EFFECT OF *MI'AWA* MINERAL SOIL SUPPLEMENTATION ON FEED INTAKE, WEIGHT CHANGE AND CARCASS CHARACTERISTICS OF BLACK HEAD SOMALI SHEEP

MSc THESIS

SEAD TAHA MUSA

HAWASSA UNIVERSITY, HAWASSA, ETHIOPIA

MARCH, 2020

EFFECT OF *MI'AWA* MINERAL SOIL SUPPLEMENTATION ON FEED INTAKE, WEIGHT CHANGE AND CARCASS CHARACTERISTICS OF BLACK HEAD SOMALI SHEEP

SEAD TAHA MUSA

ADVISOR: PROF. ADUGNA TOLERA (PhD)

A THESIS SUBMITTED TO SCHOOL OF ANIMAL AND RANGE SCIENCES

HAWASSA UNIVERSITY

COLLEGE OF AGRICULTURE

IN PARTIAL FULFILLMENT OF THE REQUIREMENTS FOR THE DEGREE OF THE MASTER OF SCIENCE IN ANIMAL AND RANGE SCIENCES

(SPECIALIZATION: ANIMAL PRODUCTION)

MARCH, 2020

ACKNOWLEDGMENT

Above all my greatest thank goes to ALLAH who helped me in all directions and time to be strong and patient to handle and finalize this piece of work even in terrible situations I faced during my study period.

First, I would like to express my sincere gratitude and heartfelt thanks to my Advisor Prof. Adugna Tolera for his endless help in correcting, commenting and encouraging me to accomplish this work starting from of proposal development to this time. I also like to appreciate his patience in following up this thesis work from the very beginning to the end.

Special thanks to Mr. Hussein Abdullahi for helping me in vaccination of experimental animals. Thanks and appreciations also go to Mr. Umar Haji for house cleaning, care and feeding of the sheep during the experimental period. I wish also to express my sincere and heartfelt gratitude to my wife w/o Mominati Abduselam for her understanding, encouragement and endurance at all stages of my studies. Greatest debt goes to all my family members for their devotion, unlimited material and moral support, affection and encouraging me to handle and overcome trouble situations in my life.

Lastly, but not the least the support of my friends and relatives, Awal Ahmed, Awal zeyni and Seifu Adem are highly appreciated and acknowledged.

DEDICATION

I dedicate this script to my uncle Aliyi Musa who passed away without seeing my achievements.

STATEMENT OF THE AUTHOR

By my signature below, I declare and affirm that this Thesis is my own work. I have followed all ethical and technical principle of scholarship in the preparation, data collection, data analysis and compilation of this Thesis. Any scholarly matter that is included in the Thesis has been given recognition through citation.

This Thesis is submitted in partial fulfillment of the requirements for an MSc degree at the Hawassa University. The Thesis is deposited in the Hawassa University Library and is made available to borrowers under the rules of the Library. I solemnly declare that this Thesis has not been submitted to any other institution anywhere for the awards of any academic degree, diploma or certificate.

Brief quotations from this Thesis may be made without special permission provided that accurate and complete acknowledgement of the source is made. Requests for permission for extended quotations from or reproduction of this Thesis in whole or in part may be granted by the Head of the School or Department when in his or her judgment the proposed use of the materials is in the interest of scholarship. In all other instances, however, permission must be obtained from the author of the Thesis.

Name: Sead Taha Signature: _______________

Date: ________________

School: Animal and Range Science

LIST OF ABBREVIATION AND ACRONOMYS

ADF	Acid Detergent Fiber
ADG	Average Daily Gain
ADL	Acid Detergent Lignin
ADP	Adenine Di Phosphate
AFRC	Australian Feed Research Council
ANOVA	Analysis of variance
AOAC	Association of Official Analytical Chemists
ATP	Adenine Tri phosphate
BHS	Black Head Somali
CSA	Central Statistical Agency
DM	Dry Matter
DP	Dressing Percentage
EBW	Empty Body Weight
EO	Edible Offal
FAO	Food and Agricultural Organization
FCE	Feed Conversion Efficiency

GIT	Gastro Intestinal Tract
GLM	General Linear Model
HCW	Hot Carcass Weight
IBW	Initial Body Weight
LHWPDO	Lega Hidha Woreda Pastoral Development Office
NDF	Neutral Detergent Fiber
NEO	Non Edible Offal
NRC	National Research Council, USA
PADS	Pastoral Area Development Study
Ppm	Parts per million
RCBD	Randomized Complete Bock Design
REMA	Rib Eye Muscle Area
SW	Slaughter Weight
T	Treatment
TEO	Total Edible Offal
TNEO	Total Non Edible Offal

TABLE OF CONTENTS

Contents **Page**

LIST OF TABLES

LIST OF TABLES IN APPENDIXS

ABSTRACT

A study was conducted to determine mineral composition of Mi'awa mineral soil and evaluate the effect Mi'awa supplementation on feed intake, weight gain and carcass characteristics of Black Head Somali Sheep, using 25 yearling Black head Somali sheep with initial body weight of 17.98 ±1.82 kg (mean ±SD). Sheep were blocked in to five blocks based on their initial weight and assigned to one of the five treatments randomly making 5 animals per treatment. Experimental diet consisting of natural pasture hay ad libitum, 300g concentrate (65 % of wheat bran, and 35 % of linseed cake) and Mi'awa mineral soil supplemented at level of 0%, 2%, 4%, 6% and 8% of concentrate feed representing treatments 1, 2, 3, 4 and 5, respectively. Feeding trial was continued for 90 days and data on feed intake and body weight change were collected. At the end of the feeding trial, 3 sheep from each treatment were slaughtered for determination of carcass characteristics. The mineral contents of Mi'awa mineral soil were found to be 2.68% sodium, 1.3% calcium, 0.03% potassium, 0.001% phosphorus, 0.14% magnesium, 156.2 ppm Iron, 2.84 ppm copper, 0.57 ppm zinc and 60.74 ppm manganes. The total DM intake of the experimental sheep was highest (P < 0.05) for those supplemented with 8% Mi'awa (T5) whereas the lowest was in the unsupplemented group (T1). The sheep supplemented with 6% and 8% Mi'awa (T4 and T5) had higher (P<0.05) average daily weight gain than animals in T1. Sheep supplemented with 8% Mi'awa mineral soil (T5) had significantly (P<0.05) higher feed conversion efficiency as compared to other treatment in order of T1=T2<T3<T4<T5. Slaughter weight, empty body weight and HCW of sheep in treatment T5 was significantly higher (P < 0.05) than sheep in T1. Lower slaughter weight, empty body weight and HCW were observed in sheep which were not supplemented with Mi'awa (T1). Higher weights of loin, rib with muscle and hind-leg (P < 0.05) were observed for sheep in T4 and T5. The study showed that Mi'awa has a good potential as a mineral supplement, particularly in smallholder livestock production systems where access to commercial mineral supplement is not easy.

Key words: *Black Head Somali sheep, Body weight change, carcass, feed intake, Mi'awa mineral soil*

1. INTRODUCTION

Mineral nutrients are simple-structured, inorganic substances that constitute a small proportion of an animal's diet. They are vital for many metabolic processes that ensure the animals are healthy and productive (Soetan *et al.*, 2010). Minerals play their role through activation of enzymes; they functions as cofactors, as components of molecular structures, body's acid-base and electrolyte balance. As part of the diet, minerals are so potent, their inadequacy hinders the utilization of other nutrients and thereby the productivity of the animals (Szefer and Nriagu, 2007).

At least 22 minerals are essential in the metabolism of livestock, but numerically less than fifteen are considered in the dietary supplements (Tisch, 2006). The essential macro-elements are: calcium (Ca), phosphorus (P), potassium (K), magnesium (Mg), sodium (Na), chlorine (Cl) and sulphur (S), while the essential trace elements include iron (Fe), iodine (I), zinc (Zn), copper (Cu), manganese (Mn), cobalt (Co), and selenium (Se) (Underwood and Suttle 1999). Animals obtain minerals through dietary sources, which comprise of natural and commercial feeds, drinking-water and mineral supplements (Shamat *et al.*, 2009).

Consumption of natural licks is common among domestic animals under natural circumstances and as a substitute to commercial mineral licks it believes that animals obtain potential nutritional benefits from them. Natural licks can be an alternative source of minerals where commercial mineral licks are not available (Ochieng Ombak, 2015).

Previous studies (Hishashi *et al.*, 2006; and Ulli, 2010) showed that animals travel long distances away from their natural habitats to consume the naturally occurring minerals and this demonstrates how useful the licks could be in animal's health. It is believed that natural licks are major sources of sodium for herbivores because tropical plants do not accumulate adequate levels for the animals to depend on them, due to poor aerosol deposition especially in areas far from the ocean (Bravo *et al.*, 2010; and Dudley *et al.*, 2012).

Mineral in forages are dependent upon the interaction of a number of factors including soil, plant species, stage of maturity, yield, pasture management and climate (Poland *et al*., 2001). Minerals derived from feedstuffs are sometimes insufficient to meet animal requirements, these later exhibiting subclinical symptoms as a result (Serra *et al*., 1996). In the absence of mineral supplements, forages should then contain sufficient macro- and micro-elements to cover the requirements of goats and sheep.

Deficiency of minerals in sheep under grazing and grazing plus concentrate supplementation has been reported (Samanta and Samanta, 2002). During the dry season when the available forage is low in quantity, quality and in mineral contents, what usually occurs is loss of live weight, low birth weights, lowered resistance to disease and reduced animal performance. Supplementation with multi-nutrient blocks and local mineral soils such as Bole and Megadua in some parts of Ethiopia may provide an adequate or even excess amount of most of the essential minerals except phosphorus (Tolera and Said, 1994). Studies by Sisay *et al.* (2007) showed that consumption of natural licks improved total weight gain in sheep, which indicates a positive performance in livestock production. Natural licks can be an intervention measure to mitigate mineral deficiencies in the diets and hence maintain healthy animals which translates into improvement of food security (Bishaw and Melaku, 2008).

In eastern lowlands of Ethiopia, some camel owners use various types of indigenous minerals such as rock salt, mineral soils, and aye or mineral water as mineral supplement for sheep and camels (Temesgen et al 2012). Farmers in many parts of Ethiopia use local mineral soils as mineral supplements. Supplementation of *Bole* to Arsi sheep resulted in higher gains than unsupplemented sheep and ranked similar to sheep supplemented with a commercial mineral lick. The licks were found to be good in their sodium and copper compositions. Encouraging farmers to regularly feed local mineral licks such as *Bole* and *megado,* traditionally used in many parts of the country, is beneficial (Alemu, 2008).

The main sources of mineral for animals in the Lega Hidha district are salty water (*Hora*), salt and natural lick (*Mi'awa* and *Buranbura*). Pastoralists in this district commonly supplement *Mi'awa* mineral soil to their animals since it is relatively free and easily obtainable as compared to commercially produced mineral supplements. However mineral composition of *Mi'awa* mineral soil is not known and supplementation value of *Mi'awa* mineral soils has not been evaluated in the study area. Therefore, the objectives of this study were:

- To determine the mineral composition of *Mi'awa* mineral soil
- To evaluate the effect of supplementation of *Mi'awa* mineral soil on feed intake, weight gain and carcass characteristics of Black Head Somali Sheep

2. LITERATURE REVIEW

2.1. Characteristics of Black Head Somali Sheep

The Blackhead Somali sheep is indigenous to the Ogaden area of the Somali Region. The breed is commonly known as Blackhead Somali sheep and by other various names such as Blackhead Persian. It is widely distributed within 42–48 ºE longitudes and 3–9 ºN latitudes. The Black Head Somali is distinguished by the black color of the head. The body is predominantly white but other colors may be observed. The hair is short, stiff and shiny. Both rams and ewes are hornless, though males can sometimes have rudimentary horns. The forehead is convex and the nose tends to be of the Roman type. The ears are short and pointed with an outward-forward inclination. Most animals have a well-developed dewlap which sometimes extends from the chin to the chest with considerable fat deposits. The tail is a fat rump type with a very distinct fat depot having a thin tip sticking straight backward and sometimes hanging down. The adult weight of Blackhead Somali ewes is between 30 and 35 kg. The Blackhead Somali sheep are also hardy and well adapted to the dry, drought-prone environments of the Somali and southern tip of Oromia regions (Kasahun and Solomon, 2008).

2.2. Live stock Feed Resources in Ethiopia

The major livestock feed resources available in Ethiopia are natural pasture grazing, crop residues and aftermath grazing, improved pasture, fodder trees and browse, forage crops and agro-industrial byproducts (Alemayehu, 2005; Adugna, 2007; Yayneshet, 2010). Most of these feed resources are generally low in forage quality and quantity and not evenly distributed throughout the year. Natural pastures from river and roadsides and weed from crop production are also used as feed sources in the country (Ahmed *et al*., 2010). Reports on the major livestock feed resource base in Ethiopia indicated that grazing on natural grasslands contributes 61.92%, crop residues 27.01%, hay 6.55%,improved forage 0.52%, agro-industrial by-products 0.78%, and other type of feed 3.6% of the total supply (CSA, 2010).

2.2.1. Natural pastures and browses

Sheep more than any other class of livestock are dependent on natural pasture for maintenance and production (Clan and Rose, 2005). Sheep consume low quality feeds, particularly fibrous vegetation, which cannot be consumed by human and non-ruminant animals. Sheep can feed very short grass and grass on steep slope unsuitable for cattle and other large animals. When sufficient quantity of forage is available, sheep can meet their nutrient requirement from forage alone with supplemental source of salt and minerals. However the availability of natural pasture does not support growth especially during the long dry season due to their poor quality and less digestibility. Pasture growth is not disturbed throughout the year and the performance of animal grazing on poor pasture of low quality roughages resulting in low energy intake (FAO, 1986).

