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EVALUATING THE EFFECTS OF BREED AND DIET ON DIGESTIBILITY, GROWTH, CARCASS AND MEAT QUALITY OF THREE INDIGENOUS GOAT BREEDS OF ETHIOPIA

Mekonnen, Wondimeneh

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M.Sc. Thesis

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THESIS APPROVAL SHEET

As member of the Board of Examiners of the Master of Sciences (M.Sc.) thesis open defense examination, we have read and evaluated this thesis prepared by **Wondimeneh Mekonnen Getahun** entitled " **Evaluating the Effects of Breed and Feed on Digestibility, Growth, Carcass and Meat Quality of Three Indigenous Goat Breeds of Ethiopia** ".

We hereby certify that, the thesis is accepted for fulfilling the requirements for the award of the degree of Master of Sciences (M.Sc.) in **Animal Production and Technology**.

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This is to certify that this thesis entitled "**Evaluating the Effects of Breed and Feed on Digestibility, Growth, Carcass and Meat Quality of Three Indigenous Goat Breeds of Ethiopia**" submitted in partial fulfillment of the requirements for the award of the degree of Master of Science in **Animal Production and Technology** to the Graduate Program of College of Agriculture and Environmental Sciences, Bahir Dar University by **Wondimeneh Mekonnen Getahun (ID. No. BDU0805574PR)** is an authentic work carried out by him under our guidance. The matter embodied in this project work has not been submitted earlier for award of any degree or diploma to the best of our knowledge and belief.

Wondimeneh Mekonnen	________________	________________
Name of the student	Signature	Date

Name of the Supervisors

Firew Tegegne Amogne (PhD)	________________	________________
Name of major supervisor	Signature	Date
Tekeba Eshetie Nega (PhD)	________________	________________
Name of co-supervisor	Signature	Date

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LIST OF ABBREVIATION

ADG	Average Daily Gain
AGP	Agriculture Growth Program
ANOVA	Analysis of Variance
BWC	Body Weight Change
CDM	Cold Dressing Mass
CSA	Central Statics Agency
DM	Dry Matter
DNA	Deoxy Ribo Nuclic Acid
DP	Dressing Percentage
EBW	Empty Body Weight
FBW	Final Body Weight
FCE	Feed Conversion Efficiency
FCR	Feed Conversion Ratio
FMS	Finger Millet Straw
GDP	Gross Domestic Product
GLM	General Linear Model
HCW	Hot Carcass Weight
HH	Highland Harerge
HSD	Honestly Significant Difference
IBW	Initial Body Weight
IGAD	Inter Governmental Authority on Development
ILRI	International Livestock Research Center
LES	Long Eared Somali

MOA	Ministry of Agriculture
NEOC	Non-Edible Offal Component
NGN	Nguni Breeds
NIRS	Near Infrared Spectrophotometer
NSC	Noug Seed Cake
SAS	Statistical Analysis Software
SEM	Standard Errors Mean
SLW	Slaughter Weight
SS	Short eared Somali
TEOC	Total Edible Offal Component
TUP	Total Usable Products
UAE	United Arab Emirates
USAID	United State Aid
WB	World Bank
XBC	Xhosa–Boer Cross Breed
XLE	Xhosa lop-eared breed

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ABSTRACT

*This study was conducted with the objective of evaluating the effects of diet on growth performance, carcass characteristics and meat quality of three selected indigenous goat breeds (Afar, Gumuz and LES) of Ethiopia. The study was conducted on thirty six intact yearling male goats (IBW = 16.89 ± 0.32). Twelve goats from each breed were randomly assigned for two dietary treatments groups (diet 1: 2 % body weight commercial concentrate and 2 % body weight natural pasture hay and diet 2: 2 % body weight commercial concentrate and 2 % body weight finger millet straw) and fed on dry matter basis for 90 days with 2×3 factorial RCBD. At the end of feeding experiment digestibility study was conducted. Finally, four animals per treatment were randomly selected and slaughtered for carcass and meat quality evaluation. Carcass measurements were taken and four meat samples from logismus dorsi muscle were taken for determination of chemical composition and sensorial meat color evaluation at different days after slaughter. The chemical analysis result showed that natural pasture hay had higher nutritive value (DM, OM, CP, ADF and NDF) than finger millet straw. It was observed that no interaction effect between breeds and diet (G*D) in growth rate, feed intake, digestibility, carcass and meat quality. The average daily dry matter intake was 792.70 ± 11.42 g/d/goat and no significant difference ($p \geq 0.05$) on dry matter and nutrient intake between breeds. However, the effect of dietary type on most nutrient intake parameters was significantly higher ($p \leq 0.05$) in goat groups fed diet 1. Similarly there was no significant difference ($p \geq 0.05$) between goat breeds on nutrient intake (% BW) and the mean values for intakes of DM, OM, CP, ADF, NDF, ADL and IVOMD were 4.007, 3.658, 0.468, 0.982, 2.135, 0.160 and 0.274 kg, respectively. Regarding to digestibility of nutrients the mean digestible coefficient of DMD, OMD, CPD, NDFD and ADFD were 45.93 ± 0.03, 55.92 ± 0.02, 72.44 ± 0.03, 50.58 ± 0.02 and 26.79 ± 0.02, respectively. The Effect of breed was revealed only on NDFD however effect of diet was observed on CPD and NDF. Breed and diet did not show differences ($p \geq 0.05$) on FBW but it was observed there is a significant difference ($p \leq 0.05$) on BWC, ADG and FCE. Gumuz goat breed showed significantly lower ($p \leq 0.05$) results of BWC, ADG and FCE than Agew and LES goat breeds. Similarly, goats under diet one (hay) was significantly higher on these parameters than diet two (FMS) groups. Only weights of hind quarter and tail were significantly lower in Gumuz goat breed* *than LES and Agew breeds however totally there was no difference between Agew and LES goat breeds in main carcass characteristics. Likewise breed was non-significant on most non carcass parameters except, weight of testicle and spleen, at both parameters Agew goat breed had significantly higher than two breeds. Effect of diet was higher in main carcass characteristics and minimal on non-carcass parameters. Out of main carcass parameters only dressing percentage, thoracic lumbar part, rib eye muscle and tail were not affected by roughage feed type. In contrast to this among non-carcass parameters heart, testicle and lung showed different responses for dietary types. The mean TEO,TUP and TUP (% SLW) of three indigenous goat breeds were 3.32 ± 0.08, 13.59 ± 0.37 and 60.51 ± 0.64, respectively and they were insignificantly affected by breed and dietary types except TUP which was significantly higher in diet one fed goats. Regarding to internal fat components only pelvic fat was higher in diet one fed goats, the other parameters were independent of breed and diet. The mean KF, PF and OMF contents of indigenous goats were 110.81 ± 26.84, 105.94 ± 17.01 and 250.19 ± 39.23 grams. Effects of breed and diet were non-significant on meat physio-chemical properties of indigenous goat breeds. The moisture, ash, protein, fat and carbohydrate contents of meat were 71.94 ± 0.33, 3.04 ± 0.14, 20.03 ± 0.58, 4.61 ± 0.48 and 0.38 ± 0.03 percent respectively. The Likert scale result showed that breed type is the main factor for meat color than diet. LES goat breed had lighter and meat from Agew goat breed found darker color than other goat breeds starting from slaughter to ten days after slaughter. Generally, the study confirmed that the effect of breed on growth performance, nutrient digestibility, carcass characteristics and meat chemical composition was minimal however the color of meat was inherited and feed had no effect on it. Moreover, improving the infrastructural issues in shortening time required from slaughter to destined market would allow acceptance of meat from other breeds since meat of highland goat was acceptable till five days after slaughter. Searching of other export markets that are not sensitive for meat color could other option of increasing meat export of the country.*

Key words; *Breed; Carcass; Digestibility; Goat; growth; Meat*

1. INTRODUCTION

1.1. Background and Justification

Agriculture is a back bone of economic and social life of people, in which 85 percent of the population has engaged and more than 80 percent of Ethiopia foreign exchange earnings are directly or indirectly originated. The 45 percent of the GDP contribution of the sector is partitioned in to 29, 12 and 4 percent to crop, livestock and forestry sub sectors, respectively (World Bank, 2012).

Ethiopian livestock sector is recognized by its immense potential of population, genetic diversity and low productivity of animals. The country has 59.49 million cattle, 30.70 million sheep, 30.20 million goats, 1.21 million camels and 59.49 million chickens (CSA, 2017). On the other hand according to AGP report (2013) the country ranks sixth in the world for cattle population, seventh for goats and tenth for sheep which collectively mean the eighth top owner of livestock population in the world.

Including the value of ploughing services livestock sub sector in Ethiopia provide 45% of the agricultural output share and 11% of national total export earnings via live animals, meat, hides and skins and leather products (IGAD, 2013). Field studies in different highland parts of Ethiopia showed that livestock account for 37–87% of total farm cash income of farmers, indicating the importance of livestock in rural livelihood (Eyob Eshetu and Zewedu Abraham, 2016).

Despite the huge potential of livestock population, productivity of animals remained low and the gross importance of the sector to the national economy is disproportionate as compared with its potential. Among the major problems attributed to the low productivity, animals feed shortage, absence of modern breeding strategy, poor animal health and extension services, drought, weak marketing system and other infrastructures are the major ones (Belay Derbie *et al*.,2013, Seid Guyo and Berhan Tamir, 2014).

The carcass weights per head of animals in Ethiopia are 108, 10, 8.5 and 0.8 kg for cattle, sheep, goats and chickens respectively, all of which is below the average productivity of all least developed countries. Milk yields in Ethiopia are also very low at 210 kg/year/cow, a level which is less than half of the Kenyan milk yield of 550 kg/year/cow (Asfaw N. *et al.*, 2011). Similarly, domestic per capita consumption of meat and milk are 9 and 17 kg respectively in which both are much lower than recommendations of FAO and WHO (Zelalem Yilma *et al.*, 2011).

In recognizance the untapped potential, the government of Ethiopia has restructured and set up new organizations that endeavor for the overall importance of the sub sector. The establishment of Livestock and Fishery Development Ministry and Ethiopia Meat and Dairy Industry Development Institute are among the decisions made by the government to increase productivity of livestock as whole and supporting the growing meat and milk industry. Under these reforms, in GTP II (2015 - 2020) the government planned to export mass of red meat produced in the country and substitute domestic consumption by chicken meat (Shapiro *et al.*, 2015).

Goats comprise 5.32% of the total tropical livestock units of Ethiopia, contributing an estimated 12 to 14% of meat products, 10.5% of milk production and 6% of all animals exported (http://borlaug.tamu.edu/2011/08/22/ethiopias-meat-and-live-animal-export-sps-lmm/). With 30.2 million goat population Ethiopia stands 9th in goat meat production globally and 2nd in Africa next to Sudan. Annually, the country produced around 100,000 metric tons of goat meat from slaughtering 7.6 million goats (Mahmoud Abdel, 2010).

Indigenous populations generally dominate the goat flocks in Ethiopia and have developed certain valuable genetic traits such as ability to perform better under low input condition and climatic stress, tolerance to infectious diseases and parasites. Morphological characterization by farm Africa (1996) classified the goat breeds in to twelve, though microsatellite DNA markers in to nine (Tesfaye Alemu, 2004). Recent study on analysis of molecular variance (AMOVA) on goat population revealed that higher value of within population (97.37 %) than among populations (2.63) (Getinet Mekuriaw *et al.*, 2016). Phenotypic characterization of

Amhara Region goat population confirmed six distinct ecotypes in the region vis. Gumuz, Begia-Medir, Agew, Bati, Central Abergelle and Abergelle (Halima Hassen *et al*, 2012).

The top export markets of Ethiopian meat in order of sales volume are the United Arab Emirates, Saudi Arabia, Angola, Egypt, Bahrain, and Kuwait though in all countries meat is sold through informal market due to high degree of regulation in importer countries. Goat meat only exported to middle east countries and their requirement include as the goat meat should be from young animals with low fat content, preferably from low land breeds (Borana, Somali and Afar), considered to have pink and red colored meat (AGP, 2013).

High land goat breeds are not preferred by export abattoirs due to the alleged darkening of meat from these areas during storage (Alemu Yami and R.c Markel, 2008). In many cases compilation regarding meat discoloration in Ethiopia associated with breed despite no comprehensive scientific finding that confirmed the hypothesis. In contrast there are reports showed as the reason of high land shoat meat discoloration is not confirmed by abattoirs since it could be from possible reasons like breed, environment, management and post slaughtering techniques (Getachew Legese *et al.*, 2008).

The lowland part of the country is known as pastoralist and agro pastoralist where goats relies on browsing and grazing while in highland goat depend on crop residue and fallow lands. In contrast grazing land in high land part of the country has depleted due to crop intensification and cultivation. Here the dominant feed sources for animals are crop residues (Aschalew Tsegahun *et al* 2000).

Therefore, this proposal was intended for studying the growth performance, carcass characteristics and meat quality of three selected indigenous goat breeds of Ethiopia under different feeding conditions.

1.2. Statement of the Problem

Managing goat production for meat quality is a deliberate, active process that reaches from conception to consumption. The concept of quality in meat is universal, being wholesome, nutritious and palatable. Goat meat is a product of many different production systems from widely varying environments, nutritional regimes and genotypes (N.H. Casey and E.C. Webb, 2010).

Currently, goat meat export of Ethiopia is limited in some selected pastoral areas like Somali, Borena and Afar while significant population out of those areas is unexploited. This is mainly due to criticizes as meat from high land goat breeds has quality problem particularly darkening and short shelf life when stored under chillers (Alemu Yami and R.c Markel 2008; Getachew Legese *et al.*, 2008). Because of this reality on the ground, meat export industries compete for limited resources of pastoral areas. On the other hand, potential domestic and international meat export industries are joining the sector. The collective result of these situations will deplete the reproductive portion of pastoral stock and weakening of industries unless high land livestock populations has exploited in the system.

Goat meat quality studies in Ethiopia are very limited and works were focused only on growth performance and carcass evaluations. The moderately compressive research was by Ameha Sebsebie *et al.,* (2007) for evaluations of different concentrate to roughage ratios on three selected indigenous goat breeds. Based on the result, daily weight gain of Afar, Central highland and long eared Somalia intact male goat breeds were 36.7, 34.7 and 43.9 gm per day, respectively. It also noted the breed effect on dressing percentage which ranged from 42.5 - 44.6% and 54.3 - 55.8% on both slaughter weight and empty body weight basis, respectively.

