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ASSESSMENT OF CATTLE FATTENING PRACTICES IN DESSIE AND KOMBOLCHA URBAN AND PERI-URBAN AREAS OF ETHIOPIA, AND EFFECTS OF CONCENTRATE SUPPLEMENTATION ON FATTENING PERFORMANCE OF WOLLO OXEN

PhD Dissertation

By

Kassahun Ahmed Seid

Addis Ababa University, College of Veterinary Medicine and Agriculture

Department of Animal Production Studies

PhD Program in Animal Production

February 2018

Bishoftu

ASSESSMENT OF CATTLE FATTENING PRACTICES IN DESSIE AND KOMBOLCHA URBAN AND PERI-URBAN AREAS OF ETHIOPIA, AND EFFECTS OF CONCENTRATE SUPPLEMENTATION ON FATTENING PERFORMANCE OF WOLLO OXEN

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

By

Kassahun Ahmed Seid

February 2018

Bishoftu

Addis Ababa University

College of Veterinary Medicine and Agriculture

Department of Animal Production Studies

As members of the Examining Board of the final PhD open defense, we certify that we have read and evaluated the Dissertation prepared by Kassahun Ahmed Seid entitled 'Assessment of Cattle Fattening Practices in Dessie and Kombolcha Urban and Peri-Urban Areas of Ethiopia, and Effects of Concentrate Supplementation on Fattening Performance of Wollo Oxen' and recommend that it be accepted as fulfilling the dissertation requirement for the degree of Doctor of Philosophy in Animal Production.

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DEDICATION

I dedicate this dissertation manuscript to my unlived mam, dad and grandmother for nursing me with affection, love and for their sacrifice in the success of my life. Their dedication will remain memorable forever.

Yet again, this dissertation manuscript is dedicated to my orphan brothers and sisters for harbouring me with care, endless love and for their keen partnership in the success of my life.

.

STATEMENT OF AUTHOR

First, I declare that this dissertation is my *bonafide* work and that all sources of materials used in the preparation of this dissertation have been duly acknowledged. This dissertation has been submitted in partial fulfillment to the requirements for the Degree of Philosophy of Science (PhD) in Animal Production in Addis Ababa University, College of Veterinary Medicine and Agriculture, Department of Animal Production Studies and is deposited at the University's Library to be made available to borrowers under rules of the Library. I truly declare that this dissertation is not submitted to any other institution anywhere for the award of any academic degree, diploma or certificate.

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BIOGRAPHICAL SKETCH

I, the author of this dissertation, Kassahun Ahmed Seid was born on August 1, 1982 in Dessie town of Amhara Region. I attended elementary education at Segno Gebeya Elementary School and my Junior High School in the then Negus Michel Junior Secondary School. I attended my High School study in the then W/ro Siheen Technical and Vocational School in Dessie town.

After the completion of my High School education, I joined the then Ambo College of Agriculture in 2001 and graduated with diploma in General Agriculture (GAG) in 2002. Soon after graduation, I joined the Amhara Region, Albuko *Woreda* Agricultural and Rural Development Office and served as Agricultural expert and head of work unit up to 2004. In the year 2005, I was transferred to Berhale *Woreda* of Afar Regional State and served as Agricultural expert in Pastoral and Agro-pastoral Rural Development Office. Consistently, I was working with GOAL Ethiopia in the position of human nutrition surveyor. In 2004 summer program, I joined the then Alemaya University, Department of Animal Sciences to pursue my BSc study and obtained BSc degree in Animal Sciences in September 2008.

Soon after, in October 2008, I joined the School of Graduate Studies of the Haramaya University to pursue my MSc Study in Animal Production and Graduate in September 2010. In a little while after graduation, I was employed of Arba Minch University and served as a lecturer and higher diploma leader up to 2013. In the year 2014, I joined Addis Ababa University, College of Veterinary Medicine and Agriculture, Department of Animal Production Studies to follow my PhD Study in the program of Animal Production studies through study support granted by the Arba Minch University. Including the currently published articles from this PhD document, I published 12 scientific publications in different journals.

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LIST OF ABBREVIATIONS

ACDI/VOCA	Agricultural Cooperative Development International/ Volunteers in Overseas Cooperative Assistance
ADG	Average Daily Gain
ANRS	Amhara National Regional State
BW	Body Weight
BWG	Body Weight Gain
DAs	Development Agents
DBG	Dried Brewery Grains
FBW	Final Body Weight
FCE	Feed Conversion Efficiency
FCR	Feed Conversion Ratio
FGS	Fixed Ground Scale
GTP	Growth and Transformation Plan
HH	Household
HHs	Households
IBW	Initial Body Weight
LSD	Least Significance Difference
LMIS	Livestock Market Information System
ME	Metabolizable Energy
MJ	Mega Joules
NCFR	Non-Conventional Feed Resources
NR	Net Return
RCBD	Randomized Complete Block Design
SAS	Statistical Analysis System
SPSS	Statistical Package for Social Science

TABLE OF CONTENTS

CONTENT **PAGE**

TABLE OF CONTENTS (continued)

TABLE OF CONTENTS (continued)

LIST OF TABLES

LIST OF TABLES (continued)

LIST OF FIGURES

LIST OF APPENDICES

ASSESSMENT OF CATTLE FATTENING PRACTICES IN DESSIE AND KOMBOLCHA URBAN AND PERI-URBAN AREAS OF ETHIOPIA, AND EFFECTS OF CONCENTRATE SUPPLEMENTATION ON FATTENING PERFORMANCE OF WOLLO OXEN

Kassahun Ahmed Seid
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ABSTRACT

This study embraced a survey and feeding trial. The survey was conducted with the objectives of assessing cattle fattening practices and identifying common conventional and non-conventional feed resources used for cattle fattening in urban and peri-urban kebeles of Dessie and Kombolcha areas. The feeding trial was carried out with the objective of evaluating the effects of supplementing different concentrate feeds of varied protein sources on feed intake, weight gain and dressing percentage of Wollo oxen and economic feasibility of treatments. For the survey, peri-urban and urban cattle fatteners were selected using systematic random sampling and complete enumeration techniques. Nine (3 urban and 6 peri-urban) and 10 (4 urban and 6 peri-urban) kebeles from Dessie and Kombolcha areas were included in the study, respectively. Thus, 337 cattle fatteners (190 and 147 from Dessie and Kombolcha, respectively) were interviewed using pre tested structured questionnaire. Focus group discussions, key informant interviews and field observations were also employed for data collection. Feed resources used for cattle fattening, their availability, potential suppliers, price and distribution in the study areas were identified and the chemical composition of most commonly used feeds were determined. For the feeding trial, fifteen Wollo oxen were used for 90 days experiment. Experimental animals were randomly distributed into 3 treatments each replicated 5 times in a randomized complete block design (RCBD). Treatments included; grass hay as basal diet, wheat bran and crushed corn grain as energy sources across the treatment and grass pea leftover, poultry litter and dried brewery grain were represented T1, T2 and T3 as a protein sources, respectively. Feed intake and body weight measurements were taken daily and at 15 days interval, respectively. In addition, body condition score measurement was taken. To identify the most promising treatment diet, partial budget analysis was calculated. Data generated in the survey were analyzed for descriptive statistics and index ranking, while data generated in feeding trial were subjected to

two way analysis of variance (ANOVA) and least significance difference (LSD) was used for mean separation. The survey results indicated that, cattle fattening practices in Dessie and Kombolcha areas were structured into two categories, viz., urban and peri-urban cattle fattening practices. A byproduct based and a combination of traditional and byproduct based cattle fattening systems were identified in both areas. The cattle fattening practices in both areas were tightened with so many limitations that need short and long-term interventions, although there were so many favorable opportunities for the sector. In both study areas, 42 feed resources used for cattle fattening were identified, where 39 feeds were common for both towns. The rest three were unique to Kombolcha town. There was seasonal variability in feed distribution and availability in both study areas. Results of the feeding trial showed that, final body weight (FBW), overall body weight gain (BWG), average daily gain (ADG), feed conversion efficiency (FCE) and feed conversion ratio (FCR) were significantly higher ($P < 0.05$) for oxen in T2 than T1 and T3. The dressing percentage on the basis of slaughter body weight was significantly higher ($P<0.001$) for oxen supplemented with poultry litter (T2). The partial budget analysis revealed that T2 resulted in a higher profit margin than T1 and T3. From the results of the present study, it can be concluded that poultry litter (T2) is biologically more promising and economically beneficial for cattle fattening on grass hay based diet supplemented with a mixture of wheat bran and crushed corn grain. Furthermore, it is advisable to focus on the identified opportunities in the survey and there should be functional linkage between stakeholders for profitable cattle fattening practices and to alleviate the recognized limitations in urban and peri-urban areas of the study areas.

Keywords: Cattle fattening practices, conventional feeds, dressing percentage, feed intake, non-conventional feeds, weight gain, Wollo oxen,

1. INTRODUCTION

The Ethiopian Growth and Transformation Plan (GTPI) of 2010/11-2014/15 clearly stated the strategic importance of the livestock sector in general and the meat processing industry in particular to the country's economic growth (AACCSA, 2015). Particularly, cattle in Ethiopia play an important role in the provision of products and byproducts since cattle population in Ethiopia is the highest among other livestock species that represent the largest population in Africa (Aleme and Lemma, 2015).

Consequently, cattle fattening is one of few agricultural commodities in Ethiopia from which the country earns foreign currency through export of both live and processed forms of the commodity. Most of rural and urban communities are engaged in cattle rearing to fulfill their needs for food and income (Metaferia *et al*., 2011). Moreover, the feedlot industry is recognized as an important business area (Bakhshinejad, 2015). Therefore, at both rural and urban areas of the country (Ethiopia), cattle fattening is emerging as an important source of income and a good source of livelihood among farmers and urban dwellers (Harko, 2015).

In the current study areas, livestock are an integral component of agriculture and make multidimensional contributions to the growth and development of the agricultural sector. Hence, in most *Woredas* of Amhara region, where the environment is suitable for cattle fattening, there are large numbers of smallholder farmers engaged in fattened animal production (Aklilu, 2004). Besides, growing population, urbanization and economic growth are contributing to the growing demand for livestock and livestock products particularly meat is one of the main products from fattening cattle in Ethiopia (Harko, 2015).

Consistent to the above, the current study towns (Dessie and Kombolcha) hold large human population and particularly Kombolcha town is relatively one of the industrialized zones of the country. Urban expansion projects in Kombolcha town have started since the town was selected and recognized at national and regional levels as one of the centers of

industrial development clusters. Because of this fact, there is a high demand for meat both in quantity and in quality. In addition, the presence of flour, brewery and meat factory in the proposed study areas is an opportunity for the existence of agro-industrial byproducts and cattle market. As a result, cattle fattening has been identified as an effective tool for poverty alleviation and has become an important business sector for those urban and peri-urban cattle fattening individuals and many smallholder farmers who were displaced due to urbanization and industry zone establishment (Muluwork, 2014).

On the other hand, even though there is high cattle population in the country and ample potential in the region to produce enough fattened cattle for the population and the neighboring countries, the major meat and live animal exporters are complaining about the shortage of supply and inferior quality of animals and meat. Besides, cattle fattening in Ethiopia in general and in the current study areas in particular is characterized by minimum investment. Due to this fact, the potential has remained unexploited for a number of reasons that hindered increased production of fattening cattle in quantity and quality. The fattening performance of local cattle type is not vastly determined and documented properly (Adebabay *et al.*, 2013). Moreover, the important aspects and limitations of the different farming systems in the urban and peri-urban areas of Northwestern Ethiopia have not yet been well-studied (Yitaye *et al.*, 2007).

In addition, there are a number of challenges that need to be identified and overcome to enhance the cattle fattening practices of smallholder cattle fattening (Harko, 2015). Particularly, the ever-rising prices of feed ingredients remain to be the greatest single item determining the profit margins in fattening farming especially in developing countries. Likewise, current and up-to-date baseline information is lacking on common types of feeds used, their nutritive values, feed availability and the feeding management under the prevailing situations in urban and peri-urban areas (Aklilu, 2004).

Moreover, majority of previous research works focused on rural cattle fattening practices, and information regarding urban and peri-urban cattle fattening practices are rather

limited (Getinet *et al*., 2009). Generally, due to the above-mentioned constraints and challenges, the potential of the cattle-fattening sector has not been fully utilized. Consequently, it is essential to generate information regarding urban and peri-urban cattle fattening practices and carry out a feeding trial to evaluate the fattening performance of local cattle types to supply quality-fattened animals for both domestic and export markets. Furthermore, to use the above specified opportunities and to fill and avert the gap of feed resources for fattening cattle in Dessie and Kombolcha areas, one of the most viable and simple management interventions is comprehensive identification of locally available potential feed resources.