2.2.2. Hay

Hay is forage harvested during the growing period and preserved by drying. The aim of hay making is to reduce the moisture content of green crops to 15-20% to inhibit the action of plant and microbial enzymes. Hay is primary source of nutrients for small ruminants during the winter or non-grazing season (Susan, 2003). Hay varies extremely in quality and the only way to know the nutritional content is analyzing hay by forage testing laboratory. Hay is the standard dry season feed of animals when condition of pasture requires supplemental feeding

(Ensminger et al., 1990). Grass hay is lower in protein, calcium and vitamin than legumes; hence for best result, protein and mineral need to be supplemented. The highest qualities of grass are reached during stem elongation and quality decreased after heading (Ibrahim, 1998).

2.2.3. Agro- industrial by–products

Most tropical forages do not supply energy beyond maintenance requirement of animals (Solomon *et al.,* 2010). Improved animal performances thus depend on the supply of good quality feed to animals kept extensively under traditional management. Hence to obtain sufficient energy for rapid growth and fattening, supplemental concentrates must be provided to animals. Among the existing agro-industrial by products noug seed cake, sesame seed cake, linseed cake, peanut seed cake and wheat bran are available for potential utilization as animal feed in some localities. Several oil seed cakes are produced from extraction of vegetable oils for human consumption (Ensminger, 2002). Feed source of agro-industrial products include the easily fermentable energy, protein supplement and by-products of cereal milling which are source of energy and protein.

2.2.4. Crop residues

Crop residues (cereal straw, stovers and grain legume haulms) make the bulk of the feed supply for ruminants in tropical farming systems. Crop residues are the plant materials remaining after food crops had been harvested. Straws from cereals such as *tef*, barley and wheat and pulse crops are stored after threshing and serve as a useful feed to animals in Ethiopian highlands (Solomon, 2004). In most intensively cultivated central highland, crop residues and aftermath grazing account for about 60-70% of the basal diet (Seyoum *et al*., 2001).

2.3. Mineral Requirement of Ruminants

Energy and protein are primary importance to any animals, but optimal animal performance is possible only if there is an adequate supply of minerals and vitamins (McDowell, 1986). The minerals play important role in augmenting animal production and health, correcting deficiencies and preventing diseases through activation of immune system of the body. Macro element are utilized either structurally (Ca, P, S) or in the maintenance of acid-base balance (Na, K, Cl) as well as functioning in the energy, nerve impulse transmission and enzyme activation (P, Ca, Mg, K, Cl) (Suttle, 1991).

The micro mineral elements Cu, Zn, Mo, Mn, and Se mainly contribute to the structure and function of enzyme systems, while Fe is an integral component of hemoglobin and related compounds, I of the iodthyronines and Co of cynocobalamin. Micro minerals are those for which essentiality has been demonstrated relatively recently via body growth responses using highly purified diets and isolated environments (Little, 1984). Minerals in adequate quantity and proportion need to be supplemented in addition to those available from different feeds. Acute mineral deficiencies show characteristic syndromes but the marginal deficiencies or excesses express non-specifically in the form of reduced growth, production, viability and fertility (Underwood, 1981).

As plants mature, the contents of most minerals decline (McDowell *et al*, 1983). Gatenby (1986) also reported that as the dry season precedes the nutritive value of some vegetation declines. Barrows (1977) reported that growth rate and milk production influence mineral needs and adequate levels of mineral intake will result in to high levels of productivity.

Further the author emphasized that mineral consumption tended to decline with increasing age of animals.

2.3.1 Macro Minerals

There are seven major minerals Calcium (Ca,), phosphorus (P), magnesium (Mg), potassium (K), sodium (Na), and sulfur (S).Each of these minerals has been found to be deficient for grazing livestock under specific conditions, with the exception of Cl (McDonald et al., 2010).

Calcium

Calcium is the most abundant mineral in the body, 98% of Ca is found in the bones and teeth (Rick, 2007). Small amount of Ca may be absorbed from the rumen but the major absorptive site is small intestine (Yano et al., 1991). Control of absorption is achieved by two hormones, parathyroid hormone (PTH) and physiologically active form of vitamin D3 (Brown, 1991). The basic function of Ca is therefore to provide a strong frame work for supporting and protecting delicate organs, jointed to allow movement and malleable to allow growth (Underwood, 1981). Some of the non-skeletal functions of Ca are blood clotting, membrane permeability, muscle contraction, nerve functions, and cardiac regulation and enzyme activations (Rick, 2007). Weaver and Heaney (1999) reported that Ca binds to many cellular proteins, resulting in their activation. Calcium deprivation occurs in sheep fed largely on grain diets, designed as drought rations when little or no grazing is available (Larsen *et al*., 1986). Nutritional Ca deficiency is associated with weakness, poor animal performance that has swollen joints, lameness, weak bones, and a propensity for broken bones (Puls, 1994). Hypocalcaemia usually appears at the beginning of lactation, normally after giving birth to the first litter, and it may occur a few days before or after delivery, when the Ca requirement is at its highest (Satish Kumar, 2003).

Phosphorus

Phosphorus is the second most abundant mineral in the animal body and 80% is found in bone and teeth (Cohen 1980). The 20 % of phosphorus is widely distributed in the fluids and soft tissue of the body, where it serves as a range of essential functions. P is a component of deoxy- and ribonucleic acids, which are essential in cell growth and differentiation; as phospholipids it contributes to cell-membrane fluidity and integrity; as phosphate, it helps to maintain osmotic and acid-base balance; and it plays a vital role in a host of metabolic functions, protein synthesis and the activity of sodium/potassium (Na+/K+) pump (Underwood and Suttle, 1999). P is further involved in the control of appetite, in a manner not yet fully understood, and in the efficiency of feed utilization (Ternouth, 1990).

Sign of P deficiency are not easily recognizable, except in severe cases when fragile bones, general weakness, weight loss, emaciation, stiffness, reduced milk production, and chewing of wood, rocks, bones and other objects may be noticed (McDowell and Valle, 2000). Reduction in dry matter intake from 40 to 41% and low dry matter digestibility coefficient was reported in lambs fed low P diets (Ternouth, 1990). The most devastating economic result of P deficiency is reproductive failure. Reduced fertility and reduced or delayed conceptions are the prime signs of phosphorus deficiency which are reported to be overcome with proper phosphorus supplementation (Rojas and McDowell, 1997).

According to Underwood (1981), P is known to be the most deficient element in the soils all over the world. In a review made by McDowell et al. (1983), P deficiency was reported in 46 tropical countries of Latin America, South-East Asia and Africa. Phosphorus deficiency is more prevalent for tropical than for temperate grazing regions because the soils are often low in phosphate, the use of fertilizers is often uneconomic, and the forages mature and senesce more rapidly than temperate species (Norton, 1982). Little (1984) reported that forages and local mineral supplements consumed by livestock have low in Ethiopia.

Potassium

Potassium is crucial for the maintenance of osmotic and fluid balance in the body (Underwood, 1981). The K content of plants is high compared with the K requirements of sheep and goat. Therefore K deficiency is rare but K concentration decline in dry swards, due to a combination of ageing and leaching effects (Preston and Linser, 1985). Potassium absorption occurs principally in the rumen. All soft tissues are much richer in K than in Na, making K the third most abundant mineral in the body (Ward, 1966).

Potassium deficiencies, in ruminant results in non-specific sign, such as slow growth, reduced feed and water intake, lowered feed efficiency, muscular weakness and stiffness, (McDowell and Valle, 2000). Preston and Linser, (1985) reported that the K supplementation of finishing diets for beef is now a common practice to improve gains and mortality, thus the inclusion of K in supplements fed during drought may be beneficial. McDowell (1997) recommended 0.5-1.0 % potassium (on dry basis) as a requirement for Sheep.

Magnesium

Magnesium has a great role in carbohydrate and fat metabolism and it acts as catalyst in over 300 enzyme systems. The practical importance of Mg is its relationship to the serious metabolic disorder of grass tetany (hypomagnesaemia). Grass tetany is a complex ruminant disorder that is affected by forage species and mineral composition, soil properties, fertilizer practices, season of the year, temperature, animal species, breed and age (McDowell, 1992).

Clinical signs of hypomagnesaemia in ruminants including reduced appetite, increased excitability, profuse salvation and convulsion. When sheep are fed semi purified diets grossly deficient in Mg, there is a marked loss of appetite within few days due to rumen dysfunction (Ammerman *et al*, 1971). Some of the reasons for fewer reports of grass tetany in tropical regions include the prevalence of the condition during cooler temperature and for many tropical countries, the generally low productivity of pasture and of herds and lack of fertilization of pasture with nitrogen and potassium (McDowell and Valle, 2000). Minimum needs of sheep and cattle for growth can generally be met by pastures or rations containing 0.10%.

Sodium

Sodium is usually considered occur with chlorine (Cl) as NaCl salt and it functions in amino acid and glucose transport and muscle contractions (Rick, 2007). Sodium and Chloride maintain osmotic pressure, regulate acid- base balance and control water metabolism in the body (Underwood and Suttle, 1999). Sodium deficiency occurs in tropical Africa and the inland parts of Australia (Underwood, 1981). Kabaija and Little (1988) and Tolera and Said (1994) reported that most forages and crop residues in the highlands of Ethiopia are deficient in sodium. White et al. (1995) reported that Na deficiency is most likely to occur in sheep when salt losses are high as a result of heat stress or lactation.

The initial sign of Na deficiency that is craving for salt is demonstrated by the avid licking of wood, soil, and sweat from other animals, and drinking water. Animal deprived of salt may be so voracious that they often injure each other in attempting to reach salt (McDowell, 1992). A prolonged deficiency causes loss of appetite, decreased growth, unthrifty appearance, reduced milk production and loss of weight. More pronounced sign of Na deficiency include shivering, incoordination, weakness and cardiac arrhythmia, which can lead to death (McDowell and Valle, 2000). Pasture in the tropics is deficient in Na and this could be supplemented with water containing high NaCl (Carles, 1983). According to Underwood (1981), supplementation of Na using salt licks is the most common method as ruminants ingest the right quantity to satisfy their own requirements. The presence of salt in a feed can contribute to the palatability of that feed (Grovum and Chapman, 1988).

2.3.2. Micro Minerals

There are 16 trace minerals recognized as being essential for farm livestock (Mertz, 1987), only eight are likely to be of practical significance, deficiencies of the other occur only rarely, if ever. Those of most practical significance are Cu, Zn, Co, Mn, I, Fe, Se and Mo. The required daily amount of trace mineral consumed in the diet must be sufficient to support all present physiologic states of a given animal and account for availability of the mineral source(s) in the diet.

Copper

Copper is involved in hemoglobin formation, enzyme systems, nervous and immune system function (Rick, 2007). The availability of Cu in the diet depends on the concentration of other minerals. In particular, high levels of molybdenum and sulphate decrease the availability of copper (McDowell et al, 1983). McDowell (1992) stated that intakes of Zn, Fe, Mo and S would generally affect Cu utilization. Copper deficiency in ruminants occurs mainly under grazing conditions (Ammerman *et al*., 1975). Copper deficiency can be induced by a lack of Cu by high intakes of Mo and S or by high intakes of Fe.

Clinical signs of Cu deficiency are manifested as loss of hair color, coarse hair that has hooked end tips, abortions, stillbirths, anemia, poor appetite, reduced growth rates, decreased fed conversion, weight loss, decreased milk production and sudden death (Graham, 1991; Puls, 1994). The consumption of soil lick in Ethiopia has a great economic importance in livestock production since forages and local mineral supplements consumed by livestock are low in Cu (Kabaija and Little, 1987). According to Kabaija and Little (1988) and Tolera and Said (1994) most forages and crops in the rift valleys of Ethiopia are deficient or marginal in Cu.

Zinc

Zinc is important in stress management, immune response, enzyme systems and protein synthesis (Rick, 2007). Underwood and Suttle (1999) reported that Zn is second to Cu in the list of likely micro mineral deficiencies. Early effects of Zn deficiency include reduced feed intake, growth rate and feed efficiency, followed by skin disorders (McDowell *et al*, 1983). Tropical forage was slightly higher in mean Zn content than temperate ones (Minson, 1981). Faye et al (1987) reported the presence of Zn deficiency in Ethiopian forages and hence recommended the supply of essential minerals to ruminants.

In studying the effects of Zn on reproductive performance of animals, Egan (1975) from South Australia, reported better reproductive responses of grazing Dorset Horn ewes to supplemental Zn. Zinc supplemented ewes consumed about 15% more feeds than the control, had a higher fertility rate, were more prolific (89% vs. 49%) and produced heavier lambs at birth (4 vs. 2.9 kg) and at weaning (17 vs. 14.2 kg).

Manganese

Manganese is needed in the body for normal bone structure, reproduction and the normal functioning of the central nervous system (McDowell, 1997). Moreover, Mg is a metal factor for many enzymes involved in carbohydrate metabolism (Underwood, 1981).Manganese deficiency is manifested clinically as impaired growth, skeletal abnormalities and ataxia of newborn and will depress reproductive functions (Rick, 2007). According to Underwood and Suttle (1999) the growth impairment results from both in appetence, that is, reduced feed consumption and decreased deficiency of feed use. Manganese requirements are substantially lower for growth than for optimal reproductive performance and they are increased by high intake of Ca and P (McDowell *et al*, 1983). According to NRC (1985) mineral requirement table, the Mn requirement of ruminants was reported to be 40 ppm. Moreover, McDowell (1997) emphasized that the minimum dietary Mn requirement of ruminants ranges between 20 to 40 ppm.

