EFFECT OF SUBSTITUTION OF *KOCHO* FOR MAIZE ON FEED INTAKE, DIGESTIBILITY, AND BODY WEIGHT GAIN OF SHEEP FED RHODES GRASS HAY AS BASAL DIET

M.Sc. THESIS

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APPROVAL SHEET
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As members of the Examining Board of the Final MSc Open Defense, we certify that we have read and evaluated the thesis prepared by Aman Getiso entitled **effect of substitution of *kocho* for maize on feed intake, digestibility, and body weight gain of sheep fed Rhodes grass hay as basal diet** and recommend that it be accepted as fulfilling the thesis requirement for the degree of

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DEDICATION

This piece of work is dedicated to my beloved father Getiso Keti who passed away while I was doing this work and my late brother Megarsa Getiso who was the base for this achievement.

I would also like to dedicate this work to my wife Chaltu Abdela and Child Rabira Aman and also to my Mother, Brothers and Sisters.

STATEMENT OF THE AUTHOR

First, I declare that this thesis is my original work and that all sources of materials used for this thesis have been accordingly acknowledged. This thesis has been submitted in partial fulfillments of the requirement for MSc degree at Hawassa University and is deposited at the University Library to be made available to borrowers under rules of the Library. I seriously state that this thesis is not submitted to any other institution anywhere for the award of any academic degree, diploma, or certificate.

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LIST OF ACRONYMS/ABBREVIATIONS

ADF	Acid detergent fibre
ADFD	Acid detergent fiber digestibility
ADFI	Acid detergent fibre intake
CP	Crude protein
CPD	Crude protein digestibility
CPI	Crude protein intake
CSA	Central Statistical Agency
DB	Dry basis
DM	Dry matter
DMD	Dry matter digestibility
DMI	Dry matter intake
DOM	Digestible organic matter
EME	Estimated metabolizable energy
FAO	Food and Agriculture Organization of the United Nations
ILRI	International Livestock Research Institute
Mcal	Mega calorie
ME	Metabolizable energy
MOARD	Ministry of Agriculture and Rural Development
EARO	Ethiopian Agricultural Research Organization
MJ	Mega joule
N	Nitrogen
NDF	Neutral detergent fibre
NDFD	Neutral detergent fibre digestibility
NDFI	Neutral detergent fiber intake
OMD	Organic matter digestibility
OMI	Organic matter intake

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EFFECT OF SUBSTITUTION OF *KOCHO* FOR MAIZE ON FEED INTAKE, DIGESTIBILITY, AND BODY WEIGHT GAIN OF SHEEP FED RHODES GRASS HAY AS BASAL DIET

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ABSTRACT

A study was conducted to evaluate the effect of substitution of kocho for maize on feed intake, digestibility, and body weight gain of sheep supplemented Rhodes grass hay as basal diet. Twenty four yearling male Adilo lambs with initial body weights of 15.03 ±1.96 kg (mean ± SD) were used. Animals were grouped into six blocks of four animals, and fed with 74% maize + 25%noug cake + 1% salt (T1), 46.25% maize + 27.75% kocho + 25% noug cake + 1%slt (T2), 27.75% maize + 46.25% kocho + 25% noug cake + 1% salt (T3), and 74% kocho + 25%noug cake + 1% salt (T4). Rhodes grass hay was offered as a basal diet ad libitum. The supplements were offered at the rate of 300 g/d during the feeding and digestibility trials of 72 and 7 days, respectively. There were no significant differences (P>0.05) in dry matter, organic matter, acid detergent and Metabolizable energy intake, dry matter and organic matter digestibility and weight gain among treatments. Lambs in T1 had the highest (P < 0.05) CP intake (49.03 g/d) followed by T2, T3 and T4 with 42.85, 39.35 and 33.50 g/d, respectively. Nitrogen intake was lowest (p<0.05) for sheep fed T4 and highest (P<0.05) for sheep fed T1, T2 and T3 diets which had comparable values among themselves. The highest (P<0.05) N retention was for T2 and the lowest (P<0.05) was for T1 and T4, while T3 had an intermediate value. The study conducted inferred that kocho can replace maize without any unfavorable effect on nutrient intake, digestibility and weight gain. It was concluded that kocho could be used as an alternative good energy source to replace maize in areas where its economic advantages are practicable.

Key words: *Body weight gain, lambs, digestibility, Enset ventricosum, feed intake, kocho*

1. INTRODUCTION

Ethiopia's livestock population is believed to be the largest in Africa. The sector has a significant contribution to the country's economy, and is still expected to support its economic development (CSA, 2013). However, the contribution of the sector at either the macro or micro level is below its potential and the performance of the animals is poor because of different factors of which feed shortage is a major one. Feed shortage is more aggravated during dry season in both the highlands and lowlands of Ethiopia (Mengistu, 2006). Different feeds are used as a supplement especially during the dry season. One of such supplement which is available during wet and dry season in the southern and southwestern part of Ethiopia is different parts of enset (Nurfeta, 2008).

Enset (*Enset ventricosum*), also known as 'false banana', is a perennial herbaceous monocarpic plant, which grows for human consumption and animal feed. Among the root crops, enset is one of the most important staple crops in Ethiopia. It is drought tolerant and green all year round. It is cultivated mainly for a starchy human food as well as livestock feed. The pseudostem, corm and the stalk of inflorescence constitute the most important components used for human food, whereas all parts of the plant can be fed to livestock. Leaf pruning and thinned enset plants are used for feeding animals as well (Tolera, 2008).

The pseudostem and corm are rich in starch while leaf has high protein content (Nurfeta et. al, 2008a). Hence enset is a vital part of the production system in areas where enset is grown since the leaves are good protein source for livestock, while the pseudostem and corm provide energy for human and animals.

The major products obtained from enset which are used as foods are *kocho*, *bulla* and *amicho*. *Kocho* is the bulk of the fermented starch obtained from the mixture of the decorticated (scarped) leaf sheaths and the grated corm (underground stem base). *Bulla* is a water soluble starchy product which is separated from *kocho* during processing. It is made from scraping parenchyma tissue of leaf sheath and corm. It is obtained by squeezing the mixture and keeping the liquid to stay for one or two days to dehydrate. *Amicho* is the boiled enset corm which is eaten. Tsegaye (2002) indicated that the *kocho* (a starchy food obtained from the pulp of the pseudo stem and corm) yield of enset per unit space and time, in terms of edible dry weight and energy, was much higher than the yields of any other crop cultivated in Ethiopia. Cheesman (1947) reported that enset products are high in carbohydrate and low in protein and fat. The main feature of enset foods is their high energy value (1410–1950 kJ per 100 g dry matter of *kocho*, 1580–1850 kJ per 100 g dry matter of *bulla*) (Atlabachew, 2007).

Nurfeta et al. (2008a) indicated that the use of enset as animal feed could play a significant role because of on-farm availability and easy access by farmers. Similarly, several studies indicated that enset can be a very important crop for livestock feeding particularly during the dry season (Desta and Oba, 2004; Nurfeta et al., 2008a; Nurfeta et al., 2008b). The *kocho* DM yield potential of enset was estimated to range from 17.1 to 33.9 t/ ha/ year (Tsegaye, 2002) which is very high compared with other feed resources in Ethiopia. Therefore, due to high DM yield and high energy value (Atlabachew, 2007); k*ocho* could be regarded as a useful energy supplement for smallholder farmers who do not have access to concentrate feed. Apart from some studies conducted to determine the chemical composition (Nurfeta *et al*., 2008c) digestibility, nitrogen utilization and intake of un processed enset varieties (Nurfeta *et al*., 2009) and effect of *kocho* as a substitute for maize in concentrate mixture in sheep feeding (Tsegaye, 2013), there are no comprehensive studies conducted to evaluate the nutritive value of *kocho*. Thus; this study was proposed with the general objective of evaluating the effect of substitution of *kocho* for maize as a sole supplement on body weight gain, intake and digestibility of sheep fed a basal diet of Rhodes grass hay.

2. LITERATURE REVIEW

2.1. Sheep Production and Productivity in Ethiopia

Ethiopia is home for diverse indigenous sheep and goat populations, numbering 25.44 million and 24.06 million heads (CSA, 2013), respectively, parallel to its diverse ecology, production systems and ethnic communities. Sheep and goats are owned by smallholder farmers as an integral part of the livestock sub-sector and contribute to both subsistence and cash income generation (EARO, 2000). Ethiopia has a diverse indigenous sheep population. Sheep contribute significantly to farm livelihoods, particularly where crop production is unreliable and where livestock is the mainstay of livelihoods (i.e., pastoral areas).

Many different breeds of sheep and goat are found in different parts of Ethiopia. These breeds are characterized by varying physical, productive and reproductive features. There are about 14 traditionally recognized sheep populations in Ethiopia. These populations are called sheep *types* in some literatures. They are also designated as breeds according to some definitions of 'breed'. The sheep types are named after their geographic location and/or the ethnic communities keeping them. The sheep types in Ethiopia are classified into four major groups based on their physical characteristics: short fat-tailed, long fat-tailed, thin-tailed and fat-ramped sheep. Based on DNA differences Ethiopian sheep types have been classified into nine genetically distinct breeds [Simien, (Sekota, Farta, Tikur, Wollo, Menz), washera, Horro, (Arsi-Bale, Adilo), Bonga , Afar Black head Somali, Gumz] (Gizaw, 2008).