The other study worked on four indigenous breeds of South Africa the response of sunflower cake supplementation showed significantly higher slaughter weight (SLW) and cold dressing mass (CDM) than non-supplemented Boer and Xhosa–Boer cross (XBC) goats breeds however dietary effect was insignificant in Xhosa lop-eared (XLE) and Nguni (NGN) breeds (Xazela *et al.*, 2011).

Growth performance, carcass characteristics and meat quality are affected by breed (Ameha Sebesebie *et al*., 2007; Xazela *et al.,* 2011,), nutrition (Vasta, 2008 a; Vasta 2008 b, Banon *et al.*, 2005 and Ramili *et al.,* 2005), production system (Carlucci 1998) and interactions of these factors.

Agew and Gumuz goat ecotypes are among breeds found in Amhara region under western clusters group (Halima Hassen *et al.*, 2012) which have not been used by the export abattoirs. In contrast long eared Somali breed is found in Somali Region and commonly used by export abattoirs. In most cases (close 95%), the meat export from Ethiopia is from goat meat only. The rest 5-6 % of the meat is from sheep and beef (ERCA reports). The origins of these goat breeds which are used for export purpose are limited in the pastoralist areas. In order to increase meat export, it is important to explore means for export of highland goats.

Therefore, quantifying the effect of goat breed and nutrition on growth performance and meat quality particularly from export market requirement point of view is very important so as to make the export abattoirs globally competitive and benefit the country as a whole. Hence, this proposal was initiated to quantify the growth performance, carcass characteristics and meat quality of Agew, Gumuz and long eared Somali goat populations of Ethiopia under different roughage feeds.

1.3 Objectives

1.3.1 General objective

- To evaluate the effect of breed and roughage feed on digestibility, growth, carcass and meat quality at three indigenous goat breeds of Ethiopia

1.3.2 Specific objectives

- To evaluate the feed and nutrient intake, digestibility of two diets on Agew, Gumuz and LES goat breeds of Ethiopia
- To determine effects of breed and diet on growth performance of indigenous goat breeds at feedlot condition
- To examine carcass characteristics of three selected indigenous goat breeds of Ethiopia fed different feed types
- To evaluate breed and dietary effect on goat meat composition and sensorial evaluation of meat color

2. **LITERATURE REVIEW**

2.1. Goat Domestication, Origin and Population in the World

In human and animal relation different species of animal have domesticated at different ages and places in the globe. Domestication of goat backed to 7000 B.C. in Neolithic age perhaps, sometime before the cultivation of cereals at the slopes of the Zagros Mountains (presently on the borders of Iran and Iraq). They are almost first to be domesticate by human being from bezoar goat (*Capra hircus*) for their skin, fibers, milk and meat to human consumption and raw material for clothing.

Goat is a member of the family Bovidae and is closely related to the sheep as both are in the goat-antelope subfamily Caprinae. However, number and status Capra species and subspecies is still under debate, with estimates ranging from 6-9 species (Nathalie *et al*, 2006), recent molecular technology (DNA) research suggests that there are over 300 distinct breeds of goat in the world (Table 2.1).

The contribution of goat to the people and economies of developing countries is obscured by several factors combining to give an underestimate of their true value. Most goats kept in developing countries are inaccurately estimated in number. The current population of goats estimated to be 875.5 million and Asia and Africa are homes of world goat population that embrace 539 million (61.6%) and 276 million (31.6%) of total goat population (FAOSTAT, 2011). China and India are leading in the world by goat population having 149.4 and 125.7 million goats respectively while Ethiopia is eighth in the world (21.8 million) and third in Africa next to Nigeria and Sudan (Mahmoud Abdel, 2010).

Table 2.1 Taxonomy and geographic distribution of the genus Capra (except the cosmopolitan domestic goat C. hircus) (Nathalie *et al,* 2006)

Species	Subspecies	Common name	Geographic range
Capra aegagrus Erxleben, 1777	*C. a. aegagrus*	Bezoar (or wild goat)	Afghanistan, Armenia, Azerbaijan (Nakhichevan), Lebanon (extinct), Russia (East Caucasus), Turkey, Georgia, Iran
	C. a. blythi		Pakistan, Iran, Iraq, Turkmenistan
	C. a. hialtanensis	Chiltan's Wild Goat	Pakistan
	C. a. cretica		Greece
Capra falconeri Wagner, 1839	*C. f. falconeri*	Markhor	India, Pakistan
	C. f. heptneri		Afghanistan, Tajikistan, Turkmenistan, Uzbekistan
	C. f. megaceros		Afghanistan, Pakistan
Capra [ibex]a ibex Linnaeus, 1758		Alpine ibex	Austria, France, Germany, Italy, Switzerland
Capra [ibex] nubiana F. Cuvier, 1825		Nubian ibex	Egypt, Ethiopia, Israel, Jordan, Lebanon (extinct), Oman Saudi Arabia, Sudan, Syria (extinct), Yemen
Capra pyrenaica Schinz, 1838	*C. p. hispanica*	Spanish ibex	Spain
	C. p. lusitanica		Extinct
	C. p. pyrenaica		Extinct
	C. p. victoria		Spain
Capra [ibex] sibirica Pallas, 1776		Asiatic or Siberian ibex	Afghanistan, China, India, Kazakhstan, Tajikistan Kyrgyzstan, Mongolia, Pakistan, Russia (Altai, Sayan, and Tuva)
Capra [ibex] walie Rüppell, 1835		Walia ibex	Ethiopia
Capra [ibex] caucasica Güldenstaedt and Pallas, 1783		Kuban or West Caucasian tur	Georgia, Russia (West Caucasus)
Capra cylindricornis Blyth, 1841		Daghestan or East Caucasian Tur	Azerbaijan, Georgia, Russia (East and Central Caucasus)

2.2 Production Systems and Importance of Goats in Ethiopia

2.2.1 Goat production system

Livestock production system is a subset of the farming systems, including cases in which livestock contribute more than 10 percent to total farm output in value terms or where intermediate contributions such as animal traction or manure represent more than 10 percent of the total value of purchased inputs (FAO, 1995). Cattle, goat, sheep, camel, hen, etc. have been reared as domestic and subsistence animals in Ethiopia using traditional techniques. Few commercial form of livestock husbandry rarely existed in milk and meat producers but most farms remained small scale to meet local demands (Berhanu Gebremedhin *et. al*., 2007).

Ethiopia owns immense but largely untapped livestock resources scattered over diverse agro-ecologies. The country's main livestock resources that have both monetary and food value for humans are cattle, shoats, camels, poultry and bees. Sheep and goats are among the major economically important livestock in Ethiopia playing an important role in the livelihood. They contribute a quarter of the domestic meat consumption; about half of the domestic wool requirements; 40% of fresh skins and 92% of the value of semi-processed skin and hide export trade in Ethiopia. An estimated 1,078,000 sheep and 1,128,000 goats are used annually in Ethiopia for domestic consumption. Booming population growth, expanding urbanization and growth in income in developing countries like Ethiopia, are expected to create more than double demands and greater market opportunities for meat and milk (Dereje worku *et al*, 2015).

Currently, goats are important components of livestock production having better adaptation behavior for harsh environments made them suited for marginal areas where keeping other livestock is impossible or limited. Their higher tolerance for heat stress and ability to grow on poor quality feed, higher fertility rate and feed conversion efficiency over other ruminants considered goats as special animal for tropical farmers. Particularly in South East Asia and Africa goats are the major source of meat and milk despite, they are considered as exotic animal in temperate regions or developed countries (Dhanda *et al*, 2003).

Indigenous goat populations generally dominate the goat flocks in Ethiopia and have developed certain valuable genetic traits such as ability to perform better under low input condition and climatic stress, tolerance to infectious diseases and parasites as well as heat stresses.

Goats are distributed in all agro-ecological zones of the country although the majority of the goat population is found in arid and semi-arid agro–ecological zones, where goats are kept by nearly all pastoralists, often in mixed flocks with sheep, freely grazing or browsing in the rangelands (Yoseph Mekasha, 2007). Geographically it covers the South, East and West parts of pastoralists keep them for milk and meat production and for sale.

Goats are also widely distributed in crop-livestock mixed farming system in the highlands with very small flock sizes as a means of cash earnings and meat. Goat production system in Ethiopia is characterized by low input and is operated by smallholder farmers. The main features of the low input goat production system are its full dependence on natural resources and the limited demand for inputs.

Annual growth rates for large and small ruminants are estimated at 1.1% and 0.2% over the period 1990-93, respectively. This compares unfavorably with the corresponding figure for the human population's annual growth rate of 2.9% across the same period. This gap is a cause for concern, since the subsector is failing to supply adequate food to satisfy the domestic consumption and export market need (AACCSA, 2006). Increasing in population will result in limitation of land for production of food crops and increasing demand of animal products. Thus, competition for land between livestock and crops will be continued.

2.2.2 Importance of goats in Ethiopia

Sale of goats and goat products (meat, skin and milk) by farming communities is the major economic source for their subsistence (Zewedie and Woleday, 2015). According to study conducted in western Amhara goats are the first in Gonji kolela and second next to cattle livestock species Ebnat woredas in their order of importance (Kefeyalew Alemayehu *et al*, 2015). Goats contributed 23.2% and 30.9% to the total gross margin and livestock gross margin respectively in goat producing parts of the country (Tatek Woldu *et al*, 2015).

Although Ethiopia is endowed with large livestock resources, the country has not been getting adequate economic benefits from its livestock trade due to its low annual off-take, which is estimated at 10%, 35% and 38%, respectively, for cattle, sheep and goats (Belachew and Jemberu, 2003).

The country's annual livestock and meat export potential is currently estimated to be more than USD 136 million; however, the realized export earning over the past years is far below the expected (FAO, 2010). Despite the aforesaid scenarios, the livestock sub-sector remained to be traditional and largely undeveloped. There are several technical and non-technical constraints that hinder the full exploitation of the sector. Among which, inadequate livestock feed availability in terms of quality and quantity is the most underlined. Shortage of feed is even more exacerbated by seasonal fluctuations and land cultivation.

2.3 Goat Breeds, Population and Their Geographical Distribution in Ethiopia

Generally, goat breeds can be divided into three namely: indigenous, meat and milk breeds. Indigenous breeds which have been naturally selected for adaptability to harsh environments and which are generally used for meat production, but are also important for cultural purposes. On the other hand, meat and milk breeds are results of human selection by their genetic merit for meat and milk (Heifer international, 2015).

Huge and diverse goat population of Ethiopia plays an important role in the livelihood of resource-poor farmers. The goat population of Ethiopia is estimated to be 30.2 million (CSA, 2017). It is believed that these goats have evolved through a process of natural selection that resulted in selection for adaptation and survival rather than production potential. (Solomon Abegaz *et al.*, 2008).

Though productivity of indigenous goats is generally considered as low, there is high potential among the indigenous Ethiopian goat breeds under improved management systems

(Dereje Worku *et al.*, 2015). This low level of productivity in Ethiopian goats could be attributed to disease, lack of proper management, poor nutrition and low emphasis given to genetic improvement. Genetic improvement has been a fundamental part of the many goat development programs in the tropics, where breeding policies mostly aimed to upgrade local goats by crossbreeding with either temperate or tropical exotic breeds (Shumeye *et al.*, 2014).

Despite, Indigenous goat populations generally dominate the goat flocks in Ethiopia exotic breeds like Boer goats which are meat type breed and originated in South Africa have been introduced to Ethiopia. Ethiopia with its great variation in agro-ecological zones represents a potential reservoir of sheep and goat diversity (Tesefaye Alemu *et al.,* 2004). Based on differences in physical characteristics and genetic differences at the DNA level, four families and 12 breeds of goats have been identified in Ethiopia (Farm Africa, 1996).

Table 2.2 Goat families and breeds of Ethiopia

Family Name	Breed Name	Other Local Names
Nubian family	Nubian	
Rift Valley family	Afar	Adal, Danakil
	Abergelle	
	Arsi-Bale	Gishe, Sidama
	Woito-Guji	Woyto, Guji, Konso.
Somali family	Hararghe Highland	
	Short-eared Somali	Denghier or Deghiyer
	Long-eared Somali	Large white Somali, Degheir, Digodi, Melebo
Small East African family	Harareghe Highland	
	Western Highland	
	Western Lowland	Gumz
	Keffa	

Source: ESGPIP, 2009

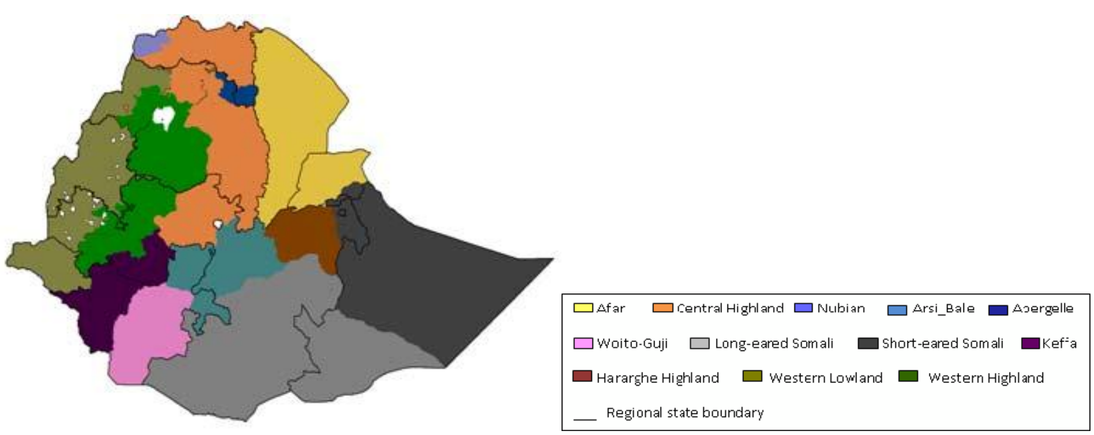
Microsatellite DNA markers characterization resulted as Ethiopian goat populations are very closely related to each other and in contradiction with the phenotypic characterization classified Ethiopian goat breeds in to eight. These are Arsi-Bale, Gumez, Keffa, Woyto-Guji, Abergalle, Afar, Highland goats (previously separated as Central and North West Highland) and the goats from the previously known Hararghe, Southeastern Bale and Southern Sidamo provinces (Hararghe Highland, Short-eared Somali and Long-eared Somali goats) (Tesfaye Alemu, 2004).