Therefore, there is a need to undertake a comprehensive scientific study to answer the following sets of research questions in the current proposed towns. How does a cattle fattening practices (feeding systems, watering, housing, health care, cattle selection, fattening duration and frequency, season of fattening, transportation) and marketing in the study towns look like? What are the common conventional and non-conventional feed resources used for cattle fattening and what is the respondents' experience about cattle fattening? What are the constraints, challenges and opportunities of cattle fattening in both study towns? What are the possible interventions to enable a successful cattle fattening in the study towns? Does a different concentrate feed of varied protein feeds affect the feed intake, weight gain and dressing percentage of Wollo oxen? Which concentrate supplement is more usable to the cattle in relation to weight gain, dressing percentage and economic return?

Hence, studying the existing cattle fattening practices, identification of available feed resources and undertaking a feeding trial using local cattle particularly, Wollo oxen will help to suggest possible recommendations for further improvement of the urban and peri-urban cattle fattening practices, local cattle fattening performance and to address related problems. Moreover, the information obtained from this study will contribute to policy makers, researchers and institutions as a practical guide and baseline data for further development of cattle fattening practices in similar situations.

Accordingly, this study was designed with the general objectives of assessing cattle fattening practices, identification of common conventional and non-conventional feed resources used for cattle fattening in Dessie and Kombolcha towns and evaluate the effects of supplementing with different concentrate feeds of varied protein sources on fattening performance of Wollo oxen. The specific objectives include**:**

- assessment of cattle fattening practices in Dessie and Kombolcha towns;
- identification of common conventional and non-conventional feed resources used for cattle fattening;
- evaluation of the effects of supplementing concentrate feeds of varied protein sources on feed intake, body weight gain and dressing percentage of Wollo oxen;
- estimation of the economic feasibility of the use of supplementation of different protein source concentrates for cattle fattening.

2. LITERATURE REVIEW

2.1. Livestock Production Systems in Ethiopia

The diversity of Ethiopia's topography, climate and cultural conditions make it difficult to generalize about livestock production systems in the country. Numerous authors used different criteria to classify livestock production systems in Ethiopia (Andualem, 2016). However, about five livestock production systems have been identified based on integration of livestock with crop production, level of input and intensity of production, agro-ecology and market orientation. The following systems have been defined viz. pastoral, agro-pastoral, mixed crop-livestock farming, urban and peri-urban farming and specialized intensive farming systems as reported by Yitay *et al*. (2007) and Melkamu and Gebreyohannes (2014). However, the livestock production systems are predominantly categorized as agro-pastoral system in the lowlands and the mixed crop–livestock system in the highlands (Belete, 2006).

2.1.1. Mixed crop-livestock production system

Mixed crop-livestock production system is a dominant mode of production especially in the highlands of the country (Ethiopia) (Jimma *et al*., 2016). The high crop-related livestock production system in Ethiopia is found between 1,500 and 3,000 meter above sea-level especially in the highlands of Tigray, Wollo, Gondar, Gojjam, Shewa and parts of Wellega. Farmers engaged in mixed farming are to gain complementary benefit from an optimum mixture of crop and livestock farming and spreading income and risks over both crop and livestock production. Cattle are the most important livestock species in this system because they are used for ploughing, threshing crops and providing manure (Duressa *et al*., 2014). However, due to increased activity of crop cultivation, the number of livestock kept per household in mixed farming areas is low (FFILLS, 2016).

In the north eastern part of Ethiopia, crop and livestock productions is the means of livelihood of the people to meet farmers' consumptions and to generate income. The

major crops grown are improved and local wheat, barley, teff, local and improved horse bean, field pea, maize, local and improved potato, oat, fenugreek, garlic, lentil, chickpea, grass pea, sorghum, haricot bean and linseed. The major animals reared are improved and local cattle (dairy), improved and local poultry, local and improved beehives, sheep and goat. The outputs of crops and livestock is used mainly for home consumption but rarely used for markets to obtain cash income. The straw of crops is used for animal feed. Animals like oxen are used for draft power in plowing and planting. Moreover, the wastes of animal in the form of manure are used for improvement of soil fertility. Generally, the integration of crop and livestock production also serves as a means to cope up with the market and the environmental risks (Hassen, 2011).

2.1.2. Pastoral and agro-pastoral livestock production system

The suitability of an area for either animal or crop production, and the type of animal or crop to be produced in the area depends on the agro-ecological conditions of the area. The feasibility of cropping and the type of crops to be produced depend on climatic, edaphic and biotic factors. The extent of cropping and the type of crop, in turn, determine the quantity, quality and distribution of animal feed resources throughout the year. On the other hand, the feed resource base and disease challenge determine the animal production system of the area (Adugna and Aster, 2007).

The arid and semi-arid lowlands are characterized by high spatial and temporal variability in rainfall distribution and pattern. Although there are general rainy and dry seasons, the rains may start at different times in different years, increasing irregularity and distorting the normal pattern. Chances for prolonged dry spells at the end of the dry season and the beginning of the rainy season are very high. In such conditions meaningful crop production cannot be attained in rain-fed agriculture and extensive livestock production appears to be a better means of exploiting the grazing and browse resources in the arid and semi-arid lowlands. Semi-arid areas of Ethiopia support the livestock that are highly valuable to the nation as direct sources of consumption for the pastoral and agro-pastoral population, as sources of cash income and foreign currency for the nation and for

provision of draught power for small-holders in the highlands. However, extended dry season and drought very often result in critical decline in quantity and quality of feed and shortage of water leading to decreased productivity and increased mortality of animals. During severe drought the whole herd may be decimated (Adugna and Aster, 2007).

2.1.3. Urban and peri-urban production system

Urban and peri-urban production systems are developed in areas where the population density is high around big cities like Addis Ababa and other regional towns and where agricultural land is shrinking due to urbanization. Urban and peri-urban production systems include commercial to smallholder dairy, shoat and beef farms (Sintayehu *et al*., 2008).

Urban agriculture is practiced on small to medium size areas within the city for raising small livestock for home consumption or sale. Peri-urban agriculture happens on farm units close to town that operate intensive, semi or fully commercial farms to raise chickens and other livestock. Urban and peri-urban agriculture is an activity whereby dwellers produce food, earn extra income and use available land and labor resources. In addition, peri-urban and urban livestock keeping is an essential livelihood activity for many, particularly vulnerable groups such as female-headed households, jobless youth and retired government employee. With increasing demand for land in cities for housing, urban livestock keeping appears to be favored over crop production as it requires less land and provides better return (Zelalem *et al*., 2009)

2.2. Cattle Fattening Systems in Ethiopia

As cited by Belete *et al*. (2010) according to the Fourth Livestock Development Project (MOA 1996a), there are three types of cattle fattening systems in Ethiopia. These are traditional, byproduct based fattening and the Hararghe type of fattening. Only a small fraction of Ethiopian beef is raised in feedlots. Smallholders throughout the country fatten the vast majority of cattle in backyard systems (Harko, 2015). In addition to the

above classification, emerging feedlot-fattening systems in towns are included as fourth fattening systems (Yohannes, 2011).

2.2.1. Byproduct based fattening

The byproduct based fattening is a type of fattening in which agro- industrial byproducts such as molasses, cereal milling byproducts and oil seed meals are the main sources of feed and which is concentrated more along the highway from Addis Ababa to Nazerate as reported by Belete *et al*. (2010), Yohannes (2011) and Harko (2015). In Modjo, large and medium investors as well as smallholder farmers undertake both commercial fattening and dairy. However, fattening is more popular than dairy. Both urban and rural producers use agro-industrial byproducts for fattening (Berhanu *et al.,* 2009).

2.2.2. Hararghe fattening system

In the Hararghe fattening system, farmers usually buy young oxen from the adjacent lowland pastoral areas for fattening. The livestock production system in Hararghe areas is market oriented. Almost all farmers in all places commonly practice fattening across the region. Farmers keep a small number of oxen mainly one and some of them two, which are mostly purchased from market, fattened and sold for beef (Shitahun, 2009). The system is largely based on cut-and-carry feeding of individually tethered animals. Grazing is rare (Belete *et al*., 2010).

The Hararghe highland fattening system depends upon thinning from annual crops during the growing season and feeding to the individually tethered animals on cut and carry system and on stored crop stover during the dry season. The major feed resources are sorghum and maize stover, straw, maize and sorghum leaves, thinned maize and sorghum seedlings and sterile plants, and weeds grown in crop fields as reported by Adugna (2008) and Gebregziabher and Gebrehiwot (2011). According to Tsigereda (2010) Hararghe highland farmers use, common baking Yeast (such as *Saccharomyces cerevisiae*), Abish flour (*Fenugreek*) and fermented dough or their combination for

fattening purpose as additional feed resources. Of those practicing feeding these items, majority of the farmers perceived that the use of yeast fatten the animal within a short period. Generally, intensive feeding of available feed supply to young oxen could best describe the Hararghe fattening practice (Harko, 2015).

2.2.3. Traditional fattening system

In the traditional system, oxen are usually sold after the ploughing season while they are in poor body condition. Meat yields are low, the beef is of poor quality and returns to farmers are often inadequate even to buy a replacement ox. Cattle in the lowlands are rarely fattened and are often sold in poor body condition and at low prices (Belete *et al*., 2010).

In rural Ethiopia, such cattle fattening is practiced based on locally available feed resources (Harko, 2015). This system generally depends on grazing natural or planted pastures with variable degrees of supplementation. Under this system, animals require a long period to attain market weight and condition. Oxen are usually used for fattening and sold after the ploughing season. It is also associated with huge fluctuations in the weights and conditions of the animals depending on feed availability (Yohannes, 2011). Under traditional cattle fattening system, there are fattening practices that are recognized by the public/consumers in Ethiopia because of the popularity of the practice in certain areas of the country, such are for example, described as Wolayta backyard fattening system (Takele and Habtamu, 2009), Arsi Negele backyard fattening system as reported by Addisu *et al.* (2012) as cited by Bezahegen (2014) and Bure area of the Amhara region (Shitahun, 2009).

Fattening activity in the Amhara Region, however, differs substantially from the above-mentioned enterprises. Smallholder farmers commonly fatten mature and therefore much older animals (5 to 7 years old) for short durations (usually three months). Ordinarily, farmers fatten their draught oxen so that they can fetch better price when brought to market. On the other hand, some farmers purchase oxen specifically to fatten and sell

them so as to get higher price per weight margins on each fattened animal. In such cases, animals are purchased based on their large skeletal frames and body conformation. In any case, whether purchased or own animals are used for fattening purposes, they have already reached their full skeletal size (Belete *et al*., 2010).

2.2.4. Commercial and small scale fattening practices

Both large scale (commercial feedlots) and small scale fattening practices are carried out in Ethiopia. A commercial beef cattle production system in Ethiopia is becoming increasingly important in areas surrounding major cities and towns in the country that have high demand for livestock products. Commercial feedlots feed relatively large number of animals at a time and keep from as few as 20-50 animals to as many as 5000 heads of cattle at a time (Adugna, 2008). On the other hand, under small scale fattening operations, there are traditional and indigenous systems of cattle and small ruminant fattening practices in different parts of the country in which several households are engaged in small scale fattening activities with about 1-3 head of cattle are stall fed (Adugna, 2007).

2.3. Cattle Types and their Distributions in Wollo Zones of Amhara Region

Based on results of cluster analysis of Dereje *et al.* (2008) morphologically, at least three distinct cattle types are found in south and north zones of Amhara region, north-western Ethiopia, namely the Wollo Highland Zebu (comprising of cattle from Gimba, Were-Ilu and Kutaber sites), the Raya Sanga (Raya/Kobo site) and the Afar Sanga (Afar site). The fourth cluster is considered as intermediate cattle that are found in the adjacent areas of Sanga and highland zebu cattle types. The Wollo highland zebu cattle type comprises compact animals with short legs, ears and horns with coat color being dominantly black. Wollo Highland Zebu cluster consists of the cattle populations from Gimba, Were-Ilu and Kutaber sites. This cluster appears to reflect more zebu-like characteristics. This cattle type is not known before in the literature.

Raya Sanga are known by the name Raya cattle and already known in literature but not well described in terms of population size and reproductive performances. They are found in North Wollo Zone particularly in Kobo *Woreda* with the Raya people. The main functions of this cattle breed type are traction, milk, meat and reproduction. The population size of this cattle type in this area is estimated to be around 120,000. They have big body frame and long horns (48.7± 0.67 cm), which are thick at the base with an upward and slightly forward orientation to 50% of the length and then turning inward, and continue to grow upward. In some animals, the tip of the horn turns backwards. Predominantly, they have light red coat color. Their ear is longer 18.9± 0.19 cm than that of the Wollo Highland Zebu but smaller than the Afar Sanga. Mature females measure 119.0 ±1.65 cm for body length, 110.9 ± 0.49 cm for height at withers, 138.2 ± 0.66 cm for heart girth and 35.2 ± 0.24 cm for pelvic width (Dereje *et al.,* 2008).

