in Table 5. Intakes of all nutrients were positively and significantly (P<0.001) correlated with each others, digestibility and body weight gain. Similar strong and close associations between nutrient intake and body weight change has been reported by Abebe (2008). According to Getahu, (2006), there were also significant and linear correlations between ADG, nutrient digestibility and nutrient intake.

Conclusion

This study was conducted to determine the effect of *enset, atella* and their mixtures supplementation to urea treated wheat straw on feed intake, digestibility and body weight change of Adilo sheep.Results of this study suggested that supplementation of urea treated wheat straw with *atella* and *enset*to have a positive effect on feed intake, digestibility and ADG. The effect is more evident for *atella* than*enset* or the two mixtures possibly due to the higher CP content of *atella*. Thus, depending on availability, the two non-conventional supplements can be used to supplement animals to improve animal production performance in straw based crop-livestock mixed farming systems.

Conflict of Interest

The authors have not declared any conflict of interest.

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