JIMMA UNIVERSITY COLLEGE OF AGRICULTURE AND VETERINARY MEDICINE

EVALUATION OF LOCAL FORAGE (*MOMORDICA FOETIDA SCHUMACH*) REPLACEMENT WITH CONCENTRATE ON FEED INTAKE, DIGESTIBILITY, AND BODY WEIGHT GAIN OF BONGA SHEEP FED ON DESHO GRASS HAY AS A BASAL DIET

BY

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I declare that the research work has not been done anywhere else before or is not part of ongoing work.

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We have agreed to supervise the proposed research work. We have evaluated the contents of the proposal and found it to be satisfactory, complete according to the standards and formats of the university. We have also verified that the work has not been done anywhere else before.

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DEDICATION

This work is dedicated to my wife Simegn Wondimu, my Sons Estifanos Kochito and Dagim Kochito. They have sacrificed something in their life up to the accomplishment of this study.

STATEMENT OF THE AUTHOR

I hereby declare that this thesis is my original work and all sources of materials used for this work have been duly acknowledged. This thesis has been submitted in partial fulfillment of the requirements for MSc. degree in Animal Production at Jimma University, College of Agriculture and Veterinary Medicine and is deposited at the University's Library to be made available to borrowers under the rules and regulations of the University library. Brief quotations from this thesis are allowable without special permission provided that accurate acknowledgment of the source is made. Requests for permission for extended quotation from or reproduction of this manuscript in whole or in part may be granted by the head of the major department or the Dean of the college or Coordinator of the Graduate Program or Head of the Department of Animal Production when in his or her judgment the proposed use of the material is in the interests of scholarship. However, permission must be obtained from the author in all other instances.

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BIOGRAPHICAL SKETCH

The author was born at Decha woreda, Kaffa Zone South West Regional State on 15th May 1981 from his mother Worke Haile and his father Yebo Tegegn. He attended his Elementary and Junior Secondary School Education at Teppi Elementary and Junior Secondary School respectively and High School Education at Teppi Senior Secondary School. He completed his high school education in 2002 and joined Dilla ATVT College and graduated on 07 August 2006 with a college diploma. in Animal Production. After his graduation, he was employed as a livestock extension field expert by Kaffa zone, Gesha Woreda from August 10, 2006, to March 2016. He has again joined Mizan Tippi University in 2010 attained his Bsc program in animal production in the off-summer program and was awarded BSC In December 2014. On March 2016 he transferred from Gesha woreda agriculture office to Kaffa zone livestock department and served as a zonal livestock expert until he left in September 2018 to pursue his MSc. study in Animal Production at Jimma University.

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LIST OF ABBREVIATIONS

ADF	Acid detergent fiber
ADG	Average daily gain
ADL	Acid detergent lignin
AOAC	Association of Official Analytical Chemists
BAPH	Bureau of Animal Production and Health
CF	Crude fiber
CP	Crude protein
CSA	Central Statistical Agency
DM	Dry matter
DOMD	Digestible organic matter in dry matter
FAO	Food and Agricultural Organization
GDP	Gross domestic product
ILCA	International Livestock Centre for Africa
IRLI	International Livestock Research Institute
IVDMD	*In vitro* dry matter digestibility
IVOMD	*In vitro* organic matter digestibility
LAB	Lactic acid bacteria
ME	Metabolizable Energy
MJ	Mega Joule
MRR	Marginal Rate of Return
NDF	Neutral Detergent Fiber
NFC	Non-Fiber Carbohydrate
NH3-N	Ammonia Nitrogen
NI	Net Income
RC	National Research council
SAS	Statistical Analysis System
SWC	Water Soluble Carbohydrate
TDN	Total Digestible Nutrient
TLU	Total Livestock Unit
TR	Total Revenue

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1. INTRODUCTION

Livestock farming is the part and parcel of the Ethiopian economy accounting for 25.3% of the national gross domestic product (GDP) and 39-49% of agricultural GDP (including the non-monetary values) and over 50% of household income (Shapiro *et al*., 2017). Livestock provides draught power and manure for crop production and are sources of food (milk, meat and egg) and industrial raw materials (hides, skin and wool). They contribute significantly to economic growth and poverty reduction. The livestock population of the country (based on sedentary areas as well as pastoral area) is estimated to be 70.2 million cattle, 42.9 million sheep, 52.4 million goats, 2.15million horses, 0.38 million mules,10.8 million donkeys, 8.1 million camels and 57 million poultry (CSA, 2019). However, the livestock production system is largely traditional and characterized by low input-output, suffering from various challenges among which insufficient feeds and feeding systems are prominent.

According to CSA (2019), the country is endowed with various feed resources having different feed use shares, which encompassed natural pasture grazing (54.54%), crop residues (31.13%), hay (7.35%), agro-industrial byproducts (2.03%), improved feed (0.57%) and others like animal byproducts, vegetable and fruit wastes (4.37%). However, most of the feed resources are low in quality and quantity, adversely affecting livestock performances (Adugna, 2008, Shapiro *et al.*, 2017). The use of grain-based concentrates for ruminant feeding is little practical due to competition with human food and monogastric animals and the high cost of production. Besides, the introduction and adoption of improved forage crops into the farming system have been constrained by the lack of land and forage seeds (Adugna *et al*., 2012).

On-farm livestock feed insufficiency is aggravated by changes in land-use patterns, frequent drought occurrence, increased feed cost and livestock population, and limited use of feed technologies. The expansion of crop production has significantly reduced formerly known natural pasture lands in the highlands. Feed accounts for 75-80% of the total costs of livestock production in the country (Demisse, 2017) and it is critically deficient in the dry season. This, in turn, increases the market price and reduces the supply of quality products, which impairs competitiveness in markets.

In Ethiopia, feed production, its availability and requirement vary with the production system and agro-ecology. According to Shapiro *et al.* (2017), the annual national feed availability was estimated to be 145.2 and 81.3 million tons of DM in good and bad years (based on rainfall intensity), respectively. Positive feed balances (20.6 and 3.6 million tons DM per year) were reported for agro-pastoral areas only in good and average years. Conversely, negative feed balances (21.5 and 48.7 million tons DM in average and bad years) were reported for the mixed crop-livestock systems, implying that most animals are fed below their DM requirement (2.5-3% body weight) (Shapiro *et al.*, 2017).

Feed deficit in quality and quantity has adverse effects on animal performances, levels of production, and economic benefits. Undernourished farm animals respond little to production interventions (*e.g.,* artificial insemination and estrus synchronization) and are susceptible to diseases and parasites. Feed deficit also restricts feedlot animals' expression of genetic growth potential, allowing them to take a longer time to finish. Feed remains the major challenge for most smallholder and commercial feedlots and dairy farms in the country, leading to withdrawal from the business and reduced stock size. It also limits the number of new farms coming into the business and increases the market price of products for consumers.

As a coping strategy to feed the deficit, looking for alternate local forages and improving their utilization through proper processing and conservation is imperative. In this regard, local forage species of *Momordica foetida schumach* is potentially produced in most African countries, but less exploited as conventional livestock feed in Africa and Ethiopia. *Momordica foetida schumach* is grazed by cattle in Sudan. Leaves are used as fodder (Kenya, Tanzania) and are said to be especially suitable for fattening rabbits. The forage is produced and available in all seasons of the year at the study area, which coincides with the period of feed shortage. However, feeding practice by farmers is not well supported technically for livestock feeding.

The use of multipurpose shrubs and trees are regarded as good fodder sources in the country. Among those, tree foliage and shrubs take a large share of ruminant feed sources in arid and semi-arid areas of the country. *Momordica foetida* schumach is a perennial vine climbing forage found in tropical and east Africa including Ethiopia. *M. foetida* is a perennial climbing forge that dominates swampy areas as a weed and forest edges of tropical forestland. Momordica foetida (Cucurbitaceae) is believed to be curative medicine for different types of human diseases in most parts of tropical Africa like South Africa, Uganda, Kenya, and Ethiopia (Muronga M.etal 2021).

The leaf extract of *M. foetida* can be effective for antidiabetic, abortifacient, anthelmintic, contraceptive, and Antimalarial. Also, *M .foetida* are collected from the wild and eaten after boiling as a vegetable in Gabon, Sudan, Uganda, Tanzania, and Malawi (Mashudu Muronga et al., 2021). The plants are grazed by cattle (Ruffo, 2002) in Sudan. *M. foetida* is used as a fodder plant and is believed to be useful fodder to fatten rabbits in Kenya and Tanzania (Mashudu Muronga et al., 2021). Thus, there are reports from Kenya that cattle avoid it and that it has a bad smell when crushed in animals' mouths (Mashudu Muronga et al., 2021). *M. foetida* as its name indicates has a fetid "*bad smell*" that cannot be frequently grazed by ruminants and is a widely distributed forage having a weedy character that climbers on other trees and shrubs dominate later. The *forage* is more dominant at forest edges and farmlands of the study area. *M. foetida has* a nutritional composition per 100g edible portion is; energy 92kj (22kcal), protein 3.3g, fiber 3.2g, calcium 1.1mg, iron (Fe)3.4mg, zinc (Zn)0.4mg, Beta-carotene 5.4mg, foliate40?g, ascorbic acid 20.6mg (Steyn, 2001) by its greenly color at the time of the rainy season and can produce large biomass during this period. In recent years farmers of the study area tried to feed *M. foetida* as a supplement feed for their small ruminants during its abundance period. The trend of farmers initiates the finding of alternative tropical forages as animal feed resource and develops the use of conventional feed resources in the animal's sub-sector. Therefore, feeding alternative feeds from *M. foetida* for ruminants increases production and productivity because of its easy accessibility, wide variety, and it can reduce the cost of the requirement for expensive concentrate feeds. The forages improve livelihood through better livestock performance with their adaptation to the natural environment and adoption by the farmer can upgrade its utilization.

