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EFFECTS OF FEEDING DRIED *Acacia saligna*, *Sesbania sesban* OR *Vigna unguiculata* LEAVES AS A REPLACEMENT FOR COTTON SEED CAKE ON PRODUCTION PERFORMANCES AND SEMEN QUALITY OF BEGAIT SHEEP IN NORTHWESTERN TIGRAY, ETHIOPIA

PhD Dissertation

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Addis Ababa University, College of Veterinary Medicine and Agriculture
Department of Animal Production Studies
PhD Program in Animal Production

May, 2018
Bishoftu, Ethiopia

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A Thesis submitted to the College of Veterinary Medicine and Agriculture of Addis Ababa University in fulfillment of the requirements for the degree of Doctor of Philosophy in Animal Production

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As members of the Examining Board of the final PhD open defense, we certify that we have read and evaluated the Dissertation prepared by Michaele Yirdaw in titled: **"EFFECTS OF FEEDING DRIED *Acacia saligna, Sesbania sesban* OR *Vigna unguiculata* LEAVES AS A REPLACEMENT FOR COTTON SEED CAKE ON PRODUCTION PERFORMANCES AND SEMEN QUALITY OF BEGAIT SHEEP IN NORTHWESTERN TIGRAY, ETHIOPIA''** and recommend that it be accepted as fulfilling the Dissertation requirement for the **Degree of Philosophy in Animal Production**

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I hereby certify that I have read the revised version of this dissertation prepared under my direction and recommend that it be accepted as fulfilling the dissertation requirement.

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DEDICATION

This dissertation is dedicated to my family, for nursing me with love and for their committed partnership in the success of my life.

BIOGRAPHICAL SKETCH

I was born in Adwa, Tigray Regional state, in 1986. I attended my Primary education in Adwa Nigiste Saba Primary School and my Secondary education in Enticho Secondary School, Enticho. After completion of my high school education, I joined Mekelle University in 2006 and awarded BSc Degree in Animal, Rangeland and Wildlife Sciences in 2008. Soon after graduation, I joined Mekelle University to pursue my MSc study in Livestock Production and Pastoral Development and was awarded MSc Degree in 2010. Immediately after graduation, I was employed by Aksum University as a Lecturer. Then, I joined Addis Ababa University, College of Veterinary Medicine and Agriculture (Department of Animal Production Studies) in 2013 for my PhD study in Animal Production. In 2014 I was awarded international certificate pig production Technology at PTC+, Barneveld, Netherlands. In 2016 International Diploma Animal feed at Barneveld, Netherlands and Diploma for course of Laboratory analyzing feed samples for nutritive value, Nutrilab B.V at Giessen, Netherlands. I have taught almost all types of animal science courses and published six scientific publications in reputable journals.

STATEMENT OF THE AUTHOR

First, I declare that this thesis is my genuine work and that all sources of materials used for this thesis have been duly acknowledged. This thesis has been submitted in fulfillment of the requirements for PhD degree at Addis Ababa University, College of Veterinary Medicine and Agriculture and is deposited at the College library to be made available to borrowers under rules of the Library. I solemnly declare that this thesis is not submitted to any other institution anywhere for the award of any academic degree, diploma, or certificate.

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ABBREVIATIONS

ADF	Acid Detergent Fiber
ADL	Acid Detergent Lignin
ANOVA	Analysis of Variance
AOAC	Association of Official Analytical Chemists
CF	Crude Fiber
CP	Crude Protein
CT	Condensed Tannin
DM	Dry Matter
DMD	Dry Matter Digestibility
DP	Dressing Percentage
EBW	Empty Body Weight
g	Gram
GDP	Gross Domestic Product
GLM	General Linear Model
HCW	Hot Carcass Weight
IAEA	International Atomic Energy Agency
ME	Metabolisable Energy
N	Nitrogen
NDF	Neutral Detergent Fiber
OM	Organic Matter
REMA	Rib Eye Muscle Area
SW	Slaughter Weight
TDN	Total Digestible Nutrient
TEOCs	Total Edible Offal Components
TNEOCs	Total Non Edible Offal Components

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By

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ABSTRACT

The study was conducted in Tahtay Adyabo Wereda of Tigray National Regional State with the objectives of assessing sheep production system and determines feed intake, digestibility, body weight change, carcass characteristics and semen quality of Begait rams. To collect the quantitative and qualitative data, questionnaire, group discussions and field observation were employed. A total of 108 households owning Begait sheep were individually interviewed. The experiment was carried out at Humera Begait Cattle and Small Ruminants breeding and Multiplication Ranch of Tigray Regional Government. This study was designed to assess the effects of replacing cotton seed cake by Dried Acacia saligna, Sesbania sesban or Vigna unguiculata on production performance and semen quality of Begait rams fed grass hay as basal diet and wheat bran as energy source. Twenty four yearlings Begait male sheep with an average initial body weight of 25 ± 1.39 kg (mean ± SD) were used in randomized complete block design (RCBD) that lasted for 90 days. Treatments consisted of ad libitum feeding of grass hay plus 200g DM wheat bran and additionally supplementing with 100g, 250g, 140g and 180g DM per head per day of cotton seed cake, Acacia saligna, Sesbania sesban and Vigna unguiculata forages for T1, T2, T3 and T4 respectively, each calculated to give 67.6g CP on isonitrogenous basis. Rams were categorized into six blocks of four Rams in each block based on their initial body weight and the four feed treatments were randomly assigned to each animal in a block, giving six animals per treatment. The survey result indicated that, mixed crop-livestock production system was the dominant farming system. Farmers reared sheep primarily for two main purposes, for cash income and home *consumption. On average, one household had 13.6 ±2.15 heads of Begait sheep. The major feed resources were natural pasture and natural pasture (standing hay) in wet and dry season respectively. Feed shortage, water scarcity and health problem were the major factors hampering sheep production in the area. Results related to the feeding trial showed that, the hay DM intake was lower ($P < 0.05$) for T2 as compared to the other three treatments. Total DM and OM intakes appeared to be highly impacted by the supplemental DM intake. Digestibility of CP was in the order of T1 > T3 >T4 > T2, the value in T2 was significantly different ($P < 0.05$) with T1 and T3 (74.6, 60.4, 72.2 and 67.9 for T1, T2, T3 and T4, respectively). T1 and T3 resulted in higher ($P<0.05$) final body weights than T4; However, the results of BWC, ADG and FCE in T1, T2 and T3 were not significantly different ($P > 0.05$) from each other. There were also similarities among T2 and T4 in BWC, ADG and FCE. Hot carcass weight ranged from 14 kg to 16 kg. Slaughter weight, empty body weight and dressing percentage on slaughter body weight were higher in T1 (cotton seed cake), T3 (S .sasban) and T2 (A .saligna) as compared to rams supplemented with T4 (Vigna unguiculata) while T4 was not significantly different with T2 and T3. Body condition, semen volume, mass motility, live and dead count and percent did not show significant difference ($p>0.05$). Scrotum Circumference was 27.4, 26.6, 27.9 and 26.0cm for rams in T1, T2, T3 and T4, respectively. Testicle size and scrotum circumference were statistically different ($P < 0.05$) between T3 and T4. The supplements were comparable in their potential to supply nutrients to improve the productivity of sheep. Therefore dried A. saligna and S. sesban foliages can be used to replace protein sources commercial concentrate feeds.*

Keywords: *Begait sheep; cotton seed cake; feed intake; forage; production constraints; semen quality.*

1. INTRODUCTION

Ethiopia has the largest livestock population in Africa with an estimated population of about 59.5 million cattle, 30.7 million sheep, 30.2 million goats, 2.16 million horses, 0.41 million mules, 8.44 million donkeys, 1.21 million camels, and 56.53 chickens (CSA, 2017).

Livestock production in Ethiopia contributes up to 80% of the farmer's income (Alemayehu, 2002), 18% of overall GDP (FAO, 2004), 45% of agricultural GDP and above 20% of all the national exports (IGAD LPI, 2010). Despite the large livestock population, their productivity is low with average carcass weights of 108, 10, 8.5, and 0.8 kg/head for cattle, sheep, goats, and chicken respectively (Asfaw *et al.,* 2010). Similar to other species of livestock, sheep are also very important sources of food and manure. The short generation interval ability to give multiple births and their small size make sheep adaptable to smallholder farmers (Adane and Girma, 2008).

Sheep production in Ethiopia is characterized by low productivity in terms of growth rate, meat production and reproductive performance (Adugna *et al.*, 2000). CSA (2010) indicated that the average daily growth rate of indigenous meat sheep is 50 g per animal.

Tigray region is potential for small ruminant production with 2,041,731 heads of sheep in the region, but the output in terms of meat and milk is below their expectation (CSA, 2017). This is mainly because of poor feeding management of the available feed resources (Solomon, 2001). To achieve the desired benefit of these animals, proper feeding is crucial. As reported in Snowder and Van Vleck (2003), increased profitability of lamb production is dependent on reducing input costs and increasing production output.

Increase in human population by itself increases the demand for livestock products and increased household income also pushes people to diversify their food habits for which livestock products contribute much more than any other sector (Tesfay, 2007). sheep are convenient for indoor feeding because of a docile character. In addition to this high prolificacy, fast growth and less initial capital requirement make them preferable for smallholder farmers.

The causes for low productivity of sheep are multifaceted that include poor genetic makeup, poor veterinary services, inadequate quantity and quality of feed, and poor breeding strategy (Betsha, 2005). Among these limiting factors, poor feed supply and feeding system is the most important as the feed resources in the highlands of Ethiopia are generally natural pasture and residues of different crops. Acute shortage of feed supply during the dry season and very poor quality of the available feeds are the prime limiting factors for increasing production and productivity of small ruminant in most of the agro-ecological zones (Solomon *et al.,* 2010). Especially, energy and protein are the major factors affecting productivity of sheep (McDonald *et al*., 2002). The lowest energy density at which sheep does not loss weight is between 8 and 10 MJ ME/kg DM and the minimum protein level required for maintenance is about 8% CP in DM (CTA, 1991).

McDonald *et al*. (2002) confirmed that all the straws and related byproducts are extremely fibrous, most of them have a high content of lignin and all are of low nutritive value. In addition to this, most dry forages and roughages found in Ethiopia have a crude protein (CP) content of less than 7 % which indicates microbial requirement can hardly be satisfied unless supplemented with protein rich feeds (Vansoest *et al*., 1994). Limitations of crop residues to be used as ruminant feed are the slow rate and low total digestibility, the rate at which feed particles break down to a size that can leave the rumen, the low propionate fermentation pattern in the rumen and the negligible content of both fermentable nitrogen and bypass protein (Solomon, 2001). In this condition looking for other potential sources becomes mandatory in order to fulfill nutrient requirements of the animals in return the desirable livestock product and by product will be generated.

Poor utilization of locally available feed resources leads to low performance of animals in general and high impact on overall livestock production and reduces the income of farmer's and decreases the profitability of the sector. This is because animal production is a result of utilizing the right feed in terms of accessibility, profitability and animal preference. Utilization of concentrate feeds in developing countries like Ethiopia is difficult as they are very expensive and not easily accessible. In addition to this, population pressure harms the potential feed sources like pasture land, grazing land and the other resources. Gemeda *et al*. (2003) noted that with the steady increase in human population much of the grazing and browsing areas are put under arable farming for food crop production, which further aggravates the scarcity of feed resources.

Currently there is a tendency to rehabilitate the degraded areas by constructing water and soil conservation structures, making grazing lands out of animal contact and reseeding with different seeds, seedling plantation and other conservation activities. This forces farmer's to keep their animals confined at their homesteads with the feeding of crop residues and hay; these feeds are not in a position to support the maintenance requirement of the animal. Imbalanced nutrient supply in particular of fermentable nitrogen and protein, is considered an important reason for the low productivity of ruminants on low quality pastures and fibrous cereal straws (Salem and Znaidi, 2008).

In order to mitigate the problems associated with the lack of protein supplements due to reasons of availability and high cost, there is a need to look for alternative protein sources such as supplementation with forage legumes that farmer's can produce at their own farms and multipurpose fodder trees from enclosure areas. Among the forages, cowpea (*Vigna unguiculata*), Sesbania (*Sesbania sesban)* , *Acacia saligna*, lablab (*Lablab purpureus*) and alfalfa could be easily grown at farmer levels and play an important role in supplementing diets of growing lambs as alternative to concentrate supplements. These forages can improve the growth performance of young ruminant animals on fibrous diets through the provision of more nutrients and optimization of fermentative digestion in the rumen. This implies that among other things, it is important to supplement growing ruminants not only with energy sources, but also with protein sources in order to increase the efficiency of growth to the desired market weight so that the economic benefit of sheep production could be enhanced. In addition to this assessment of sheep production system and identification and prioritization of the constraints of sheep production are prerequisites to bring improvement in sheep productivity. Understanding the production system helps to design appropriate technologies which are compatible with the system. Therefore, this study was designed with the following specific objectives:

Specific Objectives

- To describe traditional sheep husbandry practices of sheep production in *Tahtay Adyabo Wereda*, Northwestern Tigray;

- To evaluate feed intake, digestibility, body weight gain and carcass parameters of rams supplemented with different forages as replacement for cotton seed cake fed on grass hay as basal diet; and

- To evaluate semen quality characteristics of rams supplemented with different forages as replacement for cotton seed cake fed on grass hay as basal diet.

2. LITERATURE REVIEW

2.1. Sheep Production and Their Role in Livelihood of Ethiopian Farmers

Sheep are widespread in the tropics and are important to the subsistence economic and social livelihoods of a large human population in these areas (Tesfay, 2007). Sheep production in the crop-livestock production system of the Ethiopian highlands also has a very important role in contributing to the food security as well as in generating cash income (Fantie, 2007).

Ethiopia with the largest population of sheep and great variation in climate and topography represents a good reservoir of sheep genotype. Ethiopian sheep population is estimated to be 30.7 million. About 25- 27% of Ethiopia's sheep are located in the lowlands which are arid and semi-arid areas and about 73 to 75% are located in the mid and highland areas (CSA, 2017). They provide their owners with a vast range of products and services (Adane and Girma, 2008). Skin of sheep contributed substantially to foreign exchange earnings as well as for uses in the local tanneries and leather craft industries (Zemicheal, 2006).

Sheep are especially important to women, children and the aged, usually the most vulnerable members of the society in terms of under nutrition and poverty (Kosgey, 2004). They serve also as monetary saving and investment, source of risk mitigation during crop failure and they are closely linked to the social and cultural life of many farmers (Seare, 2007).

According to Fantie (2007), an increase in sheep production is needed both to maintain self sufficiency in meat consumption for the increasing number of human population as well as to increase export earnings. In the large urban areas of Ethiopia, mutton is preferable than goat meat and beef meat and have higher price during the holidays, but profitability from sheep farming is limited by lower performance in market weight and overall reproductive efficiency (Zemichael, 2006).

Sheep contributes close to 30% of the total ruminant livestock meat output and 14% of the total domestic meat production, with live animal and chilled meat export surpluses (Workneh et al., 2004). Despite the economic importance of sheep to the farming household and overall economic development of a country, efforts to improve the productivity and production systems of sheep are lacking (MFED, 2010).

Natural pasture is the main source of feed during all seasons and sheep are supplemented with crop residue during the critical dry season. However, feed shortage is the main challenge since productive pasturelands are gradually turning into crop fields and communal pasturelands are shrinking (Tegegne et al., 2011). As a result feed shortage in supply and quality is considered to be a challenge to increase livestock productivity in highland areas of the country (Mengesha and Tsega, 2012).

