ORIGINAL ARTICLE

Effects of substituting maize with *kocho* on intake, digestibility, nitrogen utilization and body weight gain in sheep fed a basal diet of Rhodes grass hay

Ajebu Nurfeta[1*], Meseret Tsegaye[2] and Aster Abebe[1]
[1]School of Animal and Range Sciences, College of Agriculture, Hawassa University, P.O. Box 222, Hawassa, Ethiopia

[2] Hawassa Zuria Agricultural Office, Dore Bafano, Rural Job Creation and Development Agency Expert, P.O.Box 1294, Hawassa, Ethiopia.
*Corresponding author: ajebu_nurfeta@yahoo.com

ABSTRACT

The study was carried out to investigate the effect of substituting maize with *kocho* on intake, digestibility, nitrogen utilization and weight gain in intact Adilo sheep fed a basal diet of Rhodes grass hay. Twenty four yearling male sheep with an initial body weight of 18.55 ± 0.38 kg (mean ± SE) were assigned to treatments using a completely randomized block design with four treatments. The sheep were blocked based on their initial body weight into six and each of the four treatment diets were randomly assigned to each animal in each block. Dietary treatments were comprised of 100% maize and 0% *kocho* (T1), 65 % maize and 35% *kocho* (T2), 35% maize and 65% *kocho* (T3) and 0% maize and 100% *kocho* (T4) in a concentrate mixture. The concentrate portion was composed of noug (*Guizotia abyssinica*) cake, wheat bran, alfalfa powder, limestone and salt. Rhodes grass hay was offered as a basal diet ad libitum (~20% refusal). Two hundred gram concentrate mixture supplement was given twice a day in equal portions. A 70-day growth trial and an eight day digestibility trial were conducted. There were no significant differences (P>0.05) on intake, digestibility and weight gain among treatments. The study conducted inferred that *kocho* can replace maize without any adverse effect on nutrient intake, digestibility and weight gain. It is concluded that *kocho* could be used as an alternative ingredient to replace maize in concentrate mixture in areas where its economic advantages are feasible.

Keywords: *Ensete ventricosum*, *kocho,* Southern Ethiopia, Adilo sheep

INTRODUCTION

Despite the huge livestock resources in Ethiopia, the overall contribution of the sub-sector achieved so far has been meager. The low productivity of livestock is mainly due to poor feed quality and inadequate feed supply (FAO, 2010). Under such conditions, the demand for livestock products by consumers cannot be sustainably satisfied.

Ethiopia's livestock feed resources are mainly natural pasture and crop residues. These feed resources could not fulfill the nutritional requirement of animals particularly in the dry season. Moreover, even the supply of these feed resources is inconsistently distributed over the seasons. The implications of such poor nutritional values and inadequate supply are slow growth rates, poor fertility, and high rates of mortality and consequently reduced production of livestock (Adugna and Sundstøl, 2000). Moreover, the ever growing human population increases the 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. To improve the productivity of these animals supplementation of these available low quality feed resources with concentrates including cereal grains has been a common practice in many intensive and semi intensive production systems to enhance the energy and/or protein status of low quality feeds.

There are different types of locally available feed resources that are used as supplements in ruminant diets among which enset is widely used especially in the southern parts of Ethiopia. Enset (*Ensete ventricosum*) could be used as a source of protein (leaves) and energy (pseudostem and corm), with all plant parts being utilized for human food and animal feed (Brandt et al., 1997). It is widely grown in southern and south-western parts of Ethiopia. It supports approximately 20% of the Ethiopian population (Admasu, 2002). Over 70% of the enset plant is composed of pseudostem and corm (Ajebu et al., 2008c). The major food products obtained from the enset plant are *kocho, bulla* and *amicho*. *Kocho* is made of a mixture of decorticated leaf sheath and grated root. *Kocho* is made by scraping the starchy pulp out of the stem and fermenting it with yeast, traditionally in a dug out pit. Admasu (2002) indicated that *kocho* is a starchy food obtained from the pulp of the pseudostem and corm. *Kocho* can be stored for many years without spoilage once processed.

