ASSESSMENT OF THE UTILIZATION PRACTICES OF BANANA AND MANGO RESIDUES, AND EFFECT OF ENSILING ON SILAGE QUALITY AND PERFORMANCE OF INDIGENOUS SHEEP GRAZING NATURAL PASTURE IN ARBA MINCH ZURIA DISTRICT OF GAMO GOFA ZONE

Msc Thesis

ASKALE DUBALE

HAWASSA UNIVERSITY

College of Agriculture

Hawassa, Ethiopia

June, 2017

ASSESSMENT OF THE UTILIZATION PRACTICES OF BANANA AND MANGO RESIDUES, AND EFFECT OF ENSILING ON SILAGE QUALITY AND PERFORMANCE OF INDIGENOUS SHEEP GRAZING NATURAL PASTURE IN ARBA MINCH ZURIA DISTRICT OF GAMO GOFA ZONE

ASKALE DUBALE

MAJOR ADVISOR: AJEBU NURFETA (PhD, Prof)
CO-ADVISOR: YOSEPH MEKASHA (PhD, Associate professor)

A Thesis Submitted to the School of Animal and Range Sciences

HAWASSA UNIVERSITY
College of Agriculture

In Partial Fulfillment of the Requirements for the Degree of Master of Science in Animal and Range Sciences (Animal Production)

Hawassa, Ethiopia

June, 2017

APPROVAL SHEET-I

This is to certify that the thesis entitled **"Assessment of the utilization practices of banana and mango residues, and effect of ensiling on silage quality and performance of indigenous sheep grazing natural pasture in Arba Minch Zuria district of Gamo Gofa zone"**, submitted in partial fulfillment of the requirements for the degree of **Master's** with specialization in Animal Production, to the Graduate Program of the School of **Animal and Range Sciences, Hawassa University College of Agriculture,** has been carried out by Askale Dubale**,** under our supervision. Therefore, we recommend that the student has fulfilled the requirements and hence hereby can submit the thesis to the school.

Ajebu Nurfeta (PhD. Prof.)	_____	_____
Name of major advisor	Signature	Date
Yoseph Mekasha (PhD. Assoc. Prof.	_____	
Name of co-advisor	Signature	Date

APPROVAL SHEET- II

We, the undersigned, members of the Board of Examiners of the final open defense by Askale Dubale have read and evaluated her thesis entitled **"Assessment of the utilization practices of banana and mango residues, and effect of ensiling on silage quality and performance of indigenous sheep grazing natural pasture in Arba Minch Zuria district of Gamo Gofa zone",** and examined the candidate. This is therefore to certify that the thesis has been accepted in partial fulfillment of the requirements for the degree of Master of Science.

_____	_____	_____
Name of the chairperson	Signature	Date
_____	_____	_____
Name of major advisor	Signature	Date
_____	_____	_____
Name of co-advisor	Signature	Date
_____	_____	_____
Name of internal examiner	Signature	Date
_____	_____	_____
Name of external examiner	Signature	Date
_____	_____	_____
SGS Approval	Signature	Date

Final approval and acceptance of the thesis is contingent upon the submission of the final copy of the thesis to the School of Graduate Studies (SGS) through the School Graduate Committee (SGC) of the candidate's department/ School.

ACKNOWLEDGEMENT

First and foremost, I would like to thank the Almighty God for giving health, strength and patience so as to accomplish this study.

All the financial supports of this research was funded by Livestock and Irrigation Value Chains for Ethiopian Smallholders (LIVES)—International Livestock Research Institute (ILRI) and I would like to express my deepest appreciation for the support and the overall effort and dedication of the project it has played for the betterment of farmers.

Special thanks and heart-felt appreciation goes to my advisors Prof. Ajebu Nurfeta, and Dr. Yoseph Mekasha, for their unreserved support and guidance during my research work without them the work was not so.

I wish to express deep appreciation is to my beloved husband Ato.Teshome Daniel for his continuous encouragement and moral support throughout the study period as well as for being with me at times of my failures.

STATEMENT OF AUTHOR

I declare that this thesis is my bonafied work and all sources of materials used for this thesis have been duly acknowledged. I solemnly declare that this thesis is not submitted to any other institution anywhere for the award of any academic degree, diploma or certificate.

Name Askale Dubale **Signature:** ……..……

Place: College of Agriculture, Hawassa University, Hawassa

Date of Submission: …….

LIST OF ABBREVIATIONS

ADF	Acid detergent fiber
ADL	Acid detergent lignin
AOAC	Association of Official Analytical Chemists
CACC	Central Agricultural Census Commission
cm	Centimeter
CP	Crude protein
CSA	Central Statistical Agency
DM	Dry matter
EPA	Ethiopia Privatization Agency
FAO	Food and Agriculture Organization of the United nations
g	Gram
Ha	Hectare
HH	House holds
IVTDMD	*In vitro* true dry matter digestibility
m.a.s.l	meter above sea level
ml	Milliliter
N	Nitrogen
NDF	Neutral detergent fiber
OM	Organic matter
SAS	Statistical Analysis System
SPSS	Statistical Package for Social Science
t	Tone
WSCs	Water soluble carbohydrates

TABLE OF CONTENTS

Contents **Page**

LIST OF TABLES

LIST OF TABLES IN THE APPENDIXS

Assessment of the utilization practices of banana and mango residues, and effect of ensiling on silage quality and performance of indigenous sheep grazing natural pasture in Arba Minch Zuria district of Gamo Gofa zone

Askale Dubale
Major advisor: Ajebu Nurfeta ((PhD, Professor)
Co-Advisor: Yoseph Mekasha (PhD, Associate professor)

ABSTRACT

The study was conducted to assess the experiences of banana and mango residue utilization, and effect of ensiling banana using mango residues as an additive on silage quality and evaluate the effect of feeding banana residues silage on growth performance of sheep. For the diagnostic survey, 120 households (HH) were selected from four banana and mango producing potential kebeles from which 30 respondents were selected to assess utilization of banana and mango residue for sheep feeding. Open ended structured questionnaire, focused group discussions and secondary data were used to collect the required data. For silage quality evaluation the banana and mango residues were collected from the farm at the time of harvest and banana residue was wilted for 8 hours. Five different silages were prepared using different proportion of mango peel and flesh (0, 2.5, 5, 7.5 and 10%) and molasses (10, 7.5, 5, 2.5 and 0%) as an additive to banana wilted psudostem and leaf. The ensiling was done with three replicates in buckets and was ensiled for 21 days. The on-farm feeding trial was undertaken to evaluate the effect of feeding banana silage prepared using mango residues and molasses as an additive on the growth performance of indigenous sheep. Eighteen yearling sheep were assigned to three treatments (T1= Grazing, T2=Ensiled Banana using 10% mango residues as additive, T3 = Ensiled Banana residue using 10% molasses as an additive). The sheep were blocked to six and assigned to HHs in Randomized Complete Block Design, each HH contributing three sheep and within a household the three sheep were randomly allocated to the three treatments. Feed and grazing land shortage followed by shortage of input and disease and parasites are the major constraints hindering sheep production. Income followed by saving/asset are the major reasons for keeping sheep. Sampled households prefer sheep than other livestock species because of the expected immediate return, easy to manage and high market demand. Most of the respondents stated that during the wet season natural pasture was the main source of feed for sheep followed by farm side grazing and feeding on rejected banana. During the dry season crop residue followed by road side grazing were the major sources of feed for sheep. All the samples households (100%) across the four kebeles feed banana residues to sheep in a fresh form. The residues (banana and mango) were fed without any improvement. The physical and chemical assessment of the silage showed that making silage from banana using mango residue or molasses as an additive indicates the suitability of silage making from banana and mango residue with good quality. There was no significant difference in feed dry matter, organic matter, and crude protein intake between T2 and T3. The average daily body weight gain was the higher ($P<0.05$) for sheep fed T2 and T3 diets compared with those based on grazing. In conclusion, banana residue could be ensiled using mango or molasses as an additive with similar performance of sheep. Therefore, due to the

availability of mango residue at farmers' level, mango residue could be used as an additive to make silage from banana residue.

Key words: Banana residue, mango residue, utilization, silage, intake, daily gain

1. Introduction

Naturally endowed with different agro-ecological zones suitable for livestock production, Ethiopia is a home for many livestock genetic resources. Ethiopia possesses about 59.5 million cattle, 30.7 million sheep and 30.2 million goats (CSA, 2016/17). The livestock subsector has an enormous contribution to Ethiopia's national economy and livelihoods of many Ethiopians, and still promising to rally round the economic development of the country. Livestock plays vital roles in generating income to farmers, creating job opportunities, ensuring food security, providing services, contributing to asset, social, cultural and environmental values, and sustain livelihoods. The subsector contributes to about 16.5% of the national Gross Domestic Product (GDP) and 45% of the agriculture GDP and contributes to about 15% of export earnings and 30% of agricultural employment (Behnke, 2010). The GDP of livestock related activities valued at birr 59 billion (Metaferiaet al., 2011). Despite high livestock population and existing favorable environmental conditions, the current livestock output of the country is low. This is associated with a number of complex and inter-related factors such as inadequate feed and nutrition, widespread diseases, poor genetic potential of local breeds, undeveloped livestock marketing, inefficiency of livestock development services, extension, marketing, and infrastructure (Benin et al., 2003; Negassa et al., 2011; Solomon et al., 2003).

Feed scarcity is one of the reasons for low animal productivity observed and underlying contributing factor in many other animal production problems. Although natural pasture is the dominant feed resources for livestock in mid to highland agro-ecology, its production and productivity remained low due to high population pressure, expansion of cropping land, and poor management. Alternatively crop production has been intensified and leaves behind enormous quantity of crop residue, which has potential to serve as livestock feed. Efficient

utilization of crop residue, however, faces a number of intriguing challenges that include low levels metabolized energy and crude protein, seasonal variability, bulky and poor keeping qualities. These challenges should be acknowledged and appropriate technological innovations should be introduced to improve its feeding value and keeping quality and thereby enhance animal performance.

On the other side, banana *(Musa acuminata)* and mango *(Mangifera indica L.)* residue can and should play significant role in the nutrition of ruminants. Banana is grown in almost all farms in the humid tropics and constitutes one of the staple foods for human consumption. Banana residue includes leaves, young stalks and pseudo-stems, which remain behind after removal of the bunch for food. The vegetative part of the plant, the pseudo-stems and leaves, contains more than 60% of the dry matter of the whole plant (Garcia *et al.,* 1991). Banana leaf has moderate CP content (about 15%) while the pseudo-stem is rich in fermentable energy (Ffoulkes et al., 1978). Banana leaves and pseudo-stems have also relatively moderate digestibility (65% and 75%, respectively) (Ffoulkes et al., 1978).Thus, banana leaves and pseudo-stems can be used as supplementary feeds to pasture and crop residue based diets. The banana plant has a high yield of total biomass. The residual biomass (leaves and pseudo-stem) yield could be as high as 13 to 20 tons of DM/ha in a year (Ffoulkes et al., 1978). However, banana residue (mainly leaf and pseudo-stems) are bulky feed resources due to its high moisture content (85-90%), which limits its utilization (Ffoulkes et al., 1977). It is important to look for appropriate techniques to extend the shelf life of the residue and improve its utilization.

Mango is the most important tropical fruit crop after banana and plantains. Mango peels can be used as livestock feed either as fresh, dried or ensiled with other feeds.

Unlike banana residue mango peel has high sugar content (13.2 %), which makes it palatable to ruminants, and can be considered as an energy supplement. Mango residues have been used as additives for ensiling more conventional materials to achieve proper indexes in the silos (Rego *et al*. 2010). Sugar is essential for good silage fermentation needed by bacteria. The ripe pulp of mango is rich in soluble sugars (70-90%), most of it fructose (60-67% of soluble sugars) (Kansci et al., 2008). The use of mango wastes in livestock feeding is a way of reducing environmental concerns (Jedele et al., 2003; El-Kholy et al., 2008). The fruit which could be considered unfit for human consumption due to bruises, infections, improper handling, and activities of animals (especially birds) on the fruit, and as such rejected (Valdez *et al*., 2012) can be used as animal feed. These rejected fruits, also known as cull fruits (Sruamsiri and Silman, 2009) litter the ground during its season, constituting environmental hazard. Emphasis on the processing of mango fruit has been to generate products for human consumption. Even value addition to the rejected fruit has been done with more attention given to generation of products for human consumption.

The fresh by-product of mango juice extraction (mixture of peels, kernels and cull fruits) was found to have a higher energy value than maize silage and could partly replace energy concentrates in diets for ruminants (Azervedet al., 2011). Making silage from agricultural by-products like banana and mango is a proven system, which offers considerable potential to improve farm incomes and profits.

Gamo Gofa is one of the zones in the Southern Nation Nationalities People Regional State (SNNPR). The zone holds 10-12% of the total ruminant livestock population and 47% of the total fruits (mainly banana and mango) coverage of the region. During the dry season there is inadequacy of grazing resources as a result animals are not able to meet even their

maintenance requirements and lose weight substantially. Although the area has potential for banana and mango plant production, most of its residues are poorly utilized and wasted. The residues are not well utilized as animal feed by livestock producers, and there is no tradition to preserve the feed for dry season. Most of banana and mango residue is left in the fields after the harvest, and/or disposed around roads and lake side, which pollutes the environment. There is miss-understanding about the use of banana and mango residue as animal feed and lack of awareness and experience on suitable technological innovations to improve the feeding and keeping quality of the residue. The findings of this action research will help livestock producers and fatteners to use banana and mango residues efficiently and there by improve livestock productivity. It helps livestock extension staff and policy makers to scale out the technology to other areas which have potential in livestock and fruits production within the zone and beyond. The objectives of the current study were:

- To assess the experiences of banana and mango residue utilization in Arba Minch Zuria district of Gamo Gofa zone, SNNPR.
- To assess the effect of using mango residues as an additive on banana silage quality
- To evaluate the effect of feeding banana residues silage on growth performance of indigenous sheep

2. Literature review

2.1. Over view of feed resources in Ethiopia

In Ethiopia there are various feed resources, however, there is variation in type and quantity of the resources which is mainly attributed to environmental conditions and other factors. The major livestock feed resources in the country are natural grazing and browse, crop residues, improved pasture, forage crops and agro-industrial by-products. Currently, crop residues and natural pasture are the main feed resources in the country (Alemayehu, 2005).

During the dry season livestock feed shortage as well as nutrient deficiency is the most prevailing problem. In most areas of the lowland as well as the highland areas of the country there is considerable fluctuation in forage quantity and quality in the different seasons (Teferra and Abaye, 1995). The greater lignin content and low in nutritive value (McDonald *et al*., 2002 Masiiwa, 1998) as well as low in CP content and low digestibility (Ranjhan, 1997) are the most prominent characteristics of crop residues which usually affect their intake and animal productivity.

On the other hand, natural pastures are the largest feed resource, but estimates of the contribution of this feed resource vary greatly (Alemayehu, 1998). Natural pastures include annual and perennial species of grasses, forbs and trees.