Poor nutrition of sheep in Ethiopia is reflected in the low dressed carcass of 10 kg per sheep as compared to 17.5, 13.0, 14.0 and 12 kg per sheep for Sudan, Somalia, Uganda and Kenya, respectively (FAO, 2001). The low dressed carcass can partially be attributed to high demand for meat without an organized program of production that may lead to slaughtering of young animals as observed in other areas in the tropics (Devendra, 2001). On the other hand, the demand for animal product in the country is likely to rise significantly as a result of population growth, urbanization and rising income (FAO, 1997). At the same time, there is a high export demand for live sheep and meat from Ethiopia to North Africa and Middle East countries (CSA, 2001).

The demand for meat by the increasing human population growth in Ethiopia may not be easily satisfied and the current high price for the product cannot be maintained with the low level of per capita income. Therefore, development policies in the livestock sector have to look for mechanisms to balance the demand and supply of meat by improving the productivity of animals. In this regard, sheep by virtue of their small size provide an opportunity to increase meat production, because of their ability to thrive on locally available and low quality and quantity feeds as well as for possessing high reproductive performance. However, continuous use of low quality feedstuffs like straws will not benefit in increasing the rate of live weight gain and animal off-take from the pastorals as well as smallholder livestock production systems (Awet, 2007). Therefore, it is a time to consider alternative strategies for the improvement of the feeding system to raise productivity of sheep.

2.2. Ethiopian Sheep Breeds and Their Habitat

Ethiopia is a home of most populous and diversified indigenous sheep breeds. There are about 14 traditionally recognized sheep populations in Ethiopia, furthermore, the sheep populations are classified into 9 genetically distinct breeds and 6 breed groups (Gizaw, 2008). Table 1 shows the classification of the sheep population. They are found in different ecological zones of the country.

Table 1: Classification of Ethiopian sheep breeds.

Breed group	Breed	Tail type/shape	Fiber type
Short-fat-tailed	Simien	Fatty and short	Fleece
Short-fat-tailed	Sekota, Farta, Tikur, Wollo, Menz		Fleece
Washera	Washera	Fatty and short	hair
Thin-tailed sheep	Gumz	Thin and long	hair
	Begait	Thin and long	
Long-fat-tailed	Horro	Fatty and long	hair
Arsi	Arsi-Bale, Adilo		hair
Bonga	Bonga	Fatty and long	hair
Fat-rumped sheep	Afar	Fat rump/fat tail	hair
Black-Head-Somali	Black-Head-Somali		hair

In Ethiopia, most sheep are kept in a traditional, low input and subsistence-oriented production system. In such a production system, sheep is the main source of cash, manure, meat, skin, coarse wool, security, gifts, religious rituals and medicine (Adane and Girma, 2008).

Sheep are widely adapted to different climates and are found in all production systems. This allows easy integration of sheep in to different farming systems (Adane and Girma, 2008). Moreover, they are highly adaptable to a broad range of environments. Sheep have short generation cycles and high reproductive rates, which lead to high production efficiency (Ibrahim, 1998). Their small size together with early maturity makes them suitable for meeting subsistence needs for meat and milk (Adane and Girma, 2008). Sheep have higher survival rates under drought conditions compared to cattle. Moreover, because of their reproductive rates, flock numbers can be restored more rapidly. As a result, it allows farmers a quick interval of selling part of their flock and generating cash income.

Begait sheep is a local breed reared in the North West and Western zone of Tigray regional state of Ethiopia. Begait sheep is characterized as tall, long tail; consume large amount of feed and known for their good productive and reproductive performance and have a dual purpose, for meat and milk production (MYARC, 2011). Amare *et al.* (2012) reported that Begait sheep breed is characterized as having muscular body size, white, white and black, grey, slightly red and white creamy color dominated, long and thin tail, long eared, polled and are also known for their ability to resist diseases and heat stress (Figure 1). According to Zelalem *et al.* (2014), Begait is found in *Tahtay Adyabo* and *Tsegede weredas* of Tigray, and has good value for all body measurements and good muscling conformation.

a

b

Figure 1: Depiction of a flock of Begait sheep

2.3. Nutrient Requirements of Sheep

Energy, protein, minerals, vitamins and water are the main nutrients required by sheep, similar to other animals. Nutrient requirements are the values considered necessary for maintenance, optimum production and prevention of any signs of nutritional deficiency (Awet, 2007). Dietary nutrients, especially energy and protein are the major factors affecting productivity of sheep, the low energy density at which the sheep does not lose weight is between 8 and 10 MJ/kg DM and the minimum protein level required for maintenance is about 8% in the DM (Gatenby, 2002).

Protein requirement of growing sheep is affected by growth rate, weight, age, body condition and protein to energy ratio (Table 2). In proportion to fast growth, adequate amount of protein should be supplied. Poor body conditioned animals require protein rich feeds to compensate for their growth. Rate of gain and protein to energy ratio affects growth in a similar manner as the energy required. Energy need of sheep is mainly attained through the consumption and digestion of roughage-pasture and hay (Awet, 2007). The micro-flora action in the rumen of sheep efficiently converts roughages into suitable energy sources provided they have an adequate supply of nitrogen. Larger animals require higher energy to attain their maintenance requirement than smaller animals. This is because of the increased rate of metabolism for energy in large animals. Moreover, fast rate of growth demands energy rich feeds or consumption of large amount feed. Protein rich feeds may also reduce feed consumption, and thereby energy intake (Ensminger, 2002).

Agro-industrial byproducts are important sources of protein and energy for supplementing fibrous basal diets (Mc Donald, 2002). To meet the nutrient demand of sheep for feedlot fattening, it is important to identify supplements that are cheaper and easily available (Zemichael, 2006).

Table 2: Energy and protein requirements of sheep for growth

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

Source: ARC (1980)

2.4. Feed resources for sheep in Ethiopia

A major constraint to livestock production in developing countries especially in Ethiopia is the scarcity and fluctuating quantity and quality of the year round feed supply (Yayneshet, 2010). The reasons for shortage of feed vary depending on the agro-ecology and livestock production systems (Solomon *et al.*, 2010).

The major feed resources for livestock in Ethiopia are natural grazing and browse, crop residues, improved pasture, forage crops and agro-industrial byproducts (Alemayehu, 1997). Similarly, in the highland and mid altitude areas of Tigray, cereal and pulse crop residues and limited oil crops are providing considerable quantity of dry season feed supply for livestock (Yayneshet, 2010). However, the major use of crop residues and cultivated forages in most African countries and particularly in Ethiopia are restricted to cattle (especially draught oxen) and small ruminants have low chance of being fed on these feeds (Ben Salem *et al.*, 2004). Other reports also demonstrated that, grazing on communal natural pasture, private pastures, fallow grazing, road sides, crop stubble and residues, browses, grains, improved forages, and non-conventional feeds including household food leftovers, weeds from crop fields, tillers from dense crop fields and traditional brewers grains (locally known as *Atella*) serves as feed resources for sheep in Ethiopia (Ben Salem *et al*., 2004; Solomon *et al.*, 2010). The availability and utilization extent of feed resources by small ruminants depend on the type of cropping patterns and intensity, prevailing animal production system, farmers' livestock management practice and the production environment (Solomon *et al.*, 2010).

According to Bruh (2008), it is also indicated that about 68% of the crop residue is fed to draft oxen, 20% to milking cows and newly castrated bulls, while the remaining balance is fed to other livestock species during critical periods. This hinders to get reach the desired weight at preferred age and this further affects the contribution of the sector to the region's economy.

Natural resources including grazing lands and rangelands are being over exploited for the last many years. Thus, forage productivity declines through time. Considering the total number of livestock and the contribution of different sources of feed, the grazing lands are supporting livestock beyond their carrying capacity (Genet, 2011). Since the shortage of feed is the major problem in the livestock farming in Tigray region, farmers of the region have different coping strategies to overcome the feed problem faced by animals. For example, farmers around the arid and semi-arid parts of the region practice seasonal migration to feed resource areas, conservation of crop residue, hay making from grazing areas, cultivable lands, area closures and some farmers supplement their livestock with concentrate during the long dry season when the problem of feed shortage is much more critical (Genet, 2011). There is a need to search for alternative feed resources which could supplement the poor quality roughage feeds to enhance productivity of livestock (Tesfay 2007). Concentrate feed sources; especially grains are expensive and out of reach for many smallholders to use them as animal feed in developing countries. To combat this problem utilizing of locally available feed resources is a means.

The current agricultural policy of Ethiopia focuses towards market oriented agricultural development, whereby trained farmers who can effectively apply new technologies in agriculture will be the target group. In addition to this, the local NGO and bureau of Agriculture in Tigray are initiating a program for poor and landless farmers, especially women by giving loan for purchasing sheep, goats and cattle for fattening purpose as one means of poverty reduction. To make such initiatives a success, feeding systems using locally available feeds should be developed (Zemicheal, 2006).

2.5. Browse Species as Ruminant Feed

The urgent need of the farmers for high quality feed for ruminants in developing countries can be achievable through intensive utilization of multipurpose trees and shrubs as they have better nutritional quality nearly equivalent to that of grain based concentrates (FAO, 2002). Browse tree and shrub fruits from successfully constructed enclosures could be used as important dry season protein supplements thereby increasing the economic benefits of enclosures (Yayneshet *et al*., 2008). Recognition of the potential of tree foliage to produce considerable amounts of high protein biomass has led to the development of animal farming system that integrate the use of tree foliages with local bulky feed resources (Leng, 1997). Moreover, browse species provide fodder for ruminants in many parts of the globe because most of them maintain their greenness and nutritive value throughout the dry season when grasses dry up and deteriorate both in quality as well in quantity (Bruh, 2008).

The role of fodder trees in ruminant diets can be seen as a source of post ruminal protein for digestion, nitrogen and mineral supplement to enhance fermentative digestion and microbial growth efficiency in the rumen on poor quality forage and a total feed supplying almost all the biomass and other needed nutrients to support high levels of animal products (Leng, 1997). Foliages of browse species are generally rich in CP and minerals and they are used as a dry season supplement to poor quality pasture and fibrous crop residue (Bruh, 2008). In general, legumes are higher in Ca, K, Mg, Cu, Zn, Fe and Co than grass (Zelealem, 2004). It is also indicated that at least

75% of the shrubs and trees of Africa serve as browse plants and many of them are leguminous (Bruh, 2008). Shrubs provide their greatest benefits to grazing animals during periods of nutritional stress when nutritional value of dominant grass hays and forbs are low (Getachew, 2005).

In very recent times, trees and shrubs have been introduced into cropping and grazing systems to provide green fodders high in protein content to supplement the available low protein forage. Tree foliage is being increasingly recognized as a potentially high quality feed source for ruminants, particularly to supply crude protein. This is especially true in harsh and arid conditions where trees often provide more edible biomass than pasture (Bruh, 2008).

Fodder from trees and shrubs have been an important source of protein for grazing animals. However, in some cases not only their CP digestibility has been observed to be low, but also several cases of livestock death have been associated with high tannin content of some foliage (Leng, 1997). The tannins found in some tree legumes form a complex with plant proteins, which decreases their rate of digestion in the rumen, thereby reducing rumen ammonia concentrations and increasing the amount of plant protein bypassing the rumen (Norton, 1994).

Many leguminous fodder trees and shrubs have high protein levels and are potentially promising supplements to overcome nutrient deficiencies provided that anti-nutritional factors such as tannins and other secondary compounds controlled (Wina *et al*., 2005). In general, most browses species contain phenolic compounds that reduce digestibility of CP, contribute to un-palatability and reduce intake (Bruh, 2008). Tannins are poly phenolic substances that occur widely in plants and have the ability to bind proteins (Makkar, 2003a; Min *et al*., 2003). Tannins are defined as naturally occurring water-soluble poly phenols of varying molecular weight, which differ from most other natural phenolic compounds in their ability to precipitate proteins from solution (Makkar *et al*., 1995). There are two chemically distinct types of tannins;

hydrolyzable tannins, which are readily hydrolyzed by acid and condensed tannins (flavolans), bind feed nitrogen and relatively stable to hydrolysis (Leng, 1997). Bruh (2008) described that the most important property of tannins is their strong affinity to enzymes and feed protein, but even this varies depending on species Tannin content. Therefore, partially alters the use and value of tree foliages and may at times be responsible for the poor utilization of such forages by ruminant livestock. The significance of secondary plant compounds becomes more evident when tree foliage is the only feed consumed (Norton, 1994). Lowry *et al*. (1997) stated that condensed tannins may decrease voluntary feed intake by adversely affecting palatability. Reductions in intake would in turn affect overall animal performance (Reed, 1995).

The presence, however, of secondary plant compounds could provide major constraints to their uses. The primary anti-nutritional agent in acacia species and many other browse species are condensed tannins.

2.6. Improved Forage Crops as Ruminant Feed

Over the past three decades several introduced forages were tested on-station in different agro-ecological zones, and considerable efforts were made to test the adaptability of different species of pasture and forage crops under varying agro-ecological conditions (Alemayehu, 1997). As a result, quite a number of useful forages have been selected for different zones. Improved pasture and forages have been grown and used in government ranches, state farms, farmer's demonstration plots and dairy and fattening areas. Forage crops are commonly grown for feeding dairy cattle with oats and vetch mixtures, fodder beet, elephant grass mixed with desmodium species, phalaris/trifolium mixture, hedgerows of sesbania, leucaena and tree-Lucerne being common ones (Alemayehu, 1997).

In Ethiopia, the introduction of exotic multipurpose fodder trees such as *Sesbania, Leucaena, Calliandra, Acacia saligna* and Tree Lucerne in the mixed crop-livestock system started in the 1970s. The Ministry of Agriculture through the Fourth Livestock

Development Project (FLDP) and the National Soil and Water Conservation programme have disseminated a huge amount of seeds and seedlings of exotic fodder trees for animal feed and soil conservation (Alemayehu, 1997). More recently, about 32 government and non-governmental organizations in the Ethiopian highlands are involved in promoting multipurpose fodder trees in an integrated rural development program (Abebe, 2008). These fodder tree species were extensively distributed in most parts of the country because of their adaptation for a wide range of soils, moisture regimens and ease for establishment and fast growth rate.

2.6.1. Sesbania sesban as ruminant feed

Sesbania sesban is one of the exotic multipurpose fodder tree species that have been introduced in the Ethiopian highlands to alleviate feed shortages, maintain soil fertility and prevent land degradation (Abebe, 2008). *Sesbania sesban* is botanically described as: fast growing, reaching a height of 4-5 m in 6 months; deep-rooted single or multi stemmed shrub or small tree, 1-8 m tall; pods are usually 10-30 cm long and 5 mm wide producing 10-50 seeds per pod; and leaves are 2-18 cm long with 6-27 pairs of leaflets (Gutteridge and Shelton, 1998). Cutting frequencies are generally 3-4 cuts/annum, but up to 8 cuts are made in some areas. Yields have ranged from 4-12 ton DM/ha/year, depending on location. Cutting height can also influence yield, with cutting heights of 50-76 cm favoring plant survival and productivity (Orwa *et al.*, 2009).