Despite the abundant availability of *M. foetida* species in Ethiopia, they are less exploited as livestock feed, and farms in such areas are suffering from feed shortage as elsewhere in the country. Moreover, limited research have been done on the production, availability, utilization, management (conservation and processing) of *M. foetida* as alternative livestock feed in the country. In line with the development of feed industries, the production volume of the local feed is expected to raise many folds, calling for proper manipulation for their efficient feed use. Furthermore, livestock feeding packages based on local forage utilization need to be developed. Therefore, this research was conducted on: Evaluation of local forage (*Momordica foetida schumach*) replacement with concentrate on feed intake, digestibility and body weight gain of

Bonga sheep fed on desho grass hay as a basal diet. Hence, also the study was initiated with the following specific objectives:

- To evaluate feed intake, digestibility, and body weight gain of yearling Bonga sheep fed on local forage (*Momordica foetida schumach)*
- To evaluate the replacement value of *yuumbiraa`o (M. foetida)* for concentrate on performance of Bonga sheep
- To analyze economic feasibility of feeding local forages

2. LITERATURE REVIEW

2.1. Sheep Production in Ethiopia

Sheep is the second most important species of livestock in the country (Solomon Gizaw *et al*., 2008). Ethiopia's sheep populations are estimated at 30.70 million and the trend is increasing from time to time (CSA, 2017). Sheep in Ethiopia are reared mainly by the smallholder farmers and grazed in small flocks on communal open natural pasture (Kassahun Awgichew, 2000). In addition production potential of different indigenous sheep breeds are characterized by small body size, produce low quality wool, have low lamb growth rate, and quite a high lamb mortality (Markos Tibbo *et al*.,2006). The mean carcass production of such sheep is estimated at around 10 kg (FAO, 2009), which is low as compared to the average of sub-Saharan countries with annual off-take rates of around 33% (EPA, 2002). Indigenous sheep breeds have great potential to contribute more to the livelihoods of the people in low-input, smallholder crop-livestock and pastoral production systems (Kosgey and Okeyo, 2007). There are, however, several constraints that affect the productivity of sheep such as mortality, feed scarcity and inadequate indigenous breed utilizations to production (Tsedeke, 2010). Despite the low productivity of indigenous breeds compared to temperate breeds, their ability to survive and produce in the harsh and mostly unpredictable tropical environment is remarkable.

2.2 Bonga Sheep

According to the report of (ESGPIP, 2009), there are about 14 traditionally recognized sheep populations in Ethiopia. The sheep types are named after their geographic location and/or the ethnic communities keeping them and Bonga sheep is one of the countries' sheep found around southwest Ethiopia Kaffa Zone. Bonga sheep is widely distributed in the southwest parts of the country in wet highland ecologies.

Sheep production systems were classified using criteria that included degree of integration with crop production and contribution to livelihood, level of input and intensity of production, agro-ecology, length of growing period and relation to land and type of commodity to be produced. There are three major production systems, these are Highland barley-based production system, Mixed crop-livestock system, Pastoral and agro-pastoral production systems ESGPIP,(2008).

The International Center for Agricultural Research in the Dry Areas (ICARDA), International Livestock Research Institute (ILRI), and BOKU University, Vienna in collaboration with national and regional research systems in Ethiopia initiated community-based breeding programs in four regions representing different Agro-ecologies that are the habitats of four indigenous sheep breeds (Afar, Bonga, Horro, and Menz) (Haile et al., 2011). According to Haile *et al.*, (2014) and Gutu *et al.* (2015), preliminary results of the evaluation carried out on the performance of the breeding programs indicated a promising result of the breeding programs in three communities (Bonga, Menz and Horro) and the efforts of community-based breeding programs for small ruminants were successful in the Country (FAO, 2015).

Bonga sheep community-based breeding program was started in the year 2012 and it is based on selecting viable phenotypic traits. Community-based breeding programs have emerged as a viable option to bring about genetic gains that improve sheep productivity and ultimately enhance smallholder farmers' livelihoods. Such community-based breeding programs (CBBP) can be described as a system of genetic resources and ecosystem management in which the livestock keepers are responsible for the decisions on identification, priority setting and the implementation of activities in conservation and sustainable use of the livestock (Rege, 2003; Tesfahun et al., 2008). Bonga sheep breed is one of the known sheep breeds are known selected for the improvement of some economic traits, twin or triple birth, mothering ability, weaning weight, lambing, lambing interval, litter size, and ewe productive life and can produce under poor housing and feeding management (Edea et al., 2012). As a result of sheep being managed by resource-poor smallholder farmers under traditional and extensive production systems, the level of production and productivity of the livestock sector is under question (Solomon et al., 2011). Edea,(2008) reported that the Bonga sheep depending on quantitative traits Bonga for males were 29.70 ± 1.17kg, 68.27 ± 0.89cm, 70.0 ± 1.026cm, 66.53 ± 0.85cm, 20.85 ± 0.97cm and 35.40 ± 0.96cm, for body weight, body length, chest girth, wither height, tail circumference and tail length, respectively. similarily for male Horo breed was 31.66 ±1.23kg, 69.30 ± 0.94cm, 76.12 ±1.08cm and 71.66 ± 0.90cm for body weight, body length, chest girth and wither height. Both have brown coat color, but Bonga sheep were polded horned. Mean scrotal circumferences in Bonga and Horro rams were 23.02 ± 0.47cm and 27.17 ± 0.48cm, respectively (Edea,2008). Selection for breeding male and females based up on Body size, tail conformation and color are given due emphasis in selecting breeding animals; and parameters such as chest girth, tail circumference, body length, and pelvic width are the most important body measurements required for selection and breeding in Bonga sheep. Therefore, this thesis will also show useful quantitative traits of Bonga sheep under intensive management by replacing totally or partially concentrate mixture with *M.Foetida Schumach* leaves on DM based on feed intake, body weight gain, and digestibility.

2.3 Red Meat Production in Ethiopia

Ethiopia is endowed with 51 indigenous ruminant livestock breeds (23 cattle, 14 sheep, 14 goats) (PSRC, 2017) and camel, which generates red meat representing about 96.3% of the total meat production (cattle- 79.98%, sheep- 9.78%, goat- 5.58, camel- 0.91%) (Shapiro *et al*., 2017). These animals are raised by pastoralists, high-land smallholder farmers, and commercial feedlots. Despite the presence of a large livestock population and genetic resources, the country contributes about 0.2 % to global meat production being ranked 55th in the world (AACCSA, 2015). The high contribution of ruminant livestock to domestic meat production is due to an increase in the number of animals slaughtered rather than by improved productivity.

The demand for meat is rising in developing countries driven by an increase in the human population, urbanization, and income of the people (Delgado *et al*., 1999). Per capita meat consumption in Ethiopia is about 9 kg, of which red meat accounts for 94%. Unless intervention is made in Ethiopia, the current increase in the human population (2.9% per annum), urbanization (3.57% per annum), and income will lead to a deficit of 1.3 million tonnes of meat in 2028 (Shapiro *et al*., 2017). Also, the volume of red meat exported from the country is very low considering the available potential and opportunities (high animal resource base, proximity to the markets and high demand for meat). Based on shapiro et al,(2017) more attention and improvement strategies have been given to genetics and health service for red meat producing species (sheep,goat and camel) even with this intervention there will be a 7% red meat deficit, that only cattle improvement is not sufficient to meet the overall meat consumption goal in 2028.

2.4 *Momordica foetida schumach* as a Protein Supplement

Momordica foetida schumach is a medicinal plant belonging to the family of Cucurbitaceae, kingdom *plantae*, phyllum *Schumach*, genus *Momordica*, and species *foetida* (O.I. Oloyede and O.M. Aluko, 2012). Momordica (gourd family, Cucurbitaceae) is an Old World genus comprising 59 species but the seven ones are believed to be important species those of *momordica balsamina*, *momordica charantia*, *momordica cochinchinesis*, *momordica cymbalaria*, *momordica dioica*, *momordica enneaphylla*, *momordica foetida*. The majority of which are perennial climbers (Schaefer and Renner, 2010) spread nearly worldwide and Hossain, 2014).