Afar Sanga is very limited within the South and North Wollo Zones. They are long framed but look thinner when compared to Raya cattle. Many animals have a combination of black and white spots being distributed over the body giving them ashy or grey or light chestnut colors. They have straight facial profile and the longest horns (61.9± 1.45 cm) of all cattle types in the area. In most animals the tip of the horn turns backward after forming a spiral-twisting curve. The horns appear thinner at the base than they are for the Raya breed type. They have also the longest ear (20.3 ± 0.42 cm). Mature females are 126.0 ± 1.39 cm long and 115.4 ± 1.05 cm high. They also measure 147.9 ± 1.42 cm for heart girth and 38.7 ± 0.51 cm for pelvic width (Dereje *et al.,* 2008).

2.4. Cattle Fattening Practices

2.4.1. Cattle source and selection criteria

Sources of fattening cattle are culled oxen due to old age or being unproductive from their own farm and immediate purchase for fattening purpose (Belay, 2013). Different criteria are used for purchasing of cattle to be fattened. Among selection criteria majority of beef cattle fattening operators used to select animals for fattening. Breed type,

castration condition, adaptability, physical appearance and/or frame size, age, health and initial price are considered as the top priority. Moreover, body condition, coat color, horn size and skin conditions (stretchable upon pulling and smoothness) are considered and used as the selection criteria to purchase beef animals as reported by Addisu (2016) and Genet *et al*. (2017).

Farmers prefer male animals for fattening after draught oxen and bulls for fattening activity. Majority of the draught oxen used for fattening after 1-3 years of services. Farmers have long tradition to select fattening animals using different conformation such as long and tall, long smooth muscle, wide shoulder and round (Tsigereda and Mengistu, 2011). Traditionally, fattening of animals in agro-pastoral system in the lowlands and the mixed crop–livestock system in the highlands concentrates on male animals and on females which are either infertile or have finished their reproductive cycle (Elias *et al.*, 2007).

2.4.2. Fattening duration

Feeding length (duration) is dependent on feeding methods (Tsigereda and Mengistu, 2011). According to Belay (2013), 4-9 months, 10-15 months and greater than 16 months are the identified fattening durations. Most of the farmers fattened cattle for 3-6 months (79.1%) and the rest fattened for a prolonged period (Ahmed *et al*., 2010). Cattle being fatten with pure feedlot finished within 3 months of feeding length and so enhance the producer economic return. Cattle fed with supplementary feed would finish within 3 to 3.5 months of feeding length. But, those cattle fattening entirely depend on the basal feed. Fattening on maize stover and pasture grazing required 4 to 4.5 months of feeding to attain the average slaughter weight. Whereas those fattening on fresh cut green forage and/or hay required 3 to 3.5 months of feeding length to finish. The end of finishing period is decided by considering live-weight change of fattening cattle with visual observation based on their feed intake and by anticipating the current and future price (Tsigereda and Mengistu, 2011).

2.4.3. Season of cattle fattening

According to Takele and Habtamu (2009), Shitahun (2009) and Addisu (2016) cattle fattening is time-bounded activity considering the available resources like feed, labor and demand of the market. In Ethiopia cattle fattening is done starting from mid-August up to December when the plowing activity is finished and seasonal supply of feed becomes optimum and mainly targeting to deliver fattened cattle for Christmas. Some fatteners' fatten cattle starting from January to April targeting to deliver fattened cattle for Easter. This low percentage of cattle fattening activity for Easter market is attributed to the absence of green feed supply and increased purchasing price of fattening cattle. It is also associated with relative low market demand for fattened cattle because of the custom of the local people preference towards consumption of fattened sheep and goats instead of fattened cattle during Easter. Fattening cattle from May (after Easter) up to mid-August is generally uncommon. The majority of the feedlot operators considered January to March and October to December to be the most suitable seasons to start fattening operation (Genet *et al*., 2017).

2.4.4. Feeding system

Feeding systems of cattle fattening is categorized in to partial and pure feedlot methods (Shitahun, 2009). Moreover, both extensive and semi-intensive feeding systems are practiced for cattle fattening. Extensive system consists of grazing their own croplands after harvesting crops and grazing on roadside grasslands. Semi-intensive system included cut and carry and stall-feeding system (Ahmed *et al.*, 2010).

Farmers have experiences in supplementing locally available high nutritious feeds. Major feed resources for their fattening animals and used as a basal diet are crop residues and natural pasture. Majority of the farmers (89.54%) provide both basal and supplementary feeds in a stall feeding system where as 10.46% of the respondents alternate the feeding systems in the form of stall feeding and grazing. Farmers during the first few weeks of fattening period or prior to actual fattening period, keep their fattening animals on good

and enclosed pasture land for a short time per day for exercising, herbage consumption purpose, take a time to clean the barn and to reduce the feed cost (Shewangizaw *et al*., 2014).

Fattening cattle in Amhara region usually fed concentrates out of simple wooden feed boxes or cut barrels, and they generally had access to roughage (locally produced hay or crop residue) in hayracks. Most farmers fed their cattle twice a day and the ration usually consisted of a set amount of concentrate, plus ad-lib forage. Most cattle fatteners replied that fattening oxen is grazed solely or with other cattle for the most part of the fattening period. In some Woredas such as Insarona Wayu, Moretna Jiru and Gondar, etc, however, a tradition of stall-feeding based on cut-and carry systems prevails over grazed fattening. If concentrates fed, they transported to farms using donkeys, whilst the bulk of roughage feed is usually produced on the small-scale feedlot's farm. Some farmers constructed rudimentary shelters for their fattening cattle, whilst others simply fed their cattle in existing pens and corrals. In all instances, the short supply of concentrate feeds, and their expensive price repeatedly mentioned as the major obstacle to the popularity of fattening activities (Aklilu, 2004).

2.4.5. Water resource

Having a plentiful supply of fresh clean water is essential for good animal welfare (Temple, 2016). Main sources of water for livestock in highland production system are river and tap water (Zewdie, 2010). The majority (88.9%) of feedlot operators uses pipe water and animals drink *ad libtum* but few of them use river and ground water sources for fattening animal (Genet *et al*., 2017). The major water resources for livestock are wells and rivers (Belete *et al.,* 2010).

With respect to watering frequency, farmers offered drinking water for their fattening cattle twice and three times per day (Adugna, 2008). Watering frequency of cattle depends on access to water sources, the age structure of the herd, physiological stage of

animals and season. For instance, in the urban and peri-urban system about 36% of the households water their cattle once a day (Azage *et al.*, 2013).

2.4.6. Housing

Beef cattle are housed for fattening in large outdoor pens on a soil surface. Outdoor feedlot housing is becoming more popular. Three major welfare issues are related to this specific type of housing. They are problems with muddy pens and keeping cattle clean, heat stress caused by lack of shade and issues associated with handling large numbers of cattle (Temple, 2016).

Open shed with no enclosure is the predominant type of housing system. Provision of enclosed barns for fattening cattle varied between the production systems. The roofs of the shelter are generally made of corrugated iron sheet, grasses and majority of the farmers used plastic sheet as roofing materials. However, plastic materials are degraded by environmental impact and exposed the animals' to effect of adverse climate. Most of the shelter prepared for fattening cattle are located near the farmer's house or under the shade tree but some of them are located in the farming land (Bezahegn, 2014).

According to Belay (2013) as a unique management tool farmer separate fattening animals from other herd and provide shelter. They also restrict movement of animals by tethering them. Three types of houses used to keep the fattening cattle are separated room in the family house, separated house constructed for the cattle (homestead shed), and enclosed barn with simple shed (Fikru, 2015). In the Highland production system animal houses are mostly concrete floor types with roofs (Zewdie, 2010).

2.4.7. Healthcare of fattening cattle

The major diseases constraining feedlot operation in the order of their importance include Lumpy skin disease, Foot and Mouth disease, Bovine Respiratory disease and digestive system disorder (Genet *et al*., 2017). Due to this fact, cattle fattener immediately after

purchase or finished his plowing activity and decided to fatten, brings his cattle for injection and deworming with broad-spectrum *anthihelmentics*. One tablet of broad spectrum *antihelmentics* is given per month for every fattening cattle but vaccination is given for *Trypanosomiasis* case once per fattening period as curative and prophylaxis measure. These practices helped the producer to finish fattening cattle within 3 to 4 months of feeding period. Similarly, the good performance of animals dewormed with broad-spectrum *anthelmintics* without considering the type of feed given is an indicative of the importance of internal parasites in limiting productivity of beef cattle (Shitahun, 2009).

2.5. Feed Resources, Availability and Distribution in the Highlands of Ethiopia

The major sources of animal feed in the country fall under three main categories: natural pasture, crop residues/byproducts and agro-industrial byproducts categorized under conventional and non-conventional feed resources (ACDI/VOCA, 2010).

2.5.1. Conventional and non-conventional feed resources

A major gap exists between the demand and supply of conventional feed resources for feeding livestock in the world. In order to manage this problem, it is essential to identify the available conventional feed resources. Natural pasture is the main source of feed for most of Ethiopia's livestock, complemented by fodder and crop residues during the dry season. On the other hand, it is advisable to increase efforts to exploit the use of non-conventional feed resources (NCFR) in livestock production systems. Non-conventional feeds are feeds that are not the regular ingredients of the diet of animals. The use of non-conventional feed resources in the ration of livestock have become crucial to minimize the shortage of feed and fodder for livestock, to improve productivity as well as to formulate inexpensive rations for the wellbeing of the subsistence farmers (ACDI/VOCA, 2010).

A major biological constraint to smallholder fattening development in Amhara Region is Feed resources potentially available to livestock in the Region, can be classified into 4 categories: vegetation available on non-arable grazing land; crop residues and aftermaths from harvested fields; by-products of food processing; and finally weeds and excess plants from sown fields. In highly experienced cattle fattening areas such as Inewari, Kombolcha, etc., in addition to buying dried fodder, the majority of fattening households seem to purchase grains for supplemental feeding. Such farmers buy sorghum and Teff, which they roast, bake and feed to their fattening oxen. The main concentrate feeds in Amhara region mainly used for fattening are cereal bran, oilseed cake, and byproducts from brewing. Even though these are potentially available in the region, farmer cited the first two as the main ones. Thus, wheat and maize brans (locally called as *furushka*) and noug seed cake (locally called as *fagullo*) are the predominant concentrate feeds used as supplement by the overwhelming majority (Aklilu, 2004).

The type of feed used by households that stall-feed cattle in Amhara region are various in nature and mixture. However, the principal sources feed include: Crop residues, crop stubble, and sorghum and millet stalks; Agricultural by-products, such as legume leaves and weeds from crop fields; Standing forage that is grazed during the dry season; Local beer brewing by-products (*Atela*) and home food leftovers and salt. The composition of stall-fed cattle rations varies dramatically by season. During the dry season and initial months of the rainy season (December-May), the ration is comprised of dried grasses and agricultural by-products, which are stored at the household compound. Cattle are also released to graze after the harvest (November-January). The animals first graze the crop stubble and then any standing forage, which becomes increasingly dry and decreasingly nutritious as the dry season progresses. During the dry season, stall-fed cattle typically gain little if any weight, and some animals actually lose weight. The crop stubble, standing forage and stored hay and agricultural by-products barely provide a maintenance ration during this period of greatest nutritional stress. The arrival of the rainy season then changes the feed mix significantly. Freshly cut and carried grasses, which contain ample moisture, predominate the ration during this period. Agricultural byproducts such as

legume leaves and weeds from crop fields become progressively more important over the course of the growing season (Aklilu, 2004).

In the case of feeding, however, there is a wide variety of practices applied by participating farmers. The prominent feed used as mentioned by almost all contacted fatteners seems to be grass hay, which either is produced on own farms or purchased from neighbors. The next important feed used by most cattle fatteners are crop residues such as teff and wheat straw and pulse residues such as been and *guaya* straw. Feeding noug cake as a protein supplement is also found to be common as it is the commonly available supplement in most areas of Amhara region. Other concentrate feeds included wheat bran and shorts which are locally called *furushka*, and leftovers of the household level local beer termed as *'Atela'*. Molasses seems also to be fed in small amounts in and around D/Birhan, Inewari, etc, as these are near to the supply and have long experience in traditional fattening (Aklilu, 2004).

2.5.1.1. Hay

Hay is commonly used way of feed preservation technique in Ethiopia which is expected to mitigate problems of livestock feeding during the dry period and therefore such experience is a good indicator that feeds are being efficiently utilized. Natural hay is the major feed resources for animals in the peri-urban highlands of Ethiopia (Zewdie, 2010). Hay in central highland of Ethiopia is usually harvested after the crude protein (CP) of the pasture passed peak production. The protein content of hay on DM basis is usually less than 5%, which is below the level of maintenance requirement for ruminants (Solomon *et al*., 2008a).

