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Evaluation of Nutritional Value of Korch (Erythrina Abyssinica) and Its Utilization as Livestock Feed in Sekela District, Amhara Region, Ethiopia.

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COLLEGE OF AGRICULTURE AND ENVIRONMENTAL SCIENCES SCHOOL OF ANIMAL SCIENCE AND VETERINARY MEDICINE DEPARTMENT OF ANIMAL SCIENCE

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MSc. THESIS

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THESIS APPROVAL SHEET

As a member of the Board of Examiners of the Master of Science (MSc.) Thesis open defense examination, we have read and evaluated this thesis prepared by **Mr. Taye Getachew** entitled **"Evaluation of nutritional value of Korch (*Erythrina abyssinica*) and its utilization as livestock feed in Sekela district, Amhara region, Ethiopia."** We here by certify that, the thesis is accepted for fulfilling the requirements for the award of the degree of Masters of Science (MSc.) in feeds and Animal Nutrition.

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DECLARATION

This is to certify that this thesis entitled **"Evaluation of nutritional value of Korch (*Erythrina abyssinica*) and its utilization as livestock feed in Sekela district, Amhara region, Ethiopia. "** submitted in partial fulfillment of the requirements for the award of the degree of Master of Science in **"Feeds and Animal Nutrition"** to the Graduate Program of College of Agriculture and Environmental Sciences, Bahir Dar University by **Mr. Taye Getachew** is an authentic work carried out by him under My guidance. The matter embodied in this project work has not been submitted earlier for an award of any degree or diploma to the best of My knowledge and belief.

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STATEMENT OF THE AUTHOR

First, I declare and affirm that this thesis is my own work and that all sources of materials used for this thesis have been duly acknowledged. This thesis has been submitted in partial fulfillment of the requirements of an M.Sc. degree at Bahir Dar University and is deposited at the University's Library to be made available to borrowers under the rules of the library. I solemnly declare that this thesis is not submitted to any other institution anywhere for the award of any academic degree, diploma, or certificate. Brief quotations from this thesis are allowable without special permission provided that accurate acknowledgment of the source is made. Requests 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 School of Graduate Studies when in his or her judgment the proposed use of the material is in the interest of scholarship. In all other instances, however, permission must be obtained from the author.

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BIOGRAPHICAL SKETCH

The author, Taye Getachew, was born on September 30, 1992, in the Borena district, South Wello Zone, Amhara Regional State, Ethiopia. He attended his elementary, secondary, and preparatory education at Chiro Cherkos Elementary School, Walelign Mekonen, and Borena Mesenado, Secondary and preparatory Schools respectively in Mekaneselam town.

After successful completion of the University Entrance Examination, he then joined Wolayita Sodo University in 2011 earned his degree in Animal and Range Sciences, and was awarded a bachelor of sciences degree in August 2013. After graduation, he was employed at Wolayita Sodo University as a Graduate Assistant in the Department of Animal and Range Sciences. After a year of experience, he was given the opportunity of MSc study at Bahir Dar University, School of Graduate Studies of Bahir Dar University in October 2015, to pursue his post-graduate study in the field of Feeds and Animal Nutrition.

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DEDICATION

I dedicate this thesis to my Mother Habtam Meshesha and my Sister Yetmwork Getachew who sacrificed their time and resources to help me to be strong and successful in my life.

LIST OF ABBREVIATIONS

ADF	Acid Detergent Fiber
ADL	Acid Detergent Lignin
ANOVA	Analysis of Variance
AOAC	Association of Official Analytical Chemists
Cm	Centi meter
CP	Crude Protein
CSA	Central Statistical Agency
DM	Dry Matter
FAO	Food and Agriculture Organization
GDP	Gross Domestic Product
HA	Hectare
HARC	Holeta Agriculture Research Center
IVDMD	Invitro Dry Mater Digestibility
IVOMD	Invitro Organic Matter digestibility
KM	Kilo meter
LSD	Least Significant Difference
M	Meter
M.A.S. L	Meter Above Sea Level
ME	Metabolizable Energy
MPFT	Multipurpose Fodder Tree
NCFR	Non-conventional Feed Resource
NDF	Neutral Detergent Fiber
NRC	National Research Council
OM	Organic Mater
SPSS	Statistical Package for Social Science
TLU	Tropical Livestock Unit

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ABSTRACT

This study aimed to evaluate the nutritional value of Korch (Erythrina abyssinica) and its utilization as a livestock feed in the Sekela district, Amhara region, Ethiopia. The experiment was done during the dry season (February to April 2024). Data were collected using semi-structured questionnaire interviews, field observations, key informant conversations, and focus group discussions. The study area was divided into two agroecologies: the highlands and the midlands. A total of 357 respondents, 231 from the highlands and 126 from the midlands were chosen randomly and given one-on-one interviews. E. abyssinica samples were collected from two altitudes, and the chemical composition and in vitro digestibility were assessed. Data were gathered and examined using statistical procedure for social sciences (SPSS) version 26 (SPSS, 2011). The results of the study showed that a mixed crop-livestock production system was the dominant farming system in both altitude regions. The mean total land holding was 3.81±0.069 ha per HH. The average livestock holding size per HH was 7.01±0.11TLU and was significant ($p<0.01$) varied across agroecologies. The major feed resources were crop residues, natural pasture, aftermath grazing, atela, and hay. The major constraints related to livestock production were feed shortage, diseases, poor genetic potential, shortage of veterinary service, and water shortage. The feed utilization practice of E. abyssinica in the area was cut and carrying system. Many farmers appreciate the benefits of E. abyssinica for improving animal performance. According to farmers' perceptions in the study area, E. abyssinica can improve the growth rate and productivity of ruminant animals such as sheep, goats, and cattle. And also, their perception indicates that E. abyssinica can partly fill the deficient nutrients available in low-quality feeds during the dry season. Generally, E. abyssinica is very important for ruminant animal production and productivity if farmers provide timely and properly The DM and CP content is 93.38% and 22.06% respectively and there was no significant difference ($p>0.05$) among agroecologies. IVDMD (57.09%) and estimated biomass yields (2.85±0.038Kg) were significantly higher ($P<0.05$) in the highland. Its ME (8.32 MJ/kg) was not significantly different ($p>0.05$) among agroecologies. In general, due to its high crude protein contents, better digestibility, and low fiber content E. abyssinica is able to be a dry season supplemental feed to increase ruminant performance and to maximize the utilization of low-quality feed resources when feed is in short supply.

Keywords: *Biomass yield, Chemical composition, Erythrina abyssinica, Fodder trees, IVDMD*

CHAPTER ONE: INTRODUCTION

1.1. Background and Justification

Ethiopia is home to the majority of Africa's Livestock population with an estimated number of 70 million cattle, 42.9 million sheep, 52.5 million goats, 2.15 million horses, 10.8 million donkeys, 0.38 million mules, 8.1 million camels, 57 million poultry and 6.99 million hives (CSA, 2021). This huge livestock population has a great contribution to Ethiopia's national economy and the livelihoods of many Ethiopians (FAO, 2017; Samson Leta & Frehiwot Mesele, 2014). Livestock is essential to farmers because it provides several benefits, including cash income generation, food security (meat, milk, eggs, and honey), energy for crop growth, transportation, export commodities (live animals, hides, and skins), manure for home and farm energy, security in the event of crop failure, ability to accumulate wealth, create job opportunity, and reduce poverty (Belay Duguma & Janssens, 2021). Smallholder farmers in the mixed crop-livestock agricultural system mostly depend on this subsector for their livelihood. Livestock Contributes 15 - 17 % of GDP, 35 - 49 % of agricultural GDP, and 37 - 87 % of household incomes (Ayele Solomon *et al*., 2003; Shapiro *et al*., 2017).

Despite their large numbers and their variety of functions, Ethiopian livestock output remained low and unable to meet the demands of the country's rapidly expanding population. Factors such as lack of feed in terms of quantity and quality, a high prevalence of diseases and parasites, low genetic potential in local breeds, poor veterinary service, restricted access to credit, seasonal variation, and poor management techniques are the most bottleneck that retarded the growth of livestock production and productivity (Gebeyanesh Zerssa *et al*., 2021; Shimelis Mengistu *et al*., 2021; Tesfalem Aseged *et al*., 2023). However, of these factors poor nutrition both in quality and quantity is the major limiting factor that hinders livestock productivity in all of Ethiopia's ecological zones (FAO, 2019; Jabesa Ayele *et al*., 2021). According to Malede Birhan & Takele Adugna, (2014), lack of livestock feed in Ethiopia is related to the following problems like drought, over grazing, cropping land expansion, border conflict, weed and bush encroachment, soil infertility and lack of seed and planting material.

Among different requirement things, feed is the most crucial input in livestock production that determines the productivity and production of livestock. Therefore, to get maximum livestock output feed must be available in sufficient quantities and of high quality. Natural pasture, crop residue, post-harvest grazing, improved forage, agro-industrial by-products, and other by-products such as food and vegetable rejection are the different categories of livestock feed supplies in Ethiopia (Alemayehu Mengistu *et al*., 2017; Hussen Abduku, 2022). Among those, the majority of livestock feed resources in Ethiopia are contributed by crop residues and natural pasture; however, these sources are deficient in nutrients and cannot sustain higher livestock output (Getahun Belay, 2020). According to Fekede Feyissa *et al*. (2022) natural pasture and crop residues aren't only insufficient in quantity but also inferior in quality and cannot meet even the maintenance requirement of the country's livestock resources, especially during unreliable seasons which could decrease livestock productivity and livestock disease resistance.

Tesfaye Feyisa *et al*. (2021) also reported that crop residues and natural pasture are the most widely available feed resources; however, their low CP and IVDMD content and high NDF and ADF content show that they are unable to meet animals' nutritional needs without being supplemented with higher-quality feeds. The contribution of natural pastures is gradually declining due to soil degradation, overgrazing, poor management, population growth, and the continuing expansion of crop farms (Abadi Nigus, 2017). According to Alemayehu Mengistu *et al*. (2017), the ongoing conversion of grazing land to cropland is exacerbating the country's livestock feed scarcity. Because of inadequate management, the accessible grazing pastures are also susceptible to degradation, which turns them into gullies and barren areas.

To overcome the problem of feed scarcity and to boost livestock productivity, the use of native multipurpose fodder trees (MPFTs) is thought to be a viable way to address the issue of feed availability (Assefa Ashenafi *et al*., 2016). Native Ethiopian multipurpose fodder trees are a potentially expensive locally generated protein supplement for ruminants, especially during the seasons when there is a restricted supply of feed both in quantity and quality (Habtamnesh Adane & Agena Anjulo, 2023; Muleta Debela *et al*., 2017). Multipurpose fodder trees (MPFTs) are thought to be a more dependable source of high-

quality feed that can increase livestock output due to their high crude protein content and digestibility (Takele Geta *et al*., 2023). Indigenous fodder trees contain appreciable amounts of nutrients that are deficient in other feed resources such as grasses during dry seasons. They have deep root systems enabling the extraction of water and nutrients from deep in the soil profile (Getachew Mulugeta & Wondimu Ayele, 2022; Gezahagn Kebede *et al*., 2017).

Multipurpose fodder trees (MPFTs) are woody perennials grown for a variety of purposes such as shade, shelter, windbreak, firewood, and land sustainability (Takele Geta *et al*., 2014). Local fodder trees and shrubs are superior to exotic ones because they are more suited to the local climate, have longer lifespans, are familiar to farmers, and locally available planting material is abundant (Getachew Mulugeta & Wondimu Ayele, 2022). Even though the majority of native improved forage production is thought to be the solution to feed scarcity however, it is hampered by many issues, such as small land holdings, the production of food crops predominating, a lack of forage seeds, a lack of knowledge, a lack of extension services and a lack of understanding of forage species and their production systems (Shimelis Mengistu *et al*., 2021).

Therefore one potential strategy to improve the nutritional supply for livestock is growing herbaceous and tree forage legumes and incorporating them into food or income crops for use as supplemental feeds (Berhanu Alemu *et al*., 2014). In this regard, korch (*Erythrina abyssinica*) is a potential multipurpose legume tree species endemic to Ethiopia (Getachew Abraham *et al*., 2022). In livestock farming, these plant leaves are used as fodder for animals. In addition to livestock feed *Erythrina abyssinica* being a legume is well known for fixing nitrogen into the soil and thus enhancing soil fertility (Obakiro *et al*., 2021). Its flowers also release nectar that can be consumed by pollinating insects, especially bees; hence its importance in apiculture is extremely high. Although this plant usually grows naturally in the wild, some communities cultivate it in their homesteads as an attractive plant, for live fencing purposes due to its brightly colored flowers. The stem of this plant is also harvested to obtain timber and charcoal for furniture and energy purposes, respectively (Obakiro *et al*., 2021).

1.2. Statement of the Problem

Ethiopia is home to the majority of Africa's livestock population (CSA, 2021). Despite the large and diverse livestock genetic resources, the productivity and economic contribution remains low due to several factors such as shortage of feed in terms of quantity and quality, widespread disease, land shortage, poor health care services, poor genetic potential of indigenous animals and insufficient knowledge on the dynamics of the different farming systems (Elema Jateni, 2023; Tesfalem Aseged *et al*., 2023). One of the main factors affecting and impeding livestock productivity in Ethiopia is the scarcity and the poor quality of available feed, particularly during the dry season (Shimelis Mengistu, 2020). In Ethiopia, the main sources of feed resources for livestock are natural pasture and crop residue, however, these sources have poor biomass yields, low nutritional values, low digestibility, and high fiber content making them insufficient to meet the dietary needs of livestock (Lelisa Diriba & Mengistu Urge, 2020). The natural grazing lands are gradually shrinking from time to time due to cultivation to satisfy the food needs of the ever-increasing human population and livestock are forced to graze in marginal areas combined with the use of low-quality crop residues (Hiwet Gebremedhin *et al*., 2017). This source of animal feed can't satisfy the nutrient requirement of livestock. As a result, the performance of animals can be decreased which means the animal products are reduced and this can increase poverty by diminishing farmers' incomes.

A major issue affecting livestock producers in Sekela district, as in other parts of Ethiopia, is an inadequate availability of feed, both in terms of quantity and quality. This is particularly problematic during the dry season when pasture and crop residues are scarce both in quantity and nutritional quality. Under this condition using feed resources from nearby legume plants would be the most sensible supplement to alleviate the burden of the feed shortage problem. The use of locally available indigenous fodder species could be a good feed resource for livestock during feed gaps and drought season to boost livestock production and productivity as well as to increase the income of the livestock producer (Almaz Ayenew *et al*., 2021).

Korch *(Erythrina abyssinica)* is one of the legumes locally available species trees that are commonly grown throughout the year in the study area. It provides benefits to livestock feed, homestead fences, and soil protection. However, there were no detailed studies on how the local people utilized and their perceptions of the sustainable use of this desirable livestock feed. Generally, despite the indigenous knowledge of local people, the nutritional characterization, feeding practice, and digestibility of korch *(Erythrina abyssinica)* hasn't been studied as a major topic of research. Therefore, to fill the gap this research was employed with the following objectives.

1.3. Objectives

1.3.1. General objective

The general objective of this study was to evaluate the nutritional value of Korch (*Erythrina abyssinica*) and its utilization as a livestock feed in the Sekela district, Amhara region, Ethiopia.