2.5 Desho and Natural Grass Hay as Energy Feed

Pennisetum pedicellatum, known simply as desho or as desho grass, is an indigenous grass of Ethiopia of the monocot angiosperm plant family Poaceae. It is also known as annual kyasuwa grass in Nigeria, bare in Mauritania, and deenanath grass in India. It grows in its native geographic location, naturally spreading across the escarpment of the Ethiopian highlands. Widely available in this location, it is ideal for livestock feed and can be sustainably cultivated on small plots of land. Thus desho is becoming increasingly utilized, along with various soil and water conservation techniques, as a local method of improving grazing land management and combating a growing productivity problem of the local region. An animal's energy requirement for maintenance is that amount of dietary energy it must consume daily to neither gain nor lose body energy. Experimentally it is the amount of metabolizable energy resulting in zero change in body energy and zero product (NRC,1985). Body maintenance ration as the amount of energy needed to maintain life processes of an animal (e.g. vital cellular activity, respiration, and blood circulation) under the fasting and resting state in a thermoneutral environment. The intake of energy below or above the BMR would result in a decrease or increase in body weight (BW); respectively (Luis Orlindo Tedeschi et al 2008).

In Ethiopia, livestock production is hindered by a shortage of feeds in quality and quantity (FOA,2010) to alleviate the feed shortage problem it is important to see the alternative forages and natural pasture species of the locality. From such forage species, desho grass has a diversified use in the agricultural sector. Desho grass serves as livestock forage and for rehabilitation of degraded and bare land playing crucial economic importance. Desho grass is grown in a wide range of ecologies and is native to Africa, Asia and India. Desho is believed to be native to Ethiopia and used as a livestock fodder source in the highlands of Ethiopia (Bimirew Asmare *et al*.,2016).

There was research conducted to evaluate the nutritive composition of natural grass as well as desho grass in Ethiopia. In animals, production profitability assured only animals must require the above maintenance requirement. Protein requirements depend on the stage of production,and sheep require a minimum of 7-8% dietary crude protein for maintenance. Bimirew Asmare *et al*. (2016) reported that inclusion of desho grass with increasing level (50-100%) in basal diet ration showed significant results in feed intake and daily body weight gain. The CP or total nitrogen content of desho grass varies with the variety, agro ecology and soil tpe. The CP content of desho ranges from 9.57-14.129% resulting in that variety and agro ecology could affect CP content of desho grass. Accordingly, the report by Denbela Hidosa, Berako Belachew and Sintayehu Kibiret (2020), desho having CP content of 9. 57-14.129% could fulfill the maintenance requirement of sheep and the above figure of CP could categorize as medium CP requirement. The commonest grasses in Ethiopian highland areas are *Chloris pychynothrix, Cenchrus ciliaris, hyparrhenia spp., Setaria sphacelata, paspalum spp., Cynodon dactylon, Pennisetum plicatulum, Eleusine floccifolia, eragrostis spp., cymbopogon* and *andropogon spp.* Perennial legumes include *Neonotonia wightii, indigofera spp., desmodium spp., rhynchosia spp., vigna spp.*of annual forage *spp. Trifolium steudnery, Trifolium rueppellianum* and *Medicago polymorpha* are quite frequent above 1700 m.a.s.l Aemayehu *et al.*, (2017). Natural grass hay differs in CP content the differences observed could be due to variations in the stage of harvesting and agroecology as suggested by McDonald *et al.* (2010). The recent result by Gebregiorgis Gebrehiwot *et al,* (2017) showed that natural pasture hay has CP 9.81 %. However, natural pasture hay offered alone could not fulfill the maintenance requirement of sheep (Mac Donald,2010). Thus, natural pasture hay in proportion (50-100%) mixed with desho grass (Bimirew et al.,2020) can meet the sheep requirements. Icontrary to mentioned above the recent report by Getahun Belay and Tegene Gesese, (2018) reported natural pasture resulted in CP content of 23.6%, and the authors believed to be this result was due to the presence of legume varieties in the pasture, agroecology and soil type.

2.6 Fodder and Shrub Species as Ruminant Nutrition

In Ethiopia, feeds high in protein are expensive and inaccessible to the majority of smallholder farmers engaged in small ruminant rearing (CSA, 2017). Most farmers engaged in small ruminant rearing were constrained with a lack of protein source supplements due to unavailability and high costs. To alleviate problems associated with protein supplements, there is a need to look for alternative protein source feeds which are preferably locally available and easily accessible. supplementation with indigenous and introduced multipurpose fodder trees and shrub leaves has a great advantage.

Improved fodder and pasture species have diversified advantages with high biomass yield and best quality in the perspective of ruminant livestock production (Feleke Tadesse, 2016). Fodder trees and shrubs have high potential value as a source of feed for domestic livestock and wildlife in many parts of the world (Diriba Geleti, 2014). They are readily accepted by livestock and presumably because of their deep-root systems, they continue to produce well into the dry season. The urgent need of the farmers for high-quality feed for ruminants in developing countries can be achievable through intensive utilization of multipurpose trees and shrubs as they have a better nutritional quality nearly equivalent to that of grain-based concentrates (FAO, 2002). Recognition of the potential tree's foliage and leaves of shrubs to produce a considerable amount of high protein biomass has led to the development of animal farming systems that integrate the use of tree foliage with locally bulky feed resources (Leng, 1997).

Supplementation of low-quality feeds with concentrates or forage legumes enhances the utilization of the basal diet, thereby improving the performance of ruminants. According to Mekoya *et al.*, (2008) result shows that supplementation concentrates with multipurpose fodder trees of those *S.susban*, *Acacia spp*, *F.thonningii*, *D.bruceana*, *G. bicolar*, *millitene spp* has higher feeding value. As seen by the author most fodder trees were good protein supplements, and they have degraded adequately in the rumen to make the protein available to the animal and non-toxic (Leng, 1997).

Feeding of low-quality straw supplemented with 100g WB and 200g *Acacia albida* leaf meal to local sheep has been observed increased feed intake and digestibility (Hunegnaw Abebe, 2018). There is also a report revealed by Takele and Getachew, (2011) that 38 g day gain was obtained from Horro lams fed vetch haulm and supplemented with wheat bran and *Acacia albida* leaf mixtures.Thus, supplementation of wheat straws with different browses species and wheat bran had higher effect on the total CP intake and ADG (Sisay Kumsa *et al.*, 2019).

Including Ethiopia there were different studies that show the replacement value of different fodder tree leaves, pods, and shrub species with concentrate feed put prominent economic weight in ruminant nutrition. According to, the study result by Araya *et al.*, (2003) verified that browse species of *Vechilla tortil* pods at up to 75% of the diet had higher DM & OM digestibility and body weight gain. Similarly, the nutrient content of *Vechilla brevispica* leaf and *Vechilla nilotica* also contain (196,160), (824,980) g/kg DM, CP and OM respectively (Aster *et al.*, 2012). Research conducted by Michaele Yirdaw, (2018) showed that the replacement value of local forages (dried *Acaci saligna* and *Susbania sesban* foliages) with commercial concentrate can have higher protein sources in supplements. Thus, these supplements were comparable with concentrates in their potential to supply nutrients to improve the productivity of sheep.

Fodder trees contain significant fiber, but in-vitro digestion studies indicated that the fiber was as digestible as that of alfalfa hay and much better than that of cereal straws (El Hassan *et al*., 2000). The macro and micro mineral content of fodder trees are usually adequate to cover animal requirements (Smith, 1992). Hence, the use of multi-purpose trees and shrubs, as alternative sustainable feed sources for ruminants is increasingly becoming important. In general view, the inclusion of fodder and shrub species as a supplement is believed to be minimized the feed shortage, improve the utilization of low-quality feed resources and improve animal performance during the dry season.

Anti-nutritional factors found in some species of fodder trees and shrubs can affect growth, the onset of puberty and reproductive functions via direct toxicity, interference in the metabolic process or reduction of nutrient availability or a combination of these pathways. The negative effect of the foliage and fruits of tanniniferous species on livestock performance has been demonstrated, According to the report of Heba-tollah M. Sweelam *et al*.,(2017) few examples anti nutritional factors such as alkaloids, triterpenes, sterols and chromenes were identified in *M.Foetida* spp.In Ethiopia, the report by Tadesse Dinku *et al*., (2010) verified that the phytochemical screening carried out on the total leaf extracts of the plant confirmed the presence of flavonoids, saponins, steroids and tannins.

Incontrovertible or an irrefutable argument of both, Makkar, (2003) demonstrated that the administration of small amounts of such vegetation, either fresh or sundried, in concentrate diets can increase sheep growth. Ben Salem et al. (2005) demonstrated benefits from adding small amounts of *A. cyanophylla* foliage (*acacia*) to soybean meal (SBM) in the diets offered to Barbarine lambs. Lambs receiving oaten hay ad libitum supplemented with 200 g soybean meal and 100 g *acacia* grew at a rate of 67 g/day compared to those receiving the above diet, but without acacia (42 g/day) showed significant effects. Nsahlai *et al.* (1999) concluded that feeding sheep oilseed cake after they had eaten *Acacia albida* pods (rich in tannins) enhanced liveweight gain. Recent studies confirmed that tannins in some plant species reduced worm burden and parasite development in sheep and goats (Hoste, 2005).