The chemical analyses of natural pasture hay prepared in West Gojjam, Ethiopia contain 925 g/kg DM, 115g/kg Ash, 885 g/kg OM, 69 g/kg CP, 672 g/kg NDF, 464 g/kg ADF, 90 g/kg ADL, 208 g/kg Hemicelluloses and 374 g/kg Cellulose all in DM basis (Simachew, 2009). A study made by Mulu (2005) in Gondar city indicated that hay contain 93.3% DM, 4.2% CP, 76.8% NDF, 52% ADF, 52.4% IVDMD, and 6.8% ME (MJ/kg DM) all in

DM basis. Moreover, Fentie (2007) reported that hay contains 93.42% DM, 6.98% Ash, 93.02% OM, 3.56% CP, 79.22% NDF, 45.33% ADF and 5.60% ADL all in DM basis. Contrarily, McDonald *et al*. (2002) noted that natural pasture hay of good quality could have CP content up to 11%. The CP content of hay reported by Jemberu (2008) is 52 g/kg.

2.5.1.2. Wheat bran

Wheat bran is the major milling byproduct used as livestock feed in Ethiopia. It is the outer fibrous layer of wheat grain separated from the rest of the grain and germ with a protein content of 14-18% and ME content of 12 MJ/kg. Wheat bran is quite palatable and readily digested in the rumen with high energy yielding potential (Adugna, 2007). In general, wheat bran typically contains about 93.53% DM, 5.34% Ash, 94.66% OM, 23.08% CP, 43.83% NDF, 12.39% ADF and 3.14% ADL all in DM basis (Fentie, 2007). Similarly, Simret (2005) also reported the chemical composition of wheat bran to be 90.56% DM, 85.15% OM, 20.1% CP, 44.13% NDF, 12.74% ADF, 3.52% ADL and 5.41% Ash all in DM basis.

2.5.1.3. Dried brewers grain

Dried brewers grain is one of the agro-industrial byproducts that can supply both energy and protein. It is the dried extract residue of barley malt alone or in mixture with other cereal grains and a suitable cheap substitute. It is very palatable to cattle, provides bulk to the concentrate mix and serves as a good by-pass protein (degraded relatively slowly in the rumen). They are considered as good source of un-degradable protein. This material can be fed in un-dried form (wet brewers' grain) or dried form. Wet brewers' grain is fed shortly after it is produced, because of spoilage if stored for long period as wet. Dried brewers' grain (DBG) is also recognized due to its high digestible fiber content and ruminal escape protein. Moreover, because of its bulky, fibrous nature and low energy content, DBG is more suitable for ruminants than non-ruminants (McDonald *et al*., 2002).

Kwatu *et al.* (1983) reported that up to 20% DBG could be incorporated into fattening diets, but levels as high as 40% would affect the performance of animals by disturbing the digesting process since it is more of un-degradable protein. These authors concluded that since brewers dried grains are not as palatable in the dried form as the original grain, it should be included at the level of 25% or less in a daily concentrate mix and 1-20% in feedlot rations.

The chemical analysis revealed that DBG contained 92.9% DM, 4.3% Ash, 95.7% OM, 25.1% CP, 87.6% NDF, 27.4% ADF, 6.3% ADL, 21.1% Cellulose and 60.2% Hemicelluloses (Emebet, 2008). Similarly, Mulu (2005) found that DBG contains 93.7% DM, 19.8% CP, 76.5% NDF, 28.4% ADF, 52.9% IVDMD and 7% ME (MJ/kg DM) all in DM basis.

2.5.1.4. Poultry litter

Poultry litter is a product that is obtained where poultry are raised on floor. It contains poultry droppings, bedding material and spilled poultry feed (Adugna, 2008). Poultry litter has been identified as one of the non-conventional feeds for ruminant production, although its inclusion in the diets of animals may be aesthetically difficult to accept. Coprophagia is a common behavior among animals. On the other hand, feedstuffs for animals are getting progressively expensive, thus necessitating minimization of feed cost, which could be achieved through the incorporation of relatively cheap and non-conventional feed ingredients. Thus, utilization of poultry litter as animal feed ingredient, apart from reducing environmental pollution is assumed to have the advantages of providing a low cost feed ingredient (Asrat *et al.*, 2008).

Many factors could contribute to the differences in CP content of poultry litter that include methods of processing, types of bedding material, the proportion of excreta in the litter and the environmental conditions under which the manure is conserved (Bakshi and Fontenot, 1998). It has high ash content with high levels of the minerals like calcium, phosphorus, potassium, magnesium, sulphur and copper. It can serve as a good source of

fermentable nitrogen and essential minerals. Poultry litter may contain about 15-35% CP depending upon the proportion and quality of its constituents (Adugna, 2008).

The chemical composition of poultry litter reported by Asrat *et al.* (2008) is 905.3 DM g / kg, 823.4 OM g / kg, 265.1 CP g / kg, 108.3 CF g / kg and 176.6 Ash of g/kg DM. The CP content is 24.5% as reported by Bakshi and Fontenot (1998). The calcium and phosphorus contents are around 2.1% and 1.8% of DM, respectively. The fiber content of poultry litter varies depending upon the type and amount of the bedding materials included in the litter (Adugna, 2008).

2.5.1.5. Grass pea

Grass pea seed is a major source of protein for large sections of the population in Asia and Africa as reported by Grela *et al*. (2001) and Anna and Małgorzata (2010). Ahmadi *et al.* (2012) reported that grain yield contains a relatively high level of protein (19-32.5% of DM) with adequate concentrations of most macro and microelements as well as amino acids, particularly lysine. It is low in fat (1.6%) but its starch content (41.2%) supplies abundant energy.

Like the other legume seeds, grass pea seed contains anti nutritional elements such as tannins, lectins, phytate and oligosaccharides. It also contains a non-protein amino acid, ODAP (ß-n-Oxalyl- L-α, ß-Di Amino Propanoic acid) as reported by Grela *et al*. (2001) and Anna and Małgorzata (2010). It is reported that grass pea seed contains 0.22-7.2 g per kg of ODAP (Campbell, 1997). The CP content of grass pea seed can be considered as a protein source in animal nutrition. Grass pea seed contains low levels of total and condensed tannins. However, heat processing reduces its tannins contents. Non heat-treated grass pea seed contains higher rapidly degradable portion of CP. Heat treatment decreased the rapidly degradable DM and CP fractions of grass pea seed (Riasi *et al.*, 2014).

2.5.2. Feed resources availability

Purchased hay and crop residues are the major feed resources available in the peri-urban highlands, while agro-industrial byproducts, concentrates, non-conventional feed like '*Atella*' and crop residues are the major sources of feeds utilized in the urban production system as reported by Yitaye (2008), Zewdie (2010) and Firew and Getenet (2010).

Agro-industrial by-products produced in Ethiopia include byproducts from flour milling, sugar factory, oil processing factories, abattoir and breweries. The most commonly used concentrate feeds in Ethiopia is composed of different agro-industrial byproducts including: milling byproducts such as wheat bran, oilseed cakes such as noug seed cake, cottonseed cake, peanut cake, linseed cake, sesame cake, molasses from sugar factories, brewery byproducts and occasional surplus grain or grain damaged during processing. These products are mainly used for dairy, fattening and commercial poultry production and the scope of their uitilaization by smallholder producers is low due to availability and price. Agro-industrial byproducts have special value in feeding livestock mainly in urban and peri-urban livestock production system, as well as in situations where the productive potential of the animals is relatively high and require high nutrient supply. The current trends of increasing urban population has a significant effect on the establishment of agro-industries due to the corresponding increasing demand for the edible main products (Andualem, 2016).

The major agro-industrial byproducts available in Amhara national regional state (ANRS) are wheat bran, wheat middling, rice bran, oats bran, noug seed cake, cottonseed cake, sesame seed cake, groundnut cake and brewery byproducts. Most of the agro-industrial byproducts are produced from small-size flour mills and oil processing plants. The contribution of agro-industrial byproducts, which mainly come from small-size flour and oil mills, as feed sources is very insignificant (1.3%) (Yayinshet, 2010).

2.5.3. Seasonal distribution of feed resources

The availability of tropical feed resources is seasonal, being governed by seasonal rainfall dynamics. Animal productivity is thus determined by the fluctuation of feed resources. Whereas, natural pasture is the major feed resource during rainy season, crop residues are the main source of feed for livestock during the dry period (early January to May). Starting from September to February, harvested hay, aftermath grazing and grazing/browsing constitute the main feeds available to livestock. However, there is severe livestock feed shortage during the dry season (January to May) (Solomon, 2008a).

According to Zelalem *et al*. (2009), shortage of feed resources is critical in dry seasons (January-May) in most areas when all grazing and crop aftermath are completely finished. Thus, crop residues and hay are available during this period, and are provided to livestock from January to June; such feeds are normally conserved during the beginning of the dry season and preserved for dry period when feed shortage is severe. Feed supply in Ethiopia is inhibited by different factors. The main problems are conversion of grazing land to cropland, expensive market price of concentrate feeds, increasing urbanization and use of arable land for housing, recreation, floriculture and industrial development, increasing the size of the herd and lack of proper management (Zewdie, 2010).

Generally, there is feed deficit during dry seasons, especially from March to June while in moisture-deficit *Woredas* the feed shortage may even extend to July. The period from September to January is relatively considered sufficient in feed supply when plenty of crop stubble grazing, crop residues and pasture are relatively better in availability, though quality of the feed resources from grazing may decline due to over maturity and moisture stress in the dry season (Firew and Getenet, 2010). Generally, seasonal variations in feed quality and quantity is the main limitation to animal production and cause fluctuation in productivity throughout the year, particularly in the dry seasons during which feed is limited and poor in nutritive value. Moreover, lack of knowledge on feed conservation has created feed shortage both in the highland and in lowland ecologies of Ethiopia (Tesfaye *et al*., 2010).

2.6. Role of Supplementation and Feed Requirement of Fattening Cattle

The purpose of supplementation is to provide rumen microorganism optimum readily energy, nitrogen and/or minerals that will enhance their activity and rumen function. Consumption of low quality roughages such as straw and poor grass hay can be increased markedly by the addition of protein supplements. Therefore, supplementation especially with protein sources is critical particularly for young, rapidly growing animals, as protein sources can determine the quantity or the quality of protein (essential amino acids) reaching the small intestine that are required for growth and production (McDonald *et al.*, 2002).

As described by David (2006), dry matter intake must be substantially greater than 2% body weight for higher roughage rations in order for animal to get energy requirements. Dry matter refers to the amount of dry materials in a given feed. Cattle in low condition may consume 3% of their body weight, while cattle with a high degree of finish have a lower capacity (Hamilton, 2010). According to NRC (2000), roughage is required for the satisfactory functioning of the digestive system. Generally, a ration containing 75:25 or 80:20 grain to roughage ratio gives satisfactory weight gain at minimum risk, although the ration can vary from 50:50 to 90:10. The higher the percentage of grain in the ration, the higher weight gain potential, but the risk of digestive upset is greatly increased when grain in the feed is more than 80% (NSW, 2004).

2.7. Live Weight Gain and Measurement Techniques

Live weight is the measurement used mostly to evaluate body development in animals. The live weight of an animal is measured using fixed ground scale and body condition score. It is highly desirable to know the weight gain of animals at various stages during the fattening processes so that rations can be evaluated and rate of gain can be calculated (Adugna, 2008). According to Nicholson and Butterworth (1986), body condition score (BCS) is a measure of fat cover over an animal's body and assessed visually and expressed as a condition score. For *Bos induces* cattle, nine scales grouped in to three

main categories such as, fat (F), medium (M) and lean (L) are used. The scores are abbreviated as F+, F, F-, M+, M, M-, L+, L and L-. Each scoring is given a number from 1 (L-) to 9 (F+). The score of animal depends on the visibility of the anatomical parts and the flesh and fat covers at these points. For body condition scoring, the following anatomical parts are important in determining the score: tail head, brisket and hump, transverse process of the lumbar vertebrae hips and ribs, the shape of the muscle mass between the hooks and pins.

Average daily gain (ADG) is an important parameter in beef production as it is used to determine the rate of growth and development. Live weight gain is affected by plane of nutrition, breed type, age, sex and growth promoters (McDonald *et al*., 2002).