1.3.2. Specific objectives

- To evaluate the chemical composition and biomass yield of Korch (*Erythrina abyssinica*)
- To evaluate the in-vitro dry matter digestibility and in-vitro organic matter digestibility of Korch *(Erythrina abyssinica)* and determine its potential as a feed source.
- To assess the farmer's perception and utilization practices of Korch *(Erythrina abyssinica)* as livestock feed.

CHAPTER TWO: LITERATURE REVIEW

2.1. Livestock Feed Resources in Ethiopia

For livestock Production, feed is the foundation of all vital functions. It provides the essential nutrients to fuel their metabolic processes, maintain body health, enable efficient milk production, support a healthy pregnancy, and promote desirable body condition gain (Ahmet Baris, 2023). Conversely, poor-quality feed or inadequate nutrition can lead to stunted growth, lower production, reduced fertility, and increased susceptibility to diseases (Ahmet Baris, 2023). Therefore, for a particular area to achieve its maximum livestock output, the number of animals and the chosen production techniques must be balanced with the carrying capacity of the land and the feed availability (Tibebu Kochare *et al*., 2018; Tikabo Gebremariam & Shumuye Belay, 2023). Low milk output, slow growth rates, long calving and lambing intervals, and a very late age at maturity are characteristics of Ethiopia's small-holder livestock production system. Lack of livestock feed is the main problem to raising livestock output to fulfill Ethiopian's rising demand for meat, milk, and milk products (Jabesa Ayele *et al*., 2021). In Ethiopia, the common livestock feed resource is natural pasture, crop residue, improved forages, agro-industrial by-products, and other by-products like food and vegetable refusal, of which the first two contribute the largest share (Emana Megersa *et al*., 2017; Hussein Abduku, 2020).

Table 1: Proportion of Livestock Feed Resources in Ethiopia

No	Feed source	Percentage
1	Green fodder/Grazing	54.54
2	Crops residue	31.13
3	Improved feed	0.57
4	Hay	7.35
5	Agro-industrial by-products	2.03
6	Others feed/Concentrate feeds	4.37

Source: CSA (2021)

2.1.1. Natural pasture

Natural pasture is an area of land used for animal feeding that naturally produces grasses, legumes, herbs, shrubs, and tree foliage without interference from human beings. For most of the year, Natural pastures serve as the primary feed supply for smallholder agricultural systems throughout the majority of sub-Saharan Africa (Boote *et al*., 2022). It is the major livestock feed resource in Ethiopia, which is currently declining in coverage due to the conversion of pasture lands into croplands (Alemayehu Mengistu *et al*., 2017). The current condition of pasture lands is lacking in nutrients due to overstocking, excessive grazing, fragmentation, degradation, and poor management techniques (Deribe Gemiyo *et al*., 2013). Alemayehu Mengistu *et al*. (2017) estimated that 80-85% of the livestock feed in Ethiopia is derived from natural pasture. However, Natural pastures are characterized by high fiber content, low digestibility, low nitrogen, and very low protein and energy content (Topps, 1995). Obviously, during the rainy seasons, natural pastures would be sufficient for maintaining and gaining weight, but they wouldn't support upkeep during the dry season. Ethiopia's highland natural pastures are rich in species diversity, especially native legumes and grasses. Due to the current rapid population growth and rising food demand, grazing lands are being converted to arable land, which is causing them to rapidly diminish (Alemayehu Mengistu *et al*., 2017). Feed values of natural pasture fluctuate considerably in quality based on components such as protein and fiber, which are generally inversely proportional to each other. According to Alemu Gashe *et al*. (2023), the dry matter yield and crude protein contents of natural pasture were low, which would have an impact on feed intake, digestibility, and livestock productivity.

2.1.2. Crop residue

Crop residue is the portion of sown crops that remain after the main product is processed or after human food crops have been harvested (Lukuyu *et al*., 2021). It comprises cereal and legume residues such as wheat straw, barley straw, teff straw, faba bean straw, and maize stover. Although crop residue cannot fulfill the nutrient requirement of livestock, however, they are important in fulfilling feed gaps during periods of acute shortage of other

feed resources (Getnet Assefa *et al.*, 2022). Crop residue biomass is rising as a result of the periodic conversion of pasture areas to cropland.

However, quality and digestibility are very low with less than 50% digestibility, high fiber content (more than 70% NDF), and low crude protein (< 5% CP) (Chala Edea *et al*., 2024; Tesfaye Feyisa *et al*., 2021). The crops grown are mainly used as food for humans as well as a means of income, whereas residues from cereal and pulse crops are the major source of livestock feed (Dawit Assefa *et al*., 2013). Crop residues are a byproduct of higher crop yields, which provide a substantial amount of feed during the dry season in most of Ethiopia's farming regions, especially in the highland and mid-altitude agro-ecologies (Alemayehu Mengistu *et al*., 2017). A report by Alemu Gashe, (2023) indicated that crop residues contribute to about 50% of the total livestock feed supplied in Ethiopia. The farming system, the kinds of crops grown, and the level of cultivation all have a significant impact on the availability of crop residues. Crop residues are used soon after the main crop harvest and threshed and conservation for the next dry and wet season is mostly stalked in the open air (Kassahun Gurmessa *et al*., 2016).

2.1.3. Improved forages

Various efforts have been made to choose a variety of beneficial fodder crops according to their nutritional value and ability to adapt in various regions of the country (Alemayehu Mengistu *et al*., 2017; Diribi Mijena, 2022). As a result, many improved forage and browse species have been identified and recommended for different ecologies. Production of improved forages should focus on those species that have high biomass yield potential and high nutritive value such as Napier grass (*Pennisetum purpureum*), Rhodes grass (*Chloris gayana*), Guinea grass (*Panicum maximum*), Buffel grass (*Cenchrus ciliaris*), Sudan grass (*Sorghum Sudanese*) and Columbus grass (*Sorghum almum*) (Fekede Feyissa *et al*., 2022). As a result, many government and non-government organizations have released and registered forage species and promoted them to users to improve the quantity and quality of fodder that is accessible across the country. However, some obstacles have prevented smallholder farmers from adopting these technologies such as land shortage, lack of capital to purchase inputs (improved forage seed), lack and high cost of planting materials, lack of

knowledge or awareness, crop-dominated farming systems, and poor extension services (Diribi Mijena, 2022; Shimelis Mengistu *et al*., 2021). Improved forage production has diversified advantages. The primary benefit is to produce a high amount of quality forage by providing an appreciable number of crude proteins to be used as feed for farm animals. On the other hand, improved forage cultivation is practiced for soil conservation, crop rotation, windbreak, fence, and cooking wood. Improved forages mainly legumes, can improve the productivity of natural pastures by improving the fertility status of the soil.

Improved forage yield is higher than the naturally occurring swards and has higher nutritional value (Abadi Nigus, 2017). Most importantly, the production of improved forages provides a source of protein, which greatly enhances the productivity of animals placed on crop residues as a source of energy for ruminant animal feeding (Alemayehu Mengistu *et al*., 2017). Supplementation of leguminous forage improves voluntary feed intake and digestibility of crop residues and poor-quality pasture-based diets (Malede Birhan & Takele Adugna, 2014). Improved forages could also improve the feed value of the native pastures since they are better in protein content and quality than naturally occurring grass. Generally, improved forage production could provide useful nutrients, especially in rural areas where the availability and accessibility of agro-industrial by-products is a problem (Samuel Mena, 2021).

2.1.4. Agro-industrial by-products

Agro-industrial by-products (AIBPs) that are not intended for human consumption can be used as alternatives to conventional feedstuffs in animal nutrition to produce animal products without competing for land or triggering the food-feed competition, thus leading to environmental, social, and economic sustainability (Georganas *et al*., 2023). They have special value in feeding livestock, particularly in urban and peri-urban livestock production systems and in circumstances where the animals' potential for productivity is very high and they need a significant supply of nutrients (Andualem Tonamo & Ermias Belete, 2016; FAO, 2019). The main agricultural products that are frequently used in Ethiopia come from a variety of agricultural industries, including breweries, sugar factories (molasses), edible oil extraction plants (noug cake, cottonseed cake, peanut cake, sesame cake, sunflower

cake, etc.), and flour milling industries (wheat bran, wheat short, wheat middling, and rice bran) (Hussen Abduku, 2022).

Nutritional qualities of agro-industrial products are rich in energy and protein contents or both; however, their relative contribution to smallholder farmers is low. This could be attributed to the unaffordable prices of the products by most smallholder farmers, the limited availability of the resources, and a lack of awareness of the feeding values of these feed resources. Thus, the availability and utilization of these feed resources are limited only around towns where different agro-industries are found and the beneficiaries of the products are mainly livestock fattening operations and urban and peri-urban dairies located in the area with better accessibility to the resources.

2.1.5. Non- Conventional feed resources

The term "non-conventional feed resources" (NCFR) generally refers to any feeds that haven't been offered to animals historically or that aren't manufactured commercially for use in livestock feeds (Amata, 2014; Patel & Katole, 2023). Non- Conventional feeds commonly used in Ethiopia include fish offal, duckweed, kitchen leftovers (such as potato, carrot, onion, and cabbage peels), poultry litter, algae/Spirulina, Leucaena leaf, sisal waste, cactus, coffee parchment, and coffee pulp (Tegene Negesse *et al*., 2009). These feed resources could be extremely beneficial for small and medium-sized livestock owners.

With increasing demand for livestock products as a result of rapid growth in the world economy and shrinking land area, future hopes of feeding the animals and safeguarding their food security will depend on the better utilization of non-conventional feed resources that don't compete with human food (Onte *et al*., 2019). Non-conventional feeds have the potential to partially close the feed supply gap, lessen animal-human competition for resources, lower feed costs, and promote nutrient self-sufficiency from locally accessible feed sources (Tegene Negesse *et al*., 2009).

2.2. Livestock production constraints in Ethiopia

Inadequate feed supply, both in terms of quantity and quality, is the major constraint affecting livestock production and productivity in Ethiopia (Fekede Feyissa *et al*., 2022).

Feed scarcity is indicated as a main factor responsible for the lower reproductive and growth performance of animals especially during the dry season. The dry season is characterized by inadequacy of grazing resources as a result of which animals aren't able to meet even their maintenance requirements and lose a substantial amount of their weight. According to Aman Gudeto *et al*. (2020), the major bottlenecks for livestock production among Ethiopian farmers are feed shortages, diseases and parasites, drought, shortage of grazing land, market access, veterinary services, extension services, and other infrastructure. The interaction of these constraints affects the performance of the genetic potential of animals leading to a subsistence level of livestock production.

2.3. Fodder Trees and Shrubs

In the tropics and subtropics, dry seasons are often associated with nutritional inadequacies in ruminants. However, fodder tree/shrub legumes may help to partially mitigate the feed scarcity and nutritional deficiencies that occur during the dry season (Simbaya, 2018). Among different Indigenous fodder trees in Ethiopia *Cordia africana, Buddleia polystachya, Dombeya torrida, Hagenia abyssinica, Yushania alpine, Combretum molle,* and *Erythrina abyssinica*, which are grown by farmers as hedges of homesteads, were found to have high potential as nutritious animal feed (Begashaw Mitiku, 2020; Muleta Debela *et al*., 2017). Fodder trees are an important substitute for animal feed Because they can generate large amounts of biomass nearly year-round and are nutrient-rich (Asmelash Tesfaye *et al*., 2020). Fodder trees and shrubs are important sources of energy and protein to keep the animal's body healthy, improve growth rate, and even increase milk and meat production (Tilahun Debela, 2021). According to Aman Abeje & Adane Kore, (2023), in many parts of the Gamo zone, lopping and feeding tree foliage is becoming a common practice to maintain sustainable productivity or to overcome the fodder deficit in livestock production. Similarly, according to Getachew Mulugeta & Wondimu Ayele (2022), fodder trees play a crucial role in meeting the deficiency of animal feeds in highland areas during the dry season. They are preferred due to their high biomass yield, adaptability, easy of propagation, multi-functionality, long life span of the tree, high compatibility with the cropping system, and high feed value as compared to other improved fodder trees (Gezahagn Kebede *et al*., 2017). However, because of variations in chemical composition

and related traits that result from both intrinsic and environmental causes, the nutritional quality varies throughout species (Almaz Ayenew *et al*., 2021). Being perennial plants, fodder trees are not susceptible to sudden climatic changes and continue to maintain their green leaves longer into the dry season and known to produce high-quality fodder even during drought years when grasses and other annual forages are dry and long gone due to their deep root systems (Emana Megersa *et al*., 2017). However, no farmers climb up fodder plants to lop down for their livestock except very few farmers when they face critical feed problems (Emana Megersa *et al.*, 2017)

2.3. 1. Origin and distribution of korch (*Erythrina abyssinica*)

According to Orwa *et al*. (2009), the origin of the name *Erythrina* comes from the Greek word ‘erythrose-red, alluding to the showy red flowers of the *Erythrina* species. *E. abyssinica* is Native to Botswana, Burundi, Central African Republic Congo, Democratic Republic of Congo, Eritrea, Ethiopia, Gabon, Kenya, Lesotho, Mozambique, Namibia, Rwanda, South Africa, Sudan, Swaziland, Tanzania, Uganda, Zambia and Zimbabwe and Exotic to Afghanistan, Bangladesh, Bhutan, India, Nepal, Pakistan and Sri Lanka (Orwa *et al*., 2009).

2.4. Taxonomy, Morphology and Propagation of Korch (*Erythrina abyssinica*)

Korch, scientifically known as *Erythrina abyssinica* belongs to the kingdom Plantae, phylum Spermatophyta, subphylum Magnoliophyta (flowering plants), class Magnoliopsida (dicotyledons), order Fabales, family Fabaceae (legumes), subfamily Papilionoideae, genus *Erythrina* (L.), and species *abyssinica* (Lam ex. DC.). It grows up to a height of 12-15 meters and has a trunk diameter of up to 70cm (Orwa *et al*., 2009). It has been wildly propagated via stem cutting and hence used for live fences and hedgerows in the midland and highland areas of Ethiopia (Getachew Abraham *et al*., 2022).

The leaves of Korch are compound and arranged in a spiral manner. They are dark green and have a length of about 20-30cm. The tree produces beautiful red flowers that bloom from December to January. These flowers are large, showy, and have a tubular shape. They grow in clusters at the ends of branches and attract a variety of pollinators such as birds,

bees, and butterflies. The fruit of Korch is a pod-like structure that is about 15-25cm long. It contains numerous seeds that are dispersed by wind and animals.

2.5. Importance of korch (*Erythrina abyssinica*)

Erythrina abyssinica is highly valued for its various uses around the world, which include medicine, Apiculture, fuel, Tannin or dyestuff, Poison, Erosion control, Shade or shelter, Nitrogen fixing, Intercropping, timber, fodder, and ornamental purposes (Orwa *et al*., 2009). The foliage of *E. abyssinica* is considered a good protein supplement for ruminants (cattle, sheep, and goats) and has been used as a fodder source for rabbits and pigs (Orwa *et al*., 2009). Larbi *et al*. (1993) also indicated *E. abyssinica* has high forage potential and can effectively serve as a cheap source of protein supplement for low-quality diets during the dry season for resource-poor farmers with stall-fed sheep and goats. One of the most important uses of *E. abyssinica* is in traditional medicine (Ayalew Temesgen, 2015). The bark, leaves, and roots of the tree are used to treat a wide range of ailments, including fever, cough, and stomach problems. According to Chitopoa *et al*. (2019) in Zimbabwe reported that *E. abyssinica* is a medicinal plant that has been used traditionally for the treatment of various infections, snakebites, and some sexually transmitted diseases. Getachew Abraham *et al*. (2022) also reported that extracts from a young shoot of *E. abyssinica* have been used to treat lice and itching in cattle in the Geresse district of Southern Ethiopia. The tree also has anti-inflammatory and analgesic properties, which make it useful in treating pain and inflammation. It is also highly valued for its timber. The wood is hard, strong, and durable, making it ideal for construction and furniture making. The tree is also used for fuel wood, charcoal, and fencing. The tree is also a favorite among birds and pollinators, making it a great addition to any garden or landscape (Obakiro *et al*., 2021).