Livestock production system in Ethiopia is generally subsistence-oriented and productivity of small ruminants is very low. Growth rate in indigenous sheep and goats is low and drops dramatically from about 100 g/day at the earlier stage of growth to less than 50 g/day after weaning (EARO, 2000).This low level of productivity in Ethiopian sheep and goats could be attributed to disease, lack of proper management, poor nutrition and poor genetic potential (Gall, 1981), out of which poor nutrition plays a vital role. In addition to these, breeding is not properly controlled (Tibbo, 2006). In many parts of tropics, animal productivity including that of sheep and goats is constrained by regular feed shortages occasioned by dry seasons and droughts. During such periods animals are mainly dependent on poor quality roughages and crop-byproducts with little or no supplementation, leading to low animal performance (Kariuki, 1998).

2.2. Feeding and Nutrient Requirement of Sheep

The nutrition of sheep and goats is the most important factor affecting performance. Feed costs are a high percentage of the total cost of livestock production, especially for meat animals which is 75% to 80% of the total cost of feed (Bush, 1979). The biggest expense in sheep production is feed cost (55-66%), regardless of the source and kind of feeds (Ranjhan, 1997). Sheep, more than other any classes of farm livestock are dependent on natural pastures for maintenance and production. Pastures and ranges are the natural habitats of the sheep and they thrive on them under an extremely wide variety of climatic conditions and utilize most adverse types of vegetations. Even though there may be wide variation in plants, sheep are able to find the necessary nutrients from grasses, legumes, weeds, shrubs, and herbs that are grown on cultivated and uncultivated lands (Ranjhan, 1997). For profitable production, proper and year round feeding management is essential as over feeding is expensive and not necessary, while underfeeding can lead to decreased performance and increased health problems. Sheep and lambs should be fed according to their nutrient requirements. Nutrient requirements vary by the age and size (weight) of the sheep and their stage and level of production. Thus, knowledge of the nutrient requirements of sheep is the primary issue. Feeding sheep successfully consists of matching nutrients and forage type and quality with stage of sheep production (Ranjhan, 1997). The nutrient requirements of sheep can be conveniently considered as requirements for the essential components of feed (energy, protein, mineral, vitamins free amino acid and water) within the limit of feed intake (Gatenby, 1986). The nutrient requirement of sheep varies at different physiological state and daily live weight gain**.**

Dry matter intake is the main determinant of growth rate, but is seldom determined on a commercial scale under intensive feeding conditions due to the difficulty in accurately measuring feed wastage. As a general rule of thumb, sheep and goats will consume at least 3.5-4% of their body weight on a dry matter basis in feed (Devendra and Burns, 1983a). The voluntary DM intake of sheep depends on the type of diet offered to the sheep and the physiological age of the animal. The intake of nutritionally adequate feeds increases with animal size (growth) increase, but it is not maintained at the same proportion of live weight (Forbes, 1986), and intakes per unit weight decrease as the size increase.

According to NRC (1981) standards the DM intake would be 780 g at DM intake of 2.6% body weight for 30kg sheep, and such sheep lose weights if they consume less than 737 g DM. Dry matter consumption above this quantity maintained body weight (Ranjhan, 1993). Based on NRC (1981) standards, for a 20 kg sheep 0.648 kg DM intake per day, at 3.23 DM intake as percent of body weight and 68.31g DMI / kg $W^{0.75}$ could formulated (Ranjhan, 1993). The DM intake of some Ethiopian sheep types to be between 368-784 g/day (Table 1) based on some data collected from different feeding trials conducted in different parts of Ethiopia.

Table 1: Dry matter intake of some Ethiopian sheep types.

Area	Dry matter intake			Ingredients	Author
	g/day	%BW	g/kgW$^{0.75}$		
North Gondar	565-710			Hay, BDG	Moges (2005)
Horro	522			Forage and concentrates	Abdisa *et al(2001*)
Metekel	368-490	2.9-3.1	59-61	Millet straw, concentrates	Mulat (2006)
Tigray	643-784	2.6-3		Teff straw, cactus, NSC	Gebremariam (2005)

BDG =Brewery Dried Grain; NSC=Noug seed cake. Source: Nega, 2007.

Similarly, research result in Ethiopia indicated that different breeds of sheep have variable DMI, for instance, in Tigray sheep lambs (weighing 18-22 kg) offered mixture of cactus, teff straw and 60 g/head/day noug seed cake meal, had DMI that ranged between 643-784 g /day (Gebremariam, 2005), whereas Horro lambs offered feeds containing desmodium hay, ground maize and noug seed cake, had daily DMI between 274-522 g/head/day (Abdisa *et al.*, 2001). Moreover, according to Moges (2005), Wogera sheep weighing 18-23 kg offered brewery dried grain and grass hay had daily DMI of 565-711 g.

All growing animals including sheep need protein for maintenance and growth. Moreover, sheep need protein for the production of wool (a protein product). The protein requirement of growing sheep is affected by growth rate, weight for age, body condition and protein to energy ratio. Protein is the most common nutrient deficiency that reduces the activities of rumen microorganisms, which can be corrected by supplementation with rumen-degradable protein or a non-protein (NPN) source (McDonald et al., 2002). The estimate for the amount of protein requirements for maintenance varies from 54 g DCP for 45 kg body weight to 36 g DCP for 30 kg adult sheep (Ranjhan, 1997). The author emphasized that the requirements relatively increase for growing and fattening animals as compared to the requirement of adult animals, and thus the daily DCP requirements for 20 kg body weight of growing and fattening sheep are 47 and 70 g/head/day, respectively. Ranjhan (1993) indicated that a 25 kg sheep requires 806-891 g DM, 94-137 g CP for average daily body weight gain of 64-101g. He added that 20kg sheep daily nutrient requirements for growth are 85 g CP and 46.8 g of DCP. Deficiencies in total protein reflect in decreased voluntary feed intake and in less efficient use of the feed that is consumed. Marked surplus of protein over optimum level also reduce the efficiency of the ration by increasing the heat increment loss from the body (Crampton and Harris, 1996).

Usually, the most limiting factor in a diet is energy whereas protein is the most expensive. Energy is supplied in the ration through the hay and concentrates mix. Low energy intake that results from either inadequate feed intake or low digestibility prevents sheep and goats from meeting their requirement and from attaining their genetic potential. According to Cheeke (1999), deficiencies of a nutrient will decrease the bacterial growth, and therefore lessen digestion in the rumen. The level of maintenance and growth energy requirement estimated for sheep by different authors indicated that, a 10 kg live weight sheep requires 2 MJ ME for maintenance and 2.7-4.5 MJ ME for 50-150 g gain per day (Chesworth, 1992). Similarly, according to Cheeke (1991), lambs with 10 kg and 20 kg live weight and 250 g daily weight gain had daily ME requirements of 1.4 and 2.9 Mcal (5.99 and 12.42 MJ), respectively. As an example, the energy and protein requirements for growth of sheep weighing between 20-40 kg are given in Table 2.

Table 2: Energy and protein requirements of sheep for growth.

Nutrient	Live weight (kg)	Gain (g/day)			Calculated requirement per kg $W^{0.75}$	
		0	50	100	Maintenance	For 1 g gain
ME (MJ/day)	20	4.1	5.1	6.2	0.43	0.02
	30	5.6	7.0	8.5	0.44	0.03
	40	7.0	8.7	10.7	0.44	0.04
Protein (g/day)	20	30	40	60	3.17	0.30
	30	45	55	65	4.76	0.20
	40	45	70	85	2.83	0.40

Source: ARC (1980)

2.3. Available feed resources for sheep and goats

Natural grazing land is the predominant feed source for sheep and goats in Ethiopia. Very little land is planted to introduced pastures or forage crops. This is especially true for the pastoral and agro-pastoral areas. Grazing areas are usually communally owned. Crop residues and agro-industrial by-products represent a large proportion of feed resources in the mixed crop–livestock system. Reliance on crop residues for animal feed is ever-increasing as more land is cropped to feed the fast-growing human population. This has decreased available grazing land and has forced livestock to graze more fragile, less productive lands not suited for high livestock numbers. Erosion and environmental degradation result in decreased soil fertility and forage productivity. This, in turn, leads to poor animal productivity. Table 3 presents a summarized listing of feed resources in Ethiopia by cropping system.

Table 3: Availability of feed resources by cropping system.

Coffee-Enset system	Coffee-Crop system	Crop production system	Pastoral-agro-pastoral system
Natural grazing	Natural grazing	Natural grazing	Natural grazing
Hay	Hay	Hay	Hay Standing hay
Enset by-products Sugar cane tops/leaves	Cereal crop residues Oilseed cakes	Cereal crop residues Pulse crop residues	Browse
Root crop leaves Local brewery by-products	*Enset* by-products Sugar cane tops/leaves	Oilseed cakes Sugar cane tops/leaves	
	Root crop leaves	Local brewery by-products Molasses*	
	Local brewery by-products		
	Molasses*	* Milling by-products*	
	* Milling by products*		

*available only near sugar factories. Source: Yami (2008).

2.3.1. Roughages

Hay is forage harvested during the growing period and preserved by drying. Fodder conservation in the form hay and silage is not a common practice in many parts of Ethiopia with the exception of the central highlands around Addis Ababa. Locally produced native hay can serve as useful source of roughage in feedlots and small scale fattening operations.

Despite its several advantages, hay has some shortcomings. It varies in nutrient content and palatability more than any other feed, late hay harvest affects its quality (Ensiminger *et al*., 1990). Hay in central highlands of Ethiopia is usually harvested after the CP of the pasture passed peak production, and the protein content harvested on DM basis was usually less than 5%, which is below the level of maintenance requirement for ruminants (Bogale *et al*., 2008a).

Feeds low in digestible protein such as mature dry native grasses require supplementation with some kind of nitrogenous feed (Devendra, 1986). Natural pasture would be adequate for body maintenance and weight gain during wet season, but would not support maintenance level for the rest of the year (Sileshi *et al.*, 1995).