The nutritional analysis of *Sesbania sesban* leaves revealed higher nutritive value and total digestible nutrients (Siaw *et al*., 1993). The CP content of *Sesbania sesban* foliage is generally greater than 20% and often above 25% (Gutteridge and Shelton, 1998; Orwa *et al*., 2009). It has been reported that, *Sesbania sesban* contains 23.8-31.7% CP, 89.2% OM, 21.4-25.5% NDF, 16.6-17.2% ADF, 51-57% ADL and 13.9-19% soluble tannin (ST) content (Abebe, 2008). Other studies also indicated that the tree has 23.9% CP, 36.4% NFE, 6.6% EE, 22.6% CF and 10.6% ash content on DM basis (Sabra *et al*., 2010). All these results show higher content of CP and lower CF in

Sesbania sesban, therefore, it can be considered as a high quality source of protein to supplement the deficiencies in free grazing sheep flocks (Evans, 2001; Orwa *et al*., 2009).

The variations in chemical composition of *Sesbania sesban* is due to differences in accession, stage of plant growth, cutting frequency and harvesting regimen, the parts of the plant (leafs, twigs, stems, seeds) included during feeding and chemical analysis, and soil type and fertility status (Abebe, 2008). *Sesbania sesban* supplementation in sheep fed grass hay as basal feed increased DM and OM intake and digestibility as well as nitrogen retention (Bonsi *et al.*, 1994). In another study, sheep fed *teff* straw and supplemented with *Sesbania sesban* showed significantly higher voluntary DM and N intake, and higher DM, OM and N digestibility compared to animals received concentrate alone (Abebe, 2008).

2.6.2. Acacia saligna as ruminant feed

The leaves of *Acacia saligna* could provide the source of fodder, particularly for small ruminant production (Berhane and Getachew, 2009). Browse species such as *Acacia saligna* play a major role in providing feed for ruminants in arid and semi-arid regions, particularly during the dry season when poor quality roughage and crop residues prevail. *Acacia saligna* is a thorn less shrub usually 2–5 m tall and belongs to the family leguminasae and subfamily mimosaceae (NAS, 1980). The leaves are long and thin to 22 cm (feathery acacia type leaves in seedlings, on mature plant flattened leaf stalks become leaves looking similar to eucalyptus leaves) (NAS, 1980). Forage development, with such drought tolerant and productive species is vital not only for the promotion of forage production, the control of soil erosion and environmental protection but also for an effective means of utilizing marginal lands on which traditional crop production is inappropriate. In an effort to alleviate livestock feed problems such programs have to be encouraged and technically supported (Getachew, 2005). In most of the gullies, *Acacia saligna* is the dominant species used as a biological control measure, thereby producing forage for livestock (Getachew, 2005).

Acacia saligna species are one of the evergreen leguminous browse tree/shrub species that can be used as livestock feed resource during the scarcity of feed both in quality and quantity. In different parts of Ethiopia, it is planted in gully areas, enclosures areas; in backyards etc. (Shumuye, 2011). According to Maslin and Donald (2004), *Acacia saligna* species serve as environmental rehabilitation, windbreak, fuel wood, and as soil and water conservation. They also added that the leaves of *Acacia saligna* could provide the source of fodder, particularly for small ruminant production. Acacia saligna is potential feed source but not recognized in our country. They simply use for conservation and other household uses like for fire wood. However this plant is beneficial as livestock feed as it has been studied in other places.

Condensed (non hydrolyzable) tannins in *Acacia saligna* are considered to be the primary anti nutritional factors other than the fiber quality that affect its utilization as fodder for livestock(Ben Salem *et al*., 1998). Similarly Degen *et al*. (1997) reported that condensed tannins (CT), which form insoluble complexes with proteins, proved to be the major constraints reducing the feeding value of acacia. The effect of tannins can be either adverse or beneficial for the animal depending on their concentration and chemical structure (Min *et al*., 2003; Makkar, 2003a).

Anti-nutritional factors such as condensed tannins protect proteins from degradation in the rumen (Mousa, 2011). Tannin protein complex on one hand reduces the availability and digestibility of protein for ruminants, but on the other hand it allows more dietary protein to escape rumen degradation to reach the lower digestive tract (Reed, 1995 and Min *et al*., 2003). Bhatta *et al*. (2005) also reported that, the formation of Condensed Tannins (CT) protein complex had a positive effect for sheep grazing in semi-arid range; this was due to the level of tannins ingested. Therefore, the feeding strategies should always be designed so that the parts of the dietary nutrients that can bypass and digested post ruminal are present in the diet (Mulu, 2005). A decreased animal performance due to condensed tannin ingestion is most often observed in diets containing concentrations higher than 55 g CT/kg; however, below 55 g CT/kg concentrations can have beneficial effects in ruminants, including improved amino acid absorption, reduced bloat and increased post ruminal protein absorption (Caygill and Mueller-Harvey, 1999).

The tolerance to tannins and alkaloids varies between species with goats being more tolerant followed by sheep and cattle. The ability of goats to tolerate tannin rich feeds is attributed to the content of prolin rich protein in the saliva which, by binding with tannins, provides the dietary CP for ruminal rumination (Bruh, 2008). Sheep consumed more *Acacia saligna* treated with polyethylene glycol, and gained better weight than those fed untreated (Ben Salem, 1998). But chemical treatments while successful, present several practical problems for smallholder agriculture. The lower intake of tannin-rich feeds is generally attributed to their astringent taste, besides the lower rate of digestion in the presence of tannins (Makker, 2003). Thus there is a need to find out practically feasible and cheaper processing technique that increases palatability of *Acacia saligna*, which is increasingly being adopted by smallholder farmers as a biological control against gullies (Getachew, 2005).

By reducing the effect of tannin in digestibility and palatability of *Acacia saligna* we can make exploit as a potential feed source for ruminants (Berhane and Getachew, 2009). *Acacia saligna* leaves could serve a dual purpose of soil conservation and source of animal feed, if the limitation of *Acacia saligna* leaves as a source of fodder for ruminants could be overcome through different feeding managements. According Van Thanh *et al*. (2005), Condensed Tannins (CT) in *Acacia* cyanophylla foliage were reduced after two days of drying under shade or in the sun. The total tannins were reduced by 22.6 and 11.3% for the drying and wilting. The effect of drying and wilting of the leaves of acacia on intake varies from species to species. Kaitho *et al*. (1996) reported that *Acacia nilotica* and *Acacia persiciflora* are preferred in the wilted form while *Acacia poyancantha* is preferred in dried form by sheep and goats.

Among the different means investigated to reduce the deleterious effects of anti-nutritional factors were air-drying and supply of exogenous nutrients (Mousa, 2011). Kaitho *et al*. (1996) noted that drying of fodder tree species reduces odor, leading to improvement in palatability. Therefore, *Acacia saligna* without treating the tannin content reduces the intake and also have lowered digestibility. Treating *Acacia saligna* leaf with chemical and other labor intensifying is not practical to apply in farmers so that air drying of *Acacia saligna* is preferred than the others. The digestibility of dry matter (DM), organic matter (OM) and energy contents of fresh *Acacia saligna* has been reported to be generally low mainly due to the presence of anti-nutritional factors, such as tannins whose contents range from 47 to 55 g/kg DM (Ben Salem *et al*., 1998).

2.6.3. Vigna unguiculata as ruminant feed

Cowpea is an important component in mixed systems and in semi-arid regions of the tropics and is valued for its potential to produce high levels of fodder for livestock in addition to grain for people. A number of studies have been conducted to evaluate cowpea fodder as a supplement to poor quality hay and stover. Cowpea haulm addition improves nutrient supply and growth of livestock over the use of low quality forages alone but degree of weight change varies relative to total nutrient supply (Baloyi *et al.*, 2008). It should be noted that only a limited number of studies reported the specific variety of cowpea used and animal response has been reported to differ with variety and its associated forage quality (Anele *et al.*, 2010).

One benefit of the use of cowpea and other legume fodders as a supplement is the provision of nitrogen to the rumen microbes, allowing them to improve utilization of the low quality forage. At some levels of supplementation, nitrogen becomes surplus to available carbohydrates for microbial growth and additional nitrogen may be wasted. An example of this diet development is found in the study of Koralagama *et al.* (2008) who fed either 150 or 300 g/d haulms from either a forage- or dual purpose-type cowpea to Ethiopian sheep fed a basal diet of maize stover. Dietary nitrogen was increased by cowpea haulm addition and higher levels of cowpea feeding resulted in higher nitrogen intakes. Total feed intake increased with increasing levels of cowpea supplementation and diet digestibility was greater for diets containing cowpea haulms. The results of the study indicated that nitrogen level for the lower levels of cowpea supplementation likely matched the needs of the rumen microbes for the type of carbohydrate found (fiber) in these diets. This is also supported by increased urinary nitrogen excretion in sheep fed cowpea at 300 g/d compared to 150 g/day, indicating that some nitrogen was likely leaving the rumen as ammonia nitrogen rather than being incorporated into microbial cells. Sheep in these studies gained between 32 and 51 g/d when supplemented with cowpea.

Chakeredza *et al.* (2002) found a 22.7% increase in microbial protein supply when cowpea haulms were added to a diet of maize stover which also illustrates how cowpea improves nitrogen supply for rumen microbes. This hypothesis supports the results of the study reported by Singh *et al.* (2003), in which additions of about 200 g cowpea haulms were shown to be the most economically viable level in feeding systems based on cereal stover compared to feeding either 400 or 600 g of supplemental haulms.

Although increasing amounts of cowpea in a diet based on sorghum stover resulted in increased gains, the amount of increase diminished with each subsequent increase, resulting in the lowest level of cowpea addition (200 g) being the most economical. This is also consistent with economic theory that the economically optimal supplementation level will always be somewhat less than the maximum biological efficiency from supplementation (Torell and Rimbey, 2010).

To provide options for optimal mixes of sorghum stover and cowpea haulms Savadogo *et al.* (2000) fed 21 kg rams varied levels of cowpea haulms in addition to sorghum stover at levels that allowed selective consumption of stover. This allowed rams to select between sorghum leaf and stem, a factor that affects digestibility and intake of the diet. The researchers then calculated the varied amounts of cowpea haulms needed to reach various levels of maintenance intake up to two times maintenance. For example, maintenance intake was reached with 61 g organic matter (OM) per $kg^{0.75}$ body weight (BW) for sorghum stover and an additional of 48 g cowpea OM/ $kg^{0.75}$ BW was required to reach two times maintenance. The studies showed the wide range in stover–cowpea combinations that could result in the same level of maintenance intake. This approach provides information useful for mixing diets relative to targeted production goals and can be used in combination with feed price information to develop diets producing the best economic returns.

The use of low-quality forage, such as cereal stover, as the major feedstuff in ruminant diets can limit both energy density and intake. Supplementation of low-quality forage with legumes will increase diet utilization to some extent, but for higher levels of production increased dietary energy density through the use of higher quality forage and some grain may become of interest to livestock producers. Legume fodders such as cowpea can remain an important part of these higher energy diets. Though there are limited studies previously reported on the DM yield of cowpea, 3.4 ton DM/ha are recorded in Ghana (Aikins and Afuakwa, 2008).

2.7. Agro-Industrial Byproducts as Ruminant Feed

Agro-industrial byproducts such as noug seed cake, cotton seed cake, and wheat bran are important sources of protein and energy for supplementing fibrous basal diets. Oil seed cakes are residues remaining after the removal of the greater part of the oil from oilseeds. These residues are rich in protein (200-500 g/kg) and most are valuable feeds for farm animals (McDonald *et al*., 2002).

Cotton seed (*Gossypium hirsutum*) cake, like other oil seed meals is obtained after the oil has been extracted from the cotton seed using either of two common methods of extraction, namely, expeller extraction (mechanical) and solvent extraction (chemical). The composition and nutritive value of the cake depend up on the raw material and the method of extraction used (Weiss, 1983). Cotton seed contains 41% CP, 10.6% fiber, 72% TDN, 6.2% ash, and 4.6% EE, the energy content ranges 8.5 to 12.3 MJ ME/kg DM (McDonald, 2002). Cotton seed meal is one of the richest feeds in phosphorus, containing about 1% or more. In contrast to the high phosphorus content, it has only about 0.2% calcium. Cotton seed meal is used as a source of protein in concentrate mixture, rather than to use cotton seed meal as the only supplement (McDonald, 2002).

Cotton seed has a thick coat or husk, rich in fiber and of low digestibility, which lowers the nutritive value of the material (McDonald, 2002). It may be completely or partially removed by cracking and riddling, a process known as decortications. Removal of the husk lowers the crude fiber content and has an important effect in improving the apparent digestibility of the other constituents. Cotton seed cake is an excellent protein supplement for fattening lambs and is practically equal to linseed meal for fattening lambs. When sheep are fed with large amounts of cotton seed meal, there is danger of cotton seed meal injury, unless they are offered plenty of good legume hay or other roughages (Morrison, 1984). A major constraint to the use of cotton seed and cotton seed meal as feedstuff is the presence of toxic constituents of gossypol, a yellowish pigment that occurs in seeds. Ruminants are more tolerant of gossypol, but even in ruminants prolonged feeding of whole cotton seed for many weeks or months can cause heart and liver damage (Cheeke, 1991).

Wheat bran is characterized as high water absorbing feed supplement, because of its fiber and non starch carbohydrate content, which results in a bulky effect in the colon, and giving it laxative property. The bulky nature and high fiber content of bran and other mill feeds makes them suitable for ruminant feeding (Cheeke, 1991 cited in Awet, 2007). Wheat bran is one of the energy source concentrates containing α-linked polysaccharides. Feeds with such linkages are readily degraded in the rumen and have high values of ME (Chesworth, 1992). According to Lonsdale (1989) wheat bran is described as the outer fibrous layer from the rest of the grain and the germ. It is also physically fibrous, flaky product and has a characteristic wheat smell. During milling wheat, the effect of the initial shearing rollers (first break) is broad to separate the outer fibrous layer from the rest of the grain and the germ. This separated portion predominantly consists of the husk (pericarp and taste or coarse bran) and the thin papery layer from around the starch (aleurone, or fine bran). But very little starch (endosperm) is found in bran (Awet, 2007).

The CP in wheat bran has a relatively high digestibility coefficient of 0.75 and the degradability ranges from 0.50 to 0.70 (Lonsdale, 1989). Fiber and metabolizable energy (ME) contents vary slightly depending on the specification of the wheat being milled and the exact processing method used, as these factors affect the overall blend of bran components. Byproducts of the flour milling industry such as wheat bran are potential nutrient sources for livestock. During the processing of cereals by milling, the endosperm, which consists mainly of starch and gluten, is separated from other fractions of the seed. The outermost layer of seed is high in fiber, and when removed, consists mainly of the bran fraction (Zemichael, 2006). Wheat bran is quite palatable and is well known for its ability to prevent constipation because of its swelling and water holding capacity. This capacity of wheat bran is due to its fiber and non-starch carbohydrate content (Cheeke, 1991). Wheat bran has an amino acid balance superior to the whole wheat, high phosphorous content and low calcium. The CP content of wheat bran was reported at 17.19% (Getnet, 1998), 16.5 - 17% CP (Solomon, 2001) and little more CP content of 20% was reported by Simret (2005).

In Tigray region currently there are many flourishing flour factories. This provides great opportunity to promote fattening and dairying in urban and semi urban areas using this Agro-industrial feeds (Genet, 2011). Not only the factories but also farmers produce wheat bran in their households following milling their wheat. The byproducts of the flour milling industries provide a potential source of supplemental feed for livestock (Awet, 2007).