2.2. Role of Sheep Production in Ethiopia

In Ethiopia, sheep are reared mainly by smallholder farmers and grazed in small flocks most often on communal open natural pasture (CSA, 2004). The diverse sheep genetic resource of Ethiopia is distributed in the highland and lowland areas. Although the production potential of different indigenous sheep breeds has not been adequately studied, the available limited

information indicates that indigenous sheep breeds have small body size, produce low quality wool, have low lamb growth rate and low carcass weight (Markos *et al.,* 2006). The annual off take rate of sheep flock in Ethiopia was estimated to be 33% (EPA, 2002), with an average weight of about 10 kg (FAO, 2001; CSA, 2004) which is the second lowest in Sub Saharan Africa. Various recent research reports also agree with this fact. Awet (2007), Mulu *et al.* (2008), Abebe (2008) and Tesfay and Solomon (2008) reported carcass yield of 9.7, 9.6, 10.8 and 9.6 kg in different indigenous breeds of sheep on different types of feeds, respectively. It is estimated that most of the local sheep breeds have a very low post weaning average body weight of 15-20 kg (Awigichew, 2000). This shows that there is scope for improvement through management practice such as improved feeding and veterinary service. Even if the productivity of indigenous breeds is low compared with temperate breeds, their ability to survive and produce in the harsh and mostly unpredictable tropical environment is remarkable. In mixed crop-livestock system, sheep represents less than 10% of farm capital invested in livestock, yet contribute as much as 23-63% to the net cash income and 19-23% to the food subsistence value derived from livestock production (Zelalem and Fletcher, 1991). The total mutton produced in the country is 551,000 metric tons and small ruminant meat export from Ethiopia is 21,000 metric tons (FAO, 2006). Small ruminants are useful to rural households during periods of cyclical and unpredictable food shortages. The small size and early maturity of sheep give them several distinct economic advantages in smallholder farming situations, such as that found in Ethiopia. They can efficiently utilize marginal and small plots of land; the risk on investment is reduced by smaller individual size, allowing more production units per unit of investment; and there is a faster turnover of capital because they mature early and younger at slaughter (Chipman, 2003).

2.3. Major constraints of sheep production

Lack of adequate feed resources as the main constraint to animal production is more pronounced in the mixed crop-livestock systems, where most of the cultivated areas and high human population are located (Sisay, 2006). The problem of good quality and quantity feeds observed in lowlands where pastureland seems relatively abundant. There is a great seasonal variation of quality and quantity of feed resources in most part of the country. According to Alemayahu (1998), there is excessive supply of feed during the rainy season which is usually followed by a deficit in grazing in the following dry season. On the other hand, the allocation of more land for crop production resulted in availability of crop residues as alternative feed, particularly in the smallholder livestock production system. In central rift valley, feed shortage was reported as one of the limiting factors in small ruminant productivity (Abule, 1998). In these areas where there are few rainy months with limited rainfall of erratic nature feed production for small ruminants is inadequate. In southern part of the country, although the degree of shortage varies within farming systems/agro-ecologies feed shortage is reported as a major constraint for small ruminant production (Endeshaw, 2007 and Getahun, 2008).

Seasonal fluctuations of feed resources in the tropics follow the pattern of vegetation growth that is affected by the availability of rainfall. This resulted in a seasonal pattern of wet season gain and dry season loss of live weight. Seasonal fluctuations in the availability and the poor quality of feeds are considered to be the main constraints on sheep production in arid regions (Guada, 1989). In spite of this, the productivity of livestock is low mainly due to several factors such as genetic make-up, poor nutrition and poor veterinary care.

Another serious constraint for small ruminant production in Ethiopia has been the high prevalence of diseases and parasites. This causes high mortality amongst kids and lambs,

diminishing the benefits of their high reproductive performance (Solomon *et al*., 1995; Yohannes *et al*., 1995; Solomon and Gemeda, 2000; Markos, 2006). Tsetse flies, with the highest infestation in the humid and sub humid zones, are also major problems in these areas. Further losses are caused by abortions and stillbirths (Getahun, 2008; Markos, 2006). Other diseases that have limited the productivity of small ruminants in Ethiopia include pneumonia, Contagious Caprine Pleuropneumonia, Ecthyma, Caseous Lymphadenitis and Brucellosis. Individually, these diseases might not constitute serious problems, but combinations of them or their occurrence under marginal conditions could result in serious losses (Markos, 2006; Tsedeke, 2007).

The indigenous sheep and goat are year round breeders and mating is not controlled. However, the current off take rate is very low (Markos, 2006). In Ethiopia, the marketing of livestock and livestock products is underdeveloped. The major problems are the traditional management systems which are not market oriented, underdeveloped marketing systems and poor infrastructure, poor financial facility, and presence of cross-border trade (Azage *et al.*, 2006, Berhanu *et al*., 2007).

2.4. Banana residues for ruminant animal feeding

Banana leaves and pseudostems are a by-product of banana production. Banana leaves and pseudostems can be fed to animals in fresh, ensiled or dried form (Ecoport, 2010; Ecocrop, 2010). Banana production yields large quantities of forage biomass. For an average crop fruiting 1.5 times a year, forage biomass can amount to 13t/ha/year (Ffoulkes et al., 1977). They can be found in all tropical and subtropical regions of Asia, America, Africa and Australia where bananas are grown. Although it would appear that the ruminants are well suited to use the vegetative parts and peels of bananas and plantains, the amount of

experimental work reported on the feeding of these products to ruminants is surprisingly less than that carried out with pigs. In 1981, Bo Göhl reported that banana leaves could be used as emergency feed for ruminants, but that the digestibility decreased as the level of banana leaves increased in the ration. He further stated that the pseudostems could be fed fresh, but that chopped ensiled pseudostems enriched with readily fermentable carbohydrates was the best way of feeding them to ruminants.

Foulkes and Preston (1978) reported that the dry matter of banana leaves and pseudostems was relatively digestible for ruminants, i.e.; 65% digestibility for leaves and 75% for the pseudostems. However, despite this apparently high DM digestibility, the leaves and pseudostems alone can barely meet the maintenance requirements of ruminants. They recommended that urea and a highly digestible forage or sweet potato foliage should be used as supplements to pseudostems or leaves being fed. In fact, it has been well established that the greatest limitation to using bananas as a feed for ruminants is the lack of fermentable nitrogen and hence banana diets must always be supplemented with a source of nitrogen such as urea. Perez and Roldan (1984) further clarified this situation when they compared banana diets fed with and without cotton seed cake to cattle in Colombia. Dehydrated, green, milled banana (banana pulp flour) has been successfully used as a source of starch in the preparation of calf feeds and specifically in the manufacture of milk replacers. In Ecuador, Spiro (1973) Rihs *et al*. (1975) tested various levels of banana flour in ruminant diets and found that banana flour could successfully replace up to 50% of the cereal in the feeds of young growing and finishing cattle.

Chenost *et al*. (1971) and Geoffroy and Chenost (1973) carried out digestibility trials on goats in cages and reported that when bananas and forages were offered *ad lib*. separately, the kids

consumed bananas at a level amounting to about 20–40% of their ingested dry matter. When the two were blended together, the dry matter and digestible organic matter rose sharply as the content of bananas increased in the ration from 0 to 20%. Also, the DM intake was greater when ensiled rather than fresh green bananas were fed. Banana leaves and pseudostems can be fed to animals in fresh, ensiled or dried form (Ecoport, 2010; Ecocrop, 2010, 210).

2.4.1. Banana fruits

Banana *(Musa acuminata)* is a fruit crop mostly found in the humid and sub humid tropics as human food. It has a considerable potential for use as food and feed crop as it produces starch-rich fruits for human consumption and leaves, pseudo-stems and peelings that could be used as important sources of animal feed. About 30−40 percent of the total banana production is rejected for failing to meet quality standards and is potentially available for feeding to livestock (Babatunde, 1992).

2.4.2. Banana waste

Banana wastes include small-sized, damaged bananas, banana peels, leaves, young stalks and pseudo stems, which can be fed to livestock. Fresh plantain and banana fruits may be ensiled with molasses, grass, legumes, rice bran etc. Green fruits are easier to ensile than ripe fruits. The leaves have moderately high CP content (about 17.6%) while the pseudo-stem is rich in fermentable energy. Banana leaves and pseudo-stems can be used as supplementary feeds to pasture and crop residue based diets. The banana plant has a high yield of total biomass. The residual biomass (leaves and pseudo stem) yield could be as high as 13 to 20 tons of DM/ha in a year (Ffoulkes et al., 1978). The fully expanded lower leaves of the banana plant can be harvested and fed to animals almost throughout the year without adverse effects on its fruit

production. Banana leaves and pseudo-stems have relatively high digestibility of 65% and 75%, respectively. Intake of large amount of water in fresh pseudo-stem may decrease the capacity of the animal to raise its DM intake. The low CP content of the pseudo-stem is another factor contributing to its low DM intake. On the other hand, the difference in DM intake could partly explain the differences in DM digestibility between the leaf and the pseudo-stem of the banana plant.

2.4.3. Leaves, young stalks and pseudo stems

Whole, fresh banana leaves, stalks and pseudo stems are chopped and directly fed either fresh, sun-dried or ensiled with molasses in many tropical countries. Pseudo stems are easily ensiled if chopped and mixed with molasses or rice bran. Banana leaves contain about 15 percent DM and 10−17 percent CP, while pseudo stems contain 5−8 percent DM and 3−5 percent CP. The NDF and ADF vary between 50−70 percent and 30−40 percent, respectively. Banana leaves contain 8 percent polyphenols, but very few condensed tannins (Marie-Magdeleine *et al.*, 2010). The organic matter (OM) digestibility of pseudo stems is higher than that of leaves (Foulkes and Preston, 1978) mainly because the erectness of pseudo stems is primarily due to the presence of water in the cells, and not because of the presence of lignin in the cell wall. The high tannin content of leaves may also be responsible for low digestibility (Marie-Magdeleine *et al.*, 2010). Banana leaf meal (leaves chopped and sun dried) up to 40 percent in the forage based ration on DM basis increased weight gains and feed efficiency of Zebu cattle and sheep (Garcia et al., 1973). Fresh banana foliage up to 15 percent (El-Ghani, 1999); dried foliage ensiled with dried broiler litter in a 40:60 ratio and rehydrated with either molasses or whey, included at percent (Khattab *et al.*, 2000), foliage and wheat straw (75:25) ensiled with

molasses and urea (Baloch *et al.*, 1988) could replace 50 percent of green maize in the rations of lactating cows/buffaloes without altering milk production.

Table1. The chemical composition of banana leave and pseudo steam

Feedstuff	Chemical composition						
	DM	CP	CF	EE	Ash	NFE	Digestibility
Leaves	27.1	16.1	23.7	8.4	9.4	42.2	64
Banana whole plant	18.5	3.7	28.0	3.6	17.8	46.9	62

Source: Devendra (1992); Dixon and Egan, (1987)

2.5. Mango

Mango *(Mangifera indica L.)* is the most important tropical fruit crop after bananas and plantains (FAO, 2011). The mango fruit is a large fleshy drupe, highly variable in size, shape, color and taste and weighing up to 1 kg in some cultivars. Green when unripe, the fruit turns orange-reddish as it ripens after 3 to 6 months. The fruit consists of a woody endocarp (pit), a resinous edible mesocarp (flesh) and a thick exocarp (peel). Mango processing yields is about 40-50% of by-products, which can be used to feed livestock (de la Cruz Medina et al., 2002; Sruamsiri et al., 2009). These by-products are also potential sources of pectins and phenolic compounds (antioxidants) (Berardini et al., 2005). Mango by-products include:

• Cull fruits: fresh fruits unsuitable for human consumption.

• Mango seeds (pits, stones): the seed represents from 20% to 60% of the whole fruit weight, depending on the mango variety. Ground mango seeds can be called mango seed meal.

• Mango seed kernels (mango kernels): the kernel inside the seed represents from 45% to 75% of the whole seed (Maisuthisakul et al., 2009). Ground mango kernels can be called mango kernel meal.

• Deoiled mango kernel meal (deoiled mango seed kernel meal) is the by-product of the extraction of mango oil from the kernels. This product contains only residual oil, unlike mango kernels or seeds.

• Mango peels: the peels represent 7-24% of the whole fruit weight (Berardini et al., 2005).

• Mango waste: mango processing units yield mango wastes made of variable proportions of peels, pulp, seeds, and cull fruits.

Fresh mangoes spoil rapidly, and several methods for ensiling them have been proposed. In one method, immature fruits are sliced and ensiled with 1% salt in 1.5 m (Göhl) 1982. In another method, mangoes are cut into 1.5 cm slices and ensiled for 30 days with maize stover, molasses and urea (Aguilera et al., 1997) pits lined with large leaves. The pits are then tightly covered with leaves and soil.

2.5.1. Mango fruits, peels and processing by-products

The chemical composition of mango processing by-products is extremely variable. There are about 1000 mango varieties with different proportions of seeds, hulls, pulp, peels and sugar content. Moreover, mango by-products contain variable (and often unknown) amounts of fruit components. It is, therefore, difficult to provide accurate or even representative compositions for mango by-products. As a rule they are generally poor (<10% DM) or very poor (<5% DM) in protein. Unripe mango pulp contains starch that turns into sugar when the fruit ripens. The ripe pulp is rich in soluble sugars (70-90%), most of it fructose (60-67% of soluble sugars) (Kansci et al., 2008). The fiber content is highly dependent on the amount of seeds present it the product: the crude fiber content of peels and pulp ranges from 2 to 16% while mango

waste from juice extraction (that contains peels, pulp, whole seeds and whole fruit) has ADF values over 20% DM.

2.5.2. Mango seeds and kernels

Mango seeds can be used fresh, dried or ensiled and ruminants can tolerate concentrates with up to 50% mango seed kernels without adverse effects (Göhl, 1982). In an experiment with sheep, DM digestibility of dried seed kernels was found to be 70% but intake was rather low (1.2% LW). The mango seed kernels showed low palatability probably due to the tannin content. When offered (Sanon et al., 2013). However, a limited amount of kernels (<10%) mixed with mango peels, rice straw and supplemented with urea would be able to sustain 50 g DWG in sheep (20kg LW) (Sanon et al., 2013; Sanon et al., 2010). *ad libitum* to sheep, mango seed kernel intake varied.

2.5.3. Mango peels

Mango by products can be used as livestock feed (de la Cruz Medina & Garcia 2002; Sruamsiri & Silman 2009) as they have a higher energy value than maize silage and could partly replace energy concentrations in diets for ruminants (Azevêdo et al. 2011). Mango peels are especially palatable to ruminants because of their high sugar content. A recent study showed that mango peels have promising potential for utilization as feed or feed additives due to their *in vitro* digestibility, chemical composition and favorable volatile fatty acid (VFA) composition and have the potential to attenuate rumen methanogenesis, thereby greenhouse gas emissions (methane) can be reduced (Geerkens et al. 2013). However, high moisture and acidity of fresh peels may limit their use (Sruamsiri & Silman 2009). In addition, supplementation of nitrogen or protein source to peels is necessary to allow an efficient

utilization of energy since they contain low protein. Fermentation can greatly influence the nutritional composition of mango peels. An increase in the protein content and a decrease in the levels of antinutrients such as tannins and phytate were observed upon fermentation of the ripe mango peels (Ojokoh 2007). In addition, fermentation enhances the nutrient, vitamins, essential amino acids and fibre digestibility. Low quality of non fermented agro-byproducts can be upgraded after fermentation with selective microorganisms and such fermented products could be used as healthy animal feed. In an experiment with sheep, DM digestibility of dried mango peels was found to be 74% and the mango peels intake reached 2% live weight (Sanon et al., 2010). Napier-bajra hybrid grass could be ensiled with of 10% mango peel west instead of 2% molasses without affecting the quality of silage (Bandeswaran, 2007).