Maximum production cannot be achieved on hay alone, even if the productive requirements of animals are low rather it is used for feeding during the time of year when grazing is not available or for feeding of confined animals and it might also be satisfactory for maintenance of mature ruminant animals (Church, 1986). According to FAO (1997) annual and perennial grass from natural pasture consumed during the dry season and often at late stage of maturity together with the straw and stalk from cereal crops constitutes low quality forages, with high lignified cell wall and poor nitrogen. Therefore, for reasonable level of production, animals subsisting on hay require supplementary protein, which can be obtained from different sources such as from oil seed cakes or non- protein nitrogenous (NPN) and energy sources (Kabaija and Little, 1988).

The quality of hay prepared varies with grass legume proportion, leaf to stem ratio and physiological development of the forage up on harvest (Table 4). Mature grass, especially those that are weather leached or bleached are low in digestible energy and protein, as well as in soluble carbohydrate, carotene and some of the minerals (Ensminger *et al.*, 1990). Several scholars reported that in experiments conducted on sheep fed hay alone lost their daily body weight gain. Moges *et al.* (2008) reported that sheep fed hay alone lost 3 g/day with the CP content being 35g/kg. Hence, hay alone may not be even enough to satisfy the maintenance requirement of animals.

Table 4: Nutritive value of some grass and legume hay

Feed Quality Parameter	Grass hays			Legume hays			
	Native grass	Rhodes grass	Oats Hay	Alfalfa Hay	Vetch hay	Cowpea hay	Lablab hay
Dry matter (%)	92.3	92.3	96	89.3	87.7	92	91.1
Organic matter (% DM)	90.3	90.2	92	88	89.3	90.4	87.5
Neutral detergent fiber (% DM)	73.2	72.9	74	42.6	50.7	42.3	41.2
Lignin (% DM)	7.5	5.9	8.0	7.2	11.4	7.7	6.5
Crude protein (%DM)	6.4.	7	8.8	19.2	19.1	14.4	18.2
In vitro DM digestibility (%)	57.2	58.6	58.8	66.3	65.8	68.5	66.6
Net energy for maintenance (Mcal/kg DM)	0.92	1.28	1.27	1.39	1.5	1.5	1.39
Net energy for gain (Mcal/kg DM)	0.23	0.7	0.70	0.81	0.91	0.9	0.8
Phosphorus (% DM)	0.01	0.32	-	0.23	-	0.34	0.32
Calcium (% DM)	0.24	0.44	-	1.6	-	1.08	1.51

Source: Tolera (2008).

2.3.2. Concentrate Feeds

Agro-industrial by-products are the by-products of the primary processing of crops, including bran and related by-products of flourmills, oilseed cakes from small and large-scale oil processing plants and by-products of the sugar factory such as molasses (Tolera, 2008). Agro-industrial by- products can be grouped according to the contents of nutrients as energy rich supplements, protein rich supplements, and mineral rich supplements and miscellaneous by-products (Gillepsi, 2002). Industrial by-products that are once thought of as wastes are now a day considered valuable livestock feeds (Ensiminger *et al.*, 1990). Almost every type of plant that is produced or processed as human food or animal feed yields one or more by -products that can be utilized as feed for animals. With the increase in world population and the decrease in the reserve stock of food grain for human consumption, the methods of off-setting the forage in basic roughage feed to livestock with cereal grains and protein concentrates will no longer be applicable in the future because of strong competition for valuable feeds to humans (Ranjhan, 1997).

Noug seed cake – Noug seed cake is one of the oil seed cake commonly produced in Ethiopia and used as animal feed. The total land coverage of noug seed cultivation in Ethiopia is 358,828 hectare. From this land about 84,802.3 tones of noug seed is produced yielding an estimated amount of 19,000 tone noug seed cake production annually (MOARD, 2005). Noug cake is a good source of quality protein if carefully and economically utilized in livestock nutrition and will contribute greatly to the improvement of animal performance (Wendifraw, 2005). Earlier works indicated that noug seed cake and urea molasses blocks (UMB) can be used along with poor quality hay and teff straw for milk production (Little *et al.*, 1987) and fattening sheep. Several researchers indicated that noug seed cake when added to energy source feeds improved intake, digestibility and growth performance of animals. Similarly Gizaw *et al.* (1991) reported 94.8-136.7 g per day weight gain for grazing Horro sheep supplemented with graded level (200-500 g /day) of concentrate mixture of noug seed cake and maize. Moreover, according to Preston and Nuwanyakpa (1986), sheep offered noug seed cake as supplement to straw had significantly higher apparent DM (73%) and nitrogen (70%) digestibility and growth rate (23 g/day) than those without the noug seed cake which resulted in DM digestibility of 65% , nitrogen digestibility of 63%, and daily growth rate of 6 g/day .

Oil seed cakes like noug seed cake are important source of protein for supplementing fibrous basal feed diets. Supplementation of Farta sheep fed on grass hay with noug seed cake, wheat bran and their mixtures resulted in significantly higher ($P<0.001$) daily body weight gain, final body weight gain and higher feed conversion efficiency than feeding only hay (Bishaw and Melaku, 2008). Also Hagos and Melaku (2008) indicated that supplementation of graded level of noug seed cake, sesame cake and wheat bran increase total dry mater intake, crude protein intake and promote body weight gain when afar ram was supplemented with 150g, 250 g and 350 g concentrate mixture.

The crude protein and fat content of noug seed cake varies depending upon the method and efficiency of oil extraction from the noug seeds (Tolera, 2008). Processes that affect efficiency of edible oil extraction equally affect the cake quality (Yami, 1981). The chemical composition of noug seed cake is 94.7% DM, 10.5% Ash, 89.4% organic matter (OM), 28.9% CP, 38.7% NDF, 30.4% ADF and 12.2% ADL (Bishaw and Melaku , 2008). Similarly Alemu (2008) reported that noug seed cake contains 91.9% DM, 29% CP, 11.2% ash, 38.5% NDF, 28.3 % ADF, 11.2 % ADL and 7.1% (ether extracts) EE. The protein content of noug seed cake varies from 28 to 38% with most values lying between 30 and 35%. The fat content varies from 2.1 to 12.6% with an average of 8.4% and an energy value of 2.37 Mcal ME/kg DM. It has high fiber (34.4% NDF and 8.4% lignin) content and relatively low digestibility (61.7% in vitro DM digestibility) compared to most other oilseed cakes. Noug seed cake can be highly lignified if the seed is not dehulled before extraction (Tolera, 2008).

Table 5: Chemical composition and in vitro dry matter digestibility of noug seed cake extracted by mechanical (with and without pre-cooking) and solvent extraction methods.

Component	Mechanical (press) extraction		
	Without precooking	With precooking	Solvent extraction
Ether extract (% DM)	12.2 (7.8-20.1)*	10.2 (6.0-16.5)	2.8
Crude protein (% DM)	31.4 (27.0-34.2)	30.9(27.6 -33.8)	33.4
Neutral detergent fiber (% DM)	36.7 (32.1-42.7)	35.9 (31.8-42.9)	32.7
Lignin (% DM)	13.3 (11.5-21.1)	12.4 (10.5-13.6)	14.6
In vitro DM digestibility (%)	61.8 (59.5-64.3)	62.8 (59.5-71.5)	58.8

*Values in the parenthesis are ranges Source: Tolera (2008).

2.3.3. Enset (*Enset ventricosum*)

2.3.3.1. Uses of Enset

Enset is a multipurpose crop and nearly every part of the plant has some sort of uses (Tesfaye, 2002). Actually there is no part of enset that is not used, except the root. It is used for food, fiber, medicine, wrapping, storage and livestock feed. There are three major food products obtained from enset plant which are locally called (*Kocho*, *Bulla*, and *Amicho*). *Kocho* is made up of mixture of decorticated leaf sheathes and grated corm which are allowed to ferment in a pit for certain period of time. *Bulla* is a water soluble starchy product which is separated from *kocho* during processing. It is made from scraping parenchyma tissue of leaf sheath and corm. It is obtained by squeezing the mixture and keeping the liquid to stay for one or two days to dehydrate. *Amicho* is the boiled enset corm which is eaten. The number of enset trees to be harvested in 2012/203 from all over the country is estimated to be 113,999,188. Thus, the total produce in the form of *Amicho, Kocho, and Bula* is 1,093,662.8, 1,298,512.3 and 46,128.1tons respectively (CSA, 2013). Farmers have multiple uses of enset landraces (Tsegaye, 2002). Household wealth is usually assessed in terms of the number and diversity of enset plant (Pankharsit, 1996). According to Tesfaye (2002) enset possesses many desirable features that have made it best suited for traditional agriculture. First, it has high yielding capacity. The perennial enset with its underground corm survive drought periods better than annual crops. Therefore, it serves as standing food reserves even during adverse environmental conditions. Apart this, enset provide fiber. In rural area the fiber is used to make sacks, bags, ropes, cordages, mats, construction materials, etc. Particular clones or varieties and parts of enset plants are claimed to be a cure for different ailments such as healing of bones features, broken bones, child birth problems, and livestock. In different growing areas various clones are said to have specific medicinal value such as Gefetanuwa, Suitia, and Lochinge in Wolayta area (Alemu and Sandford, 1991; Temesgen, 2007). Enset produces remarkable quantities of energy per hectare per day, more than cereals do. Enset corm and pseudo stem is rich in carbohydrates which is better than sweet potato, taro, and yam. It contains more calcium (ca) and iron (Fe) than most cereals, tubers and root crops. Enset products, however, are low in proteins and vitamins (Atlabachew, 2007).

2.3.3.2. Enset as animal feeds and its role in alleviating feed shortage

Livestock production is an integral component of the smallholder farming system in Ethiopia where the farmers rely largely on natural pasture as a feed resource. The existing grass species in the natural pasture mature rapidly resulting in a high dry matter (DM) and having low nutritional value (Pratt and Gwynne, 1977), which is a root cause of low production/reproduction and increased susceptibility to disease. The cost of conventional supplements limits the wide scale use of supplements, especially by smaller holder farmers in Ethiopia. Therefore, the use of locally available feed resources such as enset plays a paramount importance for household food security through maintaining crop and livestock productivity (Tsegaye, 2002).