2.8. Reproductive Characteristics of Rams

Reproductive inefficiency in sheep results in reduced dissemination of superior genetic material and lower producer profitability (Zelealem, 2004). The productivity and profitability of our meat and milk industries effectively depend on reproductive performance for which the goals have not changed since the early stages of domestication (Martin, 2004). The success of a sheep production enterprise is highly dependent, among others on the ability of rams to breed a maximum number of ewes, which is a factor of libido and mating ability of the rams (Zelealem, 2004).

Libido in sheep, as in all other animals, is influenced by factors such as genotype, nutrition and climate, health of animal and farm management practices. Nutrition manipulation fluctuation in particular trace elements has a major influence in libido expression in animals (Puls, 1994). A general trend in Semen characteristics in relation to age was observed common in all lambs. During the first weeks in which a fluid was ejaculated only leukocytes were observed. Progressively spermatozoa (usually dead) began to be observed. As the number of spermatozoa and of live spermatozoa began to increase, leukocytes began to disappear from the ejaculate. Throughout this period, the percentage of abnormal spermatozoa also decreased progressively. Although this general trend was common to all lambs, increases and decreases in the maturation of semen obtained were also observed in all lambs (Ungerfeld, 2007).

The time at which leukocytes and spermatozoa were first observed in ejaculate, and first semen observations with more than 30% of spermatozoa alive, more than 30 million of spermatozoa and less than 30% of abnormal spermatozoa were observed earlier in greater than lesser lambs (Ungerfeld, 2007).

Overall, high-ranked lambs increased their body weight and scrotal circumference earlier than lesser ranked lambs. Semen production and male–female sexual behavior also matured earlier in high-ranked than in lesser ranked lambs. Highest ranked rams participated more frequently and at an earlier age in male–male mounting activities. It remains to be determined the relative influence of hierarchy and body growth in the earlier onset of puberty (Ungerfeld, 2007).

3. MATERIALS AND METHODS

This dissertation research work involved two major components: assessment of sheep husbandry practices and an on–station feeding experiment described as follows.

3.1. Survey

3.1.1. Description of the study area

The survey was conducted in *Tahtay Adyabo wereda,* located in north western zone of Tigray National Regional State, 350 km northwest of *Mekelle*. Its location lies within the co-ordinates of 14^0 23' north latitude and 37^0 55' east longitudes (Fig 2). The total area coverage of the *wereda* is estimated to be 536,989 ha. The agro-ecology of the *wereda* is hot to warm semi-arid lowland plains which are characterized by hot temperature, erratic rainfall, vast area of plain lowlands suitable for large scale and subsistence agriculture including crop and livestock production. This *wereda* was selected purposively based on sheep distribution and population in the region.

Livestock are valuable components of the farming system contributing enormously to smallholder producers. There are quite large numbers of farmers engaged in small and medium scale fattening of cattle and small ruminants. The major feed resources for livestock include crop residues, hay, grazing, and agro industrial byproducts. In terms of feeds for livestock, sorghum Stover contributes the largest share of the crop residues. Chickpea is a major pulse widely grown by smallholder farmers. Sesame is by far the largest oil seed crop (Yaynshet, 2010).

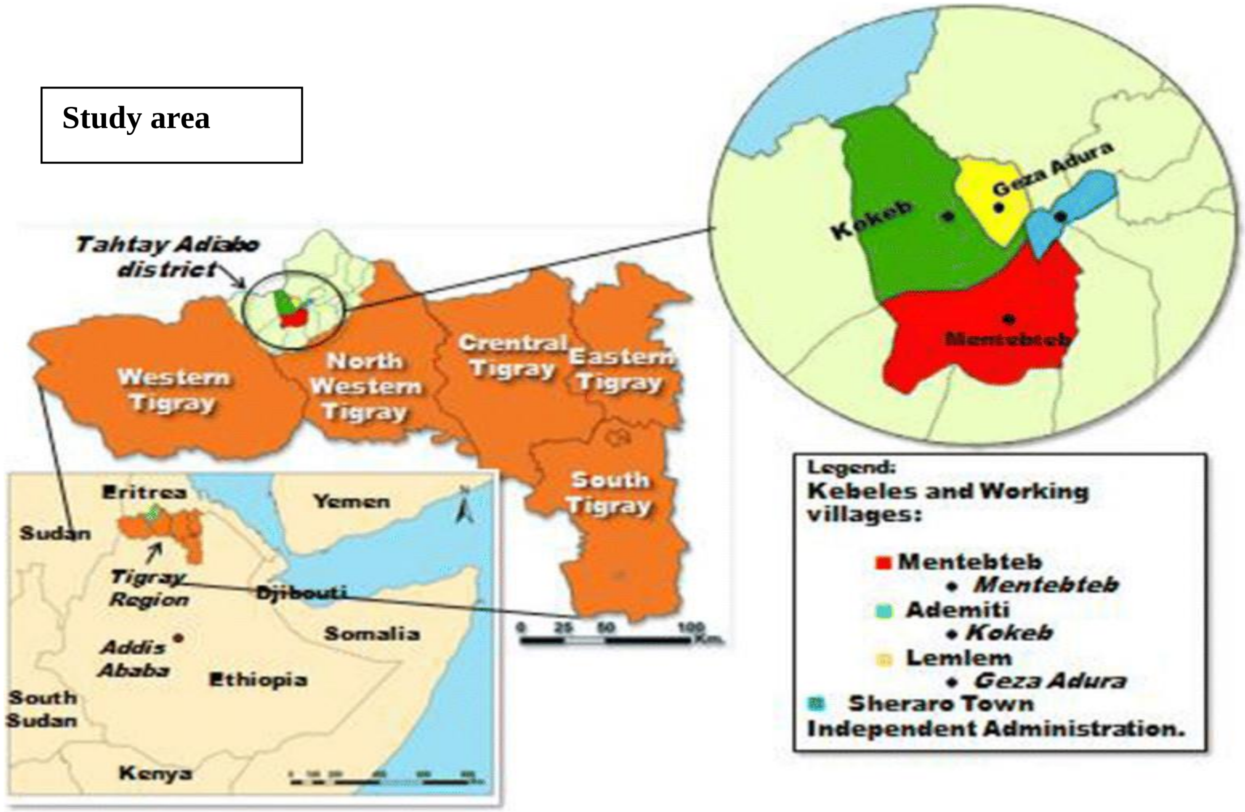

Figure 2: Map of the study area

3.1.2. Sampling methodology

Prior to sampling of the *kebeles*, discussions were held with *wereda* livestock experts and development agents by preparing workshop to make the purpose of the study clear. Two *kebeles* (*Lemelem* and *Ademiti*) were purposively selected from the *wereda* based on the population of sheep. Sample size was calculated based on the formula 0.25/ (SE) ^{2} (Arsham, 2007). A total of 108 households (54 from each *kebeles*) were randomly selected. Fifteen farmers from each *kebeles* were purposively chosen for group discussion based on their experiences on keeping/rearing of sheep for longer period of time (more than 10 years sheep rearing experiences).

3.1.3. Data collection

Data were collected through household interviews in local language by trained enumerators using structured questionnaire (Appendix). The questionnaire were designed to obtain information on general household characteristics, livestock and herd holding, purpose of keeping sheep, feed resources and feeding practices and production constraints of sheep. The questionnaire was pre-tested for clarity and appropriateness. Some of the information collected during interview was supported by observation and group discussion. Some of the points mentioned for group discussion were sheep production constraints and available feed resources for sheep in the area.

3.2. Feeding trial

This experiment was a feeding trial involving different supplementation options to replace feeding cotton seed cake to Begait sheep measuring animal responses.

3.2.1. Study site

The experiment was carried out at *Humera* Begait Cattle and Small Ruminants Breeding and Multiplication Ranch of Tigray regional government. The ranch was established on 2000 ha of land and it is located in western part of Tigray. The mean annual rainfall and mean minimum and maximum temperatures are 448.8mm, 25^{o}C and 32^{o}C, respectively (EARO, 2002).

3.2.2. Experimental animals and their management

Twenty four yearling Begait male sheep with an average initial body weight of 25 ± 1.39 kg (mean ± SD) were used for this experiment. The sheep were quarantined for two weeks in the experimental area. During the quarantine period, sheep were de-wormed and sprayed against internal and external parasites with a broad spectrum *Albendazole* against internal parasites and sprayed accaricide against external parasites. They were also vaccinated against the common diseases (anthrax and *pasteurelosis*) during the quarantine period. Then all sheep were transferred to individual pens.

3.2.3. Experimental feeds and design

Grass hay and the forage legume *Vigna unguiculata* harvested from the ranch were used. The hay was chopped to a length of approximately 4-5 cm, weighed and offered to the sheep *ad libitum* as a basal diet throughout the experimental period. The leaves of *A. saligna* and *S. sesban* were collected by hand stripping from area enclosures and individual farm boundaries. The leaves were subjected to air drying for about four - five days till the stage that leaves are crushed by twisting easily. Wheat bran and cotton seed cake were purchased from Momona wheat flour milling factory and Shire town market, respectively. The daily amount of grass hay and supplemental feeds were offered in separate troughs. The rams had free access to clean and fresh water and common salt at all the time.

The experiment was conducted using randomized complete block design (RCBD) with four treatments consisting of six sheep per treatment. The experimental sheep were blocked in to six blocks of four animals each based on their initial body weight (IBW), which was determined as a mean of two consecutive weighing after overnight fasting at the end of the adaptation period, and they were placed in an individual pen. Sheep within a block were assigned to one of the four dietary treatments randomly.

The amount of concentrate mixture in this experiment was determined to be 300 g in the proportion of 65 % wheat bran to 35 % cotton seed cake on DM basis based on the research findings of Michaele and Yaynishet (2014) for Tigray highland sheep and by considering their body weight and the expected weight gain. The supplement feeds for the other treatments were formulated on iso-nitrogenous basis. Samples of treatment feeds were analyzed for dry matter (DM) and crude protein (CP) contents before the commencement of the experiment to determine the amount of the experimental rations. The concentrate mixture was formulated to give 67.6 g/day CP on DM basis. To supply the same amount of CP, 450 g (Wheat Bran + *Acacia saligna* leaf), 340 g (Wheat Bran + *S.sesban* leaf) and 380 g (Wheat Bran + *Vigna unguiculata* leaf) on DM basis were supplied for sheep in the other treatments daily (Table 3).

Table 3: Arrangement of experimental treatments

Treatments	**Type of feeds**	
	Basal feed	Supplements (g on DM basis)
T1	Grass hay **	200 WB+ 100 CSC
T2	Grass hay **	200 WB + 250 ASL
T3	Grass hay **	200 WB + 140 SSL
T4	Grass hay **	200 WB + 180 VUL

ASL = *Acacia saligna* leaves; CSC= Cotton seed cake; SSL= *Sesbania sesban* leaves; T= Treatment; WB= Wheat bran; VUL= *Vigna unguiculata* leaves; basis; **= *Ad libitum*.

3.2.4. Feed intake, body weight gain and feed conversion efficiency

For each animal, daily offered and refusal of each treatment diet was measured and recorded throughout the experimental period (90 days). Samples of feeds offered were collected on batches of feeds and that of refusals were collected for each animal and pooled for each treatment. Daily feed intake of individual sheep was recorded as a difference between the feed offered and the refusal.

Initial body weight of the experimental animals was taken at the beginning of the study during morning hours after overnight fasting using a weighing scale with sensitivity of

100 grams. Body weight changes were recorded at an interval of 10 days. Daily body weight gain was calculated as the difference between final body weight and initial body weight divided by the number of days. The feed conversion efficiency was calculated by dividing the daily body weight gain by daily DM intake.

3.2.5. Digestibility trial

Digestibility trial was conducted at the end of the feeding trial. All sheep were harnessed with faecal collecting bag to collect fasces for digestibility determination. Sheep were allowed to acclimatize to the fecal collecting bags for 3 days and this was followed by collection of feaces for 7 days, which was done every morning before provision of feed and water. The collected faces were weighed daily and 20% of the daily faces voided by each animal was sampled and pooled over the collection period for each sheep separately. Faces samples from each sheep were placed in airtight polyethylene plastic bags and stored in deep freezer (–20^{o}C) up to the completion of the digestibility trial. At the end of the digestibility trial, the collected faces samples were thoroughly mixed, and 10% of the total collected sample from each animal was sub-sampled, weighed, partially dried at 60°C for 72 hours, ground to pass 1mm sieve and stored in airtight polyethylene plastic bags pending chemical analysis. The apparent digestibility of DM, OM, CP, NDF, and ADF was determined by the following equations (McDonald *et al.*, 2002):

$$\text{DC}(\%) = \frac{\text{Total amount of nutrients in feed - total amount of nutrients in feces}}{\text{Total amount of nutrient in feed}} \times 100$$

3.2.6. Carcass characteristics

At the end of the feeding and digestibility trial, four experimental animals from each feeding treatment were randomly selected and fasted overnight then slaughtered.

Slaughter weight (SW) was taken 30 minutes before slaughter. Hot carcass weights, empty body weight and rib eye (*longissimus dorsi*) area were measured. The weights of omental fat deposits and of the major internal organs (lungs with trachea and esophagus, heart, kidneys, liver with gall bladder, spleen and pancreas, testis and penis), the entire alimentary canal (full stomach, and empty gut), skin with feet, tail, blood and head with tongue were recorded separately using sensitive balance weighing from 0.00g to 5 kg.

The carcass was partitioned into hind and fore quarter between 9th and 10th ribs. The four ribs from (10th to 13th) were chilled overnight in deep freezer and the rib eye (*Longissimus dorsi*) area (cm^2) was measured at the 11th and 12th rib site (Gallal *et al*., 1997a). The rib-eye area value was the mean of the left and right sides. The cross sectional area of the rib eye muscle (*longissimus dorsi*) area was traced first on plastic paper after it was cut at the 11th and 12th ribs perpendicularly to back bone. The rib-eye area was again traced on graph paper and computed using mechanical polar planimeter (model series 20) and cross checked with graph paper squares each with a size of 1mm x 1mm. The area of the squares that fall within the tracer mark was then counted on both sides and the average of the two sides was used to calculate rib-eye area in cm^2.

Empty body weight was determined by reducing the gut fill from slaughter body weight. Dressing percentage was calculated on the bases of slaughter and empty body weight using the formula:

$$\text{Dressing Percentage} = \frac{\text{Hot carcass weight}}{\text{Slaughter body weight}} X100$$

And

$$= \frac{\text{Hot carcass weight}}{\text{Empty body weight}} X\,100$$

The hot carcass weight was calculated in two ways with and without including the tail weight to see the influence of the fat tail of the breeds on dressing percentage. The dressing percentage on both slaughter and empty body weight bases was also computed accordingly in both ways.

Total edible offal component (TEOC) was taken as the sum of liver with gall bladder, empty gut, visceral fat (kidney fat + omental fat), testis, kidneys, head with tongue and tail. Total non-edible offal component (TNEOC) was computed as the sum of lung with trachea and esophagus, blood, spleen and pancreas, skin with feet, penis and total gut fill.