According to Halima Hassen Hassen *et al.*, (2012) based on their clear morphological variations between and within these goat ecotypes in terms of body coat color, head profile, horn orientation, ear form and head shape six distinct indigenous goat populations are found in Amhara region namely Gumuz, Begia-Medir, Agew, Bati, Central Abergelle and Abergelle.

Recent molecular study showed Ethiopian goat populations are genetically very close each other and variation within population showed higher value (97.37) than among populations (2.63) while agro ecology, production system and goat family accounts 0.73, 0,33 and 0.37 percent for genetic variation among populations (Getinet Mekuriaw *et al.*, 2016).

Figure 2.1 Geographic map of Ethiopian goat breeds

Figure 1Figure 2.1 Geographic map of Ethiopian goat breeds



2.4 Phenotypic Descriptions of Experimental Goat Breeds

2.4.1 Agew goat

Agew goats are found in Awi zone of Amhara region in which the area is high land with high precipitation. Agew goat breed dominantly had white with spot (26.67 %) and brown with patch (20.00 %) coat color and had short hair on their body. In most cases the breed is characterized by slight concave head profile, horizontal ear form, different horn shapes but commonly oriented spirally up warded (Halima Hassen *et al.*, 2012).

2.4.2 Gumuz goat

The breed is found in North Gonder zone of Amhara region and Benshangul Gumuz regional state of Ethiopia. Predominantly these breeds coat color is black and white with spots and the head is straight (66.67 %) and slight concave (33.33 %). The ear is oriented horizontal; horn is common in this breed (96.7 %) (Halima Hassen *et al.*, 2012).

2.4.3 Long eared Somalia goat

This breed is found in southern parts of Oromia and Somali regions are known by their preference by export abattoirs in Ethiopia. They are relatively large, white and short hair. Other features predominantly include straight face, horns are curved and pointed backward (Alemu Yami and Markel, 2008).

2.5 Growth and Fattening in Goats

Several major changes occur as an animal passes from the zygote to its mature form and size. Perhaps the most obvious change is in size and mass - these have been termed growth. In addition to these, there are fundamental changes in shape and body composition which have been termed differentiation. Because growth and differentiation are inseparable their combination is called development. A thorough understanding of growth and development in goats and the factors that affect these processes is important, because it affects the efficiency of production and it has a direct bearing on product quality. Although the use of growth promotants or molecules that change the efficiency of growth are not generally employed in goats, other more natural pathways exist to manipulate growth and development. These approaches do not detract from product quality and provide the opportunity to produce meat, milk, fiber, leather and related products that meet the demands of consumers for more environmentally friendly and natural production systems. Growth and development in goats occur in a similar way compared with other land-living mammals, and these processes are directly dependent on influences in the external and internal environment. There is great significance in the way in which the growth and developmental processes have evolved in goats to ensure the propagation of this unique species (Webb *et al.*, 2016).

Fattening is the deposition of unused energy in the form of fat within the body of the animal and its objective is to make the meat tender, juicy and of good flavour. Fattening increases the requirement for protein to promote good digestion. Fattening animals are usually full fed because the energy which is beyond the maintenance requirement is available for fattening. In general, growth is a much cheaper form of gain than fattening. Body weight gain in growth is in the form of protein and bone while in fattening it is in the form of fat.

Variations in performance of goats can be partitioned into genetic and environmental components. Environmental variance, albeit not transferable from parent to offspring, plays an important part in the performance of livestock and their products. Knowledge of non-genetic factors helps in standardizing management of the breeding animals. Some non-genetic effects, such as farm, sex and age on growth and carcass traits have been reported in goats (Maghoub *et al*., 2004). Difference in breed had effect on both reproductive and productive performance of animals. Accordingly, the growth traits are highly heritable hence breed has significant effect on growth and fattening of animals.

2.5.1 Birth weight

One of the most important breed characteristics in animal is birth weight since, it considered as reference point with regard to subsequent development of individuals as well as other characteristics. In general factors affecting birth weight may be grouped in to genetic and environmental factors. Breed, sex and genetic anomalies considered as genetic factor while dam age, birth weight at kidding, mothering ability, nutritional condition of dam, litter size, gestation length, kidding year, season, geographical region and altitude are considered as environmental factor.

Though there are only few studies has been done on the reproductive and productive performance of goats under improved management birth weight between 3 and 3.5 kg is recorded for Begait and Abergelle goats (Berhane and Eik, 2006) and Somali goats (Muluken Zeleke *et al.*, 2007) under improved management conditions.

Relative much on farm monitoring and cross sectional studies were conducted on indigenous goat breeds of Ethiopia. On the different feeding system the Woyto-Guji goat breed the birth weight of kids were ranged from 1.5 to 1.8 kg (Tekle Yohannes *et al*, 2013), with higher values Aberegelle breed kids weighted 1.98 kg at Ziquala and Tanqua at farmers condition (Belay Derbie *et al*, 2008). The CHG breed known by its wider geographical coverage showed by far higher birth weight (2.31 kg) than other breeds at Lay Armacho district (Alubel Alemu *et al*, 2015).

However, it ranged from 1.5 to 1.8 in different feeding systems the goat breed weighted on average 1.8 kg at birth while the monitoring data showed that the birth weight of Aberegelle breed at Ziquala and Tanqua Abergelle district were 1.98 and 1.97 respectively. CHG showed much higher value (2.31 kg) birth weight based on monitoring data at Lay Armachiho district (Alubel Alemu *et al*, 2015). This may attributed to difference in feed availability and production system caused by study site variation or the genetic potential of CHG breeds. Better birth weight had reported by (2.29 kg) for Aberegelle goat breed Muluken Zeryhun (2006) which again lower from CHG.

Generally, here it is possible to conclude as there is difference in performance between goat breeds of Ethiopia. The difference in performance did not only genotype but also differences in feed availability, season of the study and type of data collected by scholars also contributed to this difference. Moreover, the birth weight performance would be improved by improving animal's management.

2.5.2 Early body weight and growth rate

Body weight and growth rate of tropical goats are described to be low when compared with other temperate breeds. Similar to reproductive performance, body weight and growth rate of tropical goats are described to be low when compared with other temperate breeds. Average weaning weights of Abergelle and Begait goats at the age of three months are found to be in the range of 9 and 10 kg. Under traditional management system in Sokota district, lower weaning weight (7.9 kg) have been recorded for Abergelle and with pre-weaning daily growth rate (PWGR) of 62.6 g/day (Muluken Zeryhun 2006). Tesfaye Getachew *et al* (2006) also reported that the average weaning weight and PWGR for central highland goats are 6.7 kg and 62.6 g/day, respectively. On the other hand, a lower growth rate of 45g/day between birth and 150 days has been reported for Afar goat breed under pastoral free ranging condition (DAGRIS 2007). The lower growth rate is probably due to the harsh environmental conditions prevailing in the area. Goats in the mixed production system generally are heavier than goats in pastoral areas, where meat and milk, respectively are given priority by the farmers and pastoralists.

2.6 Feed Resource in Ethiopia

Livestock Feed resources are classified as natural pasture, crop residue, improved pasture and forages, agro industrial by products, other byproducts and vegetable refusal, of which the first two contributes the largest feed type. Inadequate nutrition and feeding are major constraints to livestock production in Sub-Saharan Africa (SSA). The feeding systems include communal or private natural grazing and browsing, cut and-carry feeding, hay and crop residues. At present, in the country stock are fed almost entirely on natural pasture and crop residues.

Grazing is on permanent grazing areas, fallow land and cropland after harvest (Stubble). The availability and quality of forage are not favorable year round. As a result, the gains made in the wet season are totally or partially lost in the dry season (Alemayehu Mengistu, 2003).

Feeds (usually based on fodder and grass) are either unavailable in sufficient quantities due to fluctuating weather conditions or are available but in a poor quality that they do not provide adequate nutrition. These constraints result in low milk and meat yields, high mortality of young stock, longer inter calving intervals and low animal weights.

Feed is the major production input and the major cost item in any livestock production activity accounting for about 60-70% of the total cost of production (Adugna Tolera, 2012). Inadequacy of feed in terms of quality and quantity is considered to be critical among the constraints of livestock in the country and this is exacerbated by the expansion of cropping land, urbanization and industrial development, all of which results in proportional decrease in grazing land (Alemayehu Mengistu, 2004). The contribution of native pasture is declining from time to time due to poor management systems and continued advance of crop farming into grazing lands (Adugna Tolera *et al.*, 2007; Dirriba Geleti *et al.*, 2013).

The continued expansion of crop farming is resulting in the increasing share of crop residues as livestock feed resources. For example, in Ethiopian highlands, crop residues provide on average about 50% of the total feed source for ruminant livestock and the contributions of crop residues reach up to 80% during the dry seasons of the year (Adugna Tolera, 2007) which further increases as more and more of the native grasslands are cultivated to satisfy the grain needs of the rapidly increasing human population (Ahemed Hassen *et al.,* 2010). Knowledge of the potential feed resources availability and utilization practices would be necessary in order to make judicious and effective use of available feed resources for enhancing livestock productivity.

2.6.1. Natural pasture

The feeding systems of natural pasture include communal or private natural grazing and browsing, cut and-carry feeding, hay and crop residues. At present, in the country stock are fed almost entirely on natural pasture and crop residues. Grazing is on permanent grazing areas, fallow land and cropland after harvest (Stubble). The availability and quality of forage are not favorable year round. As a result, the gains made in the wet season are totally or partially lost in the dry season (Alemayehu Mengistu, 2003).

2.6.2 Crop residue

Crop residues are roughages that become available as livestock feeds after crops have been harvested. They are distinct from agricultural by-products (such as brans, oil cakes, straws, stover, haulms etc), which are generated when crops are processed. Residues can usually be grouped along crop types-cereals, grain legumes, roots and tubers, and so on. Apart from being a source of animal feed, residues are sources of building, roofing and fencing materials. They are used also as fuel and as fertilizers or as surface mulch in cropland. Their value as feed depends on the demand from livestock owners, which varies with the overall supply and demand situation for feeds. This, in turn, depends on the density of livestock, usually expressed in tropical livestock units per square kilo meter (TLU km-2) and the supply of other feed resources, in particular, forage and browse from natural vegetation (Tesfaye Desalew, 2008). The supply of crop residues is a function of the proportion of land used for cropping and the amount of edible feed yields per unit of land. Where consumable livestock feeds from CRs exceeds from natural pastures (expressed in t DM ha^{-1}), the expansion of cropland has a positive effect on overall feed supplies.

2.6.3 Commercial feeds

Annual compound feed production by both private and farmers' unions feed processing plants in 2015/16 has been estimated at 61416 tonnes (excluding home-made mixed feed). In terms of enterprise category, privately owned feed processing plants account for 84 percent while those of farmers' unions accounted for the rest 16 percent of the total annual production. Regarding feed type, poultry feed accounted for 56 percent of annual compound feed production while dairy feed, beef cattle feed and other feeds respectively accounted for 26, 15 and 3 percent (Seyoum Bedeye *et al.*, 2018).

Ensuring feed safety and quality is recently one of the key challenges in the commercial feed sector. It is also of high importance for the livestock producers and consumers of animal source foods. Among feed safety issues, the recent detection of high aflatoxin levels in oilseed cakes and compound feeds has raised serious concerns in ensuring the desired quality and safety of feed along the food value chain. Additionally, the need for maintaining the desired level of nutritional and quality standards of feed ingredients and compound feeds is also a challenge for commercial feed producers, the regulatory body and livestock producers. Lack of confidence of livestock owners on the quality of compound feed is also one of the reasons for not using such feeds. There is also a need to update feed quality and safety standards.

2.7 Digestive System and Digestibility of Feeds

2.7.1 Ruminant digestion

The foods of ruminants, forages and fibrous roughages, consist mainly of β-linked polysaccharides such as cellulose, which cannot be broken down by mammalian digestive enzymes. Ruminants have therefore evolved a special system of digestion that involves microbial fermentation of food before its exposure to their own digestive enzymes.

Many of the organic components of food are in the form of large insoluble molecules, which have to be broken down into simpler compounds before they can pass through the mucous membrane of the alimentary canal into the blood and lymph. The breaking down process is termed ‘digestion’, and the passage of the digested nutrients through the mucous membrane ‘absorption’. The processes important in digestion may be grouped into mechanical, chemical and microbial activities.

The mechanical activities are mastication and the muscular contractions of the alimentary canal. The main chemical action is brought about by enzymes secreted by the animal in the various digestive juices, though it is possible that plant enzymes present in unprocessed foods may in some instances play a minor role in food digestion. Microbial digestion of food, also enzymic, is brought about by the action of bacteria, protozoa and fungi, microorganisms that are of special significance in ruminant digestion (McDonald *et al.*, 2010).

2.7.2 Digestibility of feeds

Nutritive value of feeds is determined by a number of factors, including composition, odor, texture and taste. These factors are generally measurable in the case of the animal as digestibility and intake. Digestibility is simply a measure of the availability of nutrients. When digestibility is combined with intake data, one can make an accurate prediction of overall nutritive value. Of the two factors, intake is relatively more important than digestibility in determining overall nutritive value because highly digestible feeds are of little value unless consumed by the animal in question.

However, digestibility usually provides a fairly reliable index of nutritive value because more digestible feeds are normally consumed to a greater extent than less digestible feeds. Only that portion which is soluble or is rendered soluble by hydrolysis or some other chemical or physical change can be taken up into the circulation and assist in supplying the animal body with material for building and repair of tissue or supply the energy necessary for body functions. In addition, measures of digestibility are somewhat easier to obtain than measures of intake and thus, considerable effort has been made by animal nutritionists to develop effective means of determining digestibility (Ajmal *et al.*, 2003).

The study of digestibility is important for measuring animal performance and measuring the nutritive value of feeds. It also maximizes the accuracy of measuring animal performance since laboratory results must mimic field performance and animals and diet must match field conditions. The standardized digestibility study protocol requires mature animals, maintenance level of intake, no selection or refusals, measure maximum digestibility and weighing feed, refusal and feces for five to seven days (US Dairy Forage Research Center).

The advantage of working with animals in pens is knowledge of the intake and composition of feed offered. Hence data can accumulate on the productivity of animals in response to particular diets and from these data general relationships can be drawn regarding diet composition, level of feeding and such production responses as milk production and weight gain.