2.8. Growth and Development of Fattening Cattle

Growth in animals is defined as accretion of protein, fat and bone. Although growth typically is measured as the change in live weight, nutrient retention is estimated more precisely by measuring empty body weight and composition, whereas production economics are measured ideally through carcass weights and quality. As a percentage of live weight gain, carcass weight gain usually is a much higher percentage during the feedlot phase than during the growing phase of production because dressing percentage (ratio of carcass to live weight) increases with maturation and is greater with concentrate than with roughage diets. At a given fraction of mature body size (maximum body protein mass), body fat percentage seems to be a constant. Mature size may be altered genetically and nutritionally. Protein accretion declines to zero when cattle reach their mature body size (approximately 36% fat in empty body weight in modern cattle) even though mature animals can continue to accrete fat. Although fat accretion can be reduced by limiting the supply of net energy, rate of fat accretion by finishing steers given ad libitum access to high-concentrate diets seems to reach a plateau at approximately 550 g daily. Protein mass, in contrast, increases in proportion to empty body weight. The protein, fat ratio of the carcass can be increased through increasing mature size, by administering hormones or hormonal modifiers, by limiting energy intake during the

growing period or finishing period, or by slaughtering cattle at an earlier stage of maturity. Energetically, efficiency of accretion of fat is approximately 1.7 times that of protein. But because more water is stored with deposited protein than with deposited fat, lean tissue gain is four times as efficient as accretion of fat tissue. Conversion of protein to fat is very inefficient, suggesting that excess protein is utilized inefficiently (Owens *et al*., 1995)

2.9. Fattening Cattle Marketing

According to Tsigereda and Mengistu (2011) cattle marketing system is one of the least developed aspect of the livestock sub-sector. It is characterized by a large number of highly dispersed markets, which generally lack basic infrastructural facilities like fencing, cattle pens, weighting scale, watering, feeding, resting, and quarantine place. Marketing of fattening cattle and other cattle took place by mixing and at the same open area with no any shade and separation structure.

Market participants of fattened cattle are identified as producers, traders, smallholder farmers, local butchers, hotel owners, brokers, tax collectors and consumers. Producers, traders and brokers are the main actors in fattened cattle marketing systems. Producers are ranked first followed by traders even if brokers have significant role in connecting both the buyers and sellers via bargaining (Getachew *et al*., 2017). Prices of beef cattle vary from places to place and depend on the availability and volume of supply. Prices depend mainly on supply and demand, which is heavily influenced by the season of the year and the existence of religious and cultural festivals (Daniel, 2008). Domestic consumption, official exports and high demand of animals by the export abattoirs are among the major opportunities for the demand of live animals and meat. However, absence of effective grading system, absence of market information system, absence of promotional activities, supply problems, illegal export trade and inadequacy of infrastructure are described under the challenges of live animals and meat marketing system (Eyob and Zewudu, 2016).

3. MATERIALS AND METHODS

The study had two major components, namely, (*i*) survey of cattle fattening practices and feed resources, and (*ii*) feeding trial experiment. The survey was carried out first and then the feeding trial followed.

3.1. Survey

3.1.1. Description of the study areas

The survey study was conducted in two major towns of South Wollo Zone, Amhara National Regional State of Ethiopia, namely, Dessie and Kombolcha towns representing highland and mid highland agro ecologies, respectively (Figure 1). The two study towns were selected based on their agro-ecological differences, cattle fattening practices and proximity to each other for the study (being within 24 km distance).

Dessie town is located in northern part of Ethiopia in Amhara National Regional State, South Wollo Zone at a distance of 401 km from Addis Ababa, Ethiopia. Its location is between $11^0 8'$ N - $11^0 46'$ North latitude and $39^0 38'$ E - $41^0 13'$ East longitude. It is bounded by Kutaber *Woreda* in the North, Dessie Zuriya *Woreda* in the East and by Kombolcha town in the South. The topography of Dessie is a highland type surrounded by '*Tossa*' mountain (Dawit, 2013). Its elevation ranges between 2470 and 2550 meter above sea level. Its mean annual rainfall is 893.8 mm while its annual maximum and minimum temperature is 23.7^0C and 9^0C, respectively, as recorded in 2015 (Kombolcha Meteorology Station, 2016 personal communication). Dessie is one of the reform towns in the region and has a city administration consisting of municipality, 10 urban and 6 peri-urban *kebeles* (Dawit, 2013).

Kombolcha town is an industrial town found in the northern part of Ethiopia located at immediate South East of Dessie in South Wollo Zone of the Amhara Regional State. It is situated at a distance of 377 km from Addis Ababa, 505 km from the regional capital city,

Bahirdar and 533 km from Djibouti port. The town is located at about 11^0 6′ North latitude and 39^0 45′ East longitude. The town is bounded by Dessie Zuria *Woreda* in the Northeast and Northwest, Kalu *Woreda* in the South and Albuko *Woreda* in the Southwest (Muluwork, 2014). Mean annual rainfall is 725.1 mm while its annual maximum and minimum temperature is 28.1^0C and 12.9^0C, respectively, as recorded in 2015 (Kombolcha Meteorology Station, 2016 personal communication). The town is located at an altitude range of 1500 to 1840 meter above sea level. Kombolcha is one of the reform towns in the region and has a town administration municipality, 5 urban and 6 peri-urban *kebeles*. The town shares Kombolcha airport with its neighboring town, Dessie. Kombolcha town is one of the few towns in Ethiopia with a relatively greater number of large-scale manufacturing plants including Kombolcha Meat Processing Factory (ELFORA), Kombolcha Leather Factory, Kombolcha Textile Industry, Kombolcha Brewery Factory (BGI-ETHIOPIA), COSPI Steel and Metal Industry and flour factories. On top of this, the town is selected to be an industrial zone by Amhara National Regional State and the Federal Government of Ethiopia (Eskinder *et al.,* 2010).

Currently, Kombolcha town is enjoying expansion of industries because of the Ethiopian government policy of urban development. Due to this fact, the Kombolcha municipality administration has taken actions to expand its spatial coverage towards the peri-urban *kebeles* through reclassification program (Muluwork, 2014).

3.1.2. Study population

For this study, urban and peri-urban cattle fatteners found in urban and peri-urban *kebeles* of both the study towns, respectively and feed suppliers represented the study population in both study areas. *Kebeles* in both the study towns classified in to urban and peri-urban based on the proximity to the central areas, economic base/ source and infrastructure issue.

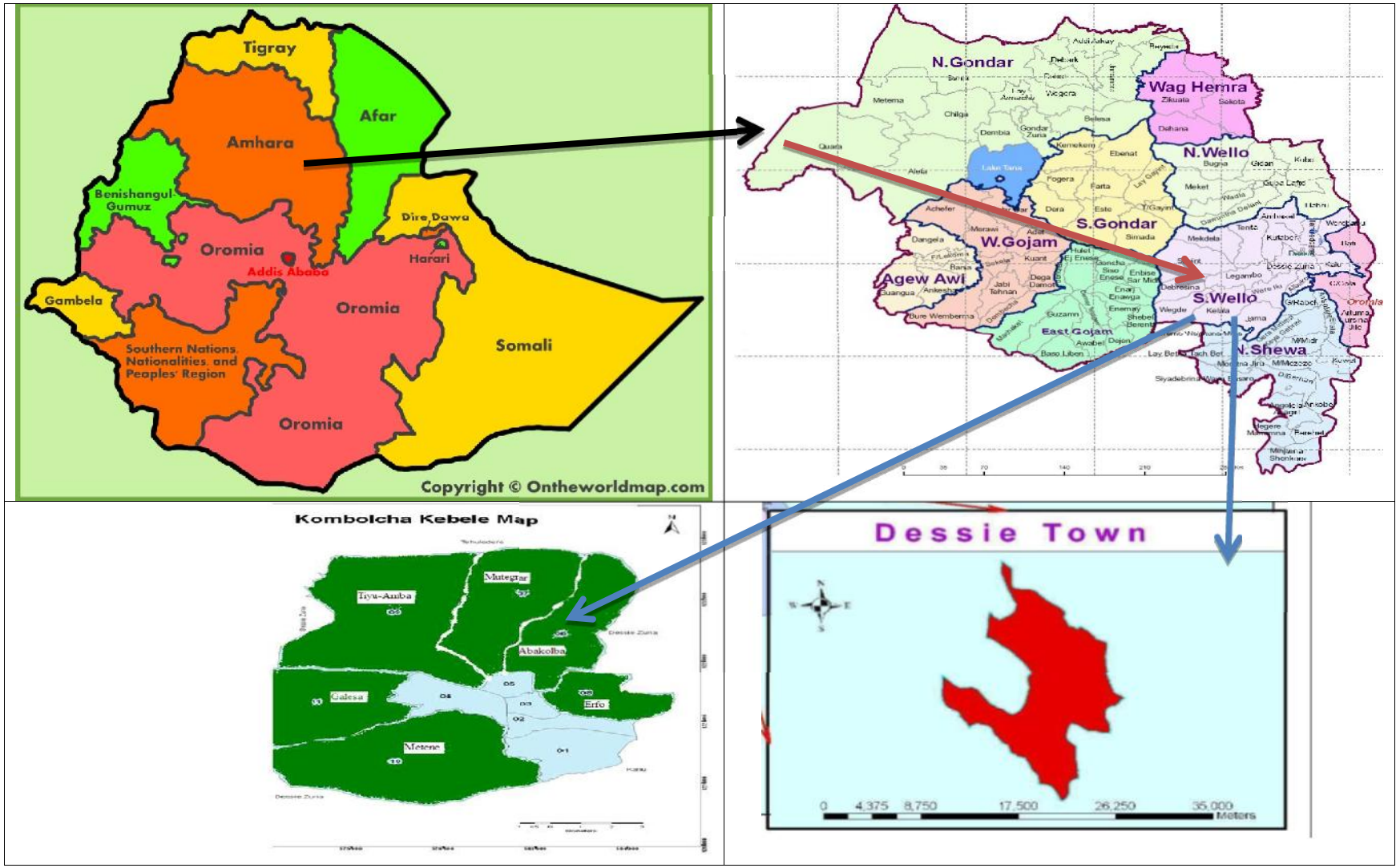

Figure 1. Map of the study areas

3.1.3. Data collection methods on cattle fattening practices and feed resources

Primary data related to cattle fattening practices and common feed resources used for cattle fattening in Dessie and Kombolcha areas were collected via questionnaire interviews, focus group discussions, key informant interviews and field observations. The later three methods were carried out first in order to complement the information gathered via structured questionnaire and to have prior knowledge about the study areas and enumerators monitoring.

3.1.3.1. Primary and secondary data sources

The primary data were collected from urban and peri-urban cattle fatteners, and feed suppliers (brewery and flour factories, small-scale food processors, feed traders, local brewery houses, poultry farms and farmers). Secondary data related to the investigation were collected from different governmental organizations. Consequently, reports of Agricultural Offices, Meteorology Agency, Trade and Industry Coordination Offices, Small and Micro Enterprise Offices of Dessie and Kombolcha towns were used as a secondary data source. Moreover, previous studies or literatures, guidelines and manuals were reviewed to describe the study areas. Information on administrative boundary, rainfall and temperature of the study areas were considered. Other information related to infrastructure data such as available cattle market and its facilities, and distance from the central areas of each study *kebeles* was included. Generally, secondary information relevant to the study was gathered.

3.1.3.2. Sampling methods and sample size determination

The study *kebeles* in both study areas were selected based on presence or absence of experiences on cattle fattening practices. Accordingly, from a total of 16 (10 urban and 6 peri-urban) and 11 (5 urban and 6 peri-urban) *kebeles* found in Dessie and Kombolcha towns, respectively, all *kebeles* practicing cattle fattening activities were considered. Complete enumeration technique was applied to select *kebeles*. Accordingly, 9 (3 urban

and 6 peri-urban), and 10 (4 urban and 6 peri-urban) *kebeles* were selected from Dessie and Kombolcha towns, respectively. The *kebeles* with no experience in cattle fattening in both areas were excluded from the study.

To select individual households (HHs) from urban and peri-urban *kebeles* of Kombolcha town and urban *kebeles* of Dessie town, complete enumeration technique was applied due to presence of manageable number of cattle fatteners, while, in the case of peri-urban areas of Dessie town, systematic random sampling technique was employed due to presence of large and homogenous cattle fatteners' practices.

Accordingly, in peri-urban *kebeles* of Dessie town uniquely the sample size (n) was determined using the formula recommended by Arsham (2002). $N = 0.25/SE^2$, where N is sample size and SE is the standard error (4%). Sampled households in each peri-urban *kebeles* of Dessie town were determined based on the principle of proportional to size'. Thus, totally, 190 cattle fatteners from Dessie town (41 urban and 149 peri-urban) and 147 cattle fatteners from Kombolcha town (66 urban and 81 peri-urban) were selected and interviewed. To collect data from the surveyed cattle fatteners, a single visit survey with practical observation of their practices were employed and each cattle fattener was taken as a unit of analysis. During data analysis, seven incomplete questioners were excluded from peri-urban *kebeles* of Dessie town.

3.1.3.3. Questionnaire interview

Based on objectives of the research and the parameter required, unadjusted structured questionnaire was prepared using English language and translated in to Amharic. In the course of the questionnaire preparation, information generated from the secondary data sources were used. In addition, the questionnaire used by other researchers on cattle fattening practices and related works were consulted. Pre-test and necessary adjustments were made on the questionnaire prior to the actual interviews. Four diploma holder enumerators were selected and trained. The adjusted structured questionnaire was administered to the cattle fattener by the researcher and enumerators, and interviewed

with close supervision. From each *kebele*, one Development Agent who is familiar with the area was assigned as a facilitator for the interviews. Finally, using the adjusted structured questionnaires all the required data were collected at household (HH) level at their home. The researcher carried out majority of the interviews to ensure the originality of the data, to see the actual cattle fattening practices and to minimize financial limitations.