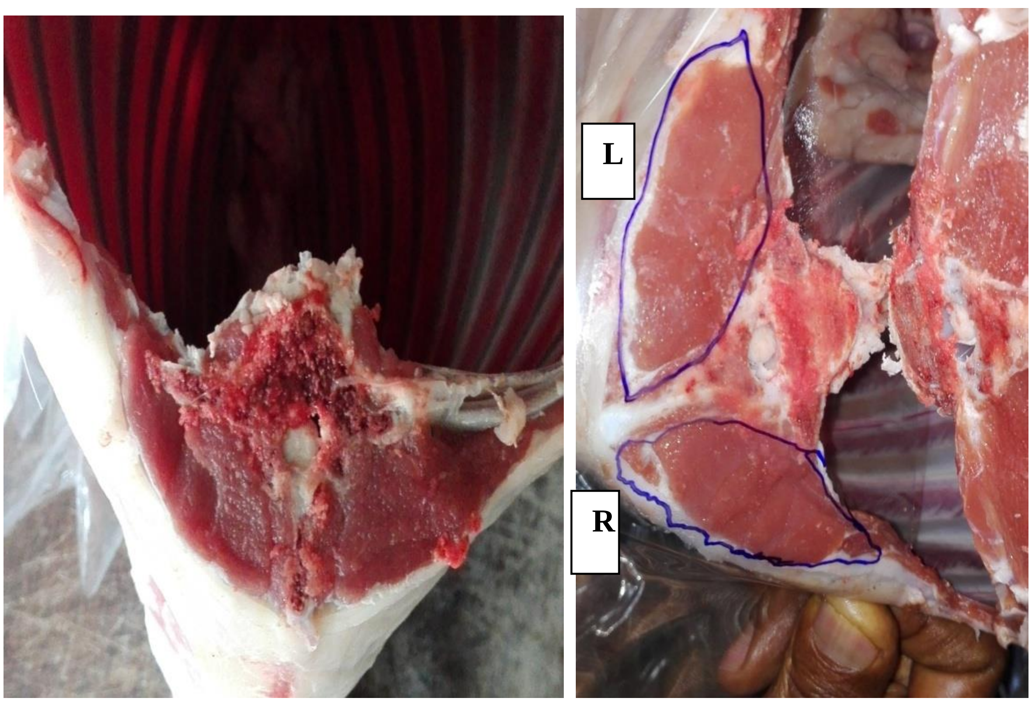

Figure 3: Rib eye (*Longissimus dorsi*) area, R = right side and L = left side

3.2.7. Evaluation of reproductive characteristics of Begait rams

Reproductive characteristics of rams were evaluated by measuring scrotum weight, scrotum circumference and libido character. During the feeding trial and before the digestibility trial, semen was taken for three weeks at weekly interval and semen quality measurements were done. All equipment necessary to undertake semen quality artificial vagina (AV), microscope, chemicals (Xylen, 10% nigrosin solution, Eosin- Nigrosin stain), were prepared in collaboration with Mekelle University Faculty of Veterinary Science and Aksum University Department of Animal Production. Artificial Vagina filled with hot water up to 40^0C which is consistent with natural sheep vagina temperature was used for semen collection. Then, each ram was allowed to mount the ewe in heat but not allowed to serve; after doing this, rams were allowed to ejaculate in the prepared AV. Right after ejaculation, the evaluation for semen quality was undertaken in the laboratory. Semen volume was measured using a measuring test-tube and were recorded for every ejaculated semen from every ram and finally summarized according to their treatments. Mass motility was measured using grades (1-5) that is 1 for the less motility (movement) and 5 gave to higher motility following direct observation in microscope by putting a drop of semen in the slide. By making smear following adding a solution of Eosin-Nigrosin to the collected semen, live and dead sperm cells were counted in the microscope by magnifying 100 times and putting oil. Counting of live and dead semen was done till total number reached 400. Both consistency and color of semen were identified by physical observation. Consistency was measured using 4 grades (very thick, thick, thin and very thin) while the color was measured using 4 grades (cream whitish, creamy, brown and light brown). Scrotum weight (post mortem slaughtering) was measured right after slaughtering using sensitive balance

Semen was characterized according to the measurement outlined by Salamon and Maxwell, (2000). Scrotum circumference (anti mortem) was taken using a tape by circling the scrotum. Two ewes in heat were used for measuring libido. It was measured by observing individual ram's sexual desire and recorded in five grades (excellent, very good, good, fair and poor), higher sexual desire (excellent) mount the ewe continuously for more than five times, and the poor one cannot even interested to sniff the ewe in heat. Body condition was measured by physical observation of the rams according ESGPIP,(2008) and graded as 1 to 5 (5= excellent (very fat), 4= very good (fat), 3= good (moderate), 2= fair (thin) and 1= poor (very thin)).

3.2.8. Chemical analysis

DM, OM, Ash and Nitrogen (N) content was determined according to the Association of Official Analytical Chemists, (1990). Crude protein (CP) was calculated by N content multiplied by 6.25. The fiber content, neutral detergent fiber (NDF), acid detergent fiber (ADF) and acid detergent lignin (ADL), of sample experimental feeds were analyzed according to Van Soest *et al.*, (1994).

Figure 4: Feed chemical composition determination at Nutrilab, Netherlands.

The DM, CP, ash, NDF, ADF and ADL contents of the experimental ingredients and grass hay are given in Table 4.Hay had lower CP and higher NDF and ADF content than the supplemental feeds. Although *A. saligna* was slightly lower and cotton seed cake was higher in CP content, the four supplemental diets are generally rich sources of CP. However, the NDF and ADF levels in *S. sesban* were lower than the other supplemental diets used in this study, and the ADL content was lower for cotton seed cake.

Table 4: Chemical composition of the experimental feeds on DM basis

Treatment Feeds	DM	OM	Ash	CP	NDF	ADF	ADL
Grass hay	94.61	91.77	8.23	6.04	76.15	50.62	10.43
Wheat bran	93.58	93.73	6.27	16.2	25.54	12.0	4.35
Cotton seedcake	89.52	94.49	5.64	35.5	41.76	25.78	5.8
A.saligna	93.0	85.5	14.50	14.20	44.29	32.02	9.25
S.sasban	92.0	87.95	12.05	25.3	21.23	18.04	9.08
V.unguiculata	88.44	85.92	14.08	19.5	24.1	21.0	16.3

ADF=Acid detergent fiber; ADL=Acid detergent lignin; CP=Crude protein; DM=Dry matter; NDF=Neutral detergent fiber; OM= organic matter.

3.2.9. Data management and analysis

Data collected from survey were coded and entered into the computer for further analysis. Data collected were analyzed using Statistical Package for Social Sciences (SPSS 20.0 for windows, 2004). Index was computed by employing the principle of weighted average of Musa *et al*., (2006).

$$\text{Index} = \frac{Rn*C1+Rn\text{-}1*C2\ldots.+R1*Cn}{\Sigma Rn*C1+Rn\text{-}1*C2\ldots+R1*Cn;}$$

Where, Rn = Value given for the least ranked level (if the least rank is 5th, then Rn = 5, Rn-1 = 4, R1 = 1) Cn = Counts of the least ranked level (in the above example, the count of the 5th rank = Cn, and the count of the 1st rank = C1).

The data obtained from the feeding trial were analyzed using Statistical Package for Social Sciences (SPSS 20.0 for windows, 2004). Treatment means were separated using Tukey HSD. The model used for the analysis of the data was:

$$Y_{ijk} = \mu + \alpha_i + \beta j + \varepsilon_{ijk}$$

Where: Y_{ij} = response variable

μ = overall mean

α_i = i^{th} treatment effect

βj = block effect and

ε_{ijk} = i^{th} random error

4. RESULTS

4.1. Survey

4.1.1. Households Characteristics

The study area is characterized by mixed crop-livestock system. The majority of respondents in the study area were male headed. The mean age of the respondents was 45 years. The average family and land size was 5.6 persons and 1.54 ha per household, respectively (Table 5). Farmers in *Ademiti kebele* had more ($P<0.05$) land per household than those farmers found in *Lemlem kebele*. From the interviewed households, about 48.1% could read and write while 51.9% were illiterate.

Table 5: Average age, family size, land holding, educational level and sex of respondents in Tahtay Adyabo Wereda

	Kebeles		
Parameters	*Lemelem*	*Ademiti*	Total
	Mean ± SD	Mean ± SD	Mean + SE
Age (years)	48.2± 6.9	41.63±7.7	44.91±8.03
Family size	6.2±2.03	5.19±1.74	5.60±1.91
Land size (ha)	1.37±0.76	1.72±1.02	1.54±0.83
Gender head ratio	N (%)	N (%)	N (%)
Male	39(72)	44(81)	83(76.8)
Female	15(28)	10(19)	25(23.2)
Educational status	N (%)	N (%)	N (%)
Illiterate	25(46.3)	31(57.4)	56(51.9)
Read and write	29(53.7	23(42.6)	52(48.1)

N=Sample respondents, the figures in the brackets are percentages from N

4.1.2. Sources of livelihood of the respondents

The primary sources of livelihood of the respondents in the study area are given in Table 6. The majority of respondents reported livestock and crop production as the most important source for their livelihood followed by crop, livestock and off-farm activities combined, livestock and off-farm activities and livestock production only.

Table 6: Household income sources in sampled respondents of Tahtay Adyabo Wereda

	Kebeles		
Income source	*Lemelem* N (%)	*Ademiti* N (%)	Total N (%)
Livestock production only	4 (7.4)	2 (3.7)	6 (5.5)
Livestock and crop production	28 (51.8)	34 (62.9)	62 (57.4)
Livestock and off-farm activities	7 (12.9)	5 (9.3)	12 (11.1)
Crop, livestock and off-farm	15 (27.8)	13 (24.0)	28 (25.9)

N=Sample respondents, the figures in the brackets are percentages from N

4.1.3. Livestock holding and species composition

The livestock possession of the studied households is summarized in Figure 5. The major livestock species owned by sample households were sheep, goats, cattle and equines. Sheep and goats were the dominant livestock species followed by cattle. There was significant difference in livestock holding for cattle, sheep, goats and chicken among *Lemlem* and *Ademiti kebeles*. However, there was no significant difference for equines and beehives holding for the two *kebeles*. Equines were mainly kept for transportation and packing purposes in both *kebeles*.

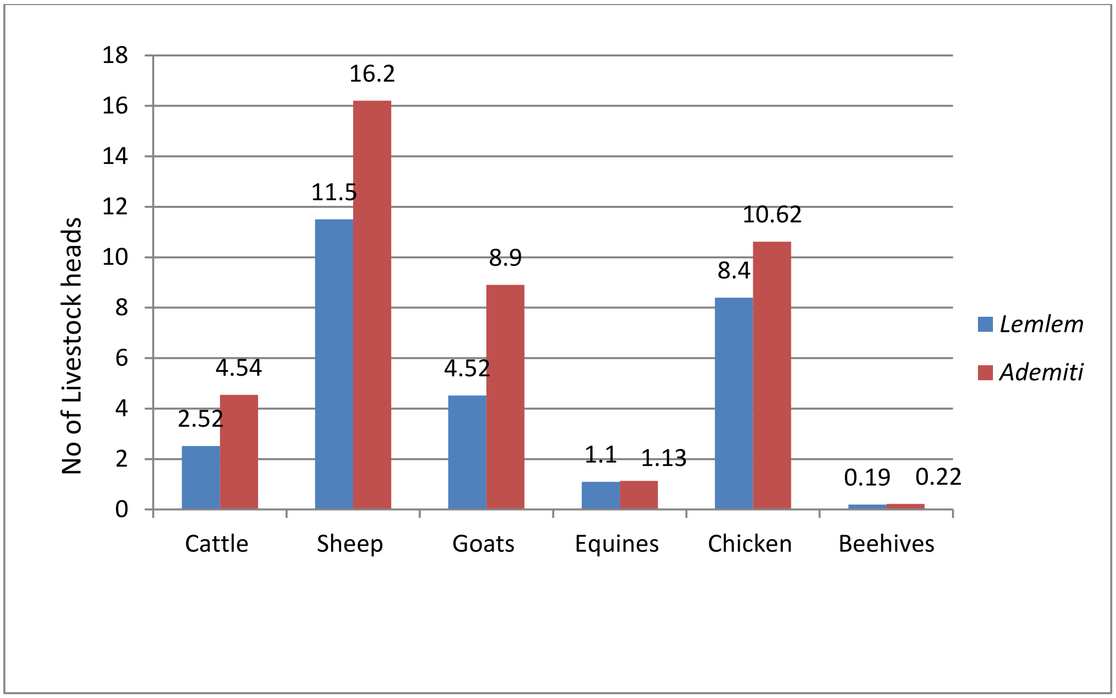

Figure 5: Average holding of livestock heads per household in sampled respondents of Tahtay Adyabo Wereda

4.1.4. Purpose of keeping Begait sheep

The results of this survey revealed that Begait sheep played multi-functional roles in the study area. Based on the ranking of purposes for keeping Begait sheep in Table 7 it was observed that farmers kept these animals for income source, as sources of meat for home consumption, saving as live animal, manure for soil fertilization and social values.

Table 7: Purpose of keeping Begait sheep in sampled respondents of Tahtay Adyabo Wereda

	Kebeles							
Parameters	*Lemelem*				*Ademiti*			
	Rank1	Rank2	Rank3	I	Rank1	Rank2	Rank3	I
Source of income	55.5	33.3	7.4	0.400	59.2	27.7	5.55	0.395
Saving as live animal	14.8	14.8	40.7	0.191	12.9	18.5	42.5	0.195
Home consumption	29.6	51.8	22.2	0.357	27.7	50.0	18.5	0.336
Source of manure	-	-	25.9	0.043	0	3.7	31.4	0.064
Social values	-	-	3.7	0.006	0	-	1.85	0.003

N= number of respondents; I=index; I=sum of [3 for rank 1+2 for rank 2 + 1 for rank 3] given for an individual purpose divided by sum of [3 for rank 1+2 for rank 2 + 1 for rank 3] summed for all the purposes

4.1.5. Livestock feed resources and feeding practices in the study area

The main feed resources for sheep production in the study area are natural pasture, browse trees and crop residues (Table 8). The main feed resources in the dry and rainy seasons for sheep were different. Natural pasture was the main feed resource during the rainy season; natural pasture (standing hay) and crop residues, in the dry season. In *Ademiti kebele*, the grazing lands have more browse species and sheep utilize these feed resources. In this *kebele*, there was more land that was available for grazing and hence feed shortage was not the main problem when it is compared with the *Lemlem kebele*.

Table 8: Feed sources in wet and dry season in the study area

	Kebeles		
Wet season	*Lemelem* N (%)	*Ademiti* N (%)	Total N (%)
Grazing on pasture	54(100)	54(100)	108(100)
Browse trees	54(100)	51(98)	105(97.2)
Crop residues	11(20.3)	7(12.9)	18(16.6)
Dry season			
Pasture(standing hay)	54(100)	54(100)	108(100)
Crop residues	54(100)	54(100)	108(100)
Crop after math	45(83.3)	51(94.4)	96(88.8)
Browse trees	16(29.6)	26(48.1)	42(38.8)
Feed supplement	30(55.5)	13(24.0)	43(39.8)

N= number of respondents and in bracket are % of respondents

Results showed that supplementation using commercial feeds like wheat bran, sesame seed cake, cotton seed cake and noug seed cake to their sheep were practiced (Table 9). The major concentrate utilized under farmers management was wheat bran as it was cheap. Few farmers also used a mix of concentrates like wheat bran with cotton seed cake, wheat bran with sesame seed cake and wheat bran with noug seed cake.