2.6. Nutritional value of Korch (*Erythrina abyssinica*)

According to the study by Muleta Debela *et al*. (2017) in the Daro Labu district, West Hararghe Zone of Oromia Regional State *Erythrina abyssinica* had higher potential as animal feed in terms of crude protein contents and relative feeding value. The same author reported that the Ash, CP, NDF, ADF, and ADL content of *Erythrina abyssinica* is 13.7%, 15.84%, 50.17%, 37.44%, and 20.3% respectively. The other study by Larbi *et al*. (1993)

indicated that *E. abyssinica* has high forage quality and that could effectively serve as a cheap source of protein supplement for low-quality diets during the dry season for resource-poor farmers. As reported by Larbi *et al*. (1993) the ash, CP, and NDF content is 10.3%, 20.6%, and 57.8% respectively.

2.7. Anti-nutritional value of fodder tree

Plants that are grown as fodder for animal feeding purposes is the base feedstuff for animal feeding which provides nutrients and energy. The presence of toxic substances limits the utility of the leaves, pods, and edible twigs of shrubs and trees as animal feed and fodder (Ramteke *et al*., 2019). Different roughs, legumes, shrubs, herbs, trees, and other non-conventional feed of animal contain some anti-nutritional component in green as well as in its dry matter basis. Anti-nutritional factors affect the nutritive value of forages and feedstuffs, and hence animals (including humans) that feed on them (Jacob Nte *et al*., 2023). The main anti-nutritional factors in eatable forage and fodder contain tannins, saponins, phytic acid, gossypol, lectins, amylase inhibitors, goitrogens, and protease inhibitors (Kemboi *et al*., 2023).

CHAPTER THREE: MATERIALS AND METHODS

3.1. Description of the study area

The study was conducted in Sekela district, west Gojjam zone of Amhara regional state, Ethiopia. The administrative center of Sekela is Gish Abay town. It is located 411 km in the North West of Addis Ababa, the capital city of Ethiopia, and 174 km in South East of Bahir Dar, the capital city of Amhara National Regional State. The district is located between 10°58′45" N latitude and 37°09′29"E longitude. The altitudes range from 1999 to 3399 meters above mean sea level (m.a.s.l) with an annual rainfall of 1,600 to 1,800 mm. The average minimum and maximum temperatures are 8.6^{o}C and 28.8^{o}C, respectively. The agro-climatic zone of the district can be categorized as 70% highland and 30% midland (Zemenu Tadesse & Werkineh Tadese, 2021). The midland and highland sites are situated at an elevation ranging from 1999 to 2500m and 2500 to 3399m above sea level respectively (FAO, 2003). The district is bounded by the Mecha district in the north, the Yilmana Densa district in the northeast, the Burie district in the south, the Jabi Tehnan district in the southeast, the Awi zone in the west, and Quarit district in the east. The district is the origin of River Abay. In addition, the district has a total of 28 kebeles of which 27 are rural based kebeles and only 1 is urban kebele (SWAO, 2024).

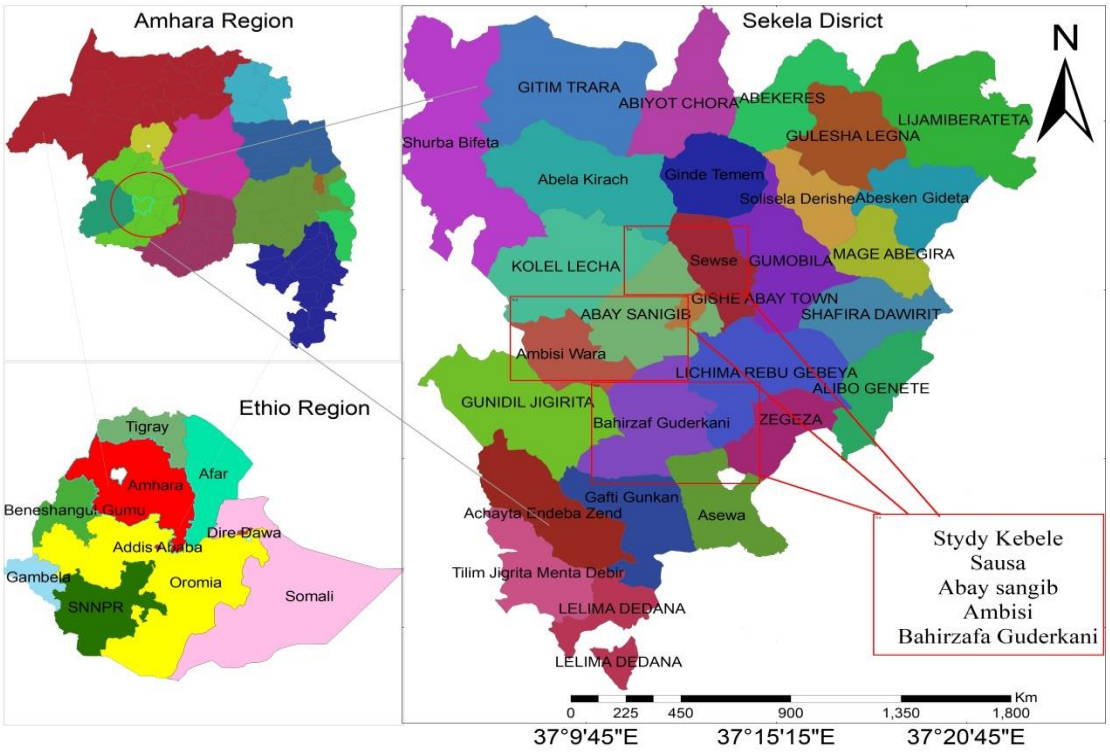

Figure 1: Map of the study area

3.2. Study design

To achieve the objective, the study involved the use of questionnaire surveys, field visits observation, and focus group discussions with the main objective of chemical characterization of the selected fodder species.

3.3. Sample size and sampling technique

Multi-stage sampling procedure was employed at three different stages. In the first stage, the district was categorized into two agroecology, which are highland (70 %) and midland (30 %) (Zemenu Tadesse & Werkineh Tadese, 2021). In the second stage, based on the area coverage of korch (*Erythrina abyssinica*) and road access, four *kebeles* were selected purposively; three *kebeles* from highland (Abay sangib, Sausa, and Ambisi) and one *kebele* from midland (Bahirzafa Guderkani) were selected. In the third stage, 357 individual households were selected randomly from each *kebeles.* To determine the appropriate sample size for survey data, the level of precision (sampling error is 5%) and confidence are at a 95% confidence level that is, 95 out of 100 samples will have the true population

value within the range of precision specified. Therefore in this research, the sampling technique was used Yamane (1967) provides a simplified formula to calculate sample sizes. The formula used to calculate the sample sizes was a 95% confidence level and P = 0 .05 assumed. Then the formula used is

$$n = \frac{N}{1+N(e)^2}$$

Where:

n= Sample size

N= Population size = 3361

e= Error term (significant level) (5%)

As households were not evenly distributed among the kebeles, the sample size for each kebele was calculated as follows.

$$ni = \frac{Ni}{N}(n)$$

Where ni = the required sample size from each *kebele.*

Ni= Total number of households in each *kebele.*

N = Total number of households in all *kebele*

n = sample size of all *kebele* household

Table 2: Sample households selected across agro-ecologies in Sekela, west gojjam zone

Agro ecology	*Kebele*	Total household	Sample household
Highland	Abay sangib	960	(960*357)/3361 = 102
	Ambisi	602	(602*357)/3361 = 64
	Sausa	612	(612*357)/3361 = 65
Midland	Bahirzafa Guderkani	1187	(1187*357)/3361 = 126
	Total	3361	357

3.4. Method of Data Collection and Sources of Data

A questionnaire household survey, focus group discussion, and observation were used to collect primary data. Secondary data was collected from published materials like census, survey reports, abstracts, etc., or unpublished materials like dissertations, official records, memorandums, etc. The questionnaires were pre-tested before the actual survey. The data collected focused on the feeding calendar, purpose of feeding, utilization practices of *Erythrina abyssinica*, palatability, types of animals they feed, methods of feeding, the major constraints of livestock production, and other necessary information. From each selected *Kebele* three households a total of twelve persons were selected and a focus group discussion was held based on checklists for general information regarding the available feed resources and the utilization of *Erythrina abyssinica*. Model farmers and elders who were knowledgeable about past and present social, production, and economic status of the area participated in the group discussion.

3.5. Sample collection and preparation

Representative samples of *Erythrina abyssinica* leaf were collected from two agroecological zones of the study area. The *Erythrina abyssinica* tree samples were selected randomly (along the horizontal line) in the area within a distance of 0.2 kilometer (Km). A total of 25 trees per *Kebele* were selected. The sample trees were aged 3-5years. Then the selected plant (*Erythrina abyssinica*) was measured from the starting points of the branch up to the end parts and divided into three equal parts based on its main branches (Lower branch, Middle branch, and Upper branch) after that the sample leaf was collected from each branch. The sample leaf was plucked by hand in each *kebele* for both agroecological zones (highland and midland) separately. From each *Kebele* 500 g of composite sample leaves were taken. The sample feed was collected during the dry season, a critical time when this plant serves as an alternative feed source for livestock. The leaf samples were dried partially at 65 ^{0}C for 48 hours. The samples were placed in airtight plastic bags until taken to Bahir Dar University Animal Nutrition Laboratory and Holeta Research Center-Animal Nutrition Laboratory for further chemical analysis.

3.6. Chemical analysis of sample feeds

3.6.1 Chemical analysis

The chemical composition analysis of CP, OM, DM, Ash, ADL, NDF, and ADF was done at Bahir Dar University Animal Nutrition Laboratory. The dry matter (DM) content was determined by oven drying of all the samples at 105^0C for 24 hours. Oven-dried feed samples were ground using a Wiley mill to pass through a 1 mm sieve for chemical analyses. Ash was determined by complete burning of the feed samples in a muffle furnace at 500^0C overnight according to the procedure of AOAC (1990). The structural plant constituents such as neutral detergent fiber (NDF), acid detergent fiber (ADF), and acid detergent lignin (ADL) were analyzed by using the detergent extraction method Van Soest *et al.* (1991). Total nitrogen (N) was determined by the Kjeldahal method (AOAC, 2004). Crude protein (CP) was calculated from the total N by the formula: N x 6.25.

3.6.2. In-vitro Dry matter and In-vitro Organic matter Digestibility and Estimation of ME

The IVDMD and IVOMD determination were done at Holeta Research Center in the Animal Nutrition Laboratory. In vitro, dry matter digestibility (IVDMD) of sample feed was determined by incubating the samples in rumen fluid using the two-stage digestion method of Tilley and Terry (Tilley & Terry, 1963) as modified by Van Soest and Robertson (Van Soest *et al*., 1991). The rumen fluid was obtained from rumen-fistulated sheep kept on a maintenance diet. About 0.5g of the sample was incubated in 125ml Erlenmeyer flasks containing rumen fluid-medium mixture for 48 hours in an incubator at 39°C. The microbial digestion is then followed by neutral detergent refraction for the following 48 hrs. The residues were oven-dried overnight at 105ºC to determine IVDMD. The oven-dried residue was then ashed to estimate *In vitro* OM digestibility.

To estimate the energy value of the sample feed, the metabolizable energy (ME) was estimated from digestible energy (DE) and IVOMD using regression and summation equations developed by (NRC, 2000)

DE= (0.01*(OM/100) *(IVOMD+12.9) *4.4)-0.3

ME (MCal/kg) = 0.82*DE.

ME (MJ/Kg) =4.184*ME (MCal/kg).

Where: DE = digestible energy, OM = organic matter, IVODM = in vitro organic matter digestibility, ME = metabolizable energy, MCal= Mega Calori, MJ= Mega Joule.

3.7. Leaf Biomass yield estimation

Sample feed was taken by randomly selected *Erythrina abyssinica* in which the dry matter yield was determined. Randomly selected *Erythrina abyssinica* along the horizontal line within a distance of 0.2 km. Using a measuring tape, the circumference of the trunk of each selected *Erythrina abyssinica* species was measured and recorded. The diameter was calculated as described by Petmak (1983) as follows.

D =0.636c where

D = the diameter of the trunk (cm) at 130 cm height for a tree

C = circumstance of stem

Therefore, the potential yield of *Erythrina abyssinica* (dry matter yield) will be estimated by entering the measured diameter into the equation developed by (Petmak, 1983).

Then LogW=2.24logDT-1.50, for the tree where W=leaf yield in kilogram of dry weight

DT=the trunk diameter (cm) at 130cm height above the ground

3.8. Statistical Analysis

Data was cleaned and entered into a Microsoft Office Excel sheet after administering the questionnaire. All the survey data were organized summarized and analyzed using statistical procedures for social science (SPSS) version 26. Descriptive statistics such as frequency, mean, percentage, standard deviation, and range were used to present the

results. The numerical data was subjected to t-test. the significant differences will be considered at P<0.05%. The appropriate statistical model used was:

$Yij = \mu + bi + eij$

Where, Yij = response variable,

μ= overall mean,

bi= location (agro-ecology) effect

Eij = the random error.

The purpose of keeping livestock, types of feeding systems, and Livestock production constraints were ranked by calculating the index. This is because households mentioned different parameters according to their significance. The index was computed with the principle of weighted average according to the following formula:

$Index = Rn*C1+Rn-1*C2\ldots. R1*Cn/\Sigma\ Rn*C1+ Rn-1*C2\ldots. R1$

Where;

Rn = Value given for the least ranked level (for example if the least rank is 5th rank, then

Rn-5, Rn-1=4 and … R1= 1)

Cn = Counts of the least ranked level (in the above example, the count of the 5th rank =Cn, and the counts of the 1st rank = C1)

CHAPTER FOUR: RESULTS AND DISCUSSION

4.1. Socio-economic characteristics of the Respondents

4.1.1. Household Characteristics

The household characteristics of the respondents are presented in Table 3. In the study district from the total interviewed respondent majority 67.2% of the respondents were male and 32.8% were female-headed households. This is similar to the observations of several previous studies (Amistu Kuma, 2016; Dargo Kebede & Haftay Hailu, 2019; Wubetie Adnew *et al*., 2018) which means most of the responses were given by men on behalf of their households. From the interviewed households 7.6, 80.4, 1.4, 2.2 and 8.4% were single, married, widowed, widower, and divorced, respectively. The overall average age of the respondents is 45.42±9.6 years ranging from 20 to 68 years, which indicates that the household heads of the respondents fall in the economically active age group. This is in agreement with other studies (Belay Duguma & Janssens, 2021; Negasa, 2017).

The overall mean family size of the respondents in the study area was 5.05±0.108 person per household. This result is similar to the average family size (5.53) reported by Ashenafi Miresa & Solomon Demeke (2020) conducted in Bedele District. However, it was lower than reports (6.47) (Sefa Salo, 2019) for the Anelemo district Hadiya zone Ethiopia and 6.89, 6.23 and 6.42 at Bako-Tibe, Toke-Kutaye and Ejere districts, respectively (Ashenafi Mulugeta *et al*., 2019).