The questionnaire encompassed major questions regarding socioeconomic profile, farm characteristics, feed resources and feeding systems, water and watering practices, salt supplementation and housing practices, health care and marketing practices, means of transportation and service while transportation, institutional support regarding information and training access, cattle fatteners indigenous knowledge, constraints, challenges and opportunities of cattle fattening practices (Appendix 1).

3.1.3.4. Focus group discussion

To strengthen the survey data, focus group discussions were held with elder and model cattle fatteners who have knowledge and experience about cattle fattening practices and common conventional and non-conventional feed resources used for cattle fattening. The date for focus group discussions was arranged in collaboration with Development Agents (DAs). Discussions were held in *Kebele* offices, shade areas in villages and marketing areas. Totally, 156 discussants (84 and 72 from Dessie and Kombolcha towns, respectively), were selected by the help of DAs. Several focus group discussions (at least one in each selected *kebeles*) were held to capture discussants' indigenous knowledge. One group discussion took 1:30-2:30 hour and composed of a maximum of 12 discussants to encourage participation and to avoid dominance of ideas of few cattle fatteners. The points of discussion encompassed ideas related to cattle fattening practices, feed resources used for cattle fattening, cattle marketing, challenges, constraints and opportunities of the sector. Guidelines and key questions were prepared (Appendix 2). Discussions begun via general introduction lead by DAs. The researcher gave a brief overview of the research and summarized key expectations from the meeting. All

participants were encouraged to participate and consider each answer as relevant. Refreshments were offered to the participants at the end of each discussion. The researcher facilitated the discussions and collected the required data.

3.1.3.5. Key informants interview

The key informant interviews were deliberately made with professionals believed to have comprehensive knowledge about the study areas and cattle fattening practices. Moreover, an effort was made to include the different concerned professionals from different backgrounds. Consequently, 66 participants (34 from Dessie and 32 from Kombolcha) that encompass individuals from meat processing and brewery factories, poultry farms, small and micro enterprise offices, agriculture offices, *kebele* administrators, managers, and agriculture academicians from W/ro Siheen Polytechnic College and traders were involved in the key informant interviews. Key informant interviews were made on cattle fattening practices, feed resources used for cattle fattening, constraints, challenges and opportunities of the sector using guidelines questions (Appendix 2). Key informant interviews were made at the respective interviewee's offices, working place and marketing areas.

3.1.3.6. Field observation

In this phase, field observations on actual cattle fattening practices, feed resources and marketing process were carried out to identify and witness the real practices going on in both the study areas. Moreover, different pictures, videos and short notes were captured to strengthen and triangulate with the data obtained through questionnaire interviews, focus group discussions and key informants interviews. Accordingly, the field observations were carried out at cattle marketing areas, transportation site, individuals' farms, feed supplier shop and different organizations level.

3.1.3.7. Feed resources identification and categorization

Common feed resources used for cattle fattening in Dessie and Kombolcha areas were identified after analysis and assembling of the data of the structured questionnaire, key informant interviews, focus group discussions and field observations. Point's considerd in feed resources assessment and identification were feed types, sources, month of availability and distribution, price and current and overall production capacity of feed suppliers (Appendix 3).

For proper triangulation of the analyzed data, the actual feeds samples were collected from respondent farms, brewery factory, small-scale food processors, feed traders, local brewery houses, poultry farms and flour factories available in Dessie and Kombolcha areas. The feed samples were categorized into conventional and non-conventional. Again, based on their nature, conventional feed sources were further classified in to dry roughage, green roughage and concentrate according to Habib and Siddiqui (1994) as cited by Younas and Yaqoob (2005). Thus, conventional feed resources were used commonly for fattening practices, while, non-conventional feeds were not commonly used but play a major role in meeting the feed shortage. In addition, as per focus group discussions and based on cattle fatteners' practical experiences, the overall identified feed resources were categorized into three groups as *1st choice*, *2nd choice* and *3rd choice* feed resources based on significance for cattle fattening purposes and irrespective of their roughage, concentrate or conventional and non-conventional nature.

3.2. Feeding Trial

The feeding trial was conducted in Kombolcha town nearby Kombolcha Meat Processing Factory (ELFORA) using 15 Wollo oxen to determine feed intake, weight gain and dressing percentage and economic feasibility of concentrate feeds of varied protein sources. For feeding trial, Kombolcha town was selected by considering the survey results, environmental merit for cattle fattening and availability of experimental facilities. The feeding trial was carried out within the month of December to March for 90 days.

The indicated period of fattening was selected to simulate the local cattle fattening practices of the study areas.

3.2.1. Experimental design

The experiment was conducted in randomized complete block design (RCBD) with three dietary treatments, each replicated with five fattening oxen representing blocks. Experimental oxen were grouped into five blocks of three animals each after arranged in ascending order based on their initial body weight. The three treatments were then randomly assigned within a block via lottery system. The initial weight of cattle was determined by taking the mean of the two consecutive weighings on the same day of the start of the feeding trial and the mean initial body weight was 305.0±6.9 kg. After blocking there was no significant difference in the initial body weight among the oxen assigned into the different treatments.

3.2.2. Dietary treatments and experimental feeds processing

Major and common feed ingredients used to formulate the dietary treatments were selected from the already identified feed resources during survey. Feed resources selection was made through consideration of availability, accessibility, significance and cost of feeds. Again, dietary treatments were also formulated by considering the respondents' traditional cattle feeding and fattening practices. Consequently, three most commonly and widely used protein feed sources were selected and used to represent treatments. Accordingly, grass pea leftover, poultry litter and dried brewery grain were selected as sources of protein. Wheat bran and crushed corn grain were used as energy sources across the treatments. Native grass hay was used as a basal diet. The total amount of a daily feed intake was calculated at 3% of the body weight on dry matter basis assuming that 40% comes from provision of roughage and 60% from mixed concentrates. The concentrate mixtures formulate to be iso-nitrogenous (13% CP) and iso-caloric (13.17 ME, MJ/kg DM) rations across the treatments (Table 1).

Table 1. Concentrate proportion of experimental feed ingredients

Concentrate feed ingredients, %	Treatments		
	T_1	**T_2**	**T_3**
Wheat bran	56	39	74
Processed corn grain	16	27	12
Grass pea leftover	27	0	0
Poultry litter (layer)	0	33	0
Dried brewery grain	0	0	13
Salt	1	1	1
CP %	13	13	13
ME, MJ/kgDM	13.0	13.2	13.3

The treatment feeds such as corn grain, wheat bran and grass pea leftover were purchased from feed trader, flour factory and small scale food processors, respectively, in Dessie and Kombolcha towns. The corn grain was processed or crushed in milling house, while, wheat bran and grass pea leftover were used as it is. Filtrated, purified and prepared poultry litter for sell for local cattle fattener was collected from Kombolcha Poultry Farm Enterprise, particularly from layer house. Layer poultry litter was used due to its availability during the research period.

The wet brewers' grain was obtained from Kombolcha Brewery Factory. With health assurance permission from human health station, the wet brewers' grain was spread on properly designed cemented ground in '*Gedeb*' area in Kombolcha town and then sun dried. After drying, the dried brewers' grain collected, properly stored using sacks for latter feeding and directly used for cattle. The native grass hay dominated by *Cynodon dactylon* (Tsegaye Gobezie, personal communication) was purchased from local farmers in wet form near to Wollo University in Dessie town. It was harvested at flowering stage, dried, transported and stored in ventilated shade in the experimental site. The grass hay was provided for the experimental cattle without chopping based on local cattle fattener's practices.

Finally, feed ingredients across the treatment groups were thoroughly mixed manually on a concrete floor with polyetelen sheet. The daily ration per cattle per treatment was calculated based on dry matter bases and measured using mechanical weighing scale.

3.2.3. Experimental animals and their management

The experiment was conducted using castrated and healthy Wollo oxen. The oxen were identified according to their characteristics as described by Dereje *et al*. (2008) and by the help of local community. Experimental animals have big body frame, medium horns, hump and more inclined to Senga type. The oxen were purchased from the same and nearby common local market. Ages of the cattle were determined by dentition with the help of Agricultural Experts, Veterinarians, local cattle traders and farmers supported with graphic dentition photograph as described by Ron *et al.* (2003). Accordingly, 5 years old oxen were purchased and used for the experiment since oxen under 4-5 years of age show a higher body weight gain (Osuji and Capper, 1992).

At arrival to the experimental station, cattle were quarantined for a period of 21 days, during which oxen were dewormed against internal parasites with *Albendazole* 2500 mg and *Tetraclozan* 3400 mg bolus provided using canola and vaccinated with *Oxytetracycline* 20% and *Ivermectin* 1% against external parasites. The animals were also vaccinated against *Bovine Pasteurellosis, Blackleg* and *Anthrax*. In addition, vitamin B complex was provided for each experimental ox. Moreover, the experimental animals were carefully observed for the occurrence of any ill health with the support of veterinarian assigned for this purpose from Agriculture Office and persistent records were taken for any physiological disorder during the experimental periods.

Following quarantine, oxen were identified with name and number using ear tag, horn collars, blocked on the basis of their initial body weight and adapted for 15 days to the respective treatment diets, pens and overall experimental procedure before the start of the actual feeding trial. The oxen were kept in well-ventilated, concrete floor and individually partitioned open and closed house. Depending on the environmental

condition, the experimental animals were exposed to sunlight in open shed during day and housed at night period. They were penned separately in pens equipped with watering and feeding troughs. The experimental rations were offered for each ox during the day and night period. The body of experimental animals was brushed using hand brush and showered once per week, whereas, the open shade and bedding concrete floor were cleaned daily.

Basal feed and concentrate were offered four times a day at 7:00 am, 10:00 am, 2:00 pm and 4:00 pm to minimize refusals. The daily amounts of grass hay and concentrate ration were offered in a separate feeding trough that was made from wooden kit locally called '*Yatekilt Saten'* and plastic containers, respectively. The experimental animals accessed powdered common salt at all the time with the mixed concentrate ration. The experimental animals had free access to drink fresh pipe water *ad libitum* through concrete watering trough.

3.3. Measurements and Data Collection

3.3.1. Feed intake

The daily amount of supplement offered and the refusal of each experimental animal were weighed daily throughout the experimental period using mechanical weighing scale and recorded to determine the amount of feed consumed as a difference between the feed offered and refused. Leftovers were collected after 24 hours at 6:00 am daily in the early morning. Representative samples of diets offered and refusal per cattle as well per as batch of treatment feeds were collected daily over the experimental days and stored in coded plastic bags pending chemical analysis. The feed offered was always adjusted based on the new weight after each body weight measurement that was taken every 15 days interval.

3.3.2. Body weight change

All body weight measurements were carried out in Kombolcha Meat Processing Factory (ELFORA) using fixed ground scale. Before and after each measurement, the scale was cleaned from dung and droppings and fixed to zero kg. At the beginning of the feeding trial and throughout the 90 days of experiment, weight of all experimental animals was taken every 15 days at 6:00 am in the morning after overnight fasting. Average daily weight gain (ADWG) (kg) of the experimental animals was determined as a difference between the final and initial weights divided by feeding days.

3.3.3. Body condition score

For consistent result and proper handling of the experimental animals, body condition score was assessed at the same time with taking body weight measurements. Body condition score was assessed in a scale 1 to 9 (L-, L, L+, M-, M, M+, F-, F, and F+ or 1= Emaciated up to 9 = Obese) according to the procedure described by Nicholson and Butterworth (1986). To maintain the consistency between assessments, the same technician, the researcher did all body condition scores every 15 days throughout the experimental period.

The body condition scoring of a nine point system for African Zebu cattle developed by ILCA (Nicholson and Butterworth, 1986) are described as follows: Score 1: (L-) Marked emaciation (animal would be condemned at anti-mortem examination). Score 2: (L) Transverse processes project prominently; neural spines appear sharply Score 3: (L+) Individual dorsal spines are pointed to the touch; hips, pins, and tail-head are prominent. Transverse processes visible individually. Score 4: (M-) Ribs, hips and pins clearly visible. Muscle mass between hooks and pins slightly concave. Slightly more flesh above the transverse processes than in L+. Score 5: (M) Ribs usually visible, little fat cover, dorsal spines barely visible. Score 6: (M+) Animal smooth and well covered; dorsal spines cannot score condition features be seen, but are easily felt. Score 7: (F-) Animal smooth and well covered, but fat deposits are not marked. Dorsal spines can be felt with

firm pressure, but feel rounded rather than sharp. Score 8: (F) Fat cover in critical areas can be easily seen and felt; transverse processes cannot be seen or felt. Score 9: (F+) Heavy deposits of fat clearly visible on tail-head, brisket and cod, dorsal spines, ribs, hooks and pins fully covered and cannot be felt even with firm pressure (Appendix Figure 1).