As indicated by Tsegaye (2001) *kocho* has high carbohydrate content than maize. Moreover, Mohammed et al. (2013) reported high starch content in unprocessed corm (71.2%) and pesodstem (64.9%). The same author also reported that enset corm contained 17 amino acids where the amounts of most amino acids are higher than that from potato. Also, Ajebu et al. (2009) reported high non-fiber carbohydrate contents in pseudostem and corm than other parts of enset. In enset cultivating regions, enset and its by-products are widely available. For intensive farms where concentrate feeding is common for ruminants, *kocho* could be used as a replacement for maize as a source of energy for different classes of livestock. However, apart from some studies conducted to determine the chemical composition (Ajebu et al., 2008a), the intake and digestibility of different morphological fractions of enset in sheep feeding (Ajebu, 2010) and the effect of different levels of enset leaf as supplement to the basal diet of wheat straw on growth, feed intake, digestibility and nitrogen utilization (Ajebu et al., 2008b) there were no studies conducted to evaluate the nutritive value of *kocho* as animal feed. Therefore, this experiment was conducted to study the potential of *kocho* as a substitute for maize in sheep feeding.

MATERIALS AND METHODS

Description of the study area

The experiment was conducted at Hawassa University, College of Agriculture (7^0 4' N latitude and 38^0 31' E longitude), located 270 km south of Addis Ababa, Ethiopia. The average monthly minimum and maximum temperatures and mean annual rainfall is 13.3 ^{0}C and 27.5 ^{0}C, respectively. The area has an altitude of about 1650 m and receives average annual rainfall of 1110 mm.

Experimental animals and their management

Twenty four yearling intact male Adilo sheep with an initial body weight of 18.55 ± 0.38 kg (mean ± SD) were purchased from a local market. The age of the animals was determined by dentition. Each sheep was ear tagged, dewormed by giving albendazole as prescribed by the manufacturer before the commencement of the trial to control internal parasites and they were also injected with 2 ml oxytetracycline (long acting) to control pneumonia. The animals were penned individually in well ventilated pens (1.5 m × 1.10 m × 1 m) with concrete floors and had access to feeding and watering trough. Pen cleaning has taken every morning before feed offer. The house is made of corrugated iron roof.

The experiment was carried out from February to April 2012.

Experimental feeds preparation

The experimental feeds were composed of Rhodes grass hay (*Chloris gayana*) as a basal diet and concentrate supplement. Baled Rhodes grass hay was bought from Belito state farm. The physical characteristics of the grass indicated that it was harvested at late stage of maturity with high proportion of stem than leaf. The hay was chopped into small pieces of about 8-10 cm to minimize preferential selection and wastage.The ingredients of concentrate (alfalfa meal, maize, noug cake, and wheat bran, salt and limestone) were purchased from Hawassa city. Fresh alfalfa (*Medicago sativa*), which was harvested at 50% blooming stage was purchased from Shebedino woreda (district). It was chopped, dried under shade and mixed with concentrate at the required proportions as indicated in Table 1.

For the current experiment, wet *kocho* was purchased from Aleta Wondo market and sun dried without squeezing the water part. The fibre of wet *kocho* was separated by hand since the fiber of *kocho* is very strong. Then the flour of the *kocho* was spread over local mat (*Selen*) to dry till it becomes safe for storage. All ingredients of the ration were mixed at required proportion for feeding. All ingredients are similar in proportion for all the treatments except maize and *kocho*.

Experimental design and treatments

The experiment was conducted using a completely randomized block design with four treatments and six replications. The sheep were blocked based on their initial body weight into six and each of the four treatment diets were randomly assigned to each animal in each block.

Digestibility trial

Following the feeding trial all the sheep were put on individual metabolic cages to evaluate the digestibility of diets. The sheep were allowed three days of adaptation to the cages. This was followed by eight days of actual digestibility trial in which feed offered, refused and faeces and urine outputs were measured. Feeds preparation and feeding routines were the same as in the feeding trial. The amounts of feed offered and refused were recorded.

Faeces from each sheep were collected every morning before provision of feed and water. Daily total faeces excreted from each sheep were weighed, mixed thoroughly and 10% was sub-sampled. Similarly daily total urine from each sheep was collected in urine collecting bottles containing 100 ml of 10% H_2SO_4 and 10% of the total daily voided was sampled. The urine and faeces sampled were stored in a deep freezer (-20 °C) and pooled per animal over the collection period for further chemical analysis.

Table 1. Proportion (%) of experimental feed ingredients (on DM basis)

Ingredient	Treatments			
	T1	T2	T3	T4
Maize	20	13.33	6.67	0
Kocho	0	6.67	13.33	20
Noug (*Guizotia abyssinica)* cake	41	41	41	41
Wheat bran	36	36	36	36
Alfalfa	1	1	1	1
Limestone	1.5	1.5	1.5	1.5
Salt	0.5	0.5	0.5	0.5
Total	100	100	100	100

T1=100 % maize: 0% *kocho*, T2= 65% maize: 35% *kocho,* T3= 35% maize: 65% *kocho,* T4= 0% maize: 100% *kocho* in concentrate mixture.