The mean family size indicates that the survey respondents have relatively large household sizes this is mainly due to labor-demanding for agricultural activities in the area contributing to such higher family sizes. Large family size was considered very important for farming activities. One of the best and most practical uses of large family size is always labor division in the activity of cattle rearing, feeding, milking, and collecting feed for the animals. In most rural parts of Ethiopia family members are the main sources of household labor. Hence, large family sizes could be taken as an opportunity concerning accomplish laborious farm activities (Muhammad Ayaz & Mazhar Mughal, 2022). However large family size could harm the livelihood of the family's economic activities.

Table 3: Household characteristics of the respondents in the study area

Characteristics		Agro ecologies		
		Highland (N=231)	Midland (N=126)	Overall (N=357)
Sex of the respondent %	Female	90 (39.0)	27 (21.4)	117 (32.8)
	Male	141 (61.0)	99 (78.6)	240 (67.2)
	Total	231 (100)	126 (100)	357 (100)
Marital Status of the respondent%	Married	180 (77.9)	107 (84.9)	287 (80.4)
	Single	22 (9.5)	5 (4.0)	27 (7.6)
	Widowed	5 (2.2)	-	5 (1.4)
	Widower	7 (3.0)	1 (0.8)	8 (2.2)
	Divorced	17 (7.4)	13 (10.3)	30 (8.4)
Age of The Respondent (Mean ± SD)		44.9±10.06	46.22±8.77	45.42±9.6
Average Family Size (Mean ± SE)	Male	2.67±0.082	2.60±0.108	2.64±0.065
	Female	2.42±0.091	2.44±0.126	2.43±0.074
	Total	5.08±0.135	5.00±0.179	5.05±0.108
	children≤14 years	1.43±0.058	1.44±0.073	1.4±0.046
	Adult 15 – 64	2.28±0.095	2.7±0.125	2.43±0.076
	Dependent ≥65	0.29±0.039	0.08±0.029	0.22±0.028
	Active Workers	2.28±0.095	2.7±0.125	2.43±0.076

N: number of respondents; SD, standard deviation; SEM, standard error of means;

4.1.2. Educational status of the respondent

The respondents' level of education in the study area is displayed in Figure 1. From the total sampled household heads, in the study area, about 33.1, 44, 16, 3.9, and 3.1 % were illiterate, read and write only, elementary, junior, and secondary school, respectively. Though a relatively higher proportion of the respondents attended formal education however (33.1%) of the respondents did not get formal education or basic education this might be due to lack of school, farness of school, and lack of wealth. This result is similar to Asrat Ayza *et al*. (2023) who reported that 75% of the respondents attended formal education which disagrees with the result of Belay Duguma & Janssens (2021) who reported that a higher proportion of the respondents illiterate in Gilgel Gibe Catchment,

Southwest Ethiopia. Literacy rate varies from place to place and is associated with various factors such as access to education, and lack of awareness about the importance of education. An increase in the literate class percentage encourages acceptance of new technology. On the contrary, the low education level of the households can have a negative influence on the transfer of agricultural technologies and their participation in development. Therefore, there is a need to provide basic education for uneducated people in the study area especially> 45 years of age.

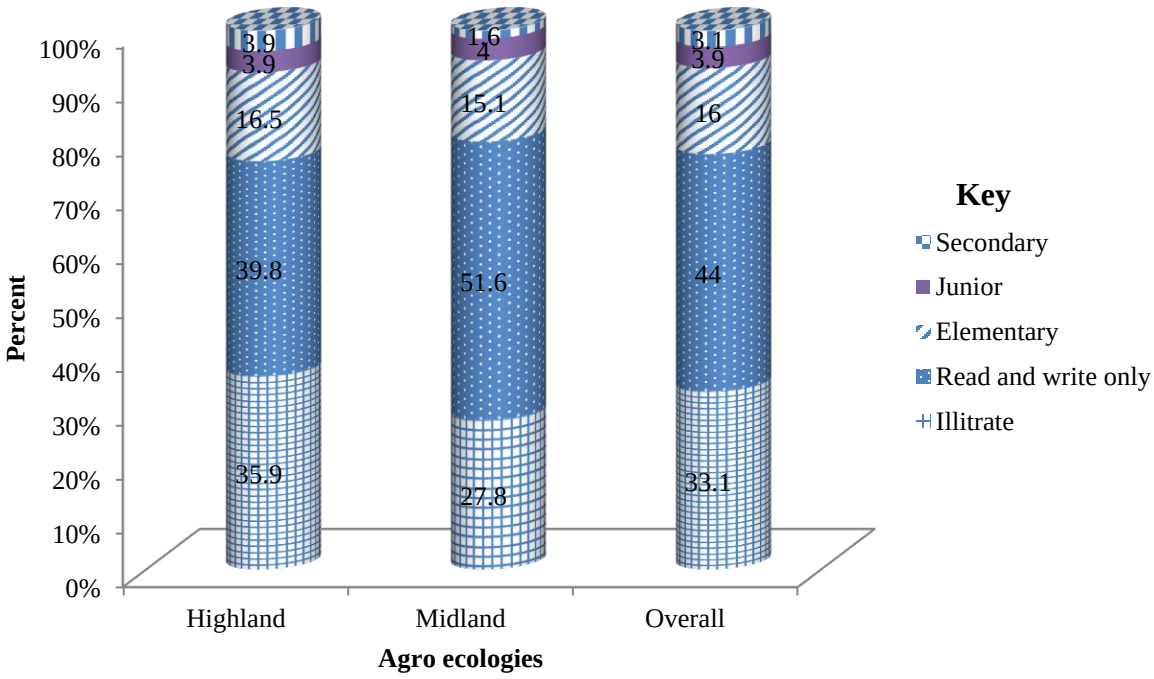

Figure 2: Educational status of the surveyed household heads

4.1.3. Main farming activity of the respondent

The main farming activity of the respondents in the study area is presented in Table 4. Of all respondents, 19.9, 6.2, and 73.9 are engaged in livestock production only, crop production only, and mixed livestock-crop production respectively. This result indicates that the mixed crop-livestock production system was the dominant farming system in the study area and it was used as means of major source of income. This observation is in agreement with Andualem Tonamo & Ermias Belete, (2016), Derbie Alemu *et al*. (2019), and Gezahegn Mengistu *et al*. (2017) who pointed out that the livestock-crop production

system is the main means of livelihood and source of income in different rural parts of Ethiopia. Of the respondents (19.9%) engaged only in livestock production in the study area this might be due to a lack of cultivable land. Contrary to this (6.2%) of the respondents engaged only in crop production this might be due to lack of grazing land and lack of labor to keep the livestock.

Table 4: Main farming activity of the respondent

	Agro ecologies		
Activity	Highland (N=231)	Midland (N=126)	Total (N=357)
Livestock production	39 (16.9)	32 (25.4)	71 (19.9)
Crop production	20 (8.7)	2 (1.6)	22 (6.2)
Livestock-crop production	172 (74.5)	92 (73)	264 (73.9)

N: Number of Respondents, Numbers out and in the bracket, indicate frequency and percent of respondents respectively

4.2. Landholding

In the study area, land is the most important wealth and a basis of farmers` livelihood respondents heavily depend on it to full fill their needs. Land holding of respondents in the Sekela district is presented in Table 5. According to respondents; the overall average land holding was 3.81 ha. Out of which, the size of a homestead, cropland, private grazing land, and communal grazing land were 0.34, 2.34, 0.075, and 0.43 ha respectively (Table 5). The results revealed significant variation ($p<0.001$) in the landholding of a homestead, ($p<0.05$) in the land holding of cropping land, and ($p<0.01$) in the land holding of private grazing land between agroecologies. The difference might be due to population differences among agro-ecologies. Abera Gemechu, (2017) reported that people with large family sizes have large farm sizes. However, there is no significant difference among land holding of communal grazing land ($P>0.05$) between agroecologies. The size of homesteads is higher in the midlands than highlands the size of crooping land is higher in the highlands than the midlands this could be the population difference among agroecologies. Tsedeke Kocho & Endrias Geta, (2011) reported that highland agro-ecologies has densely populated with scarce grazing lands. According to the respondents, the majority of the land is devoted to cropping rather than grazing which leads to feed shortage. In the study area private grazing land is less than communal grazing land this might be due to the respondent converting

their private grazing land into cropping land. Though there is a large communal grazing land in the study area however it is not important for livestock producers because the land could be vulnerable to degradation and soil erosion due to over grazing and improper management. The total land holding of the study area was greater than the average total land holding of 2.85 ha reported by Ashenafi Mulugeta *et al*. (2019) in Bako-Tibe, Toke-Kutaye and Ejere district of West Shewa Zone, Oromia Regional state Ethiopia. However, the present result was lower than the values of 4.08 ha reported by Fantahun Dereje *et al*. (2020) in Aumuru District, Horro Guduru Wollega Zone, Western Oromiya Regional State, Ethiopia. Matawork Gobena *et al*. (2022) also reported much higher land holding (5.834 Ha) in Shaka zone, (4.29 Ha) in Kaffa zone and (3.91 Ha) in Bench Maji zone in Southwest Ethiopia than the current study area. The difference might be due to the population density difference in different agro-ecologies of the country.

Table 5: Average land holding size in the study district

Land use type	Agro ecologies			
	Highland (N= 231) mean±SE	Midland (N=126) mean±SE	Overall (N=357) mean±SE	*p*-value
Homestead	0.28 ± 0.23^{b}	0.43 ± 0.26^{a}	0.34 ± 0.17	0.000
Cropping land	2.42 ± 0.074^{a}	2.17 ± 0.107^{b}	2.34±0.061	0.049
Private grazing land	0.76 ± 0.32^{a}	0.6 ± 0.27^{b}	0.075 ± 0.023	0.002
Communal grazing land	0.44 ± 0.21^{a}	0.4 ± 0.02^{a}	0.43 ± 0.02	0.314
Total	3.91 ± 0.08^{a}	3.625 ± 0.11^{b}	3.81 ± 0.069	0.050

N: number of respondents; $^{a, b}$, means with different superscripts in the row are significantly different $P \leq 0.05$; SEM, standard error of means; P, probability of obtaining the observed result.

4.3. Livestock holding

The average livestock holding of respondents, in Tropical Livestock Unit (TLU) per household, is presented in Table 6. Almost all farmers possess livestock regardless of number and species. In the study area, livestock production was a very important component of a mixed farming system and well-integrated with crop production. The overall average livestock holding of respondents per household in the study area is 1.08,

0.64, 0.91, 0.57, 0.15, 0.8, 0.12, 1.57, 0.7, 0.27 and 0.18 TLU for ox, bull, cow, heifer, calves, Sheep, Goats, horse, donkey, mule, and poultry, respectively. There was a significant difference in livestock holding between the two-studied agro-ecologies. The average livestock holding per household was higher ($P<0.01$) for the midland (7.41±0.17 TLU) than the highland (6.79±0.14 TLU) altitude region.

The reason for the difference in livestock holding might be associated with that farmers in the midland altitude region have relatively better natural grazing land holding size than highland altitude regions (Table 5). Other reasons for the cause of livestock holding variation between agro-ecologies might be feed availability, lack of labor, market problems, disease conditions and resource status of the farmers. Assen Ebrahim & Aklilu Hailemichael, (2012) reported that the distribution of livestock species and the size of the herd/flock per household vary from one agro-ecological zone to another depending on the availability of feed resources, water, and prevalence of diseases and parasites.

Small ruminants such as Sheep and goat were widely reared in the study area, this might be due to available feeding material, easier to manage, and initial investment cost and accommodates them in smaller areas. This finding is in line with the previous reports by Shimelis Mengistu *et al*. (2021) in the Damot Gale District of Wolayita Zone, Ethiopia who reported that sheep were the dominant livestock species than others. The average number of oxen owned per household was higher than the number of cows. This is because oxen are very important for crop farming activities in the study area. This is comparable to Yassin Esmael *et al*. (2019) result in West Arsi Zone, Oromia National Regional State, Ethiopia.

The overall average milking cows and calves owned per household was higher as compared to heifers. This is comparable with the result of Amba Chufa *et al*. (2022) and the reason could be farmers aimed to produce more milk for their family consumption and income. The overall average number of bulls owned per household was higher as compared to heifers. The reason could be farmers used bulls for the replacement of oxen. In the study area farmers reared horses and donkeys rarely for ploughing purposes in addition to transporting however, they reared mules only for transport purposes. Equines also used for threshing purposes in the study are.

Table 6: Average number of tropical livestock units (TLU) per sampled household

Livestock	Agro ecologies			
	Highland (N=231) mean±SE	Midland (N=126) mean±SE	Total (N=357) mean±SE	P-Value
Ox	1.07±0.43[a]	1.11±0.04[a]	1.08±0.03	0.522
Bull	0.62±0.024[a]	0.66±0.036[a]	0.64±0.019	0.418
Cow	0.89±0.04[a]	0.96±0.05[a]	0.91±0.33	0.285
Heifer	0.54±0.033[a]	0.63±0.055[a]	0.57±0.029	0.136
Calves	0.15±0.006[a]	0.15±0.007[a]	0.15±0.005	0.871
Sheep	0.77±0.015[b]	0.87±0.208[a]	0.8±0.12	0.000
Goats	0.12±0.005[a]	0.13±0.0075[a]	0.12±0.0045	0.113
Horse	1.6±0.105[a]	1.5±0.059[a]	1.57±0.07	0.489
Donkey	0.63±0.027[b]	0.84±0.043[a]	0.7±0.024	0.000
Mule	0.26±0.023[a]	0.3±0.034[a]	0.27±0.019	0.326
Poultry	0.14±0.0175[b]	0.26±0.035[a]	0.18±0.017	0.001
Total	6.79 ±0.14[b]	7.41 ±0.17[a]	7.01±0.11	0.007

N: number of respondents; [a, b], means with different superscripts in the row are significantly different, SE, standard error; P, probability of obtaining the observed result.

4.3.1. Purpose of Livestock keeping

The purpose of livestock keeping in the study district is presented in Table 7. The majority of the respondents in highland ranked traction as the 1st major purpose of keeping cattle, income (by selling livestock and livestock products) was ranked as the 2nd, home consumption (milk and meat) was 3rd and transportation was the last and 4th reason for the production of livestock in the study area. The primary reason for keeping livestock for the traction purpose in the highland area might be due to the higher crop land holding compared to the midland (Table 5). However, in midland, income was the 1st reason for keeping livestock followed by traction, home consumption, and transportation. Similar results on the purpose of keeping livestock with highland were reported by Adinew Dessie *et al*. (2020) and by Aynalem Haile *et al*. (2012) who reported that farmers keep livestock for draught power, milk production, income, manure, threshing crops, social value, and meat.