Table 9: Feed supplements for sheep production in Tahtay Adyabo Wereda

Feed supplements	*Lemelem* N (%)	*Ademiti* N (%)	Total N (%)
Wheat bran	31(57.4)	28(51.8)	59(54.6)
Cotton seed cake	11(20.3)	8(14.8)	19(17.5)
Noug seed cake	7(12.9)	8(14.8)	15(13.8)
Sesame seed cake	5 (9.2)	10(18.5)	15(13.8)

N= number of respondents and in bracket are % of respondents

Grazing land in the studied area was entirely communally owned. Farmers used different feeding/grazing practices. Free grazing was the most common practice during wet and dry seasons (Table 10). A few farmers feed their animals using cut and carry system during both the dry and wet seasons. The natural pasture dries up and becomes standing hay and animals graze up on this. Moreover, feed conservation was practiced in the form of crop residue (sorghum stover, *teff* straw, millet straw, and maize stover).These conserved feeds were given to cattle during feed shortage (dry season) primarily to lactating cows and work oxen during the cropping season and to sheep occasionally.

Table 10: Feeding practices of sheep in Tahtay Adyabo Wereda

	Dry season			Wet season		
Feeding practices	*Lemelem* N (%)	*Ademiti* N (%)	Total N (%)	*Lemelem* N (%)	*Ademiti* N (%)	Total N (%)
Free grazing	22(40.7)	28(51.8)	50(46.2)	44(81.4)	46(85.1)	90(83.3)
Grazing plus Cut and carry of green feeds	8(14.8)	1(1.8)	9(8.3)	8(14.8)	6(11.1)	14(12.9)
Grazing plus household wastes	6(11.1)	3(5.55)	9(8.3)	2(3.7)	2(3.7)	4(3.7)
Grazing plus Agro industrial byproduct	18(33.3)	22(40.7)	40(37.0)	-	-	-

N= number of respondents; the figures in the brackets are percent of respondents

4.1.6. Water resources and watering

Rivers, boreholes and pond water were the major sources of water for livestock in the study area. Sheep were mostly watered in rivers, pond, and boreholes; Shortage of water was common in dry season. Sources and distance of water by season is presented in Table 11 and 12. During the dry season, the majority of the households obtained water supply from rivers, while some got water from boreholes, pond and from piped sources. In wet season the majority of the respondents obtained water from rivers while the rest got water from bore wells, ponds and from piped source.

Table 11: Sources of water for sheep in the Tahtay Adyabo Wereda

	Kebeles		
Dry season	*Lemelem* N (%)	*Ademiti* N (%)	Total N (%)
Ponds	2(3.7)	3(5.55)	5(4.6)
Rivers	35(64.8)	37(68.5)	72(66.6)
Boreholes	14(25.9)	13(24.0)	27(25.0)
piped	3(5.5)	1(1.85)	4(3.7)
Wet season	*Lemelem* N (%)	*Ademiti* N (%)	Total N (%)
Ponds	9(16.6)	11(20.3)	20(18.5)
Rivers	22(40.7)	20(37.0)	42(38.8)
Boreholes	17(31.4)	21(38.8)	38(35.1)
piped	6(11.1)	2(3.7)	8(7.4)

N= number of respondents; the figures in the brackets are percent of respondents

About 72.5% and 25% of the respondents trek their animals for water 1-5 km and < 1km respectively and the 2.7% of the respondents possess water source at their home.

Table 12: Distance to watering point for sheep in Tahtay Adyabo Wereda

	Kebeles		
Dry season	*Lemelem* N (%)	*Ademiti* N (%)	Total N (%)
< 1km	18(33.4)	12(22.3)	30(27.8)
1-5km	36(66.6)	42(77.7)	78(72.2)
Wet season	*Lemelem* N (%)	*Ademiti* N (%)	Total N (%)
< 1km	26(48.2)	24(44.4)	50(46.3)
1-5km	28(51.8)	30(55.5)	58(53.7)

N= number of respondents; the figures in the brackets are percent of respondents

4.1.7. Housing of sheep in the study area

According to the discussion held with the respondents, most of the households in the study area house their sheep. Majority of the respondents construct house for sheep adjacent to family house which is made from wooden wall, earth mud floor and thatch or corrugated iron sheet roof. The rest of the respondents made the floor of sheep houses were earth material and house was roofed temporarily using grasses and sorghum residues. In addition, in all cases of the study area small ruminants were housed separated from other livestock.

4.1.8. Major constraints of sheep production

Major constraints of sheep production as ranked by respondents in the study area are presented in Table 13. Feed shortage, water scarcity, health problem, market problem and poor extension service were considered as the most important constraints limiting sheep production in the study area. There was variation in index intensity in prioritizing constraints among the study *kebeles*. Among the constraints feed shortage, water scarcity and diseases were considered as the most important problems ranked first, second and third with different index values, respectively. This study revealed that in both areas farmers stressed the lack of feed to be the most important limiting factor for productivity of their sheep, and indicated the importance of improving their feeding regime as an essential step towards any improvement program. Communal grazing was the most important feeding system in the area. However, communal grazing land was decreasing from year to year due to expansion of crop fields, over grazing and human population growth.

Table 13: Ranking of Begait sheep production constraints in Tahtay Adyabo Wereda

	Kebeles							
	Lemelem				*Ademiti*			
Parameters	Rank1	Rank2	Rank3	I	Rank1	Rank2	Rank3	I
Feed shortage	81.4	9.2	3.7	0.443	66.6	5.5	9.2	0.366
Health problem	5.5	24.0	61.1	0.209	9.2	11.1	53.7	0.172
Water scarcity	7.4	55.5	24.0	0.262	11.1	61.1	22.2	0.296
Market problem	1.8	5.5	7.4	0.039	3.7	12.9	9.2	0.076
Poor extension service	3.7	5.5	3.7	0.043	9.2	9.2	5.5	0.085

I=index; I=sum of [3 for rank 1+2 for rank 2 + 1 for rank 3] given for an individual constraint divided by sum of [3 for rank 1+2 for rank 2 + 1 for rank 3] summed for all the constraints.

4.2. Feeding Trial

4.2.1. Feed and nutrient intake by Begait sheep

The daily DM and nutrient intakes of Begait sheep rams fed grass hay and supplements are presented in Table 14. There was higher DM intake in T2 followed by T4, T3 and T1. The hay DM intake was lower ($P < 0.05$) for T2 as compared to the other three treatments. Total DM and OM intakes appeared to be highly impacted by the supplemental DM intake in this study. Total DM and OM intakes were lower for T1, intermediate for T3 and T4 and highest for T2 ($P < 0.05$). Total NDF and ADF intake was in the order of T2 > T4 > T3 > T1. Although T3 had slightly higher CP intake as compared to the other three treatments, the numerical difference was not significant ($P > 0.05$).

Table 14: Daily feed and nutrient intakes by Begait rams fed on basal diet of grass hay supplemented with different protein source feeds.

FeedIntake (g)	Treatments					
	T1	T2	T3	T4	SL	SEM
Hay DM	342^{c}	339^{c}	366^{a}	350^{b}	*	1.33
Supplements DM	300^{d}	450^{a}	340^{c}	380^{b}	**	1.50
Total DM	642^{d}	789^{a}	706.4^{c}	730.3^{b}	**	1.41
Nutrient intake (g/d)						
OM from GH	313.76^{c}	311.71^{c}	336.0^{a}	321.15^{b}	**	0.82
OM from WB	187	187	187	187	Ns	0.00
OM from PS	94^{d}	212^{a}	120^{c}	155^{b}	**	0.95
Total OM	595.76^{d}	711.67^{a}	643.94^{c}	663.15^{b}	**	1.20
CP from GH	18.02^{ab}	17.89^{b}	19.09^{a}	18.44^{ab}	**	0.04
CP from WB	32	32	32	32	Ns	0.00
CP from PS	35.5	35	35	35.5	Ns	0.00
Total CP	86	85.85	87.09	85.57	Ns	0.04
NDF from GH	260.41^{c}	258.63^{c}	278.83^{a}	266.50^{b}	**	0.68
NDF from WB	51	51	51	51	Ns	0.00
NDF from PS	41.99^{c}	108.00^{a}	31.00^{d}	43.06^{b}	**	0.65
Total NDF	351.10^{c}	418.05^{a}	361.32^{b}	361.06^{b}	**	0.86
ADF from GH	173.12^{c}	171.97^{c}	185.27^{a}	177.14^{b}	**	0.45
ADF from WB	24	24	24	24	Ns	0.00
ADF from PS	25.99^{d}	76.00^{a}	27.00^{c}	38.00^{b}	**	0.43
Total ADF	223.06^{c}	272.06^{a}	236.93^{b}	239.11^{b}	**	0.58
ADL from GH	35.50^{c}	35.30^{c}	38.11^{a}	36.38^{b}	**	0.09
ADL from WB	9	9	9	9	Ns	0.00
ADL from PS	5.99^{d}	20.00^{b}	12.00^{c}	29.00^{a}	**	0.18
Total ADL	50.18^{d}	63.99^{b}	58.68^{c}	74.00^{a}	**	0.20

$^{a, b, c, d}$ = means within a row not bearing a common superscript letter significantly differ; ADF= acid detergent fiber; ADL= acid detergent lignin; DM= dry matter ; CP= crude protein; GH= grass hay; Ns = not significant; OM= organic matter ; PS= protein supplement; SEM= standard error of mean; SL= significant level; WB= wheat bran.

4.2.2. Apparent dry matter and nutrient digestibility

The mean apparent digestibility of DM and nutrients are presented in Table 15. Apparent digestibility of DM was similar among treatments. The apparent digestibility of CP was lowest for T2 and values for T1 were greater than those for T4 but similar with T3. Digestibility of OM was lower for T2 as compared to T1 and T3 ($P < 0.05$). Digestibility of NDF and ADF was lower for T2 as compared to the other treatments.

Table 15: Apparent Nutrient Digestibility of Begait rams fed on basal diet of grass hay and supplemented with different protein source feeds.

Apparent	Treatment feeds					
Digestibility (%)	T1	T2	T3	T4	SL	SEM
DM	69.5	64.6	68.1	66.8	Ns	1.55
OM	75.2^{a}	61.1^{b}	74.7^{a}	68.3^{ab}	**	2.25
CP	74.6^{a}	60.4^{b}	72.2^{a}	67.9^{ab}	**	1.52
NDF	67.4^{a}	51.6^{b}	65.7^{a}	61.5^{a}	**	1.76
ADF	58.6^{a}	44.2^{b}	57.4^{a}	51.8^{ab}	**	2.32

A, b mean values in a row having different superscripts differ significantly; Ns= not significant; **= significant at $P < 0.05$; ADF = acid detergent fiber; CP = crude protein; DM = dry matter; NDF = neutral detergent fiber; OM = organic matter; SL= significance level; SEM = standard error of the mean;

4.2.3. Body weight change and feed conversion efficiency of Begait rams

The mean initial body weight (IBW), final body weight (FBW), body weight change (BWC), average daily body weight gain (ADG) and feed conversion efficiency (FCE) of Begait sheep fed on grass hay as basal feed was presented in Table 16. In the present study, initial body weight (IBW) was similar ($P > 0.05$) among treatments. Sheep that received concentrate mixture (T1) and wheat bran + *S. sesban* (T3) had higher FBW, FCE, BWC and ADG (P < 0.05) than those supplemented with wheat bran + cowpea (T4), but differences in BWC, ADG and FCE among T1, T2 and T3 were not significant (P > 0.05).

Table 16: Body weight change of Begait rams fed on basal diet of grass hay and supplemented with different protein source feeds.

	Treatment feeds					
Parameter	T1	T2	T3	T4	SL	SEM
IBW (kg)	27	26.33	26.83	26.83	Ns	0.28
FBW (kg)	33.50^{a}	31.50^{ab}	32.83^{a}	31.17^{b}	**	0.37
BWG(kg)	6.33^{a}	5.33^{ab}	5.83^{a}	4.50^{b}	**	0.22
ADG (g/d)	70.5^{a}	59.33^{ab}	66.17^{a}	49.17^{b}	**	2.28
FCE	0.109^{a}	0.075^{ab}	0.093^{a}	0.067^{b}	**	0.73

a, b Means with different superscripts in the same row differ significantly; (**) = P<0.05; ADG=average daily gain; BWC=body weight change; FBW=final body weight; FCE = feed conversion efficiency; IBW=initial body weight; S.L =significance level; SEM= standard error of mean;

4.2.4. Carcass characteristics

The average slaughter weight (SW) and empty body weight (EBW) were higher (P<0.05) for lambs fed on T1, T2 and T3 as compared to lambs supplemented with T4 (Table 17). Dressing percentage on slaughter body weight basis was higher (P<0.05) for the lambs fed on T3 as compared to the other treatments.

Table 17: Carcass characteristics of Begait rams on basal diet of grass hay and supplemented with different protein source feeds.

	Treatment feeds					
Parameter	T1	T2	T3	T4	SL	SEM
Slaughter weight (kg)	32.25[a]	30.5[ab]	31.5[ab]	30.25[b]	**	0.51
Empty body weight (kg)	26.25[ab]	25.5[ab]	26.5[a]	24.0[b]	*	0.54
Hot carcass weight (kg)	15.3	15.0	15.6	14.0	Ns	0.47
DP on Slaughter weight bas	47[b]	48.5[ab]	49.7[a]	46.5[b]	*	0.91
DP on Empty body weight base	58.5	58.8	60	58.5	Ns	0.74
Rib-eye area (cm^2)	11	10.5	11.3	10	Ns	0.14

[a, b] mean values in a row having different superscripts differ significantly; ns= not significant; **= significant at P < 0.05; DP= Dressing percentage; SEM= standard error of mean; S.L= significance level.

4.2.5. Edible offal component of Begait rams

Edible offal components of Begait rams fed on grass hay and different supplements are given in Table 18. Heart, liver with gallbladder, empty gut (reticulo-rumen + omaso-abomasum + small intestine + large intestine), visceral fat (kidney fat + omental fat), tail, head with tongue, testicles and kidneys were considered as edible offals. Where-as blood, spleen and pancreas, skin and feet, penis and gut contents were considered as non-edible offals based on the eating habit of people in the study area. In the current study, the size of heart, total fat and testis were significantly (P<0.05) affected by type of supplement. However there were no significant differences (P>0.05) in the combined weight of Head with tongue, empty gut (reticulo-rumen + omaso- abomasum + small intestine + large intestine), Liver, tail and kidney.

Table 18: Edible offal components of Begait rams fed on basal diet of grass hay and supplemented with different protein source feeds.

	Treatment feeds					
Parameter	T1	T2	T3	T4	SL	SEM
Heart (g)	217^{a}	161^{bc}	197^{ab}	128^{c}	**	10.5
Liver +Bile (g)	497	437	462	462	Ns	16.1
Kidney (g)	140	142	130	180	Ns	52.2
Empty gut (g)	2130	2380	2150	2100	Ns	9.24
Total fat (g)	250^{a}	192^{ab}	190^{ab}	177^{b}	**	13.3
Head &tongue (g)	1450	1480	1520	1430	Ns	12.4
Testis (g)	362^{ab}	330^{b}	398^{a}	326^{b}	**	57.6
Tail (g)	387	382	410	395	Ns	9.27
TEOC (kg)	5.43	5.49	5.46	5.19	Ns	0.12
TEOC (%)	16.8	18	17.3	17	Ns	-

$^{a, b}$ mean values in a row having different superscripts differ significantly; ns= not significant; **= significant at P < 0.05; SEM= standard error of mean; S.L= significance level; TEOC= Total edible offal components.