Feeding trial

The feeding trial was conducted for 70 days after acclimatizing the sheep for 14 days to the environment and 14 days to the experimental diet. In all the treatments 200 g (on as fed basis) of concentrate feed were offered to all experimental units from their respective experimental concentrate feed twice a day at 8:00 AM and 1:00 PM in equal portions throughout the experimental period. The Rhodes grass hay was offered *ad libitum* (~20% refusal). Clean drinking water was available at all times. Daily feed offer and refusals were measured and recorded for each animal throughout the trial period. Concentrate diet and Rhodes grass hay were offered daily and the refusal was collected and recorded for each animal. Representative samples of feed offered and refused for different treatments were taken for nutrient analysis. The daily average feed intake was determined by the difference between the amounts of feed offered and refused on DM basis. Body weight of each sheep was recorded every 14 days after overnight fasting to determine body weight change. Average daily weight gain was calculated as the difference between final body weight and initial body weight of the sheep divided by the number of feeding days.

At the end of the experiment, samples of faeces and urine were allowed to thaw for 24 h at room temperature before sub-sampling for chemical analysis. Samples of faeces, feed offered and refusal used for chemical analysis were dried at 60 °C for 48 h and finely ground to pass through l mm sieve size and kept in tightly covered plastic bottles until analysis. Fresh faeces for nitrogen determination were left in a freezer until analysis. The apparent digestibility of dry matter (DM), organic matter (OM), crude protein (CP), neutral detergent fiber (NDF), and acid detergent fiber (ADF) were determined as a percentage of the nutrient intake not recovered in the faeces using the following formula:

Apparent digestibility (%) = (Nutrient in take – Nutrient in faeces) * 100/ Nutrient in take

Chemical analysis of the feed samples

The DM and ash content of feed offered, refusal and fecal samples was determined by the standard methods of the Association of Official Analytical Chemists (AOAC, 1990). Total nitrogen (N) content of the feed, faeces and urine samples was determined using micro-kjeldahl method. The CP content was calculated as N × 6.25. The ADF and NDF content were determined according to Van Soest et al. (1991) using ANKOM® 200 Fiber Analyzer (ANKOM Technology Corp., Fairport, NY, USA).

Statistical analysis

Data on feed intake, digestibility and body weight gain and nitrogen utilization were analyzed using the General Linear Model (GLM) procedure of the statistical analysis system (SAS, 2001). Duncan Multiple Range test was used for comparison of mean differences between treatments. The model used for data analysis was $Yij= \mu + Ti + Bj + eij$ where Yij= response variable (feed intake, digestibility, body weight gain and nitrogen utilization); μ = overall mean; Ti = the fixed effect of diet; Bj = the block effect; eij = random error. Results are presented as least square means with their standard errors of mean (SEM).

RESULTS

Chemical composition of experimental feed

The chemical compositions of the feed ingredients are given in Table 2. The CP content in *kocho* was similar with Rhodes grass hay. The CP content of maize was higher than that of *kocho.* The cell wall contents (NDF and ADF) were higher in maize compared with *kocho.*

Table 2. Chemical composition of feed ingredients used for the experiment

Feed ingredients	% DM	CP	Ash	NDF	ADF
		% DM			
Rhodes grass hay	94.6	2.7	12.7	64.1	34.7
Kocho	93.8	2.7	1.9	12.3	3.4
Maize	92.5	9.4	1.6	33.6	6.4
Wheat bran	94.0	12.8	4.3	33.4	9.4
Noug cake	95.1	30.1	6.0	35.6	23.4
Alfalfa hay	89.3	19.2	1.3	30.4	22.2

DM = dry matter; CP = crude protein; NDF = neutral detergent fibe; ADF = acid detergent fiber.

Feed intake

The mean daily DM and nutrients intakes of sheep fed *kocho* as a substitute to maize in concentrate mixture are presented in Table 3. There were no significant differences (P>0.05) on the intake of DM, OM, CP, NDF and ADF among the treatments, despite the wide numerical gap. *Kocho* was acceptable by the animals as there was no refusal in all treatments. Numerically, the intake of DM and OM for T4 was the highest. Even though not significant, there was a decreasing trend in CP intake with increasing levels of *kocho*.

Dry matter and nutrient digestibility

There were no significant differences (P>0.05) in DM, OM, CP, NDF and ADF digestibility among treatments (Table 4). Generally, the digestibility of DM and OM were low.