2.6 Feed Resources in Ethiopia

Feeds are materials which after ingestion by the animals are capable of being digested, absorbed and utilized (McDonald *et al*., 2010). These feed resources are classified as green fodder (grazing pasture), crop residue, improved feed, hay, industrial by-products, and other feeds of which the first two contribute the largest share (CSA,2017). Green fodder means pasture grasses; crop residue includes harvested by-products like straw, cereals and pulses also improved forage like alfalfa, hay includes any type of grass, clover, etc.

2.3.1 Natural pasture

In most areas of sub-Saharan Africa including Ethiopia the major even the sole feed source available for large parts of the year in smallholder production systems are natural pastures (Endale Yadessa, 2016). Also, it is permanent pasture is the predominant source of nutrition for the sheep flock in Ethiopia. It is naturally occurring grasses that include annual and perennial species of grasses, legumes, forbs, trees, and shrubs used as livestock feed (Fekede Feyissa *et al.*, 2011). Natural pasture with its wide range of species composition provides more than 90% of the livestock feed in lowlands (Alemayehu, 2006).

In crop-based farming, areas formerly covered by natural pasture have been sharply decreased due to the expansion of croplands derived by the increase in human population and urbanization. Recently, land used exclusively for grazing is ever diminishing sharing about 11.5% of agricultural landmass (CSA, 2017). Even in most of the vast grazing lowlands, where crop production is less implemented, natural pasture productivity is sub-optimal due to land degradation, emanating mainly from poor grazing management and frequent drought occurrence. The productivity of natural pasture in Ethiopia ranges from 1 to 2 tonnes DM/ha on freely drained and relatively infertile soils and from 4 to 6.4 tonnes DM/ha on seasonally waterlogged fertile lands (Adugna, 2007; Fekede *et al*., 2013). Generally, the contribution of natural pasture as feed for ruminants in the mixed crop-livestock systems has been decreasing being replaced by crop residues and aftermath grazing.

In the highlands of Ethiopia, natural pasture is often conserved as hay for use during the dearth period. However, its nutritional quality is a little above most cereal crop residues associated with poor management (lack of fertilizer application, improper stage of harvest, skill gap in haymaking, and poor storage condition). It is often harvested when the soluble nutrients greatly deplete (e.g., CP content falls below 5%), becoming inadequate even for maintenance requirements (Solomon *et al*., 2008). Fekede *et al.* (2014) reported a delay in natural pasture harvesting time from mid-October to late November reduced hay CP, IVOMD, and ME contents by 30.2, 17.8 and 17.8%, respectively, while the respective increase in NDF, ADF and ADL content was 13.8, 21.6 and 36%, indicating the nutritive value of natural pasture hay decreases with maturity (higher in the growing (wet) season than a dry season). Moreover, a 23.3% and 36.7% loss in CP content of natural pasture hay was observed after storing under the shed and in an open-air for eight months, respectively (Fekede, 2013).

Factors influencing the nutritive quality of natural pasture hay include its grass-legume proportion, leaf to stem ratio, and stage of growth at harvest (Ensminger *et al.*, 1990). Besides, soil and climatic factors, poor conservation and storage condition do affect its quality. The low soluble nutrient contents of natural pasture have negative consequences on rumen fermentation, feed intake and digestibility and animal performances. Sheep-fed natural pasture hay alone had poor performances (Fentie and Solomon, 2008). The nutritive quality of natural pasture can be improved by applying improved management practices. According to Adane and Berhan (2007), the application of nitrogen (22.5 kg/ha) and phosphorus (25.9 kg/ha) fertilizers to natural pasture at the growing stage improved CP from 6.8 to 11.8%, total ash from 12.3 to 22.5% and *in vitro* dry matter digestibility (IVDMD) from 67.8 to 79.7% at harvesting stage, while fiber fractions were not changed as compared to unfertilized natural pasture. The same study also showed a significant reduction in IVDMD, CP, mineral, but an increase in fiber fractions with delay in harvesting times (30 to 120 days).

2.3.2 Crop Residues

An enormous variety of food and cash crops have grown in the country, generating residues (straws, stovers and stubble grazing) that are important feed resources. Crop residues are available relatively at a low cost compared to other feed resources, and reliance on it as animal feed is ever-increasing in line with the expansion of cropping. The types of available crop residues vary with agro-ecology and farming systems. Maize, sorghum, and millet crop residues are dominant in the mid and lowland agro-ecologies, while teff straw, wheat straw, barley straw and oat straw are dominant in mid to highland areas. Pulse crops are grown in different agro-ecologies and the principal residues is generated from faba bean, field pea, lentil and chickpea. Some crop residues (e.g., teff straw, wheat/barley straw) are sold on local markets and generate income for farmers and traders (Mesfin *et al*., 2014).

Crop residues are bulky and low in nutritive quality, and if fed alone to an animal can not support even the maintenance requirement. They are low in CP and dry matter digestibility but are high in fiber components (cellulose, hemicelluloses, and lignin). Strategies used to improve crop residues' nutritive value includes supplementing with protein and energy-rich feeds and physical and chemical treatments (*e.g.*, chopping, ensiling with Urea). However, the degree of their adoption by the farmer is low due to socio-economic factors. A survey conducted in the Tigray region showed that lack of capital, knowledge and skill, molasses, and urea had influenced the adoption of straw urea-molasses treatment (Tesfay *et al*., 2016).

Crop residues have lower CP content than natural grass hay and support a CP requirement of less than 7.8 % ranging from 3.44, 3.62, 3.92, 3.88, 3.78, and 7.02% of wheat, barley, emmer wheat, teff and pulses respectively (ARC, 1980). But concerning other feed sources crop residues supply a higher share followed natural pasture in the country. Accordingly study by Mekuanint Gashaw and Girma Defar,(2019) revealed that feed supplied by crop residues accounts; 40.49% was barley straw, 30.82% wheat and the other 28.69% were supplied by teff, wheat, pulses and maize stovers. Digestibility of crop residues is also low and varies with the crop type from which the residue is produced. Teff straw has better digestibility compared with wheat (45%), and oats (48%) straws. Pulses have medium to high digestibility ranging from 34-56%. The energy value of cereal straws ranges between 7.14 Mj/kg (wheat) to 8.35 Mj/kg (tef) while pulse straws have a fairly higher energy value in the range of 7.4 (beans) to 9.4 MJ/kg (lentil) (Seyoum and Zinash, 1989). Nutritional quality of crop residues is influenced by several factors like morphological fractions of the residue and varietal difference of the crop (Seyoum *et al*., 1996); storage method and storage duration (Fekede *et al*., 2015) as investigated in tef and wheat straws CP content and IVOMD showed decreasing trend while the NDF content showed an increasing trend with prolonged storage duration in both the crop residues.

Supplementation of tef straw-based diet resulted in a live weight gain of 629g/day for indigenous animals and this performance was about 78, 56 and 32% higher than similar animals fed on a basal diet of wheat straw, oats hay and native hay (Getnet *et al*, 2016*)*.Also, maize residue was used as a basal diet at the level of 35-50% of the daily intake and supplemented with concentrate growth performances of about 750g/day and 913g/day were realized for native steers and crossbred bulls, respectively (Alemu *et al.*, 1978, O'Donovan and Alemu, 1978).

2.3.3 Natural grass Hay

Preserving forage is means of distributing forage throughout the year and usually in excess during spring and early summer and in deficient for the rest of the year. Thus, forage conservation is desirable to provide feed during the dry season. Hay is forage harvested during the growing period and preserved by drying. Haymaking aims to reduce the moisture contents of green crops to 15-20% to inhibit the action of plant and microbial enzymes (Banerjee, 1998). Despite its several advantages, hay has some shortcomings. It varies in nutrient content and palatability more than any other feed, late hay harvest affects its quality (Ensiminger *et al*., 1990).

Hay can be made from sufficiently well-managed natural pastures (meadowlands) that are well maintained for this purpose or from cultivated forage crops. It can be made from grasses and tall and erect legumes or a combination of grasses and legumes. The legumes increase the nutrient content, digestibility, and intake of the hay (Adugna, 2008). Legume hays, alfalfa, clover tend to be higher in protein, vitamins and minerals, especially calcium, than grass hays. The energy, as well as protein content of hay depends upon the maturity of the forage when it was harvested. Proper curing and storage is also necessary to maintain the nutritional quality of hay. Haymaking is very useful to bridge the dry season feed gap as it may support the basic maintenance needs of animals and in some cases may even support marginal production of milk and meat during periods of critical feed shortage.