To overcome the limitations application of feeding practice of the enset leaf and *kocho* can be recognised which is high in crude protein and energy, respectively (Fikadu and Ledin 1997) and is comparable with legumes. This supplementary practice with enset leaf can increase fibre digestion, production and productivity of the livestock (Van Eys et al., 1986). The product *kocho* has a long shelf-life, in the way of traditional storage practice, as long as desired and thus helps to overcome the severe drought years which occur very frequently in Ethiopia. It is no wonder then that enset has a special place in the socio-cultural structure of the society, besides being an important food and livestock feed resource.

Yitaye et al. (2000), estimated livestock feed from various sources in Hawassa Woreda (district). The dry matter (DM) obtained from crop residues was 469.3 tonne per year, of which the contribution of enset parts was 274.4 tonnes. The contribution of enset parts was higher than that of grazing land (75.4 tone), stable grazing 8.6 tonne) and browses (24.5 tonne) as estimated by the same author. The estimate *kocho* yield (Table 6) was high compared with other forages (Yitaye et al., 2000) and crops (Tsegaye and Strunk, 2003). Enset leaves contribute to livestock diets in all areas where enset is grown and they may be used for as long as seven to eight months. Surprisingly, the shortage of feed is even higher during the rainy season compared to the dry season in some enset producing areas because land is being cultivated during the rainy season

(Nurfeta, 2008). In such areas enset is a vital source of animal feeds and the farmers in the Bale highlands of southern Ethiopia provide enset leaves, corm, pseudo stem, fluid and processed by-products of enset (raw *kocho*) to livestock during the dry season. Sometimes the whole enset plant is chopped and fed to livestock during the dry seasons (Nurfeta, 2008).

Table 6: Estimated *kocho* Yield.

Author	Yeild (Kg/plant)	Remark
Mekiso (1980)	27-34	
MOA (1987)	17-63	
Pijls et al. (1995)	34	
Tsegaye (2007)	1.96-9.43	Corm
Tsegaye (2007	5.92-21.6	Pseudostem
Fekadu and Ledin (1997)	13.9-25.7	Including leaf lamina and leaf midrib

Source: Adapted from Nurfeta (2008)

2.3.3.3. The Nutritive Value of enset plant

The qualities of the individual plant parts such as leaves, petioles and stems may affect the nutritive value of the whole plant. Analysis of different carbohydrate and protein fractions, lignin, ash and crude fat is one of the approaches for a better characterization of the forage (Nurfeta, 2008). The pseudostem, corm and the stalk of inflorescence constitute the most important components used for human food, whereas all parts of the plant can be fed to livestock. Leaf pruning and thinned enset plants are used for feeding animals. The very low DM content of the pseudo-stem poses DM intake limitation on animals while it could be an advantage if drinking water is in short supply (Fekadu and Ledin, 1997). The relatively high CP content of the leaf (about 17%) makes it a favorable feed resource in ruminant feeding as the protein content is comparable to that of many browse species (Table 7). The CP content of the pseudostem is usually less than 7%. Thus, unless properly supplemented with nitrogen sources, the low protein content could depress the feed intake and utilization of the corm and pseudostem when fed to ruminant animals (Nurfeta, 2008).

Table 7: Chemical composition of different parts of the enset plant

Component	Whole enset	Pseudostem	Corm	Enset leaf
Dry matter (g/kg)	100	144	202	101
Ash (g/kg DM)	119	135	84	138
Crude protein (g/kg DM)	67	62	27	123
Neutral detergent fiber (g/kg DM)	501	415	231	562
Acid detergent fiber (g/kg DM)	260	267	113	366
Acid detergent lignin (g/kg DM)	51	29	20	70
Cellulose (g/kg DM)	209	238	93	296
Metabolizable energy (MJ/kg DM)	10.2	7.8	10	7.7

Source: Nurfeta et al. (2008)

2.3.3.4. Enset fractions as a feed supplements

2.3.3.4.1. Effect of ssupplementation on feed intake and body weight gain

Enset leaf is rich in crude protein while pseudostem is poor in N content (Nurfeta et al., 2008; Fekadu and Ledin, 1997). The very low N content of pseudostem could have an effect on intake since N intake is positively correlated to the N content of feed. Fekdau and Ledin (1997) fed enset leaf and pseudostem with or without urea and observed significant improvement in intake in cows fed pseudotem diet when treated with urea where as no significant effect was observed in cows fed enset leaf with or without urea. This indicates that for the efficient utilization of pseudostem, protein supplementation is required. Studies has shown low intake when corm or pseudostem is fed to sheep. According to Nurfeta et al. (2008) higher DM and CP intakes were observed in sheep fed *D.intortum* (830 g and 133 g, respectively) than those fed pseudostem (92 and 7.8 g, respectively) which is attributed to low DM and CP contents of pseudostem. However, when a protein source is used, lack of significant difference in DM, OM, CP, NDF and ADF intake was reported by Tsegaye (2013) in sheep fed different levels of *kocho* in concentrate mixture. Likewise, Nurfeta et al. (2008b) reported sheep supplemented with enset mixture consumed more wheat straw DM (335 g/day) than those supplemented with corm and pseudostem (318 and 295 g/day, respectively). Enset mixture contained higher CP content compared with other enset fractions. According to Bino (2013) in goats supplemented with different levels of enset leaf the intake of DM, CP, OM, NDF and ADF increased with increasing levels of enset leaf which is in agreement with Nurfeta et al. (2009) who reported higher mean DM (510 and 514 g/day) and OM (447 and 454 g/day) intake at medium and high levels of enset leaf supplementation than at low level (470 and 415 g/day, respectively) in sheep fed untreated or urea and calcium oxide-treated wheat straw.

Though there were no differences in body weight gains between sheep fed pseudostem (29.3 g), corm (27.0 g) and enset mixture (36.5 g) positive body weight gain was observed (Nurfeta et al., 2008). Similar body weight gain was noted in sheep fed a basal diet of Rhodes grass hay supplemented with different level of *kocho* and maize (27, 29, 25 and 33 g/day with 0%, 35%, 65% and 100% level of *kocho* replacement respectively) (Tsegaye, 2013). Daily weight gain increased with increasing level of enset leaf supplementation and weight is lost at low level (-2.1 g/day, 14.8 g/day and 24.3 g/day, respectively) (Nurfeta et al., 2009). Weight loss at low level of enset leaf supplementation is attributed to reduced protein. An increase in growth rate and average daily gain was reported by Bino (2013) in kids born from supplemented does (90.4, 99.1 and 94.6 g/day) with increasing level of enset leaf supplementation (74, 148 and 220 g/day, respectively) when compared with kids which were born from non-supplemented does (79.4g/day).

2.3.3.4.2. Effect of supplementation on digestibility

Different enset fractions have different digestibility values. For example, highest organic matter digestibility was observed for corm (0.780) followed by whole enset (0.776) (Nurfeta et al., 2008). Moreover, higher apparent digestibility of DM was observed in pseudostem (0.53) followed by corm (0.46) and enset mixture (0.41) in sheep (Nurfeta et al., 2008b). Similarly, Nurfeta et al. (2009) noted that the DM digestibility of enset leaf (0.589) was lower than that of whole enset (0.765), pseudostem (0.717) and corm (0.783), which could be because of the high lignin content of enset leaf.

2.3.3.4.3. Effects of supplementation on Nitrogen utilization

Not only intake and digestibility, the N utilization of feed is affected by the type of enset fractions fed to animals. Nurfeta et al. (2008) fed different enset fractions and *D. intortum* hay as a sole diet to sheep and observed a negative nitrogen balance in corm and pseudostem diets where as positive N balance was observed for those fed enset leaf, whole enset (a mixture of different fractions) and *D. intortum* hay. This indicates that corm and pseudostem are poor in N content (Fekadu and Ledin, 1997) and needs to be supplemented with protein source. The low and negative N balance in sheep fed corm and pseudostem is attributed to low DM intake and hence N intake and high nitrogen losses in faeces and urine besides low DM and N intake.

Tsegaye (2013) observed a similar N retention in sheep fed *kocho* as a substitute to maize in concentrate mixture where noug cake was used as a protein supplement. This indicates that if supplemented with a source of protein to enset based diets such as *kocho*, corm and pseudostem, the efficiency of utilization of N would improve.

Hence, enset which is locally available feed resources play a vital important for house hold through maintaining livestock productivity. Therefore; if processed in the form of *kocho* (mainly pseudostem and corm) and dried it could be used as valuable sources energy and can replace maize grain. *Kocho* has high energy value (1.41–1.95 MJ per 100 g dry matter) (Atlabachew, 2007). So, *kocho* due to having high energy value it can be used as energy source.

Table 8: Nutritive value of *kocho*

Content (% DM)	Variety		Processing methods		Fermentation time				Author
	Astare	Kinnare	Traditional	Improved	10^{th}	20^{th}	30^{th}	Mean	
Crude fiber	4.42	3.37	3.96	3.75	2.67	2.29	1.89	2.28	Temesgen (2013)
Ash	2.33	2.18	2.24	2.29	3.41	3.39	3.52	3.44	
Crude fat	1.04	1.27	1.2	1.11	1.6	1.52	1.5	1.54	
CP	3.17	3.43	3.47	3.26	4.42	4.78	5.09	4.76	
CHO	32.75	35.53	34	31.24	44.08	39.63	33.8	39.17	
CP			2.7						Tsegaye (2013)
Ash			12.7						
NDF			64.1						
ADF			34.7						

CHO (carbohydrate).