Table 3. Dry matter and nutrient intake (g/day) of sheep fed Rhodes grass hay basal diet supplemented with different proportion of maize and *kocho* in concentrate mixtures

Intake	Treatments				SEM
	T1	T2	T3	T4	
Dry matter					
Hay	402	416	411	429	19.4
Concentrate	190	190	189	189	0.2
Total	592	606	599	618	19.4
Organic matter					
Hay	317	333	325	341	16.9
Concentrate	164	162	164	166	0.1
Total	481	495	489	507	16.9
Crude protein	47.3	46.5	45.3	44.7	0.2
Neutral detergent fiber	291	306	298	311	14.3
Acid detergent fiber	153	160	158	161	7.7

T1= 100 % maize: 0 % kocho; T2 = 65% maize: 35% kocho; T3 = 35% maize: 65% kocho; T4 = 0% maize: 100% kocho in concentrate mixture; SEM = standard error of the means.

Table 4. Dry matter and nutrient digestibility of experimental diets with different levels of maize grain and *kocho* for sheep fed a basal diet Rhodes grass hay

Digestibility (%)	Treatments				SEM
	T1	T2	T3	T4	
Dry matter	53.1	51.7	53.4	51.6	1.2
Organic matter	57.2	56.2	57.5	56.3	1.1
Crude protein	77.1	76.8	77.2	77.3	0.49
Neutral detergent fiber	46.2	45.4	44.9	42.6	1.6
Acid detergent fiber	41.5	39.7	40.4	37.5	1.95

T1= 100 % maize: 0 % *kocho*; T2 = 65% maize: 35% *kocho*; T3 = 35% maize: 65% *kocho*; T4 = 0% maize: 100% *kocho* in concentrate mixture SEM = standard error of the means.

Nitrogen utilization

The intake, excretion and retention of nitrogen by sheep feed the treatment feeds are presented in Table 5. The N intake and faecal N were similar (P >0.05) among treatment diets. The highest N was lost in sheep fed T3 diet as a result of which the lowest N was retained in this treatment group.

Table 5. Nitrogen utilization of experimental diets with different levels of maize grain and *kocho* for sheep fed a basal diet Rhodes grass hay

N balance (g/day)	Treatments				SEM
	T1	T2	T3	T4	
N intake	7.62	7.63	7.60	7.59	0.02
N in the faeces	1.7	1.8	1.8	1.7	0.04
N in the urine	2.9^{b}	3.2^{b}	4.7^{a}	2.9^{b}	0.31
N retained	2.9^{a}	2.7^{a}	1.2^{b}	3.0^{a}	0.31
N retained (% of intake)	38.4^{a}	35.3^{a}	15.8^{b}	39.5^{a}	4.1

T1= 100 % maize: 0% *kocho*, T2 = 65% maize: 35% *kocho*, T3 = 35% maize: 65% *kocho*; T4 = 0% maize: 100% *kocho* in concentrate mixture; SEM = Standard error of means.

Body weight gain

Mean initial body weight, final body weight, total weight gain and average daily weight gains of sheep fed the experimental treatments are presented in Table 6. There was no significant difference in daily weight gain among treatments.

Table 6. Body weight gain of sheep fed Rhodes grass hay basal diet supplemented with different proportion of maize and *kocho* in concentrate mixtures

Body weight	Treatments				SL
	T1	T2	T3	T4	
Initial weight (kg)	18.8 ± 0.72	18.6 ± 0.72	18.4 ± 0.79	18.5 ± 0.79	NS
Final weight (kg)	20.6 ± 0.69	20.6 ± 0.69	20.1 ± 0.76	20.8 ± 0.76	NS
Total weight gain (kg)	1.9 ± 0.17	2 ± 0.17	1.7 ± 0.18	2.3 ± 0.18	NS
Average daily gain (g)	27 ± 0.002	29 ± 0.002	25 ± 0.003	33 ± 0.003	NS

T1 = 100 % maize: 0% *kocho*; T2 = 65% maize: 35% *kocho*; T3 = 35% maize: 65% *kocho*; T4 = 0% maize: 100% *kocho* in concentrate mixture; NS = Non siginificant.

DISCUSSION

Chemical composition of experimental feeds

The CP contents of grass hay as observed in this study is lower than the results (51.5 g/kg; 37.5 g/kg DM) reported by Ajebu et al. (2009) and Feleke et al. (2011), respectively. The CP content of Rhodes grass hay could vary from 30 to 70 g/kg DM depending upon stage of maturity and handling conditions (Adugna, 2008). Such variations could also be partly attributed to location, soil type, variety, post harvest handling and stage of maturity at harvest. The physical characteristics of the hay used for this experiment indicates that it was harvested at late stage of maturity which is explained by low CP and high fiber contents.