3.3.4. Feed conversion ratio and efficiency

Feed conversion ratio (FCR) and feed conversion efficiency (FCE) were calculated using the following formula:

$$FCR = \frac{\text{Feed DM intake (kg) during the study period}}{\text{Weight gain (kg) during the study period}}$$

$$FCE = \frac{\text{Weight gain (kg) during the study period}}{\text{Feed DM intake (kg) during the study period}}$$

3.3.5. Carcass characteristics

At the end of the experiment, 12 oxen (4 from each treatment) were slaughtered for dressing percentage evaluation. The animals were deprived of feed and water overnight. Pre-slaughter body weight was taken immediately before slaughter. Cattle were stunned on the head with axe to immobilize and killed by severing the jugular vein and the carotid artery on both sides of the throat with sharp knife. The head was held over prior-weighted empty metal container to collect blood before weighing. The value of blood was obtained through deduction. When the blood flow ceased, the head was cut from the body and weighed after the tongue was removed. The body was de-skinned and the alimentary canal with its contents removed. Before and after the digesta was removed from the alimentary tract, the guts were weighed. The abdominal fat was removed from the entire tract and kept separate from the gut. The tongue, fat (kidney, bladder and abdominal), heart, liver, kidney, and tail root was weighed together and kept separately. The remaining organs (lung with trachea, spleen, urinary and gall bladder, penis, testicles,

intestine) were removed and weighed after kidney and bladder fats were separated. Due to fear of contamination and slaughtering time management, it was difficult to measure every single component individually. Accordingly, some of the parts non-edible offal components and non-carcass edible components within the same category were measured together as clearly indicated in the result section.

After the viscera were removed from the carcass, the dressed hot carcass weight was recorded by deduction of total non-edible offal components and non-carcass edible components. Finally, the skin with tip tail and feet was separately weighed as employed by Yohannes (2011).

Total non-carcass edible component (TNCEC) was taken as the sum total weight of (heart, liver, kidney, tongue, tail root, fat (kidney, bladder and abdominal) and empty gut. Total non-edible offal component (TNEOC) was considered as the sum of the weight of hide, feet, head without tongue, blood, gut fill, lung with trachea, spleen, testicles, penis, urinary and gall bladder, and intestine (Yohannes, 2011). All the required measurement were taken using scale that has a capacity to measure 400 kg at once.

The empty body weight (EBW) was calculated as the difference between slaughter weight (SW) and gut content. Dressing percentage was calculated as proportion of hot carcass weight to slaughter or empty body weights bases multiplied by 100 (Yohannes, 2011).

3.4. Chemical Analysis of Experimental Feeds

The feeds used for the experiment were subjected for chemical analysis at Holleta Agricultural Research Centre Animal Nutrition Laboratory. Each feed ingredient and the offered and refusal samples of the basal as well as concentrate feeds were thoroughly mixed based on their category and enough sub-samples (100 gram per sample) were taken and ground to pass through 1 mm sieve screen. Then, the ground sub samples were dried in an oven for 12 hours at 105^0C to determine the DM content of feeds according to

the standard procedure of AOAC (1990) and the ash content was determined by igniting feed samples in a muffle furnace at 500^0C for 12 hours. N (nitrogen) content of feeds was determined according to Kejldhal procedure and the crude protein (CP) was calculated as N*6.25. Neutral detergent fibre (NDF), acid detergent fibre (ADF) and acid detergent lignin (ADL) were analyzed according to the procedure of Van Soest and Robertson (1985).

Hemicellulose (HC) and cellulose (C) were calculated as NDF minus ADF, and ADF minus ADL, respectively. Moreover, nutrient content which includes Digestible Crude Protein (DCP) (g/kg DM), *In vitro* Dry Matter Digestibility (IVDMD) (%), Metabolisable Energy (ME) (MJ/kg DM), phosphorous (P) (%) and Calcium (Ca) (%) of offered feeds were also determined. The Ca and P contents were determined by atomic absorption spectrophotometry (AAS) and flow injection analysis (FIA), respectively (Harris, 1970). The IVDMD was determined according to Tilley and Terry (1963). The ME was estimated as ME (MJ/kg DM) =0.015*IVDMD (g/kg) (MAFF, 1984) and DCP as DCP (g) = 0.929*CP (g) -3.48 (Church and Pond, 1982) as employed by Zewdie (2010).

3.5. Partial Budget Analysis

Partial budget analysis was conducted to evaluate the economic advantage of the different treatments. The partial budget analysis considered the calculation of variable costs (cost of feed ingredients used to formulate across the treatments, labor expense for the attendants at the time of the experiment, service charge while purchasing oxen, oxen transportation cost and purchased cost of experimental animals) and benefits. The costs of the feeds used were computed by multiplying the actual feed intake for the whole feeding period with the prevailing market price. The actual price difference between the selling and purchasing of oxen in each treatment at the end of the feeding trial was considered as total return (TR) or gross benefits in the analysis. Accordingly, before slaughtering, three cattle traders estimated the live selling price of individual oxen and the average value was taken as live selling price. Finally, partial budget was analyzed as a measure of the profit or loss, which was the difference between gains and expenses. Net

return (NR) was calculated from the amount of money left when total variable costs (TVC) are deducted from the total returns (TR): NR = TR - TVC.

3.6. Data Management and Statistical Analysis

All the collected survey data were coded and entered into a database using Statistical Package for Social Science (SPSS) for windows, version 16.0, 2007). Descriptive statistics such as frequency, percentage, range, standard deviation and mean were used. Indices were calculated to provide rank of the constraints of cattle fattening practices and identified feed resources according to the following formula. Index = Sum (n x number of households (HHs) ranked first) + (n-1) x number of HHs ranked second + (n-2) x number of HHs ranked third +…+ 1 x number of HHs ranked last) for one factor divided by the sum of (n x number of HHs ranked first+ (n-1) x number of HHs ranked second +…. +1 x number of HHs ranked last) for all factors, and where n = value given for the least ranked factor. The variable with the highest index value has the highest impact according to the formula employed by Yohannes *et al*. (2017).

All data related to body weight gain, feed intake, feed conversion efficiency, feed conversion ratio, dressing percentage were subjected to two-way analysis of variance (ANOVA) in a randomized complete block design using the general linear model procedure of SAS version 9.00 (2002). When the treatment effect was significant, least significance difference (LSD) was employed to separate treatment means. Pearson correlation (r) was employed to see the associations' between body condition score and fixed ground scale body weight measurement.

The model used was $Yij = \mu + Ti + Bj + eij$, Where;

Yij = Response variable;

μ = Overall mean;

Ti = The fixed effect of feed (treatment effect T1, T2 and T3);

Bj = The block effect (initial BW);

eij = The effect of random error

4. RESULTS

This unit consists of three major sections of results. These included (i) survey on cattle fattening practices in Dessie and Kombolcha areas; (ii) identified feed resources used for cattle fattening and *(*iii*)* feeding trial experiment and carcass characteristics determination.

4.1. Survey of Cattle Fattening Practices

4.1.1. Socio-economic characteristics and cattle fattening experiences of households

The socio-economic characteristics of the urban and peri-urban cattle fattener households of the study areas are presented in Table 2. The present study revealed that almost all of household (HH) heads involved in cattle fattening in both areas were male-headed. On the other hand, in urban areas, female-headed participants were slightly higher than in the peri-urban areas in Dessie and Kombolcha towns. This was due to the raising of urban cattle fattening practices gave better chance for urban females to organize with males.

In both study towns' majority of the interviewed cattle fattners are within the age category of 24 to 34 age years (Table 2).

In Dessie and Kombolcha towns, highest number of urban cattle fatteners had attended 2^{nd} cycle primary school and above, whereas, peri-urban cattle fatteners in Dessie and Kombolcha towns attended 2^{nd} cycle primary school and below (Table 2).

The family size of peri-urban cattle fatteners was higher than that of the urban in both study areas. A large family size will create better opportunity for peri-urban households (HHs) to have better labor access for cattle fattening practices than urban HHs (Table 2).

Table 2. Socio-economic characteristics and cattle fattening experiences of households in Dessie and Kombolcha areas

Variable	Dessie town n (%)			Kombolcha town n (%)			Overall total
	PUK n = 149	UK n = 41	Total n = 190	PUK n = 81	UK n = 66	Total n = 147	n = 337
Sex of HH heads							
Male	142 (95.3)	38 (92.7)	180 (94.7)	79 (97.5)	57(86.4)	136 (92.5)	316 (93.6)
Female	7 (4.7)	3 (7.3)	10 (5.3)	2 (2.5)	9 (13.6)	11(7.5)	21 (6.4)
Age of HH heads (years)							
15-24	0 (0.00)	0 (0.00)	0 (0.00)	4 (4.9)	2 (3.00)	6 (4.1)	6 (1.8)
24-34	46 (30.9)	34 (82.9)	80 (42.1)	43 (53.1)	38 (57.6)	81 (55.1)	161 (47.8)
34-44	53 (35.5)	7 (17.1)	60 (31.6)	34 (42.0)	26 (39.4)	60 (40.8)	120 (35.6)
44-54	31 (20.8)	0 (0.00)	31 (16.3)	0 (0.00)	0 (0.00)	0 (0.00)	31 (9.2)
≥ 54	19 (12.8)	0 (0.00)	19 (10.0)	0 (0.00)	0 (0.00)	0 (0.00)	19 (5.6)
Mean ± SD	41.4± 10.3	30.0±3.7	39.0±0.8	42.2 ± 10.1	32.9±4.2	38.0±0.8	38.5± 0.8
Education status of HH heads							
Illiterate	11 (7.4)	0 (0.00)	11 (5.8)	12 (14.8)	0 (0.0)	12 (8.2)	23 (7.0)
'*Meserete timihert'*	25 (16.8)	0 (0.00)	25 (13.2)	22 (27.2)	3 (4.5)	25 (17.0)	50 (15.0)
1st cycle primary school (1-4)	49 (32.9)	0 (0.00)	49 (25.8)	18 (22.2)	2 (3.0)	20 (13.6)	69 (19.7)
2nd cycle primary school (5-8)	46 (30.9)	5 (12.2)	51 (26.8)	9 (11.1)	11 (16.7)	20 (13.6)	71 (20.2)
Secondary school (9-10)	15 (10.0)	26 (63.4)	41 (21.6)	17 (21.0)	26 (39.4)	43 (29.2)	84 (25.5)
Preparatory school (11-12)	3 (2.0)	10 (24.4)	13 (6.8)	3 (3.7)	24 (36.4)	27 (18.4)	40 (12.6)
Family size (persons)							
3-5	18 (12.1)	15 (36.6)	33 (17.4)	9 (11.1)	34 (51.5)	43 (29.3)	76 (22.6)
5-7	63 (42.3)	25 (61.0)	88 (46.3)	17 (21.1)	31 (47.0)	48 (32.6)	136 (40.3)
7-9	68 (45.6)	1 (2.4)	69 (36.3)	55 (67.8)	1 (1.5)	56 (38.1)	125 (37.1)
Mean ± SD	5.30 ± 1.3	4.0± 1.0	5.0± 1.4	6.2± 1.9	3.7± 0.9	5.1± 2.0	5.1± 1.7

n (%) depicts number and percent of respondents; SD = Standard Deviation; PUK = Peri-urban *Kebeles;* UK = Urban *Kebeles:* Illiterate = used for those cattle fatteners who has religious knowledge but they don't have formal education at all; '*Meserete timehert*'= used for those cattle fatteners who able to read and write.

Table 2. Socio-economic characteristics and cattle fattening experiences of households in Dessie and Kombolcha areas (continued)

Variable	Dessie town n (%)			Kombolcha town n (%)			Overall total
	PUK n = 149	UK n = 41	Total n = 190	PUK n = 81	UK n = 66	Total n = 147	n = 337
Income sources of HH heads							
Farming	143 (96.0)	0(0.0)	143 (75.3)	59 (72.8)	10 (15.2)	69 (46.9)	212 (62.9)
Cattle fattening	1 (0.7)	39 (95.1)	40 (21.0)	21 (26.0)	56 (84.8)	77 (52.4)	117 (34.7)
Civil servant	1 (0.7)	2 (4.9)	3 (1.6)	1 (1.2)	0(0.0)	1 (0.7)	4 (1.2)
Other trade other than cattle	3 (2.0)	0 (0.0)	3 (1.6)	0 (0.0)	0(0.0)	0(0.0)	3 (0.9)
Cattle trade	1 (0.7)	0 (0.0)	1 (0.5)	0 (0.0)	0(0.0)	0(0.0)	1 (0.3)
Cattle fattening experiences (years)							
Min.	1.00	2.00	1.00	4.00	1.00	1.00	1.00
Max.	13.00	3.00	13.00	13.00	3.00	13.00	13.00
Mean ± SD	7.4±2.8	2.0±0.2	6.2± 3.3	7.6±2.6	1.9 ±0.4	5.0±3.4	5.6±3.4
Average number of cattle fatten/year/household							
Min.	1.00	3.00	1.00	1.00	2.00	1.00	1.00
Max.	5.00	9.00	9.00	6.00	19.00	19.00	19.00
Mean ± SD	2.2±0.9	5.8±1.8	3.0±1.9	3.0 ±1.4	8.3±3.8	5.4±3.8	4.0±3.1

n (%) depicts number and percent of respondents; SD = Standard Deviation; PUK = Peri-urban *Kebeles;* UK = Urban *Kebeles*

Majority of the cattle fatteners in the study town reported that farming was the primary source of income in Dessie town followed by cattle fattening, whereas, in Kombolcha town cattle fattening was the primarily source followed by farming different crops and employment in government and non-governmental organizations as civil servant. In urban *kebeles* of both areas, cattle fattening constituted the largest share as a source of income than in peri-urban *kebeles* (Table 2).