3. MATERIALS AND METHODS

3.1. Description of the study area

The experiment was conducted at Hawassa University, College of Agriculture which is situated 275 km south of Addis Ababa at $7^0 4'$N latitude and $38^0 31'$E longitude at an altitude of 1650m above sea level. The average annual rainfall is 1110mm (NMA, 2012).

3.2. Experimental feed preparation

Bales of Rhodes grass hay were bought from Belito government farm. Rhodes grass hay was chopped by knife into small pieces of about 8-10 cm to reduce preferential choice and wastage before feeding. Maize, noug seed cake and salt were bought from local market. *Kocho* was bought from the surrounding farmers; sun dried on plastic sheet and the fibre was separated by hand before feeding.

3.3. Experimental Animals and treatments

Twenty-four yearling male growing lambs of Adilo sheep with initial body weight of 15.03 ±1.96 kg (mean ± SD) were used in a randomized complete block design experiment with four dietary treatments of six lambs in each treatment. The four dietary treatments were randomly assigned to animals in the block in such a way that each animal within the block had equal chance of receiving one of the treatment diets. The initial body weight of lambs was determined by weighing the lambs twice after overnight fasting of the lambs at the commencement of the feeding trial. The sheep were given 1/2 a bolus of Albendazol 300 mg, using a balling gun, against internal parasite as prescribed by the manufacturer. The dietary treatments consisted of:

T1 = Rhodes grass hay ad libitum + 222 g maize + 75 g noug cake + 3 g salt
T2 = Rhodes grass hay ad libitum + 138.75 g maize + 83.25 g *kocho* + 75 g noug cake + 3 g salt
T3 = Rhodes grass hay ad libitum + 83.25 g maize +138.75 g *kocho* + 75 g noug cake + 3 g salt, and
T4 = Rhodes grass hay ad libitum + 222 g *kocho* + 75 g noug cake + 3 g salt.
Kocho replaced maize at 0%, 27.75%, 46.25% and 74% in T1, T2, T3 and T4 respectively.

3.4. The growth Experiment

The feeding trial was conducted for 70 days after quarantining the sheep for 14 days to the environment and accustoming to the experimental diet for 14 days. In all the treatments 300 g (on as fed basis) of concentrate feed were offered to all experimental units from their respective experimental concentrate which were 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 (*~30% refusal*)*. Clean drinking water was available at all times. Samples of daily feed offered and refused were collected, measured and pooled over experimental period for each feed and animal and stored in plastic bags. Representative samples of feed offered and refused for different treatments were taken for chemical 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.

3.5. Digestibility Experiment

At the end of the feeding trial, all sheep used in prior feeding trial with average body weight of 19.3 (±2.14) were adapted to carrying faecal collection bags for 3 days, which was followed by total faeces collection of 7 days. Total faeces voided was collected and weighed every morning before feeding and 10% of the total faeces were sampled. Composite samples per lamb were stored in airtight plastic bags in deep freezer at -20 °C pending chemical analysis. Separate samples of faeces were dried daily at 105°C overnight to determine the dry matter (DM) content.

The total urine output of each sheep was collected in bottles containing 100 ml of 10% hydrochloric acid. Ten percent of the samples collected each day was taken and stored in a freezer. At the end of the experiment, samples of faeces and urine were kept at room temperature and allowed to thaw for 24 h before sub sampling for each sheep. Samples of feed offer and refusals for individual animal were separately collected for chemical analysis.

3.6. Chemical analysis

The composite samples of feeds offered and refused, and faeces were thoroughly mixed for each sheep and sub-samples were dried in an oven at 60 °C for 48h, ground (Wiley mill, UK) to pass through 1 mm sieve screen and kept in air-tight plastic bags. The analysis of DM, N, OM and total ash contents of the samples was done according to AOAC (1990). Total nitrogen content of the feed, faeces and urine samples were determined using micro-Kjeldahl method. Crude protein (CP) was estimated as N × 6.25. The analysis of NDF and ADF was done according to Van Soest et al. (1991) in an ANKOM® 200 Fiber Analyzer (ANKOM Technology Corp., Fairport, NY, USA).

3.7. Statistical Analysis

Data from feeding and digestion trials were subjected to analysis of variance (ANOVA) using the General Linear Model (GLM) procedure of SAS (2001). Treatment means were separated using Duncan's Multiple Range Test. The model used for treatments was: $Yij = \mu + \alpha i + \beta j + eij$, where Yij = the observation in i^{th} treatment and j^{th} block, μ = Over all mean, αi = the i^{th} treatment effect, βi = the jth block effect and eij = the random error.

4. RESULTS

4.1. Chemical composition of treatment feeds

The chemical compositions of the feed ingredients and treatments are given in Table 9. 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 9: Chemical compositions (% DM, unless stated) of feed ingredients and treatments used in the experiment.

Ingredients/Treatments	DM (%)	CP	NDF	ADF	OM
Rhodes grass hay	94.4	3.2	76.6	43.0	89.1
kocho	95.6	3.3	21.7	5.2	98.8
Maize	94.8	7.8	24.8	5.4	98.3
Noug Cake	95.6	25.0	45.3	29.4	88.8
Treatments					
T1	95.2	13.5	30.5	12.7	94.3
T2	94.3	10.4	27.8	11.9	95.4
T3	95.0	9.4	22.8	11.8	94.9
T4	93.8	7.3	19.9	10.1	96.5

DM = dry matter; CP = crude protein; NDF = neutral detergent fiber; ADF = acid detergent fiber; OM= Organic matter; T1= 74% maize, 25% noug cake and 1% salt; T2 = 46.25% maize, 27.75% *kocho*, 25% noug cake & 1%slt; T3=27.75% maize, 46.25% *kocho*, 25% noug cake & 1% salt; T4=74% *kocho*, 25% noug cake & 1% salt.

4.2. Dry matter and nutrient intake

The mean daily DM and nutrient intake of sheep fed basal diet of Rhodes grass hay supplemented with different proportions of maize and *kocho* is presented in Table 10. The total daily DM, OM, ADF and ME intake were similar (P>0.05) among treatments. The highest (p<0.001) total CP intake was for sheep fed T1 diet, while the lowest CP intake was for sheep received T4 diet. The NDF intake for T1 was higher (P>0.05) than that of T3 but comparable with T2 and T4.

Table 10: Daily dry matter and nutrient intake of sheep fed basal diet of Rhodes grass hay supplemented with different proportions of maize and *kocho*.

Intake	Treatment				SEM	**SL**
	T1	T2	T3	T4		
Dry matter						
Basal feed (g/d)	354.3	346.3	343.2	360.3	8.3	Ns
Supplement (g/d)	270.2	283	285	281	6.9	NS
Total DM (g/d)	624.3	629	628.3	641.5	13.3	NS
Total DM (g/kg $W^{0.75)}$	70.8	72.5	73.5	74.2	1.5	NS
Total OM (g/d)	560.7	569.3	567.7	582.8	12.5	NS
Total CP (g/d)	49.0^{a}	42.9^{b}	39.4^{c}	33.5^{d}	1.1	***
Total NDF (g/d)	351.2^{a}	333.3^{ab}	322.7^{b}	327.3^{ab}	7.8	*
Total ADF (g/d)	192.5	192.5	189.7	190.5	4.4	NS
ME (MJ/d)	6.5	6.2	6.4	6.5	0.3	NS

$^{a, b}$, = means with different superscripts in a row are significantly different. * = (*P* < 0.05); ** = (*P* < 0.01); *** = (*P* < 0.001); ADF = acid detergent fiber; CP = crude protein; DM = dry matter; NDF = neutral detergent fiber, OM = organic matter; SEM = standard error of mean; SL = significance level; T1= 74% maize, 25% noug cake and 1% salt; T2 = 46.25% maize, 27.75% *kocho*, 25% noug cake & 1% salt ; T3=27.75% maize, 46.25% *kocho*, 25% noug cake & 1% salt; T4=74% *kocho*, 25% noug cake & 1% salt.

4.3. Dry matter and nutrient digestibility

The apparent digestibility of DM and nutrients in sheep fed a basal diet of Rhodes grass hay supplemented with maize and *kocho* at different proportions are presented in Table 11. There was no variation (p>0.05) in DM and OM digestibility among treatment diets. The CP digestibility for sheep received T1, T3, and T4 were comparable (P>0.05) but the CP digestibility in these treatment groups was higher (P<0.05) than that of T2. The NDF digestibility in sheep fed T1 diet was higher (P<0.05) than that of T2 and T3, but comparable with T2.

Table 11: The apparent digestibility of sheep fed basal diet of Rhodes grass hay supplemented with maize and *kocho* at different proportions.

Digestibility (%)	Treatments				SEM	SL
	T1	T2	T3	T4		
DM	66.9	59.8	62.0	63.9	2.25	NS
OM	70.3	63.7	65.6	67.6	2.07	NS
CP	76.8^{a}	68.4^{b}	75.3^{a}	70.3^{ab}	1.68	*
NDF	63.9^{a}	51.1^{b}	58.0^{ab}	51.8^{b}	3.10	*
ADF	62.5^{a}	52.1^{b}	58.4^{b}	52.1^{ab}	3.07	*

$^{a, b, c}$ = means with different superscripts in a row are significantly different. * = ($P < 0.05$); ** = ($P < 0.01$); *** = ($P < 0.001$); ADF = acid detergent fiber; CP = crude protein; DM = dry matter; NDF = neutral detergent fiber, OM = organic matter; SEM = standard error of mean; SL = significance level; T1= 74% maize, 25% noug cake and 1% salt; T2 = 46.25% maize, 27.75% *kocho*, 25% noug cake & 1%slt; T3=27.75% maize, 46.25% *kocho*, 25% noug cake & 1% salt; T4=74% *kocho*, 25%noug cake & 1% salt.