The CP content of *kocho* (27 g/kg DM) in the present study was higher than the value (15 g/kg DM) reported by Yewelsew et al. (2006). Higher CP contents (37.5 g/kg DM; 47.6 g/kg DM) of *kocho* were reported by EHNRI (1997) and Melese (2013), respectively. The difference in CP content may be due to the variation of enset varieties from which *kocho* is produced. Ajebu et al. (2008a) observed varietal differences in

CP and ME contents of unprocessed corm and pseudostem. Moreover, fermentation time, processing method (traditional *vs* improved) and variety has been reported to influence the CP content of *kocho* (Melese, 2013). Also, Abrham et al. (1980) reported a decrease in CP content during fermentation process. On the other hand, a decrease in crude fiber, ash content and an increase in crude protein content were reported as fermentation time increased (Melese, 2013). In general, the CP content of corm and psedostem from which *kocho* is produced is low. Ajebu (2010) reported a CP content of 47.7 and 34.2 g/kg DM for unprocessed pseudostem and corm, respectively. Such a low CP content was also reported for corm (33.3 g/kg DM) and pseudostem (36.5 g/kg DM) by Mohammed et al. (2013).

The CP content of wheat bran (128 g/kg DM) used in the current report was lower than the result (149 g/kg DM) observed by Tesfaye (2008). The CP content of the noug seed cake used in this study was higher than that reported (289 g/kg DM) by Fentie and Solomon (2008).The variation observed in CP content may be due to the difference in efficiency of extraction while extracting oil and method of extraction (Adugna, 2008).

The CP content of Rhodes grass hay and *kocho* used in the current experiment are very low. According to Van Soest (1994) feeds containing less than 70 g/kg DM CP are unable to satisfy the minimum rumen microbial requirements for optimum activity and also maintenance requirements of the host animal. The low CP content of Rhodes grass hay and *kocho* in the present study clearly suggested that these feed are unable to fulfill the rumen microbial and the host animal CP requirements and needs to be supplemented with feeds of higher CP contents. However, *kocho* could be used as a source of energy because Mohammed et al. (2013) reported 11.9 and 11.70 MJ ME/kg DM for unprocessed corm and psedostem.

Feed intake

The mean daily DM and nutrient intake of sheep fed with different treatment diets in this study were similar. The similarity in total DM intake indicates that feeding *kocho* as a substitute to maize in concentrate mixture had no negative effect on palatability. No refusal was recorded for all treatments indicating that *kocho* is acceptable by the animals. Though improvement in total DM and OM intakes were observed in sheep supplemented with different levels of corm as a supplement to grass hay in another experiment, no significant differences were observed among the different levels of corm (personal communication). The result of this study indicates that the nutrient intake across the treatment diets was similar which might be due to the offer of small quantity of concentrate (200 g/day) for all the sheep which could be below the requirement. There is no literature information with regard to the feeding value of *kocho* with which comparison could be made. Ajebu (2010) fed fixed amounts of unprocessed (fresh and chopped) pseudostem or corm supplemented with graded levels of *Desmodium intortum* hay as a supplement to wheat straw. In pseudostem diet, the same author reported no significant different in total DM intake among treatments which is consistent with the current experiment while the total DM increased with increasing levels of legume in corm diets. Moreover, Ajebu et al. (2009) fed unprocessed fresh enset corm or psedostem as a sole diet to sheep and observed a very low DM intake for both fractions even lower that that of wheat straw owing to the high moisture content and low CP content in these fractions. This indicates that feeding fresh enset corm or psedostem alone has low nutritive value unless supplemented with protein sources. If processed in the form of *kocho* and dried it could be used as valuable sources of replacement for maize grain. An estimated ME content of 11.3-12.6 and 12.1-13.3 MJ/kg DM was reported for psedostem and corm, respectively (Ajebu et al., 2008a). Though not statistically different, the CP intake decreased with increasing levels of *kocho* in concentrate mixture because of low CP content of *kocho* compared to maize. An optimum level of supplementation has a positive effect in increasing rumen microbial population and efficiency, thus enabling them to increase the rate of breakdown of the digesta.

The total DM intake of supplemented sheep (592- 618 g/day) in the present study was higher than the values (482-524 g/day) observed for sheep fed pseudostem but similar to the values (533-649 g/day) for sheep fed corm supplemented with graded levels of *Desmodium intortum* hay as reported by Ajebu (2010). Moreover, Ajebu et al. (2009) reported lower DM intake in sheep fed different enset fractions (92-554 g/day) in a fresh form as a sole diet. Hence, the current result indicates that feeding enset in the dried form such as *kocho* would enhance intake. As observed in the current experiment, it could replace maize with similar performance for all the treatment groups. Numerically higher DM and OM intakes were observed when *kocho* replaced maize (T4).