Iron

Iron is involved in cellular respiration and oxygen transport through hemoglobin (McDowell, 1997). Approximately 60 % of body Fe is present as hemoglobin that can antagonize copper and zinc availability (Rick, 2007). Fe is essential for normal cellular function of all cell types. Iron is naturally well supplied by forages, and deficiencies of the element in grazing livestock are unlikely to occur normally. Fe deficiency is associated with reduced growth, poor immune function, weakness and anemia (Graham, 1991; Puls, 1994). Parasitic infestation involving severe blood loss or infections including disturbances in metabolism can produce a secondary Fe deficiency anemia (Underwood, 1981).

Table 1.Macro and micro mineral requirements of sheep/day

Macro mineral (%)	Requirements	
Calcium	0.2-0.82	
phosphorus	0.16-0.38	
potassium	0.5-0.8	
sodium	0.09-0.18	
magnesium	0.12-0.18	
Sulfur	0.14-0.26	
Micro mineral (ppm)	Requirement	Maximum tolerable level
Iodine	0.10-0.80	50
Iron	30-50	500
Copper	7-11	25
Molybdenum	0.5	10
Cobalt	0.1-0.2	10
Manganese	20-40	1,000
Zinc	20-33	750

Source: NRC (1985).

2.4 .Sources of Minerals for Ruminants

Animals obtain minerals through dietary sources, that comprise of natural and commercial feeds, drinking-water and mineral supplements. Mineral deficiencies and excesses adversely affect animal performance. However, sub-optimal mineral deficiency and imbalances are more serious in reducing performance than manifested mineral deficiency that can be detected and rectified (Shamat *et al.*, 2009). Similarly a study conducted in the vast area of Somali region confirmed, minerals for animal supplementation were mainly obtained from natural soil, salty shrub plants and salty water (Sisay *et al.*, 2007).

2.4.1. Grazing and Browsing of forages

Feeds, mineral soil and water are the major mineral sources for grazing animals (Miles and McDowell, 1983). Grazing livestock in the tropics most often do not receive mineral supplementation, except for common salt and must depend almost solely upon forages for their mineral requirements (McDowell *et al*, 1984). Among the feeds that ruminant consume, forage provides bulk of the elements particularly in the tropical countries (McDowell, 1997). The concentration of minerals in the forages are influenced by several factors such as soil type, soil pH, moisture content, plant species, plant maturity, season, vegetative part, pasture management, and locality (Khan, *et al*, 2006; McDowell *et al.*, 1993).

Mineral concentration in forages varies among different forage type and plant species. Except for sodium, manganese and zinc, legumes have higher content of minerals than grasses (Mayland and Wilkinson, 1996). Green plants are excellent sources of Mg, attributed to the presence of magnesium in the chlorophyll moiety (Wilkinson, *et. al.*, 1990). In the arid and semi-arid lands, evergreen browse plants are thus expected to be rich sources of magnesium (Mg). Grasses generally have high concentration of manganese than legumes (Underwood, 1977). Many tropical legumes have low content of sodium, with most of them having less than 4g Na /kg of dry matter (Minson, 1990).

2.4.2. Minerals in drinking-water

Most minerals, which are essential as dietary nutrients for livestock are found in water (Buttery *et al*., 2005). The principle anions dissolved in drinking water include chlorides, sulphates, nitrates while the cations are Na, Ca and Mg (Harris and Van Horn, 2003). Drinking water is not normally considered a major source of minerals to livestock (Underwood and Suttle, 1999). However, some deep aquifers and salty water sources contain exceptionally high levels of sulphur and sodium that can be a valuable supplementary source in areas where the diet is low in such minerals (Smart *et al*, 1986; Smith and Middleton, 1978a).

2.4.3. Mineral supplements

Mineral supplementation provides a safety margin against potential deficiency (Beede, 1991). Mineral supplements can be administered to animals via drinking water, mineral licks, salt mixtures, oral drenches, rumen boluses and regular injections (Underwood, 1981; McDowell *et al.*, 1993).

2.4.3.1. Soil and natural mineral licks

Ingestion of soil and natural salt licks can supplement the intake of some minerals (Mayland and Wilkinson, 1996).Ruminants on pasture may inadvertently consume large quantities of soil as a natural of grazing. The eating of soil by domestic animals was observed on soils supposed to have a high mineral content (Gatenby, 1986). In Ethiopia various type of indigenous minerals such as rock salt, mineral soil and mineral water used by pastoral nomads for cattle and camel feeding (Temesgen, 2012, Kabaija, 1989). Mohammed *et al*. (1989) also reported the importance of providing mineral soils in Arsi and the southeast Borena lowland.

Moreover, in some parts of Ethiopia, supplementation with mineral waters and mineral soils are generally the common indigenous source of mineral supplements for livestock and may provide an adequate or even excess amount of essential minerals to animals (Tolera and Said 1994, Sisay *et al* 2007, Temesgen, 2012).

Bole (an Ethiopian name for soil lick) is one of widely spread resource, cheap and well licked by animals once they accustomed to it. *Makaduwa* is also a type of lick soil used in Wolayta Zone, Southern part of Ethiopia (Muluken, 2015). Sisay *et al.;* (2007) also reported that natural mineral soil such as Arabi soil, Jair soil and Hermokale used as mineral supplement to animal in Jijiga and Shinile districts, Somali region and Bole soil used mineral supplement around Zeway area in Oromiya region.

In Ethiopia, chemical analysis of natural licks obtained from seven different natural licks deposited in different areas. Based on analytical data, the researcher concluded that none of materials are able to supply adequate amount of micro minerals like copper, manganese and zinc. But all samples were found to be high in Iron (Kabaija and Little, 1987). Mohammed et al. (1989) indicated a similar trend on the chemical composition of samples obtained from four natural licks area in Ethiopia. From analytical data, Mohammed et al. (1989) conclude that the natural lick cannot sufficiently supplement macro elements with the exception of Na in a sample obtained from Lake Shala. The micro elements zinc, manganese and iron were found within the acceptable range for sheep.

Table 2.Macro mineral compositions of soils licks from different sites of Ethiopia

Soil types	Ca	P	Mg	K	Na	Reported by
Jair (ppm)	39.42	2.06	16.20	5.07	191.00	
Hermokale (ppm)	52.20	8.00	6.91	5.26	179.00	Sisay (2007)
Arabi (ppm)	67.86	6.30	8.42	6.31	60.32	
Bole (ppm)	4.10	2.54	0.98	3.35	84.73	
Bole (%)	0.43	0.02	0.02	0.31	3.01	
Mekaduw (%)	0.51	0.04	0.16	0.40	4.86	Muluken (2015)
Bole (%)	0.62	0.02	0.01	0.5	5.62	Belete (2016)
Addua(%)	0.46	0.01	0.19	0.62	2.44	Temesgen (2018)

Table 3.Micro mineral compositions (ppm) of soils licks from different sites of Ethiopia

Soil types	Fe	Cu	Mn	Zn	Reported by
Jair (ppm)	2.42	2.22	2.36	0.36	
Hermokale (ppm)	1.78	1.50	4.58	0.64	
Arabi (ppm)	0.78	0.66	2.96	0.50	Sisay (2007)
Bole (ppm)	1.00	0.28	0.90	0.50	
Bole (ppm)	0.43	0.02	0.02	0.31	
Mekaduw (ppm)	0.51	0.04	0.16	0.40	Muluken (2015)
Bole (ppm)	63.97	1.01	71	4.73	Belete (2016)
Addua(ppm)	5717	2.22	244.2	26.99	Temesgen(2018)

2.4.3.2. Commercial mineral supplements

The commercial mineral supplements are made from such compounds as salts, oxides, carbonates and phosphates depending on availability, solubility, price and freedom from toxicity (Underwood and Suttle, 1999). For mineral supplements to be beneficial they should be formulated to correct mineral deficiencies of animals in specific regions (Khan *et al.*, 2008). A variety of salt and mineral supplements specifically formulated for sheep are commercially available. These supplements range from trace mineralized salt (TMS) fortified with selenium to complete mineral mixes containing all of the macro and micro minerals required by sheep. Minerals can also be supplied as a commercial mineral mix that is specifically designed to meet the mineral requirements of sheep based on an analysis of homegrown feeds. When the nutrient content of homegrown feeds become poor in minerals, it is advisable to supply the commercial mineral mix for animals. A commercial mineral mix contains balanced proportion of macro and micro minerals and vitamins like A and D (Susan, 2013).

2.5. Effect of mineral supplementation on performance of sheep

Sisay *et al*. (2007) and Muluken *et al.* (2015) reported that higher body weight gain and FCE for mineral supplemented treatments compared to control group. Mineral supplementation significantly enhanced growth rate of sheep. NRC (1985) showed that inadequate mineral intake in the diet of sheep result in decreased feed consumption and decreased efficiency of nutrient utilization, wool production and reproduction rate and a very severe deficiency may cause death whereas adequate mineral supplementation can enhance feed consumption, feed conversion efficiency and average daily gain (ADG) of the animals. Quality feed and mineral inclusion in animal diet affects weight of hot carcass and DP, which could be increased with increasing amount of concentrate and mineral supplementation in the diets of small ruminants (Hagos, 2007).

The higher dressing percentage on empty body weight basis in sheep offered mineral supplements compare to non supplemented groups indicates that mineral supplementation resulted in higher final body weight and hot carcass weight (Belete, 2016). Fazlallah and Shahab (2015) reported that higher average hot carcass yield, final weight and daily weight gain were observed in mineral supplemented groups compared with non supplemented groups. Sheep supplemented with minerals (salt, commercial mineral mix and *bole* soil) showed significant impact on weight of blood, gut content, spleen, esophagus, skin with feet, lung and total non-edible offals (Belete, 2016).

3. MATERIALS AND METHODS

3.1. Description of the Study Area

The study was carried out in Bahima town Lega-Hidha district, Bale Zone of Oromia Regional State, Ethiopia. Lega-Hidha district is located between 7°45′N 41°15′E and at about 678 km south east of Addis Ababa. The mean annual rainfall is ranging from 500 to 800 mm. The district has an elevation ranging from 1200 to 1400 masl with average temperature between 25 and 28^{o}C. Pastoralism and agro-pastoralism are an integral part of the land use system in the district. The livestock population in the area is estimated to be 251500 goats, 181,820 cattle, 14,754 sheep, 27089 equine and 50058 camels (LH WPDO, 2019).

3.2. Animals and Management

Twenty five yearlings male Black Head Somali (BHS) Sheep with average initial body weight of 17.98±1.82kg were purchased from local markets (Beltu and Bahima). The age of sheep was determined based on dentition and information from the owners. The sheep were ear tagged, dewormed with Albendazole against internal parasite, and sprayed with diaznol against external parasite upon arrival to experimental house. They were also vaccinated against the common diseases prevailing (Pest des Petits of Ruminants, Sheep Orf and Foot and Mouth Disease) in the area. They were acclimatized to the environmental condition of the experimental site for two weeks and then they were allowed for two weeks to adapt the respective experimental feeds before starting of data collection. Experimental animals were kept in the house which has no concrete floor in individual pen through the experimental period.

3.3. Experimental feed preparation

The experimental ration consisted of hay, concentrate and mineral soil. The concentrate portion of diet was 65 % of wheat bran, and 35 % of linseed cake on a DM basis, which were purchased from the nearest market (Ginnir). The basal feed was natural grass hay (mixture of Hasere, *Cynodon dactylon* (Serdo), Sembeleta and Deremo). Natural grass hay was harvested manually from the compound of Bahima Primary school; it was properly dried and stored. Mineral soil (*Mi'awa*) was collected from Lega-Hidha district where pastoralist mostly use (locally called Werdha) for mineral supplementation to their animals and it was dried under shade; sand was carefully removed and stored in sacks until the commencement of experimental period. Mineral soil *(Mi'awa*) was properly mixed with concentrate portion of the ration.

3.4. Experimental Design and Treatments

The experiment was conducted using randomized complete block design (RCBD). The animals were blocked into 5 blocks of 5 animals each based on their initial body weight (IBW), which was determined as a mean of two consecutive weighing after overnight fasting at the end of the quarantine period. One sheep from each block were randomly assigned to one of the five dietary treatments.

The treatments (T) were assigned as follows

T1 (control) = Grass Hay (*ad libitum*) + 300g Concentrate

T2 = Grass Hay (*ad libitum*) + 300g Concentrate + *Mi'awa* 2% of concentrate (6 g *Mi'awa*)

T3 = Grass Hay (*ad libitum*) + 300g Concentrate + *Mi'awa* 4% of concentrate (12 g *Mi'awa*)

T4 = Grass Hay (*ad libitum*) + 300g Concentrate + *Mi'awa* 6% of concentrate (18 g *Mi'awa*)

T5= Grass Hay (*ad libitum*) + 300g Concentrate + *Mi'awa* 8% of concentrate (24 g *Mi'awa*)

3.5. Measurements

3.5.1. Feeding trial

Experimental sheep were acclimatized to the experimental diets for a period of 15 days before starting data collection and then the feeding trial was continued for 90 days. Basal feed and water was available *ad libitum* to the experimental sheep. The concentrate mineral mix (supplement) was divided in to two equal portions and offered at 08:00 and at 16:00 h. Basal feed offered was adjusted every 10 days ensuring a refusal of 20% based on previous days intake of an individual animal. The amount of feed offered and refused for each sheep was recorded daily throughout the experimental period. Daily feed intake of experimental animals was calculated on DM basis as the difference between the feed offered and refused.

3.5.2. Body weight change and feed conversion efficiency

The body weights of experimental sheep were measured using suspended weighing balance which was done in the morning before provision of feed and water. To determine the weight change, subsequent body weight measurements was made at 10 days interval throughout the experimental period. Daily body weight gain (ADG) was calculated as the difference between final and initial weight divided by the feeding days (90 days). Feed conversion efficiency (FCE) was determined as gram ADG per gram daily DM intake.

