Weight Gain and Carcass Characteristics of Adilo Sheep Fed Urea Treated Wheat Straw Supplemented with Enset (Ensete Ventricosum), Atella and Their Mixtures

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Abstract
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 Enset ventricosum, atella and their mixture supplements to urea treated wheat straw (UTWS) on body weight gain (ADG) and carcass parameters. The experiment consisted of ninety days of feeding followed by carcass evaluation. 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 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. Hot carcass weight was 5.4, 8.2, 7.2, 6.7 and 6.6 (± 0.25) kg for T1, T2, T3, T4 and T5, respectively and followed similar trend like that of ADG. Results of this study highlighted that supplementation of urea treated wheat straw with enset and atella to have a positive effect on, ADG and carcass parameters. However, the effect is more pronounced for atella than enset or the two mixtures possibly due to the higher CP content of atella.
Keywords: Atella, Carcass, Enset, 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 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 22-63 % 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 hectare (WZFEDD, 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 Wolaita Soddo 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 body weight gain and carcass characteristics 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 Wolaita Soddo 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 meter 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 ^{0}C with minimum and maximum temperatures of 11 ^{0}C and 26 ^{0}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 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 tella from 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 2m x 2m 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 hours daily. All animals had free access to drinking water and salt block.

Table 1. Experimental treatments

Treatments	Urea treated wheat 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

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.

Data Analysis

Data generated on weight gain and carcass parameters were analyzed using the General

Linear Model (GLM)procedure of the SAS (SAS, 2002). The treatment means were separated using least significant difference (LSD). The model used for data analysis was:

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

Where: Y_{ij} = response variable

μ = overall mean effect

α_i = treatment effect

β_j = block effect

e_{ij} = residual error

Results and Discussion

Body Weight Gain

Mean initial and final body weight, average daily gain (ADG) and feed conversion efficiency (FCE) are presented in Table 2. Supplemented sheep gained more ($P<0.05$) body weight and had a greater FCE as compared to non-supplemented ones. In this study, supplementation promoted the more 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. Consistent to the current study, Matiwos (2007) reported that goats supplemented with concentrate body weight and daily live weight gain.

Weight loss during the experimental period was recorded for sheep offered urea treated wheat straw alone indicating that the straw failed to meet the maintenance requirements. 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 (Kitho, 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, Hadjipanayiotou *et 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). Firew et 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 significant and greater ($P<0.05$) ADG than the 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 than the 36.5 g/day recorded by Ajebu et al. (2008a) in sheep fed on wheat straw and *Desmodium intortum* hay supplemented with 250 g DM/day whole *enset* fractions.

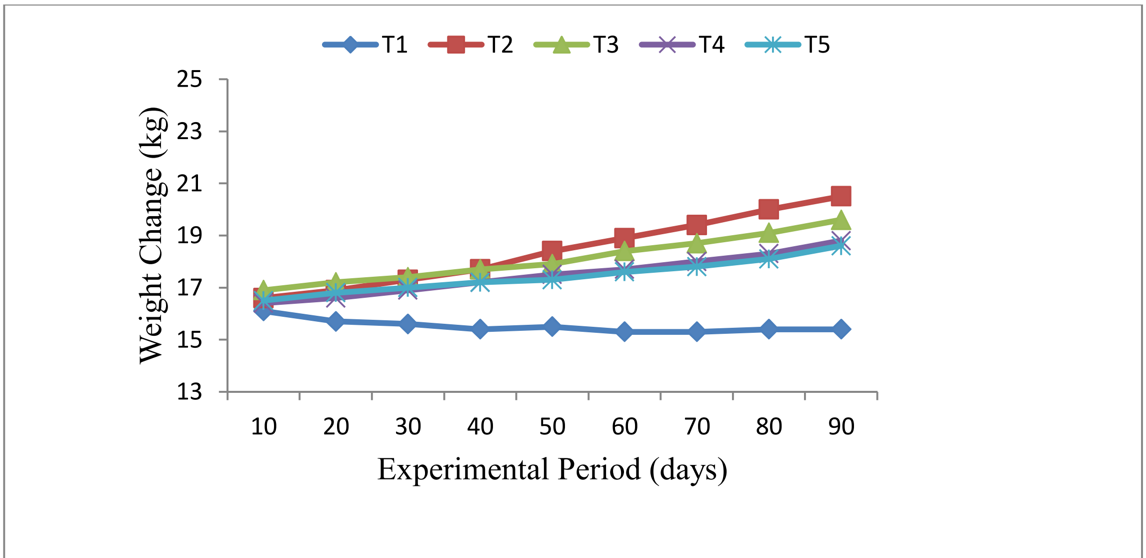
The highest ($P<0.05$) FCE was recorded for sheep supplemented with *atella* alone as compared to other treatment groups. The FCE (0.08) of sheep fed finger millet basal diet supplemented by 300 g *atella* (Almaz, 2008) was similar to the result of the current study. Sheep fed urea treated wheat straw 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 better CP intake. As indicated by Pond *et al*. (1995), the improved feed conversion efficiency may also be due to the relatively higher nutrient 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 2. Body weight change of Adilo sheep fed urea treated wheat straw alone or supplemented with *atella, enset* and their mixture