Table 7: Purpose of livestock production in the study area (best four ranks)

Reason	Highland (N=231)						
	1st	2nd	3rd	4th	Total	Index	Rank
Traction	94	62	31	44	668	0.2796	1st
Income	86	66	46	33	667	0.2792	2nd
Home consumption	57	61	55	58	579	0.2424	3rd
Transportation	29	40	77	85	475	0.1988	4th
Total					2389	1	
Reason	Midland (N=126)						
	1st	2nd	3rd	4th	Total	Index	Rank
Traction	66	40	12	8	416	0.2861	2nd
Income	70	41	9	6	427	0.2937	1st
Home consumption	48	37	20	21	364	0.2503	3rd
Transportation	10	23	45	48	247	0.1699	4th
Total					1454	1	

N = Number of respondents. Index = [(4*Number of HH ranked 1st) + (4-1*Number of HH ranked 2nd) + … + (1* Number of HH ranked 4th) for each parameter considered] / [(4*Number of HH ranked 1st) + (4-1 *Number of HH ranked 2nd) + … + (1* Number of HH ranked 4th) for all parameter considered]

4.4. Major livestock feed resource in the study area

The major feed resources in the study area were natural pasture (28%), crop residues (Wheat, Teff, and barley straw) (42.9%), *atella (*3.6%), crop aftermath (17.1%), hay (8.4%) are the commonly available livestock feed resources (Figure 2). The findings of the present study are in agreement with previous reports by (Adinew Dessie *et al*., 2020) who indicate that natural pasture, crop residues, crop aftermath, non-conventional feed (*Enset*, banana, and sugar topes), agro-industrial by-products (wheat bran) and improved forage were the most important feed resources used in different parts of Ethiopia. Accordingly, the respondent, crop residue was the main feed resource used in the study district, which is consistent with previous reports by Merga Bayssa & Ajebu Nurfeta, (2023) in Melka Soda district, Southern Ethiopia. These wheat, barley, and teff residues were by far the most

dominant feed resource of the study area. This is in line with Asrat Ayza *et al*. (2023) reported that crop residues mainly used in Damot Sore districts, southern Ethiopia were maize and sorghum Stover, wheat, teff, and barely straw were the major crop residues. Generally, natural pasture and crop residues were the dominant feed resources in the study district but agro-industrial by-products such as noug seed cake, linseed cake, molasses, and brewery by-products, non-conventional feed (except *Atela*) and improved forage were not common in the area.

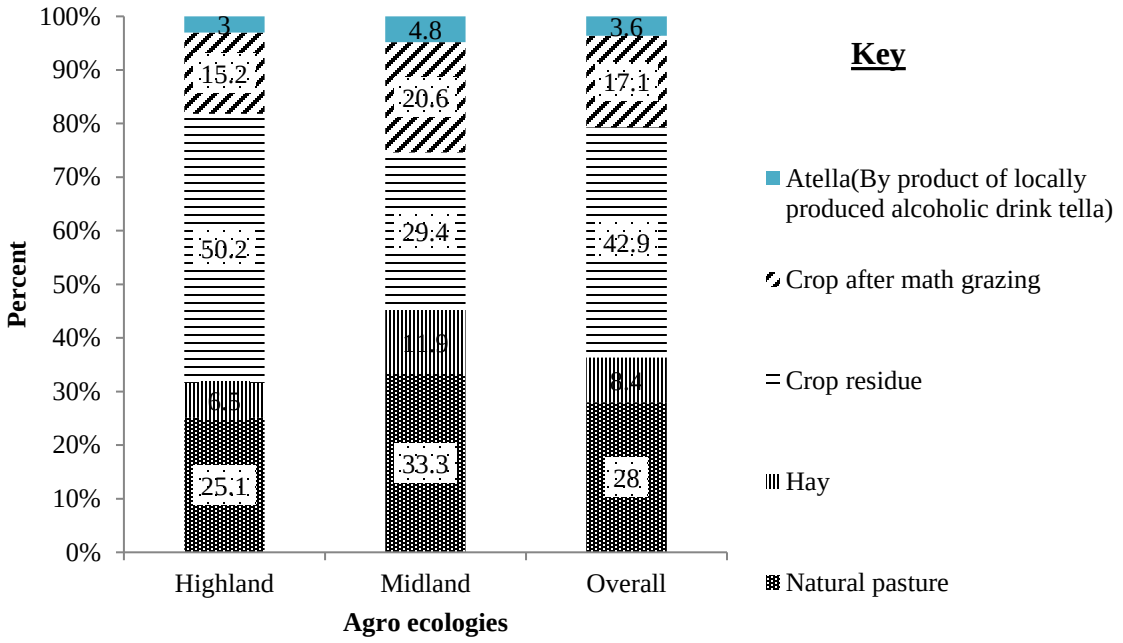

Figure 3: Available livestock feed resources

4.4.1. Livestock feed resource during dry and wet season

In the study area, during the dry season, 51 % of the respondents use crop residues as the major feed resource followed by natural pasture 23.8%, fodder tree 8.7%, aftermath grazing 7%, *atela* 6.4%, and hay 3.1% (Table 8). In line with this study (Bizelew Gelayenew *et al*., 2016; Kasa Biratu & Saba Haile, 2018), and Sosena Fentahun *et al*. (2020) reported that crop residue was the dominant feed resource during the dry season. Guyo Demisse *et al*. (2022) also reported that crop residues, grass hay, browse trees, grazing natural pasture, and stubble grazing are the most common dry-season feed sources. In wet seasons contrary to dry season the major feed resource is natural pasture (45.9%)

followed by crop residue (23.8%), aftermath grazing (10.6%), hay (9.8%), fodder tree (5%), and *atela* (4.8%). Similar to this result Ararsa Derara *et al*. (2018) reported that the dominant feed resources available in the Weliso District South West Shoa Zone were natural pasture in the wet season and crop residues in the dry season. The use of improved forage as an animal feed source was not common in both agroecologies this might be due to a shortage of land, lack of improved forage seed, lack of extension services, and lack of awareness about it. Similarly, the use of agro-industrial by-products as animal feed sources in the study area was also not common due to the high cost and no availability in the area similar to the previous report (Alemu Gashe & Awoke Kassa, 2017).

Table 8: The proportion of livestock feed resources available in the wet and dry season

Feed resources (%)	Agro ecologies					
	Highland (N=231)		Midland (N = (126)		Overall mean (N=357)	
	Wet	Dry	Wet	Dry	Wet	Dry
Natural pasture	48.1	26.8	42.1	18.3	45.9	23.8
Crop residues	25.5	46.8	20.6	58.7	23.8	51.0
Hay	10.0	2.6	9.5	4.0	9.8	3.1
Fodder trees	4.3	7.4	6.3	11.1	5.0	8.7
Aftermath grazing	9.5	8.2	12.7	4.8	10.6	7.0
Atela	2.6	8.2	8.7	3.2	4.8	6.4
Total	100.0	100.0	100.0	100.0	100.0	100.0

N: number of respondents, %: Percentage of the respondent

4.4.2. Livestock feeding systems

The livestock feeding system in the study area is presented in Table 9. In the study area, livestock owners follow different feeding systems for efficient utilization of the available feeds. In the highland, tethering was the first feeding system followed by group feeding, indoor feeding, and let to graze. As indicated above, a large percentage of farmers practiced tethering this might be due to a shortage of grazing land and labor shortage. However, in the midland parts of the study area let to graze was the first feeding system followed by group feeding, tethering, and indoor feeding. This might be due to the presence of larger grazing areas in the midland than highland parts of the study area.

Table 9: Livestock feeding system in the study area

	Highland (N= 231)						
Type of feeding system	1st	2nd	3rd	4th	Total	Index	Rank
Indoor feeding	48	57	62	64	551	0.2364	3rd
Group feeding	64	67	56	44	613	0.2630	2nd
Let to graze	40	46	65	80	508	0.2179	4th
Tethering	88	64	36	43	659	0.2827	1st
Total					2331	1	
Type of feeding system	Midland (N=126)						
	1st	2nd	3rd	4th	Total	Index	Rank
Indoor feeding	38	19	21	48	299	0.2103	4th
Group feeding	52	34	24	16	374	0.2630	2nd
Let to graze	54	39	28	5	394	0.2771	1st
Tethering in the grazing land	48	27	31	20	355	0.2496	3rd
Total					1422	1	

N, Number of respondents. Index = [(4*Number of HH ranked 1st) + (N-1*Number of HH ranked 2nd) + … + (1* Number of HH ranked 4th) for each parameter considered] / [(N*Number of HH ranked 1st) + (4-1 *Number of HH ranked 2nd) + … + (1* Number of HH ranked 4th) for all parameter considered]

4.4.3. Methods of feed storing

Different feed storage methods used in the study area are shown in Table 10. Storage of feed is important to utilize the available feed efficiently during times of feed shortage and to keep the quality of feed for a long time. In the study area (73.1%) of the respondents used different types of feed-storing methods however, (26.9%) of respondents did not practice feed feed-storing method. The reason for the respondent who did not practice feed storing might be due to lack of feed to store, lack of knowledge, lack of extension services, and lack of awareness thus increasing feed shortage, decreasing the quality of feed, and decreasing livestock productivity. According to the respondent in the study area, their storage practice of feed like crop residue, hay, and other feed material is under-stacked outside (18.5%), stacked under shade (27.5%), Stacked inside the house (*Gomo*) (32.2%),

and stacked near the homestead (21.8%). This is consistent with the findings of the previous study (Bizelew Gelayenew *et al*., 2016).

Table 10: Method of feed stores in the study area

	Agro ecologies		
Do you store feed?	HL (N=231)	ML (N=126)	Overall (N=357)
Yes	168 (72.7)	93 (73.8)	261 (73.1)
No	63 (27.3)	33 (26.2)	96 (26.9)
Total	231 (100.0)	126 (100.0)	357 (100.0)
If yes, what kind of storage do you use?	HL (N=231)	ML (N=126)	Overall (N=357)
Stacked outside (in open air)	45 (19.5)	21 (16.7)	66 (18.5)
Stacked under the shade	69 (29.9)	29 (23.0)	98 (27.5)
Stacked inside the house (*Gomo*)	72 (31.2)	43 (34.1)	115 (32.2)
Stacked near the homestead	45 (19.5)	33 (26.2)	78 (21.8)
Total	231 (100.0)	126 (100.0)	357 (100.0)

HL= Highland, ML= Midland, N= Number of respondents, Numbers out and in the bracket, indicate frequency and percent of respondents respectively

4.5. Types of crop production

A type of crop production is an indicator of crop residue production as livestock feed. Crop productions are mainly for the purpose of human food as well as the residues are available for livestock feed. The major annual food crops grown in the study are presented in Table 11. According to the respondents in the study area Wheat (*Triticum aestivum*) (39.8%), Barley (*Hordeum vulgare*) (14.3%), Maize *(Zea mays)* (5.6%), Potato (Solanum tuberosum) (4.8%), and Teff (*Eragrostis teff*)) (15.1%) and pulses such as beans (*Phaseolus vulgare*) (11.5%), and peas (*Pisum sativum*) (9%) were the major crop production. Among these, the dominant cereal crops produced in the study area were wheat and teff as indicated in Table 11. As indicated in Table 8, crop residue is the major feed resource in the study area and from it the major crop residue available for livestock feed is wheat and teff straw took the largest share (Table 11). A comparable result was reported

by Tibabu Kochare (2018) in the Wolayita zone, southern Ethiopia reported that crop residue avilable for livestocks are from wheat and teff straw.

Table 11: Type of Crop Production in the Study Area

	Agro ecologies		
Major types of crops grown (%)	Highland (N=231)	Midland (N=126)	Overall (N=357)
Barley	15.6	11.9	14.3
Wheat	42.4	34.9	39.8
Teff	14.7	15.9	15.1
Maize	1.7	12.7	5.6
Potato	4.3	5.6	4.8
Beans	11.7	11.1	11.5
Pea	9.5	7.9	9.0
Total	100.0	100.0	100.0

N: number of respondents interviewed

4.6. Watering system, source of water, and watering frequency

The watering system in the study area was practicing group watering (70.9%) and individual watering 29.1% (Table 12). In the study area, the majority (70.9%) of the respondents practiced group watering systems and livestock get water from rivers (47.6%), springs (23.8%), ponds (20.7%), and pipe water (*Bono*) (7.8%). The majority of the respondent practicing group watering system might be the avilable of river in the study area. In the study area, (40.6%) of the respondents water their animals twice a day, (40.1%) once a day, and (19.3%) free access. Similar to this study, Bizuayehu Abebe & Denbela Hidosa (2020) reported that in Hamer wereda of the South Omo zone, there are three water sources and these include rivers, streams, and springs, and the majority of the households (65%) water their animals at the river. In the same report, during the dry season, when animals are herded, watering takes place almost all at rivers and streams, and 76.12% of the respondents water their animals once a day whereas 23.88% twice a day. The majority of the respondent in the study area get water from the river for their livestock this is similar

to Andualem Tonamo & Ermias Belete (2016) who found that the sources of water for cattle were river (75.5%).

Table 12: Watering systems and frequency of watering in the study district

	Agro ecologies					
	Highland (N=231)		Midland (N=126)		Overall (N=357)	
Watering system	Frequency	%	Frequency	%	Frequency	%
Group watering	159	68.8	94	74.6	253	70.9
Individual	72	31.2	32	25.4	104	29.1
Total	231	100.0	126	100.0	357	100.0
Source of water						
River	108	46.8	62	49.2	170	47.6
Spring	70	30.3	15	11.9	85	23.8
Pond	43	18.6	31	24.6	74	20.7
Pipe water (*Bono*)	10	4.3	18	14.3	28	7.8
Total	231	100.0	126	100.0	357	100.0
Frequency of watering						
Once in a day	83	35.9	60	47.6	143	40.1
Twice in a day	102	44.2	43	34.1	145	40.6
Free Access	46	19.9	23	18.3	69	19.3

N: number of respondents interviewed

4.7. Livestock production challenges

Different livestock production challenges identified in the study area are presented in Table 13. The study indicated that respondents faced multiple constraints to livestock production which led to decreased livestock productivity and increased mortality. According to the respondents, the major livestock production constraints in highland and midland are feed shortage followed by disease, shortage of veterinary service, poor genetic potential, and market access. Among those constraints, feed shortage both in quantity and quality was identified as a primary constraint that hindered the production and productivity of livestock in the study area. This is in line with previous studies in different parts of the Country (Getahun Belay, 2020; Kidanemariam & Fesseha, 2020). However contrary to this finding

Bizelew Gelayenew *et al*. (2016) reported that the major livestock production constraints in Gambella Regional State were disease and parasite (67%) followed by feed shortage (50%) and water scarcity (46%).

Table 13: Livestock production challenges

Characteristics	Highland (N=231)							
	1	2	3	4	5	Total	Index	Rank
Feed shortage	120	48	34	21	8	944	0.2350	1st
Diseases	90	66	26	30	19	871	0.2168	2nd
Poor genetic potentials	74	51	42	33	31	797	0.1984	3rd
Shortage of veterinary service	75	36	56	34	30	785	0.1954	4th
Market access	32	48	30	57	64	620	0.1543	5th
Total						4017	1	
Characteristics	Midland (N=126)							
	1	2	3	4	5	Total	Index	Rank
Feed shortage	54	30	20	12	10	484	0.2515	1st
Diseases	44	29	15	18	20	437	0.2271	2nd
Poor genetic potentials	29	43	8	16	30	403	0.2094	3rd
Shortage of veterinary service	10	20	25	30	41	306	0.1590	4th
Market access	6	22	23	32	43	294	0.1528	5th
Total						1924	1	

N = Number of respondents. Index = [(5*Number of HH ranked 1st) + (5-1*Number of HH ranked 2nd) + … + (1* Number of HH ranked 5th) for each parameter considered] / [(5*Number of HH ranked 1st) + (5-1 *Number of HH ranked 2nd) + … + (1* Number of HH ranked 5th) for all parameter considered]

4.7.1. Livestock feed shortage and coping mechanisms

To overcome feed shortages during the critical season of the year, livestock producers in all altitude zones use different strategies Table 14. The majority of the respondents in the study area face feed shortages, especially during the dry season for their livestock. The shortage of feed in the study area retarded the productivity and production of the livestock sector by decreasing livestock body condition, decreasing disease resistance, and increase livestock mortality. Therefore, in the study area farmers practiced different coping

mechanisms to alleviate feed shortage problems and to increase livestock output, like purchasing concentrate feed, renting grazing land, using crop residue, preserving any feed during high production season, and undergo destocking. However, purchasing grass is the most-adopted coping mechanism in the study area. This is similar to Getachew Assefa *et al*. (2018) reported that purchasing additional feed during times of feed shortage was the first measure employed by per-urban production system dairy farmers in North western Ethiopia.