4.4. Live weight gain and feed conversion efficiency

Body weight changes of sheep fed basal diet of Rhodes grass hay supplemented with maize and *kocho* at different proportions is presented in Table 12. Mean initial body weight, final body weight, total weight gain and average daily weight gains of sheep were not significantly (P >0.05) influenced by treatment diets.

Table 12: Body weight changes of sheep fed basal diet of Rhodes grass hay supplemented with maize and *kocho* at different proportions.

Body weight changes	Treatments				SEM	**SL**
	T1	T2	T3	T4		
Initial body weight (kg)	16.5	16.5	16.2	16.6	0.18	NS
Final body weight (kg)	19.8	19.3	18.9	19.1	0.29	NS
Total weight gain (kg)	3.30	2.81	2.71	2.47	0.31	NS
Weight gain/day (g)	47.2	40.2	38.8	35.2	4.38	NS
FCE (g ADG/g DMI)	0.08	0.07	0.07	0.05	0.007	NS

Means with different superscripts in a row are significantly different. * = (P < 0.05); ** = (P < 0.01); *** = (P < 0.001); SEM = standard error of mean; SL = significance level; T1= 74% maize, 25% noug cake and 1% salt; T2 = 46.25% maize, 27.75% *kocho*, 25% noug cake & 1%salt; T3=27.75% maize, 46.25%k*ocho*, 25%noug cake & 1% salt; T4=74% *kocho*, 25% noug cake & 1% salt.

The trend in body weight gain was more or less similar for all treatments across experimental periods (Fig 1).

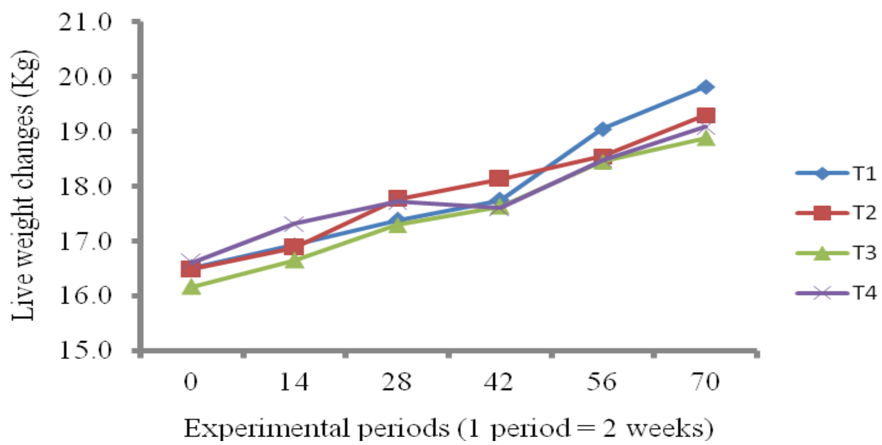

Figure 1: Trends of body weight change in sheep fed Rhodes grass hay as basal diet supplemented with maize and *kocho* at different levels.

4.5. Nitrogen Utilization

The intake, excretion and retention of nitrogen by sheep fed a basal diet of Rhodes grass hay supplemented with maize and *kocho* at different proportions is presented in Table 13. Nitrogen intake was lowest (p<0.001) for sheep fed T4 and highest (P<0.001) for sheep fed T1. The fecal N excretion was not significantly (P>0.05) affected by treatments. The total and urinary N excretion was the highest (P<0.05) for sheep fed T1 diet whereas similar for T2, T3 and T4. The nitrogen retention was the lowest (P<0.01) for T4 while T1, T2and T3 were not significantly differed (Table 13).

Table 13: Nitrogen utilization of Sheep fed diet of hay supplemented with maize substituted with *kocho* at different proportions.

Item	Treatments				SE	SL
	T1	T2	T3	T4		
Nitrogen intake (g/d)	8.20^{a}	7.01^{b}	6.36^{c}	5.49^{d}	0.07	***
N excretion (g/d)						
N in Faeces (g/d)	1.34	1.54	1.47	1.61	0.10	NS
N in Urine (g/d)	2.63^{a}	1.50^{b}	1.38^{b}	1.44^{b}	0.22	**
Total (g/d)	3.97^{a}	3.04^{b}	2.85^{b}	3.05^{b}	0.28	*
% of N intake	48.68	43.29	44.96	55.7	4.12	NS
N retained (g/d)	4.23^{a}	3.98^{a}	3.51^{a}	2.44^{b}	0.32	*
% of N intake	51.32	56.7	55.0	44.3	4.12	NS

Means with different superscripts are significantly different (p<0.05), SEM: Standard error of the mean, *p<0.05; **P<0.01; ***P<0.001; T1= 74% maize, 25% noug cake and 1% salt; T2 = 46.25% maize, 27.75% *kocho*, 25%noug cake & 1%slt; T3=27.75% maize, 46.25% *kocho*, 25% noug cake & 1% salt; T4=74% *kocho*, 25% noug cake & 1% salt.

5. DISCUSSION

5.1. Chemical Composition

The CP content of the hay used in this study is 3.24% which is lower than the results (7%; 5.15%) reported by Tolera (2008) and Nurfeta et al. (2009), respectively, but higher than the value (2.7%) observed by Tsegaye (2013). The chemical composition and the quality of hay prepared varies with location, soil type, variety, post harvest handling, grass legume proportion, leaf to stem ratio and physiological development of the forage up on harvest (Ensminger *et al.*, 1990;Tsegaye, 2013). The comparatively high NDF and ADF content of hay show that the hay has a poor nutritional potential and may not succeed to support the maintenance requirements of sheep as it contains CP below the minimum level (7%) required for microbial function (Van Soest, 1994). Also Norton (1994) reported that feeds with less than 6% CP levels are unlikely to provide the minimum ammonia levels required for maximum microbial growth in the rumen and voluntary feed intake rapidly falls if CP concentration of forage is below 6.2%. Consequently, these roughages are poorly digested and often unable to support the maintenance requirements of ruminant animals.

The low CP and high NDF content could be attributed to the maturity of the grass at harvesting. Advance in maturity of plants was reported to be usually associated with low CP and high cell wall content (McDonald *et al.*, 2002). This is expected since with plant maturity the cell wall constituent increase and therefore, the proportion of the structural carbohydrates such as cellulose increase and the percentage of CP normally decrease (McDonald *et al.*, 2002). Mature grass, especially those that are weather leached or bleached are low in digestible energy and protein, as well as in soluble carbohydrate, carotene and some of the minerals (Ensminger *et al.*, 1990).

The higher NDF content could be a limiting factor on feed intake and it is negatively correlated with voluntary feed intake (Ensminger *et al.*, 1990). Although hay intake without supplementation was not measured in this study, the high NDF content of the hay might imply that intake of basal diet may be limited since a major factor regulating forage intake is NDF content, as it is the major component limiting rumen fill, and directly correlated with rumination or chewing time (Cheeke, 1999).

The CP content of *kocho* (3.27%) in the present study was higher than the value (2.7%) reported by Tsegaye (2013). This variation could be associated with fermentation time, processing methods and enset variety that had resulted in differences of chemical composition, physic-chemical characteristics and microbial proliferation of *kocho* (Temesgen, 2013). Temesgen (2013) also noted remarkable increase in crude protein content of *kocho* as fermentation time increased from 10 to 30 days (4.42% Vs 5.09%), respectively, due to the action of fermenting microorganisms in the synthesis of some amino acids, and improved the quality of the protein, as determined by amino acid profiles. In general, the CP content of corm and pseudostem from which *kocho* is produced is low. Nurfeta (2010) reported a CP content of 4.77% and 3.42% for unprocessed pseudostem and corm, respectively. Beyan et al. (2013) also reported the CP content of 3.3% and 3.6% for corm and pseudostem, respectively.

The low CP content of *kocho* in the present study clearly suggested that it cannot fulfill the rumen microbial and the host animal CP requirements and needs to be supplemented with feeds of higher CP contents which is the reason for using noug seed cake in the current experiment.

Though the CP content of *kocho* used in the current experiment is very low the pseudostem (from which *kocho* is made) was rich in soluble carbohydrates and starch similar to sorghum (Beyan et al., 2013) which has the highest concentration found among cereals while it contained relatively small amount of protein. However, *kocho* is energy rich which contain higher 14.1-19.5 MJ/kg DM (Atlabachew, 2007) than maize (12.3 MJ/Kg DM) (ILRI, 2011). Moreover, *kocho* is also rich in carbohydrate (960 g/kg of food) which is relatively high compared with maize (830 g/kg) with annual energy yield of 79 KJ and 67 KJ /ha for *kocho* and maize, respectively (Yilma, 2001). According to Lonsdale (1989), feeds that have < 120, 120 - 200 and > 200 g CP/kg DM and < 9, 9 – 12 and > 12 MJ ME/kg DM are classified as low, medium and high protein and energy sources, respectively. Hence *kocho* could be a good energy source.

5.2. Dry matter and nutrient intake

Lack of significances in DM intake among treatments could be attributed to the similar offer of total supplement DM. No refusal was recorded for all treatments indicating that *kocho* is acceptable by the animals. It also shows that feeding *kocho* as a substitute to maize had no negative effect on palatability which is consistent with the report by Tsegaye (2013) in sheep fed different level of *kocho* in concentrate mixture. The lack of significant differences in total dry matter intake among supplemented treatments suggests that *kocho* can at least be a good substitute to maize if available and price is practicable. Similarly, lack of significant different in total DM intake among treatments was observed by Nurfeta (2010) in sheep fed fixed amounts of unprocessed pseudostem or corm supplemented with graded levels of *Desmodium intortum* hay as a supplement to wheat straw. Nurfeta et al. (2009) observed low DM intake in sheep fed unprocessed fresh enset corm (404 g/d) or pseudostem (406 g/d) as a sole diet compared with the current experiment (624.3 g/d – 641.5 g/d). This indicates that if processed in the form of *kocho* and dried it could be used as valuable sources of energy and could replace maize grain. The benefit of using *kocho* as an energy source is associated with its availability as enset plant is perennial compared with maize. In the south and south western part of Ethiopia, almost all households even those without maize grow enset. Therefore, under small scale production systems where enset grows, kocho could be used as a source of energy for sheep fattening.