	Treatments					
Parameters	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 *enset*; T5 = UTWS *ad libitum* + 300 g/d *enset.*

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 failed to maintain their body weight.



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 *enset*; T5 = UTWS *ad libitum* + 300 g/d *enset.*
Fig. 2. Change in live weight in Adilo sheep fed urea treated wheat straw alone or supplemented with *atella, enset* and their mixtures

Carcass Components

Mean values of slaughter weight, empty body weight, hot carcass weight, dressing percentage and rib-eye area are presented in Table 3. Sheep on the supplemented group had heavier carcass ($P < 0.05$), higher empty body weight, slaughter weight and rib eye muscle area (REA) ($P < 0.05$) than non-supplemented ones which is in agreement with other reports (Simret, 2005; Biru, 2008; Hirut, 2008). The significantly higher carcass traits in the supplemented sheep compared with the non-supplemented ones might be due to higher FCE and body weight gain. Carcass weight, dressing percentage and REA were greater for animals supplemented with sole *atella* than other supplemented groups. This is in line with the ADG and FCE noted in this study.

Although REA was higher than the result of the present study, Mulu (2005) also revealed that supplementation has a positive effect on REA. According to the report of Wolf *et al*. (1980), greater rib eye muscle area is associated with a higher production of lean in the carcass and higher lean/bone ratio. The dressing percentage on slaughter weight basis in the current study was in a range of 34-40%, which is comparable with the value for Afar rams that ranged between 32 to 40 % (Tesfaye, 2007), 31 to 41% for Harrerghe highland sheep (Hirut, 2008) and 32 to 41% for Adilo sheep (Biru, 2008).

Table 3. Carcass characteristics of Adilo sheep fed urea treated wheat straw alone or supplemented with *atella, enset* and their mixtures

	Treatments					
Parameters	T1	T2	T3	T4	T5	SEM
Slaughter weight (kg)	15.4^{b}	20.5^{a}	19.6^{a}	18.8^{a}	18.6^{a}	0.82
EBW (kg)	11.5^{c}	15.6^{a}	14.6^{ab}	14^{ab}	13.6^{b}	0.64
HCW (kg)	5.4^{c}	8.2^{a}	7.2^{b}	6.7^{b}	6.6^{b}	0.25
DPS (%)	35.2^{c}	39.9^{a}	36.9^{b}	35.5^{bc}	34.4^{bc}	0.52
DPE (%)	47.3^{c}	52.5^{a}	49.4^{b}	47.8^{bc}	48.4^{bc}	0.66
REA (cm^2)	6.6^{d}	9.5^{a}	8.6^{b}	$8.\ 1^{bc}$	7.7^{c}	0.17

[a,b,c]Means with different superscripts in rows are significantly different (P<0.05; SEM: standard error of mean; EBW: Empty body weight; HCW: Hot carcass weight; DPS: Dressing percentage on slaughter weight basis; DPE: Dressing percentage on empty body weight basis; REA: Rib-eye area 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 *enset*; T5 = UTWS *ad libitum* + 300 g/d *enset.*

Non-carcass Components

Non-carcass components for edible offals are presented in Table 4. With the exception of omaso-abomasum, heart and tongue, other edible offals of supplemented sheep were heavier (P<0.05) than non-supplemented ones. The mean total edible offals of the supplemented sheep was greater (P<0.05) than non-supplemented ones. Higher weight of TEO in the supplemented sheep indicated that supplementation has a positive effect on the weight of TEO. This agrees with the work of Awet (2007) and Biru (2008) in Afar and Adilo sheep, respectively. The higher abdominal fat (P<0.05) in supplemented sheep might relate to greater CP supply that may result to more fat in viscera which is in agreement with the result of Hirut (2008). Higher values of liver, kidney, spleen and different parts of alimentary tract with increasing supplementation level were reported by Mulu (2005). Similarly, Simret (2005) reported a positive effect of supplementation on the weight of some edible offals like kidney, liver and blood.