Table 14: Coping mechanism of livestock feed shortage

methods used to alleviate feed shortage	Agro ecologies					
	Highland (N=231)		Midland (N=126)		Over (N=357)	
	Frequency	%	Frequency	%	frequency	%
Purchase concentrate	40	22.9	25	26.3	65	24.1
Purchase forage	82	46.9	26	27.4	108	40.0
Rent grazing land	12	6.9	27	28.4	39	14.4
Use crop residue	13	7.4	5	5.3	18	6.7
Preserve any feed during high production season	13	7.4	6	6.3	19	7.0
Undergo destocking	15	8.6	6	6.3	21	7.8
Total	175	100.0	95	100.0	270	100.0

N = Number of respondents

4.8. Management and Utilization of Korch (*Erythrina abyssinica*) in Sekela District

A survey conducted in the study area revealed that all respondents (100%) were familiar with a plant called "Korch" (Table 15). According to the respondent korch (*E. abyssinica)* is a very important tree which used for different purposes in the study area. The majority of the respondents indicated that they utilized *E. abyssinica* as a feed resource for livestock feed during the dry season when other feeds are scarce (limited both in quantity and quality). However, due to the abundance of other feeds during the rainy season, the entire respondent did not use *E. abyssinica* for their livestock feed. Therefore, the use of *E. abyssinica* as livestock feed is most common during the dry season in both study areas. The survey further explored the edible parts of the *E. abyssinica* plant by livestock. All of

the respondents (100%) in the highland and midland reported that leaves were the edible and preferred parts of the plant by ruminant animals rather than twigs, fruits, stems, and other parts of korch. The twig part of Korch is not readily available for livestock feeds because there is a presence of thorns on it. Based on group discussion, *E. abyssinica* is fast growing tree during establishment and best re-growth potential after pruning. In general, based on the farmers' indigenous knowledge; *E. abyssinica* is preferred in its biomass yield, adaptability, and ease of propagation as a dry season feed source.

Table 15: Management and Utilization of Korch (*Erythrina abyssinica*) in Sekela District

	Agro ecologies		
Variable	Hl (N=231)	Ml (N=126)	Overall (N=357)
Do you know korch (*Erythrina abyssinica*) in your locality? (%)			
Yes	100	100	100
No	-	-	-
Which parts of Korch are edible by livestock			
Leaves part	100	100	100
Twigs	-	-	-
Stems	-	-	-
Pods	-	-	-

Hl= Highland, Ml= Midland, N= Number of respondents

4.9. Propagation of *Erythrina abyssinica*

The study revealed that all of the respondents in the study area reported that Korch is propagated by both, seeds and stem-cutting propagation. However, of these propagation methods, the majority of respondents favored cuttings propagation (Table 16) due to the readily available source of planting material from mature Korch plants. This is in agreement with Getachew Abraham *et al*. (2022) who reported that *E. abyssinica* has been wildly propagated via stem cutting rather than seedling. According to the respondent, the unique advantage of this locally available livestock feed does not require any excessive amount of water to grow throughout the year. The majority of the respondent in the study area grow *E. abyssinica* around their homestead for fence. Due to its long roots, it stayed

green throughout the year, which served as a potential feed supplement for livestock; especially during severe feed scarcity. According to the respondent, the appropriate planting season of *E. abyssinica* for their homestead fence and soil protection is from March to May (Table 16). Furthermore, the study found that the majority of the respondent rely primarily on *E. abyssinica* as a feed source for their livestock, often using it without mixing with other feed resources. They likely feed their animals based on availability rather than adhering to a structured schedule (e.g., one, two, or three times a day) (Table 16).

Table 16: Propagation of *Erythrina abyssinica*

	Agro ecologies		
Variable	Hl (N=231)	Ml (N=126)	Overall (N=357)
Do you grow Korch in your homestead? (%)			
Yes	96.1	94.4	95.5
No	3.9	5.6	4.5
If yes what is the source of planting material (%)			
Stem cutting	100	100	100
Seedling	-	-	-
Both cut and seedling	-	-	-
When is your planting season?			
September- November	-	-	-
December- February	-	-	-
March-May	100	100	100
June-August	-	-	-
How to grow it (%)			
By irrigation	-	-	-
By waiting rainy season	-	-	-
It does not require water	100	100	100
Do you currently use korch as livestock feed (%)			
Yes	89.2	91.3	89.9

No	10.8	8.7	10.1
If your answer is yes how often do you feed it to your animals (%)			
As available	65.4	61.9	64.1
One time a day	19.5	19.8	19.6
Two times a day	15.2	18.3	16.2
Total	100.0	100.0	100.0

Hl= Highland, Ml= Midland, N= number of respondents

4.10. Feeding practices of korch (*Erythrina abyssinica)*

The feeding practice of *E. abyssinica* in the study area is presented in Table 17. The entire respondent (100%) replied that *E. abyssinica* is given to livestock by cutting the leave parts by hand and by other cutting materials (like axes and sickle) because it is large and the livestock cannot reach it to browse directly from the tree (Figure 6). The other reason for using cut and carry system is for sick and weak animals, which are kept around the homesteads. According to the respondent, the edible parts of *E. abyssinica* by livestock are leaves during the dry season. This finding is supported by Tamene Tadesse *et al*. (2024) who reported that during the dry season, the fodder tree leaves are available for animal feed due to their greenness around the year. The respondents indicated that cattle, sheep, and goats consume the leaves of korch (*E. abyssinica).* However, Goat was the dominant livestock species that utilized korch rather than sheep and cattle. This might be due to the feeding behavior of goats which prefers to feed leaves, shrubs, and other browsing plants than grazing grasses.

Table 17: Feeding practices of *Erythrina abyssinica*

	Agro ecologies		
Variable	Hl (N=231)	Ml (N=126)	Overall(N=357)
Feeding system to livestock (%)			
Cut and carry system	100.0	100.0	100.0
Direct loping by livestock	-	-	-
Why you use cut and carry system?			

It is big and animals cannot reach	76.6	79.4	77.6
For sick and weak animal	23.4	20.6	22.4
Which livestock species more utilize korch? (%)			
Cattle	29.4	30.2	29.7
Goat	35.1	38.9	36.4
Sheep	28.6	15.9	24.1
Both	6.9	15.1	9.8
Total	100.0	100.0	100.0

Hl=Highland, Ml=Midland N=Number of respondents

4.11. Farmer's perception of feeding *E. abyssinica* on animal performance

Farmer's perceptions of the effect of feeding *E. abyssinica* on animal performance are shown in Figure 4. Farmers' perceptions of feeding korch (*Erythrina abyssinica*) to their livestock vary from farmer to farmer this might be due to different factors like lack of knowledge on these trees, limited awareness, and feeding practice. Around 12.9%, 12.3% and 12.6% of respondents indicated that *E. abyssinica* primarily provides a rumen-fill and maintenance purpose for sheep, Goats, and cattle respectively. The respondents' perceptions that *E. abyssinica* serves primarily a rumen-fill and maintenance purpose could rise from its role as a supplementary feed during challenging times, limited awareness of its full nutritional potential, and traditional feeding practices. Further education on the benefits and proper use of *E. abyssinica* could help shift these perceptions and encourage more effective use of this fodder source. Contrary to this 57.1%, 42% and 36.7% of the respondents observed that feeding *E. abyssinica* improves the growth rate and body weight change of Sheep, Goat, and cattle respectively. This suggests that *E. abyssinica* contributes essential nutrients which can enhance livestock growth and milk production. On the other hand, 30%, 46.2%, and 50.7% of the respondents also indicated that feeding *E. abyssinica* increases the output of livestock like milk of cows and meat of Sheep and Goat which is very important for human consumption.

Moreover, respondents in both study areas reported that health and/or production problems associated with the feeding of korch appeared to be non-existent. All of the respondents

indicated that there was no abortion, other health problems, or deaths of animals regarding to feeding *E. abyssinica*.

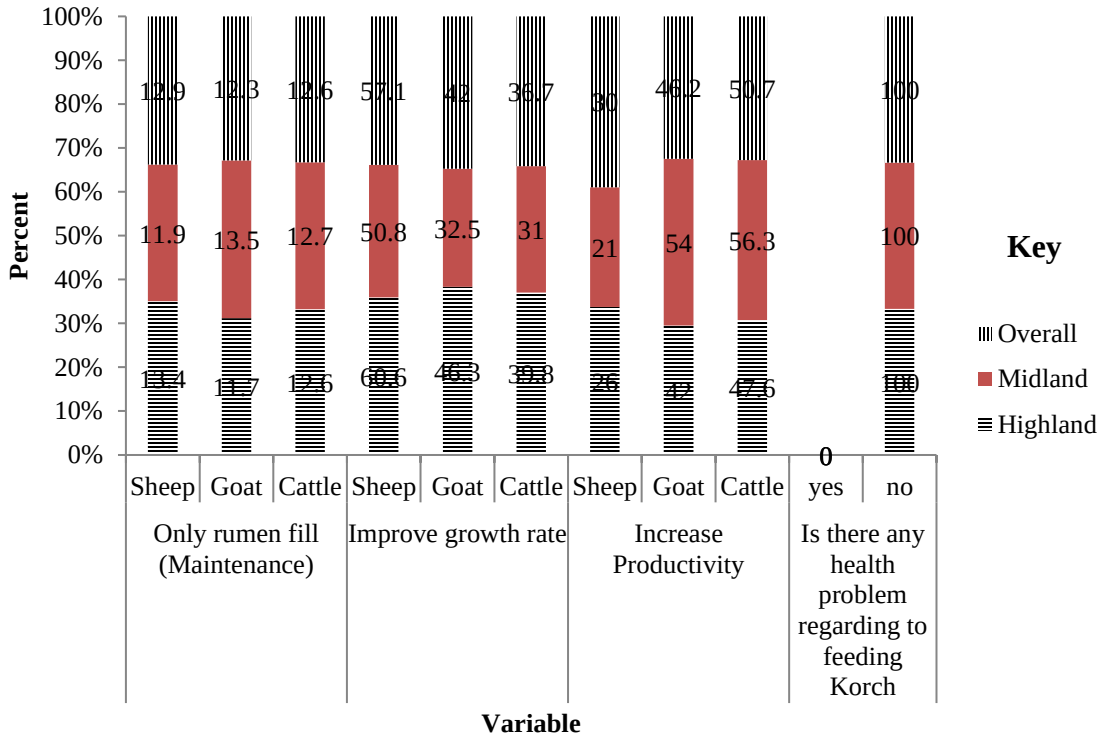

Figure 4: Farmer's perception of feeding E. abyssinica on animal performance

4.12. The other purpose of *Erythrina abyssinica*

Even though the study primarily focused on *E. Abyssinica*'s value as livestock feed, however besides its use as animal feed, respondents replied that *E. abyssinica* provides additional services. They reported that it is used for soil fertility, homestead fences, and other purposes like a shed, windbreak, and firewood (Table 18). The majority of the respondents (80.7%, 12.3%, and 7%) reported that they used *E. abyssinica* for homestead fences; soil conservation, and other purposes like a shed, windbreak, and firewood. Based on the survey result *E. abyssinica* is a multipurpose tree species with significant value beyond animal feed. This finding is supported by Adugna Gebregiorgis *et al*. (2024) who reported that in addition to fodder supply, indigenous fodder tree contributes to soil fertility improvement, income sources, and timber production.

Table 18: Other purpose of *Erythrina abyssinica* In Sekela district

	Agro ecologies		
Variables %	Hl(N=231)	Ml(N=126)	Overall (N=357)
Homestead fence	81	80.2	80.7
Soil conservation	12.1	12.7	12.3
Others (shed, wind break and fire)	6.9	7.1	7
Total	100.0	100.0	100.0

N = number of respondents

4.13. Feeding calendar of *Erythrina abyssinica*

In the study area, the feeding calendar of *E. abyssinica* was shown in Table 19. The majority (54.3%) of the respondents provide *E. abyssinica* leaves to animals from December to February because those months are the driest season and other feed resources like natural pasture are not available. The remaining 41.7% and 3.9% of the respondents feed *E. abyssinica* leaves to animals from March to May and September to November, respectively. In general, to improve the performance of animals and to mitigate feed shortage the respondents utilize *E. abyssinica for their* livestock feed from December to May since these months are times of critical feed shortage seasons in the study areas. This study was in line with Aman Abeje & Adane Kore (2023) who reported that fodder trees were mainly utilized in the dry season. The abundance of other types of feed during the wet season (June-August) likely reduces dependence on *E. abyssinica*. This finding is consistent with the observations of Tamene Tadesse *et al*. (2024) who reported that livestocks were more utilized fodder trees during the dry seasons.

Table 19: Feeding calendar of *Erythrina abyssinica*

	Agro ecologies		
Variables	Highland (N=231)	Midland (N=126)	Overall (N=357)
When you provide korch to livestock (%)			
September-November	2.6	6.3	3.9
December-February	52.4	57.9	54.3
March-May	45	35.7	41.7
June-August	-	-	-

Total	100	100	100

N: Number of respondents

4.14. Constraints of *Erythrina abyssinica* production and utilization

In the study area, major constraints that hampered *E. abyssinica* production and utilization are presented in Table 20. According to the respondents land shortage, lack of knowledge, lack of awareness, and lack of extension services are the major constraints that hampered the planting and use of *E. abyssinica*. Of those constraint land shortage was the main problem that retarded the production and utilization of *E. abyssinica.* This might be due to the expansion of crop cultivation and farmers allocated more land for crop production than planting livestock feeds. In addition to those constraints lack of research about the nutritional value and feeding practice is also the major constraint in the study area. Except for their homestead fence and soil protection due to those constraints, the majority of the respondents did not practice the plantation of *E. abyssinica* for their livestock feed. Though different researchers (Ayalew Temesgen & Addisu Tamir, 2015; Chitopoa *et al*., 2019; Getachew Abraham *et al*., 2022; Orwa *et al*., 2009) indicates that *E. abyssinica* is used for medicinal purposes in different parts of the world. However, due to a lack of knowledge, lack of extension services, and lack of awareness none of the respondents use *E. abyssinica* for medicinal purposes. Therefore, lack of knowledge is also the major constraint for the utilization of *E. abyssinica* in the study area.