Table 2. Composition of ripe mango by-products

Mango by-product	DM (%)	% of DM					GE
		CP	CF	EE	NDF	ADF	(kcal/g DM)
Mango peel	20.10	4.68	10.10	1.21	25.87	19.14	3,827

Sompong et al. (2009)

2.5.4. Mango wastes

The fresh by-product of mango juice extraction (mixture of peels, stones and cull fruits) was found to have a higher energy value than maize silage and could partly replace energy concentrates in diets for ruminants (Azevêdo et al., 2011). In sheep, supplementing elephant grass silage with increasing amounts (up to 16% of the DMI) of dried mango juice extraction by-product improved the chemical composition of the diet but not its nutritive value, as it reduced intake and the digestibility of some nutrients (Rêgo et al, 2010). A mixture of peels and seed kernels gave a higher intake than peels and kernels separately (Sanon et al., 2010). The edible pulp makes up 33–85 percent of the fresh fruit, while the peel and the kernel

amount to 7–24 percent and 9–40 percent, respectively, on a fresh weight basis (Wu et al, 1993). The by-products/wastes available after processing of mango includes cull fruits (fresh fruits unsuitable for human consumption), mango kernel meal (containing 6−16 percent mango oil on DM basis), deoiled mango kernel meal and mango peels.

2.6. Silage Making

Silage refers to crop residues or agricultural by products preserved by acids, either artificially added or produced by natural preservation in the absence of air (John, 2005). Ensiling is a more practical alternative when weather conditions preclude sun-drying. This process involves the bacterial fermentation of carbohydrates under anaerobic conditions whereby fatty acids especially lactic acid are produced which causes a decrease in the pH. Silage making is a way of preserving succulent roughage and high quality feed for later feeding. Its main uses include saving surplus forage during season of abundance that would otherwise be wasted, damaged or lost because of insufficient number of livestock for utilizing the forage. Silage is a material produced by controlled fermentation of a crop of high moisture content (McDonalds et al., 1995). Besides saving surplus of forage, silage making has an advantage of minimum loss of nutrients in the harvesting and conserving processes and less weather dependency (Horrocks and Vallentine, 1999).

2.7. The potential use of silage

In order to increase the durability of feed there are several conservation techniques today being used in a modern farming systems. Sun drying, artificial drying, and addition of acids are the most common ones and are effective storage methods when it comes to avoiding feed scarcity during periods when feed resources are being limited. However, hay making in the

tropics can be difficult because at the time when the forage is of good quality for conservation (early in the wet season), the weather is likely to be too unpredictable for sun drying. Artificial drying is too expensive and the facilities are not available. Fermentation with the addition of acids is beyond the resources of smallholders and can be dangerous to handle (FAO, 2012). Fermentation only using naturally produced acids is however a convenient and economical alternative for ensuring constant availability of feed resources for the smallholders. Yet, fermentation without additives places greater demand on the moisture content, the chemical composition and the management of the silage material. The strong correlation between the fermentation process and the nutritional values of the fermented feed make factors like silo packing speed, chop length, silage pack density and silo management during storage and feed-out, of great importance in order succeed (Kung and Shavers, 2001). Secondly, the quality of the ensiled product also depends on the properties of the fresh material. Silage making using only naturally present bacteria is preferably practiced with materials having a low buffering capacity, a DM content higher than 20%, and with naturally occurring lactic acid fermentative microorganisms present (FAO, 2012). Additionally, in order to achieve a rapid lowering of the pH and restrict the activities of undesirable bacteria without losing nutrients, the concentration of easily fermentable carbohydrates is another factor of great importance (FAO, 2012). Also, in order for the ensiling system to be worthwhile to the low income, small-scale farmer it must have a low investment cost, uncomplicated technology, give rapid and significant returns on investment and be reliable and repeatable (FAO, 2012). Banana crop residues are likely to ferment successfully when the moisture content is reduced to below 70% prior to ensiling and a fermentable carbohydrate source such as molasses is added.

3. Materials and methods

3.1. Description of the study area

The study was conducted in Arba Minch Zuria district of Gamo Gofa Zone in the Southern Nation and Nationality Peoples Regional State (SNNPRS). The study area was selected based on its potential on livestock and irrigated agriculture commodities by the Livestock and Irrigation Value Chain for Ethiopian Smallholders (LIVES) Project (www.lives-ethiopia.org). The area is situated with an astronomical location of roughly $5^{o}70"$-$6^{o}21"$N latitude and $37^{o}31"$-$37^{o}67"$E longitude lines found in Great Rift Valley. According to CSA (2007), the district has a total area of 1214.1sq.km with the population of 164,529 and consists of 25 kebeles. The area receives 800-1200 mm of rainfall annually, and it has an average of 16^{0}C, 26^{0}C and 37^{0}C of minimum, medium and maximum temperature, respectively, with an altitude of 1200-3310 m above sea level. Climatically, the district is classified in to three ecological zones i.e. Dega (temperate), Woina-dega (sub-temperate) & Kola (tropical) which comprise 30.1%, 41.44%, & 28.46% respectively. The district is located at about 500 kilometers south of Addis Ababa and 272km to the west of regional capital (Hawassa). With mixed crops grown in the area included cereals such as maize, teff and wheat, fruits such as banana and mango, and root crops such as cassava and yam.

3.2. Study design, sampling and data collection procedures

This study has three parts. The first part was survey which assesses the potential, experiences, challenges and opportunities of banana and mango residues utilization as livestock feed in the study area. The second part was silage making from banana using mango residues as an additive and evaluation of its quality (*in vitro*). The third part of the study was assessing the effect of feeding banana silage on growth performance of indigenous sheep.

3.2.1. Assessment of the experiences of banana and mango residues as feed for sheep

Arba Minch district has 25 kebeles out of which 10 kebeles are producing banana and mango. Thus, based on secondary data source four potential kebeles were selected purposively for the study. For household survey the criteria for selection of household was availability of banana and mango farm, experience in sheep farming, and gender where about 50% of the sampled households were women (female headed or actively engaged women with in male headed households). Thus, one hundred twenty respondents (30 from each kebeles) were purposively selected based on the criteria listed above for the study. Information on this part of the study was collected by interviewing sampled households using structured open-ended questionnaire and focus group discussions. A total of 4 group discussions (8 participants from each kebele) were conducted (one per kebele) involving households with banana and mango farm and engaged in sheep production. The farms were both rain-fed and irrigated. About 40-50% of the focus group participants were women.

3.3. Suitability of silage making from banana and mango residues

3.3.1. Silage preparation and treatments

For silage making, banana and mango residues were collected from the farm of the households at the time of harvest. Banana residue (leaf and pseudo stem) were chopped manually to a

length of approximately 2 cm in order to obtain well-packed material. The chopped material was allowed to wilt for about 8 h until its moisture content was reduced to 65% (Sheikh, 1989). Mango residue was used as an additive in this study since it is a good source of soluble carbohydrate *(*Sruamsiri et al., 2009). Mango seed stone was removed from the ripe fruits and the remaining materials (peel and flesh) were chopped into about 1.5 cm lengths (Aguilera et al., 1997) and mixed with chopped banana residue to form treatments for silage experiment.

The treatments were formed from wilted and chopped banana residue (90%), and different proportion of molasses and mango (chopped and wilted) residue (Table 3).

Table 3. Treatments for silage experiment

Treatments	Proportion (%)				Replications
	Banana (wilted and chopped)	Molasses	Mango	Total	
1	90	0	10	100	3
2	90	2.5	7.5	100	3
3	90	5	5	100	3
4	90	7.5	2.5	100	3
5	90	10	0	100	3

Note: T1=banana residue silagewith10% mango, T2= banana residue silage with 7.5% mango and 2.5% molasses, T3= banana residue silage with 5% mango and 5% molasses, T4= banana residue silage with mango 2.5%and 7.5 molasses % and T5=banana residue silage with 10% molasses

Thus, chopped and wilted banana residue was mixed with additives (mango peel & flesh and molasses) according to the respective treatments described above (Table 1). For example for treatment 3, 5 % of molasses (Rahman et al., 2002) was used and mixed with wilted banana and rubbed by hand to ensure thorough mixture. For treatment 4, 7.5% molasses and 2.5% chopped mango fruit residue (peel and flesh) were mixed with chopped and wilted banana residue. The mixture of wilted banana residue and additive was then filled in to cylindrical

bucket with the capacity of 10 liters and then packed with a wooden stick. The cape of the cylindrical bucket was closed and additional double plastics were used. The mixture was pressed to remove air and then the bucket was closed. To make sure that there is no entry of air, plastic was used to cover the lid. The prepared silages (cylindrical buckets) were stored in a room for about 21 days. Each treatment was replicated 3 times.

3.3.2. Assessment of silage quality

After 21 days of ensiling, all the plastic pouches were opened for subjective and objective assessment of the quality. Visual and olfactory tests such as color, smell and presence or absence of mould was assessed and scored subjectively using experts with experience in the area. The silage samples of each treatment were removed completely and mixed thoroughly and a sample from each cylindrical bucket was taken for immediate pH and DM determination and the rest were stored at -21^{o}C in a deep freezer until analysis. Samples which were stored in a deep freeze were allowed to thaw overnight for preparation of samples for further analysis. Silage samples were dried at 40^{o}C in air-forced oven for 48 hrs and ground (Zereu et al., 2015) and ground using Thomas Willy mill (model 4) to pass through 1 mm sieve size and were used for chemical analysis and *in vitro* DM digestibility determination. The best silages (based on subjective and objective evaluation) were promoted for animal evaluation using sheep.

3.3.3. In vitro true dry matter digestibility measurements

In-vitro true dry matter digestibility (IVTDMD) of all samples was determined by ANKOM Technology- DAISY^{II} Incubator. About 0.25 g dried samples (ground to pass via 1 mm sieve size) were weighed in to ANKOM Filter bag (Ankom® Technology, # F57) and then incubated in the ANKOM jars containing rumen fluid and medium mixture (solution A and B)

for 48 hours. The rumen fluid was collected from two fistulated sheep fed twice a day with a diet of grass hay and concentrate based on their daily requirements. Water was provided *ad libitum.* After incubating for 48 hrs, the filter bags were washed with tap water until it was clear, soaked with acetone and then further extracted with neutral detergent solution in the ANKOM^{200} fiber analyzer.

3.4. Feeding trial with sheep

3.4.1. Silage preparation for feeding trial

Based on subjective and *in-vitro* assessment 2 silage treatments (wilted and chopped banana combined with 10% mango, and 10% molasses) with good quality were selected and promoted for animal evaluation. Similar ensiling process was followed for this part of the study. Thus, this part of the experiment evaluated 3 independent treatments as presented in Table 4. Each household prepared silage with close supervision and guidance of the researcher. For the silage treatments, the material was tightly packed into double plastic bags, squeezed to remove residual air, and tied closed. Bags contained approximately 100 kg of wilted banana residue. The prepared silages (plastic bags) were stored in a room for protection from external damage for 21 days. At feeding time, material to be fed was harvested and bags were re-sealed to protect the entry of air. Samples of silage during opening of the bag were taken for determination of pH and DM by the procedure of Wilson and Wilkins (1972) and Zereu et al. (2015). Moreover, visual observations were made similar to *in-vitro* experiment. This part of the study was conducted at Shara PA of Arba Minch district.

3.4.2. Animals and management

A total of six households who were willing to participate in the study were identified from those involved in the first part of the study. The households allocated experimental animals for

the feeding trial. The households were trained and demonstrated on silage making, and briefed about the objective and importance of the silage. Each household contributed 3 healthy and uniform indigenous rams with initial body weight of 25.08 ± 1.05kg. Thus, the total number of animals was 18. Efforts were made to select uniform animals from the households. The animals were ear tagged, treated against internal and external parasites (ivermectin), and adapted to the experimental feeds and housing for 21 days. Initial body weight of the animals was taken using suspended balance.

3.4.3. Treatments and design

Dietary treatments included grazing on natural (communal/private) grazing lands and supplemented with two different type of banana silage (Table 4). The experiment consists of three treatments, which were replicated six times (a total of 18 animals). Animals were ear tagged and blocked by households. Treatments were assigned to each animal within a block randomly. The experiment was laid down using a Randomized Complete Block Design (RCBD). The actual experiment lasted 90 day.

Table 4. Dietary treatments

Treatments	Composition
1	Grazing on natural grazing lands alone
2	T1 + supplementation with silage at 1.5% of body weight (10% of mango additive)
3	T1+ supplementation with silage at 1.5% of body weight (10% of molasses additive)

3.4.4. Feeding, housing and watering management

The animals were grazing in communal grazing land for about seven hours/day during day time. During evening the animals were housed in traditional sheep house and restrained with rope to avoid movement and consumption of non-treatment feed resources. The pen/house of the animals was cleaned every day. The animals were given water three times per day (AM-before leaving for grazing, PM-after getting back from grazing and evening).

3.4.5. Feeding Trial

The feeding trial lasted for 90 days (without 21 days of adaptation period) during which the ram were supplemented with the experimental feeds at 1.5% (dry matter base) body weight, with amounts adjusted after determining BW and adjustments were made every 10 days.

The feed offered and refused were collected and weighed daily. Half of the daily feed offer was given at 7:00 am in the morning and the rest after the ram were back from grazing at 6:00 PM. Representative samples from each plastic bag of silage were collected throughout the experimental periods and stored for further analysis. Bulked refusal samples for the silage was stored in the refrigerator below -20^{o}C at the woreda veterinary clinic before it was brought weekly to Arba Minch University for DM determination and the refusal were taken in plastic bag in the same manner. The daily intake was computed by subtracting the refusal from what was offered. Early in the morning the daily feed offer was weighed early in the morning and prepared for the households. The refusals were collected every morning for each sheep.

Before undertaking the actual feeding trial the initial body weight of the sheep was taken based on the weight on the first two consecutive days and it was undertaken every ten days in order to understand the trend in body weight gain. The average daily live weight (LW) change was computed as the difference between the initial and final live weights divided by the

number of the days on the trial which is given as final weight minus the initial weight divided by total experimental days.

3.5. Grazing land sampling

The biomass yield of the grazing land was estimated after harvesting the feed using 1m*1m quadrant. Hence representative samples of the feed were collected from each quadrant four times per 21 days period until end of the trial period.

3.6. Chemical analysis

This was carried out at Hawassa University College of Agriculture Animal Nutrition laboratory and Arba Minch University chemistry laboratory. Chemical analyses were performed on dried and 1 mm sieve ground banana residues silages. The DM content of silage samples was determined by drying in air-forced oven at 40 ^{o}C for 48 hrs (Zereu et al., 2015). The total Nitrogen (N) content of all samples was determined by the Kjeldahl method (AOAC, 1990) and then crude protein (CP) content was calculated as N x 6.25. The ash content of the samples was determined by complete burning of the samples in a muffle furnace at 600 ^{o} C for 3 hours (AOAC, 1990). The neutral detergent fiber (NDF), acid detergent fiber (ADF) and acid detergent lignin (ADL) were determined according to procedures of Van Soest et al. (1991) by using filter-bag (Ankom® Technology, # F57) technique of ANKOM technology (ANKOM A200, ANKOM Technology, Macedon, New York 14502, USA).

The pH of silage samples was performed on water extracts using pH-meter. 20 gram silage sample was macerated in 180 ml of distilled water for 60 seconds using a blander. The extracts were filtered first with double cheese-cloth and then through Whatman No. 1 filter paper.

3.7. Statistical Analysis

The data collected from the survey was analyzed using descriptive statistics in Statistical Procedures for Social Sciences (SPSS) software version 16. Index was calculated for variables that were ranked. The data collected during the feeding trials were analysed using the General Linear Model (GLM) procedure of ANOVA in SAS (2004). Tukey's Test was used to determine the statistical significances among treatment means. The following statistical models were used to analyze the data.