2.3.4 Improved forage crops

In the last 5 decades, various fodder development strategies have been assessed and proven successful under Ethiopian conditions. Adugna Tolera, (2008) reported that the production of improved fodder should focus on grass and legume species that have high biomass yield potential. The average productivities of improved fodder crops in Ethiopia is about 13, 8 and 10.5 t/ha DM yield for grasses, herbaceous legumes and browse trees, respectively, while the average herbage DM yield obtained from seasonally rested pasture and continuously grazed pasture was 4 and 1 t/ha (Getnet Assefa *et al.,* 2012). The average productivity of the improved fodder crops per unit area has been found to exceed the productivities of seasonally rested and continuously grazed natural pastures by about 3 fold and 10 fold, respectively (Fekede *et al.,* 2015). They also have a long growing season and help to extend the green feed period to provide useful nutrients mainly in rural areas where availability and accessibility of agro-industrial by-products are limited.
Leguminous species like leucine and sesbania were had a large number of proteins (18-34% high digestibility values 53-60%, supplementation of these species gave higher milk yield result from higher feed intake and digestibility of organic matter and crude fiber. Comparatively, lueceanea supplementation also has higher milk yield but slower digestibility was observed (IAEA,2006). The appropriate level of supplementation of Napier grass-based basal diet with various level vetch (*Vicia dasycarpa*) hay (Aemiro *et al.,* 2009) to dairy cows were observed increased milk yield. The preferred level of vetch supplementation was noted to be up to 20% of their daily dry matter intake and with this level of supplementation daily milk yield of 8.81 ltr was recorded per cow per day.

2.3.5 Concentrate feeds

There are two types of concentrate feeds Energy and Proteins. Energy feeds provide more calories but tend to be low in protein (8-11%). They include the cereal grains corn, barley, wheat, oats, milo, and rye. Protein supplements contain high levels of protein (>15%) and may be of animal or plant origin. They include soybean meal, cottonseed meal, and fish meal. Protein quantity is generally more important than protein quality (amino acid content) in ruminant livestock since the microorganisms in the rumen manufacture their body protein. Now a day the use of grain-based concentrates for ruminant feeding is little practical due to competition with human food and monogastric animals and the high cost of production. Concentrate feed sources; especially grains are expensive and out of reach for many smallholders to use them as animal feed in developing countries. To combat this problem utilizing locally available feed resources is a means (Michaele Yirdaw, 2018)

Grains

Grain represents a concentrate feed resource have a higher energy source which includes maize grain, barley, oats, sorghum and rice have higher digestibility (80-85%) rich in energy and have a protein content of 8-12% of DM compared to other grain, maize have high energy content and abundant available with a reasonable price most of the time. Also, fourth-grade barley screening has a crude protein content of 12%NDF and ADF content of 21.5 and 7.8 % respectively and invitro OM digestibility of about 83% (Adugna, 2012).

Agro-Industrial Byproducts

The available brans and oilseed cakes are well utilized as livestock feed in Ethiopia; however, there is a need to enhance the utilization of other by-products such as brewers grains, fruit and vegetable wastes, food wastes, slaughterhouse offal, molasses, bagasse and sugarcane tops. Due to the report of FAO, (2018) that all the available by-products of cereal, pulse and oilseed milling units and brewery by-products are used as animal feed. The total production per individual byproducts accounts for 2.08 million tonne DM Cereal byproduct, 202,134 tonne DM oilseed cakes and 26,992 tonne DM pulses waste byproducts FAO, (2018). Out of these, the use of the by-products as animal feed was 5.1 million tonnes containing 639, 559 tonnes of CP, and 52.15 x10^9 MJ of ME. As the report of FAO, (2018) there are other agro-industrial by-products which not accounted in the report more because of their production and processing habit and are out of reach for many smallholder farmers in the rural community.

Bran and wheat middling

Wheat bran is the major byproduct of wheat processing industries and is commonly used as supplemental feed to livestock in Ethiopia. It is relatively rich in protein (14-19% DM), total ash

(4-7% DM), phosphorus (0.9-1.3% DM) and oil (3-5% DM), but low in calcium (0.07-0.2% DM) (Heuzé *et al*., 2015). More of the protein, mineral, oil and fiber contents are contained in the bran than the grain alone or, whole grain. Its metabolizable energy content was about 12 MJ/kg DM (Adugna, 2008). Wheat bran is fed to livestock often mixed with protein-rich feeds (oilseed cakes); salts and others, making the largest share of concentrate feed mix in the country. The other important byproducts derived from grain flour industries and mill houses are wheat middling (finer which may contain bran, endosperm and germ), wheat short, maize bran, rice bran and screenings). Wheat middling is similar to bran except that they have lower fiber and higher flour contents, so they are higher in digestible energy than bran. It has about 92% energy value of maize but is higher in protein content and contains 40% NDF highly digested in the rumen (Adugna, 2008).

Oilseed cakes

The byproducts from oilseeds in Ethiopia include *noug* seed (*Guizotia abyssinica*) cake, cottonseed (*Gossypium spp*.) cake, linseed (*Linum usitatissimum*) cake and rapeseed (*Brassica carinta*) cake or Ethiopian mustard seed cake, groundnut cake, sesame cake, peanut cake and safflower cake. These feed resources are produced mainly by large- and small-scale edible oil factories, which usually operate below their potential (<50%) due to inadequate supply of oilseeds that in turn influenced by its low production, high demand on the export market and partly by the importation of edible oils from abroad.

Oilseed cakes are rich sources of rumen degradable and by-pass protein and are well palatable to animals. For example, *noug* seed cake varies in the composition of protein (28 - 38%), fat (2.1 to 12.6%) and energy (2.37 Mcal ME/kg DM) depending on the oil extraction method employed (mechanical and solvent) (Adugna, 2008). Cottonseed cake is another potential protein supplement, containing 36-40% protein. However, it contains a toxic chemical- gossypol, which is harmful to young animals with immature rumen. Linseed cake is also a protein supplement containing nearly 30% CP but has a laxative effect. It results in a shiny coat appearance of feedlot animals, which attracts buyers. However, the majority of oilseed cakes are low in essential amino acids (cystine, methionine and lysine) (Adugna, 2008).

2.3.6 Minerals and Vitamins

The minerals play important role in augmenting animal production and health, correcting deficiencies and preventing diseases through activation of the immune system of the body. Macro elements 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, 1990). The proper calcium to phosphorus ratio is 2:1. Inadequate calcium can lead to milk fever (hypocalcemia) in pregnant or lactating ewes/does. Mineral supplement to enhance fermentative digestion and microbial growth efficiency in the rumen on poor quality forage, legumes are higher in Ca, K, Mg, Cu, Zn, Fe and Co than grass (Zelealem, 2004). Cereal grains are low in calcium content and need to be supplemented with limestone to correct deficiency (Adugna Tolera *et al*., 2012). In constrat to low-quality roughages, leguminous forges are important as source of nitrogen, fermentable organic matter and minerals in pure quality pasture-based diets (Adugna Tolera *et al*., 2012)

Vitamins are essential compounds for the proper animal body working. Vitamins play an important role in body metabolism feed intake, digestion and absorption of important nutrients in the body. Mature sheep require all the fat-soluble vitamins: A, D, E, and K, and sheep are ruminants that can synthesize B vitamins in their body. The forage and feed supply contain all essential vitamins in adequate amounts, but vitamin A can only be gain from green forages. Animals that has no access to green forage have a deficient of vitamin A.

2.4 Nutrient Requirement of Sheep

Successful small ruminant animal production requires an adequate supply of feed throughout the year. The nutrient need of sheep may be classified as energy, protein, minerals, vitamins and water. These nutrients are necessary for maintenance, optimum production, and prevention of any signs of nutritional deficiency. The nutrient requirement of sheep varies at different physiological states, breed type; age, and daily body weight gain (Mike N., 2007).

The nutritional intake increases with animal size (growth) increase to fill the requirements of the rumen stomach. In other words, larger animals show more feed intake to maintain their body functions and production (ESGPIP, 2008). When the voluntary intake is too low the rate of production will be depressed, resulting in requirements for maintenance becoming a very large proportion of the metabolizable energy consumed and so giving a poor efficiency of feed conversion. Intake of feed by ruminant can be improved through supplementation of concentrate and multipurpose fodder trees like tree lucerne leaves. This indicated that the ability of the supplements to provide nitrogen and energy for the ruminal microbes to enhance fermentation of DM in the rumen (Desta Tekle *et al*., 2017 and Michaele Yirdaw *et al*., 2017).

Protein requirements

Proteins are a very essential requirement for growing sheep for maintenance, growth, synthesis of new tissues especially, animals that are reproducing. That means it depends on growth, weight for age, body condition, the rate of gain and protein to energy ratio. Green pastures and legume hay (alfalfa, clover, soybeans, and others) are excellent sources of protein for sheep feeding in most parts of the country (Bimrew Asmare, 2016). The minimum protein level required for maintenance is about 8% in DM (Mc Donald *et al*., 2010). These levels are considerably higher than the average crude protein values of crop residues.

Fodder trees and shrubs had above 22 % CP and it can be higher than 30 % provides adequate protein for most classes of sheep when fed as a complete ration. Depending on the amount and quality of the forage, the supplemental feed may be used to maintain a higher rate of growth or to get lambs to a market finish at a faster rate.