Table 20: Constraints for *Erythrina abyssinica* Production in the Study Area

	Agro ecologies		
Constraint for korch production (%)	Hl (N=231)	Ml (N=126)	Overall (N=357)
Land shortage	50.6	59.5	53.8
Lack of awareness	37.7	25.4	33.3
Lack of extension services	11.7	15.1	12.9
Total	100.0	100.0	100.0

Hl= Highland, Ml= Midland, N= Number of respondents

4.15. Potential leaf biomass yield of Korch (*Erythrina abyssinica)*

The leaf biomass yield of *E. abyssinica* that can be used for animal feed in the study area is presented in Table 21. The dry mater yields of Korch were 2.93 kg and 2.85 kg in the highland and midland, respectively. The leaf dry matter yield of *E. abyssinica* was significantly different ($P < 0.05$) across agroecologies. The results showed that high-altitude had greater leaf biomass yield of *E. abyssinica* than mid-altitude areas. Similarly, Badege Wondimu *et al*. (2024) reported that the fodder tree biomass yield significantly differed between agroecologies in Essera district, Dawuro zone, southwest Ethiopia. The difference in leaf biomass yield for fodder trees between agroecologies might be attributable to spatial differences, climatic situations, and soil fertility. Upreti & Devkota, (2017) reported that the biomass yields of tree species were increased in the highland than in the midland due to the increased number of branches and other morphological traits (tree size and tree height). The biomass yield had a positive relationship with the circumference and diameter of the stem. As the circumference and diameter of the stem increased the biomass also increased, which confirmed the principle of Petmak (1983). The biomass yield obtained both in the highland and midland was greater than the report of Getachew Abraham *et al*. (2023) for *Acacia seyal* (2.78 kg/tree) and *Acacia albida* (2.7 kg/tree). Abebe Mekoya *et al*. (2008) also reported a lower biomass yield (2.4 kg/tree) for *Cordia africana* than the current result. The potential leaf biomass yield is the key parameter that estimates the amount of forage available for ruminants to feed.

Table 21: Estimated biomass yield Of *Erythrina abyssinica*

Parameter	Highland	Midland	Mean	SEM	p-value
TC (cm)	161.6^{a}	137.8^{b}	149.7	5.74	0.027
TD (cm)	102.78^{a}	87.64^{b}	95.21	3.65	0.027
PBY (Kg/tree)	3^{a}	2.85^{b}	2.93	0.038	0.028

[a, b] rows mean with different superscripts are significantly different ($P<0.05$) PBY, potential leaf biomass yield; TC, trunk circumference; TD, trunk diameter

4.16. Chemical Composition

The chemical composition of *E. abyssinica* in terms of dry matter, ash, crude protein, neutral detergent fiber, acid detergent fiber, and acid detergent lignin for both highland and

midland was presented in Table 22. Analysis of variance showed that there was a Slight variation in chemical composition among agroecologies. The differences might be attributed to the variations between the two agroecologies in climate, soil fertility, rainfall, and temperature. Due to moisture content, temperature, rainfall, and soil fertility altitude had different effects on the nutritive value of indigenous fodder trees (Tesfaye Feyisa *et al*., 2021).

4.16.1. Dry matter (DM) content

The dry matter content of *E. abyssinica* was not significantly different (P>0.05) between highland and midland altitudes Table 22. The overall mean dry matter content of E. *abyssinica* is 93.38%. This result is lower than the study report for *Dovylas abssinica* (95.35%) and for *Cordiya africana* (94.31%) by (Takele Geta *et al*., 2023). However, the present findings are, comparable to reports on *Dendrocalamus giganteus* (93.32%), *Balanites aegyptiaca* (91.67%), and *Terminalia brownii* tree leaves (93.03%) (Habtamnesh Adane & Agena Anjulo, 2023). Muleta Debela *et al*. (2017) also reported similar results with the current finding (93.28%) for *Acacia brevispica*, (94.64%) for *Erythrina abyssinica,* and (94.18%) for *Cordia africana*. Dry matter indicates the amount of feed nutrients other than water that is available to the animal.

4.16.2. Ash

The ash content of *E. abyssinica* was significantly higher (P< 0.05) for highland than midland altitude (Table 22). The overall mean ash content of *E. abyssinica* in this finding is (9.36%). This result agreed with the reports of Mandal (1997) who reported that the ash contents for most of the tree leaves varied from 6 to 15%. A similar value of ash content with the current finding (9.2%) was reported for *Terminalia brownii* tree leaves by Habtamnesh Adane & Agena Anjulo (2023), (10.67%) for *Cordia africana* tree leaves and (10.16%) for *Millettia ferruginea* by Assefa Ashenafi *et al*. (2016). In another study, higher ash content values (14.11, 13.83, and 13.31%) for *Cordia africana, Ehertia cymosa* and *Vernonia amygdalina,* respectively, were reported by (Takele Geta *et al*., 2023). However, Muleta Debela *et al*. (2017) reported that lower ash content than the current finding (7.31%) for *Combretum molle* and (8.74%) for *Acacia brevispica*. Generally, the high ash

content of korch in high land and midland indicates a high concentration of minerals (Fantahun Dereje *et al.*, 2020). The ash content is the concentration of minerals in the forages which play an important role in the body function of the overall animal production and productivity activity (Valdez-cepeda & Muro-reyes, 2017).

4.16.3. Organic matter

The organic matter content of *E. abyssinica* was significantly higher (P< 0.05) for midland than highland altitude (Table 22). The overall mean organic matter content of *E. abyssinica* in this study is 90.65%. This result is in line with the organic matter content of *Millettia ferruginea* (*Birbra*) leaf (89.45%) reported by (Berhanu Alemu *et al*., 2014). However, the current finding result is greater than the organic matter content of *Dendrocalamus giganteus* (72.23%), *Balanites aegyptiaca* (80.3%), and *Terminalia brownii* tree leaves (83.82%) reported by (Habtamnesh Adane & Agena Anjulo, 2023). The other finding of lower values of organic matter content (87.99%) for *Albizia gummifera* and *(86.7%) for Piliostigma thonningii* was reported by Assefa Ashenafi *et al*. (2016). High-quality feed should have a high proportion of organic matter. Organic matter includes digestible components like carbohydrates, protein, and fats.

4.16.4. Crude protein (CP)

The crude protein content of *E. abyssinica* was not significantly different (P>0.05) between highland and midland agro ecologies (Table 22). In this result The CP content of *Erythrina abyssinica* is higher than the different Indigenous fodder trees like *Yushanya alpine* (20.9%), *Bundelija polystachya* (14.6%), *Domboya torrida* (14.8%), *Hygenia abysinica* (16%), however, this result is lower than *Chamaecytisus palmensis* (25.7%) reported by (Begashaw Mitiku, 2020). Assefa Ashenafi *et al*. (2016) also reported that lower crude protein content (18.31%) for *Croton macrostachyus* and (19.66%) for *Albizia gummifera* than the current finding. The CP content of *E. abyssinica* in the highland (23.86%) and midland (20.27%) was much higher than the minimum required CP level (7%) of beef cattle (Minson & Miifoord, 1967). This result is greater than the finding reported by Shigdaf Mekuriaw *et al*. (2023) (15.41%) of the cp content of Korch, this might be due to the method of sample collection, age of sampled Korch, and fertility of the soil. Feeds with

a CP level of less than 7.5% inhibit voluntary feed intakes and the activity of microbial action declines, resulting in lower digestibility of roughages (Van Soest, 1994). According to Kindu Mekonnen *et al*. (2009) indigenous fodder trees and shrubs in the highland area provided good forage access with good nutritional composition during low feed source season.

4.16.5. Neutral detergent fiber (NDF)

The Neutral detergent fiber content of *E. abyssinica* was significantly higher (P< 0.05) for midland than at highland altitude (Table 22). The present average result (50.59%) is in line with the findings of (53.71%) for *Tamarindus indica* and (48.75%) for *Balanites aegyptiaca* (L.) Del. reported by (Assefa Ashenafi *et al*., 2016). The NDF content is important in ration formulation because it reflects the amount of forage that can be consumed by animals. According to Singh & Oosting (1992), the NDF content of roughage feeds with less than 45% was grouped as a high-quality feed, while feed with NDF content of 45-65% was categorized as medium-quality feed. Therefore, in this experiment, *Erythrina abyssinica* had less than 65% NDF content and can be categorized as medium-quality feed. According to Van Soest (1967), NDF content above 55% was reported to limit DM intake, indicating that the NDF content of *E. abyssinica* (50.59%) however, this result could not affect the feed intake of animals which may not limit productivity. The NDF value greater than the threshold level, of 60% resulted in decreased voluntary feed intake, increased rumination time, and decreased conversion efficiency of ME (Reed & Goe, 1989).

4.16.6. Acid detergent fiber (ADF)

The Acid detergent fiber content of *E. abyssinica* was not significantly different (P> 0.05) between midland and highland altitudes (Table 22). In this study, the average ADF content of *E. abyssinica* is (32.73%). This result is similar to (32.05%) for *Tamarindus indica* and comparable with (34.67%) for *Acacia seyal* reported by (Assefa Ashenafi *et al*., 2016). However, the Acid detergent fiber (ADF) of *E. abyssinica* values was much lower than what was reported by Deribe Gemiyo, (2015) for *Cordia africana* (36.5%) and *Vernonia amygdalina* (41%) sampled in the dry season. However, it is higher than the values

(24.87%) reported by Muleta Debela *et al*. (2017) for the browse trees *Acacia brevispica*, leaves. This might be due to the species difference between them. The ADF is the percentage of indigestible and slowly digestible material in a feed (McDonald *et al*., 2002). Roughages with less than 40% ADF are categorized as high quality and those with greater than 40% as poor quality (Kellems & Church, 1998). Thus, the ADF value of *E. abyssinica* both in highland and midland was less than 40%.

4.16.7. Acid detergent lignin (ADL)

The Acid detergent lignin content of *E. abyssinica* was significantly higher (P< 0.05) for midland than at highland altitude (Table 22). The differences might be attributed to the variations between the two agro-ecologies in climate, soil rainfall, and temperature. This result (8.86%) is similar to the result (8.61) for *Cordia africana* and comparable (9.48%) for *Balanites aegyptiaca* (L.) Del, however, lower than (12.1%) for *Tamarindus indica* (Assefa Ashenafi *et al.*, 2016). The ADL contents of korch in the current study were higher than the results of Abera Melese (2011) for *Moringa stenopetala* (5.52%) and *Moringa oleifera* (6.49%). Digestibility of the feed decreased with increasing maturity and this could be linked with an increased fiber concentration in plant tissue and increased lignification during plant development (Wilson *et al*., 1991).

Table 22: Chemical composition of Erythrina abyssinica (sampled during dry season)

Parameter	Percentage Chemical composition of *E. abyssinica* (%)				
	Highland	Midland	Overall mean	Overall SEM	p-value
DM	92.58[a]	94.18[a]	93.38	0.57	0.187
OM	89.74[b]	91.55[a]	90.65	0.47	0.028
Ash	10.26[a]	8.45[b]	9.36	0.46	0.028
CP	23.86[a]	20.27[a]	22.06	1.15	0.122
ADF	30.85[a]	34.61[a]	32.73	2.09	0.431
NDF	48.65[b]	52.52[a]	50.59	1.05	0.045
ADL	8.58[b]	9.15[a]	8.86	0.15	0.039

[a, b,] rows Means followed by different superscripts within a raw are significantly different at P < 0.05 DM= dry matter; CP=crude protein; NDF=neutral detergent fiber; ADF= acid detergent fiber; ADL= acid detergent lignin

4.17. In vitro dry matter digestibility (IVDMD), In vitro organic matter digestibility (IVOMD), and Metabolizable Energy (ME)

4.17.1. In vitro dry matter digestibility (IVDMD)

The IVDMD of *E. abyssinica* was higher (P< 0.01) for highland than midland altitude (Table 23). The higher IVDMD of *E. abyssinica* in highland than midland could be due to variations in ecological or climate factors such temperature, perceptions, soil fertility and light intensity. Similarly, Badege Wondimu *et al*. (2024) reported that higher IVDMD of fodder trees in highland than midland in Essera district, Dawuro zone, southwest Ethiopia. This finding overall mean (57.09%) of IVDMD is in agreement with the previous study on *E. abyssinica* (58.6%) reported by (Almaz Ayenew *et al*., 2021). However, the present result is higher than (55.7%) for *Acacia seyal* (57.01%) for *Apodytes dimidiata* and lower than (62%) for *Vernonia amygdalina* reported by (Almaz Ayenew *et al*., 2021). This result is also higher than the finding of Getachew Abraham *et al*. (2023) for *Acacia seyal* (57.5%) and for *Acacia albida* (52.06%). Higher IVDMD signifies the animal can absorb more nutrients from the feed, leading to better growth, performance, and overall health.

4.17.2. In vitro organic matter digestibility (IVOMD)

The IVOMD of *E. abyssinica* was significantly higher (P< 0.01) result for highland than midland altitude Table 23. The variation in IVOMD might be associated with differences in temperature, precipitation and soil characteristics. The nutritional value of plant community were affected markedly by soil characteristics and temperature situations that arise from agro-ecological differences (Geleta Gobena *et al*., 2022). This result (55.64%) is lower than the finding of (62.2%) for *Acacia nilotica* reported by (Abayneh Derero & Getu Kitaw, 2018). Abayneh Derero & Getu Kitaw (2018) reported higher IVOMD (68.67%) for *Acacia tortilis* and similar IVOMD (55.04%) for *Ziziphus spina-christi* (L.) than the current study. Muluye Fekade *et al*. (2020) also reported higher IVOMD (75.1%) for *Ficus thoungii* than the current finding. Higher IVOMD indicates a greater proportion of the feed's organic matter can be digested by animals.

4.17.3. Digestible energy

The DE of *E. abyssinica* was no significantly difference (P> 0.05) between highland and midland agro ecologies Table 23. Digestible energy means the amount of energy in the feed minus the amount of energy lost in the feces or which is not voided in the feces (Hall *et al*., 2013; Nolan & Savage, 2009). It gives an indication of the actual amount of energy available for animal use. Feeds that have high digestible energy are important for maximum livestock product such as milk and meat and for growth rate (Ahmet Baris, 2023). Werknesh Seid & Getachew Animut, (2018) showed that feeds containing DE greater than 2.15 MCal/kg are categorized as high-quality feeds. Therefore, this result (2.42 MCal/kg) indicated that *E. abyssinica* is classified as high-quality feeds.

4.17.4. Metabolizable energy (ME)

The ME of *E. abyssinica* was no significant difference (P> 0.05) between highland and midland agro-ecologies Table 23. This finding (8.32 MJ/kg) is in agreement with the findings of Getachew Abraham *et al*. (2023) who reported that the ME of *Acacia tortilis*, *Acacia albida* and is 8.87MJ/Kg and 7.81MJ/Kg respectively. Getachew Abraham *et al*. (2023) reported higher ME of *Tamarindus indica* (10.01 MJ/Kg), and *Acacia Senegal* (10.3MJ/Kg) and lower ME of *Acacia seyal* (6.63 MJ/Kg)) than the current study. The data obtained in this study indicated that the leaves of korch trees have a good potential to supply highly digestible feeds for ruminants. Metabolizable Energy reflects the energy available to the animal after accounting for energy losses during digestion and excretion.