According to Khaing (2015) different proportion of corn silage to Napier grass showed significant difference in digestibility of feeds, intake and body weight change. Sole corn silage and equal proportion treatments showed the highest digestibility than the other proportions. The result of energy supplementation on grazing goats showed the digestibility of OM and CF significantly ($P<0.05$) increased from 62.25 to 73.68% and 43.80 to 53.21% respectively as the level of supplemental energy increased from 10.02 to 11.98 MJ ME/kg DM (Hossain *et al.*, 2003). Similarly Napier grass as basal feed and 1 % percent BW supplementation of commercial pellet increased apparent digestibility of DM (64.1 % vs. 56.3 %), OM (67.3 % vs. 58.9 %), NDF (55.9 % vs. 45.2 %) and CP (68.4 % vs. 52.1 %) as compared with goats feed molasses protected palm kernel cake and soya waste as supplementation for Napier grass (Rahman, 2013).

2.8 Carcass Profile of Ethiopian Goats

Accurate prediction of carcass evaluation in live animals may allow more efficient genetic improvement of meat quality. Effective value based marketing programs require precise techniques for assessing composition, palatability and other factors associated with consumer acceptance of meat products. The ultimate test for a carcass evaluation technique should establish carcass value.

Carcass evaluation probably has at least two important functions which include an evaluation of carcass composition at the end of scientific experiments, and the provision of a system to evaluate commercial carcasses for value based on lean meat content. The requirements for both of these functions are often quite different. For example, it might be the objective of a nutritional experiment to assess fat or protein gains over a range in weight which would necessitate the use of a serial slaughter technique combined with chemical analysis of the carcass tissues.

The average carcass production potential of indigenous goat in the tropics is about 12 kg with a maximum of 75% total edible portion. Carcass weight and dressing percentage (DP) of Small East African goats is reported to increase with increasing concentrate supplement. The

DP estimated for most of the indigenous goats in Ethiopia are between 42 and 45% on slaughter body weight basis and 53 and 55% on empty body weight basis (*ESGPIP, 2009*).

Ameha Sebesebie *et al.,* (2007) studied the effect of breed and concentrate level on some carcass and non-carcass components of three indigenous goats of Ethiopia namely Long-eared Somali, Afar and Central Highland goats. According to the authors, long-eared Somali goats have heavier slaughter (20) and carcass (8.75) weights (kg) than Afar (17.95 and 8.02) and central highland (18.38 and 7.83) goats respectively. LES goats are reported to lay more fat than the other breeds. In another study, DP (on empty weight basis) ranging between 44 and 46% have been recorded for Long-ear Somali, Afar, Arsi-Bale and Woyito-Guji goats (Addisu, 2002).

A comparative study conducted between Borena and Arsi-Bale goat under different duration of feedlot management regimes indicated that Borena goats have heavier carcass weight (11-14 kg) and carcass length (73-78 cm) than Arsi-Bale goats (6-8 kg and 65-69 cm) due to their superior growth rate (Hailu *et al.,* 2005). On the contrary, Arsi-Bale goats have higher fat percentage than Borena goats fed for 150 days. The authors explained that this difference is an indication that Arsi-Bale goat is early maturing than Borena goat.

The effect of cross breeding Ethiopian CHG indigenous breed with Boer goat breed was evaluated in terms of weight gain and carcass characteristics. Based on the result cross breeds were showed significantly higher difference in most main carcass components including empty body weight, hot carcass weight, cold carcass weight and total usable products (Mekonnen Tilahun *et al.,* 2012). In this study the corresponding values for EBW, HCW and CCW of 50 % Boer crosses with CHG were 24.36 kg, 12.86 kg and 12.3 kg respectively which all values were significantly higher than the CHG breeds. According to the result the EBW, HCW and CCW of CHG breeds were 18.18 kg, 9.13 kg and 8.71 kg.

2.9 Meat Quality of Goat

Goat meat is becoming increasingly popular because of the positive environmental image of goat ranching, the meats' dietetic and health benefits, the cultural tendency of consumers towards natural foods, recent food crises and the association of goat meat with religious celebrations (Dubeuf *et al.,* 2004). Meat is one of the most nutritious food particularly in terms of supplying high quality protein (essential amino acids), minerals (especially iron) and essential vitamins for human being. Meat is defined as all animal tissues suitable as food for human consumption. The majority of meat consumed comes from domestic and aquatic animals, but it includes also uncommon sources like game animals.

Generally, meat quality can be affected by on farm, pre slaughter animal management and post slaughter meat handling factors. On farm factors like genetics, age, weight, sex, feeds and feeding system have higher importance in determining quality of meat. While pre slaughter factors include transportation of animal from farm to lairage, management system at the lairage like nutrition, fastening, rest etc. events after slaughtering to consumption can affect meat quality and these factors are considered as post slaughter.

Meat quality can be measured by different parameters and each parameter is determined by instrument, trained personnel's or a combination of two approaches. The acceptable values for each parameter also varied across countries resulted from living standard, eating habit, safety and contamination issues.

Goat meat has higher ultimate pH than sheep with corresponding value of 5.88 and 5.74. Most of the time pH is measured by penetrating electrode (Mettler Toledo) of a portable pH-metre after 48 hrs chilling. Season of slaughter highly determined the ultimate pH of meat. According to Weglarz (2010) 30 % of meat in summer season had greater than 5.8 pH value which is the main case for formation of DFD (dark, firm and dry) meat.

In Ethiopia the pH value of goat meat at two abattoirs around Addis Ababa ranged from 4.6 to 8.39 (Yebchaye Degefe *et al.*, 2014) in contrast in feeding trial done on three indigenous goat breeds of Ethiopia higher value was recorded for CHG (5.97) and lower value for Afar (5.78) (Ameha Sebsebie *et al.*, 2007). The difference for these results could be large travelling in the first study from origin to market while the second experiment is conducted in confined environment.

The first impression consumers have of any meat product is its color and thus color is of utmost importance. The color of meat may vary from the deep purplish-red of freshly cut beef to the light gray of faded cured pork. Fortunately, the color of meat can be controlled if the many factors that influence it are understood. Meat color is an important parameter in meat quality. It can be measured numerically using a colorimeter or subjectively using trained personnel. Several factors affect meat color such as species/breed, age, sex, cut of meat, surface drying of the meat and surface spoilage.

Meat color is largely determined by the content of myoglobin and its derivatives. It is normal for meat to change color depending on the presence or absence of air. For instance, exposed meat changes its color due to reactions occurring between myoglobin and oxygen. Meat color changes in response to both the quantity of myoglobin it contains, and chemical changes in the myoglobin itself. The more myoglobin in the meat, the darker the color exhibited. Older goat meat contains more muscle myoglobin and has darker meat than kids (Amha Sebsibe *etal.,* 2007).

Color is also greatly affected by muscle pH. At a high pH, muscle has a closed structure and, hence, appears dark and the meat tends to be tough. Meat color is also affected by diet. Meat can also become discolored before reaching a retail outlet if too much drying occurs. Hence, butchers prefer carcasses to have at least some fat cover (subcutaneous fat) evenly distributed over the carcass because it aids in maintaining quality and an attractive appearance by preventing the meat from drying.

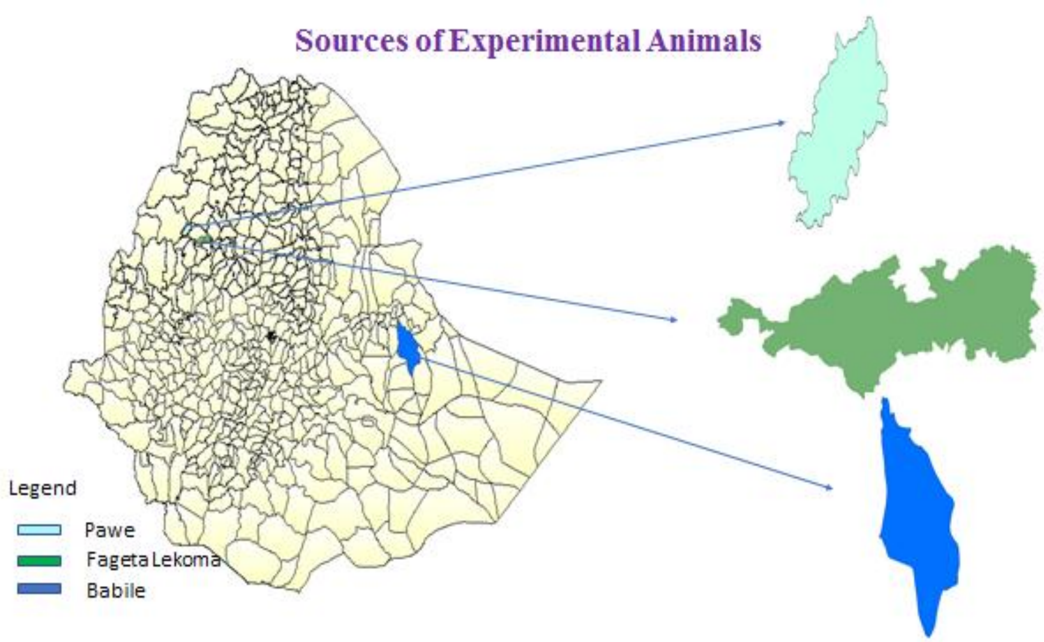
There is limitation in studying meat quality of goats in general and color in particular in Ethiopia available studies only relay on growth performance and carcass characteristics. According to Mekonnen Tilahun *et al.* (2012) central highland goat and boar goat breeds with different blood percentage do not showed significant difference in meat color.

3. MATERIALS AND METHODS

3.1 Description of Study Area and Source of Experimental Animals

Thirty six yearling intact male Agew, Gumuz and LES goats (twelve from each) were purchased from their home markets Addis Kidame, Pawe and Babile woredas respectively. Addis Kidame is capital of Fageta Lekomma woreda in Awi zone administration. Average annual rainfall found to be 2000 mm, with minimum and maximum ranges from 1500-2500 mm (Fagita Lekom Woreda BoARD, 2010). The source of Gumuz goat breeds Pawe is 1050 meters above sea level with a mean annual temperature ranging from 16.2˚C to 32.2˚C. The annual rainfall ranged between 980 and 1200 mm occurring in two seasons from March to May and from June to December (Hussein Mohammed *et al.*, 2017). While Babile district is found in eastern Hararghe zone of Oromia Regional State, located 557 km east of Addis Ababa, the capital city of Ethiopia. It is found between 8°, 9' 9°, 23'N latitude and 42°, 15'42°, 53' E longitude and is characterized by semi-arid and arid climate with average annual rainfall of 410-800 mm. The temperature ranges from 24-28°C (Tayib Mohammed *et al.*, 2015).

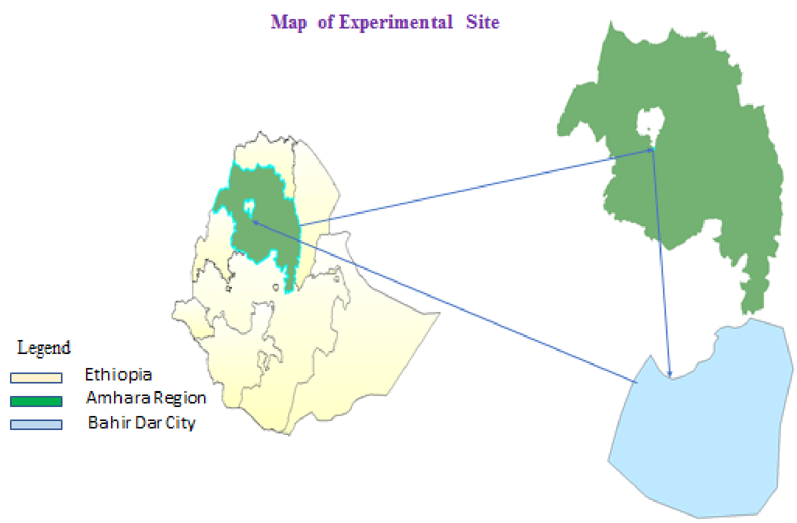
Figure 3.1 Map of areas of experimental animals



The feeding, slaughtering and carcass examination experiments were conducted at Bahir Dar University College of Agriculture and Environmental Science while meat quality evaluation was carried out at Food and Chemical Technology Institute.

The study was carried out in Zenzelma Campus it's found in the rural communities of Bahir Dar zuria woreda. It is 7km away from Bahir Dar the kebele is situated Lake Tana by West, Robit kebele by North, Tenta Kebele by East and Bahir Dar town by South. Geographically it is located at $11^{0}38$ east longitudes and it has temperature ranged from 9.26^{0}c minimum to 29.36^{0}c maximum with rain fall 1498.2mm based on information from the Kebele administration. It has the altitude of 1914m above sea level from GPS reading (kebele report).

Figure 2.2 Map of experimental site



3.2 Experimental Animals Management

Thirty six yearling intact male Agew, Gumuz and LES goats (twelve from each) were purchased from their home markets Addis Kidame, Pawe and Babile woredas respectively. The age of the experimental goats were estimated based on their dentitions and information obtained from the owners. After purchasing, animals were transported to the experimental area by truck with great care. When animals reached to the experimental area they were dewormed by broad spectrum anti helminthic for common parasites and treated by oxy tetracycline in order to avoid occurrence of pastruelosis due to long distance transportation. For the easiness of data collection all goats were given identification by ear tagging.

Then important health care actions were applied and animals adapted for 14 days for their new diet and pen. The pens were equipped with feeding trough for hay and plastic buckets for supplements and watering separately. Following the adaptation period, each goat were weighed and blocked then assigned in to two dietary treatments based on initial body weight. Six animals of each breed assigned to each of the dietary treatment. Then after all goats transferred to individual pens and offered the experimental diet for 90 days.

3.3 Experimental Design and Treatments

The experiment was conducted in a randomized complete block design (RCBD) with factorial arrangement (3 breeds × 2 diet types) and six replications. Blocking in to six was done based on their initial body weight. Two animals with nearly similar body weight from each breed were blocked together and composed six animals in one block. One goat in the same block and breed were randomly assigned to each of dietary treatments.

Two dietary treatments having roughage and concentrate mix were evaluated in this experiment. Each treatment has given four percent of body weight on DM basis (2 % roughage and 2% concentrate mix). The differences between two dietary treatments were the roughage component i.e. natural pasture hay and finger millet straw.