4.2.6. Non edible offal components of Begait rams

Non-edible offal components of Begait rams fed on grass hay and supplements are given in Table 19. Lung, trachea & esophagus, Penis, Spleen and pancreas and TNEOC did not differ (P>0.05) due to supplementation. The total non-edible offal (TNEO) was numerically higher for T1 and T4 as compared to T2 and T3 though the difference was not statistically significant (P>0.05).

Table 19: Non-edible offal components of Begait rams fed on basal diet of grass hay and supplemented with different protein source feeds.

	Treatment feeds					
Parameter	T1	T2	T3	T4	SL	SEM
Gut content (kg)	6.22[a]	5.27[b]	5.12[b]	6.1[a]	**	1.5
Lung TE (g)	665	540	652	610	Ns	24.3
Blood (g)	960[a]	900[ab]	900[ab]	712[b]	**	36.5
Penis (g)	51.3	46.2	53.7	48.7	Ns	1.58
Skin and feet(g)	3350a	3220b	3230b	3200b	**	83.66
Spleen & panc (g)	95	77	65	73.7	Ns	4.72
TNEOC (kg)	11.3	10.0	10.4	10.6	Ns	0.21
TNEOC (%)	35.2	32.9	33	35	Ns	-

[a, b] mean values in a row having different superscripts differ significantly; ns= not significant; **= significant at $P < 0.05$; SEM= standard error of mean; SL= significance level; TNEOC= Total Non-edible offal components.

4.2.7. Reproductive characteristics of Begait rams

Scrotum circumference, testicle size, semen volume, mass motility, live and dead sperm count and live and dead sperm percent of Begait sheep rams fed on a grass hay basal diet and supplements is presented in Table 20. In the present study, semen volume, Mass motility and live sperm cells count was similar ($P > 0.05$) among treatments. However, treatments differ in Scrotum circumference and Testicle weight ($P < 0.05$). Sheep that received WB + *S. sasban* (T3) had higher Scrotum circumference and testicle weight ($P < 0.05$) than those supplemented with WB + cowpea leafs (T4), but differences in Scrotum circumference and testicle weight among T1, T2 and T3 were not significant ($P > 0.05$).

Table 20: Semen quality of Begait sheep rams fed on basal diet of grass hay and supplemented with different protein source feeds.

	Treatment feeds					
Parameters	T1	T2	T3	T4	SL	SEM
Scrotum Circumference	27.40 ^{ab}	26.60^{ab}	27.85 ^{a}	26 ^{b}	**	0.231
Testicle weight	362 ^{ab}	330 ^{ab}	398.75 ^{a}	326.25 ^{b}	**	3.024
Semen Volume	0.777	0.698	0.793	0.716	ns	0.020
Mass motility	3.6	3.4	4.0	3.4	ns	0.100
Live sperm cells count	288	284	294	289	ns	2.068
Dead Sperm count	112	116	106	111	ns	2.068

a, b, c; means the same row with different superscripts differ significantly, **= (p<0. 05); SEM= Standard error of mean; SL= Significance Level;

Body condition, libido (sexual desire), color and consistency of Begait sheep rams fed on a grass hay basal diet and supplements are presented in Table 20. Rams in T1 and T4 were recorded low sexual desire that is 60% good and 40% very good, whereas rams in T2 and T3 improve their sexual desire that is 60% very good and 40% good and 70% very good and 30 % good respectively. The color of the semen was not affected by feeding of different supplementing feeds. Consistency of the semen is a little bit affected by feeding as T3 exhibit very thick semen but similar in other treatments.

Table 21: Libido, Semen color and Semen consistency of Begait sheep rams fed on grass hay and supplements.

		Treatment feeds			
Parameters	Measurements	T1	T2	T3	T4
Body condition		3.8	3.4	3.8	3.5
Libido %	Very good	40	60	70	40
	Good	60	40	30	60
Color	Creamy whitish	100	100	100	100
	Very thick	0	0	25	0
Consistency	Thick	100	100	75	100

T1, 100 g of cotton seed cake and 200 g wheat bran; T2= 250 g of air dried *A. saligna* leaves and 200 g wheat bran; T3= 140 g of *S.sasban* and 200 g wheat bran and T4= 180 g of *Vigna unguiculata* and 200 g wheat bran.

5. DISCUSSION

5.1 survey

5.1.1. Household characteristics and sources of livelihood in the study area

The majority of the respondents were male headed. The overall average age of respondent was 44.91 $\pm$ 8.03 years. This average age indicates the presence of active labor force which can play positive role in reducing the labor constraints faced in livestock production. The average family size of the present study was smaller than 6.5 persons for *Aseged-Tsimbla*, 6.2 for *Tahtay-Koraro* and 6.6 for *Medebay-Zana* reported by Desalegne (2012) and higher than 4.1 persons reported by Mulgeta (2015) for *kafta-humera* and 4.6 persons of the national average family size reported by (Hailemichael, 2013). The average land holding of the respondent households was much lesser than the national average land holding size of 2.5 ha. The land holding in the area was reduced due to the involvement of many investors to the area for sesame and cotton production and the re-distribution land policy by the government (an evenly distribution of land to male or female headed household).

In this study, the percentage of illiterate family members was comparable with 51% reported by Mulgeta (2015) for *kafta humera* and less than the reported 54.8% for north-western Tigray. The role of education is obvious in affecting household income, adopting technologies, demography, health, and as a whole the socio-economic status of the family as well (Kerealem, 2005).

The average number of sheep per household in the present study was higher than the average number of sheep reported at different districts of south Tigray (Hintsa, 2016), east Hararghe (Wossenie, 2012) and western Tigray (Mulgeta, 2015) which were 6.3, 5.7 and 4.81, respectively. A significant difference in sheep flock size found in the current study might be due to the suitability of the environment for sheep production and the role of sheep for the livelihood of the owners. Flock sizes of sheep vary with the production system and the production environment (Solomon, 2013). The same author indicated that the specific factors determining flock size include role of livestock as major source of livelihood, availability of land, feed and reliability of crop production. The relatively larger sheep flock size indicated that the area is in favor of sheep than larger animals. The same trend was observed in Afar area where sheep flock size was relatively higher than other livestock species (Getachew, 2010).

The majority of farmers reported livestock and crop production as the most important source for their livelihood followed by crop, livestock and off-farm activities combined and livestock production only respectively, this is in agreement with the findings of Mulgeta (2015) for *kafta humera wereda.*

5.1.2. Purpose of Begait sheep production.

Farmers in the study area kept sheep primarily for income source followed by home consumption and saving as live animal. Begait sheep were also used as a source of manure and manure was used mainly as a fertilizer. These findings are in agreement with Tesfay (2007) Sheep are important to the subsistence economic and social livelihoods of a large human population in Ethiopia. This is also similar with findings of Fantie (2007) Sheep production in the crop-livestock production system of the Ethiopian highlands has a very important role in contributing to the food security as well as in generating cash income. They serve also as monetary saving and investment, source of risk mitigation during crop failure and they are closely linked to the social and cultural life of many farmers (Seare, 2007).

5.1.3. Feed resources and feeding of sheep in the study area

The main feed resources in the study area are natural pasture and stubble grazing. This is in agreement with the findings of Mulgeta (2015) for *kafta humera wereda.* According to the discussion conducted with the focus group, communal grazing was the most important feeding system in the area. However, communal grazing land was decreasing from year to year due to expansion of crop fields, over grazing and human population growth. Seasonal scarcity of livestock feed was mentioned as one of the critical problems of sheep production in the area. In addition, during the dry season both quantity and quality of the pasture herbage declined and failed to meet nutrient requirements for production and reproduction.

Supplementing sheep with better quality feed resources is essential to improve sheep productivity. If increased productivity is needed, efforts should be made to increase the quantity as well as the quality of feed given (Charry *et al*., 1992). There were different feed supplements for sheep in the study area. The main locally available feed supplements are wheat bran, cotton seed cake, noug seed cake and sesame seed cake; this is in agreement with the findings of Solomon (2001).

5.1.4. Watering and Housing of Begait sheep.

Animals traveled longer distances to watering points (1-5Km) per day losing of their energy during the dry season, but in wet season animals were watered in a nearby natural water sources. This was in line with the findings of Mulgeta (2015), who reported for *kafta humera wereda* and Tessema *et al*. (2003) who reported for the livestock production system in Belessa wereda of Amhara regional state of Ethiopia. Almost all the respondents allowed their sheep to drink once per day during dry season. But during wet season water was supplied freely without any restriction.

According to the discussion held, most of the households in the study area house their sheep. Majority of the respondents construct barn for sheep adjacent to family house which is made from wooden wall, earth mud floor and corrugated iron sheet roof. This was in line with the findings of Yenesew Abebe (2013) assessment of sheep production system in *Burie* district.

5.1.5. Sheep production constraints

Feed shortage, water scarcity, health problem and poor extension service were considered as the most important constraints limiting sheep production in the study area. Solomon (2010) and Anwar (2014) indicated that feed shortage were the major constraints affecting the sheep productivity in different parts of the country. Feed shortage especially in the long dry season is critical problem in the study area. This factor extremely affects the growth rate and body energy reserve of animals rendering them to have a low quality meat (Zelealem, 2014). Proper feeding with high-energy and protein diets increases the meat quality through increasing the muscle glycogen reserve, which helps to keep the pH low after rigor mortis, and improve intramuscular fat content (Sibut, 2008). Therefore, proper feeding of animals for growth and meat quality should be practiced carefully.

Water scarcity was identified as the second major constraints for sheep production in the study area. This was in line with the findings of Mulgeta (2015), who reported for *kafta humera Wereda*. Disease prevalence was identified as the third major cause of sheep mortality and affects the productivity in the present study. This study was in agreement with the reports of (Tesfay, 2008; Solomon, 2010 and Wossenie, 2012) in different parts of the country. Kosgey (2004) Stated that poor health is the key limiting factor to the productivity of sheep raised by most rural farmers in developing countries.

5.2 Feeding Trial

5.2.1. Feed and nutrient intake of Begait rams

Total DM and OM intakes appeared to be highly impacted by the supplemental DM intake in this study. Total DM and OM intake were the lowest for T1, intermediate for T3 and T4 and highest for T2 ($P < 0.05$). Total NDF and ADF intake were in the order of T2 > T4 > T3 > T1 both of which appeared to be associated with the level of NDF and ADF in the supplemental diets. Feed intake in all treatments increased steadily with advance in the experimental period. Generally the average total DM intake of rams in this study was about 720 g/day, which was comparable with results of many studies (Hagos, 2011; Gebretinsae, 2011; Gezu, 2011; Michaele, 2014) with different Ethiopian sheep breeds. Conversely, lower total DM intake (Guesh, 2011; Neamn, 2011) and high total DM intake (Biru, 2008; Hirut, 2008; Gizat, 2011) by sheep as compared to the one noted in this study has been reported. Of course, variations in the type and amount of the basal diet as well as the supplement, breed of sheep, growth stage of the animal and other similar factors may contribute to differences in DM intake observed among the studies. Although rams which fed on T3 had slightly higher CP intake as compared to those on the other three treatments, the numerical difference was not significantly differ. This slight variation in CP intake is associated with differences in the basal diet DM intake.

The lower apparent digestibility of CP, OM, NDF and ADF in *A.saligna* supplemented rams (T2) may be associated with the higher fiber (ADF, NDF and ADL) content and the possible presence of anti-nutritional factors like tannins in the feed, which might have affected the availability of these nutrients for the sheep. The lack of significant differences in the apparent digestibility of NDF and ADF in most of the treatments (T1, T2 and T4), except in T3, are in agreement with the findings of Kaitho *et al.* (1998), who concluded that supplementation had little or no effect on fiber digestibility. Moreover, many researchers also found no significant effect of supplementation on the apparent digestibility of NDF and ADF (Emebet, 2008; Jemberu, 2008; Hirut, 2008; Hagos, 2014).

Improved digestibility values of DM, OM and CP with concentrate supplementation is in agreement with the findings of Gebreslassie (2012) and Michaele and Yayeneshet (2014).The OM digestibility and CP digestibility of the group supplemented with *S.sasban* (T2) are comparable with OM and CP digestibility reported by Hagos (2014) for Tigray highland sheep fed hay basal diet and supplemented with *S.sasban*.

5.2.2. Body weight change and feed conversion efficiency of Begait rams

Among the supplemented feeds, T1 and T3 resulted in higher ($P<0.05$) final body weights than T4. The higher performances (FBW, BWC, ADG and FCE) of sheep in T1 and T3 as compared to sheep in T4 might be due to the lower cell wall fiber contents in the concentrate mixture and *S.sasban* than the cowpea containing diet. However, the results of BWC, ADG and FCE in T1, T2 and T3 were not significantly different ($P > 0.05$) from each other. There were also similarities between T2 and T4 in BWC, ADG and FCE, which reflected that the supplements were comparable in their potential to supply nutrients to improve the weight gains of rams.

The trend in live weight change of sheep over the experimental period shows consistent increase throughout the feeding period. A number of studies on small ruminants in Ethiopia showed significant change in body weight gain when sheep with poor quality roughages are supplemented with diets rich in protein (Neamin, 2011; Almaz, 2012; Michaele and Yayeneshet, 2014; Hagos, 2014). The results of this study agreed with the finding of Nigussie (2008), Hunegnaw and Birhan (2016) and Abebe *et al.* (2011).

The ADG of rams in T1 was comparable with 62.8 g/day gain indicated by Michaele and Yayeneshet (2014) for Tigray highland sheep fed with concentrate mixture. In agreement to the result obtained in the current study in T2, Gebreslassie (2012) also reported 42.78 - 62.22 g/day gain for Tigray highland sheep fed grass hay and supplemented with wheat bran and different levels of *A.saligna* leaves. The mean daily gain of rams in T3 in the present study is higher than the findings of Solomon *et al.* (2003) who reported 33.4-35.7 g/day gain for Menz sheep fed *teff* straw and supplemented with sole *S.sesban*; but Tibebu (2005) reported higher ADG (83.3-99.8 g/day) for local sheep fed mixtures of 70-90% Napier grass and 10-30 % supplementation with *S.sesban.* In summary, results of feed intake and body weight gain in the current finding outlined that, improved browse foliages like *A.saligna* and *S. sesban* can replace the highly valued commercial concentrate feeds because of their similar effects on the performances of Begait rams as revealed in this experiment.

5.2.3. Carcass components of Begait rams

Dressing percentages were higher when expressed in empty body weight base than expressed as a portion of slaughter weight this may be happened the influence of digesta (gutfill) on dressing percentage. The DP on slaughter body weight basis in the current study was higher ($P<0.05$) for the rams supplemented with T3 (*S. sasban*) as compared to T1 (cotton seed cake) and T4 (cowpea). In the present study, the DPSW bases ranged between 46.5-49.7%, which is in agreement with 47.3-48.6% reported by Amare (2007) and 46.0-49.0% by Hagos (2014) for Tigray highland sheep respectively. Relatively lower dressing percentages of 28.73%, - 37.55%, 36-38.4%, 36-42% and 39.8-43.7% on slaughter weight basis than the present study were reported by Michaele and Yaynshet (2014) for Tigray highland sheep, Mulu (2005) for Wegera sheep, Takele and Getachew (2011) for Horro sheep and Gebresilassie (2012) for Tigray highland sheep, respectively. Generally, the variations in carcass traits in this study and other results of previous studies may be due to variations in age and breed of sheep, quantity and quality of basal and supplement feeds used for the experiment. In agreement with this McDonald *et al*. (2002) noted that, nutrition; age, sex, genetics, season and other related factors affect the growth and carcass traits of animals.