- For chemical composition and IVTDMD of silage samples

Yijk=u+Ai+eijk Where: Yijk = response variable; μ = overall mean; Ai= treatment effect; Eijk = random error,

- For feeding trial

$y_{ijk} = \mu + A_i + R_{ij} + e_{ijk}$ Where: Yijk = response variable; μ = overall mean; Ai= treatment effect; Rij=Block (Household);

Eijk = random error,

4. Results

4.1. Household characteristics

The age structure & household size of sampled households in the study area is presented in Table 5. The age range of most of the respondent family member was 16-60. The average household size of the respondents was 6.5 where it was the highest for in *Shara* and lowest for *Zyse Ellgo* kebele.

Table5. Age structure and household size of respondents in the selected kebeles of Arba Minch zuria woreda

Age range (year)	Kebeles								Over all	
	GCO		Zyse ellgo		Shara		Lante			
	n=30	(%)	n=30	(%)	n=30	(%)	n=30	(%)	N=120	(%)
< 6	42	20.2	13	8.3	28	11.9	21	11.4	104	13.27
6-9	64	30.8	33	21.2	25	10.6	32	17.3	154	19.64
10-15	15	7.2	39	25.0	49	20.9	19	10.3	122	15.56
16-60	87	41.8	64	41.0	122	51.9	104	56.2	377	48.09
>60	0	0.0	7	4.5	11	4.7	9	4.9	27	3.44
Male Total	111	53.4	80	51.3	128	54.5	94	51	413	52.67
Female Total	97	46.6	76	48.7	107	45.5	91	49	371	47.32
Total	208	100	156	100	235	100	185	100	784	100
Average HH size	6.9		5.2		7.8		6.2		6.5	

NB: GCO=Ganta canchma ochole

4.1.1. Livestock population

Livestock population of the sampled kebeles of Arba Minch zuria woreda is presented in Table 6. The overall mean number of cattle, goat, sheep, equine and poultry owned by the sampled households was 7.51, 5.14, 2.37, 0.46 and 5.66, respectively. The mean holding of cattle and poultry was the highest for households in Zyse ellgo while the mean holding of goat, sheep and equine was the highest for households in GCO kebele.

Table 6: The mean (± SE) livestock holdings per household in Arba Minch Zuria woreda

Species	Kebeles				
	GCO	Zyse ellgo	Shara	Lante	Over all
	Mean	Mean	Mean	Mean	Mean
Cattle	7.5±0.42	13.9±0.67	3.03±0.16	5.6±0.34	7.51±0.42
Goat	9.9±0.39	3.43±0.2	2.43±0.2	4.8±0.28	5.14±0.28
Sheep	3.36±0.21	2.43±0.17	1.9±0.14	1.8±0.76	2.37±0.1
Equine	0.56±0.12	0.33±0.87	0.46±0.11	0.5±0.1	0.46±0.35
Poultry	5.6±0.3	7.53±0.4	4.83±0.28	4.7±0.33	5.66±0.19

NB: GCO=Ganta canchma ochole

4.1.2. Constraints of sheep production

The major constraints of sheep production in the study area are shown in Table 7. Feed and grazing land shortage followed by shortage of input and disease and parasites are the major constraints hindering sheep production in the study area.

Table 7: Sheep production constraints in the study area

Constraints	1st	2nd	3rd	4th	5th	Index
Feed and grazing land shortage	106	14	0	0	0	0.33
Inadequate or lack of input	9	70	30	11	0	0.24
Disease and parasite	3	30	51	36	0	0.20
Marketing problem	1	6	33	53	27	0.15
Labor shortage	1	0	6	20	93	0.09

NB: Index =sum of (5×number of HHs ranked first +4 ×number of HHs ranked second +3×number of HHs ranked third+2× number of HHs ranked fourth+1×number of HHs ranked fifth) for particular constraints divided by sum of (5×number of HHs ranked first +4 ×number of HHs ranked second +3×number of HHs ranked third+2× number of HHs ranked fourth+1×number of HHs ranked fifth) for all constraints.

4.1.3. Purpose of sheep production

The most common purpose for rearing sheep in the study area is depicted in Table 8. Accordingly, income followed by saving/asset are the major reasons for keeping sheep in the study area. However, keeping sheep for breeding and meat was ranked as the third and fourth in their importance.

Table 8. Purpose of sheep production in the study area

Reason	1st	2nd	3rd	4th	Index
Income source	101	17	2	0	0.38
Asset/saving	19	98	3	0	0.31
Breeding	0	1	70	49	0.16
Meat(home consumption)	0	4	45	71	0.14

NB: Index =sum of (4×number of HHs ranked first +3 ×number of HHs ranked second +2×number of HHs ranked third+1× number of HHs ranked fourth) divided by sum of (4×number of HHs ranked first +3 ×number of HHs ranked second +2×number of HHs ranked third+1× number of HHs ranked fourth+1) for all reasons.

4.1.4. Importance of sheep compared to other species of livestock

Table 9 indicates the importance of sheep compared to other livestock species as ranked by the sampled households in the studied area. Thus, sampled households prefer sheep than other livestock species because of the expected immediate return, easy to manage and high market demand. However, short gestation interval was ranked as the lowest criteria.

Table 9. Importance of sheep compared to other livestock

Importance	1st	2nd	3rd	4th	5th	Index
High market demand	23	5	84	4	4	0.22
Easy to manage& keep	19	94	0	7	0	0.27
Immediate returns	78	20	10	12	0	0.29
Appropriate to slaughter	0	1	12	4	103	0.08
Short gestation interval	0	0	14	93	13	0.13

NB: Index =sum of (5×number of HHs ranked first +4 ×number of HHs ranked second +3×number of HHs ranked third+2× number of HHs ranked fourth+1×number of HHs ranked fifth) divided by sum (5×number of HHs ranked first +4 ×number of HHs ranked second +3×number of HHs ranked third+2× number of HHs ranked fourth+1×number of HHs ranked fifth) for all importance.

4.1.5. Feed resources for sheep

The major sheep feed resources in the study area are presented in Table 10. Most of the respondents stated that during the wet season natural pasture was the main source of feed for sheep (I=0.33), followed by farm side grazing and feeding on rejected banana. During the dry season crop residue followed by road side grazing were the major sources of feed for sheep in

the study area. During this season, farmers provide crop residues such as maize stover in order to cope with the dry season feed shortage. However, none of the respondents reported use of preserved feed for dry seasons either in the form of silage or hay due to lack of experience for silage making and less availability of grass to prepare hay for dry season. Supplementation of agro-industrial by-products and improved forages for sheep was not practiced in the study area.

Table10. Major feed resources of sheep by season as ranked by the households in the study area

Major feed resources	**1st**	**2nd**	**3rd**	**4th**	**5th**	**Index**
Dry season						
Crop residue	118	2	0	0	0	0.33
Road side grazing	0	92	12	11	5	0.24
Rejected banana and mango	0	13	22	85	0	0.16
Industrial by products	0	8	3	13	96	0.09
Farm side grazing	2	5	83	11	19	0.18
Wet season						
Natural pasture	120	0	0	0	0	0.33
Road side grazing	0	3	8	74	35	0.12
Rejected banana	0	19	92	7	2	0.20
Industrial by products	0	0	5	34	81	0.09
Farm side grazing	0	98	15	5	2	0.25

NB: Index =sum of (5×number of HHs ranked first +4 ×number of HHs ranked second +3×number of HHs ranked third+2× number of HHs ranked fourth+1×number of HHs ranked fifth) divided by sum of (5×number of HHs ranked first +4 ×number of HHs ranked second +3×number of HHs ranked third+2× number of HHs ranked fourth+1×number of HHs ranked fifth) for all feed resources.

4.1.6. Assessment of experiences of banana and mango residues use as feed for sheep

According to sampled households, all of them (100%) across the four kebeles feed banana and mango residues to sheep, in a fresh form. The residues (banana and mango) were fed without any improvement. However, none of the respondents across the four selected kebeles had experience in preservation of banana residue as silage.

Table11. Banana and mango residue utilization practices in the study area

Utilization and feeding experience		Kebeles								Over all	
		GCO		Zyse ellgo		Shara		Lante			
		N=30	(%)	N=30	(%)	N=30	(%)	N=30	(%)	N=12	(%)
Feeding for sheep	Yes	30	100	30	100	30	100	30	100	120	100
	No	0	0	0	0	0	0	0	0	0	0
Feeding methods	Fresh	30	100	30	100	30	100	30	100	120	100
	Ensiled	0	0	0	0	0	0	0	0	0	0
Preservation methods	Ensiling	0	0	0	0	0	0	0	0	0	0
	Drying	0	0	0	0	0	0	0	0	0	0
Season	Excess	4	13	7	23	9	30	9	30	29	24.2
	Shortage	26	87	23	77	21	70	21	70	91	75.8

NB: GCO=Ganta canchama ochole

4.2. Silage making from banana and mango residues

The physical characteristic of silage making from different levels of banana, mango and molasses is presented in Table 12. All 5 silage treatments had yellow color and none of them had grown mold, which indicates suitability of silage making from banana and mango residue with better quality. Similarly, the odor of all silage treatments was pleasant with mango having fruity smell and molasses having sweet smell which could associated with the nature of the additives.

Table12. Physical characteristics of silage made from different levels of banana and mango residue

Treatment	Color	Odor	Mold
1	yellow color	Pleasant with fruity smell	No
2	yellow color	Pleasant with fruity smell	No
3	yellow color	Pleasant with sweet smell	No
4	yellow color	pleasant with sweet smell	No
5	yellow color	Pleasant with sweet smell	No

The effect of different proportion of molasses and mango residue on silage quality is shown in Table 13. Lower (P<0.05) pH values were found in T1 (10% mango additives) and T5 (10% molasses additive) compared with T2 and T3. Increasing level of molasses increased DM content while the reverse was observed with increasing level of mango. The ash content in T1 was significantly lower than that of T4 and T5 while T2 and T3 had intermediate value. There was no significant difference in CP, ADL and IVTDMD content of the silage among treatments. The NDF content for T5 was lower (P<0.05) than T2 but similar (P>0.05) with other treatments. T1 and T2 had significantly higher ADF compared with T4 and T5 while T5 had intermediate value.

Table13. Effect of ensiling with different levels of banana & mango residue on silage quality

Parameter	Treatments					SE
	T1	T2	T3	T4	T5	
pH	3.75^{b}	3.90^{a}	3.93^{a}	3.85^{ab}	3.76^{b}	0.04
DM (%)	26.05^{e}	26.30^{d}	26.70^{c}	27.00^{b}	27.22^{a}	0.07
Ash (% DM)	13.35^{b}	13.52^{ab}	13.80^{ab}	14.52^{a}	14.09^{a}	0.37
CP (% DM)	13.43	13.15	12.91	13.61	13.51	0.53
NDF (% DM)	35.28^{ab}	38.56^{a}	36.94^{ab}	32.60^{ab}	31.86^{b}	2.33
ADL (% DM)	2.35	2.77	3.05	2.73	2.16	0.61
ADF (% DM)	20.73^{a}	20.77^{a}	19.95^{ab}	17.06^{b}	17.02^{b}	1.29
IVTDMD (%)	76.86	78.83	74.53	78.60	81.63	3.37

NB: Means within rows with different superscript are significantly different (P<0.05). T1=banana residue silagewith10%mango,T2= banana residue silage with 7.5% mango and 2.5% molasses, T3= banana residue silage with 5% mango and 5% molasses, T4= banana residue silage with mango 2.5%and 7.5 molasses % and T5=banana residue silage with 10% molasses, S.E.: standard error; DM: Dry matter; CP: Crude protein; NDF: Neutral detergent fiber; ADF: Acid detergent fiber; ADL: Acid detergent lignin; IVTDMD: in vitro true DM digestibility

4.3. The effect of feeding banana silage on intake and growth performance

4.3.1. Chemical composition of experimental feeds

Chemical composition of silage used for feeding experiment is presented in Table 14. The silage had a yellow color, a pleasant odor, and was soft in texture. The pH of silage ranged

from 3.83 to 3.85. Some mold in the first batch of silage occurred at some farmers' field. The CP content of the silage in T3 and T2 were similar. T1 (natural pasture alone; control) was very low in CP content which indicates the need for supplementation if sheep are dependent on grazing.

Table 14: Chemical composition of treatment feeds (% DM, unless specified)

Variables	T1	T2	T3
pH	-	3.85	3.83
DM	92.34	92.19	92.05
Ash	15.27	11.32	13.52
CP	7.7	13.43	13.53
NDF	48.67	34.42	30.53
ADF	26.91	18.98	17.73
ADL	3.82	2.33	2.22

T1=Grazing; T2= banana residue silage with 10% mango and T3=banana residue silage with 10% molasses. DM=Dry matter; CP=crude protein; NDF=neutral detergent fiber; ADF=acid detergent fiber; ADL=acid-detergent lignin

4.3.2. Feed intake

The mean feed intake of grazing sheep supplemented silage made from different levels of banana and mango residue is presented in Table 15. There was no significant difference in feed dry matter, organic matter, and crude protein intake between the two treatments. Mean daily DM intake was comparable ($p>0.05$) between the mango and molasses groups, indicating the similar acceptability of both silages by the experimental sheep.

Table15. Intake (g/day) of grazing sheep supplemented with ensiled banana residue

Intake	Treatments			SE
	T1	T2	T3	
Dry matter	-	361.69	372.51	22.71
Organic matter	-	320.73	322.18	19.93
Crude protein	-	48.62	50.45	3.06
Neutral detergent fiber	-	124.60[a]	113.47[b]	7.42
Acid detergent fiber	-	68.85	65.86	4.17
Acid detergent lignin	-	8.39	8.10	0.50

Banana residue silage offered at 1.5% of body weight (dry matter). T1= Grazing, T2= banana residue and mango silage, T3= banana residue and molasses silage

4.3.3. Growth performance of experimental sheep

Total body weight gain, average daily weight gain and final weight of sheep fed banana residue silage are presented in Table16. The average daily body weight gain was the highest for sheep in T2 and T3 but lowest for sheep maintained under control.

Table-16: Body weights and average daily gain of the grazing sheep supplemented with ensiled banana residue.

Body weight changes	Treatments			SEM
	T1	T2	T3	
Initial body weight (kg)	25.25	24.56	25.43	1.05
Final body weight (kg)	29.00^{b}	30.13^{ab}	31.28^{a}	1.11
Total weight gain (kg)	3.75^{b}	5.56^{a}	5.85^{a}	0.48
Average daily gain (g/day)	41.66^{b}	61.85^{a}	65.00^{a}	5.36

NB: Means within rows with different superscript are significantly different (P<0.05) SEM: Standard error mean.

4.4. Discussion

4.4.1. Household characteristics

This study showed that the age range of most of respondents family member in the study area between 16 and 60 years which indicate that there is adequate labor force for market oriented agricultural development in the area. Household labour is an essential resource that influences management practices, enterprise combinations, labour hiring/sharing strategies and overall levels of technical and economic performance (ILCA, 1990). The amount of household labour available and the manner of labour allocation are critical to effectively carry out farm operation and influence livestock management techniques and adoption of improved technologies (ILCA, 1990; Addisu *et al.*, 1998). Farming communities of Arba Minch district, according to this study, have better chance of benefiting from the opportunities that could be derived from readily available family labor. This result is lower than average family size reported by Kebede (2010) and Wondatir (2010). The overall mean family size in the study area was higher than the national average (5.2) and SNNPR (5.1) as noted by CACC (2003). The family size in the present study is comparable to the value reported for Wolaita zone (6.9) (Tsedeke and Endrias, 2006) but it is lower than 7.5 persons per household which reported for Dale district of Sidama zone (Endeshaw, 2007). The average family size in the current study (6.5) is higher than5.7 persons reported by Workneh *et al.* (2002) for mixed farming area in east Ethiopia.