Treatments were:

Factor one (Genotype)

- ✓ Agew goat
- ✓ Gumuz goat and
- ✓ Lone eared Somali goat breeds

Factor two (diet)

- ✓ Diet 1 (50 % concentrate and 50 % natural pasture hay) and

- ✓ Diet 2 (50 % concentrate and 50 % finger millet straw) based on 4 % body weight daily dry matter requirement

3.4 Feed Preparation and Experimental Feeds

The experimental feed consists of commercial concentrate, hay and finger millet straw. However commercial concentrate was given to all experimental goats the roughage components (hay and finger millet straw) were given based on the dietary treatments they were assigned. The commercial concentrate feed was purchased from Kality animal feed processing factory. The hay was prepared from natural pasture grass at Andassa livestock research center and it was harvested and bailed while finger millet straw purchased from millet producer farmers around Zenzelema where the feeding trial was conducted.

The daily dry matter requirement of at 4 % of body weight (Pinkerton and Pinkerton, 1996) was partitioned in to two equal halves of concentrate and roughage since equal proportion of roughage and concentrate was feasible in Ethiopia goats breeds (Ameha Sebesebie *et al.*, 2007) and 20 % percent of refusal allowance. However the company confirmed as the ration was formulated from maize, noug seed cake (Guizotia abyssinica), salt and calcium carbonate, they were not voluntary to tell us the proportions of ingredients. Though there was no chopping of roughage feeds its particle size estimated to be 10 to 15 cm for finger millet straw and 15 – 20 cm for natural pasture hay. One half of the concentrate and roughages were given twice a day at 8:00 am and 2:00 pm through the experimental period.

3.5 Growth Trial

3.5.1 Feeding, feed and nutrient intake measurements

The amount of feed offered and refused were weighed and recorded daily for individual goats. Feed intake was calculated as the difference between feed offered and refused in a daily basis. Samples of concentrate mixture, grass hay and finger millet straw offered were taken every ten days (two sub-samples of 200 g). One of the sub-samples was used for daily dry matter determination and the other portion was sent to International Livestock Research Institute (ILRI) Nutrition Analytical Laboratory for chemical analysis.

Total dry matter intake was calculated by addition of dry matter taken from roughage and concentrate. The nutrient intake from roughage and concentrate was calculated by multiplication of dry matter of roughage and concentrate by their corresponding nutrient value of feeds. Similarly, total nutrient intakes were calculated by addition of nutrient intakes from concentrate and roughage feeds and subtraction of nutrients lost in daily refusal.

3.5.2 Growth performance measurements

Body weight measurements of experimental animals were recorded every ten days (nine times) after, overnight fasting by using string scale of 50 kg weight capacity. Average daily gains (g d^{-1}) were calculated as the difference between final and initial body weights divided by number of feeding days. Total weight gain (total weight change) was determined as the difference of final body weight to initial body weight.

3.5.3. Feed conversion efficiency

Gain efficiency (g LW gain/ g DMI) calculated as a proportion of ADG to total daily feed DM intake. Feed efficiency (g DMI/ kg LW gain) calculated as a proportion of daily dry matter intake to ADG. Feed conversion efficiency was determined by dividing the daily average body weight gain (ADG) by daily total DM intake of the animal.

3.6 Digestibility Trial

The digestibility trial was conducted after the end of feeding trial and all goats were harnessed with fecal collecting bags to collect feces for digestibility determination and allow to adapting for five days followed by seven days of total feces collection. The longer adaptation period in the study was due to difficult behavior of goats to the collecting bags harness. Feed offered and refused were recorded and sampled on daily basis in the morning. Collected feces and refusal were mixed separately and representative sample of 20% were placed in polythene bags daily per animal and pooled over the experimental period. At the end of the seventh day, samples were thawed at room temperature before mixing. Twenty percent of the feces collected daily was kept in refrigerator then dried in a forced draught oven at 60 ^{0}C, milled in a 1 mm sieve and kept in air tight containers as a bulk sample until required for analysis.

The apparent digestibility coefficient (DC) of nutrients was calculated by using the following equation (McDonald *et al*., 2002).

$$Apparent\ nutrient\ DC = \frac{Nutrient\ intake - Nutrient\ in\ faeces}{Nutrient\ intake} \times 100$$

3.7 Chemical Composition Analysis of Feeds

Samples of feeds, refusal and feces were sent to International Livestock Research Institute (ILRI) for chemical analysis using Near Infrared spectrophotometer (NIRS). Dry matter, ash, organic matter, crude protein content, neutral detergent fiber, acid detergent fiber, acid detergent lignin, metabolic energy and in vitro organic matter digestibility were done on composite samples of feed offered, refusal and feces.

3.8 Carcass Evaluation

After fifteen days of from completion of digestibility study, four goats from each treatment were selected randomly and restricted from feeding overnight prior to slaughter. After fasting goats were weighed and slaughtered for determination of carcass characteristics and analysis of meat quality. Goats were slaughtered by severing the jugular vein and the carotid artery on both sides of the throat. The head was placed over container to collect the blood, and the blood was weighed. The animals were then suspended with head down. The head was detached from the body and weighed. The skin was flayed and weighed; the forelegs and the hind legs were trimmed off at the carpal and tarsal joints and weighed. Entire gastrointestinal tract with contents (full stomach, small intestine and large intestines) was removed and weighed, then after removing the gut content the gastro intestinal tract without the gut content was weighed again, and the weight of empty gut was calculated by difference and recorded.

During slaughter, all internal offal such as liver, gall bladder, heart, kidneys, lung with trachea, tail, testis, penis, spleen, urinary bladder, omental fat, intestinal (mesenteric) fat, and kidney fat were removed, weighed and recorded individually. Finally, the hot carcass weight was measured and recorded after removal of the offal components.

Empty body weight was computed by subtracting weight of gut content from slaughter weight. Total edible offal components (TEOC) were taken as the sum total weight of blood, heart, liver with gall bladder, empty gut, kidney, head with tongue, tail, testicles and fat (omental, intestinal, urogenital and kidney). Total usable product (TUP) was taken as the sum total weight of HCW, TEOC and skin. Total usable product percent on the base of slaughter weight (TUP SW base). Total non-edible offal components (TNEOC) was considered as the sum of the weight of lung with trachea, skin, spleen, feet and gut content.

3.9 Meat Quality Analysis

Both chemical composition analysis (moisture, protein, fat and ash) and sensorial evaluation for meat color was conducted. Meat temperature was recorded from muscle longissimus dorsi immediately after slaughter and weight measurement. Meat samples from longissimus dorsi muscles were also taken for determination of chemical composition and meat color. Four meat samples from each goat's longissimus dorsi muscles were taken in which one for chemical composition study by laboratory and the rest three for meat color determination at slaughter, 5 and 10 after slaughter.

3.9.1 Chemical composition analysis of meat

Meat color at slaughter was taken immediately after slaughter and other samples were taken for chemical analysis and color evaluation. The samples stored in refrigerator at – 4 degree Celsius. Chemical compositions including moisture content, ash, protein and fat contents of meat samples were done by proximity analysis at Bahir dar university food and chemical laboratory. The proximate analysis in terms of moisture content, fat, protein and ash were determined according to AOAC (1980). Carbohydrate content was calculated as the difference of sum of moisture, fat, protein and ash from 100 %.

3.9.2 Sensory evaluation of meat color

For this study we used a scale (Likert scale from 1-7 values) according to Australian meat color grade in which 1 is for lighter meat color which is preferred by exporters and consumers and 7 implies for darker and not preferable. The meat color was evaluated by six expertise's having above bachelor degree in animal production and technology. For the evaluation 24 goats from Agew, Gumuz and LES goat breeds of which 8 from each breed were considered. The expertise visually evaluated the meat at similar room light condition and sample size then, put value from the scale that we provided. They evaluated three times i.e. at slaughtering, 5 days and 10 days after slaughtering. Likert (1932) developed the principle of measuring attitudes by asking people to respond to a series of statements about a topic, in terms of the extent to which they agree with them, and so tapping into the cognitive and affective components of attitudes. Likert-type or frequency scales use fixed choice response formats and are designed to measure attitudes or opinions (Bowling, 1997; Burns, & Grove, 1997). These ordinal scales measure levels of agreement/disagreement.

3.10 Statistical Analyses

Body weight change, intake, digestibility, feed conversion efficiency and carcass parameters and meat quality data were subjected to analysis of variance (ANOVA) using the General Linear Model (GLM) procedure of SAS (2014) version 9.1.3. Duncan multiple range test was used for mean separations between treatments. The statistical model used for data analysis was:

$$Y_{ijk} = \mu + G_i + D_j + G*D_k + E_{ijkm}$$

Where Y_{ijk} = Body weight change, intake, digestibility, carcass quality and meat quality parameters (the observation in i^{th} breed and j^{th} diet).

μ = over all mean value

G_i = effects of genotype

D_j = effects of diet

$G*D_{k\ =}$ genotype breed interaction effect and

E_{ijk} = random error

4. RESULTS AND DISCUSSIONS

4.1 Chemical Composition of Experimental Feeds

The mean dry matter, ash, organic matter, crude protein, neutral detergent fibre, acid detergent fibre, acid detergent lignin contents, metabolic energy and in vitro organic matter digestibility of experimental feeds are presented in Table 4.1. The protein content of commercial concentrate that was used for this study was 183.1 g/kg DM. The CP content of commercial feed used in this experiment was lower than Shashie Ayele *et al.,* (2017) (192 g/kg DM) and Mekonnen Tilahun *et al*., (2012) (239.3 g/kg DM) however such results determined by type, quality and proportion of ingredients. Similarly according to Hunegnaw Abebe (2015), Shashie Ayele *et al.,* (2017) and Mekonnen Tilahun *et al.,* (2012) the CP content of the natural hay was 77.8, 79 and 56.9 g/kg DM which except Mekonnen Tilahun *et al*, (2012) result the others were higher than current study value of 62.8. The differences of precision of feed laboratories are major sources of variation in this regard though other factors such as location and stage of harvest, species composition of the pasture had effect on chemical composition of hay.

The DM, OM, NDF, ADF and ADL contents of the FMS in the current study was lower than that of Wude Tsega *et al.,* (2012). According to the same study the DM, OM, NDF, ADF and ADL contents of FMS were 930, 880, 688, 402 and152 g/kg DM which all were higher than the current study. On the other hand, the ash and protein content of the finger millet straw (60.40g/kg DM) used in the study was higher than Wude Tsega *et al.,* (2012) which was (43 g/kg DM). The difference in crop residue chemical composition has been highly attributed to the type of crop, variety, soil composition over which the crop grown and stages of harvest. But different methods of feed treatment could improve its content. According to Wude Tsega *et al.,* (2012), FMS after treating with urea it can improve its CP content 43 to 74 g/kg DM.

The roughage feeds in this experiment have differences in chemical composition; hay was higher in DM, OM, CP, and NDF, ADF contents than FMS and on other parameters vice versa. Therefore, however the nutritive value of hay in the study was lower than above mentioned reports (Hunegnaw Abebe (2015) and Shashie Ayele *et al.,* (2017)), it exceeds from FMS in most parameters.

Table 4.1 Chemical Composition of Experimental Feeds

Feeds	DM (g/kg)	Ash (g/kg)	OM (g/kg)	CP (g/kg)	NDF (g/kg)	ADF (g/kg)	ADL (g/kg)	ME (MJ/kg)	IVOMD (%)
Concentrate	941.1	42.2	952.60	183.1	390.30	40.68	16.40	ND	87.70
Hay	950.3	8.64	913.60	62.80	757.80	446.80	45.90	7.65	50.38
FMS	928.0	15.4	845.70	60.40	643.80	373.70	73.50	8.38	54.61

OM – organic matter; CP – crude protein; NDF – neutral detergent fibre; ADF- Acid detergent fiber ; ADL – acid detergent lignin; ME - Metabolic energy; IVOMD – in vitro organic matter digestibility; ND-not determined

4.2 Feed and Nutrient Intake

Values for dry matter and nutrient intake (g/d/head) were not significantly ($p \geq 0.05$) affected by breed, diet and their interactions (Table 4.2). The TDMI (g/d/head) of Agew, Gumuz and LES goat breeds were 779.87, 794.55 and 803.69 and their TOMI (g/d/head) were 712.10, 725.45 and 733.97 respectively with p value of interaction with diet type for TDMI (0.9400) and TOMI (0.9390). In both parameters LES had showed higher intake followed by Gumuz and Agew. These were due to higher body weight of the breed and as result higher daily offer in the experiment. Both TDMI and TOMI of the current result were higher than figures reported by Mekonnen Tilahun *et al.,* (2012) for central high land goats. In contrast the TDMI and TOMI of Arsi-bale goats were 1038 and 905 grams (Dereje Worku *et al.,* 2015) that significantly higher than the mean value of two parameters on three breeds in the current study. But reason for those differences would be the objective of the experiment, dry matter content and organic matter content of feed, palatability and adjustment of daily dry matter requirement. In the current experiment daily dry matter requirement was adjusted in every ten days based on their actual body weight.

Table 4.2 Effect of breed and roughage feed on daily feed and nutrient intakes

		Parameters (g/day)						
Genotype * Diet		DMI	OMI	CPI	NDFI	ADFI	ADLI	IVOMDI (%)
Diet 1	Agew	786.33	732.26	92.15	465.23	209.12	25.60	52.88
	Gumuz	798.12	743.24	93.53	472.20	212.26	25.99	53.68
	LES	816.93	760.76	95.74	483.33	217.26	26.60	54.94
Diet 2	Agew	773.40	691.94	90.18	366.48	173.22	36.62	53.71
	Gumuz	790.98	707.66	92.23	374.81	177.16	37.45	54.93
	LES	790.45	707.19	92.17	374.56	177.04	37.42	54.89
	p-value	0.9390	0.9359	0.9387	0.9199	0.9246	0.9575	0.9414
	Genotype							
	Agew	779.87	712.10	91.16	415.85	191.17	31.11	53.30
	Gumuz	794.55	725.45	92.88	423.51	194.71	31.72	54.30
	LES	803.69	733.97	93.95	428.94	197.15	32.01	54.92
	p-value	0.6942	0.6931	0.6940	0.6905	0.6909	0.7125	0.6952
	DIET							
	Diet 1	800.46	745.42^{a}	93.81	473.59^{a}	212.88^{aa}	$26.06^{b\ b}$	54.51
	Diet 2	784.95	702.26^{b}	91.52	371.95^{b}	175.81^{b}	37.165^{a}	54.17
	P-value	0.5020	0.0477	0.3992	<.0001	<.0001	<.0001	0.6670
SEM		11.42	10.45	1.34	6.20	2.84	0.45	0.78
Over all mean		792.70	723.84	92.67	422.77	194.34	31.61	54.17

Values in a column and under the same factor with different superscripts significantly differ at least P < 0.05 LES = long eared Somali breed; SEM= standard error of means; DMI= dry matter intake; OMI= organic matter intake; CPI= crude protein intake; AshI= Ash intake; ADFI= acid detergent fiber intake; NDFI= neutral detergent fiber intake ADLI=acid detergent lignin; IVOMDI= in vitro organic matter digestibility (%)

The mean CPIT (g/d/head), ADFIT (g/d/head), NDFIT (g/d/head) and ADLIT (g/d/head) of three goat breeds were 92.67 ± 1.34, 194.34 ± 2.84, 422.77 ± 6.20 and 31.61 ± 0.45 without difference between breeds with an insignificant interaction with diet for CPIT ($p = 0.9352$), ADFIT ($p = 0.9246$), NDFIT ($p = 0.9199$) and ADLIT ($P = 0.9575$) respectively. According to Hossain *et al.,* (2003) the CPIT of grazing female goats were ranged from 40.44 to 47.73 based on level of energy supplementation. Based on this result, the increase energy supplementation level was decrease CPI. At any level of energy supplementation, the CPIT of three male indigenous goats was higher at feedlot level than the current result (Table 4.2).