In current study, the DM intake (624.3-641.5 g/day) was within the recommended range of 530-660 g/day as adequate for sheep with body weight of 15 to 20 kg with average daily body weight gain of 50 g/day (Kearl, 1982). The total DM intake (624.3- 641.5 g/day) in the present study was higher than the values (592-618 g/d) reported by Tsegaye (2013) in sheep fed different level of *kocho* in concentrate mixture.

In the present study intake of crude protein in the supplemented treatment diets decreased with increasing levels of *kocho* in concentrate mixture which could be due to low crude protein content of *kocho* which is in agreement with the report by Tsegaye (2013) who reported decreased CP intake with increasing levels of *kocho* as a substitute to maize in concentrate mixture.

The estimated ME (6.2-6.5 MJ/d) intake by the sheep in all treatments was within the maintenance requirement range of 3.0-7.1 MJ/day estimated for a 15-20 kg lamb (Kearl, 1982). This may be associated with high energy content of *kocho* 14.1-19.5MJ/Kg DM (Atlabachew, 2007).

5.3. Dry matter and nutrient digestibility

The utilization of nutrients contained in feeds is determined by the amount of dry matter intake and digestibility. A primary consideration concerning DM intake is digestibility. The digestibility of a feed is influenced not only by its nutrient composition, but also by the composition of other feeds consumed together (McDonald *et al.*, 2002). Furthermore, ARC (1980) indicated that digestibility is much reduced when a ration has too little protein as compared to the amount of readily digested carbohydrates. All these point out that the nutrients supplied by the different combination of supplements employed in this study were enough to make more or less similar effect on the digestibility of DM and nutrients.

The lack of significant difference of DM and OM digestibility in current study is in agreement with the result reported by Tsegaye (2013) in sheep fed different level of *kocho* which could be attributed to the similar DM and OM intake (Table 10). The digestibility of DM, OM, ADF and NDF of the present study was higher than the result reported by Tsegaye (2013) in sheep fed different level of *kocho* in but the CP digestibility is lower which could be attributed to the difference in nutrient profile of the supplements used in the experiment. The higher CP digestibility of T1 compared with T2 could be attributed to high CP intake of T1. Increasing in level of crude protein in total ration improved CP intake and enhanced CP digestibility (Chobang et al., 2009). Conclusively, the results obtained from digestibility of nutrients further demonstrate that with proper supplementation of *kocho* with protein, it could be used as a partial or total substitute for maize in ruminant nutrition, thus reducing competition with human and monogastric animals for the grains.

5.4. Live weight gain and feed conversion efficiency

Lack of significant variation among supplemented sheep in daily gain and feed conversion efficiency reflected that the supplements are comparable in their potential to supply nutrients for improving live weight change of the sheep. Growth performances of animals under different experimental conditions may vary depending on many factors, amongst which the type of dietary ingredients used for the study, the quality of the basal diet, type and amount of the supplement used are the main ones to mention (Gizachew, 2012). In the current study based on the different levels of *kocho* and maize concentrate used to formulate the experimental diets the ADG (35-47 g/day) were higher than the values of 25-30 g/day noted by Tsegaye (2013) for Adilo sheep fed grass hay supplemented with different proportion of *kocho* in concentrate mixture. The ADG in the current study were within the range to the values of 38.9-55.6 g/day indicated by Gashu (2009) for Wasshera sheep fed grass hay and supplemented with maize bran, noug seed meal and their mixtures.

Sheep in all treatments had a positive weight gain. The effect on daily live-weight gain in this trial confirmed that an earlier report by Tsegaye (2013) who obtained similar live weight gain in sheep fed different level of *kocho* in concentrate mixture; this seems to indicate that *kocho* is a good carbohydrate source and it could substitute maize with protein supplement such as noug seed cake without adverse effect on voluntary feed intake and growth rate. 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 substitute maize. Moreover, the *kocho* DM yield potential of enset was estimated to range from 17.1 to 33.9 t/ ha/year (Tsegaye, 2002) which is very high compared with other feed resources in

Ethiopia. Whereas the seed yield of the maize in Ethiopia is averagely 3.09ton/ha (CSA, 2013). Not only smallholder farmers but also commercial sheep fatteners in the urban and peri-urban area can utilize *kocho* which is in fact determined by the price and availability of maize and *kocho*.

5.5. Nitrogen Utilization

Generally, the superiority in nitrogen retention due to a specific ration is affected by several factors such as possible production of microbial protein synthesis, increasing presence of fermentable energy, differences in availability of fermentable energy (Holzer and Samule, 1986), variability in nitrogen that might escape fermentation from the rumen, an increased utilization of ammonia in the rumen and the effect of free fats in protein synthesis (Hagemeister et al., 1981).

The positive nitrogen balance in all the treatment groups fed to sheep is indicative of energy and nitrogen supply much more than the maintenance requirement, although the supplementary concentrate mixture allowance and the protein level in the concentrate mixture were fixed. Nitrogen balance is an indicator of N availability for microbial protein synthesis and a positive balance shows that the captured N from dietary RDP is in excess and there is net loss of nitrogen from the rumen to the animal tissue (Clark et al., 1992).

The variation in the amount of DM consumed and the nitrogen concentration of the treatment diet determine the amount of nitrogen intake. The lack of difference in feacal nitrogen excretion was inconsistent with the study by Tsegaye (2013) who observed similar feacal N excretion in sheep supplemented with different level of *kocho*. Nitrogen retention was positively and linearly related ($P<0.001$, $r=0.71$) with daily nitrogen intake (Figure 2). Nitrogen retained was 58%

depends on NI (R^2=0.50). Thus, the relatively lower nitrogen retention in sheep fed T4 could be owing to the decrease of nitrogen intake as the level of *kocho* increased.

The higher urine N loss observed in sheep fed T1 could due to the high CP content and higher intake of this diet. Kaswari et al. (2007) noted that losses of N in urine are mainly caused by an oversupply of CP or imbalance in the supply of amino acids.

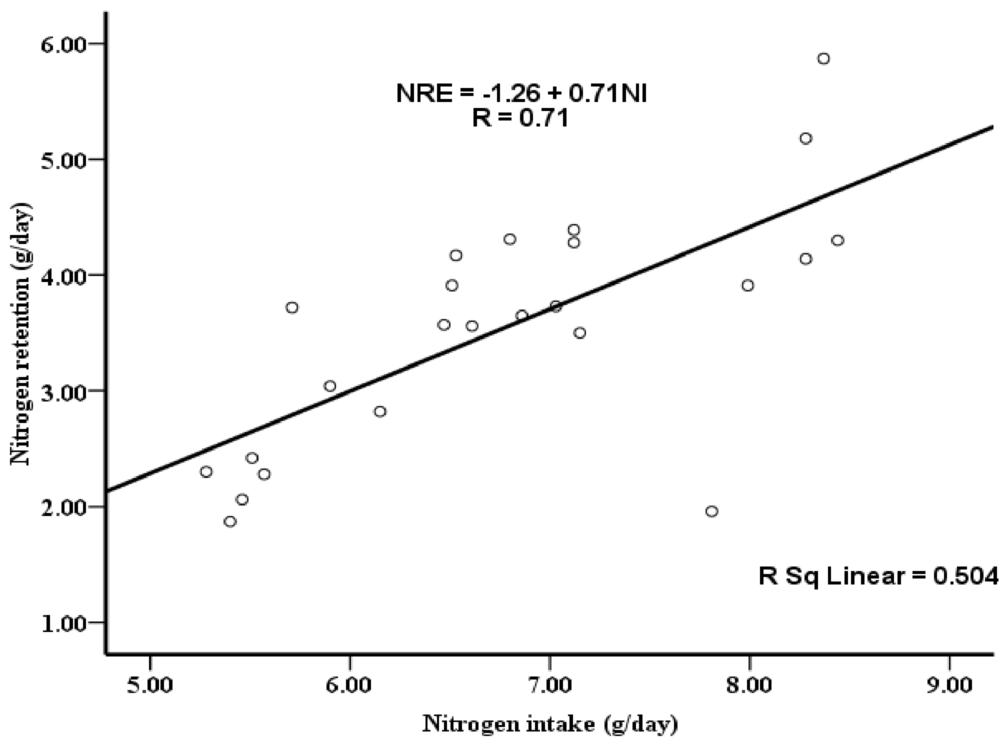

Figure 2: Regression of nitrogen retention over nitrogen intake of Sheep fed grass hay basal diet supplemented with different proportion of kocho and maize.

6. CONCLUSION AND RECOMMENDATIONS

6.1. Conclusion

Results of the present study suggested that substitution of maize with *kocho* at different proportion as a supplement to Rhodes grass hay supported similar degree of animal performance. When *kocho* is fed to animals, the animals can benefit from the large fraction of starch and the high energy. Thus, the present study has undoubtedly confirmed that *kocho* is a potential source of energy *and* could be used as a choice feed to replace maize partially or totally as long as it is economically feasible under smallholder production systems to enhance performance of growing sheep.