4.4.2. Livestock population

In the selected kebeles the most dominant livestock reared are cattle, poultry, goat and sheep, respectively. Most of the farmers in the district keep more than one species of domestic animals. The average sheep holding of the current study (2.37) is close to 2.95 reported by

Yilkal (2015) in Chencha and Mirab Abaya districts of Gamo Gofa zone. On the other hand, the mean sheep holdings in this study area was by far lower than 18.7 reported by Fsahatsion *et al.* (2013) in Gamo Gofa zone and 15.6 sheep/household reported by Agyemang *et al.* (1985) and 24.3 sheep reported by Abebe *et al.* (2000) for Debreberhan area. The difference might be attributed to differences in agro-ecology, farming/production system, species diversification etc.

4.4.3. Purpose of sheep keeping

According to Gatenby (1986), Ethiopia is one of the important sheep rearing countries in Africa. The primary reason of sheep keeping by sampled farmers in the study area is to generate income through the sale of live animals. The cash obtained from sale of animals might be used to buy clothing and food items, pay taxes, additional fertilizers to manures and household supplies (children schools). Consistent with the current findings, small ruminants are reared in many parts of the country mainly for income generation (Endeshaw, 2007; Tsedeke 2007; Getahun, 2008).The second main reason of sheep keeping in the study area is for saving. As indicted by respondents the importance of sheep compared to other livestock is due to its immediate return, easy to manage and accommodate sheep on a smaller area than large ruminants. The focus group discussants also revealed that sheep is an important source of saving similar to saving cash in a bank.

4.4.4. Major sheep production constraints

Feed scarcity is indicated as a factor responsible for the lower reproductive and growth performance of animals especially during the dry season (Legesse, 2008). The sheep production constraints have been prioritized in the woreda based on their severity. Feed and

grazing land shortage during the dry season was the major constraint of sheep production in the study area. The observations are in agreement with that of Keftasa (1996) who also indicated that shifting of grazing land into crop cultivation has dwindled the potential of the livestock in the area and also put immense pressure on the existing land. Shortage of grazing land, expansion of banana production, deterioration of natural resource and unreliable rainfall were the main factors contributing to the scarcity of feed in the areas. According to Agza *et al*. (2013), seasonality in availability of quality and quantity forage and absence of improved forage production practice to supplement the feed shortage has been a major constraint for livestock production in the study area. Berhanu *et al*. (2007) also reported that feed shortage is one of the most prominent constraints which have the potential to decrease the effectiveness of most productions. Feed is the main constraint limiting livestock productivity in the country at large (Alemayehu, 2005). There is seasonal fluctuation in feed supply both in quantity and quality. Feed shortage and nutrient deficiency are common during the dry season both in the highlands and the lowlands of the country (Alemayehu, 2005). During the focus group discussion, farmers pointed out that the main constraints to sheep production is feed scarcity and land shortage for production because of high human population growth and expansion of crop land. The most critical months were from December to April when virtually pastures could not carry the animals. This was due to the shortage of rainfall and the expansion of banana and mango production because the area has high potential for banana and mango production which minimized the land available for grazing. On the other hand, although these crops leave behind enormous quantity of leftovers as livestock feed, its utilization was poor for various reasons.

In Arba Minch Zuria Woreda due to the delay & infrequent rain in recent years there was a considerable fluctuation in the availability of grazing land as well as the quality of available forages. Also in the focus group discussion farmers pointed out that shrinking sizes of the grazing lands driven by the expansion of land cultivation was reported to be the leading reasons for feed shortage across all the study kebeles.

4.4.5. Major feed resources of sheep

As respondents indicated during household survey natural pasture and crop residue from maize are the main feed resources for sheep production in the study area. This is also true in other parts of the country. According to Alemayehu (2005), livestock are fed entirely on natural pasture and crop residues. Similarly, Tesfaye (2009) indicated that natural pasture is the main source of feed for livestock species in Ethiopia. The use of crop residues as feed source was also indicated by Assen & Aklilu (2012). The main feed resources in the dry and rainy season for sheep in the study area are different. Animals depend mainly on natural pastures for their feed requirements. Alemu, (1998) reported that due to poor management and overstocking, natural pastures are highly overgrazed resulting in severe land degradation, loss of valuable species and dominance by unpalatable species. In general crop residues and natural pasture are the major feed resources of the area which agree with the report of Tolera et al. (2012) who reported natural pasture and crop residue to be the major feed resources for highlands of Ethiopia. Some farmers feed agro-industrial by-products and rejected banana as supplement for fattening sheep during the dry season. Supplementation of agro-industrial by-products is rare and is commonly practiced only for fattening sheep particularly in urban and peri-urban areas where there is access for it. Similarly, many researchers (Tesfaye 2009; Funte

et al 2010; Hassen *et al* 2010) indicated that natural pasture were the main source of feed for livestock species in Ethiopia.

4.4.6. Assessment of the experiences of banana and mango residues as feed for sheep

Banana and mango residue is one of the common feed which is used by households in the woreda. According to the respondents banana and mango residues are fed to animals in dry season without any improvement due to lack of previous experience of improvement like physical (chopping in appropriate length and wilting) or biological (ensiling) treatments of banana residues although it has been used as the main feed source in the area during the dry seasons. There are large quantities of banana and mango crop residues available in the area with substantial potential for contributing to the livestock industry. However, after harvesting of fruit, the total crop residue produced is not utilized as animal feed as a whole. The larger proportion of the crop residue is being wasted in the field. It should be noted that the production of these residues is consistent across the different seasons, including the dry season, since both banana and mango crops are provided with supplementary irrigation during dry spell. There has been no feed conservation practice of these residues in the area. Although feed shortage is aggravated especially during the dry season in the study area, due to lack of feed preservation practices the performance of animals remained poor.

Fresh banana crop residues are used as animal feed in some tropical countries (Johri and Shrivastava, 1967). The nutrient content of banana leaves indicates that this forage is much better than many tropical types of forage found in Somalia (Yanelli, 1984). Although the current study area has potential for banana and mango production, most of its residues are poorly utilized and a large quantity of the pulp and peel of rejected fruits are wasted away. However, considering the high nutrients (energy, vitamin A, vitamin C and polyphenols) value

of mango fruits (FAO, 2011), these rejected fruits could serve as a feed resource in animal feeding, mainly as a source of energy because of its high energy constituent (3527.34 kcal/kg DM) (Porter, 2011).

Mango processing yields about 40-50% of by-products, which can be used to feed livestock (de la Cruz Medina et al., 2002; Sruamsiri et al., 2009). On the other hand, it can be estimated that mango processing yields between 150,000 and 400,000 t of wastes worldwide, which may cause environmental problems in the vicinity of the processing plants. The use of mango wastes in livestock feeding is a way of reducing environmental concerns (Jedele et al., 2003; El-Kholy et al., 2008). As indicted by respondent's banana and mango residues are not well utilized as animal feed by sheep producers, and there is no tradition to preserve the feed for dry season. Mango peels are especially palatable to ruminants because of their high sugar content. But, most of banana and mango residue is left in the fields after the harvest, and/or disposed around roads and lake side, which pollutes the environment. There is miss-understanding about the use of banana and mango residue as animal feed and lack of awareness and experience on suitable technological innovations to improve the feeding and keeping quality of the residue. However, a large portion of these crop residues are lost each year as a result of poor utilization. Constraints for poor utilization of these feed resources in animal feeding (mainly leaf and pseudo-stems of banana) are bulky feed resources due to its high moisture content (85-90%), which limits its utilization (Ffoulkes *et al.*, 1977). During focus group discussion farmers pointed out that the main constraints of banana residue utilization were its bulky nature since it contains high moisture mainly the pseudo-stems. If DM content of forages is below 20%, as in the case of young grazed grass, intake can be depressed due to increased volume of water in the rumen (Pasha *et al*., 1994).

4.4.7. Suitability of silage making from banana and mango residue: *In vitro* evaluation

The current study demonstrated suitability of silage making from banana and mango residues. Accordingly, the silage made from these residues had yellow color, pleasant odor, and was soft in texture. There was no mold occurred in all type silage treatment. This shows that the silage had good quality.

The pH of all silage treatments in the current study was within 3.5-4.2, which is optimal for well-preserved silages with low DM (Kaizer and Piltz, 2004). Nutrient losses and intake of silage by livestock are affected by the type of fermentation that occurs during ensiling (Kaizer and Piltz, 2004), which could be evaluated by silage fermentation quality parameters under laboratory conditions. One such silage fermentation quality parameter is pH (Kaya and Calsikan, 2010) which indicates the acidity of the material. Anaerobic fermentation of water soluble carbohydrates (WSCs) of ensiled forage crop by lactic acid bacteria in to lactic acid, lowers the pH of silage in to a level that inhibits the activities of plant enzyme. It was reported that mango peel is a low cost substrate for the production of lactic acid (Jawad et al. 2013). Similarly, low pH and improved fermentation of silage due to addition of molasses has been vastly reported. Sugar is essential for good silage fermentation. The ripe pulp of mango is rich in soluble sugars (70-90%), most of it is fructose (60-67% of soluble sugars) (Kansci et al., 2008). Mango residues have been used as additives for ensilaging more conventional materials to achieve proper indexes in the silos (Filho *et al*. 2010 and Rego *et al*. 2010). However, the achievement of desired pH is affected by DM, species/variety of the forage crop and type of fermentation occurred (Kaizer and Piltz, 2004). Banana crop residues are likely to ferment successfully when the moisture content is reduced to below 70% prior to ensiling and a

fermentable carbohydrate molasses is added (Sheikh, 1989). Addition of molasses improved the fermentable carbohydrates of grass fodder thus increasing the growth of lactic acid producing bacteria (Yunus et al., 2000). The significant pH concentration of silage indicated that both molasses and mango were utilized at similar rate for the growth of lactic acid bacteria and production of organic acids.

In addition, fermentation enhances the nutrient, vitamins, essential amino acids and fiber digestibility. Addition of molasses and mango lowered silage pH and increased DM with increasing level of molasses additives and decreased DM with increasing level of mango additives. DM was found in all additive level that differed significantly from other levels. The DM contents of all silage samples in the present study were lower than the recommended 30% DM optimum for good silage production (Titterton and Bareeba, 1999). The DM concentration of all treatments in banana silage was lower than ensiled banana residue (31.46%) observed by Sheikh (1989) and (28.19%) by Rahman et al (2002). The DM of silage in the current study was within the acceptable range of 24–67% for hay crop silages (Holmes and Muck, 2000).

Both molasses and mango silage had similar CP content which is related to the original chemical composition of banana leave before ensiling. Banana leaf has moderate CP content (about 15% and 16.1%) while the pseudo-stem is rich in fermentable energy (Ffoulkes and Preston, 1978; Devendra, 1992).

The decreased NDF and ADF contents with increasing levels of molasses and mango, in the current study, could have resulted from the low contents of these nutrients in the additives. According to Getu (2006), citing Singh and Oosting (1992) on the classification of roughages, these feeds can be classified into quality feeds (<45% NDF). NDF and ADF contents of

ensiled materials are low due to hemicelluloses degradation (Snyman and Joubert, 1995; Salamone et al., 2012; Taher-Maddah et al., 2012). Furthermore, Baytok et al. (2005) reported, decreased NDF and ADF contents with increasing level of molasses in corn silage, because of low NDF and ADF contents of molasses and increased fermentation resulted from the high sugar content of molasses and mango. The NDF and ADF contents of all additive treated silages were above the minimum of 30% and 19% respectively, required for healthy rumen of dairy cows (Target ,2002), except ADF of T4 and T5.

Banana leaves and pseudo-stems have also relatively better digestibility of 65% and 75%, respectively (Ffoulkes et al., 1978). The result of the current study is higher than the above result. The increased IVDMD of all treatments could also be attributed to its low cell wall contents as they are negatively related to it (Kamalak *et al*., 2004). Mango peels have promising potential for utilization as feed or feed additives due to their *in vitro* digestibility, chemical composition and favorable volatile fatty acid (VFA) composition and have the potential to attenuate rumen methanogenesis, thereby greenhouse gas emissions (methane) can be reduced (Geerkens et al.,2013). The lack of significant difference among all treatments in terms of CP, ADL and IVDMD implies that the additive can produce good quality silage.

4.4.8. Effect of silage feeding on performance of sheep (in vivo evaluation)

4.4.8.1. Chemical composition of experimental feeds

The silage used for animal evaluation in this part of the study was made at farmers field following the same procedures described for *in vitro* evaluation above. In this study too, the silage had a yellow color, had a pleasant odor, and was soft in texture. Some mold in the first batch of silage occurred at some farmers' field. This may have been related to inadequate

resealing of bags after obtaining silage for feeding, since the problem disappeared after the importance of preventing excessive air exposure was discussed with the farmers.

The DM concentration of banana silage across the treatments was comparable with fresh banana leaves (27.1%) reported by Devendra (1992) but lower than ensiled banana residue (31.46%) observed by Sheikh (1989) and (28.19%) Rahman et al (2002). The level of DM in silage was within the acceptable range of (24–67%) for hay crop silages (Holmes and Muck, 2000). The CP content in all treatments was lower than the (15.8%) reported for banana pseudostem and leaf ensiled with 5% molasses by Rahman et al, (2002) which could be due to varietal differences of the banana. The lower ash content in both silages was different from the result reported (21.50%) by Sheikh (1989). Concentrations of ADF in silage were lower than (41.2%) found by Rahman et al.,(2002) which may relate to differences in soil type and season (Norton, 1994) in addition to the possible variation in variety.

4.4.9. Feed intake and weight gain of sheep

The similarity in mean daily DM intake among the silage treatments in the current experiment indicates that there was no difference in acceptability of silages by the experimental animals. Silage intake (g/day) was comparable between both experimental groups. Silage intake was also increased across the different feeding weeks throughout the feeding trial. The rejected mango fruits could serve as a feed resource in animal feeding, mainly as a source of energy because of its high energy (3527.34 kcal/kg) DM (Porter, 2011). Mango peels are especially palatable to ruminants because of their high sugar content. Mango peels have promising potential for utilization as feed or feed additives due to their *in vitro* digestibility, chemical composition and favorable volatile fatty acid (VFA) composition and have the potential to attenuate rumen methanogenesis, thereby greenhouse gas emissions (methane) can be reduced

(Geerkens *et al*. 2013). Therefore, for optimum production, grazing animals should be supplemented with feeds such as banana residue with mango or molasses during the dry season as rumen degradability of banana leaves and pseudo stem is high (65% and 75%) (Ffoulkes *et al.,* 1978) and OM and DM disappearance follow the same pattern (Kimambo *et al.,* 1991). Banana leaves and pseudo stems can be fed to animals in fresh, ensiled or dried form (Ecoport, 2010). The DM intake was greater when ensiled rather than fresh green bananas were fed. Mango byproducts can be used as livestock feed (de la Cruz Medina & Garcia 2002; Sruamsiri & Silman 2009) as they have a higher energy value than maize silage and could partly replace energy concentrations in diets for ruminants (Azevêdo *et al.* 2011). Banana leaf meal could replace up to 15% of diet DM in growing pigs, resulting in satisfactory average daily gain and feed conversion (Garcia et al 1991). Geoffroy and Chenost (1973) carried out digestibility trials on goats in cages and reported that when bananas and forages were offered *ad libitum* separately, the kids consumed bananas at a level amounting to about 20–40% of their ingested dry matter.