Table 4. Non-carcass components (edible offals) of Adilo sheep fed urea treated wheat straw alone or supplemented with *atella, enset* and their mixtures

	Treatments					
Edible offals	T1	T2	T3	T4	T5	SEM
Heart (g)	92^{b}	101^{a}	101^{a}	96^{b}	94^{b}	1.3
Liver + gall bladder (g)	399^{c}	505^{a}	503^{a}	500^{a}	492^{b}	1.8
Kidney (g)	81^{c}	102^{a}	100^{a}	97^{b}	96^{b}	1.0
Ret-Rum (g)	498^{b}	552^{a}	560^{a}	560^{a}	552^{a}	6.6
Oma-Abom (g)	136^{a}	139^{a}	130^{b}	118^{c}	121^{c}	1.7
SI and LI (g)	553^{c}	613^{a}	604^{a}	567^{b}	567^{b}	3.5
Tongue (g)	99^{a}	93^{b}	83^{c}	78^{d}	78^{d}	1.3
Abdominal fat (g)	36^{d}	72^{a}	65^{b}	55^{c}	59^{c}	1.8
Blood (g)	970^{c}	1073^{a}	1054^{ab}	1053^{ab}	1041^{b}	8.9
TEO (kg)	2.86^{d}	3.23^{a}	3.20^{b}	3.13^{c}	3.11^{c}	0.011

[a,b,c,d]Means with different superscripts in rows are significantly different (P<0.05); Oma-Abom: omasum and abomasum; Ret-Rum: reticulum and rumen; SI and LI: small intestine and large intestine; TEO: total edible offals; SEM: standard error of mean; 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 *enset*; T5 = UTWS *ad libitum* + 300 g/d *enset.*

Non-carcass components for non-edible offals are presented in Table 5. Skin, lung with trachea, spleen and total non-edible offals (TNEO) were higher (P<0.05) for supplemented sheep than non-supplemented sheep. Abebe (2007) also reported heavier TNEO for supplemented Arsi-Bale sheep than the non-supplemented sheep fed basal diet of grass hay. Contrary to the result of this study, absence of significant difference was noticed in TNEO between supplemented and non supplemented treatments (Tesfaye, 2007; Awet, 2008; Hirut, 2008). Lack of significant difference in gut content between control and supplemented sheep in the current study is similar to the work of Biru (2008).

Table 5. Non-carcass components (non-edible offals) of Adilo sheep fed urea treated wheat straw alone or supplemented with *atella, enset* and their mixtures

	Treatments					
Parameters	T1	T2	T3	T4	T5	SEM
Head (g)	1189^{bc}	1203^{a}	1195^{ab}	1182^{c}	1187^{bc}	2.9
Skin (g)	1991^{c}	3005^{a}	3000^{a}	2480^{b}	2562^{b}	82.2
Testis (g)	161^{b}	173^{a}	165^{ab}	161^{b}	160^{b}	2.8
Penis (g)	52.8^{ab}	53.0^{a}	50.0^{bc}	51.6^{ab}	49.4^{c}	0.97
Fetlock (g)	253^{c}	303^{a}	270^{b}	258^{bc}	266^{bc}	5.4
Gut (g)	4480	5020	4980	4840	5000	248.7
Bladder (g)	37.6^{c}	44.2^{a}	42.8^{ab}	44.2^{a}	39.8^{bc}	1.08
Spleen (g)	60.8^{d}	104.2^{a}	100.2^{b}	92.2^{c}	90.4^{c}	0.80
Lung (g)	282^{d}	373^{a}	363^{b}	360^{b}	350^{c}	1.4
TNEO (kg)	8.5^{c}	10.3^{a}	10.2^{a}	9.5^{b}	9.7^{ab}	0.21

^{a,b,c,d}*Means with different superscripts in rows are significantly different (P<0.05); TNEO: total non-edible offals; SEM: standard error of mean; 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 enset; T5 = UTWS ad libitum + 300 g/d enset.*

CONCLUSION

This study was conducted to determine the effect of *enset, atella* and their mixtures supplementation to urea treated wheat straw on body weight change and carcass characteristics 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 ADG and carcass parametres. 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.

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