3.5.3. Carcass parameters

At the end of the feeding trial, all sheep were allowed to fast overnight and 3 sheep from each treatment were slaughtered. Before slaughtering, sheep were weighed to determine slaughter body weight (SBW) and slaughtering was done by severing the jugular vein and carotid arteries with a knife. During slaughtering the blood was collected into plastic buckets, weighed and recorded. The skin was carefully flayed to avoid attachment of fat and muscle tissues to the skin and weighed. Feet and the feet below fetlock joints was weighed and recorded separately for each sheep. The entire gastro intestinal tract (GIT), except esophagus, were removed with its content and weighed with and without its contents and the weight of the gut content was measured by difference. Non-edible offal (NEO) and the edible offal (EO) components were weighed and recorded separately. Classification of offals in to NEOs and EOs was based on eating habit of the people residing in and around the study area.

The total non-edible offal (TNEOs) and total edible offal (TEOs) components were computed as the sum of all NEOs and all EOs, respectively. Empty body weight (EBW) of each sheep was determined by subtracting weight of digesta from slaughter weight. Hot carcass weight (HCW) was computed by excluding contents of thoracic, abdominal and pelvic cavity, head, skin, and leg below fetlock. Dressing percentage (DP) was also calculated as a ratio of HCW to SW and HCW to EBW. The cross sectional area of rib-eye muscle (REMA) at the 12^{th} and 13^{th} ribs of each slaughtered sheep was traced from each side on transparency paper after cutting perpendicular to the back bone and measured by tracing the transparency paper on graph papers. The average measure of the left and right cross sectional areas was taken as REMA

3.5.4. Determination of chemical and mineral composition of experimental feed

Representative samples of daily feed offered and refused were collected, weighed and separately stored for each animal in bags until the end of the experimental period. Then the feed samples thoroughly mixed, sub sampled and was taken to Hawassa University Animal Nutrition Laboratory. The dry matter content of the feed was determined by drying the samples at 105 °C overnight. The ash content of the sample was determined by combusting the samples at 550 °C for 5hrs in a muffle furnace. Nitrogen (N) content was determined using the Kjeldahl method and the crude protein (CP) was calculated as N% × 6.25 (AOAC, 1995). The neutral detergent fiber (NDF) contents was analyzed using the method of Van Soest *et al.* (1991) whereas the acid detergent fiber (ADF) and acid detergent lignin (ADL) content was determined according to Van Soest and Robertson (1985) using ANKOM® 200 Fiber Analyzer (ANKOM Technology Corp., Fairport, NY, USA). The mineral contents of experimental feed (Grass hay, Wheat bran, Linseed and *Mi'awa*) analyzed at Debre Zeit Horticoop Ethiopia Soil and Water Analysis laboratory. Macro minerals (Ca, P, Mg, K and Na) and micro minerals (Mn, Cu, Fe and Zn) were analyzed using the method of Mehlich (1984).

3.6. Statistical Analysis

The data obtained from feed intake, body weight change and carcass characteristics were subjected to analysis of variance (ANOVA) using the General Linear Model (GLM) procedure of SAS version 9.2 (SAS, 2008). The differences among treatment means were tested by using Duncan's multiple range test (DMRT). The model used for data analysis was:

$Y_{ij} = \mu + T_i + B_j + e_{ij}$

Where Y_{ij} = response variable;

μ = overall mean;

T_i = treatment effect;

B_j = block effect;

e_{ij} = random error

4. RESULTS AND DISCUSSION

4.1. Chemical Composition of Treatment Feeds and Refusal

The chemical composition of treatment feeds and refusal are given in Table 4. The crude protein content of hay used in this study was comparable with the value of 8.1%, 7.56%, 7.8% and 7.9% reported by Dereje (2015), Hagos (2014), Habtom (2012) and Fasil (2015) respectively, but higher than CP contents of 4.2% and 6.6% reported by Mulu *et al. (*2008) and Simret (2008) respectively. A CP content of hay used in current study could meet maintenance requirements of CP required for sheep. The CP content in range of 7-7.5% is required to satisfy ruminant microbial requirements and would provide sufficient CP for the maintenance requirement of the animal (Van Soest, 1994).

The NDF content of hay used in the current study was comparable with the NDF content of 69.7% and 71.8% reported by Bimrew (2008) and Amansisa (2010) respectively, but lower than the NDF contents of 77.94% reported by Wondewsen (2010). Acid detergent fiber (ADF) content of hay used in current study was comparable with values of 43.2%, 40.10%, 42.70% and 43.4% reported by Fasil (2015), Alem (2014), Wondewsen (2010) and Belete (2016) respectively, but lower than values of 46.44%, 53.32% and 53.48% reported by Hagos (2014), Feleke *et al*. (2011) and Birhanu (2011) respectively.

NDF content of hay in current study is relatively high; these indicate that the basal feed has a poor quality. Singh and Oosting (1992) reported that roughage feeds containing NDF values higher than 65% are classified as low quality. High content of NDF of the hay used in this study may imply low intake of basal diet, since a major factor regulating forage intake is NDF content as it is the component limiting rumen fill, and directly correlated with rumination or chewing time (Cheeke, 1999). The hay used in current study has also high content of ADF. Kellems and Church (1998) indicated that roughage feed with higher than 40% ADF are categorized as poor quality. Feeds that contain large proportion of ADF have low availability of nutrients, since ADF is negatively correlated with feed digestibility (Beyene, 1976**;** McDonald *et al*., 2002).

Table 4.Chemical composition (%) of experimental feed offered and refused

Feed type	DM	OM	CP	NDF	ADF	ADL	Ash
Grass hay	92.04	89.08	7.88	70.34	41.39	8.03	10.92
Wheat Bran	89.86	94.82	14.66	37.65	10.90	2.36	5.18
Linseed	92.35	90.5	28.42	33.12	16.12	7.44	9.5
Mi'awa	95.65	4.2	_	_	_	_	95.8
Hay refusal							
T1	91.97	89.7	5.30	72.32	43.78	8.88	10.3
T2	91.27	89.2	5.43	72.69	43.49	8.29	10.8
T3	91.58	89.3	5.09	72.86	44.13	8.66	10.7
T4	91.82	89.5	5.68	72.78	44.07	8.50	10.5
T5	91.84	89.8	5.32	72.71	43.59	8.31	10.2

DM= dry matter, OM= organic matter, CP= crude protein, NDF= Neutral detergent fiber, ADF= acid detergent fiber, ADL=acid detergent lignin, T1 (control) = Grass Hay (*ad libitum*) + 300g Concentrate, T2 = Grass Hay (*ad libitum*) + 300g Concentrate + *Mi'awa* 2%, T3 = Grass Hay (*ad libitum*) + 300g Concentrate + *Mi'awa* 4%, T4 = Grass Hay (*ad libitum*) + 300g Concentrate + *Mi'awa* 6% ,T5= Grass Hay (*ad libitum*) +300g Concentrate + *Mi'awa* 8% .

Acid detergent fiber (ADF) content of wheat bran in this study was comparable with 38.60% and 36.4% reported by Alem (2014) and Belete (2016) respectively. The CP content of wheat bran used in the current study was comparable with the values of 14.2%,14.0%,16.3% and14.48% reported by Dereje (2015), Birhanu (2010), Hirut (2008) and Radia *et al.* (2013), but it was relatively lower than the CP contents of 17.7% and 20.10% reported by Fasil (2015)and Simret (2005) respectively.

The NDF content of linseed cake used in the present study was comparable with the value of 32.6% and 31.2% reported by Adugna (2008) and Shimelis (2017) respectively. The CP content of linseed cake in the current study was comparable with value of 29.3% and 28.7% reported by Adugna (2008) and Shimelis (2017) respectively. The variation in chemical composition of wheat bran and linseed cake might be due to the effect of processing in milling industries and the quality of the original grain used in the milling industries.

The DM, CP, NDF, ADF, ash and ADL content of the grass hay refusals were almost similar among the treatments. Comparison between the chemical composition of offered and refused grass hay revealed that the offer had higher CP and ash than refusals, but lower NDF, ADF and ADL values, which may be due to the fact that experimental sheep were selecting more edible portions of the basal diet (such as leaf) and left more of the stems parts of the plant which has higher fiber (NDF, ADF and ADL) fractions.

4.2. Mineral Composition of Treatment feedstuffs

The mineral content of the feed used in the present study is presented in Table 5. The Ca content of grass hay used in current study was lower than values of 0.4%, 0.43%and 0.6% reported by Nega *et al*. (2006), Mulukan (2015) and Temesgen (2018), respectively, but higher than the value 0.24% reported by Adugna (2008). The P content of hay used in current study was lower than the values of 0.08% and 0.17% reported by Temesgen (2018) and Muluken (2015), respectively. This finding showed that grass hay used in current was highly deficient in P and out of the range of P (0.16-0.38%) requirement for sheep suggested by NRC (1985). The Mg content of hay used in current study was lower than value 0.17% and 0.25% reported by Muluken (2015) and Temesgen (2018), respectively. The Na content of hay used in current study was lower than value of 0.08% and 0.2% reported by Muluken (2015) and Temesgen (2018) respectively. K content of grass hay in the current study was the similar with the value 0.43% grass hay reported by Muluken (2015), but lower than the value 0.86% reported by Temesgen (2018).

Ca contents of *Mi'awa* in the current study was higher than the value of 0.41% for Bole, 0.51% for *Mekaduw* reported by Muluken (2015), 0.62% for Bole reported by Belete (2016) and 0.46% for *Addua* reported by Temesgen (2018). Ca content of *Mi'awa* in the current study was above Ca requirement for sheep (0.2-0.82) set by NRC (1985). The Na content of *Mi'awa* in the current study was comparable with the value of Bole (3.01%) reported by Muluken (2015). Na content of *Mi'awa* in the current study was slightly higher than values of *Addua* (2.44%) reported by Temesgen (2018), but lower than value of Mekaduw (4.86%) reported by Muluken (2015) and Bole (5.62%) reported by Belete (2016). This indicates Na content of *Mi'awa* in the current study was above the upper limit of the recommended requirement level of 0.07% to 0.1% set by AFRC (2007) and 0.09% to 0.18% set by NRC (1985).

The P content of *Mi'awa* in the present study was lower than values 0.02% for Bole and 0.04% for Mekaduw reported by Muluken (2015) and 0.01% for *Addua* reported by Temesgen

(2018). P content of *Mi'awa* was far below recommended critical level (0.16-0.36%) set NRC (1985). This is agreed with the findings of previous studies (Kabaija and Little, 1987; Mohamed *et al*., 1989; Fikre, 1990, Temesgen, 2012, 2018; Muluken, 2015; Belete, 2016) who reported low P contents in the soils from different parts of Ethiopia. The Mg content of *Mi'awa* in the present study was comparable the value of Mekadaw (0.16%) reported by Muluken (2015). Mg content of *Mi'awa* in current study was higher than value 0.01% for Bole reported by Belete (2016), but lower than the value of *Addua* 0.2% reported by Temesgen(2018).

The K content of *Mi'awa* in the current was lower than value of Bole (0.31%) and Mekadaw (0.4%) reported by Muluken (2015) and *Addua* 0.62% reported by Temesgen(2018). The result of macro mineral composition of *Mi'awa* showed that P and K content of *Mi'awa* in the current study were deficient while Na, Ca and Mg content could meet mineral requirement for sheep as set by NRC (1985). *Mi'awa* could not be used as source of P and K in order to meet P and K requirements for sheep to recommend level. This finding was in agreement with the works of Kabaija and Little (1987), Mohammed *et al*. (1989), Fikre (1990), Sisay *et al*. (2007) and Temesgen (2012) who reported that P and K content of lick soil is lower than the recommended level for sheep.

Table 5. Mineral concentration of treatment feedstuffs

Feed type	Macro (%)minerals						Micro(ppm) minerals			
	DM	Ca	P	Na	K	Mg	Cu	Fe	Zn	Mn
Grass hay	92.04	0.33	0.03	0.02	0.43	0.1	0.34	259.92	29.69	26.37
Wheat Bran	89.86	0.14	0.79	0.03	1.17	0.31	9.73	433.60	94.46	147.84
linseed	92.35	0.55	0.85	0.05	1.28	0.05	23.23	2968.95	85.79	98.88
Mi'awa	95.65	1.13	0.001	2.68	0.03	0.14	2.84	156.92	0.57	60.74

DM=dry matter, Ca=calcium, K=potassium, Mg=magnesium; Na=sodium, P=phosphorus Ppm= Parts per million, Cu=Copper; Fe=Iron; Mn=Manganese, Zn=Zinc.

Cu content of grass hay in the current study was lower than values of 5 ppm and 3.3ppm reported by Muluken (2015) and Temesgen (2018) respectively. The Mn content of the grass hay used in the current study was comparable with the values of 30 ppm reported by Muluken (2015), but lower than value of 486.98 ppm reported by Temesgen (2018). Fe and Zn content of grass hay used in the current study were lower than values of Fe (290 ppm) and Zn (75 ppm) reported by Muluken (2015).

The Cu content of *Mi'awa* in this study was comparable with the value of 2.22 ppm for Jair soil reported by Sisay et al (2007) and 2.22ppm for *Addua* reported by Temesgen (2018), but higher than values of Hermokale (1.5 ppm), Arabi(0.66 ppm) and Bole (0.28 ppm) reported by Sisay et al (2007). Cu content of *Mi'awa* in current study was also higher than the value (1.01 ppm) of Bole soil reported by Belete (2016). Current study revealed that, Cu in *Mi'awa* mineral soil was deficient to supply the critical level of 7 to 11 ppm suggested by McDowell (2003) and NRC (1985).