In the present study, improvement in ADG was observed in supplemented sheep compared with those grazing natural pasture indicating that the nutrient supply from banana silage using mango and molasses additives was sufficient for satisfying growth requirement of yearling male sheep. Banana leaf meal (leaves chopped and sun dried) up to 40 percent in the forage based ration on DM basis increased weight gains and feed efficiency of Zebu cattle and sheep (Garcia *et al.,* 1973). The main reason for the relatively better average daily gain in the sheep supplemented with ensiled banana residue was due to the high intake of CP. Feed CP content of less than 8-10% DM may result in lower intake in mature sheep and cattle (Forbes, 2007). Crude protein, ether extract, calcium and phosphorous contents in the banana leaf were higher

than most of the grasses present in the natural grassland (Singh, 1980). The present result, a positive weight gain of sheep was maintained on the sheep supplemented with banana residue silages which showed us sufficient CP for growth requirement of sheep. In kids, green banana leaves could be included safely up to 25 % of the total diet protein (Hembade *et al.*, 2004). For optimum production, grazing animals should be given supplement such as molasses and mango silage during the dry season as rumen degradability of molasses and mango peels is high.

5. Conclusions and Recommendations

5.1. Conclusions

The current study showed that the main constraint which hinders sheep production in the study area is shortage of feed particularly during the dry season. Although there is experience in feeding banana and mango residue to sheep in the study area, there was no experience to preserve and conserve the feed to use during the period of feed scarcity. The *in vitro* study demonstrated suitability of silage making from banana residue with either mango or molasses additive. The feeding trial with sheep showed that feeding silage made from banana residue with either mango or molasses additives at 1.5% BW improved average daily body weight gain of sheep by about 48-56% compared to the control under grazing management alone.

5.2. Recommendations

Further research is recommended to evaluate all the in vitro combinations of additives on the performance of dairy animals.

6. References

Abebe Hailu. 2008. Supplementation of graded levels of concentrate mixture on feed intake, digestibility, body weight and carcass characteristcs of Washera sheep fed urea treated Rice straw An MSc. Thesis presented to school of Graduate studies of Haramaya University, Ethiopia 64p.

Abebe Mekoya., Alemu Yami and Mekonen H/Mariam. 2000. Management of traditional sheep production in Lallomamma Mider Woreda, North Shoa, Amhara Region. In: ESAP (Ethiopian Society of Animal Production) 2000. Livestock production and the environment-Implication for sustainable livelihoods. Proceedings of the 7th conference of the Ethiopian Society of Animal Production (ESAP) held in Addis Ababa, Ethiopia, 26-27 May 1999. ESAP (Ethiopian Society of Animal Production), Addis Ababa, Ethiopia. pp 143-153.

Abule E. 1998. Role and decision making power of women in livestock production around Adami Tulu. ESAP (Ethiopian Society of Animal Production). Proceedings of 6th annual conference of the ESAP held in Addis Ababa, Ethiopia, August 14-15 May 1998. pp 95-102.

Addisu Tiruneh., Teklu Tesfaye.,Wilfred Mwangi and Hugo Verkuiji. 1998. Gender differentials in smallholder livestock production in the central highlands of Ethiopia. ESAP (Ethiopian Society of Animal Production). Proceedings of 6th Annual Conference of the ESAP held in Addis Ababa, Ethiopia, August 14-15 May 1998. pp19-27.

Aguilera A.; Perez-Gil F., Grande D., de la Cruz I., Juarez J. 1997. Digestibility and corn stover fermentative characteristics of mango, lemon silages with or without addition of molasses and urea. Small Rumin. Res. 26: 87-91.

Agyemang K., Negussie Akalework., Vurtuizen A. and Anderson F.M. 1985. A rapid survey of sheep production in the traditional sector of Debre Berhan area, Ethiopian highlands. In: Wilson, R.T. and Bourzat, D. (eds). Small ruminant in African Agriculture. ILCA, Addis Ababa, Ethiopia. pp 175-185.

Agza B., Binyam K., Solomon Z., Eskinder A., Ferede A. 2013. Forage yield and nutritive value of natural pastures at varying levels of maturity in North West Lowlands of Ethiopia. World J. Agric. Sci. 1(3):106-112.

Alemayehu Mengistu. 1998. The Borana and the 1991-92 Drought: A Rangeland and Livestock Resource Study. Institute of Sustainable Development, Addis Ababa, Ethiopia. pp.10

Alemayehu Mengistu. 2005. Feed resources base of Ethiopia: Status and opportunities for integrated development. Pp: 377-386. Proceedings of the 12th Annual Conference of the Ethiopian Society of Animal Production (ESAP). Addis Ababa, Ethiopia, August 12 -14, 2004, ESAP (Ethiopian Society of Animal Production).

Alemayehu Mengistu. 2006. Country pastures/forage resource profile. (http://www.fao.org/AG/agp/agpc/doc/counprof/Ethiopia/Ethiopia.htm). (Accessed on, 21 July 2015).

AOAC (Association of Official Analytical Chemists). 1990. Official Methods of Analysis, 15th ed.USA. 728p.

Assen E., Aklilu H. 2012. Sheep and goat production and utilization in different agro-ecological zones in Tigray, Ethiopia. Livestock. Res. Rural Develop. p.24, Article #16.

Awet Estifanos. 2007. Feed utilization, body weight and carcass parameters of infect and castrated afar sheep fed on urea treated teff straw supplemented with wheat bran.

Awigichew Kassahun, 2000.Comparative performance evaluation of Horro and Menz sheep of Ethiopia under grazing and intensive feeding condition 158p. A PhD Dissertation.http://edoc. hubrlin. De dissertational/ Awgichew- Kasshun. 2000-12-20/HTNL/ Awgichew.

Azage T., Berhanu G. and Dirk H. 2006. ESAP (Ethiopian Society of Animal Production) 2006. Institutional arrangements and challenges in market-oriented livestock agriculture in Ethiopia: Proceedings of the 14th annual conference of the Ethiopian Society of Animal Production (ESAP) held in Addis Ababa, Ethiopia, September 5–7, 2006. ESAP, Addis Ababa. (1-20) pp.

Azevêdo J. A. G.; Valadares Filho S. de C.; Pina D. dos S.; Detmann E.; Valadares R. F. D.; Pereira L. G. R.; Souza N. K. de P.; Costa e Silva L. F., 2011. Intake, total digestibility, microbial protein production and the nitrogen balance in diets with fruit by-products for ruminants. Rev. Bras. Zootec. 40 (5): 1052-1060.

Babatunde G.M. 1992.Availability of banana and plantain products for animal feeding. In D. Machin & S. Nyvold, eds. Roots,Tubers, Plantains and Bananas in Animal Feeding. FAO Animal Production and Health Paper 95, FAO, Rome.

Baloch G. M.; Soomro F. M.; Isani G. B.; Carpenter J. R. 1988. Utilization of banana plant

Bandeswaran C., Radhakrishnan L., Murugan M., Ahmed Maqbool, 2007. Evaluation of mango peel waste ensiled with napier-bajra hybrid grass as livestock feed. Indian J..Anim. Nutri. (24): 167-169.

Baytok E., Aksu T., Karsli M.A., Muruz H. 2005. The effects of formic acid, molasses and inoculant as silage additives on corn silage composition and ruminal fermentation characteristics in sheep. Turkish Animal Science. 29: 469-474.

Behnke R. 2010. The Contribution of Livestock to the Economies of IGAD Member States: Study Findings, Application of the Methodology in Ethiopia and Recommendations for Further Work, IGAD LPI Working Paper 02-10.

Benin S., Ehui S., Pender J. 2003. Policies for livestock development in the Ethiopian highlands.Environ Dev Sustain 5:491–510.

Berardini N.; Knodler M.; Schieber A.; Carle R., 2005. Utilization of mango peels as a source of pectin and polyphenolics. Innovative Food Science & Emerging Technologies 6 (4): 442-452.

Berhanu Gebremedhin., Hoekstra D and Samson Jemaneh. 2007. Heading towards commercialization? The case of live animal marketing in Ethiopia. Improving Productivity and Market Success (IPMS) of Ethiopian Farmers Project Working Paper 5. ILRI (International Livestock Research Institute), Nairobi, Kenya. 73 pp.

Central Agricultural Census Commission (CACC). 2003. Ethiopian Agricultural Sample Enumeration, 2001/02. Results for Southern Nations, Nationalities and Peoples' Region. Statistical Report on Livestock and Farm implements. Part IV. (July 2003), Addis Ababa, Ethiopia.

Chenost M., Candau M., Geoff roy F. and Bousquet P. 1971. Utilisation de la banana et de l'urée dans l'alimentation des caprins en zone tropicale humide. Document. 10th International Congress on Animal Production, Versculles.

Chipman. 2003. Observations on the potential of Washera sheep for improved feed security around quairit and Adet West Gojjam, north western Ethiopia. A field study Hosted by international livestock research Institute (ILRL), Addis Ababa, Ethiopia. 17p.

CSA (central statistical agency). 2004. Agricultural sample survey, Vo. II. Report on Livestock and livestock characteristics. Statistical Bulletin 302. Federal Democratic Republic of Ethiopia.

CSA (central statistics agency). 2016/17. Agricultural sample survey: Vo .II. report on livestock and livestock characteristics. Stastatistical Bulletin 570 . CSA Addis Abeba Ethiopia.

CSA (Central Statistical agency). 2007. Report on the National population and housing census of Ethiopia, Central Statistical Authority of Ethiopia, 2007, Addis Ababa.

de la Cruz Medina J.; Garcia H. S. 2002. Mango: Postharvest operations. In: Mejia D., Lewis B. InPho Post-Harvest Compendium. AGSI/FAO.

Devendra C. 1992. Non-conventional feed resources in Asia and the Pacific. IDRC, Singapore.

Dixon R.M., R.M., Egan, 1987. Strategies for utilizing fibrous crop-residues as animal. feeds. Paper presented at the 7th AAFARR Workshop, 2.6 July, Chiang Mai, Thailand.

Ecocrop. 2010. FAOhttp://www.feedipedia.org/node/4262.

Ecoport. 2010. Ecoport database. Ecoport.

El-Ghani A. A.A. 1999. Utilization of banana plant wastes by lactating Friesian cows. Egyptian J. Nutr. Feeds, 2 (1): 29-37.

El-Kholy., Kh F., Solta M.E., Abd El-Rahman S. A. E.; El-Saidy, D.M.; Foda D. Sh. 2008. Use of some agro-industrial by products in Nile Tilapia fish diets. 8th International Symposium on Tilapia in Aquaculture 2008.

Endeshaw A. 2007. Assessment on production system and marketing of goats at Dale district Sidama Zone. MSc Thesis. Hawassa University, Awassa, Ethiopia.

EPA (Ethiopia Privatization Agency). 2002. http://WWW, Telecom net et/ epa / sectors / leather .htm.

FAO (Food and Agricultural Organization). 2001. Rural Communities Activity implementing conservation agriculture.

FAO 2012. August. Introduction to the conference on silage making in the tropics. (www.fao.org/docrep/005/x8486e03.htm). (Accessed on 11 September 2014).

FAO. 2011. Top producers of mangoes, mangosteens and guavas.www.fao.com/mango.

Ffoulkes D. and Preston T.R. 1978. The banana plant as cattle feed: digestibility and voluntary intake of different proportions of leaf and pseudostem. Tropical Animal Production, 3:114−117.

Ffoulkes D., Espejo S., Marie D., Delpeche M., Preston T. R. 1977. The banana plant as cattle feed: composition and biomass production. Trop. Anim. Prod., 3 (1): 45-50.

Forbes J. M. 2007. Voluntary food intake and diet selection in farm animals, 2nd ed. CAB International, Wallingford, UK. 453 pp.

Fsahatsion Hailemariam1., Aberra Melesse2 and Sandip Banerjee. 2013. Traditional sheep production and breeding practice in Gamogofa Zone, Southern Ethiopia International Journal of Livestock Production Research Vol. 1, No. 3, December 2013, PP: 26 - 43, ISSN: 2329 - 8634 (Online) Available online at http;//acascipub.com/Journal.php.http:

Funte S., Negesse T., Legesse G. 2010. Feed Resources And Their Management Systems In Ethiopian Highlands: The Case Of Umbulo Wacho Watershed In Southern Ethiopia. Tropical And Subtropical Agro-ecosystems, 12(1): 47-56.

García A.; Ly J.; Dominguez P. L., 1991. Uso de diferentes niveles de harina de residuos foliares del plátano (Musa spp) en piensos secos para cerdos en preceba. Resúmenes IV Congreso ALVEC, La Habana, p 94.

Garcia C.E., Chicco C.F & Carnevali, A.A. 1973. Meal of banana leaves in the feeding of ruminants. Agronomia Tropicana Venezuela, 23: 293–299.

Gatenby, R.M. 1986. Sheep production in the tropics and sub-tropics. Longman Group Limited, London and New York. 351p.

Geerkens C.H., Schweiggert R.M., Steingass H., Boguhn J., Rodehutscord M. & Carle R. 2013. Influence of apple and citrus pectins, processed mango peels, a phenolic mango peel extract, and gallic acid as potential feed supplements on in vitro total gas production and rumen methanogenesis. J. Agric. Food Chem. 61: 5727-5737.

Gemeda D., Takele K., Ulfina G., Solomon A. and Gebregziabher G.2005. Mortality and Reported Clinical Signs in Horro Sheep at Smallholder Farms in East Wollega and West Shoa Zones,Ethiopia. Eth. J. Anim. Prod. 5(1)- 2005: 33-42.

Geoffroy F. & Chenost, M. 1973. Utilisation des déchets de banana par les ruminants enzone tropicale humide. Bull. tech. Prod. Anim., (2.3), 67–75. (Mimeographed).

Getahun L. 2008. Productive and Economic performance of Small Ruminant production in production system of the Highlands of Ethiopia. Ph.D.dissertation. University of Hohenheim, Stuttgart-Hoheinheim, Germany.

Getu Kitaw. 2006. Replacement of formulated concentrate mix with vetch (Vicia dasycarpa) hay to lactating crossbred dairy cows fed on urea treated wheat straw. An MSc Thesis Presented to the School of Graduate Studies of Haramaya University. 74p.

Göhl B. 1981. Musa paradisiaca L., Banana, plantain or cooking banana. Tropical Feeds. Feed Information Summaries and Nutritive Values. FAO, Rome, 1981.

Göhl B., 1982. Les aliments du bétail sous les tropiques. FAO, Division de Production et Santé Animale, Roma, Italy

Guada J.A. 1989. Nutrition of the ewe in the dry sub-tropics. In: Ruminant production in the dry sub-tropics: Constraints and potentials. Proceedings of the international symposium on the constraints and possibilities of ruminant production in the dry sub-tropics. Pudoc, Wageningen,The Netherlands. pp.207–214.

Hassen Ahmed, Ebro Abule, Kurtu Mohammed and Treydte A C 2010 Livestock feed resources utilization and management as influenced by altitude in the Central Highlands of Ethiopia. Livestock Research for Rural Development. Volume, 22, 229. Retrieved March 14, 2012, from http://www.lrrd.org/lrrd22/12/hass22229.htm.

Hembade A. S.; Patel, P. M., 2004. Green banana (Musa sp.) leaves in the ration of kids. Indian J. Anim. Nutr., 21 (1): 5-7.

Holmes B.J., Muck, R.E., 2000. Pack silage to achieve high density, quality feed. Hoards Dairyman May, p. 378.

Horrocks R. D. & Vallentine J. F. 1999. Harvested Forages. Academic Press, San Diego, California, USA. 426 pp.

ILCA (International Livestock Centre for Africa). 1990. Livestock systems research manual. Working Paper 1, Vol. 1. ILCA, Addis Ababa, Ethiopia. 287 pp. improvement conference 13-15 November1991, Institute of Agricultural Research, Addis.

Jawad A.H., Alkarkhi A.F.M., Jason O.C., Easa A.M. & Norulaini N.A.N. 2013. Production of lactic acid from mango peel waste-factorial experiment. Journal of King Saud University-Science 25: 39-45.