Table 23: In vitro digestibility and Energy content of *Erythrina abyssinica*

Items	Agro ecologies				
	Highland	Midland	Overall mean	Overall SEM	*p*-value
IVDMD (%)	58.95[a]	55.24[b]	57.09	0.848	0.001
IVOMD (%)	57.3[a]	53.99[b]	55.64	0.749	0.000
DE (MCal/kg)	2.45[a]	2.4[a]	2.42	0.018	0.163
ME (MJ/kg)	8.42[a]	8.22[a]	8.32	0.062	0.131

[a, b,] rows mean with different superscripts significantly different($p<0.05$); IVDMD= Invitro dry mater digestibility; IVOMD= Invitro organic matter digestibility; DE= Digestible energy; MCal/kg = Mega Calori per kilogram; ME = Metabolizable energy; MJ/kg Mega joule per kilogram

CHAPTER FIVE: CONCLUSIONS AND RECOMMENDATIONS

5.1. Conclusion

This study demonstrated that korch (*Erythrina abyssinica*) has relatively high crude protein, better IVDMD, high ME, and lower fiber fraction. Therefore, it has the potential to be used as a dry season protein supplement for ruminants fed on low-quality hay and crop residues and it can correct the nutrient deficiency that exists in low-quality feeds. In addition to laboratory analysis the farmer's perception of feeding *E. abyssinica* on animal performance also indicates its high nutrient content which is important for livestock growth rate and milk production. In the study area, it is necessary to make a big effort to overcome feed shortage and to get maximum livestock productivity through proper conservation and utilization of indigenous fodder trees and more introductions of local fodder trees. Moreover, this study demonstrated that *Erythrina abyssinica* is also known for its versatility, serving as shade for livestock, soil conservation, and natural fences.

5.2. Recommendations

Based on the result of the study and the above conclusion the following recommendations are forwarded for further research and further uses:

- *Erythrina abyssinica* species could be recommended for expansion as high-potential animal feed resources due to its high biomass yield, high nutrient content, better digestibility, and easily available planting material.
- Korch (*Erythrina abyssinica*) can partly offset the shortage of feed because it is available in the dry season with a minimum production cost.
- Based on the results obtained from this study, it needs more research on live animal feeding experiments to see the effect of feeding *Erythrina abyssinica* on animal productivity, and also the content of anti-nutritional factors will make the research complete.

CHAPTER SIX: REFERENCE

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CHAPTER SEVEN: APPENDICES

Appendix 1: Questionnaires used to collect data on the research thesis

Evaluation of nutritional value korch (*Erythrina abyssinica*) and its utilization as livestock feed in Sekela District West gojjam zone, Amhara region Ethiopia.

1. Personal information

1.1. Date: _____

1.2. Region: _____

1.3. Zone and District: _____

1.4. PA's/Keble's name: _____

1.5. House holders' name: _____

1.6. Sex: _____

1.7. Age: _____

1.8. Marital status:

(A) Married (B) Single (C) Widowed (D) Widower (E) Divorced (F) Not relevant

1.9. Literacy status: circle one of it,

(A) Illiterate (B) Read and write only (C) elementary (D) junior secondary (E) Secondary (F) above secondary

1.10. Religion: (A) Orthodox (B) Muslim (C) Protestant (D) Catholic

2. Questionnaires for Household characteristics

2.1. Family size

2.1.1. How many family members do you have?

A) Male---------- B) Female---------- C) Total----------

2.1.2. Children (≤ 14 years): --------- Adult (15-64): --------- Dependent (≥ 65 years): -----

2.1.3. Number of active workers in the family including household head

(A) One (B) two (C) three (D) four (E) more than four

2.1.4. What is your main farming activity presently? Circle one of them.

(A) Livestock production (B) Crop production (C) both (D) Others specify----------

2.1.5. Landholding and land use system

Land use type	Hectare
Homestead	
Cropping land	
Private grazing land	
Communal grazing land	
Total land owned	

3. Questionnaires for Livestock production and management

3.1. A. Livestock holding size (large ruminant)

Animal species	Number
Oxen	
Bulls	
Cows	
Heifers (>6 months)	
Calves up to 6 months of age	
Total	

3.1. B. Small ruminants, equine, poultry, and Bee colonies

Type	Number
Sheep	
Goats	
Horses	

Donkey	
Mule	
Poultry	

3.2. What are the major reasons for keeping livestock? (Rank)

Purposes	Tick (✓)	Rank
Draught power		
Income		
Home consumption		
Transportation		

3.3. Livestock Production Constraints

Constraints	Tick (✓)	Rank
poor genetic potentials		
Diseases		
Feed shortage		
Water shortage		
Shortage of AI service		
Shortage of Veterinary Service		
Shortage of extension services		
Shortage of market for the products		
Others (specify)		

3.4. Type of feeds supplied for your animals?

Type of feeds	Tick (✓)
Pasture grazing	
Hay	
Crop residues	

Crop aftermath grathing	
Fodder tree and species	
Improved fodder	
Tela (waste of local alcohol)	
Agro-industrial by product	

3.5. What are the major feed resources in the dry (November- May) and wet (June-October) seasons?

Feed resources in dry and wet season.	
Dry season	Wet season

4. **Questionnaires for Crops and crop residues**

4.1. What are the major types of crops grown in your area? List down based on availability in ascending order.

_____

_____.

4.2. Do you store hay or crop residue for your livestock feed? (A) Yes (B) No

4.2. If question number 4.2 answer is yes, how do you store hay or crop residues? (A) Stacked outside (B) stacked under shade (C) Stacked near the homestead (D) Stacked inside the home (*Gomo*) (E) other (specify) _____.

4.3. What measures do you take to alleviate feed shortage? (A) Purchase forage
(B) Rent grazing land (C) Use crop residues (D) preserve any feed
During high production season (E) Undergo destocking (F) others (specify) ----------

4.4. How do you feed your animals? (A) Indoor feeding (B) group feeding (C) Let to graze

(D) Tethering in a grazing land (E) Other Specify ----------

5. Questionnaires for Water source and watering management

5.1. What sources of water are available for your animals?

Sources of water	Tick (✓)
River	
Spring	
Pond	
Pipe water (Bono)	
Others (specify)	

5.2. What type of watering system you are following while watering your animals?
(A) Group watering (B) Individual watering (C) Both

5.3. How frequently cattle are watered during the dry season? (A) Once in a day (B) Twice in a Day (C) Ad libitum (D) Once in two days (E) Once in three days (F) other (specify) ---

6. Questionnaires for utilization of korch (*Erythrina abyssinica*)

6.1. Do you know *korch (Erythrina abyssinica)* in your locality?

A/Yes B/No

6.2. Do you grow korch in your land?

A/ Yes, what is the source planting material? And what types of planting methods do you use? Mention it.

_____

_____

_____.

B/ If your answer is no, please mention the reason.

_____.

6.3. When is your planting season? List down, please.

_____

_____.

6.4. Is that an annual, perennial, or biennial plant? _____.

6.5. How to grow it?

A/ using irrigation B/ by waiting raining season C/ other (specify) _____

6.6. How to produce in your land?

A/ by sawing the seed B/ by cutting the stem and then digging the ground then cover with soil

C/ Other (specify) _____.

6.7. For what purpose do you use Koch (*Erythrina abyssinica*) primarily? A/ Animal feed B/ homestead fence C/ Soil conservation D/ other (specify) _____

6.8. Do you currently use *Erythrina abyssinica* as livestock feed?

6.9. If your answer is yes, how often do you feed it to your animals?

A/one time a day b/two times a day c/ three times a day d/ other (specify)

11.10. If you don't use *Erythrina abyssinica* as livestock feed, why not?

6.11. Are you fed to livestock alone?

A/ Yes

B/ No. what are the feeds mixed with it, mention it, please.

_____

_____

_____.

6.12. What are the methods to prepare korch (*Erythrina abyssinica*) to livestock feeds? Please mention it

6.13. How to provide korch (*Erythrina abyssinica*) to their livestock?

A/ free grazing B/ cut and carry system C/ directly browsing D/ other (grazing methods)

_____.

6.14. When does this type of livestock feed grow in different seasons of the year?

A/ during summer B/ Winter C/ Autumn D/ Spring E/ throughout the year

6.15. Which part of korch (*Erythrina abyssinica*) of feeds to livestock?

A/ Stem part B/ Leaves part C/ Flower part D/ Fruit part E/ Other (specify)

_____.

6.16. When livestock owners provide korch (*Erythrina abyssinica*) to livestock?

A/ during summer B/ during winter C/ Every time D/ Other time (specify)

_____.

6.17. Which types of animals do you feed?

A/ Cattle B/ Goat C/ Sheep D/Equine E/ Other animals (specify) _____.

6.18. What is the role of korch (*Erythrina abyssinica*) for animals? A/ Basal diet B/ Supplement C/ Both D/ other (specify) _____

6.19. How to provide for animals? Either in-group, individual, or other means please mention it briefly.

A/_____

B/_____

C/_____

6.20. From the animal feed aspect, please describe the special characteristics of korch (*Erythrina abyssinica*) to other livestock feeds.

_____

_____

_____

6.21. Have you faced any challenges in sourcing *Erythrina abyssinica* as livestock feed?

A/Yes, what type of challenge do you face?

_____.

B/ no

6.22. List any demerits of korch (*Erythrina abyssinica*) in terms of preparation, utilization, and feeding.

_____

_____

6.23. What are the utilization constraints korch (*Erythrina abyssinica*)?

_____

_____

_____.

6.24. What is the feeding problem of korch (*Erythrina Abyssinica*)?

_____

_____

_____.

6.25. Have you got training on the production and utilization of korch (*Erythrina Abyssinica)?*

(A) Yes (B) No

6.26. If Question No 6.25 answer is yes, please describe the topic of training and the

organization that offered the training.

_____

_____

_____.

6.27. Please describe the general comments to increase the production and utilization of korch (*Erythrina abyssinica*) in your area.

_____

_____

_____.

7. Checklist for Focus Group Discussions

7.1. What is the main farming activity in your area?

7.2. What is the main purpose of livestock production?

7.3. Is the number of livestock production increasing, decreasing, or no change for the past 10 years in your area? And what is the main reason?

7.4. What are the major livestock feed resources in your study area?

7.5. What are the major crop productions in your area?

7.6. What is the status of livestock productivity in your area?

7.7. What is the status of natural pasture conditions in your area Decreasing, increasing, or no change?

7.8. What are the major livestock production constraints in your area?

7.9. Do you face a feed shortage for your livestock production?

7.10. If yes, what mitigation purpose do you use to alleviate feed shortage?

7.11. What are the major causes of livestock feed Shortage in your area?

7.12. Do you know korch (*E. abyssinica*) in your area?

7.13. If yes what is the purpose of korch (*E. abyssinica*) in your area?

7.14. which method of planting methods do you apply to grow korch (*E. abyssinica*)?

7.15. which seasons are more appropriate and suitable to grow korch (*E. abyssinica*)?

7.16. Do you get extension services for korch (*E. abyssinica*)?

7.17. Is there any problem regarding to feeding korch (*E. abyssinica*)?

Appendix 2: Conversion factors of livestock number to Tropical Livestock Unit

Livestock species	TLU
Ox	1
Bull	0.6
Cow	1
Heifer	0.75
Calves	0.2
Sheep	0.13
Goats	0.13
Horse	1.1
Donkey	0.7
Mule	0.7
Poultry	0.013

Source: Jahnke (1982)

TLU=Total Livestock Unit

Appendix 3: ANOVA Tables

ANOVA for Dry mater (DM %)

t	Df	Sig (2-tailed)	Mean difference	95% confidence interval of the difference	
				Lower	Upper
-1.59	4	0.187	-1.593	-4.37	1.185

ANOVA for ASH

t	Df	Sig (2-tailed)	Mean difference	95% confidence interval of the difference	
				Lower	Upper
3.367	4	0.028	1.80333	0.31647	3.29019

ANOVA for Organic matter (OM %)

t	df	Sig (2-tailed)	Mean difference	95% confidence interval of the difference	
				Lower	Upper
-3.37	4	0.028	-1.80333	-3.29019	-.31647

ANOVA for crude protein (CP %)

t	df	Sig (2-tailed)	Mean difference	95% confidence interval of the difference	
				Lower	Upper
1.954	4	0.122	3.58667	-1.50853	8.68186

ANOVA for Neutral Detergent Fiber (NDF %)

t	df	Sig (2-tailed)	Mean difference	95% confidence interval of the difference	
				Lower	Upper
-2.88	4	0.045	-3.87000	-7.59522	-0.14478

ANOVA for Acid Detergent Fiber (ADF %)

t	df	Sig (2-tailed)	Mean difference	95% confidence interval of the difference	
				Lower	Upper
-.874	4	0.431	-3.76000	-15.69882	8.17882

ANOVA for Acid Detergent Lignin (ADL %)

t	df	Sig (2-tailed)	Mean difference	95% confidence interval of the difference	
				Lower	Upper
-3.02	4	0.039	-0.57333	-1.10118	-0.04548

ANOVA for In vitro dry matter digestibility (IVDMD %)

t	df	Sig (2-tailed)	Mean difference	95% confidence interval of the difference	
				Lower	Upper
9.191	4	0.001	3.71000	2.58929	4.83071

ANOVA for In vitro organic matter digestibility (IVOMD %)

t	df	Sig (2-tailed)	Mean difference	95% confidence interval of the difference	
				Lower	Upper
12.469	4	0.000	3.31000	2.57298	4.04702

ANOVA for Digestible Energy (MCal/kg)

t	df	Sig (2-tailed)	Mean difference	95% confidence interval of the difference	
				Lower	Upper
1.706	4	0.163	0.05333	-0.03348	0.14015

ANOVA for Metabolizable Energy (MJ/kg)

t	df	Sig (2-tailed)	Mean difference	95% confidence interval of the difference	
				Lower	Upper
1.895	4	0.131	0.19000	-0.08841	0.46841

ANOVA for Leaf biomass yield (Kg/tree)

t	df	Sig (2-tailed)	Mean difference	95% confidence interval of the difference	
				Lower	Upper
2.674	8	0.028	0.15724	0.02166	0.29282

Appendix 4 : Appendix Figures

Figure: 4.1. Some photo of individual interview during data collection

Figure: 4.2. Photo of Group Discussion

Figure: 4.2. Some photo of sampled Korch (*Erythrina abyssinica*)

Figure: 4.3. Sample Collection

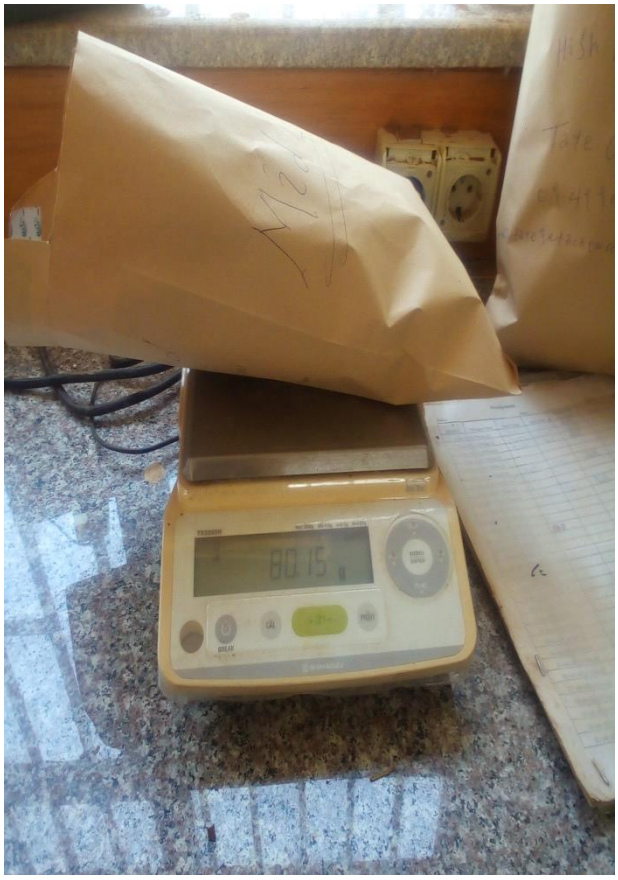
80.15

Figure: 4.4. Laboratory Analysis