6.2. Recommendation

In enset producing areas, south and south western part of the country grazing land is limited. Compared to other forage crops in Ethiopia, the DM yield of enset per hectare and/or per plant is high. Also enset is available throughout the year, rich in energy, stored for long period of time without refrigerator. Hence, *kocho* is recommended if efficiently utilized to alleviate feed shortage during the dry season. Even though *kocho* is deficient in protein, small holder farmers can occasionally afford purchased protein concentrates (such as noug seed cake), use of legumes, which can be grown on farm, could alleviate the problem. On farm research on the supplementation of *kocho* to locally available crop residue and grazing has to be undertaken to obtain more information under actual farmers' conditions.

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APPENDIX

Appendix 1: Table 1: ANOVA test regarding total intake of experimental feeds.

Total Intake	Source	Sum of Squares	DF	Mean Square	F	Sig
DM intake	Treatment	993.792	3	331.264	0.31	0.3167
	Block	56743.708	5	11348.742	10.67	0.0002
	Error	15948.458	15	1063.231		
	Total	73685.958	23			
OM intake	Treatment	1545.792	3	515.264	0.55	0.6555
	Block	49611.375	5	9922.275	10.60	0.0002
	Error	14039.458	15	935.964		
	Total	65196.675	23			
CP intake	Treatment	760.77	3	253.59	36.03	<0.0001
	Block	95.318	5	19.064	2.71	0.0615
	Error	105.565	15	7.038		
	Total	961.653	23			
NDF intake	Treatment	2804.792	3	934.931	2.56	0.0938
	Block	30273.875	5	6054.775	16.58	<0.0001
	Error	5476.958	15	365.131		
	Total	38555.625	23			
ADF intake	Treatment	37.125	3	12.375	0.11	0.9550
	Block	9981.708	5	1996.342	17.17	<0.0001
	Error	1744.125	15	116.275		
	Total	11762.958	23			

Appendix 1: Table 2: ANOVA test regarding basal grass hay intake.

Parameters	Source	Sum of Squares	DF	Mean Square	F	Sig
DM intake	Treatment	1088.125	3	362.708	0.88	0.4752
	Block	43518.708	5	8703.742	21.04	<0.0001
	Error	6206.125	15	413.742		
	Total	50812.958	23			
OM intake	Treatment	726.833	3	242.278	0.68	0.5776
	Block	37587.833	5	7517.567	21.11	<0.0001
	Error	5341.167	15	356.078		
	Total	43655.833	23			
CP intake	Treatment	2.888	3	0.963	3.43	0.0445
	Block	28.218	5	5.644	20.10	<0.0001
	Error	4.212	15	0.281		
	Total	35.318	23			
NDF intake	Treatment	1191.000	3	397.00	1.57	0.2387
	Block	27083.333	5	5416.667	21.39	<0.0001
	Error	3799.000	15	253.267		
	Total	32073.333	23			
ADF intake	Treatment	121.458	3	40.486	0.47	0.708
	Block	9199.375	5	1839.875	21.33	<0.0001
	Error	1293.792	15	86.253		
	Total	1064.675	23			

Appendix 1: Table 3: ANOVA test regarding supplement diet intake.

Parameters	Source	Sum of Squares	DF	Mean Square	F	Sig
DM intake	Treatment	789.125	3	263.042	0.93	0.4516
	Block	1418.208	5	283.642	1.00	0.4509
	Error	4254.675	15	283.642		
	Total	6461.958	23			
OM intake	Treatment	1216.5	3	405.5	1.66	0.2186
	Block	1223.33	5	244.67	1.00	0.4509
	Error	3670.00	15	244.67		
	Total	6109.83	23			
CP intake	Treatment	808.485	3	269.495	52.52	<0.0001
	Block	25.658	5	5.132	1.00	0.4509
	Error	76.975	15	5.132		
	Total	911.118	23			
NDF intake	Treatment	2664.751	3	888.250	34.24	<0.0001
	Block	129.692	5	25.938	1.00	0.4509
	Error	389.076	15	25.938		
	Total	3183.520	23			
ADF intake	Treatment	144.045	3	48.015	10.63	0.0005
	Block	22.58	5	4.516	1.00	0.4509
	Error	67.74	15	4.516		
	Total	234.365	23			

Appendix 1: Table 4: ANOVA test regarding digestibility of experimental feeds.

Digestibility	Source	Sum of Squares	DF	Mean Square	F	Sig
DM	Treatment	164.003	3	54.67	1.80	0.1903
	Block	80.030	5	16.01	0.53	0.7523
	Error	455.407	15	30.36		
	Total	699.44	23			
OM	Treatment	141.791	3	47.26	1.85	0.1821
	Block	84.494	5	16.89	0.66	0.6590
	Error	383.931	15	25.60		
	Total	610.216	23			
CP	Treatment	286.061	3	95.35	5.65	0.0085
	Block	50.482	5	10.10	0.60	0.7017
	Error	252.946	15	16.86		
	Total	589.490	23			
NDF	Treatment	647.905	3	215.97	3.76	0.0341
	Block	209.029	5	41.81	0.73	0.6137
	Error	862.273	15	57.48		
	Total	1719.206	23			
ADF	Treatment	475.041	3	158.35	2.81	0.0754
	Block	208.247	5	41.65	0.74	0.6063
	Error	845.951	15	56.40		
	Total	1529.240	23			

Appendix 1: Table 5: ANOVA test regarding body weight of experimental animals.

Body weight	Source	Sum of Squares	DF	Mean Square	F	Sig
Final body weight	Treatment	2.905	3	0.968	1.94	0.1670
	Block	94.727	5	18.945	37.9	<0.0001
	Error	7.498	15	0.500		
	Total	105.130	23			
Total weight gain (Kg)	Treatment	2.195	3	0.732	1.30	0.3115
	Block	1.435	5	0.287	0.51	0.7651
	Error	8.455	15	0.564		
	Total	12.085	23			
ADG (g/day)	Treatment	448.112	3	148.371	1.30	0.3114
	Block	292.893	5	58.579	0.51	0.7651
	Error	1725.568	15	115.038		
	Total	2466.574	23			

Appendix 1: Table 6: ANOVA test regarding feed conversion efficiency.

Source	Sum of Squares	DF	Mean Square	F	Sig
Treatment	0.00141	3	0.00047	1.68	0.2146
Block	0.00117	5	0.000234	0.83	0.5457
Error	0.00421	15	0.00028		
Total	0.0068	23			

Appendix 1: Table 7: ANOVA test regarding ME intake of experimental feed.

Source	Sum of Squares	DF	Mean Square	F	Sig
Treatment	3.645	3	1.215	1.85	0.1817
Block	2.169	5	0.434	0.66	0.6590
Error	9.857	15	0.657		
Total	15.671	23			

Appendix 1: Table 8: ANOVA test regarding total DM (g/ Kg $W^{0.75}$)

Source	Sum of Squares	DF	Mean Square	F	Sig
Treatment	38.75	3	12.917	0.92	0.4572
Block	40.28	5	8.057	0.57	0.7214
Error	211.71	15	14.114		
Total	290.74	23			

Appendix 1: Table 9: ANOVA test regarding nitrogen utilization of experimental animal.

Parameters	Source	Sum of squares	DF	Mean square	F	Sig.
Nitrogen Intake (g)	Treatment	23.39	3	7.80	257.66	<0.0001
	Block	0.44	5	0.09	2.92	0.05
	Error	4.50	15	0.03		
	Total	24.29	23			
Fecal N output (g)	Treatment	0.24	3	0.08	1.33	0.3014
	Block	0.11	5	0.02	0.36	0.87
	Error	0.88	15	0.06		
	Total	1.22	23			
Urinary N output (g)	Treatment	6.39	3	2.13	7.02	0.0036
	Block	2.19	5	0.44	1.44	0.27
	Error	4.55	15	0.30		
	Total	13.14	23			
Total N Excretion (g)	Treatment	4.53	3	1.51	3.32	0.0485
	Block	2.69	5	0.54	1.19	0.3616
	Error	6.81	15	0.45		
	Total	14.04	23			
N Retained (g)	Treatment	11.22	3	3.74	6.05	0.0066
	Block	3.81	5	0.76	1.23	0.3422
	Error	9.28	15	0.62		
	Total	24.30	23			
N retained (%)	Treatment	546.21	3	182.07	1.78	0.1934
	Block	584.03	5	116.81	1.14	0.38
	Error	1531.07	15	102.07		
	Total	2661.31	23			

Appendix 1: Table 10: Regression of nitrogen intake over nitrogen retention intake over average daily gain.

Model	Unstandardized coefficients		Standardized coefficients	t	sig
	B	Std. Error	Beta		
(constant)	-1.26	1.03		-1.23	0.232
N intake	0.71	0.15	0.71	4.72	0.00

R= 0.71, R square=0.50, Adjusted R square=0.48, Durbin-Watson= 2.024

N retention= -1.26 + 0.71N Intake

BIOGRAPHIC SKETCH

The author of the present thesis, Aman Getiso was born from his father Getiso Keti and mother W/o Dure Nuna in the year 1984 G.C

He joined his elementary (1 – 6) education at Mokona elementary school. Continued his grade 7 – 8 at Kore Junior Secondary School.

At Arsi Negelle high school he pursued his grade 9 – 10 and 11-12 at Kofale high school sat for Ethiopian School Leaving Certificate Examination (ESLCE) in the year 2001 G.C

He then joined Mekelle University in the year 2002 G.C and awarded BSc degree in Animal and Range Science in the year 2005 G.C

As of 2006 G.C he had been working as a junior instructor at Gambella Agricultural, Technical, and Vocational and training College in Gambella Region. He has been employed at Arsi Negelle Woreda Agricultural Developmen Office in 2007 as animal production extension expert and in 2010 G.C at West Arsi Zone Livestock Resource, Development and Health care office as an expert of livestock production expert until he joined Hawassa University, College of Agriculture in 2011 G.C to pursue his MSc degree in specialization of Animal production.