The rib-eye muscle area in the present study was comparable with results of Mulu (2005) 13 - 13.5 cm^2 for Wegera sheep, Gebresilassie (2012) 13.83 -15.57 cm^2 for Tigray highland sheep and Zemichale (2006) 11.5-12.75 cm^2 for Local sheep respectively. But lower results was reported by Michaele and Yaynshet (2014) 5 – 8.73 cm^2 for Tigray highland sheep, Hagos (2014) 6.9-7.7 cm^2 for Local sheep and Hirut, (2008) 7-8.4 cm^2 for Hararghe Highland sheep, respectively. In the current study, there was no significant difference in rib-eye muscle area ($p>0.05$) between the supplemented treatments. This was an implication of rams supplemented with different protein source feeds were able to accommodate better lean flesh.

In the current study, the size of heart, total fat and Testis were significantly ($p<0.05$) affected by supplementation. There was no significant difference ($p>0.05$) on the combined weight of Head with tongue, empty gut (reticulo-rumen + omaso- abomasum + small intestine + large intestine), liver, tail and kidney in the current study due to supplementation. This was in harmony with the findings of Mulu (2005) who reported, the weights of offal components rich in bone or offal components with a low metabolic activity like (head, feet and lungs) varied slightly with diet, as these organs are early maturing parts. Kirton *et al*. (1992) reported that live weight and nutritional status of the animals can affect the production efficiency of carcass offal’s. The higher weight of visceral fat in T1 may also be due to higher digestible OM and CP intake, and higher OM and CP digestibility, which promoted higher internal fat deposition in different organs (omentum, kidney and heart) in T1 compared to T4. Higher weights of testes ($p < 0.05$), were observed in T3 and T1 than T2 and T4.

Blood, Lung, trachea, esophagus, spleen, pancreas, skin and feet, penis and gut contents are considered as non-edible offal Based on the eating habit of the community in the study area. Weight of Blood, gut contents and skin with feet components were significant ($p < 0.05$), the skin and feet weight of T1 were higher than T4; and similarity was observed between T2, T3 and T4. The difference in skin weight may be due to the better subcutaneous layer fat deposition of sheep supplemented with concentrate mixture. Higher weights of blood were also observed in T1 followed by T2 and T3 and the lowest was recorded for T4. The amount of gut content was higher ($p<0.05$) for T1>T4>T2>T3. The difference in gut contents in this study might be due to differences in the degradability and escape of the supplemented feeds that neither of the feeds staying longer in GIT.

5.2.4. Reproductive characteristics

Begait rams supplemented with different protein source feeds improved their body condition even though it's not significant difference between the supplemented rams. Body condition scores found in this study were in line with Mollea *et al*. (1996) reported body condition score was not affected by the treatments. Furthermore, body condition is directly related with reproductive performance. Scrotum Circumferences were significance difference between T3 and T4 but not on other treatments. Testicle size was significant difference ($P<0.05$) T3 and T2 from T4 but not from T1. As reproductive activity undertakes in the testicle when it's well developed the size of scrotum going to be larger. Scrotal circumference increase was also greater in great rank lambs than in less rank lambs (Ungerfeld, 2007). The increased testis size indicates increased sperm production capacity. This has intriguing possibilities in animal production (Trish, 2007).

Semen volume was directly related to the above treatments body condition, scrotum Circumference and testicle weight that is the higher with these parameters exhibit higher volume of semen. In this study Semen volume was not significantly different ($p>0.05$) between supplemented treatments. However, semen volume of T3 was numerically higher than T2 and T4. In agreement to this finding Trish (2007) reported increased testis size that may be explained primarily by an increase in Sertoli cell numbers, and an increased epididymal size that may reflect increased testicular sperm production capacity. A general trend in semen production occurred earlier in rams with greater as compared with those with a lesser ranking (Ungerfeld, 2007). Semen volume of rams reported in this study was higher than 0.15-0.65ml of highland sheep rams reported by Gebresilassie (2012). Mass motility is the movement of live sperm cells after directly harvested semen using artificial vagina and seen in microscope. The mass motility of the Begait sheep rams was not significantly different between supplemented treatments. Statically were not different but numerically there was higher live sperm cells count in T3 than T2. Live and dead percent (%) is replica of live and dead count and this parameter is the best description of whether the ram is able to produce viable sperm or not. Similar to this Trish (2007) reported sperm motility exhibited some significant improvement in supplemented animals for boar. The Begait sheep ram was not affected by feed in live and dead percent of the sperm cells. The result found here is higher live and less dead sperm cell this is the best description of quality semen. From all this result feeding of Begait sheep rams on a grass hay basal diet and supplementation improves the reproductive performance of Begait sheep rams. If their intention of producers for breeding purpose feeding T3 of basal diet grass hay and supplemented with 200 g wheat bran and 140 g *Sesbania sesban* is recommended as it does not affect on live percent rather have higher motility and volume than the others.

6. CONCLUSION AND RECOMMENDATIONS

6.1. Conclusion

From the total of 108 sample households interviewed, about 76.8% and 23.2% were male and female headed household, respectively. The majority of farmers reported livestock and crop production as the most important source for their livelihood followed by crop, livestock and off-farm activities combined and livestock production only.

Natural pasture was the first and the most common feed resources used for sheep during wet and dry seasons. Grazing land in the studied area was entirely communally owned. Farmers used different feeding/grazing practice where by free grazing was the most common practices during wet and dry season in the study area.

Rivers, bore wells and pond water were the major sources of water for sheep. Shortage of water was common in dry season. Most of the households in the study area construct house for their sheep adjacent to their residence. Sheep houses were constructed using locally available materials; mainly from woods.

Communal grazing was the most important feeding system in the area. However, communal grazing land was decreasing from year to year due to expansion of crop fields, over grazing and human population growth. Seasonal scarcity of livestock feed was mentioned as one of the critical problems in sheep production in the area. In addition, during the dry season both quantity and quality of the pasture herbage declined and failed to meet nutrient requirements for good performance. The most important constraints of Begait sheep production were problems of feed shortage, water scarcity and health problem.

The CP content of grass hay used as basal feed in this experiment was below the requirement for maintenance, indicating the need for supplementation of grass hay based diets with protein riche feeds. Forages such as *Vigna unguiculata*, *S. sesban* and *A. saligna* have optimum nutrient profile.

Total DM and OM intakes appeared to be highly impacted by the supplemental DM intake. Total DM and OM intakes were the lowest for T1, intermediate for T3 and T4 and highest for T2. However, a superior daily body weight gain was recorded in rams supplemented with T1, T2 and T3.

Carcass parameters (slaughter weight, empty body weight and hot carcass weight, dressing percentage and rib-eye area) were higher for sheep supplemented with concentrate mixture and lower for sheep supplemented with *Vigna unguiculata* leaf; however sheep supplemented with concentrate mixture and *Vigna unguiculata* leaf show similar results of carcass parameters with those supplemented with *A. saligna* and *S. sesban* leaf. Therefore it was concluded that supplementation of 250 g *A. saligna* with 200 g wheat bran and 140g *Sesbania sesban* with 200 g wheat bran per day and per head can serve as an economical and locally available replacement to expensive concentrates.

In summary, results of body weight and carcass parameters in the current finding outlined that *A.saligna leaf* as sole supplement is comparable to the supplementary value *S. sesban* to improve sheep performance. Similarly, *A. saligna* and *S. sesban* can also replace the highly valued commercial concentrate feeds because of their similar performance effects on Begait rams in this experiment.

The result of reproductive characteristics exhibited great performance with T3. Sustainability of species is based on their reproductive performance even this is understood to many researchers in our country studying on reproductive performance is not well addressed because of the sophisticated materials required to study this. No information found on semen characteristics of Begait sheep rams. Therefore this study supports by providing this information to the scientific world in general.

6.2. Recommendations

The findings of the present study on the Begait sheep revealed that more studies are needed to compare the production and reproductive performance of this breed of sheep with that of other indigenous sheep.

To fully describe the Begait sheep, there should be a comparative quantities data to prove some of the information on their physical, adaptive and special genetic attributes. The meat production potential of the breed is relatively high and evidently Begait rams could compete with more productive breeds under high input production environment.

Even though, sheep groups in this experiment are supplemented with isonitrogenous amounts of protein sources, the digestible crude protein intake and digestibility of CP in sheep groups supplemented with *A. saligna* leafs was slightly low compared to other treatments. Therefore, further research is needed to address optimum level of supplementation and effects of anti-nutritional factors of *A. saligna* on sheep performance.

On station protein source supplementation improves feed intake, Body weight gain and carcass parameter of Begait rams. The trial should be conducted under farmer management for a recommendable result.

Study on reproductive performance of Begait rams should be study further on similar feeding situation.

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8. APPENDIX

Appendix 1: Household livestock holding

Kebeles			
Parameters	lemelem (N=54)	ademiti (N=54)	Total (108)
	Mean ±SD	Mean ±SD	Mean ±SE
Cattle	2.52 ±1.32	4.54± 1.43	3.5±1.35
Sheep	11.5±1.87	16.2± 2.69	13.6±2.15
Goats	4.52± 2.57	8.9± 1.94	6.71±0.39
Equines	1.1± 0.57	1.13± 0.63	1.12±0.06
Chicken	8.4± 2.93	10.62± 2.3	9.50±2.60
Honeybees	0.19± 0.78	0.22± 0.40	0.20±0.06

N= number of respondents; SD=standard deviation; SE=standard error, the figures in the brackets are percentages from N

Appendix 2: **Questionnaire**

1. Background information

1.1, Name of the household head -------------- Sex of the respondent: 1. Male 2. Female

Age of respondent ------- Address:. Woreda --------------- Tabia ---------------

1.2 Education level of the respondent.

I. Illiterate

II. Read and write

III. Primary

IV. Secondary

V. Religious school

1.3, Family size by age and sex (enter number in the boxes)

	Children (<18)	Adult (>18)
Males		
Females		

1.4, Indicate the major sources of income

Income sources	Tick here	Rank
Crop		
Livestock		
Off farm activities		
If others ,specify		

1.5, Land holding in Timad/hectare------------------

Crop ____

Grazing* ___

Forest _____

Total size______

2. Management practices

2.1. Livestock composition

Fill the following table for the total number of different animals owned by family (put number in the boxes)

Type of animal owned	Number	Type of animal owned	Number
Cattle		Bee colony	
Sheep		Equines	
Goat		Camel	
Chickens			

2.2, Purpose of keeping Begait sheep

For what purpose do you keep sheep? (Rank them in order of their importance)

Purpose	Rank
Immediate source of Income/sell	
Saving as live animal	
Manure	
Home consumption	
Others (specify)	

2.3, Feed Resources and Feeding

What are the main feed resources for sheep during dry and wet season? (Tick one or more).

Source of feed	Wet season	Dry season
Grazing on natural grazing lands		
Aftermath		
Hay		
Straws		
wheat bran		
Improved Forage		
‘Atela’		
Indigenous Plants		
Others (specify)		

2.3.1, Do you use purchased feeds for sheep? (Circle one) 1= Yes 2= No

If yes for the above question, what type of purchased feeds do you use? -----------------

If no, what are the reasons? (Circle one) 1= unavailable 2= high cost 3= lack of money 4= not aware 5= sheep don't require purchased feeds 6=other (specify)

2.3.2, Do you use communal grazing land? (Circle one) 1= Yes 2= No

2.3.3, Do you practice supplemental feeding of sheep during dry and wet season? (Circle one) 1= Yes *2*= No

If your answer is yes, what are the supplemental feeds that you use?

If your answer is no for question no 2.3.3, what are the reasons for not using supplemental feeds for your sheep? (Circle one or more)

1=unavailable 2=high cost 3= lack of money 4 = sheep don't need supplementary feeding 5=other reasons---
----

If you use supplemental feeding, is there any difference by type/classes of sheep while offering supplemental feeds? (Circle one) 1=Yes 2= No

If your answer is yes for the above equation, for which type of sheep do you give priority for supplemental feeding --

2.3.4, Are sheep grazed/ fed with other animals (cattle, horse and donkey)? (Circle one) 1= Yes 2= No

2.3.5, Are kids and lambs graze/ fed with adult sheep? (Circle one) 1. Yes 2= No

If yes, which feeding practice you normally use when fattening sheep? (Tick one or more)

No.	Feeding systems	Tick (√)
1	Cut and carry system for whole fattening period	
2	Grazing plus household wastes	
3	Grazing plus feeding supplements like industrial by products	
4		
5		

2.4., Do you practice fattening? 1, yes 2, No

How long sheep are fed during fattening? (Circle one)

1= two month 2=three month 3= four month 4= five or six month 5= other (specify)

How do you manage fattened sheep? (Circle one)

1= isolated from other herds 2= with other livestock 3= kept in and around homestead in the day times 4=other (specify) ------------

2.5, WATERING

2.5.1, What are the major water sources for your sheep ? (Tick one or more)

Season	**Borehole**	**Dam/pond**	**River**	**Spring**	**Pipe wate**	**Rainwater**
Dry						
Rainy						

2.5.2, How far is the watering point for sheep from your home during dry and wet season? (Tick one)

Distance	Watered at home	<1km	1-5 km	6-10km	>10km
dry					
rainy					

2.5.3, What is the frequency of watering during dry season? (Tick one)

1. Freely available 2. Once a day 3. Once in 2 days 4. Once in 3 days 5.Other (specify) -----------

2.6, HOUSING

2.6.1, How do you house them? (Circle one)

1=they share the same house with the family house 2=they have separate house

3=they are housed in the house compound/kraal 4= others (specify)

2.6.2, Do you give priority while housing sheep by sex and age during dry and wet season? (Circle one) 1=Yes 2= No

If yes, which classes of sheep get priority in housing during dry and wet season?

2.6.3, Are sheep housed with other livestock species (cattle, goats and equines)? (Circle one)

1=Yes 2= N

2.7, Sheep production constraints

What are the major constraints/ problems that affect your sheep production activity? *(Tick one or more problems and rank them by their Importance)*

No.	Constraint/ problems	Tick	Rank
1	Shortage of feed		
2	Health problem		
3	Water scarcity		
4	Market problem		
5	Lack of shelter		
6	Drought problem		
7	Poor Extension service		
8	Others (Specify)		

What do you suggest the solutions to the above top five problems of sheep production

Feed chemical composition determination at nutrilab, Netherlands

Experimental rams and their housing

Experimental rams

Experimental rams during digestibility trial

PUBLICATIONS

Michaele Yirdaw, Ashenafi Mengistu, Berihan Tamir and Gebreyohannes Berhane.(2017).Replacing Cotton Seed Cake by Dried Acacia saligna, Sesbania Sesban and Cowpea on Productivity of Begait Sheep in North Ethiopia. ***American-Eurasian Journal of Scientific Research*** 12 (1): 29-36

Michaele Yirdaw, Ashenafi Mengistu, Berihan Tamir, Gebreyohannes Brhane. (2017). Effect of Feeding Cotton Seed Cake, Dried Acacia saligna, Sesbania sesban or Vigna Unguiculata on Growth and Carcass Parameters of Begait Sheep in North Ethiopia. ***Agriculture, Forestry and Fisheries***. Vol. 6, No. 5, 2017, pp. 149-154. doi: 10.11648/j.aff. 0605.11

Two papers are also accepted for publication in ***journal of Livestock feed technology*** and ***journal of food security*** *at* BMC journals.