According to Ranjhan (2001) CP requirements of growing and fattening sheep with 20 kg body weight are 85 and 127 g/day, respectively. It has been emphasized by the same author that the requirements relatively increase for growing and fattening animals as compared to the requirement of adult animals. A protein deficiency is characterized by reduced appetite, lower feed intake, and poor feed efficiency. Under extreme conditions, there are digestive disturbances, nutritional anemia, and edema. The protein produced by ruminal synthesis does not supply all of the amino acids required by animals in the quality and quantity needed (Mc Donald *et al.*, 2010).

Energy requirements

The major sources of energy for sheep are from pasture, hays, silage, by-product feeds, and grains (Melese Dejen, 2011). These energy requirements of sheep are affected by body weight (BW) extent of growth (gain), breed type, age, the environment and protein content of the ration. Large animals require higher energy to attain their maintenance requirement than smaller animals. This is because of the increased rate of metabolism for energy in large animals. Moreover, a fast rate of growth demands energy-rich feeds or the consumption of large amounts of feed.

Melese Gashu *et al*. (2014) indicated that in urea treated crop residues supplementation with feed containing higher energy source is more beneficial than those with high protein content. Energy deficiencies result in reduced growth or weight loss, reduced reproductive efficiency, reduced milk, meat or fiber production, reduction in resistance to infectious disease and parasites and increased mortality (Ensminger, 2002). Moreover, the energy status of sheep is dependent on their feed intake, energy content, and digestibility of the feeds (Mike N, 2007).

2.5 Effect of Nutrient Supplementation on Nutrient Intake of Sheep

Feed intake is the first parameter that determines animal production (Savadogo *et al.*, 2000), which is likely to be influenced by the animal, characteristics of the feed and other environmental factors. The voluntary DM intake of sheep depends on the type of diet offered to the sheep and the physiological age of the animal (Forbes, 2003).

Feed intake in ruminants consuming fibrous forages is primarily determined by the level of rumen fill, which in turn is directly related to the rate of digestion and passage of fibrous particles from the rumen (Mc Donald *et al*., 2010). Feeds that are digested rapidly promote high intake. Supplementation of concentrate to poor quality roughages stimulated microorganism function in the rumen, reduced retention time and thus increased the intake of poor-quality feeds (DoThi, 2001). Concentrated supplies for poor quality feed improve fiber degradation (Liu and Lee, 2005). The highest roughage DM intake comes synchronously with the highest ruminal fibrolytic activities. According to NRC (1981) standards, the DMI would be 780 g at DM intake of 2.6% body weight for 30 kg sheep and such sheep lose weight if they consume less than 737g DM. Dry matter consumption above this quantity-maintained body weight (Ranjhan, 1993). Based on NRC (1981) standards, for a 20 kg sheep 0.648 kg DM intake per day, at 3.23 DM intake as a percent of body weight and 68.31 g DMI/ kg W 0.75 could be formulated (Ranjhan, 1993).

2.6 Effect of Nutrient Supplementation on Digestibility of Feed

Digestibility is the proportion of the feed or any single nutrient of the feed that is not recovered in feces (Ranjhan, 1997). True digestibility is difficult to determine due to not being easy to distinguish the nutrient fractions (mucosal debris, unspent enzymes, and undigested microorganisms) found in the feces whether it came from animal or feed. The digestibility of feedstuffs as affected by genotype, age, level of feeding and feed composition, interaction among feedstuffs (Ranjhan, 2001). Feeds that digest rapidly, are of high digestibility, promote high intakes that is the faster the rate of digestion, the more rapidly is the digestive tract emptied, and space is made available for the next meal (Mc Donald *et al*., 2010). The primary chemical constraint of feeds that determines their rate of digestion is neutral detergent fiber (NDF) and ADF. This constituent is a measure of cell wall content and rumen fill. Thus, there is a negative correlation between the NDF content of feeds and the rate at which they are digested. According to Tesfaye Hagos, (2007) increasing the level of supplementation by (0, 150, 250 and 350 g) improved digestibility of DM (50.1, 67.1, 68.5 and 66.6%), OM (53.0, 69.3, 70.6 and 69.3%) and CP (32.6, 71.9, 75.0 and 83.3%), respectively. Moreover, Solomon Melaku *et al*. (2005) reported that mixtures of multipurpose trees supplemented to Menz sheep fed on teff straw did not improve the digestibility of DM, OM, and NDF, but improved CP digestibility.

Body weight change and feed conversion ratio

Nutrition is the major factor influencing live weight gain and meat production in sheep (Mc Donald *et al*., 2010). The higher level of nutrition, the more fat is deposited in lambs at any given age and body weight. Increased BW gain in small ruminants was observed as a result of supplementation with high energy or protein sources or both in an attempt to bridge the gap between dry and wet season feed availability or for fattening purposes. Research result by Michael (2018) sheep received concentrate mixture, wheat bran and *S. sesban* had higher ADG and relatively FBW, FCE, BWC were observed higher than those unsupplemented animal groups. The study by Kidane *et al*. (2017) noted that daily live weight gain increased in the animals supplemented with saltbush with increasing levels than the control groups across the entire experiment period. Also, the author indicated that the replacement of commercial concentrates with *Oldman saltbush* did not show the difference in FCE of different treatments. The same to those different results observed on different supplemental feed trials, there is no more significant difference has been observed on feed conversion ratio. On the other hand, FCE is more consistent with average daily gain that diets that promote high rates of gain will usually result in greater efficiency than diets that do not allow rapid gain; as rapid gaining animals utilize less of the total feed intake for maintenance and more its body weight gain (pond et al 1995).

Small ruminants gain higher body weight on concentrate feed rather than conventional feeds, in line with this study by Getahun (2014) noted that there was a higher significant result observed on Afar lambs fed 36.95 to 79.36g day and Blackhead Ogaden lambs fed 33.48 - 65.19g day. Also report the result of Hany A. Zaher *et al*., (2020) supplementation of *Moringa oleifera* up to 25% resulted significant on LBW and ADG than the control diet. Thus, multipurpose trees resulted in higher BW gain compared to supplementation with wheat bran or sole multi-purpose trees (Solomon *et al*., 2004).

3. MATERIALS AND METHODS

This chapter describes details of methodologies which included the description of the study area, experiments and sheep feeding experiment. Moreover, the mathematical models, the statistic was be analyzed data and economic evaluation of experimental diets was discussed.

3.1. Description of the study areas

The study was conducted in Decha district of Kaffa zone. The study area is located to the Southwestern part of Ethiopia, in the Southern Nations, Nationalities and Peoples' Regional State (SNNPRS). Modiyo is one of 48 kebeles of the district and Modiyo sheep breeding center was established as Bonga sheep breeding and improvement center under Bonga research center (SARI). The area is characterized by dense rain-fed wet humid natural forest and endowed with bush, shrubs and herbaceous and climber species under large trees. The study site is within 36^{o} 14' E longitudes and 7^{o} 16 'N latitude and an altitude range 1714 to 3000 meters above seas level at Tello-Decha adjoining plateaues Tezera Chernet (2008). It has a bimodal pattern of rainfall (March to May; July to mid-October); the average annual rainfall was 1367 mm. The average temperature ranges from 13^{o}c-36^{o}c temperature. Animal production is the second but the main agricultural activity and cash source for smallholder producers (SUDCA, 2007).

3.2. Sheep Feeding Experiment

3.3.1. Feed preparation

Feed preparation was started from the collection of leaves of experimental forage *M.foetida* from farmlands, forest borders and forest edges. M. Foetida leaves were collected by hand stripping from the vine then after was transported to shade in the research center (Modiyo). The leaves were put with a tiny thickness on a plastic sheet allowed to air dry with proper turning. This was conducted four weeks prior the commencement of the feeding trial and that makes available feedstock in hand before feed trial. Air cured *M.Foetida* leaves were also exposed to the sun for half day so as to get strict moisture-free dry matter. Then the forage was stored in a clean, dry store and waiting for feed trail. Then adequate amounts of experimental (*M.foetida*) feed for 2-3 days was crashed or chopped with han blade into 1-2 cm to avail feed intake and to avoid selection feeding when mixed with concentrate mix. Commercial concentrate mix was purchased from Adis Abeba and during purchasing a concentrate the ratio of energy to protein was considered of the sheeps daily nutrient intake and daily gain. The concentrate mix was comprised of 65% energy feed, 34% protein feed, 0.5% salt, 0.5% mineral and vitamin mix. Also, the concentrate mixture comprised wheat bran and Noug seed cake with the ratio of 2:1 on DM bases respectively. Desho grass was grown in the farm with a large landmass, and it was used as a control and basal diet in this study was harvested at 70% of full-grown, then desho was harvested with sickle and exposed to sunlight with proper turnings. Desho had a rotting and fugal development nature within a short day. To protect rotting nature, it was dried with more care with proper turning and avoiding rain and moisture contact. The dried was transported to store and bailed at the store which had proper ventilation to keep the quality, then transported to feeding barn and chopped manually to approximately a size of 2-3 cm. The treatment feed will be formulated according to the recommendation of (NRC, 2007) sheep having 20kg BW may require a DMI of 3.64% BW (2.86-3.91% BW). Accordingly, formulation of the ration will to fulfill 78%TDN, 3.4%DE, 2.8% ME,16.9% CP and concentrate to roughage mixture comprises 85 to 15 percent in DM bases respectively.