This study also agreed report of Kabaija (1987), Sisay et al (2007), Muluken (2015), Belete (2016) and Temesgen (2012, 2018) who found deficiency of Cu in soil of different parts of Ethiopia.

Fe content of *Mi'awa* in current study was higher than the value of Bole 92.24 ppm and Mekaduw (87.09 ppm) reported by Muluken (2015) and 63.97ppm for Bole reported by Belete (2016), but lower than value of *Addua* (5127ppm) reported by Temesgen (2018). Fe content of *Mi'awa* in the current study was high and above the maximum requirement for sheep (30-50ppm) set by NRC (1985). The current finding is in agreement with report of Kabaija and little (1987), Kabaija (1989), Mohammed *et al.* (1989), Fikre (1990) and Temesgen (2012, 2018) mineral soil lick contained Fe from acceptable level to too excess than ruminant requirement.

Mn content of Mi'awa in the current study was lower than values of 165 ppm for Bole and 120 ppm for Mekaduw reported by Muluken(2015). According to NRC (1985), Mn requirement for sheep ranges from 20 to 40 ppm. This indicates that Mn content of *Mi'awa* in the current study was above acceptable level of Mn for sheep. Current study agreed with report of Mohammed *et al.* (1989), Fikre (1990) and Temesgen (2012, 2018) that mineral soils contained above acceptable level of Mn for ruminants. Zn content of *Mi'awa* in the current study was also lower than values of 4.73ppm for Bole reported by Belete (2016), which could not meet the minimum requirement for sheep (20 to 30 ppm) as set by (NRC 1985). This finding was agreed with the report of Kabaija (1989), Sisay et al (2007) and Temesgen (2012) who reported that lick soils are deficient in Zn concentration to supplement sheep.

Variation in mineral composition of natural mineral soil licks might be due to difference of parent materials from which soil has been derived, depth of soil collection and addition of other soil from the surrounding (Belete, 2016).

4.3. Dry Matter and Nutrients Intake

The DM and nutrient intakes of Black head Somali sheep supplemented with *Mi'awa* mineral soil are presented in Table 6. All sheep readily consumed the dietary supplement (concentrate *Mi'awa* mixture) without any refusal across the experimental period. Dry matter intake of concentrate *Mi'awa* mix was significantly different among the treatments in the order of T1<T2<T3<T4<T5. The difference in DM intake of concentrate *Mi'awa* mineral mix in the present study was due to increased level of *Mi'awa* mineral supplementation. The total DM intake was highest (P < 0.05) for sheep supplemented with 8% *Mi'awa* (T5) whereas the lowest was observed in animals that were not supplemented with *Mi'awa* (T1). Hay DM intakes were highest (P < 0.05) for sheep supplemented with 6% and 8% *Mi'awa* (T4 and T5) whereas the lowest hay DM intake was observed in T2 and T1. McDonald *et al.* (2002) indicated that, feed intake will be maximized if the feed provides all nutrients required by rumen microbes and by the tissue of the animal. Therefore, the higher hay and total DM intake in treatments with 6% and 8% *Mi'awa* (T4 and T5) could be due to the better mineral composition of *Mi'awa* specially Na which increase appetite of animals. DM intake of Woyto Guji goat was improved by supplementation of *Addua* mineral soil due to its high Na content which enhances the appetite of animals (Temesgen, 2018). Sodium is crucial for animals for better appetite, growth and efficient metabolism of protein and energy (Suttle, 2010).

The essentiality and role of minerals in rumen microbes have been well recognized in numerous studies. Church (1975) reported that microbial growth and various fermentation processes in the rumen require an adequate supply of minerals. Leng (1991) stated that mineral deficiency reduced growth efficiency of rumen microbes and decrease feed intake.

Table 6 Dry matter and nutrient intake of black head Somali sheep supplemented with *Mi'awa* mineral soil

	Treatments, Mean					
Parameters	T1	T2	T3	T4	T5	SEM
Hay DMI (g/d)	438.43^{b}	441.04^{b}	452.93^{ab}	461.93^{a}	463.01^{a}	3.19
CM MI (g/d)	273.47^{e}	278.77^{d}	284.29^{c}	289.89^{b}	295.55^{a}	0.17
TDMI (g/d)	711.90^{d}	719.80^{cd}	737.23^{bc}	751.82^{ab}	758.56^{a}	3.21
OMI	702.11^{c}	708.54^{bc}	725.82^{ab}	739.50^{a}	745.12^{a}	3.11
CPI	106.20^{c}	107.54^{c}	109.98^{b}	111.66^{b}	113.46^{a}	0.28
NDFI	420.74^{c}	425.70^{bc}	438.54^{ab}	448.13^{a}	452.04^{a}	2.25
ADFI	221.30^{b}	223.67^{b}	228.69^{ab}	233.47^{a}	236.72^{a}	1.32
ADLI	43.11^{d}	47.66^{c}	49.34^{bc}	50.80^{b}	52.80^{a}	0.29

$^{a-e}$ Mean values in a row having different superscripts differ significantly; T1 (control) = Grass Hay (*ad libitum*) + 300g Concentrate, T2 = Grass Hay (*ad libitum*) + 300g Concentrate + *Mi'awa* 2%, T3 = Grass Hay (*ad libitum*) + 300g Concentrate + *Mi'awa* 4%, T4 = Grass Hay (*ad libitum*) + 300g Concentrate + *Mi'awa* 6% ,T5= Grass Hay (*ad libitum*) +300g Concentrate + *Mi'awa* 8%, CMMI=Concentrate *Mi'awa* mix intake, TDMI=Total dry matter intake, OMI=Organic matter intake, CPI=Crude protein intake, NDFI= Neutral detergent fiber intake, ADFI=Acid detergent fiber intake, ADLI=Acid detergent lignin intake.

4.4. Body Weight Change and Feed Conversion Efficiency

The initial and final body weights, body weight change, average daily gain and feed conversion efficiency of the experimental sheep are presented in Table 7. Highest final body weight ($P < 0.05$) was observed in Sheep supplemented with 8% *Mi'awa* mineral soil (T5). But lowest final body weight was observed in sheep which were not supplemented with *Mi'awa* mineral soil (T1). BWC and ADG of sheep in T4 and T5 were significantly higher ($P < 0.05$) than sheep in treatment T1, T2 and T3. But value of BWC and ADG for T1, T2 and T3 were not different among treatments. This study shows that animal supplemented with high level of *Mi'awa* mineral soil (6% and 8%) had greater BWC and ADG than sheep in other treatments.

Table 7.Body weight parameters and feed conversion efficiency of black head Somali sheep supplemented with *Mi'awa* mineral soil

	Treatments, Mean					
Parameters	T1	T2	T3	T4	T5	SEM
IBW(Kg)	17.82	18.04	17.94	18.06	18.02	0.36
FBW(Kg)	22.08^{b}	22.46^{ab}	22.64^{ab}	24.04^{ab}	24.44^{a}	0.38
BWC(Kg)	4.26^{b}	4.42^{b}	4.70^{b}	5.98^{a}	6.42^{a}	2.15
ADG(g/d)	47.33^{b}	49.11^{b}	52.22^{b}	66.44^{a}	72.33^{a}	0.0019
FCE	0.070^{d}	0.072^{d}	0.074^{c}	0.094^{b}	0.10^{a}	0.19

$^{a\text{-}d}$ Mean values in a row having different superscripts differ significantly; T1 (control) = Grass Hay (*ad libitum*) + 300g Concentrate, T2 = Grass Hay (*ad libitum*) + 300g Concentrate + *Mi'awa* 2%, T3 = Grass Hay (*ad libitum*) + 300g Concentrate + *Mi'awa* 4%, T4 = Grass Hay (*ad libitum*) + 300g Concentrate + *Mi'awa* 6% ,T5= Grass Hay (*ad libitum*) +300g Concentrate + *Mi'awa* 8%,IBW=Initial Body Weight, FBW=Final Body Weight, BWC=Body weight Change, ADG=Average Daily Gain, FCE=Feed Conversion Efficiency.

Current study had agreement with the finding of Sisay *et al*. (2007) who reported that supplementation with different natural mineral soil licks such as Jair, Hermokale, Arabi for Black Head Ogaden sheep had higher weight gain than control group. Muluken (2015) reported that better weight gain was recorded for sheep fed with Bole soil and Mekaduw *adlibtum* while the lowest was observed for sheep fed no mineral supplementation. Mohammed *et al*. (1989) reported that weight gains of Arsi sheep increased by an average of 19 ± 8 g/day when fed with natural mineral lick offered as free choice. Sheep which were supplemented with 8% *Mi'awa* mineral soil (T5) had significantly higher feed conversion efficiency as compared to other treatments. Lowest feed conversion efficiency of sheep was observed in T1 and T2. Mineral supplementation significantly enhanced growth rate of sheep. NRC (1985) showed that inadequate mineral intake in the diet of sheep result in decreased feed consumption and decreased efficiency of nutrient utilization, wool production and reproduction rate and a very severe deficiency may cause death whereas adequate mineral supplementation can enhance feed consumption, feed conversion efficiency and average daily gain (ADG) of the animals.

4.5. Carcass Characteristics

Slaughter weight (SW), empty body weight (EBW), hot carcass weight (HCW), dressing percentage as slaughter weight (DPSW) and dressing percentage as empty body weight (DPEBW) bases, rib-eye muscle area (REMA) of experimental sheep are presented in Table 8. Highest slaughter weight, empty body weight and HCW in the current study were observed in sheep which were supplemented with 8% *Mi'awa* mineral soil (T5). But lowest slaughter weight, empty body weight and HCW in the current study were observed in sheep which were not supplemented with *Mi'awa* mineral soil (T1). Dressing percentage as proportion of slaughter weight was significantly highest ($P<0.05$) for sheep in T5. Lowest dressing percentage as proportion of slaughter weight was observed in T1 and T2. Dressing percentage as proportion of empty body weight and REMA were not different among treatments. Dressing percentage as proportion of empty body weight was similar among the dietary treatments with over all mean of 49.42%. Similarly rib-eye muscle area was not influenced by dietary treatments with over all mean of 8.34 cm^2.

Table 8.Carcass of black head Somali sheep supplemented with *Mi'awa* mineral soil

	Treatments, mean					
Parameter	T1	T2	T3	T4	T5	SEM
Slaughter weight(Kg)	22.08^{b}	22.46^{ab}	22.64^{ab}	24.04^{ab}	24.44^{a}	0.37
EBW (Kg)	17.58^{b}	18.00^{ab}	18.16^{ab}	19.58^{ab}	20.00^{a}	0.34
HCW(Kg)	8.60^{b}	8.78^{ab}	8.96^{ab}	9.78^{ab}	10.10^{a}	0.22
Dressing percentage						
Slaughter weight	38.85^{b}	38.99^{b}	39.45^{ab}	40.65^{ab}	41.29^{a}	0.43
Empty body weight	48.68	48.79	49.23	49.99	50.43	0.35
REMA(cm^2)	7.80	7.96	8.24	8.68	9.02	0.20

$^{a-b}$ Mean values in a row having different superscripts differ significantly, T1 (control) = Grass Hay (*ad libitum*) + 300g Concentrate, T2 = Grass Hay (*ad libitum*) + 300g Concentrate + *Mi'awa* 2%, T3 = Grass Hay (*ad libitum*) + 300g Concentrate + *Mi'awa* 4%, T4 = Grass Hay (*ad libitum*) + 300g Concentrate + *Mi'awa* 6%, T5= Grass Hay (*ad libitum*) +300g Concentrate + *Mi'awa* 8% and REMA=Rib eye muscle area.

This finding indicated that better slaughter weight (SW), empty body weight (EBW), hot carcass weight (HCW) and dressing percentage as slaughter weight (DPSW) were observed in better levels(8%) of *Mi'awa* mineral soil supplementation. This indicates that high level of supplementation (8%) would enable sheep to develop better feed utilization efficiency and muscling than the control and sheep supplemented at lower level. Quality feed and mineral inclusion in animal diet affects weight of hot carcass and DP, which could be increased with increasing amount of concentrate and mineral supplementation in the diets of small ruminants (Hagos, 2007).This finding was also agreed with Belete (2016) who reported that higher slaughter body weight, hot carcass weight and empty body weight in mineral supplemented than unsupplemented group.

4.5.1. Main carcass components

The main carcass components of black head Somali sheep are presented in Table 9. Higher weights of loin, rib with muscle and hind-leg ($P < 0.05$) were observed for sheep in T4 and T5. Lowest loin, rib with muscle and hind-leg were observed in sheep in T1. Highest brisket weight was recorded for sheep in T5, but lowest was recorded for sheep in T1. Neck and front leg weight were similar for all treatments in this study. The highest weights of main carcass components (weights of loin, rib with muscle and hind-leg) in may be due to higher nutrient intake which resulted higher slaughter weight and HCW (T4 and T5) in these treatments.