Digestibility of nutrients

In general, the digestibility values are low. Similarly, low digestibility of DM and OM were reported in sheep fed either corm or pseudostem supplemented with different levels of *Desmodium intortum* hay (Ajebu, 2010). According to the same author, improvement in digestibility was observed with increasing levels of *Desmodium intortum* hay for pseudostem diet. Contrary to the current experiment, high digestibility of DM and OM were reported for sheep fed corm or pseudostem as a sole diet (Ajebu et al., 2009). At low levels of legume supplementation negative and low digestibility of CP were reported by the same author. Moreover, Ajebu et al. (2009) reported negative CP digestibility in sheep fed corm as a sole diet indicating that a source of protein is necessary when *kocho* is fed. The similarity in CP digestibility in the current experiment could be due to the similar intake of CP among treatments (Table 3). Adugna and Sundstøl (2000) indicated that inadequate N intake coupled with high metabolic N loss results in low apparent digestibility of CP. There is no literature information concerning anti-nutritional substances in *kocho* which could result in low digestibility. Mohammed et al. (2013) reported low lignin content for corm (2.11%) and pseudostem (0.79%). Feeding of different levels of corm as a supplement to grass hay resulted in similar digestibility values among different levels of corm (personal communication) which is consistent to the current experiment. The digestibility (%) values of DM, OM and NDF in this study (52.5, 56.7 and 44.8) were lower than the values reported by Melese et al. (2001) in sheep fed concentrate supplements (57.5, 60.0 and 55.5), respectively. Moreover, Bowman and Paterson (1988) reported similar digestibility in lambs fed corn plus urea, corn plus soya bean meal or 50% dry, wet or ensiled corn gluten feed in high concentrate diets. The digestibility result indicates that *kocho* can totally or partially replace maize. However, the price of *kocho* and maize determines whether total substitution is necessary or not. Enset cultivation is expanding to areas where it was not traditionally cultivated. Every household in the south and south western part of Ethiopia cultivates enset, which indicates the wide availability of *kocho*. Therefore, farmers could use *kocho* instead of maize as a source of energy.

Nitrogen utilization

Nitrogen intake, feacal and urinary nitrogen are determinant of nitrogen balance, whereas nitrogen intake depends up on DM and CP intake. The N lost in urine was the highest for T3. According to Robinson et al. (2005) high N intake coupled with high urinary N excretion demonstrates feed protein catabolism. Kaswari et al. (2007) suggested that losses of N in urine are mainly caused by an oversupply of CP and/or an imbalance in the supply of amino acids. The positive N retention indicates that the intake of nitrogen containing compounds exceeds loss of N from the body and these rations can meet the requirement of the sheep.

The lack of significant difference in N utilization between treatments (except T3) could be due to the similar CP content in the treatment diets. The lack of similarity in N retention was inconsistent with the study by Hue (2012) who observed similar N retention in lambs supplemented with different forms of cassava. In an experiment where sheep were supplemented with different levels of corm to the basal diet of hay, N retention failed to improve with increasing levels of corm (personal communication). Negative nitrogen retention was reported in sheep fed corm and pseudostem as a sole diet (Ajebu et al., 2009).

Body weight gain

The similarity in average daily body weight gain of sheep could be due to the similarities in intake (Table 3) and digestibility (Table 4) observed across the treatments. The substitution of maize with *kocho* at 0%, 35%, 65% and 100% had no significant effect in the daily body weight gain. Similarly, improvement in weight gain was observed in sheep fed different levels of corm as a supplement to grass hay compared to the control diet but the weight gain among different levels were similar (personal communication). This implies that due to the year round availability and easy access by smallholder farmers in the southern and south-western part of Ethiopia where enset is widely grown, *kocho* could be used as a replacement for maize as long as it is economically feasible. Moreover, the yield of *kocho* was reported to be higher than forages (Yitaye et al., 2000) and other crops (Admasu, 2002).

The average daily weight gain (25-33 g/day) observed in the present study was comparable to the result (25 - 33.5 g/day) reported by Mulu (2005) for Wogera sheep fed grass hay basal diet supplemented with graded levels of concentrate mix. However, the range of body weight gain as observed in the current finding is lower than the values (32-63 g/day) reported by Hirut (2008) for Hararghe highland sheep supplemented with concentrate mixture.