3.3.2. Animal management

Thirty yearling intact male Bonga sheep were purchased from local markets (Boka) and transported to the experimental site. Upon purchasing their care was taken to have animals at yearling age (similar dentition, i.e., with unbroken paired incisor) and healthy. All animals were quarantined for four weeks, during which they were vaccinated against viral diseases (sheep pox, pasteurellosis and anthrax) and treated with a broad-spectrum anti-parasitic agent (Ivermectine) against e internal and external parasites subsequently dewormed with albendazole 2500mg for the internal parasite, then after deep in dipping bath filled with 3000liter water stirred by 3 litter of diazone for severe external parasites(tick)infestation of experimental sites. Following the quarantine period, sheep were identified by ear tags and were castrated before the first week of the commencement feeding trial. The animals kept in pen for 28 days to acclimatize to the environment of the experimental site. After the acclimatization period, each animal was weighed (using a movable weighing scale) after overnight fasting on two consecutive days and the average was taken as initial body weight.

Animals were then blocked into six blocks of five animals each based on initial body weight16.84±1.9 kg. Animals in each block were randomly allotted to one of the dietary treatments (five lambs/treatment) in a randomized complete block design. Experimental lambs were assigned randomly to individual pens (0.80 m × 1.30 m) with a concrete floor, a feeding trough and a watering bucket. The pens were cleaned and disinfected with malathion and well-ventilated before moving animals in and also were cleaned daily throughout the experimental period. The animals were adapted to the pens, test feeds, and feeding trough for two weeks before commencing the data collection.

3.3.3. Experimental Design and Treatments

A randomized complete block design (RCBD) was used for the experiment. At the end of the quarantine period, animals were blocked into six blocks five animals based on initial live weight and animals within a block was randomly be assigned to one of the six treatments. Treatments was T1=desho hay alone (*Ad libitum*),T2= desho hay(*Ad libitum*) + 100 % MFS, T3=desho hay(*Ad libitum*) + 75 % MFS + 25% CM, T4=desho hay (*Ad libitum*) + 50 % MFS + 50% CM, T5=desho hay (*Ad libitum*) + 25 % MFS + 75% CM and T6=desho hay (*Ad libitum)* +100% CM

(Table.1).Replacement feed was offered twice a day at 8:00 and 16:00 h in two equal portions. Water and salt block was available free of choice.

Table 1 Design of treatment feeds and animals

No	Treatment Feed	T1	T2	T3	T4	T5	T6
1	MFS	*hay adlibtum*	100%	75%	50%	25%	0%
		hay adlibtum	1000g	750g	500g	250g	0g
2	CCM	*hay adlibtum*	0%	25%	50%	75%	100%
		hay adlibtum	0g	125g	250g	375g	500g
3	Total	*hay adlibtum*	1000g	875g	750g	625g	500g
4	N of animals	5	5	5	5	5	5

CCM= commercial concentrate mix, g= gram

3.3.4. Feed Intake and Body Weight Change

Feed intake and body weight change data was collected for a period of 90 days. The desho roughage was fed *ad libtum,* allowing 15% refusal daily, while concentrate was fed twice daily at 8:00 am and 16:00 pm. Tap water was provided for all animals free of choice. Daily feed was offered and the refusal was measured and recorded for each animal to determine nutrient intake by difference (using the chemical composition of feed offered and refusal samples). Samples of the roughage and concentrate offered and refusals were taken daily and sub-sampled biweekly for DM determination. All animals have weighed every 7 days interval after overnight fasting the morning before the feed was offered. The average daily gain (ADG) of each lamb was calculated as the difference between final and initial body weights over days elapsed, while feed conversion efficiency (FCE) was calculated as the ratio of average daily gain to daily DM intake.

Bodyweight change (BWC) = Final body weight – Initial body weight

$$\text{Average daily gain (ADG)} = \frac{\text{FBW - IBW}}{\text{Number of feeding days}}$$

3.3.4. 1.Average daily gain (ADG)

Average daily gain can be defined as the average amount of weight a market animal will gain each day during a feeding period. ADG can be calculated by taking the amount of weight an animal has gained since the last weight and dividing by the number of days since that last weight.

3.3.4.2. Feed conversion efficiency

Feed conversion efficiency or ratio is a fairly simple calculation to perform. The total weight of feed is divided by the net production (final weight minus starting weight) to obtain the feed conversion. FCE can be calculated as the average daily gain of an animal dividing by the daily feed intake multiplied by a hundred percent.

$$\text{Feed conversion efficiency} = (\%) \ \frac{\text{Average daily gain (g/day)}}{\text{Daily feed DM intake (g/day)}} \times 100$$

3.3.5. Digestibility trial

At the end of the intake and growth trial, all lambs of the respective treatment were harnessed to fecal bags made from textile tailers with recommended design. The trial lasted for 10 days (3 days animals to adapt to fecal bags, and feces was collected for 7 days). The diets and feeding management were similar to that of the intake and growth trial. The daily feed offered and refusal of individual animal was recorded sampled for further analysis and feces voided were weighed and recorded for each animal and about 10% of the daily excreted feces were emptied from fecal bags put in plastic and placed in an icebox and transported to Bonga research centere and put in a deep freezer (-20°C) till used for for the end sample was taken. With similar procedures, feces samples were collected daily at the morning before the provision of feed and water and transported to Bonga Research center added to the previous samples. The end feces samples were taken and added to previous samples in the refrigerator and were mixed thoroughly and 20% of the samples was transported with a mini refractor which was connected with cars engine system to ADIS ABEBA ILRI lab and dried in a forced hot oven at 60^{0}c for 48 hours and milled by Willy mill and put in airtight then bag waited for nutrient analysis. Apparent digestibility (AD) of DM, OM, CP, NDF and ADF was determined as follows:

$$AD/DC = \frac{\text{The total amount of nutrients consumed} - \text{The total amount of nutrients in feces}}{\text{The total amount of nutrients in feed}} \times 100$$

3.3.5. Cost-benefit analysis

The partial budget analysis was used to evaluate the relative economic importance of dietary treatments using the procedures of Upton (1979). It measures profit or losses, where net income (NI) is the difference between total variable costs (TVC) and total returns (TR): NI = TR-TVC. The change in net income (ΔNI) will be the difference between the change in total return (ΔTR) and the change in total variable cost (ΔTVC), i.e., ΔNR = ΔTR - ΔTVC. While, the marginal rate of return (MRR) measures the increase in net income (ΔNI) associated with each extra unit of cost (ΔTVC), i.e., MRR = (Δ NI/ ΔTVC).

The economic benefit of production will be estimated considering the costs of major inputs (feeds and labor) and the prevailing (end of the main fasting season of Ethiopian Orthodox Christian) market price of finished lambs wiil be estimated by three experienced local sheep traders. However, the benefit that can be generated from manure production will not include in this experiment.

3.4. Chemical Analyses of Feeds and Feces

The fecal samples were thawed, thoroughly mixed and sub-sampled per sheep. Both feed and fecal samples were dried in a forced-air oven at 65°C for 72 hours to a constant weight and ground to a 1.0 mm size using a Wiley mill and stored in plastic bags and waiting for chemical analysis. Dry matter, CP (N *6.25), ash, EE, calcium (Ca) and phosphorus (P) contents were determined according to AOAC, (1990), while neutral detergent fiber (NDF), acid detergent fiber (ADF) and acid detergent lignin (ADL) contents was analyzed according to Van Soest and Robertson, (1985). The IVOMD will be determined according to Tilley and Terry (1963) by applying a two-stage digestion process, where 0.5 g samples will be first fermented in rumen fluid obtained from donor animals.

At the end of the digestibility trial, rumen fluid will be collected from each animal just before morning meal and at 4:00 and 8:00 hours after the morning meal using a stomach tube for the determination of ruminal pH and ammonia nitrogen (NH_3-N). The energy value of the treatment feeds was also estimated according to (Mc Donald, 2002); Metabolizable Energy (MJ/kg DM) = 0.0157* DOM; where DOM being gram digestible OM intake per kilogram DM and Total digestible nutrient (TDN) was driven from TDN= 82.38-(ADF%*0.7515) (NRC, 1985); Ash content was determined by igniting the DM residue at 6000^{o}C for 4 hours in a muffle furnace (AOAC, 2002)

3.5. Statistical Model and Data Analysis

Experimental data on feed intake, digestibility, body weight change, feed conversion efficiency were subjected to analysis of variance using the General Linear Model procedure of the SAS program (SAS v 9.4, 2019). When the interaction between factors was non-significant, only the main effect means were presented and discussed, otherwise simple effect means were presented. Mean separation was done using the Tukey test at 5% probability. The following statistical models were followed.