Jedele, S.; Hau, A. M.; von Oppen, M., 2003. An analysis of the world market for mangos and its importance for developing countries. Deutscher Tropentag 2003, Göttingen, October 8-10, 2003. Conference on International Agricultural Research for Development.

John Moran, 2005. Making quality silage. Tropical Dairy farming: Feeding management for small Dairy in the humid tropics. Pp.87-9. http://www.ladlinks.com.au (Accessed on July 3, 2015).

Johri P.N. and Shrivastava, J.P. 1967. Indian Vet. J. 44: 425.

Kaizer A. G. & Piltz J. W. 2004. Feeding testing: Assessing silage quality. In: Kaiser A.G., Piltz J. W., Burns H.M. & Griffiths N. W. (eds.) Successful silage. The State of New South Wales, Department of primary industries and dairy Australia. pp. 311-334

Kamalak A., Filho J. M. P., Canbolat O., Gurbuz Y., Ozay O., Ozkan C. O. 2004. Chemical composition and its relationship to in vitro dry matter digestibility of several tannin containing trees and shrub leaves. Livestock Research for Rural Development. Vol. 16, Art. #27. http://www.lrrd.org/lrrd16/4/kama16027.htm.

Kansci G.; Koubala B. B.; Mbome I. L., 2008. Biochemical and physicochemical properties of four mango varieties and some quality characteristics of their jams. J. Food Process. Preserv., 32 (4): 644-655.

Kaya S., Caliskan M. E. 2010. Effects of molasses and ground wheat additions on the quality of groundnut, sweet potato and Jerusalem artichoke tops silages. African Journal of Agricultural Research. 5 (9): 829-833.

Kebede T., Lema T.,Tadesse E., and Guru M.., 2010. Effect of level of substitution of sweet potato (Ipomoea Batatas.L) vines for concentrate on body weight gain and carcass characteristics of browsing Arsi bale goats. In: Journal of Cell and animal Biology Vol 2, pp. 036-042 http://www.academicjournals.org. (Accessed on July 6,2015).

Keftasa D 1996. Research on the integration of forage legumes in wheat-based cropping systems in Ethiopia: A review. In: J. Ndikumana and P. De Leeuw (eds). Proceedings of the second African Feed Resources Network (AFRNET) held at Harare, Zimbabwe. Nairobi, Kenya, 6–10 Dec. 1993, African Feed Resources Network (AFRNET). P. 201.

Khattab H.M., Kholif A.M., El-Alamy H.A., Salem F.A. & El-Shewy A.A. 2000. Ensiled banana wastes with molasses or whey for lactating buffaloes during early lactation.

Kimambo A.E.; Muya H. M. H., 1991. Rumen degradation of dry matter and organic matter of different parts of the banana plant. Livest. Res. Rural Dev., 3 (3): 35-40.

Kung L. and R. Shaver. 2001. Interpretation and use of silage fermentation analysis reports. Focus on Forage,Vol. 3, No. 13, University of Wisconsin Extension.

Legesse G. 2008 Productive and economic performance of small ruminants in two production systems of the highlands of Ethiopia. University of Hohenheim, Stuttgart, Germany, PhD Dissertation.

Maisuthisakul P., Gordon M. H. 2009. Antioxidant and tyrosinase inhibitory activity of mango seed kernel by product. Food Chem., 117 (2): 332-341. `

Marie-Magdeleine C., Boval M., Philibert L., Borde A. & Archimede H. 2010. Effect of banana foliage (Musa paradisiaca) on nutrition, parasite infection and growth of lambs. Livestock Science, 131: 234−239.

Markos Tibbo., Jan Phillips son and Worknesh Ayalew. 2006. Sustainable sheep breeding programmes in the Tropics: a Framework for Ethiopia conference on International Agricultural Research for Development University of Bonn, October II-13, 2006.

Masiiwa M. 1998. The impact of livestock on household income in the smallholder farming systems of Zimbabwe, Wissenschaftverlag Vauk Kiel KG. 57–60.

McDonald P., Edwards R. A., Greeham J .F. D., Morgan C.A. 2002. Animal nutrition, 6th ed. Longman Scientific a Technical. Harlow, England. 693 pp.

McDonald P., Edwards R.A., Greenhalgh J.F.D and Morgan C.A. 1995. Animal Nutrition. (5thEdition).Longman Group, Harlow, United Kingdom. 607p.

Metaferia F., Cherenet T., Gelan A., Abnet F., Tesfay A., Ali JA., Gulilat W. 2011. A Review to Improve Estimation of Livestock Contribution to the National GDP. Ministry of

Finance and Economic Development and Ministry of Agriculture. Addis Ababa, Ethiopia.

Mulu Moges., Berhan Tamir and Alemu Yami 2008. The effects supplementation of grass hay with Different level of Brewery dried grain on feed intake digestibility and body weight gain in intact Wogera Labs. East Africa Jornal of sciences volume 2 105-110.

Negassa A., Rashid S., Gebremedhin B., 2011. Livestock Production and Market ESSP II Working. International Food Policy Research Institute/Ethiopia Strategy Support Program II, Addis Ababa, Ethiopia. Paper 26.

Norton B.W. 1994. The nutritive value of tree legumes. In: Gutteridge R.C., Shelton H.M. (Eds), Forage Tree Legumes in Tropical Agriculture. CAB International, Wallingford, UK, pp. 177–191.

Ojokoh A.O. 2007. Effect of fermentation on the chemical composition of mango (Mangifera indica L.) peels. Afr. J. Biotechnol. 6: 1979-1981.

Pasha T.N., Prigge E.C., Russell R.W & Bryan, W.B., 1994. Influence of moisture content of forage diet on intake. J. Anim. Sci. 72.

Perez and Roldan 1984 (cited by Preston & Leng, 1987). In Matching ruminant production systems with available resources in tropics and subtropics. Bananas and Plantains: 157–159.

Porter L 2011. Nutritional data for dried mango. Official partner of the living strong foundation www.livingstrong.com/article.

Rahman M.M.; Huque K.S. 2002. Study of voluntary intake and digestibility of banana foliage as a cattle feed. Journal of Biological Sciences v.2, n.1, p 49-52.

Ranjhan S.K. 1997. Animal Nutrition in the Tropics. 4th revised edition. Vikas Publishing House PVT LTD, New Delihi. 553p.

Rêgo M. M. T.; Neiva J. N. M.; Rêgo A. C. do.; Cândido M. J. D.; Alves A. A.; Lôbo,R.N.B. 2010. Intake, nutrients digestibility and nitrogen balance of elephant grass silages with mango by-product addition. Rev. Bras. Zootec. 39 (1), 74-80.

Rihs T. 1975. Harina de banano un substituto del maiz en la alimentación del ganado lechero. Quito, Ecuador, Instituto Nacional de Investigaciones Agropecuarias. Boletín Divulgativo 75.

Saarisal O.E., Skytt Ä. E., Haikara A., Alava T., Jaakkola S. 2007. Screening and selection of lactic acid bacteria strains suitable for ensiling grass. J. App. Microbiol. 102: 327-336.

Salamone A. M., AbuGhazaleh A. A., Stuemke C. 2012. The effects of maturity and preservation method on nutrient composition and digestibility of Master Graze. Journal of Animal Research and Techology. 1 (1): 13–19.

Sanon H.; Kanwe A. 2010. Valorization of mango peels and seed kernels in animal feeding: nutritive value and voluntary feed intake by sheep. Adv. Anim. Biosci., 1 (2): 445-446.

Sanon H.; Kanwe A. B.; Millogo A.; Ledin I. 2013. Chemical composition, digestibility, and voluntary feed intake of mango residues by sheep. Trop. Anim. Health Prod., 45 (2): 665-669.

SAS. 2004. SAS/STAT Guide to Personal Computers, Version 9. Statistical Analysis System Institute Inc., Cary, NC, USA.

Sheikh N.H. 1989. The preservation of banana crop residues through ensiling process. Somali NationalUniversity.(http://www.fao.org/wairdocs/ILRI/x5490E/x5490e0v.htm) (Accessed on September 2014).

Singh G.P and Oosting S. J. 1992. A Model for Describing the Energy Value of Straws. Indian Dairyman XLIV. pp. 322-327.

Singh J. 1980**.** Impact of grazing on forest and derived ecosystems vis-à-vis animals themselves. Thesis submitted for the degree of Doctors of Philosophy in Animal Husbandry and Dairy Science, BHU., Varanasi.

Sisay A. 2006. Livestock production systems and available feed resources in different agroecologies of north Gonder zone, Ethiopia. M.sc. Thesis. Alemaya University. Alemaya.

Snyman L. D., Joubert H. W. 1995. Effect of maturity stage and method of preservation on the yield and quality of forage sorghum. Animal Feed Science and Technology. 57: 63-73.

Solomon A. and Gemeda D. 2000. Genetic and phenotypic parameters of growth, reproductive and survival performance of Horro sheep at Bako Research Center. Research fellowship report. International Livestock Research Institute (ILRI), Addis Ababa, Ethiopia.

Solomon A., Workalemahu A., Jabbar MA., Ahmed MM., Hurissa B. 2003. (Socio economics and Policy Research Working Institute), Nairobi, Livestock Paper52. Kenya, ILR (International livestock Research marketing in Ethiopia: A review of structure).

Solomon G., Solomon A., and Yohannes G. 1995. Factors affecting pre-weaning survival of Horro lambs at Bako Research Center. In: Proceedings of the 3rd Annual Conference

of Ethiopian Society of Animal Production (ESAP), 27-29 April 1995, Addis Ababa, Ethiopia. Pp. 140 - 145.

Sompong Sruamsiri and Pirote Silman 2009. Nutritive value and nutrient digestibility of ensiled mango byproducts Maejo International Journal of Science and Technology ISSN 1905-7873. Available online at www.mijst.mju.ac.th.

Spiro J.T. 1973. De l'utilisation de la farine de bananes vertes dans l'alimentation du bétail. Equateur, 4. (Mimeographed).

SPSS (Statistical Package for Social Sciences). Version 16. Application Guide. SPSS Inc.

Sruamsiri S. & Silman P. 2009. Nutritive value and nutrient digestibility of ensiled mango by-products. Maejo International Journal of Science and Technology, 3: 371−378.

Taher-Maddah M., Maheri-Sis N., Salamatdoustnobar R., Ahmadzadeh A., 2012. Estimating fermentation characteristics and nutritive value of ensiled and dried pomegranate seeds for ruminants using in vitro gas production. Open Veterinary Journal. 2: 40-45.

Target 10. 2002. Feeding dairy cows. A manual for use in the Target 10 nutrition program. 3rd ed. In: Jacobs, J. with Hargreaves. A. (eds.) Department of natural resources and environment, Victoria. 190 pp.

Teferra Gebre., Meskel and Abaye Tedla. 1995. Development opportunities in animal agriculture. pp. 91 – 110. Proceedings of the second annual conference of the Ethiopian Society of Animal Production (ESAP). Addis Ababa, Ethiopia, 26 – 27 May 1993, ESAP (Ethiopian Society of Animal Production).

Tesfaye Hagos and Solomon Melaku. 2008. Feed intake, digestibility, body Wight and carcass parameter of Afar rams fed teff (Eragrostics tef) straw supplemented with graded

levels of concentrate mixtures.Tropical Animals Health production Springer nether lands Springer likes Log in-resource secured .htm.

Tesfaye T. 2009. Characterization of goat production systems and on- farm evaluation of the growth performance of grazing goats supplemented with different protein sources in Metema Woreda. M.Sc. thesis, Haramaya University, Haramaya, Ethiopia.

Titterton M and Bareeba F. B. 1999. Grass and legume silages in the tropics. In: Mannetje L. (eds.) Proc. FAO e-Conf. on Trop. Silage. FAO Plant Production and Protection Paper 161. 1 Sept. - 15 Dec. 1999, Rome. Paper 4: 43-50.

Tolera A., Yami A and Alemu D. 2012. Livestock feed resources in Ethiopia: Challenges, Opportunities and the need for transformation. Ethiopia Animal Feed Industry Association, Addis Ababa, Ethiopia. Ulfina G., Habtamu A., Jiregna D. and Chala M., 2013. Utilization of brewer's waste as replacement for maize in the ration of calves. http://www.researchwebpub.org/wjar.

Tsedeke K. 2007 Production and marketing of sheep and goats in Alaba, SNNPR. Msc thesis.Hawassa University. Awassa, Ethiopia.

Tsedeke Kocho and Endrias Geta. 2006. Production and marketing of livestock in Wolaita and Dawuro zones, SNNPR. Paper presented in Annual Workshop of the Agricultural Economics Society (In press).

Valdez L.M., Ronduen B.O., Estacio E.C. 2012. Processing and Utilization of Rejects and Non-Marketable Carabao Mango Fruits".DA-RFU IILIARC, Bacnotan, Ilocos Norte.

Van Soest P.J., Robertson J.B., Lewis B.A., 1991. Methods of dietary fiber, neutral detergent fiber and non-starch polysaccharides in relation to animal nutrition. J. Dairy Sci. 74:3583-3597.

Workneh Ayalew. 1992. Preliminary survey of indigenous goat types and goat husbandry practices in southern Ethiopia. An M.Sc. Thesis, Alemaya University, Ethiopia. 153pp.

Workneh Ayallew., J.M.King E.W., Bruns and B.Kischkowsky. 2002. Practicalities of sustaining a goat cross breeding programs in Eastern Ethiopia. EJAP (Ethiopian journal of animal production) Vol2, Number1, PP81, 82.

Wu J.S.B., Chen H. & Fang T. 1993. Mango juice. In S. Nagy. C. S. Chen & P. E. Shaw. eds. Fruit Juice Processing Technology, pp. 620–655. Agscience, Auburndale, Fa, USA.

Yanelli P. 1984. The principles of pasture improvement and range management and their application in Somalia. FAO,Rome.

Yikal Tadele. 2015**.** Small Ruminant Production and Marketing: Constraints and Opportunities in Chencha and Mirab Abaya Districts, Southern Ethiopia. World J. Biol. Med. Science Volume 2 (1), 14-32, 2015.

Yohannes G., Solomon G., Thwaites, C.J. and Kassahun A. 1995. Influence of birth weight and postpartum age on lamb mortality in Ethiopian Horro sheep. In: Proceedings of the 3rd Annual Conference of Ethiopian Society of Animal Production (ESAP), 27-29 April 1995, Addis Ababa, Ethiopia. Pp 219 -222.

Yunus M., Ohba N., Furuse M & Masuda Y. 2000. Effects of adding urea and molasses on napier grass silage quality. Asian-Austral. J. Anim. Sci. 13, 1542-1555.

Zelalem Alemayehu and Fletcher 1. 1991. Small ruminant productivity in the central Ethiopia mixed farming system, pp.141. In: Proceeding of the fourth national livestock.

Zereu G., Tegene Negesse T., Nurfeta A. 2014. Nutritive value of fresh, dried (hay) and ensiled vines of four sweet potato (Ipomoea batatas) varieties grown in southern Ethiopia.Tropical and Subtropical Agroecosystems, 17: 547 – 555.