The body weight gain in the present study was lower than the daily body weight gain reported (38 g/ day) by Solomon et al. (1998) in ewes supplemented with maize. Also, the daily body weight gain observed in this study were lower than the gain (60- 95 g/day) reported by Wegene (2008) in Blackhead Somali sheep supplemented with energy and protein source. There is an established fact that supplements result in improved animal performance in several ways, such as by providing essential nutrients for rumen microorganisms, enhancing the microbial activities in the rumen and providing nutrients for the sheep (Van Soest, 1994).

CONCLUSION

The present study revealed that there were no significant differences in the performance of sheep fed different proportion of maize and *kocho* in concentrate mixture. This shows that in areas where maize or grain feeding is not common, *kocho* could be used as an alternative feed to replace maize partially or totally as long as it is economically feasible under smallholder production systems.

ACKNOWLEDGEMENTS

We would like to thank The Norwegian Agency for Development Cooperation (NORAD) and Research and Development Directorate of Hawassa University for funding the research. The laboratory assistance of Tadesse Bokore is appreciated.

REFERENCES

Abraham Besrat, Haile Mehansho and Taye Bezuneh. 1980. Effect of varietal difference and fermentation on protein quantity and quality of ensete. Nut. Rep. Int. 20: 245-250.

Admasu Tsegaye. 2002. On indigenous production, genetic diversity and crop ecology of enset (*Ensete ventricosum*) (Welw.) Cheesman. PhD Thesis, Wageningen University.

Adugna Tolera. 2008. Feed resources and feeding management: A manual for feed operators and development workers. Ethiopia sanitary and phytosanitary standards and livestock and meat marketing program (SPS-LMM). Addis Ababa, Ethiopia.

Adugna Tolera, Sundstøl, F. 2000. Supplementation of graded levels of *Desmodium intortum* hay to sheep feeding on maize stover harvested at three stage of maturity 1: Feed intake, digestibility and body weight change. Anim. Feed. Sci. Technol. 85: 239–257.

Ajebu Nurfeta. 2010. Digestibility and nitrogen utilization in sheep fed enset (*Ensete ventricosum*) pseudostem or corm and graded levels of *Desmodium intortum* hay to wheat straw based diets. J. Anim. Physiol. Anim. Nutri. 94:773-779.

Ajebu Nurfeta, Adugna Tolera, Eik, LO and Sundstøl, F. 2008a. Chemical composition and in sacco dry matter degradability of different morphological fractions of 10 enset (*Ensete ventricosum*) varieties. Anim. Feed. Sci. Technol. 146: 55-73.

Ajebu Nurfeta, Adugna Tolera, Eik, LO and Sundstøl, F. 2008b. The supplementary value of different parts of enset (*Ensete ventricosum*) to sheep fed wheat straw and *Desmodium intortum* hay. Lives Sci. 119: 22-30.

Ajebu Nurfeta, Adugna Tolera, Eik, LO and Sundstøl, F. 2008c. Yield and mineral content of ten enset (*Ensete ventricosum*) varieties. Trop. Anim. Health Prod., 40: 299-309.

Ajebu Nurfeta, Adugna Tolera, Eik, LO and Sundstøl, F. 2009. Feeding value of enset (**Ensete ventricosum**), **Desmodium intortum** hay and untreated or urea and calcium oxide treated wheat straw for sheep. J. Anim. Physiol. Anim. Nutri. 93:94-104.

AOAC (Association of Official Analytical Chemists), 1990. Official methods of the analysis 15th ed. AOAC. Arlingston, USA.

Bowman, JGP and Paterson, JA. 1988. Evaluation of corn gluten feed in high energy diets for sheep and cattle. J. Anim. Sci. 66:2057-2070.

Brandt, SA, Spring, A, Hiebsch, C, McCabe, JT, Tabogie, E, Wolde- Michael G, Yntiso G, Shigeta M, Tesfaye S. 1997. The ‘‘Tree Against Hunger’’: enset-based agricultural systems in Ethiopia. Washington, DC: American Association for the Advancement of Science.

EHNRI 1997. Food composition table for use in Ethiopia. Part III. Ethiopian Health and Nutrition Research Institute. Addis Ababa. pp. 34.

FAO (Food and Agricultural Organization). 2010. Fact sheet: livestock Ethiopia. Livestock in Ethiopia and opportunity analyses for Dutch investment NABC, http://www.nabc.nl/Portals/0/docs/Fact%20Sheet%20Ethiopian%20Livestock.pdf (accessed on 2 June 2013).