Unlikely CP intake (92.66 g/h/day) of the current study was lower than that of Dereje Worku *et al.*, (2015) CPIT for Arsi-Bale goats consumed natural pasture grass hay supplemented with concentrate mixture containing graded levels of dried mulberry leaf. In the same report TCPI was decreasing as the level of dried mulberry leaf increased. The in vitro organic matter digestibility (%) in three breeds were also similar with mean value of 31.51 ± 0.45, 22.66 ± 0.33 and 54.17 ± 0.78 for concentrate, roughage and diet mixture, respectively with an interaction p value of 0.9394, 0.9440 and 0.9414 respectively. The in vitro organic matter of concentrate was obviously higher than the roughages.

Except the DMI, CPI and IVOMDI the other nutrient intake parameters showed significant difference ($P < 0.05$) this is due to effect of diet type. Diet 1 fed goat consume significantly higher nutrient than their Diet 2 fed goat counter parts. The effect of concentrate feed amount on nutrient intake was significant ($p \leq 0.05$) in OMI only but on the other nutrients differences were because of dietary types. Goats that were assigned in diet 1 feed treatment took higher organic matter from concentrate which could attributed to the later better weight gain of hay fed goats would increase the daily dry matter offer of concentrate in the experiment protocol.

The daily OMI from concentrate of hay fed goats was 344.76 which is significantly higher ($p \leq 0.01$) than 342.48 of FMS fed goats with an interaction p value of 0.9320. The mean OMIT of goats in this study was 723.84 ± 10.45 which was lower than values of Arsi-bale goats (905 ± 19.25) grazing on natural pasture. Naturally goats are not comfortable for indoor feeding and indoor feeding in the current study had created inconvenience and lowered their intakes.

The total NDF and ADF intake of hay fed goats was significantly higher (P < 0.0001) than FMS fed goats with an interaction p value of 0.9199 and 0.9246 respectively. The differences in both intakes came from the roughage component or feed treatment they were assigned (Table 4.1). On the reverse total ADL intake of hay fed goats was significantly lower (P < 0.0001) than FMS fed goats with an interaction p value of 0.9575 (Table 4.1).

Table 4.3 Effects of breed and roughage feed on intakes on dry matter and nutrients as body weight basis

		Parameters (%BW)						
Genotype * Diet		DMI	OMI	CPI	NDFI	ADFI	ADLI	IVOMDI (%)
Diet 1	Agew	4.15	3.69	0.472	2.31	1.070	0.188	0.279
	Gumuz	4.21	3.75	0.471	2.24	1.071	0.192	0.278
	LES	3.69	3.79	0.470	2.42	1.066	0.187	0.274
Diet 2	Agew	3.83	3.59	0.468	1.95	0.890	0.132	0.261
	Gumuz	3.85	3.75	0.469	2.06	0.909	0.128	0.276
	LES	4.31	3.51	0.470	1.84	0.894	0.133	0.266
	p-value	0.8327	0.9150	0.8921	0.6983	0.7549	0.6871	0.9102
	Genotype							
	Agew	3.99	3.64	0.470	2.13	0.980	0.160	0.270
	Gumuz	4.03	3.68	0.470	2.15	0.990	0.160	0.280
	LES	4.00	3.65	0.470	2.13	0.980	0.160	0.270
	p-value	0.0854	0.8500	0.0823	0.0958	0.0752	0.6815	0.4290
	DIET							
	Diet 1	4.018	3.742 [a]	0.471	2.377 [a]	1.069 [a]	0.189 [a]	0.277 [a]
	Diet 2	3.996	3.575 [b]	0.469	1.894 [b]	0.895 [b]	0.131 [b]	0.270 [b]
	P-value	0.1019	<.0001	0.2921	<.0001	<.0001	<.0001	<.0001
SEM		0.01	0.01	0.00	0.00	0.00	0.00	0.00
Over all mean		4.007	3.658	0.47	2.135	0.982	0.160	0.274

Values in a row and under the same factor with different superscripts significantly differ at least P < 0.05 LES= long eared Somali; SEM= standard error of means; DMI= dry matter intake; OMI= organic matter intake; CPI= crude protein intake; ADFI= acid detergent fiber intake; NDFI= neutral detergent fiber intake ADLI=acid detergent lignin; IVOMDI= in vitro organic matter digestibility (%); % BW = percentage on body weight basis

ADL intake from FMS (31.27) had 50 % increment from hay ADL intake (20.13) showed higher lignification as result low palatability and nutritive value of crop residue than hay. The above facts conclude that hay has higher nutritive value than FMS and FMS has higher lignin part which could not be digested in ruminants' digestion system. Here the dominance of crop residue over hay in mixed highland farming systems could be taken as at the expense of nutrients.

Like feed and nutrient intake type of roughage feed was significant in most indicators of intake at BW % basis except DMI and CPI. Mean values of DMI (%BW) and CPI (%BW) of Agew, Gumuz and LES indigenous goat breeds fed different roughage feed were 4.007 ± 0.01 and 0.468 respectively (table 4.3). There is no a significance difference ($p \geq 0.05$) in interaction of breeds and diet on body gain bases. Opposite to this result Shashe Ayele *et al.*, (2017) reported difference between Horro and Washera fat tailed indigenous sheep breeds on DMI (%BW) and CPI (%BW) fed two concentrate supplementation levels.

Similarly type of roughage showed highly significant difference ($P < .0001$) in OMI (%BW), ADFI (%BW), NDFI (%BW), ADLI (%BW) and IVOMIDI (%BW) (table 4.3). The reason for this fact is that as we are saw in chemical composition of feeds hay were higher in important nutrients and lower in lignin content. However Shashe Ayele *et al* (2017) did not agree with current finding on DMI (%BW) and CPI (%BW) it agreed on OMI (%BW), ADFI (%BW), NDFI (%BW), ADLI (%BW) and IVOMIDI (%BW). These differences were resulted from difference on experimental feeds, animal species and levels of energy and protein ratios in the studies.

4.3 Apparent Dry Matter and Nutrient Digestibility

The mean DMD, OMD, CPD, NDFD and ADFD of roughage and concentrate mix fed goats of three indigenous breeds are presented on Table 4.4. The effect of goat breed was revealed significant ($p \leq 0.05$) on NDFD in which LES had higher value than the other breeds, though there was no difference between Agew and Gumuz goats. On the other hand there is no a significance difference ($P \geq 0.05$) in DMD, OMD, CPD, NDFD and ADFD with interaction of breed and diet.

Table 4.4 Dry matters and nutrient apparent digestibility of three Ethiopian goat breeds fed two hay and finger millet straw as roughage feed

		Digestibility (%)				
Diet * Genotype		DMD	OMD	CPD	NDFD	ADFD
	Agew	46.54	55.32	74.49	46.64	25.16
Diet 1	Gumuz	46.12	54.60	73.95	46.66	28.40
	LES	49.11	56.67	75.75	50.52	26.08
	Agew	43.46	55.18	70.75	52.52	27.02
Diet 2	Gumuz	46.34	57.24	67.19	52.50	26.02
	LES	45.05	56.51	72.51	54.32	28.68
	p-value	0.7811	0.6432	0.6893	0.7322	0.8445
	Genotype					
	Agew	44.49	55.25	72.62	49.58 [b]	26.09
	Gumuz	46.23	55.92	70.57	49.76 [b]	27.21
	LES	47.08	56.59	74.13	52.42 [a]	27.38
	p-value	0.6451	0.3420	0.1728	0.0319	0.9853
	Diet					
	Diet 1	47.25	55.53	74.73 [a]	48.38 [b]	26.34
	Diet 2	44.61	56.31	70.15 [b]	52.78 [a]	27.24
	p-value	0.4328	0.1072	0.0254	0.0187	0.3803
	SEM	0.03	0.02	0.03	0.02	0.02
Over all mean		45.93	55.92	72.44	50.58	26.79

Values in a column and under the same factor with different superscripts significantly differ at least P ≤ 0.05 LES= long eared Somali; SEM= standard error of means; DMD= dry matter digestibility; OMD= organic matter digestibility; CPD = crude protein digestibility; ADFD = acid detergent fiber Digestibility; NDFD = neutral detergent fiber digestibility;

In the current study the effect of diet was seen on CPD and NDFD. Diet one was higher in CPD and vice versa in the case of NDFD. The other parameters including DMD, OMD and ADFD remained irresponsive for both effects. Similar to the current result Mekonnen Tilahun *et al.*, (2012) the digestibility of roughage concentrate mix diets on CHG and their crosses with Boer goat was non-significant except for NDFD and digestible hemi cellulose digestibility.

According to Brosh, A. *et al.*, (2005) the effects of feed type on digestibility of nutrients were significantly different on both sheep and goats fed oak species (Quercus dumosa), chamise, and manzanita (Arctostaphylos glandulosa) particularly on DMD, OMD and CPD. But in the current study DMD and OMD were indifferent for both feed group goats.

4.4 Body Weight, Growth Rate and Efficiency

The effect of breed in this study was insignificant for IBW and FBW ($p \geq 0.05$) but it was significant in TWG and DWG. The mean IBW of Agew, Gumuz and LES goat breed were 16.34, 17.41 and 16.92 kg while FBW were 22.33, 21.88 and 22.99 kg respectively (Table 4.5). Unlike FBW, TWG and DWG were significantly lower ($p \leq 0.05$) in Gumuz goat but Agew and LES goat breeds were perform similarly. According to Ameha Sebsebie *et al.*, (2007) the IBW and FBW for LES goat were 14.76 and 20 kg which all were below the current result that is due to age of goats at the experiment. However the same author reported significant effect of breed particularly LES had significantly higher weight gain than CHG and Afar goat breeds in the current study there was no significant ($p \geq 0.05$) difference between Agew and LES goat breeds on both TWG and DWG parameters. The mean DWG of LES, Afar and CHG (Ameha Sebesebie *et al.*, 2007) were below DWG of Agew, Gumuz and LES in the current study. Moreover different studies showed significant effect of breed on weight gain performance (Ahmet Hamdi *et al.*, 2015 and Mekonnen Tilahun *et al.*, 2012).

Similar to breed effect of basal fed was in significant ($p \geq 0.05$) on IBW and FBW but had effect on precise growth measuring parameters i.e. TWG and DWG. The average IBW for hay fed goats was 16.64 and lower than goats fed FMS (17.13) but hay fed goats were higher in FBW and they significantly performs higher ($p \leq 0.05$) than FMS groups in TWG and DWG.

The TWG mean of hay fed goats was 6.16 that had 27 percent increment from FMS fed goats. The daily weight gain of hay fed groups was 69.98 while FMS fed groups were gained 53.58 grams.

Table 4.5 Effects of breed and roughage feed on body weight gain and feed efficiency

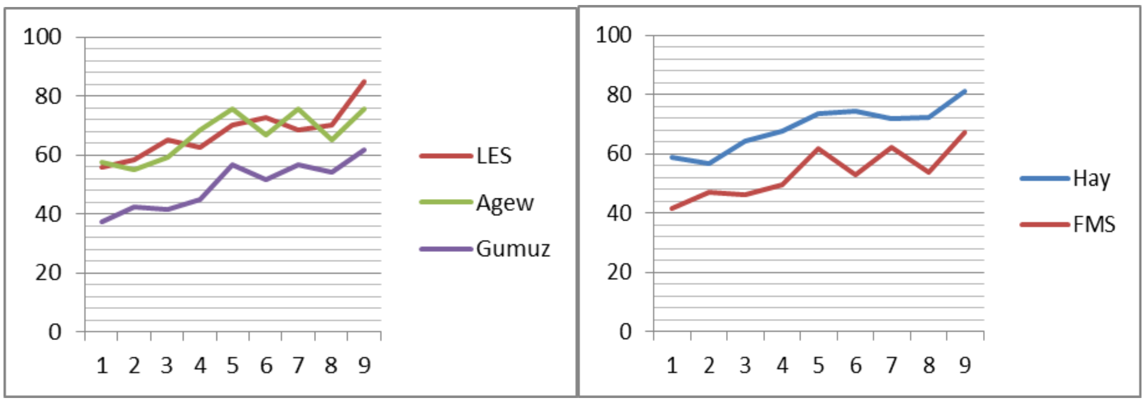
		Weights				
Diet * Genotype		IBW (kg)	FBW (kg)	TWG (kg)	DWG (g)	FCE (g DMI/g gain)
Diet 1	Agew	16.03	22.77	6.58	74.81	0.077
	Gumuz	16.97	22.27	5.30	58.89	0.081
	LES	16.93	23.52	6.58	73.15	0.065
Diet 2	Agew	16.65	21.90	5.25	58.33	0.094
	Gumuz	17.85	21.50	3.65	40.55	0.085
	LES	16.90	22.47	5.57	61.85	0.065
	p-value	0.8354	0.9795	0.87840	0.8726	0.7681
	Genotype					
	Agew	16.34	22.33	5.92 [a]	66.57 [a]	0.087 [a]
	Gumuz	17.41	21.88	4.47 [b]	49.72 [b]	0.084 [b]
	LES	16.92	22.99	6.07 [a]	67.50 [a]	0.063 [a]
	p-value	0.4065	0.3022	0.0280	0.0262	0.0442
	Diet					
	Diet 1	16.64	22.85	6.15 [a]	68.95 [a]	0.087 [a]
	Diet 2	17.13	21.95	4.82 [b]	53.58 [b]	0.069 [b]
	p-value	0.4509	0.1314	0.0133	0.0113	0.0405
	SEM	0.32	0.22	0.20	0.69	0.004
Over all mean		16.89	22.40	5.49	61.26	0.078

Values in a column and under the same factor with different superscripts significantly differ at least $P \leq 0.05$ LES= long eared Somali; SEM= standard error of means; IBW = initial body weight; FBW=final body weight; TWG = total weight gain; DWG = daily weight gain and FE = feed efficiency

There is no study conducted to evaluate FMS as goat feed however Wude Tsega *et al., et al.,* (2012) reported importance of FMS treated by urea for sheep. Based on the result the average weight gain of sheep fed urea treated FMS and untreated FMS were 90.94 grams versus 81.10 grams respectively.