$Yij = \mu + \alpha i + \beta j + eij$, Where,
Yij = Response variable
μ = over all mean
αi = the i^{th} treatment effect
βj = the j^{th} block effect
eij = the random error

4. RESULT AND DISCUSSION

Chemical Composition of The Treatment Feed

Momordica foetida grows in forest edges and clearings, margins of swamps, and disturbed on the ground as a weed and colonizer, up to 2400 m altitude. *Momordica foetida* is a climbing vine native of tropical Africa, South Africa and Ethiopia closely related to the bitter melon (*M. charantia*) and balsam apple (Momordica foetida) is widespread in tropical Africa (Welman, 2004). Among the species of the *genus Momordica*, three selected species are used as a vegetable as human food and have medicinal values these are *M.charantia, M.foetida* and *M.balsamina* (Mashudu Muronga *et al.*, 2021). In Ethiopia, the plant is widely distributed up to an altitude of 2400 m.as.l and grows on loamy soils. The nutritional composition *M.Foetida* per 100g edible portion is; energy 92kj (22kcal), protein 3.3g, fiber 3.2g, calcium 1.1mg, iron (Fe)3.4mg, zinc (Zn)0.4mg, Beta-carotene 5.4mg, foliate 40g, ascorbic acid 20.6mg (Steyn, 2001and Mashudu Muronga *et al*., 2021). The leaves of *Momordica foetida* are collected from the wild and eaten after boiling as a vegetable in Gabon, Sudan, Uganda, Tanzania, and Malawi (Olaniyi, 1975).

The fruits and leaves of these *Momordica* species are rich in primary and secondary metabolites such as proteins, fibers, minerals (calcium, iron, magnesium, zinc), and vitamins β-carotene, foliate, ascorbic acid (Mashudu Muronga *et al.*,2021). The extracts from *Momordica* species are used for the treatment of a variety of diseases and ailments in traditional medicine. The leaf extracts are reputed to possess antidiabetic, anti-microbial, anthelmintic bioactivity, abortifacient, anti-bacterial, anti-viral, and play chemo-preventive functions (Mashudu Muronga *et al*.,2021). Both species *M. Foetida and M.charantia* is preferred to be grazed by cattle (Kuete *et al.,* 2010; Mada *et al*., 2013)

Table 2 Chemical composition of feed used in the experiments

Feeds	Chemical composition and IVODM (DM%) of experimental feeds							
	DM	OM	CP	NDF	ADF	ADL	ME	IVODM
GPH	92	85	7.04	69.2	44.9	5.4	5.9	50.7
MF	95.5	81.2	28.9	20.1	15.7	67	9.5	71.5
CM	92	89	22.6	36.2	21.8	3	10.9	78
T1	93	89.9	7.2	73.9	46.9	6.5	7.1	49.8
T2	92.4	82.9	24.8	25.3	20.9	6.0	9.5	70.4
T3	92.4	84.8	23.6	27.3	21.5	6.6	9.3	69.3
T4	92.5	84.4	21.3	31.0	22.9	6.4	8.9	66.3
T5	92.8	86.6	18.8	37.2	24.1	6.1	8.5	61.7
T6	92.6	87.1	16.1	38.9	22.7	6.6	7.8	56.5

MF= Momordica fotedia, CM=concentrate mix PGH= Pennisetum glaucifolium hay, CM= concentrate mix, ; DM = dry matter; CP= crude protein; NDF= neutral detergent fiber; ADF= acid detergent fiber; ADL= acid detergent lignin; OM= organic matter; DOMD = digestible organic matter in dry matter; ME = metabolizable energy, IVODM=invitro digestabil matter

Feed and Nutrient Intake

The total DM intake was affected by supplementation in this study. The supplemented animals were different among the treatments. This is an indication of the positive influence of supplementation on the total DM intake of the experimental sheep.

The enhancement in total DM and nutrient intake due to supplementation is a common observation in different studies. The feed intake of Horro sheep fed Vetch (Lathyrus sativus) haulm was improved by supplementation with wheat bran, Acacia albida leaf meal or their mixtures (Takele 2010). In the present study, CP intake was lower in the control treatment than all other treatments. Among the supplemented treatments, there is a higher CP intake than the control treatment. This observation appeared to be due to the higher CP content of the concentrate mix.

Table 3 Feed and nutrient intake of Bong sheep fed desho grass hay supplemented with different levels Momordica fotedia as a replacement of concentrate mixture

Parameters(g/d)	**Treatments**							
	T1	**T2**	**T3**	**T4**	**T5**	**T6**	**SEM**	**P**
Basal DMI	547.2	525.7	531.8	541.2	524.3	540.5	13.5	**
Supplement DMI	-	300.8	325.3	319.7	348.3	358.6	12.6	***
Total DMI	547.2	826.5	857.1	860.9	872.6	899.1	47.8	***
OMI	491.9	685.2	726.8	726.6	755.7	783.1	23.9	***
CPI	39.4	105.0	110.8	111.8	125.1	134.7	1.9	***
NDFI	404.4	209.1	234.0	235.0	324.6	349.7	13.7	***
ADFI	256.6	172.7	184.3	197.1	24.1	204.1	9.7	ns
ADLI	35.6	49.6	56.6	55.1	49.4	59.3	1.8	ns
MEI	8.9	8.5	9.7	9.6	9.2	9.1	2.0	***

ADF acid detergent fber, BW body weight, CM concentrate mixture, CP crude protein, DMI dry matter intake, NDF neutral detergent fber, OM organic matter, MEI metabolic enery intake SL signifcant level

Apparent Nutrient Digestibility

Apparent DM digestibility coefficient was highest for treatments supplemented with *Momordica fotedia* lowest for the control treatment. Similar to this OM digestibility coefficient was also highest in treatment supplemented with *Momordica fotedia* and concentrate mix than all other treatments which feed desho grass only. These findings direct that the replacement of Momordica *fotedia* with concentrate mix (50:50) for sheep gives a healthier improvement in nutrient digestibility than supplementing them separately.

Table 4 Apparent digestibility coefficients of nutrients in sheep fed Momordica fotedia as a replacement of concentrate mixture.

Parameter	T1	T2	T3	T4	T5	T6	SEM	SL
DMD	60.7	61.3	61.4	61.4	61.5	62.6	2.3	***
CPD	60.3	68.1	69.2	69.8	70.1	72.8	1.9	***
NDFD	53.2	53.1	53.0	54.0	54.3	58.3	1.3	ns
ADFD	46.2	45.1	41.3	41.9	42.2	41.6	1.4	ns

DMD dry matter digestibility, OMD organic matter digestibility, CPD crude protein digestibility, NDFD neutral detergent fiber digestibility, ADFD acid detergent fiber digestibility; SEM standard error of mean; SL significance level, Ns non-significant

Bodyweight Gains and Feed Efficiency

Bodyweight gain, average daily weight gain, and feed conversion efficiency follow a similar trend and values. The initial body weight of sheep in all treatments is not significantly different however the final body weight varies significantly. A higher body weight (46.6kg) was recorded.

In this study, sheep fed grass hay alone lost weight which is due to low DM and CP intake in the control group, and the low CP content of the grass hay used as a basal diet in this study. This finding is in line with the idea of Van Soest (1994) who pointed out that whenever the CP content of forage is less than 8%, animal performance will be retarded. Similarly, the increased live weight gain and average daily gain in supplemented animals compared to the control group might be explained by the higher total DM and CP intake and better digestibility of the treatment diets. Bruk (2008) reported 24.5 g/day body weight loss in Adilo sheep fed grass hay alone and 13.2-36.1 g/d body weight gain in supplemented sheep where the supplement consisted of haricot bean screenings and sweet potato tubers.

Table 5 Body weight gain and feed conversion efficiency of Bonga sheep fed on graded level of Momordica fotedia as replacement of commercial mixture

Parameters	**Treatments**						SEM	SL
	T1	T2	T3	T4	T5	T6		
IBW (kg	26.9	26.8	26.8	26.8	26.8	26.9	1.01	ns
FBW	34.9	37.4	37.9	37.8	42.4	46.6	3.64	**
ADG(g/day)	88.9	117.8	123.3	122.2	173.3	218.9	5.36	**
FCE								**
	0.16	0.14	0.14	0.14	0.20	0.24	0.01	*

ADG average daily gain, BWC body weight change, FBW final body weight, IBW initial body weight, FCE feed conversion efficiency; SEM standard error of mean; SL significance level, Ns nonsignificant

4. CONCLUSION AND RECOMMENDATION

Momordica fotedia have high nutritional qualities and grows in the farmyard areas. According to chemical composition 28.9% CP, the local indigenous forage can be considered as a protein feed. As it is available in the locality of the farmers in the study area, it can replace other commercial protein supplements which are too expensive and not affordable by low-income farmers. The natural grass hay is a poor-quality feed. This underlines the necessity of supplementary feeding for animals depending on such grasses as a sole roughage. The graded replacement with concentrate mix significantly improved DM/nutrient intake and digestion and growth performance of the experimental animals.

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