Table 9. Main carcass components of black head Somali sheep supplemented with *Mi'awa* mineral soil

	Treatments, mean(g)					
Parameter	T1	T2	T3	T4	T5	SEM
Loin & Rack	1180^{b}	1260^{ab}	1280^{ab}	1380^{a}	1400^{a}	30.10
Forelegs	1920	2000	2040	2100	2240	56.24
Hind legs	2080^{b}	2220^{ab}	2280^{ab}	2440^{a}	2520^{a}	58.0
Brisket	860^{b}	900^{b}	920^{ab}	1020^{ab}	1080^{a}	28.33
Ribs	1000^{b}	1080^{ab}	1120^{ab}	1200^{a}	1240^{a}	29.73
Shoulder &Neck	1380	1400	1420	1460	1520	32.84

$^{a\text{-}b}$ Mean values in a row having different superscripts differ significantly, T1 (control) = Grass Hay (*ad libitum*) + 300g Concentrate, T2 = Grass Hay (*ad libitum*) + 300g Concentrate + *Mi'awa* 2%, T3 = Grass Hay (*ad libitum*) + 300g Concentrate + *Mi'awa* 4%, T4 = Grass Hay (*ad libitum*) + 300g Concentrate + *Mi'awa* 6%, T5= Grass Hay (*ad libitum*) +300g Concentrate + *Mi'awa* 8%

4.5.2. Edible offal components

Edible offal components of Black Head Somali sheep supplemented with *Mi'awa* mineral soil is presented in Table 10. Tongue, heart, liver, kidney, kidney fat, omental fat weight of sheep were similar among the dietary treatments. The majority of the edible offal components in this study were not affected (P>0.05) by treatment. Riley *et al.* (1989) indicated that differences in internal organs are more influenced by age, breed and sex of the animals rather than plane of nutrition which support the current result. However, small and large intestine, stomach, tail (*duba*) and total edible offal weight was significantly highest (p<0.05) for sheep in T5. But lowest stomach, large and intestine, tail and total edible offal weight were observed in sheep which were not supplemented with *Mi'awa* mineral soil (T1). Highest empty gut weight of T5 implies that as animals consume more feed, their stomach may be enlarged to accommodate the larger ingesta and thicker to resist the work load in it and this may increase the volume and weight of the gastrointestinal tract as a whole.

Table 10. Edible offal of black head Somali sheep supplemented with *Mi'awa* mineral soil

	Treatments, mean(g)					
Edible offal	T1	T2	T3	T4	T5	SEM
Tongue	76.00	78.80	79.80	83.40	89.80	2.57
Heart	107.80	106.60	112.20	112.40	115.80	2.35
Kidney	76.80	81.60	88.00	80.60	86.20	3.44
Liver	287.20	299.80	314.60	320.40	317.80	5.05
Stomach	735.4b	771.20^{ab}	781.40^{ab}	793.00^{ab}	803.40^{a}	10.06
SiLi	792.20^{b}	801.80^{ab}	829.20^{ab}	846.20^{ab}	870.0 ^{a}	11.82
Kidney fat	49.40	45.80	54.40	50.60	55.20	1.79
Omental fat	52.20	52.20	51.60	47.40	71.20	3.53
Tail(*Duba*)	824.60^{b}	850.40^{ab}	870.0^{ab}	872.20^{ab}	9.6^{a}	15.53
Total EOs	3030.4^{b}	3108.6^{ab}	3193.2^{ab}	3218.0^{ab}	3353.0^{a}	42.53

$^{a-b}$ Mean values in a row having different superscripts differ significantly, T1 (control) = Grass Hay (*ad libitum*) + 300g Concentrate, T2 = Grass Hay (*ad libitum*) + 300g Concentrate + *Mi'awa* 2%, T3 = Grass Hay (*ad libitum*) + 300g Concentrate + *Mi'awa* 4%, T4 = Grass Hay (*ad libitum*) + 300g Concentrate + *Mi'awa* 6% ,T5= Grass Hay (*ad libitum*) +300g Concentrate + *Mi'awa* 8%, SiLi = Small and Large intestine,TEOs=Total Edible Offals

4.5.3. Non Edible offal components

Non edible offal of Black Head Somali sheep supplemented with *Mi'awa* mineral soil are presented in Table 11. Most of non-edible offal components were not different among the dietary treatments. Results of the present study also indicate that, the weights of head without tongue, blood, skin, spleen and pancreas, feet lock joints, gut content and total non edible offal were not different (P>0.05) among the treatments. Higher weight of lung with trachea, testicle and penis were observed in T5, But the Lowest weight of lung with trachea, testes and penis were observed in T1. Higher weight of lung with trachea, testicle and penis in T5 may be due to higher slaughter weight of animals this treatment.

Table 11. Weight of non edible offal of Black Head Somali sheep supplemented with *Mi'awa* mineral soil

	Treatments, mean(g)					
Non EOs (g)	T1	T2	T3	T4	T5	SEM
Head-Tongue	1440.0	1416.6	1500	1416.6	1450.20	24.47
Skin	1800.0	1760.0	1860.0	1820.0	1780.00	27.97
Blood	863.80	829.80	847.80	912.60	890.20	13.50
Feet	491.80	479.60	488.20	497.40	504.00	5.54
Penis & testicles	252.0^{b}	263.8^{ab}	269.8^{ab}	273.8^{ab}	294.20^{a}	5.40
Gut content	4500	4480	4460	4460	4440	87.12
Lung + trachea	260.60^{b}	270.60^{ab}	276.2^{ab}	286.80^{ab}	299.60^{a}	5.93
Spleen& pancreas	53.20	49.40	54.20	50.40	52.40	1.81
Total NEOs (kg)	9.66	9.57	9.77	9.71	9.71	0.12

$^{a\text{-}b}$ Mean values in a row having different superscripts differ significantly, T1 (control) = Grass Hay (*ad libitum*) + 300g Concentrate, T2 = Grass Hay (*ad libitum*) + 300g Concentrate + *Mi'awa* 2%, T3 = Grass Hay (*ad libitum*) + 300g Concentrate + *Mi'awa* 4%, T4 = Grass Hay (*ad libitum*) + 300g Concentrate + *Mi'awa* 6%, T5= Grass Hay (*ad libitum*) +300g Concentrate + *Mi'awa* 8%, TNEOs=Total Non Edible Offals.

5. SUMMARY AND CONCLUSION

The study was conducted to determine the mineral composition of *Mi'awa* mineral soil and evaluate effect of *Mi'awa* supplementation on feed intake, weight gain and carcass characteristics of Black Head Somali Sheep fed a natural pasture hay and concentrate. Twenty five yearlings male Black Head Somali Sheep with initial body weight of 17.98±1.82 Kg (mean ±SD) were blocked in to five based initial body weight and assigned to one of the five treatments randomly making 5 animals per treatment. Experimental diet consisting of natural pasture hay *ad libitum*, 300g concentrate (65 % of wheat bran, and 35 % of linseed cake) and *Mi'awa* mineral soil supplemented at level of 0%, 2%, 4%, 6% and 8% of concentrate representing T1, T2, T3, T4 and T5 respectively. Feeding trial was continued for 90 days. Chemical analysis of the experimental feeds offered and refusals were carried out after taking representative sample. At the end of the feeding trial, 3 sheep from each treatment were slaughtered for determination of carcass characteristics. Data on feed intake, body weight change and carcass parameter were analyzed using the General Linear Model procedure of SAS version 9.2 (SAS, 2008).

Mi'awa mineral soil was found to have high sodium, calcium and iron contents. But it was low in potassium, phosphorus and Zinc contents. The highest total DM intake was observed for sheep supplemented with 8% *Mi'awa* whereas the lowest was observed in sheep not supplemented with *Mi'awa*.

The highest average daily weight gain was recorded for sheep fed T4 and T5. Sheep which supplemented with 8% *Mi'awa* mineral soil (T5) had significantly ($P<0.05$) higher feed conversion efficiency as compared to other treatment groups. Lowest in feed conversion efficiency of sheep was observed in T1 and T2.

Lower slaughter weight, empty body weight and HCW in the current study were observed in sheep which were not supplemented with *Mi'awa* mineral soil (T1).

The result of the study showed supplementing of *Mi'awa* to natural pasture hay and concentrate is effective in improving sheep performance. Among the different level of *Mi'awa* mineral supplementation with 6%and 8% resulted in better animal performance. Therefore, to fully confirm the advantages of supplementing *Mi'awa* on the performance of animal further study should be conducted.

1. Evaluate the maximum potential of *Mi'awa* by comparing different level of *Mi'awa* with *ad libitum* supplementation.
2. Comparing the effect Mi'awa on performance of animal with other natural soil lick and commercially produced mineral supplements.
3. Evaluate the effect of Mi'awa supplementation on other sheep breeds and livestock like dairy animal (milk production and milk quality).

6. REFERENCES

Adugna Tolera , Bayush, T., Berg, T. 2007. Effects of variety, cropping year, location and fertilizer application on nutritive value of durum wheat straw. *J. Anim. Physiol. Anim. Nutr*. 92(2).

Adugna Tolera and Said, A. N. 1994. Assessment of feed resources in Welayta Sodo: Quantity estimation and laboratory evaluation. Ethiopian.*Journal of Agricultural Science*, 14: 69-87.

Adugna Tolera. 2008. Feed resources and feeding management. A manual for feedlot operators and development workers. SPS-LMM Program. Addis Ababa, Ethiopia.38p.

Abebaw, Nega. and M. Solomon, 2009. Feed intake, digestibility and body weight change in Farta sheep fed hay supplemented with rice bran and/or noug seed cake (*Guizotia abyssinica*) meal. Tropical Animal Health Production, 41:507-515.

AFRC (Australian Feed Research Council). 2007. Nutrient Requirements of Domestic Ruminant. CSIRO publishing, Australia.

Ahmed Hassen, Abule Ebro, Mohammed Kurtu and Treydte A C. 2010**.** Livestock feed resources utilization and management as influenced by altitude in the Central Highlands of Ethiopia. Livestock Research for Rural Development. Volume 22, Article # 229.

Alemayehu Mengistu. 2005. Feed resources base of Ethiopia: Status, limitations and opportunities for integrated development. Proceedings of the 12th Annual Conference of the Ethiopian Society of Animal Production (ESAP) held in Addis Ababa, Ethiopia, August 12- 14, 2004. Addis Ababa, 410p.

Alem Dida. 2014. Substitution of concentrate mix with graded levels of dried moringa (*Moringa stenopetala*) leaf meal on feed intake, digestibility, live weight change and carcass characteristics of Arsi-bale sheep. MSc Thesis, Haramaya Universty, Haremaya, Ethiopia.95p

Alemu Yami. 2008. Nutrition and feeding of sheep and goats. In: AlemuYami and R.C Merkel(eds). Sheep and goat production hand book for Ethiopia. Addis Ababa, Ethiopia, pp103-159.

Amansisa Eresso.2010. Effect of supplementation of different levels of dried 'girawa' (*Vernonia amygdalina*) foliage and crushed maize grain mixtures on feed intake, digestibility and body weight change Horro sheep feed basal diet natural pasture hay MSc thesis submitted to Haramaya University.

Amde Mekonnen. 2015. Supplementation of Different Proportion of Corn Millilng By-Product And Noug Seed (*Guizotia Abyssinica*) Cake on Feed Intake, Digestibility, And Body Weight Gain of Horro Lambs Fed Natural Pasture Grass Hay Basal Diet. Msc Thesis, Haramaya University, Haramaya, Ethiopia.65p

Ammerman, C.B., Chicco, C.F., Moore, J.E., Walleghem, P.A. and Arrington, L.R. 1971. Effect of dietary magnesium on voluntary feed intake and rumen fermentations. *Journal of Dairy Science,* 54:1288-1293.

Ammerman, C.B. and Miller, S. M. 1975. Selanium in ruminant nutrition. *Journal of dairy science*, 58:1561-1577.

AOAC 2005 Official Methods of Analysis of the Official Analytical Chemists, 18th Edn. (Horwitz, W., Eds.), Association of Official Analytical Chemists, Washington DC.

Barrows, G.T. 1977. Research efforts have lagged in free-choice feeding. *Animal Nutrition. Journal*, 32:12-14.

Beede, D.K., 1991. Mineral and water nutrition. Vet. Clin north AM Food Anim Prac, July7 (2):373-390.Congleton, J., Welker, T. 1997. Improved nutrition to increase the viability and hatchery smolts.Fishery research, University of Idoha, USA.

Belete Kuraz, 2016.The Role of *Bole* (Lake Soil) As A Mineral Supplement to Arsi-Bale Sheep Fed Native Grass Hay and Concentrate Supplement. MSc Thesis Submittred to Hawassa University.81p

Beyene Chichaibelu, 1976. Laboratory evaluation and estimation of nutritive value of some Ethiopian feedstuffs and formulae plus animal evaluation of noug seed cake. A PhD Dissertation Cornell University Ethaca, New York.135p.

Bimrew Asmare, 2008. Supplementation of Different levels of Rice Bran and Noug seed cake Mixtures on nutrient utilization of Farta sheep fed natural pasture hay as a basal diet. An MSc Thesis presented to the School of Graduate Studies of Haramaya University. 68p

Birhanu Tesemma, 2011. Effect of green *Prosopis juliflora* pods and Noug seed cake (*Guizotia abissynica*) cake supplementation on digestibility and performance of Blackhead Ogaden sheep fed hay as a basal diet. Msc Thesis, Haramaya University, Haramaya, Ethiopia.66p

Bishaw F and Melaku S (2008), "Effects of Supplementation of Farta Sheep Fed Hay with Sole or Mixtures of Noug Seed Meal and Wheat Bran on Feed Intake, Digestibility and Body Weight Change", *Trop. Anim. Health Prod.*, Vol. 40, pp. 597-606.

Bravo A, Kyle E H and Louise H E. 2012. "Puddles Created by Geophagous Mammals are Potential Mineral Sources for Frugivorous Bats (Stenodermatinae) in the Peruvian Amazon", *J. Trop. Ecol.*, Vol. 26, pp. 173-184.

Brown, E.M. 1991. Extracellular Ca2+ sensing, regulation of parathyroid cell function and role of Ca2+ and ions in extracellular (first) messengers. Physiological Reviews, 71:371-411.