However there was increasing trend As shown in figure 3 there was inconsistency in body gain of all goat breeds which would told that as there was adaptation problem issues for indoor feeding, weather variability in throughout the feeding period.

Figure 3.1 Trends of body weight gain (ADG) of indigenous goat breeds (left) and effect of Diet type on ADG (right)



4.5. Carcass Characteristics of Agew, Gumuz and Long eared Somali Goat Breeds fed Different Diets

4.5.1 Effects of genotype and diet on main carcass parameters

Generally in all main carcass parameters there was no breed by feed interaction observed ($p \geq 0.05$). Mean SBW, EBW and HCW of three indigenous breeds of goat were 22.48 ± 0.59, 18.67 ± 0.53 and 9.85 ± 0.33 kg (Table 4.6) which all values were higher than reports of Ameha Sebesebie *et al*., (2007) for CHG, Afar and LES goat breeds. This might be related with age of the animals in which the current study was conducted on yearling goats while the second was on young goats of selected breeds.

Most carcass characteristics including total main carcass component (TMCC) of selected goat breeds of Ethiopia did not show significant difference between breeds except weight of hind quarter and tail. The mean total main carcass component weight of Agew, Gumuz and LES goat breeds feed concentrate and roughage mix was 9.41 ± 0.03 kg. The reason for this fact might be attributed to close genetic distance of indigenous goat breeds of Ethiopia (Getinet Mekuriaw *et al.*, 2016). Ameha Sebesebie *et al.*, (2007) also reported as breed did not have effect on SBW, EBW, HCW, DP at SLW base and EBW base at the initial though LES showed higher values after feeding different proportions of concentrate to roughage mixes. Unlike to other studies similar carcass weights of LES in this study may attributed to higher maintenance requirement of the breed at cooler area as compared with the hot environment where the breed reared naturally and performance of other breeds in which LES was compared with.

Regardless of indigenous goat breeds Mekonnen Tilahun *et al.*, (2012) reported significant differences of CHG and their 25 % and 50 % crosses with Boer goat breed on SBW, EBW, HCW which implies that higher potential of Boer goat genotype for meat production. However the same author also agreed with the current finding by effects of breed on dressing percentage at both SLW and EBW bases, S. Solaiman (2011) reports significantly positive effect on castrated wethers on dressing percentage than buck counter parts. Not only cross with exotic goat breed but also in three indigenous goat breeds namely Bati, HH and SS differences on above mentioned parameters reported by Dereje Tadesse (2016). The study conducted to evaluate the effect of initial weight and sex confirmed high effect of initial weight on SLW, EBW and HCW but no difference was observed by sex groups (Bonvillani *et al.*, 2010).

Hind quarter weights of Agew, Gumuz and LES were 2450.0, 2186.3 and 2679.0 grams respectively and LES goat breed had significantly higher weight ($p \leq 0.05$) than Gumuz goat breed though, the LES goat breed morphologically have similar buttock circumference and compactness with Afar and CHG (Ameha Sebesebie *et al.*, 2007). Obviously goats have much lower tail weight than sheep (Dismas *et al.*, 2013) but weights are determined by the morphology of goat breeds. This study revealed that Agew goat breed had significantly higher

($p \leq 0.05$) tail weight (36.54 g) than LES (26.57 g) despite both did not show difference with Gumuz goat breed (30.15 g) that could attributed to Agew goat breed found in the high land area and developed larger tail to protect its parts from cold weather. This assumption also strengthens by no difference of tail weight by feed groups in this study.

In all aspects of carcass parameters evaluation there is no a significance difference ($p \leq 0.05$) among interaction of breed and diet (Table 4.6). Type of diet showed significant difference on major main components of carcasses. The only parameters that did not show significant difference for feed type were dressing percentage, thoracic lumbar part, rib eye muscle and tail. Goats feed equal proportions of commercial concentrate and hay (diet one) showed higher values than goats fed equal proportion on commercial concentrate and FMS (diet two).

The mean SLW of goats fed hay was 24.17 kg which significantly higher ($p \leq 0.05$) than 20.80 kg SLW value of goats fed FMS as roughage feed (Table 4.7). Similar to the current result Endashaw Terefe *et al.,* (2013) reported determinant of feed type on SLW of Afar goat breed and Dereje Tadesse (2016) observed the significant effect of different concentrate levels on three indigenous goat breeds. Antagonistic to this crossbred (Japanese Saanen × Tokara native goats) bucks fed Lucerne hay and fermented bagasse feed as supplementation to Bermuda grass for 28 weeks did not show difference in SLW (Ramli, 2005).

Likewise goats fed hay recorded significantly higher values of EBW ($p \leq 0.01$) and HCW ($p \leq 0.05$) than FMS fed goats. The EBW and HCW of hay fed goats were 20.40 kg and 10.70 kg respectively but those values for FMS fed goats were 16.93 kg and 9.00 kg. However effects of feed on EBW and HCW were reported by many scholars (Ameha Sebesebie *et al.,* (2007) and Daniel Montanher *et al.,* (2016) its effect is determined by chemical composition of the feed, palatability, digestibility, types of animal and overall interactions of feed, animal and digestive system of the animals. Some studies also resulted with absence of feed effect on hot carcass weight of goats (Ramli, 2005).

Table 4.6 Effects of genotype and diet on main carcass traits of three goat breeds of Ethiopia

Diet * Genotype		SLW (kg)	EBW (kg)	**HCW (kg)**	DP at SLW base (%)	DP at EBW base (%)	Fore quarter (g)	Neck (g)	Sternum (g)	Thoracic and lumbar (g)	Rib eye muscle (g)	Abdominal muscle (g)	Hind quarter (g)	Pelvic region (g)	Tail (g)	Ribs (g)	REMFT (mm)	TMC (Kg
Diet 1	Agew	24.40	21.02	11.4	52.37	60.41	2884	1035	495	799	693	569	2741	678	41	883	4.60	10.3
	Gumuz	22.20	18.59	9.1	49.40	59.23	2448	888	444	603	707	538	2339	539	29	796	4.53	9.42
	LES	25.91	21.59	11.1	51.32	61.98	2399	849	501	789	837	581	2868	671	31	841	5.48	10.7
Diet 2	Agew	20.70	17.56	9.1	50.21	60.77	2021	892	392	713	680	434	2159	503	33	601	3.94	9.16
	Gumuz	19.84	15.93	8.2	48.40	60.49	1902	742	396	611	845	447	2033	456	23	667	3.91	7.90
	LES	22.07	17.33	10.2	48.96	60.28	2140	764	440	678	818	490	2490	476	28	752	4.64	8.92
	p-value	0.8102	0.8441	0.8168	0.9935	0.8761	0.4017	0.9569	0.7850	0.6536	0.9514	0.9098	0.7109	0.3822	0.7740	0.5032	0.5436	0.74
	GENOTYPE																	
	Agew	22.70	19.29	10.25	51.29	60.59	2575	961	443	756	675	501	2450^{ab}	590	36 ^{a}	744	4.27	9.75
	Gumuz	21.02	17.26	8.9	48.90	59.86	2209	815	419	606	686	492	2186^{b}	498	30^{ab}	731	4.22	8.66
	LES	23.72	19.46	10.65	50.14	61.13	2367	806	470	773	827	535	2679 ^{a}	573	26 ^{b}	796	5.06	9.82
	p-value	0.1977	0.2047	0.1701	0.2230	0.6378	0.2082	0.3192	0.4795	0.0880	0.1571	0.7428	0.0330	0.0905	0.0446	0.7386	0.1673	0.23
	DIET																	
	Diet 1	24.17^{a}	20.40^{a}	10.53^{a}	51.03	60.54	2561 ^{a}	922 ^{a}	480 ^{a}	730	842 ^{a}	629 ^{a}	2650 ^{a}	563 ^{a}	34	842 ^{a}	4.87 ^{a}	10.1
	Diet 2	20.80^{b}	16.93^{b}	9.16 ^{b}	49.20	60.51	2207 ^{b}	799 ^{b}	409 ^{b}	667	673 ^{b}	478 ^{b}	2227 ^{b}	457 ^{b}	28	673 ^{b}	4.17 ^{b}	8.66
	P-value	0.0106	0.0043	0.0195	0.1071	0.9794	0.0421	0.0191	0.0486	0.2731	0.0298	0.0003	0.0073	0.0386	0.6523	0.0298	0.0410	0.02
	SEM	0.59	0.53	0.33	0.54	0.54	80.97	45.47	16.77	27.87	34.11	23.82	69.90	17.15	1.51	35.75	0.253	0.30
Over all mean		22.48	18.67	9.85	50.11	60.52	2383	861	445	699	730	510	2438	544	31	757	4.52	9.41

Values in a column and under the same factor with different superscripts significantly differ at least P ≤ 0.05 DP = dressing percentage; EBW = empty body weight; HCW = hot carcass weight; LES = long eared Somali, SEM = standard error of means; SLW = slaughter weight REMFT = rib eye muscle fat thickness; TMCC = total main carcass components

The mean dressing percentages of goat fed hay and FMS straw as roughage and supplemented with commercial concentrate were 50.11% ± 0.54 and 60.52% ± 0.54 at SLW and EBW bases (Table 4.6). Type of roughage feed did not show significant effect on dressing percentage. The current finding was in line with Rita Nath *et al.,* (2016) finding that feeding of different proportions of medicinal leaves did not resulted with none effect on dressing percentage. The other study conducted to evaluate the inclusion rate of dried moringa (*Moringa stenopetala*) leaf meal for concentrate on Arsi-bale goat breed revealed absence of effect on dressing percentage. On the other hand different levels of concentrate supplementation on three indigenous got breeds of Ethiopia showed significant difference which could result from larger variations between feed treatments. Neck, fore quarter, hind quarter, pelvic region, ribs and sternum weights were significantly higher ($p \leq 0.05$) in hay fed goats than FMS feds but indifferent ($p \geq 0.05$) by thoracic and lumbar weight. Disparately dietary herbal antioxidants supplementation on feedlot did not resulted in difference on all above mentioned indicators (Morteza *et al.,* 2010).

The mean values of abdominal and rib eye muscles of goats fed hay as roughage were 841.8 and 745.7 grams respective that its abdominal muscle weight significantly higher ($p \leq 0.05$) than goat FMS fed goats (456.8 grams) and similar by rib eye muscle (714.4 grams) (Table 4.6). According to Mekonnen Tilahun *et al.,* (2012) report increment of bone, lean and fat content as the blood level of Boer increased from 0 % to 50 % with CHG breed has been shown that conclude higher potential of exotic genotypes as compared with indigenous genotypes.

Hay concentrate equally fed goats yielded significantly higher ($p \leq 0.05$) total main carcass yield than FMS concentrate equally fed groups which attributed to significant differences on most carcass parts like neck, fore quarter, hind quarter, pelvic region, ribs, sternum and abdominal muscle between two feed treatments. Moreover, those results were shown due to higher feed value and digestibility of hay than FMS as offered equally proportioned with concentrate.

4.5.2 Effects of genotype and diet on non-carcass parameters

Likely to most main carcass components the three indigenous goat breeds did not show significant difference ($p \geq 0.05$) in non-carcass indicators except by weights of testicle and spleen (Table 4.7). In contrast to the current finding different scholars showed breed effect on most non-carcass parameters (Ameha Sebesebie *et al.*, 2007 and Mekonnen Tilahun *et al.*, 2012). The current finding and recently Dereje Tadesse (2016) revealed as breed has minimal effect on most non carcass parameters including kidney, feet, head, skin, gastro intestinal parts and digestive contents. In negotiating the two arguments the paramount factor for determination of non-carcass parameters is weight at slaughter than others (Bonvillani *et al.*, 2010). Development of internal organs are initiated in early chronological stage of animals and matured early as compared to carcass parameters which logically associate with muscle development and fat deposition.

The mean weight of testicle for Agew, Gumuz and LES goat breeds after feeding equal proportions of concentrate and roughage in DM basis were 170.80, 198.55 and 255.19 grams respectively (Table 4.7). LES showed significantly higher weight ($p \leq 0.05$) than both breeds. In addition to the result LES bucks lively had larger and suspended testicle as compared with Agew and Gumuz goat breeds. The size of testicle mainly related with reproductive performance of animal but it had also meat value in societies like Ethiopia where eating of testicles is common. According to Ameha Sebesebie *et al.,* (2007) LES goat breed has significantly lower weight of testicles in younger age but similar with Afar and CHG breeds after feeding in feedlot and older ages. The weights of testicles of this breed were 143.8 grams and 229.6 grams in younger and after feeding in older ages respectively which both were below the value of current finding (255.19 grams). The mean spleen weight of three goat breeds was 41.72 with great variations (SEM = 36.04) and showed significant difference ($p \leq 0.05$) in goat breeds like testicle LES goat breed higher value than the two breeds. Even tough effects of breed on size of spleen was also reported by many findings (Ameha Sebesebie *et al.*, 2007 and Mekonnen Tilahun *et al.*, 2012) some finding showed indifference on size of spleen in goat breeds of Ethiopia (Dereje Tadesse, 2016).