Feleke Gebregiorgis, Tegene Negesse and Ajebu Nurfeta. 2011. Feed intake and utilization in sheep fed graded levels of dried moringa (*Moringa stenopetala*) leaf as a supplement to Rhodes grass hay. Trop. Anim. Health Prod. 44:511-517.

Fentie Bishaw and Solomon Melaku. 2008. Effect of supplementation of hay with noug seed cake (*Guizota abyssinica*), wheat bran and their mixtures on feed utilization, digestibility, and live weight change in Farta sheep. Trop. Anim. Health Prod. 40: 597-606.

Hirut Yirgu. 2008. Supplementation of concentrate mix to Hararghe highland sheep fed a basal diet of urea-treated maize stover: Effect on feed utilization, body weight change and carcass characteristics. MSc Thesis, Haramaya University, Haramaya, Ethiopia.

Hue, KT. 2012. Feeding cassava foliage to sheep-Nutrient properties and hydrogen cyanide toxicity. Doctoral Thesis, Swedish University of Agricultural Sciences.

Kaswari, T., Labzien, P., Flachowsky, G., Meulen, UT., 2007. Studies on the relationship between the synchronization index and the microbial protein synthesis in the rumen of dairy cows. Anim. Feed Sci. Technol. 139: 1-22.

Melese Abdisa, Dirba Geleti, Lema Gezachew, Temesgen Dirba and Adane Hirpa. 2001. The effect of improved forages and/or concentrate supplementation on live weight of Horro lambs and growing bulls. Pp.259-265. In: The 9th National Conference of the Ethiopian Society of Animal Production. Addis Ababa, Ethiopia.

Melese Temesgen. 2013. Improving the indigenous processing of *kocho*, an Ethiopian traditional fermented food. J Nutr Food Sci, 3: 182.

Mohammed Beyan, Gabel, M. and Karlsson, LM. 2013. Nutritive values of the drought tolerant food and fodder crop enset. Afr. J. Agri. Res. 8 (20): 2327-2333.

Mulu Moges. 2005. Effects of feeding different levels of breweries dried grain on live weight gain and carcass characteristics of Wogera Sheep fed on hay basal diet. MSc Thesis, Haramaya University, Haramaya, Ethiopia.

Robinson, TF., Roederr, BL., Schaalje, GB., Hammer, JD. Burton, S, Christensen, M. 2005. Nitrogen balance and blood metabolites of alpaca (*Lama pacos*) fed three forages of different protein content. Small Rumin. Res. 58: 123-133.

SAS. 2001. SAS user's guide, (SAS Institute Inc., Cary, NC, USA)..

Solomon Abegaz, Gemeda Dugma, Ulfina Gelemesa and Fikru Terefe. 1998. Effect of noug cake or maize grain as a flushing diet on litter size in Horro sheep. pp. 243-249. In: the proceedings of 6th National Conference of the Ethiopian Society of Animal Production. Addis Ababa, Ethiopia.

Tesfaye Negewo. 2008. Effect of supplementation with graded levels of wheat bran and noug seed cake mixtures on feed utilization of Arsi-Bale sheep fed urea treated maize cob basal diet: MSc Thesis, Haramaya University, Haramaya, Ethiopia.

Tsegaye Yilma. 2001. Coffee-enset-livestock interaction for sustainable livelihood in the Sidama area of Southern Ethiopia. J. Agr.Trop. Subtrop., 102: 119-131.

Van Soest, PJ, Roberston, TB and Lewis, BA. 1991. Methods of analysis of dietary neutral detergent fiber and non-starch polysaccharides in relation to animal nutrition. J. Dairy Sci. 74:3585-3597

Van Soest, PJ. 1994. Nutritional ecology of the ruminant. 2nd edn, Cornell University Press, Ithaca, NY.

Wegene Birhanie, 2008. Effects of increasing levels of energy and protein supplementation on feed intake, body weight change and carcass composition of Black Head Somali sheep fed on grass hay. MSc Thesis, Haramaya University, Ethiopia.

Yewelsew Abebe, Barbara, S, Margaret, H and Gail, G. 2006. Nutritive value and sensory acceptability of corn-and *kocho*-based foods supplemented with legumes for infant feeding in Southern Ethiopia. Afr. J. Food Nutr. Sci. 6 (1): 1-13.

Yitaye Alemayehu, Azage Tegegne, Mohammed Kurtu, 2000: The livestock production systems in three peasant associations of the Awassa Woreda. Pastoralism and Agropastoralism: which way forward? In: Proceedings of the Annual Conference of the Ethiopian Society of Animal Production (ESAP), Addis Ababa, Ethiopia. ESAP. Pp 155-167.