Buttery, P.J., Max, R., Kimambo, A., Ku-Vera, J., Akbar, A., 2005. Animal response to nutrient supply. In (E.Owen, A. Kitalyi, N. Jayasuriya and T. Smith, eds.): *Livestock and M>ealth creation.* Nottingham University Press, Nottingham, UK.

Carles, A.B. 1983. Sheep Production in the Tropics. Oxford tropical handbooks. Department of Animal Production, University of Nairobi, Kenya. 213 p.

Cheeke, P. R., 1999. Applied of Animal Nutrition. Feed and Feeding. Macmillan publishing company, New York. 525p.

Church, D.C. 1975. Digestive physiology and nutrition of ruminants. O & B Books, Corvalis, Oregon.

Clan, P.M. and Rose, T. 2005. Sheep production and management. New Mexico University In:htt//cahenmsu edu/pbu/-b/coob 15. html. online 10/017/2006.

Cohen, R.H. 1980. Phosphors in range land ruminant nutrition: A review, Livestock Production Science, 7:25-37.

CSA (Central Statistical Agency). 2010. Agricultural sample survey of 2004/05. Report on area and production of winter season crop for private peasant holdings. Vol. 5: Bulletin

Dudley R, Kaspari M and Stephen P Y (2012), “Lust for Salt in the Western Amazon”, *Biotropica*, Vol. 44, No. 1, pp. 6-9.

Dereje Worku, 2015.Effect of Substitution of Concentrate Mix With Dried Mulberry Leaves On Feed Intake, Digestibility, Body Weight Gain And Carcass Characteristics Of Arsi-Bale Goats Msc Thesis Submitted to Haramaya University.78p

Egan, A.R. 1975. The diagnosis of trace elements deficiencies in the grazing ruminant, pp. 371-384. In Trace Element in Soil-Plant-Animal System. Academic press, New York.

Ensminger, M.E., Goldfield, J.E. and Hineman, W.W. 1990. Feeds and Nutrition. The Ensminger publishing company Clovis, California, USA. pp. 433-400.

Ensminger, M.E. 2002. Sheep and goat science. 6th ed. Interstate publisher, INC.

FAO (Food and Agricultural Organization). 1986. Animal Genetic Resource Data Bank 2. Descriptor list of Cattle, Sheep and *Goats.* Animal Production and Health Paper, 2:59. FAO, Rome Italy.

Fasil Negussie, 2015.Effects of Different Feeding Regimes on the Performance of Blackhead Ogaden Sheep PhD Dissertation submitted to Haramaya University.128p

Faye, B. and Grillet, C. 1987. The mineral contents in forages and plasma of domesticated ruminants in Ethiopia, 39: 227-237.

Fazlallah ,A. and Shahab ,M. 2015. Mineral Dietary Supplement effects on Weight Performance and Physical Characteristics of the Components of Grazing Sheep Carcasses. *An International Journal* .**7**(1): 137-141. IRAN.

Feleke Gebregiorgis, Tegene Negesse and Ajebu Nurfeta, 2011. Feed intake and utilization in Sheep fed graded levels of dried Moringa *(Moringa stenopetala)* leaf as a supplement to Rhodes grass hay. *Journal of Trop Anim Health and Prod. 41 (3):1027-1035.*

Fikre, A. 1990. The mineral composition and effect of bole local natural lick supplementation on feed intake, digestibility and weight gain of Black Head Ogaden sheep. MSc Thesis, Alemaya University of Agriculture. Alemaya.

Gatenby, R.M. 1986. Sheep Production in Tropics and Sub- tropics. Longman, London and New York. pp.351.

Grovum, W.L. and Chapman, H.W. 1988. The effect of additives representing the primary tastes on sham intakes by esophageal fistulated sheep. *British Journal of Nutrition*, 59:63-72.

Graham, T. W. 1991. Trace element deficiencies in cattle. Veterinary clinic Journal, 7:153-215.

Habtom Negussie, 2012. Effects of substituting basal diet of natural pasture grass hay with urea treated maize stover on feed intake, milk yield and milk composition of Holstein Friesian cows. MSc Thesis, Haramaya University, Haramaya, Ethiopia.

Hagos ,T. 2007. Supplementation of Afar rams with graded levels of mixtures of protein and energy sources: effects on feed intake, digestibility, live weight and carcass parameters. Haramaya University, Ethiopia. M.Sc Thesis. Haramaya University of Agriculture. Alemaya..

Hagos Hadgu, 2014. Effect Of Supplementation Of Concentrate Mixture, Dried Local Brewery Byproduct (*Atella*), *Faidherbia Albida* And *Sesbania Sesban* on The Performance of Local Sheep Fed Hay Basal Diet. Msc Thesis Haramaya University .

Harris, B., VanHom, H.H.2003. Water and its importance to animals. University of Florida, IFAS extension, CR1017, pp.1-8.

Hishashi M, Lagan P, Noreen M, Tangah J, Jumrafiah A and Sukor K (2006), “Importance of Natural Licks for the Mammals in Bornean Inland Tropical Rain Forests”, *Ecol. Res.*, Doi 10.1007/S 11 284-006-0313-4.

Ibrahim, H. 1998. Small Ruminant Production Technique. ILRI manual 3. International Livestock Research Institute (ILRI).Nairobi, Kenya. pp207.

Jalel Fikadu, 2013. Effect of Feeding Graded Levels of Wild Silver Leaf Desmodium (*Desmodium Uncinatum*) on Feed Intake, Digestibility, Bodyweight Change And Carcass Characteristics of Horro Sheep Fed A Basal Diet of Natural Pasture Hay Msc Thesis Haramaya University. 68p

Jemberu Dessie, 2008. Effects of Supplementation of Simada Sheep with Graded levels of Concentrate cake on feed intake, Digestibility and body weight parameters. An MSc Thesis Presented to the School of Graduate Studies of Haramaya University. 68p

Jumba, I.O., Suttle, N.F., Hunter, E.A., Wandiga, S.O., 1996. Effects of botanical composition, soil origin and composition on mineral concentrations in dry season pastures in western Kenya. In; Appleton, J.D., Fuge, R., McCall, G.J.H (eds) Environmental Geochemistry and health. Geological society special Publication No. 113, London, pp.39-45.

Kabaija, E. and Little, D. 1987. Composition of native mineral supplements in Ethiopia. Forage networks in Ethiopia newsletter, 15:24-28.

Kabaija, E. and Little, D. 1988. Nutritive quality of forage in Ethiopia with particular reference to mineral elements. pp.423-427. Proceeding of the 3rd workshop held at the international conference center, Arusha, Tanzania on pasture network for Eastern and Southern Africa (panesa). ILCA, Addis Ababa.

Kabaija, E. and D. Little. 1989. Potential of agricultural by-products as source of mineral nutrients in ruminant diet. In: Overcoming Constraints to the Efficient Utilization of Agricultural By-products as Animal Feed (Eds A.N. Said and A.M. Dzowela) 379-394 p. Proceedings of the Annual Workshop Held at Institute of Animal Research, Marken Station, Bamenenda, Cameron, 20-29 October 1987, ARNAB, ILCA Addis Ababa

Kassahun Awgichew and Solomon Abegaz, 2008. Breeds of sheep and goats. pp 5-26. In:Alemu Yami and R.C. Merkel (Eds.). Sheep and goat production handbook for Ethiopia.Ethiopian sheep and goat productivity improvement program, USAID.

Kellems, R.O. and Church, D.C. 1998. Livestock feeds and feeding, 4th edition, Prentice-Hall, Inc., New Jersey, USA.

Khan, Z.I., Ashraf, M., Valeen, E.E. 2006. Forage mineral status evaluation: The influence of pastures. Pak.J., 38(4) pp. 1043-1054.

Larsen, J.W., Constable, P.D. and Napthine, D.V. 1986. Hypocalcaemia in ewes after a drought. *Australian Veterinary Journals*, 63:25-26.

Lega Hidha Woreda Pastoral Development Office, 2019

Leng, R.A. 1991. Application of biotechnology to nutrition of animals in developing countries. FAO Animal Production and Health Paper. Rome, Italy.

Little, D. 1984. The dietary mineral supplement of ruminants: implications for utilization of tropical fibrous agricultural residues. Doyle , P.T. The utilization of fibrous agricultural residues as animal feeds. International development program of Australian Universities and College. Canberra, pp: 260-283.

Mayland, H.F., Kramer. T.R.. Johnson. W.T., 1996. Trace elements in nutrition and immunological response of grazing livestock. In: *Grazing livestock Nutrition Conference Proceedings.* University of Wyoming, Jackson, Wyoming.

McDonald P, Edwards R A and Greenhaugh J F (Eds.) (1995), Animal Nutrition, 5th Edition, pp. 33-46, Longman Group (UK) Ltd., England.

McDowell, L.R. and Conrad, J. H. 1977. Trace mineral nutrition in Latin America. World Animal Review, 24: 24- 24.

McDowell, L.R., Conard, J.H., Ellis, G.L and Loosli, J.K. 1983. Minerals for Grazing Ruminants in Tropical Regions. Department of Animal Science Department, Center for Tropical Agriculture. University of Florida, Gainesville, Florida.

McDowell, L. R. 1986. Nutrition of Grazing Ruminants in Warm Climates. Academic Press, Inc., Harcourt Brace Jovanovich, Publishers. Pp 443.

McDowell, L.R. 1992. Minerals in Animal and Human Nutrition. Academic press. New York. 524p.

McDowell, L.R., Conrad, J.H., Glen Hembry, F., 1993. Minerals for Grazing Ruminants in tropical Regions, 2nd edn. University of Florida, Gainesville.

McDowell, L.R. 1997. Minerals for Grazing Ruminants in Tropical Regions. Animal Sciences Department, Center for Tropical Agriculture. University of Florida. Bulletin 3rd ed. 83 p.

McDowell, L.R. and Valle, G.C. 2000. Major minerals in forages. pp 373-375. In: D.I.N Givens, E., Owen, R.F., Axford and Omed, H.M. Forage Evaluation in ruminants Nutrition. Biddles Ltd, Guildford and King's Lynn, UK.

McDonald, P., R.A. Edwards, J.F.D. Greanhalgh and C.A. Morgan. 2002. Animal nutrition. 6th ed. Ashford color press, Gosport. 693p.

Mehlich, A. 1984. Mehlich-3 soil test extractant: a modification of Mehlich-2 extractant. Commun. Soil *Sci. Plant Anal*. 15(12): 1409-1416.

Mertz, W. 1987. Trace elements in human and animal nutrition (5th ed). Academic press, London, UK. pp480.

Minson, D.J. 1981. The effect of feeding protected and unprotected casein on the milk production of cows grazing rye grass. *Journal of agricultural science*, 96:239-242.

Minson, D.J.1990. Forages in ruminant nutrition. Academic press, San Diego California, pp.208- 229.

Mohammed,Y. Kurtu, Mugerawa, E.M. and Edo, D. 1989. Effect of supplementation with lake soil on the growth of Arsi sheep.

Muluken Zeleke, Yisehak Kechero and Mohammed, Y. Kurtu .2015. The Comparative Nutrient Utilization and Economic Efficiency of Mineral Supplements with Concentrates in Sheep. *European Journal of Applied Sciences* .7 (5): 226-234.

Mulu Moges, Berehan Tamir and Alemu Yami, 2008. The effect of Grass Hay with different level of Brewer's Dried Grain on feed intake, digestibility and body weight gain intact Wogera lumbs. *East African J. of Sci.* Vol.2, Num.2. June 2008. Issn 1992-0407, pp 105-110.

Nega Tolla, Pravee Vijchulata, Pornsri Chairatanayuth and Suwapong Sawsdiphanich. 2006. Milk yield and milk compositions of lactating cows fed hay and concentrate supplement with/without cottonseed cake and/or Bole (Lake Soil). *Kasetsart J (Nat Sci)* .40:657-667.

NRC (National Research Council). 1985. Nutrient Requirements of Sheep. National Academy of Sciences, Washington, D.C. pp75.

Norton, B. W. 1982. Nutritional Limits to Animal Production from Pastures. pp. 89–110.

Ochieng O, Onesmus M. N and Levi M. M. 2015. Effects of Natural Licks on Feed Intake, Nutrient Digestibility, Milk Production and Quality in Kenya Alpine Dairy Goat Ration Department of Animal Sciences, Chuka University Kenya *Int. J. Agric.Sc & Vet.Med.*Vol. 3, No. 4.

Olsen, S. R., C. V. Cole, F. S. Watanable, and L. A. Dean. 1954. Estimation of available phosphorous in soils by extraction with sodium bicarbonate. USDA, Circular 39: 1- 19

Pastoral Areas Development Study (PADS). (2004). Pastoral Areas Development Plan (PADP), General executive summary, Ministry of Agriculture and Rural Development, Addis Ababa, Ethiopia. 258pp.

Poland, W.W, E. Grings, J. Karn and L. Manske, 2001. Mineral concentration and availability of forages for grazing livestock in the Northern Great Plains. Dickinson Research Centre. Annual Report.

Preston, R.L. and Linser, J.R. 1985. Potassium in animal nutrition. In: Munson, R.D. (ed.) Potassium in Agriculture. American Society of Agronomy, Madison, Wisconsin, pp. 595-617.

Puls, R. 1994. Mineral Levels in Animal health. Diagnostic Data. Sherpa International. Canada.

Reid, R.L. and Horvath, D. J. 1980. Soil chemistry and mineral problems in farm livestock. A review: *Animal Science and Technology*, 5:95-167.

Rice C G (2010), “Mineral Visitation by Mountain Goats (Oreamnos americanus)”, Canadian Field Naturalist, Vol. 124, No. 3,pp. 225-237

Rick, M. 2007. Minerals. Small ruminant Series. Uvalde, Texas Agricultural Extension Service. Retrieved on December 20, 2006 http://sullontx.tamu.edu/publication/ACF275/.