Table 4.7 Effects of genotype and diet feed on weights of non-carcass parts of three goat breeds fed different roughage feeds

		Parameters (gram)														
Diet * Genotype		Blood	Heart	Liver	Kidney	Tongue	Gut full	Gut empty	Gut content	Testicles	Gall bladder	Skin	Head	Spleen	Lung with trachea	Feet
Diet 1	Agew	824	107	399	96	123	5430	1800	3842	210	52	2671	1358	36	339	920
	Gumuz	693	105	389	65	79	5510	1530	3157	214	49	2448	1302	28	343	1945
	LES	812	94	382	69	89	5515	1839	4290	272	34	2400	1360	49	383	668
Diet 2	Agew	884	90	356	58	88	5094	1910	2972	132	50	2021	1268	29	330	617
	Gumuz	661	88	331	60	88	5246	1692	4379	182	47	1902	1148	28	305	607
	LES	712	92	388	94	83	6481	1621	4246	238	48	2140	1106	80	321	623
	p-value	0.7515	0.4421	0.6640	0.3254	0.1385	0.3451	0.4820	0.5431	0.1143	0.8406	0.6813	0.3393	0.2299	0.0983	0.9451
	GENOTYPE															
	Agew	844	99	365	64	105	5262	1855	3407	171 [b]	51	2346	1313	33 [b]	361	669
	Gumuz	677	96	360	62	84	5378	1611	3768	198 [b]	48	2175	1225	28 [b]	324	1276
	LES	747	93	385	82	86	5998	1730	4268	255 [a]	41	2270	1233	64 [a]	356	645
	p-value	0.0943	0.6996	0.7614	0.2668	0.1239	0.1888	0.1804	0.1381	0.0165	0.4346	0.7581	0.5551	0.0160	0.3601	0.4145
	DIET															
	Diet 1	766	102 [a]	382	68	97	5485	1723	3763	232 [a]	45	2506 [a]	1340 [a]	38	373 [a]	1111
	Diet 2	746	90 [b]	358	71	86	5607	1741	3866	184 [b]	48	2021 [b]	1174 [b]	45	321 [b]	616
	P-value	0.7338	0.0407	0.4259	0.7675	0.2437	0.7240	0.8608	0.7630	0.0413	0.6474	0.0181	0.0339	0.4381	0.0307	0.2632
	SEM	0.30	29.46	2.87	14.47	5.22	536.63	51.62	168.82	15.92	10.89	3.22	113.62	36.04	11.15	215.19
Over all mean		756	96	370	69	92	5546	1732	3814	208	47	2264	1257	42	347	863

Values in a column and under the same factor with different superscripts significantly differ at least P ≤ 0.05 LES = long eared Somali, SEM = standard error of means

Type of diet did bring significant difference ($p \leq 0.05$) on some non-carcass organs of three indigenous goats though indifference in most parameters. Organs like heart, testicle and lung show different responses for roughage feed (table 4.9). The mean weight value of heart, testicle and lung for hay feed groups were 102.4, 323.1 and 373.2 grams which all were significantly higher ($p \leq 0.05$) than FMS fed groups. Integument and head also show similarly significant different ($p \leq 0.05$) results for feeding groups. The other edible and non-edible indicators of non-carcass parts were similar ($p \geq 0.05$) across feed treatments.

According to Dereje Tadesse *et al.*, (2016) the effect of different levels of concentrate were significant ($p \leq 0.001$) on some parameters of non-carcass parameters like liver, skin and feet, GIT empty and total edible offal though total edible offal has been determined by the feeding habit of people where the studies were conducted. Other scholars reported differences of diet resulted in differences on blood, kidney and testicle (Attiba *et al.*, 2016); none effect by (Ramli *et al.*, 2005). Generally effect of diet on none carcass components shown inconsistence by scientific findings due to differences on type of feed treatments, breeds and interactions of those factors.

4.5.3 The effect of genotype and diet feed on fat components of three goat breeds in Ethiopia

There were no interaction effect of breed and feed for all fat deposition and usable product yields (table 4.8). Separately breed had not effect on internal fat deposition and usable product yields while feed type remains insignificant for most parameters except PF and TUP yield. The mean values KF, OMF, TEO and TUP (% SLW) of indigenous goats fed equal proportion of roughage to concentrate were 110.8 grams, 250.2grams, 3.3 kg and 60.5 percent respectively. Hay fed goats show significantly higher ($p \leq 0.05$) values of PF and TUP than FMS fed groups. There is no significance difference ($p \leq 0.05$) among interaction of breed and diet in KF, OMF, TEO and TU (Table 4.8).

Table 4.8 Effect of genotype and diet on internal fat deposit of three indigenous goat breeds of Ethiopia

		Fat type/usable parts					
Diet * Genotype		KF (gram)	PF (gram)	OMF (gram)	TEO (kg)	TUP (kg)	TUP (% SLW)
Diet 1	Agew	112.11	170.38	420.21	3.64	14.48	62.86
	Gumuz	159.23	90.25	160.56	3.16	12.85	61.88
	LES	171.94	177.79	391.32	3.70	15.30	59.13
Diet 2	Agew	86.57	104.18	296.99	3.36	13.94	62.58
	Gumuz	65.49	46.65	136.04	3.00	12.27	57.36
	LES	51.52	46.41	96.06	3.04	12.70	59.25
	p-value	0.4601	0.8566	0.3431	0.5423	0.7632	0.9919
	Genotype						
	Agew	99.34	137.28	358.60	3.50	14.21	62.72
	Gumuz	121.36	68.45	148.30	3.08	12.56	59.62
	LES	111.73	112.10	243.69	3.37	14.00	59.19
	p-value	0.9454	0.2728	0.1190	0.1150	0.1749	0.0729
	Diet						
	Diet 1	150.76	146.14 [a]	324.03	3.37	14.45 [a]	61.29
	Diet 2	70.86	65.74 [b]	176.36	3.27	12.73 [b]	59.73
	P-value	0.1544	0.0295	0.0761	0.5603	0.0334	0.2383
SEM		26.84	17.01	39.23	0.08	0.37	0.64
Over all mean		110.81	105.94	250.19	3.32	13.59	60.51

Values in a column and under the same factor with different superscripts significantly differ at least $P \leq 0.05$
LES = long eared Somali; SEM = standard error of means; KF = kidney fat; PF = pelvic fat; OMF = omental and mesenteric fat; TEO = total edible offal; TUP = total usable products; SLW=slaughter weigh

4.6 Meat Quality of Three Indigenous Goat Breeds of Ethiopia Fed Different Diet Types

4.6.1. Temperature and chemical composition

The mean temperature of hot carcass meat of indigenous goat breeds of Ethiopia was 28.38 ± 0.22 and there was no effect of breed and diet on meat temperature at slaughter. The meat proximate chemical analysis result showed that there was no significant difference among indigenous goat breeds fed different types of roughage on moisture, ash, protein, fat and carbohydrate contents of the meat. The mean values of moisture, ash, protein, fat and carbohydrate of indigenous goats were 71.94 ± 0.33, 3.74 ± 0.14, 24.03 ± 0.58, 4.52 ± 0.48 and 0.38 ± 0.03 respectively (Table 4.9).

According to Moawad *et al*., (2013) the proximate analysis result showed that Egyptian Baladi Breed the moisture, ash, protein and intramuscular fat contents were 75.32 ± 0.41, 1.13 ± 0.08, 19.97 ± 0.12 and 3.28 ± 0.13 respectively . Based on the results meat from Ethiopian goat breeds have lower dry matter but higher ash, protein and fat content than Egyptian Baladi goat breeds. Similarly, meat from indigenous goat of Tanzania had higher dry matter and ash content than our current finding (Shija *et al*., 2013). However, all the above findings were from muscle longissimus dorsi unlikely Ayeb (2016) reported effect of muscle type for chemical composition of meat. Based on the report chest meat had higher dry matter and ash content than shoulder and leg muscles but, in terms of crude protein and fat content shoulder muscle was higher than others.

Table 4.9 Least square means for temperature and chemical composition of meat on indigenous goat

Source of variations							
Diet * Genotype		Temperature	MO (%)	Ash (%)	Protein (%)	Fat (%)	Carbohydrate (%)
Diet 1	Agew	28.96	72.13	3.13	20.06	4.36	0.32
	Gumuz	28.63	71.61	3.14	20.08	4.74	0.42
	LES	27.94	72.23	2.99	19.56	4.78	0.43
Diet 2	Agew	26.76	71.94	2.99	20.19	4.52	0.36
	Gumuz	28.17	71.71	3.01	20.27	4.60	0.40
	LES	29.80	72.02	2.97	20.04	4.63	0.34
	p-value	0.6754	0.2422	0.4686	0.0621	0.0939	0.1653
	Genotype						
	Agew	27.86	72.03	3.06	20.13	4.44	0.34
	Gumuz	28.40	71.66	3.08	20.17	4.67	0.41
	LES	28.87	72.13	2.98	19.80	4.71	0.39
	p-value	0.4152	0.2903	0.6341	0.0964	0.2505	0.2456
	Diet						
	Diet 1	28.51	71.99	3.09	19.90	4.63	0.39
	Diet 2	28.25	71.89	2.99	20.17	4.58	0.37
	p-value	0.9704	0.1563	0.5492	0.0878	0.1201	0.1298
SEM		0.22	0.33	0.14	0.58	0.48	0.03
Over all mean		28.38	71.94	3.74	24.03	4.52	0.38

Values in a column and under the same factor with different superscripts significantly differ at least $P \leq 0.05$ LES = long eared Somali; MO = moisture content; SEM = standard error of means

4.6.2. Meat color

There is no significant variation (P>0.05) among meat color preferences by feed type in all stages of experts' evaluation (Table 4.10). However, there were significant variations among meat color preferences by breed at a time of slaughtering and 5 days after slaughtering. There is a high significant variation between LES and Agew breeds in terms of meat color preference scores in all stages of expertise evaluation. The Somali goat breeds are much better than the Agew and Gumuz goat breeds in terms of meat quality (meat color preference scores) until 10 days and 5days of slaughtering respectively. The Gumuz goat breeds are better than the Agew goat breed in meat quality until 5 days of slaughtering. There was no significance difference in meat color among interaction of breed and diet in Ethiopian goat breeds.

The preference score values for meat color of LES, Gumuz and Agew goat breeds at slaughter were 2.67, 3.29 and 4.41 respectively and in all goat breeds there were significant differences that showed as LES goat had lighter meat color and Agew meat had the darker one. Without significant difference hay fed goat meats color was lower (3.33) than FMS fed groups (3.58).

According to the expertise evaluation result meat from Agew goat has higher color value at initial and the color loss extent was lower from slaughter day up to ten days after slaughter. The color loss values of LES, Gumuz and Agew goat breed meats were 1.45, 1.46 and 0.84. This implied that the meat color of Agew could naturally darker and the possibility of losing it color due to storage and transportation would be minimal.

Similar to the current finding Mancini (2005) reported the significance of breed in determining the color of meat. In contrast according to Park (2007) showed as pre and post slaughter managements had higher effect to the color of meat.

Table 4.10 ANOVA table of meat color preference scores for goat meat of Agew, Gumuz and LES breeds fed different roughage feed

		Days of evaluation		
Diet * Genotype		At slaughtering	5 days after slaughtering	10 days after slaughtering
	Agew	4.43	4.60	5.15
Diet 1	Gumuz	3.08	3.65	4.36
	LES	2.48	2.95	4.08
	Agew	4.39	4.78	5.35
Diet 2	Gumuz	3.50	3.89	5.16
	LES	2.86	3.09	4.16
	p-value	0.4460	0.4926	0.5993
	Genotype			
	Agew	4.41 ^{c}	4.69 ^{c}	5.25 ^{b}
	Gumuz	3.29 ^{b}	3.77 ^{b}	4.75 ^{ab}
	LES	2.67 ^{a}	3.02 ^{a}	4.12 ^{a}
	p-value	< 0.0001	< 0.0001	< 0.0001
	Diet			
	Diet 1	3.33	3.74	4.53
	Diet 2	3.58	3.92	4.89
	p-value	0.5359	0.5577	0.1310
	SEM	0.12	0.13	0.12
	Over all mean	3.77	3.86	4.82

a,b and c = means followed by different superscript letters within rows are significantly different(***=P<0.01; **=P<0.05); LES = long eared Somali

5. CONCLUSIONS AND RECOMMENDATIONS

Generally, there was no interactions effect on the main factors (breed * diet) on feed intake, nutrient intake, digestibility of nutrients, growth and fattening, carcass characteristics and meat quality on indigenous LES, Agew and Gumuz goat.

LES, Agew and Gumuz goat showed similar daily dry matter and nutrient intake and there was no effect of breed on those parameters. On the other hand, type of diet had effect on most intakes except total dry matter intake and in vitro organic matter intake.

Nutrient intake of goat breed on digestibility of nutrients was minimal. Long eared Somali had significantly higher neutral detergent fiber digestion than Agew and Gumuz goat. The other digestibility coefficients were indifferent among indigenous goat breeds. Natural pasture hay with concentrate had higher digestibility of crude protein while finger millet straw with concentrate had higher digestibility of neutral detergent fiber.

There was no difference between breeds and roughage feed types on initial body weight and final body weight gain. Without interaction effect; both main factors showed significant differences in average daily gain, total body weight gain and feed conversion efficiency. On all parameters Gumuz goat breed had lower performance than LES and Agew breeds. Similarly natural pasture hay fed goats were performed well in weight gain than finger millet straw. Type of feed and its nutritive value has a great contribution than breed type for the difference of carcass characteristics.

Chemical composition of Ethiopian goats meat is similar with other African goat breed however, it had higher dry matter, ash, protein, fat and carbohydrate composition than some breeds in Africa. Neither the breed nor the diet type had effect on chemical composition of meat from indigenous goat breeds. Unlike the chemical composition, expertise visual evaluation of meat color proved that meat color is inherent from genetic and diet had no effect on meat color. Based on the result long eared Somali goat breed had lighter color and Agew breed had darker color than others. Agew and Gumuz goat breeds meat color at 5 days after slaughter was almost similar to long eared Somali goat meat at 10 days after slaughter

Therefore, based on the present findings and over all concluding remarks, the following recommendation is made for further use.

- There should be regulation of feed processing companies and periodic examination of their out puts for the nutrient composition of their ration. Developing standards for such products also important.
- Crop residues should be treated by different methods in mixed crop livestock production system since the chemical composition and response of natural pasture hay was positive in terms of body weight gain
- In Ethiopian the productivity of indigenous goats for meat is mainly dependent on environment including feeding system and breed has no that much effect therefore, efforts on indigenous goat improvement should target in improving the management system.
- Fattening projects in this area should be at opening pasture than indoor feeding and Ethiopian indigenous goat breeds had problems for feedlot fattening
- This study confirmed positively difference of Long eared Somali breed on meat color therefore it is wise to use meats from this breed for export market
- Modernizing the infrastructure and shortening the delivery time to final consumers would create entry of Agew and Gumuz goat breeds of Ethiopia. Moreover in order to raise export earnings searching other market destinations that have low consideration to meat color is central.
- Assessing the post birth kid management, molecular identification of responsible gene for meat color trait and detail research on chemical composition and enzymatic reactions meat should get due attention.

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