7. APPENDIXS

Appendix Table 1. ANOVA for silage making and evaluation

Parameter	Source	Sum of Squares	Degree of freed	Mean Square	F	Sig
pH	Treatment	0.077	4	0.019	10.59	0.0013
	Error	0.018	10	0.001		
	Total	0.096	14			
DM	Treatment	2.838	4	0.709	25.43	0.0001
	Error	0.279	10	0.027		
	Total	3.118	14			
Ash	Treatment	2.604	4	0.651	4.57	0.0234
	Error	1.424	10	0.142		
	Total	4.028	14			
CP	Treatment	0.981	4	0.245	0.86	0.5189
	Error	2.847	10	0.284		
	Total	3.829	14			
NDF	Treatment	96.247	4	24.061	4.40	0.0262
	Error	54.697	10	5.469		
	Total	150.944	14			
ADF	Treatment	44.010	4	11.002	6.54	0.0075
	Error	16.823	10	1.682		
	Total	60.833	14			
ADL	Treatment	1.513	4	0.378	1.00	0.4497
	Error	3.769	10	0.376		
	Total	5.283	14			
IVTDMD	Treatment	82.460	4	20.615	1.80	0.2045
	Error	114.224	10			
	Total	196.684	14			

DM: Dry matter; CP: Crude protein; NDF: Neutral detergent fiber; ADF: Acid detergent fiber; ADL: Acid detergent lignin; IVTDMD: in vitro true DM digestibility

Appendix Table 2**.** ANOVA test regarding supplement diet intake.

Parameters	Source	Sum of Squares	DF	Mean Square	F	Sig
DM intake	Treatment	350.892	1	350.892	0.68	0.4471
	Block	4531.53	5	906.3063	1.76	0.2758
	Error	2580.1172	5	516.0234		
	Total	7462.541	11			
OM intake	Treatment	6.351	1	6.351	0.02	0.9043
	Block	3480.541	5	696.108	1.75	0.2765
	Error	1986.1072	5	397.221		
	Total	5472.999	11			
CP intake	Treatment	10.0833	1	10.083	1.07	0.3474
	Block	81.680	5	16.336	1.74	0.2787
	Error	46.902	5	9.380		
	Total	138.666	11			
NDF intake	Treatment	371.853	1	371.853	6.75	0.0484
	Block	484.046	5	96.809	1.76	0.2758
	Error	275.619	5	55.123		
	Total	1131.519	11			
ADF intake	Treatment	26.730	1	26.730	1.54	0.2702
	Block	152.828	5	30.565	1.76	0.2757
	Error	87.005	5	17.401		
	Total	266.565	11			
ADL intake	Treatment	0.252	1	0.252	0.98	0.3671
	Block	2.547	5	0.509	1.98	0.2352
	Error	1.284	5	0.256		
	Total	4.083	11			

Appendix Table 3: ANOVA test regarding body weight of experimental animals.

Body weight	Source	Sum of Squares	DF	Mean Square	F	Sig
Initial body weight	Treatment	2.503	2	1.251	1.13	0.3602
	Block	38.851	5	7.770	7.03	0.0046
	Error	11.050	10	1.105		
	Total	52.405	17			
Final body weight	Treatment	15.641	2	7.820	6.26	0.0172
	Block	23.116	5	4.623	3.70	0.0371
	Error	12.485	10	1.248		
	Total	51.242	17			
Total weight gain(kg)	Treatment	15.581	2	7.790	33.40	<.0001
	Block	3.631	5	0.726	3.11	0.0595
	Error	2.332	10			
	Total	21.544	17			
ADG(G/day)	Treatment	1923.467	2	961.733	33.41	<.0001
	Block	448.383	5	89.676	3.12	0.0595
	Error	287.824	10	28.782		
	Total	2659.676	17			

Questionnaire

Section 1

General information

Enumerator's name _____

Name of the respondent: _____

District _____

Peasant associations_____

Questionnaire no _____

1. Position of the respondent in the family: 1 = Head 2 = Wife 3 = Son 4 = Daughter

   5 = Others

2. Sex of the respondent: 1 = Male 2 = Female

3. Age of head of household _____ Yrs

4. Education of the head of household: 1 = No formal 2 = Adult literacy

   3 = Primary 4 = Secondary 5 = Beyond secondary

5. Household size and composition:

Age group (years)	No. of members in the household		
	Male	Female	Total
< 6 years old			
6-9 years old			
10-15 years old			
16-60 years old			
> 60 years old			

Section 2

1. What are the major types of crops cultivated in the different seasons of three year on your land? _____
   _____
   _____

2. What are the major cash crops that you cultivate? Rank the according to their economical importance?

   Cash crops Rank

   1. _____ _____
   2. _____ _____
   3. _____ _____

3. State the major farming activities which are used as income source for your family today's? 1 = Crop production 2 = Livestock production 3 = Mixed farming 4 = others (specify if any_____)

4. Describe the farming activity that has been used before 5 years ago? _____

5. What are the populations of livestock that are used in your household?

Species	Number	Species	Number
• Cattle		Goats	
• Cows		• Kids	
• Oxen [castrate]		• Breeding bucks	
• Bulls [breeding]		• Castrated bucks	
• Heifers		• Fattening bucks	

• Calves [<1 year]		• Doe's	
• Yearlings [1-2 years] -Male			
• Yearlings [1-2 years]-Female		Total # of goats per HH	
Total # of cattle		Poultry	
Sheep			
• Lambs		Pack animals	
• Ewes		• Equines	
• Breeding rams		• Donkeys	
• Castrates		• Mules	
• Fattening rams			
Total # of sheep/HH			

Section 3

Sheep production system

1. What is your production system?

   1 = Mixed crop–livestock production system 2 = Peri-urban production system

2. What are major constraints hinder production of sheep in this area? (Rank)

   1 = Disease and parasites 2 = Feed and grazing land shortages

   3 = Water shortage 4 = Labor shortage 5 = Drought 6 = Predators

   7 = Marketing problems 8 = Inadequate/lack of inputs

   9 = Inadequate/lack of extension and support

   10 = Inadequate/lack of technologies and innovations

   11 = Lack of capital and credits 12 = others _____

3. What are the major reasons for keeping sheep? And rank them according to their importance.

Purpose of keeping	Small ruminant

1 = Meat	
2 = Milk	
3 = Income	
4 = Saving/Asset	
5 = Wealth	
6 = Manure	
7 = Ceremony	
8 = Breeding	
9 = Skin	
8=others, (mention)	

4. What is importance of sheep compared to other livestock (rank them)

   _____

   _____

   _____

5. History of origin and introduction sheep breed found in the area

   1. Place of origin_____
   2. Time of introduction_____
   3. Name of ancestor's breed _____

6. Do you select the best breeding ram? 1 = Yes 2 = No

7. If yes, criteria for selection of ram(s)

   1 = Size 2 = Color 3 = Horns 4 = Character 5 = Availability

   Other (specify) _____

8. Source of ram(s) within the last 12 months *(Tick one or more boxes)*

1 = Own ram (breed) 2 = Own ram (bought) 3 = Ram donated 4 = ram borrowed

5 = Neighbor's ram 6 = Communal ram 7 = Unknown ram

9. What Breeding/mating practice/system do you employ?

   1 = Natural Mating/uncontrolled/open

   2 = Natural Mating/Controlled

10. If mating is uncontrolled, what is the reason?

    1 = Animals graze together

    2 = Lack of awareness

    3 = Lack/insufficient number of breeding ram

    4 = others (specify

11. How do you detect the on –set of heat _____

    _____

12. Which season or month of the year the highest heat of sheep observed (the main breeding season) _____

13. You fatten sheep before? 1 = Yes 2 = No

14. If yes, how long have you engaged in sheep fattening?

    1 = within last 5 years 2 = 6-10 years 3 = before 15 years ago 4 = other (specify)

15. How you select sheep for fattening? (Rank)

    1 = Conformation (height, length and appearance)

    2 = Breed (known local ecotypes)

    3 = Physical characteristics (color, horn, tail length and width, ear etc)

    4 = Age 5 = others, specify

16. If you practice select with physical characteristics, (Rank)

1 = Color 2 = Horn 3 = Ear 4 = Tail

5 = Body length and height 6 = others, specify

17. Do you practice fattening of sheep for targeted market seasons and market places? 1 = Yes 2 = No

18. If yes, which season/months (Rank)?

1=New Year festival 2= Easter 3= Christmas

4= Meskel 5 = Ed Al Fetir 6 = Arefa 7 = others, specify

19. Is there and emerging opportunity of increased demand and incentive price for fattened sheep? 1=Yes 2=No

20. For how long the activities of fattening take place?

Short time for ----------month

Medium for ----------month

Long duration for ---------- month

21. Which duration is the best and the most profitable staying period?

_____

22. How many animals you fattened at a time? _____

23. Mainly to whom you sell the sheep? (more than one answer is possible) 1 = Retailers 2 = Consumers 3 = Butchery 4 = Restaurant and hotels 5 = Collectors 6 = Exporters and abattoir agents

25. How do you decide the selling/buying price in market?

1 = Own personal observation

2 = Communicating with regular customer in destination market

3 = communicating with other traders like you

4 = Communicating with brokers

5 = Depending on previous markets information

26. In your opinion, who have the more power to set the price in this market?

1 = Producers 2 = Retailers 3 = Wholesalers 5 = the market itself 6= Broker 7=other, specify _____

Section 4

Feed resources and feeding system

1. What are the major feed resources of sheep available in your area?/rank accordingly

No.	Feed resources	Season	
		Dry season	Wet season
1	Natural pasture		
2	Crop residue		
3	Hay		
4	Silage		
5	Road side grazing		
6	Farm side grazing		
7	Rejected banana		
8	Rejected banana and mango		
9	Industrial by- products		
10	Agro-industrial by-products		
11	Others		

2. Could you mention major of feeds you are using for fattening sheep?

_____

_____

3. Is there communal grazing land in your area? 1=Yes 2= No
4. Do you graze your sheep? 1=Yes 2=No

5. If yes, for how long? _____days in a week _____hours a day
6. How sheep graze? 1= Sheep alone 2=Together with other livestock
7. How you practiced grazing your sheep in the dry season?

   1=Free grazing 2=tethered grazing 3= cut and carry
8. Do you practiced tether feeding of sheep 1=Yes 2=No
9. If yes, why? 1= To avoid crop and vegetation damages 2=Save labor

   3=Protect from predators 4=Utilize marginal land and hillsides

   5= control breeding 6=others, specify
10. Is there feed shortage or constraint for your sheep? 1=Yes 2=No
11. If yes, when? 1=Dry season 2=Wet season 3= Both
12. If feed shortage in your locality, why? (rank)

    1=Shrinking and decline in productivity of grazing lands

    2=Increase of animal population

    3=Cultivation, settlement and protection on grazing lands

    4=Drought

    5=Increase of human population

    6=others, specify
13. What are the major feeding systems at different physiological status of your sheep?

    _____

    _____
14. Is banana and mango grown in your area? 1. Yes 2. No
15. If yes, when you harvest banana and mango? (Indicate the month) _____

_____ _____ _____ _____

16. How much is the yield of banana and mango per unit of land? (In kg)_____

17. How many times per year do you harvest banana and mango? _____

18. What is the dominant type of banana variety that you grow in your area?

Type	Rank
1._____	_____
2. _____	_____
3. _____	_____

19. Do you feed the banana and mango residues as a supplemental feed? 1. Yes 2. No

20. What are the feed types that you always mix with it?

_____

21. Which variety of banana is used for animal feed dominantly? Why do you choose the varieties?

Type	Rank
1. _____	_____
2. _____	_____
3. _____	_____

22. Do you think feeding banana and mango residue increases the performance of animals?

1. Yes 2. No

23. If yes, to what extent? 1. Highly 2.Moderately. 3. Poorly

24. For which species of animal's banana and mango residues is fed (give a rank)

Cattle: Calves_____ Bulls_____ Cows_____

Small ruminant: Sheep_____ Goat_____

25. Which species of animal more prefer banana and mango residues?

1, _____ 2, _____ 3, _____

26. In which season you use banana and mango residues a major feed source?

At a time of feed shortage_____ Excess of feed_____ always_____

27. How frequently do you feed your animal banana and mango residues a day?

Once_____ Twice_____ Three times_____

28. What time do your animals feed banana and mango residues in a day?

In the morning____, afternoon____, late afternoon_____, and any time _____

29. What is banana and mango residues feeding practice in the area? Is it feeding?

- As green_____-silage and conserved_____ -others specify_____

30. Do you think that supplementary feeding of your animals is necessary? When?

_____

Section 5

Utilization and constraints of banana and mango residues

1. Do you have the experience of feed conservation? 1. Yes 2. No
2. If you practice feed conservation, list the months/season?

   Wet season_____, Dry season _____All over the year_____
3. If no, why you don't conserve feed for your animal?

   Lack of awareness about it_____, Lack of experience_____

Less availability of the residue _____Other specify_____

4. Months of feeding your animals?

   Sep_ Oct _ Nov_ Dec_ Jan_ Feb_ Mar_ Apr_ May_ Jun _ Jul _ Aug_

5. What are the challenges and constraints faced with regard to feed conservation?

   _____

   _____

6. How do you feed your animal?

   Alone _____, mixed _____, as supplement _____other specify_____

7. When was an excess of banana and mango residues production

   During harvesting season of fruit crops _____**,** any stage of plant growth_____

   Other specify _____

8. What part of banana do you feed your livestock?

   Banana peel _____, damaged bananas_____,

   Leaves _____, young stalks _____

   Pseudo- stems _____

9. Which part of banana residue is most preferred by your livestock? Rank them

   _____ _____ _____ _____

   _____ _____ _____ _____

10. What part of mango do you feed your livestock?

    Cull fruits _____, Mango seeds (pits, stones) _____

    Mango seed kernels (mango kernels) _____,

    Mango peels _____, pulp _____, seeds _____

11. Which part of mango residue is most preferred by your livestock? Rank them

_____ _____ _____ _____

12. Do you have the experience of banana and mango residue conservation before feeding your animals? 1. Yes 2. No

13. If your answer for question 12 is yes which techniques do you use?

Ensiling _____ other specify_____

14. If you conserve when do you use it

During dry season _____any time_____

15. How long will the preserved feed be enough to your livestock _____months?

16. At which season do you face feeds shortage?

Short rainy season _____Long rainy season _____

17. What are the consequences of the feed shortage?

Weight loss _____Increased mortality _____ Abortion frequency _____Weakness _____Anoestrus _____Others, specify _____

18. Measures taken to alleviate this problem

Feed preservation as hay _____Feed preservation as silage _____

Use of improved forage production _____Fodder bank _____

Forage purchase _____Destocking _____If others, specify _____

19. Have you ever tried to balance the livestock with total feed produced in your household?

Yes _____ No, if yes how?

20. List possible reasons of banana and mango residue utilization constraints

(Prioritize according to their importance)

Constraints	Codes	ranks

21. What is the size of your banana and mango land? banana _____ha

mango _____ha

22. Is the land your own or contracted? banana_____ mango_____

23. If your own, how many ha? _____and if contracted how many ha? ____

Banana _____ Mango _____

24. If your animals are confined, do you know the amount of banana and mango residues with supplement given to them daily?

Yes_____ No _____

25. And if yes what is the amount of:

1. Banana _____ kg

2. Mango _____ kg

BIOGRAPHICAL SKETCH

The author, ASKALE DUBALE ADANE was born on August 1987 in Chencha Woreda of Gamo Gofa Administrative Zone. She attended her elementary education in Chencha Elementary School from 1992 to 1997 and her junior education at Arba Minch junior and secondary school from 1998 to 1999. She also attended her Senior Secondary education at Arba Minch Preparatory and Senior Secondary School from 2000 to 2003. She joined Haramya University in 2004 and was awarded a Bachelor Degree in Animal production and Health in 2006. Soon after graduation, she was employed by the Ministry of Agriculture as Animal production and forage development expert, at Gamo Gofa zone Arba Minch zuria Woreda Agriculture and Rural Development Main office served for seven years. Then she was joined the School of Graduate Studies of Hawassa University to pursue Master of Science degree in Animal Production in October 2013.