Riley, R.R., Savell, J.W., Shelton, M. and Smith, G.C. 1989. Carcass and offal yields of sheep and goats as influenced by market class and breed. *Small Ruminant Research, 2(3).*

Rojas, L.X. and McDowell L.R. 1997. Mineral imbalance in South America and their effect on livestock production. Pp. 129-131. Proceeding of International conference on livestock in the tropics. University of Florida, Gainsville.

Samanta, A. and Samanta, G. 2002. Mineral profile of different feed and fodders and their effect on plasma profile in ruminants of West Bengal. *Indian Journal of Animal Nutrition,* 19:278-281.

Satish Kumar. 2003. "Management of infertility due to mineral deficiency in dairy animals". In proceedings of ICAR summer school on "Advance diagnostic techniques and therapeutic approaches to metabolic and deficiency diseases in dairy animals". Held at IVRI, Izatnagar.

SAS (Statistical Analysis System), 2008. SAS Version 9.2 User's Giude, SAS Institute Inc., Cary, NC, USA.

Serra, S.D., A.B. Serra, T. Ichinobe and T. Fujihara. 1996. Trace element from selected Philippine forages. *Asian-Aust. J. Anim. Sci.*, 3: 7-13.

Seyoum Bedeye, Getenet Assefa, Abate Tedla and Dereje Fikadu. 2001. Present status and future direction in feed resources and nutrition research targeted for wheat based crop livestock production system in Ethiopia: pp: 207-226.

Shamat, A.M., Babiker, LA.. Mukhtar, A.M.S, Ahmed, F.A. 2009. Seasonal and Regional variations in mineral content of some important plant species selected by Camels (*Camelus dromedaries*) in arid and semi-arid lands of Sudan. *Journal of Applied Sciences Research* 5 (10), pp. 1676-1684.

Shimelis H/Markos, 2017. Effect of Different Level of Opuntia Pear Cladodes and Bitter Leaf Supplementation on Growth and Carcass Characteristics of Arsi-Bale Sheep Consume Lentil Straw basal diet. MSc. Thesis, presented to School of Graduate Studies of Haramaya University.

Simret Betsha . 2005. Supplementation of graded levels of peanut cake and wheat bran mixtures on nutrient utilization and carcass parameters of Somali goats. M.Sc Thesis. Alemaya University of Agriculture, Alemaya, Ethiopia.75p.

Simiret Betsha and Slomon Melaku, 2008, Body weight and Carcass characteristics of Somali goats fed hay supplemented with graded levels of peanut cake and wheat bran mixture. http:// www. Springer link.com/content/166266668, 7611m /.

Singh, G.P. and Oosting, S.J. 1992. A Model for Describing the Energy Value of Straws. Indian Dairyman XLIV, 44: 322-327.

Sisay Tilahun, Pravee Vijchulata, Pornsri Chairatanoyuth and Suwapong Swasdiphanich. 2007. Effects of natural mineral soils on body weight and liver minerals of Black head Somali sheep in Ethiopia. Kasetsart J., 41:288-299.

Soetan, K.O., Olaiya, C.O., Oyewole., 2010. The importance of mineral elements for human and domestic animals and plants. A review of *African journal of Food science.*

Solomon Bogale. 2004. Assessment of livestock production system and feed resource base in Sinana-Dinsho district of Bale highlands Southeast Oromia. MSc Thesis, Alemaya University, Alemaya, Ethiopia.

Solomon Gizaw, Azage Tegene, Brhanu Gebremedhin and Hockstra, D. 2010. Sheep and goat production and marketing system in Ethiopia; characteristics and strategies for improvement. IPMS/ILRI Addis Ababa, Ethiopia.

Stoszek, M.J. 1976. Copper deficiency in the cattle in the Klamath basin. PhD. Thesis,Oregon state Univ. Corvallis. Cf., Mayland, G.F Shew marker and R.C.bull.1997. Soil ingestion by cattle grazing crested wheat grass. J. Range management, 30:264-265.

Smart, M.E., Cohen, R., Christensen,D.A., Williams, C.M., 1986.The effects of sulphate removal from drinking water on plasma and liver copper and zinc concentrations of beef cows and their calves. *Canadian journal of Animal science* 66, 669-680.

Smith. G.S.. Middleton. K.R.. 1978a. A classification of pasture and fodder species according to their ability to translocate sodium from their roots to aerial parts. *New Zealand journal of experimental agriculture* 6, 183-188.

Susan, S. 2003. An introduction of feeding small ruminants. Mary land cooperativeExtension, Mary land small ruminant page. www.sheepandgoat.com.

Susan Hosford. 2013. Salt and minerals for sheep. Sheep and Goat Management in Alberta. Nutrition Module. Alberta Agricultural Development. 4p.

Suttle, N.F. 1991. Mineral supplementation of low quality roughages. In: Proceedings of Symposium on Isotope and Related Techniques in Animal Production and Health. International Atomic Energy Commission, Vienna, pp. 101–104.

Suttle, 2010. Mineral nutrition of livestock 4th ed.MPG books group,UK

Szefer, P., and J. O., Nriagu ,2007 .Mineral components in foods, chemical and fuctional properties of food components series, CRC press, Tylor and Francis group, FL, USA. pp: 163-195.

Teklu Wegi. 2016. Effects of feeding different varieties of faba bean (*vicia faba* l.) straws with concentrate on feed intake, digestibility, and body weight gain and carcass characteristics of Arsi-bale sheep. MSc. Thesis, presented to School of Graduate Studies of Haramaya University.85pp

Temesgen Desalegn. 2012. Assessment of some critical mineral elements in feed, Nonconventional mineral supplements and serum of Camels (camelus dromedarius) in

Jijiga woreda. An Msc Thesis Submitted to School of Graduate Study of Haramaya University.

Temesgen Desalegn. 2018. Mineral status of major feeds, Indigenous mineral supplements and seum of Ruminant and effect of indigenous mineral supplementation on performance of Woyto Guji Goats in Wolaita lowland, Southern Ethiopia, Phd Dissertation submitted to Hawassa University.

Ternouth, J.H. 1990. Phosphorus and beef production in Northern Australia. 3. Phosphorus in cattle- a review. Tropical Grassland, 24:159-169.

Tilahun Mengistu, 2018. Effect of Replacing Noug Seed Cake with Stinging Nettle (*Urtica Simensis*) Leaf Meal on Feed Intake, Digestibility, Growth Performance and Carcass Characteristics of Arsi-Bale Sheep. Msc Thesis Submitted To Hawassa University. 78p

Tisch, D.A., 2006. Minerals. In: Animal feeds, feeding and nutrition, and ration evaluation, accessed at http//www.high.beam.com/doc/lGl-184231974.html.

Underwood, E.J. 1981. The Mineral Nutrition of Livestock. Common wealth Agricultural Bureaux, London. Potassium metabolism of domestic ruminants: a review. *Journal of Dairy Science*, 49:1868-1872.

Underwood E.J., Suttle N.F, 1999. The mineral nutrition of livestock 3rd edition, CABI publishing.

Van Soest P J and Robertson J B .1985. Analysis of forages and fibrous foods. A Laboratory Manual for Animal Science 613, Cornell University, USA.

Weaver, C.M. and Heaney, R.P. 1999. Calcium in Modern Nutrition in Health and Disease, 9th ed., pp. 141-155.

Wilkinson, S.R., Welch,R.M., Mayland, H.F., Grunes, D.L., 1990. Magnesium in plants: Uptake, distribution, function and utilization by man and animals. In: Metal ions In biological systems, Vol.26, compendium on magnesium and its role in biology, nutrition and physiology, Mercel Dekker, New York, USA, pp.3-56.

Wondewsen Bekele. 2010. Effect of substitution of concentrate mix with *Sesbania sesban* on feed intake, digestibility, body weight change, and carcass parameters of Arsi-Bale sheep fed grass hay. MSC Thesis Submitted to School of Graduate Studies, Haramaya University, Ethiopia. 94

Yano, F., Yano, H. and Breves, G. 1991. Calcium and phosphorus metabolism in ruminants. In: Proceedings of Seventh International Symposium on Ruminant Physiology. Academic Press, New York, pp. 227-295.

Yayneshet, T. 2010. Feed resources availability in Tigray region, northern Ethiopia, for production of export quality meat and livestock. Examples from selected Woredas in Tigray Region State. Consultation report submitted to the Ethiopia Sanitary & Phytosanitary Standards and Meat Marketing Program, 87 pp.

7. APPENDIX

Appendix table 1.Summary of ANOVA for dry matter and nutrient intake of experimental sheep

Parameters	DF	MS	SEM	F value	Pr>F
Hay DMI	4	60065.716	3.19	2.62	0.0334
CM MI	4	34388.6407	0.17	9325.16	<.0001
TDMI	4	182120.6122	3.21	7.94	<.0001
OMI	4	159701.2191	3.11	7.43	<.0001
CPI	4	4374.84784	0.28	25.95	<.0001
NDFI	4	94255.2175	2.45	7.03	<.0001
ADFI	4	21373.89341	1.44	4.61	0.0010
ADLI	4	4372.82340	0.19	62.33	<.0001
ASH	4	3421.30645	0.38	10.59	<.0001

Appendix table 2.Summary of ANOVA for Mineral intake (macro and micro) of experimental sheep

Parameters	DF	MS	SEM	F value	Pr>F
Ca	4	305.109430	0.19	1221.05	<.0001
P	4	5.69689888	0.002	2442.11	<.0001
K	4	61.8857453	0.015	145.51	<.0001
Na	4	99.1544640	0.009	107954	<.0001
Mg	4	24.13304991	0.0054	1047.88	<.0001
Cu	4	73.5239353	0.0077	21795.3	<.0001
Zn	4	718.146176	0.098	35.41	<.0001
Fe	4	120772973.7	9.80	77423.8	<.0001
Mn	4	44884.6846	0.20	2794.72	<.0001

Appendix table 3.Summary of ANOVA for body weight measurements of experimental sheep

Parameters	DF	MS	SEM	F value	Pr>F
IBW	4	0.04840000	0.36	0.01	0.9997
FBW	4	5.41960000	0.38	1.71	0.1883
BWC	4	4.78640000	2.15	29.22	<.0001
ADG	4	590.913580	0.0019	29.22	<.0001
FCE	4	0.00043599	0.19	33.17	<.0001

Appendix table 4.Summary of ANOVA for carcass characteristics of experimental sheep

Parameter	DF	MS	SEM	F value	Pr>F
Slaughter weight	4	5.41960000	0.37	1.71	0.1883
E BW	4	5.61740000	0.34	2.39	0.0852
H C W	4	2.16340000	0.22	2.09	0.1205
Dressing percentage					
Slaughter weight	4	5.76194056	0.43	2.23	0.1018
Empty body weight	4	2.91490676	0.35	0.59	0.6737
REMA	4	1.28000000	0.20	1.30	0.3030

Appendix table 5.Summary of ANOVA for main carcass components of experimental sheep

Parameters	DF	MS	SEM	F value	Pr>F
Loin & Rack	4	41000.0000	30.10	2.07	0.1228
Forelegs	4	74400.0000	56.24	0.93	0.4664
Hind legs	4	153600.0000	58.0	2.19	0.1073
Brisket	4	41400.0000	28.33	2.62	0.0657
Ribs	4	45600.0000	29.73	2.62	0.0656
Shoulder &Neck	4	15400.00000	32.84	0.53	0.7118

Appendix table 6.Summary of ANOVA for Edible offal of experimental sheep

Edible offal	DF	MS	SEM	F value	Pr>F
Tongue	4	141.1400000	2.57	0.83	0.5196
Heart	4	70.0400000	2.35	0.46	0.7624
Kidney	4	100.940000	3.44	0.30	0.8735
Liver	4	337.340000	5.05	0.48	0.7481
Stomach	4	3420.56000	10.06	1.45	0.2534
SiLi	4	5080.86000	11.82	1.60	0.2131
Kidney fat	4	73.6600000	1.79	0.91	0.4784
Omental fat	4	434.260000	3.53	1.51	0.2373
Fleece	4	8612.06000	15.53	1.56	0.2229
Total EOs	4	73835.5400	42.53	1.87	0.1554

Appendix table 7.Summary of ANOVA for Non edible offal of experimental sheep

Non EOs	DF	MS	SEM	F value	Pr>F
Head-Tongue	4	4751.26000	24.47	0.28	0.8880
Skin	4	7400.00000	27.97	0.34	0.8502
Blood	4	5454.24000	13.50	1.25	0.3240
Feet locks	4	426.500000	5.54	0.51	0.7290
Penis &testicle	4	1199.960000	5.40	1.89	0.1512
Gut content	4	2600.00000	87.12	0.01	0.9997
Lung + trachea	4	1127.340000	5.93	1.36	0.2843
Spleen& pancreas	4	19.66000000	1.81	0.21	0.9310
Total NEOs	4	0.02840394	0.12	0.07	0.9907

BIOGRAPHICAL SKETCH

The author was born at Lega Hidha district, Bale Zone of Oromia Regional state in 1991 from his father Taha Musa and his mother Hajara Abdo. He attended his Elementary and Secondary School Education at Beltu Secondary School. He attended his High School and Preparatory Education at Beltu High School and Ginnir Preparatory respectively. In 2009/2010 he joined Adama Science and Technology University and graduated on 12 July, 2012 with BSc in Animal science. After graduation, he was employed as Instructor at Agarfa Agriculture Technical Vocational Educational and Training College in November 2012. After 3 years of service, he joined the School of Graduate Studies of Hawassa University in 2015 to pursue MSc degree in Animal Production.