The data showed in Dessie and Kombolcha areas, peri-urban cattle fatteners had relatively long year's traditional cattle fattening experiences than urban cattle fatteners (Table 2).

The average number of oxen fattened per year per HH ranged from 1 to 9 and 2 to 19 in Dessie and Kombolcha areas, respectively (Table 2). The average number of oxen fattened per year per HH was higher in Kombolcha than in Dessie town. This might be due to the availability of cattle fattening inputs like feeds in Kombolcha relative to Dessie. Moreover, the data indicated that in both areas, the average number of cattle fattened/year/HH were higher in urban than in peri-urban *kebeles*. This might be due to the fact that urban dwellers fatten large number of oxen to maximize their earnings.

4.1.2. Major activities of cattle fattening and fatteners labor and time allocation

Labor and time allocation of cattle fatteners for fattening practices in the study areas are presented in Table 3. The study revealed that the surveyed cattle fatteners in both study areas used male family members dominantly for cattle fattening practices. All peri-urban and majority of urban cattle fatteners in Dessie town allocated only male family members, whereas, the rest urban cattle fatteners allotted both male and female family labor. In urban and peri-urban *kebeles* of Kombolcha town, the entire cattle fatteners had left the cattle fattening practices for male.

Table 3. Cattle fatteners labor and time allocation for cattle fattening practices in Dessie and Kombolcha areas

Variable	Dessie town n (%)			Kombolcha town n (%)			Overall total n = 337
	PUK n = 149	UK n = 41	Total n = 190	PUK n = 81	UK n = 66	Total n = 147	
Family labor allocation							
Male only	149 (100)	32 (78.0)	181 (95.3)	81 (100)	66 (100)	147 (100)	328 (97.7)
Both (male and female)	0 (0.0)	9 (22.0)	9 (4.7)	0 (0.0)	0 (0.0)	0 (0.0)	9 (2.3)
Time allocation							
2-3 hours/day	71 (47.7)	0 (0.0)	71 (37.4)	39 (48.1)	24 (36.4)	63 (42.9)	134 (39.8)
3-4 hours/day	78 (52.3)	0 (0.0)	78 (41.0)	42 (51.9)	26 (39.4)	68 (46.2)	146 (43.3)
Throughout a day	0 (0.0)	41 (100)	41 (21.6)	0 (0.0)	16 (24.2)	16 (10.9)	57 (16.9)

PUK = Peri-urban *Kebeles;* UK = Urban *Kebeles*

In Dessie town, the entire urban cattle fatteners allocated their labor throughout the day for fattening cattle management, whereas, the entire peri-urban cattle fatteners allocated limited hours (2-4) per day. In Kombolcha town except 10.9%, majority of cattle fatteners spent on average 2-4 hours per day. Such limited time allocation might have impact on the profitability of the sector and will be a cause for discouragement.

The major activities of fattening farms such as feed purchasing, collection and transportation, house preparation, cattle marketing, trekking, feeding and watering equipment preparation, cattle washing and exposing to sun light in exercising area, tying and untying cattle, support provision while cattle medication, and decision making for marketing were done by male family members. Both members of the family did ration preparation and feeding, salt provision and watering activities. Female family members predominantly do the barn and equipment cleaning, and manure collection in both the study areas. The HH husbands and young boys shared the largest responsibility and undertake majority of activities. The responsibilities of wives and daughters were very less and limited to specific activities.

4.1.3. Purpose of livestock holding, cattle fattening, and source of cattle and finance

The purpose of livestock holding, cattle fattening and sources of cattle in Dessie and Kombolcha areas are presented in Table 4. Majority of the surveyed HH had livestock in Dessie than in Kombolcha town. Similarly, majority of peri-urban cattle fatteners (91.9%) in Dessie town had livestock compared to peri-urban cattle fatteners of Kombolcha town. This was due to the presence of relatively large grazing area and dominancy of mixed crop livestock production system in Dessie and displacement of livestock holders due to urbanization in Kombolcha. However, the entire and majority of urban cattle fatteners in Dessie and Kombolcha areas respectively had no livestock.

Almost all households (HHs) in urban *kebeles* of Dessie (97.6%) and Kombolcha (93.9%) areas fattened cattle dominantly for profit purposes, whereas, peri-urban cattle fatteners in Dessie and Kombolcha areas fattened cattle for both profit and income source (Table 4). From the overall result, cattle fatteners in both areas obtained cattle for fattening purpose from own farm (51.6%) and from market (48.4%). Immediate purchase from market was the sole source for the majority of urban cattle fatteners in both areas, whereas, majority (91.9%) and below half (37%) of peri-urban cattle fatteners in Dessie and Kombolcha areas, respectively acquire cattle for fattening from their own farm, which were culled oxen from farming due to old age or being unproductive (Table 4). According to focus group discussions, the main source of money to finance the cattle fattening practices was family and relatives, micro finance institution, bank, personal saving and wealth. These all played a great role by lending money to start the fattening farm and financing it in the process of fattening.

Table 4. Purpose of livestock holding and cattle fattening, and sources of cattle in Dessie and Kombolcha areas

Variable	Dessie town n (%)			Kombolcha town n (%)			Overall
	PUK	UK	Total	PUK	UK	Total	total
	n = 149	n = 41	n = 190	n = 81	n = 66	n = 147	n = 337
Livestock holding (%)							
Yes	137 (91.9)	0 (0.0)	137 (72.1)	30 (37.0)	7 (10.6)	37 (25.2)	174 (51.6)
No	12 (8.1)	41 (100)	53 (27.9)	51 (63.0)	59 (89.4)	110 (74.8)	163 (48.4)
Purpose of livestock holding (%)							
Income source	92 (67.1)	0 (0.0)	92 (67.1)	4 (13.3)	0 (0.0)	4 (10.8)	96 (55.2)
Milk	35 (25.5)	0 (0.0)	35 (25.5)	18 (60.0)	7 (100)	25 (67.6)	60 (34.5)
Draft power	6 (4.4)	0 (0.0)	6 (4.4)	3 (10.0)	0 (0.0)	3 (8.1)	9 (5.2)
Wealth	2 (1.5)	0 (0.0)	2 (1.5)	0 (0.0)	0 (0.0)	0 (0.0)	2 (1.1)
Profit	2 (1.5)	0 (0.0)	2 (1.5)	5 (16.7)	0 (0.0)	5 (13.5)	7 (4.0)
Reason of cattle fattening (%)							
Profit (net income)	72 (48.3)	40 (97.6)	112 (58.9)	42 (51.9)	62 (93.9)	104 (70.7)	216 (64.1)
Income (gross benefit)	64 (43.0)	1 (2.4)	65 (34.2)	39 (48.1)	4 (6.1)	43 (29.3)	108 (32.0)
For better traction power	4 (2.7)	0 (0.0)	4 (2.1)	0 (0.0)	0 (0.0)	0 (0.0)	4 (1.2)
To diversify income source	4 (2.7)	0 (0.0)	4 (2.1)	0 (0.0)	0 (0.0)	0 (0.0)	4 (1.2)
Means of job to change life	3 (2.0)	0 (0.0)	3 (1.6)	0 (0.0)	0 (0.0)	0 (0.0)	3 (0.9)
As bank	2 (1.3)	0 (0.0)	2 (1.1)	0 (0.0)	0 (0.0)	0 (0.0)	2 (0.6)
Source of cattle for fattening							
Owen farm	137 (91.9)	0 (0.0)	137 (72.1)	30 (37.0)	7 (10.6)	37 (25.2)	174 (51.6)
Purchase from market	12 (8.1)	41 (100)	53 (27.9)	51 (63.0)	59 (89.4)	110 (74.8)	163 (48.4)

PUK = Peri-urban *Kebeles;* UK = Urban *Kebeles*

4.1.4. Livestock production and cattle fattening systems

Urban livestock production (33.6 %) and mixed crop livestock production systems (66.4 %) were the two identified livestock production systems practiced in the urban and peri-urban *kebeles* of both areas, respectively (Table 5). Mixed crop livestock production system is used as a source of oxen for fattening and different feeds, whereas, urban livestock production or urban agriculture is used as source of non-conventional feed like poultry litter.

Byproduct based, and a combination of traditional and byproduct based cattle fattening systems were identified in Dessie and Kombolcha areas. The fattening system was categorized based on the sources of feeds used, types of livestock production systems, *kebeles* distance from the central area. Byproduct based cattle fattening system was 100% practiced in urban *kebeles* of both study areas as means of job opportunity for urban cattle fatteners. Such fattening system mainly depended on different conventional and non-conventional feed resources purchased from flour and brewery factories, local brewery and milling houses, micro and small food processing enterprises, poultry farms and grazing lands.

Whereas, the entire peri-urban cattle fatteners in both areas adopted a combination of traditional and byproduct based cattle fattening systems (Table 5). This system relied on the use of locally available feed resources collected from farmer's farm and grazing lands. Besides, peri-urban cattle fatteners dominantly used purchased feed resources to supplement fattening cattle and to shorten the fattening duration. Accordingly, they purchase different agro-industrial byproducts from the vicinity towns. As per the focus group discussions, the use of such supplementary feed resources was mandatory to boost the fattening process. Otherwise, the cattle fattening process would be worthless since it would take long months. Due to this fact, they were highly dependent on agro-industrial byproducts particular to wheat bran and wheat middling comes from flour factories. From this scenario, it could be concluded that, the peri-urban cattle fattening system in both the study areas is neither traditional nor byproduct based. They experienced new type of

cattle fattening system that combined the features of both traditional and byproduct based.

Table 5. Livestock production and cattle fattening systems in Dessie and Kombolcha areas

Vairable	Dessie town n (%)			Kombolcha town n (%)			Overall
	PUK	UK	Total	PUK	UK	Total	total
	n = 149	n = 41	n = 190	n = 81	n = 66	n = 147	n = 337
Livestock production systems (%)							
Mixed crop livestock	149 (100)	0 (0.0)	149 (78.4)	80 (98.8)	0 (0.0)	80 (54.4)	229 (66.4)
Urban	0 (0.0)	41 (100)	41 (21.6)	1 (1.2)	66 (100)	67 (45.6)	108 (33.6)
Cattle fattening systems (%)							
Traditional and byproduct based	149 (100)	0 (0.0)	149 (78.4)	80 (98.8)	0 (0.0)	80 (54.4)	229 (66.4)
Byproduct based	0 (0.0)	41 (100)	41 (21.6)	1 (1.2)	66 (100)	67 (45.6)	108 (33.6)

PUK = Peri-urban *Kebeles;* UK = Urban *Kebeles*

4.1.5. Mode of oxen management and fattening practices

As per focus group discussions, key informant interviews and researcher's observations, oxen management practices of peri-urban cattle fatteners' were slightly altered in both study areas. In the previous year's peri-urban cattle fatteners, culturally purchase a pair of oxen after they properly selected based on the criteria matched to mixed crop livestock production system and keep for long period of years for plowing purposes. Then, after the end of the main plowing season, farmers put such oxen for fattening purpose by considering the plowing potential and working age of oxen. Such tradition indicates that oxen are not absolutely selected and purchased based on fattening cattle selection criteria. Moreover, aged oxen that incur cost and take long time to fatten are used. Likewise, the meat originating from such cattle would become tough. Currently in peri-urban *kebeles* of both the study areas the above indicated oxen management practices were slightly altered. Nowadays, farmers are not in a situation to keep a pair of oxen for many years or throughout the year. Rather, instead of keeping a pair of oxen, they keep cows and heifers for milk production and reproduction purposes. This is because of the recurrent drought, feed shortage, shrinkage of communal and private grazing lands, and negative influence

of urbanization and herding difficulties, since the youths went away to cities for engagement in urban related job opportunities. Accordingly, to mitigate the indicated problems, peri-urban cattle fatteners tried to modify their previous cattle selection tradition, purchasing time and oxen management. As a result, cattle selection only for plowing purpose was modified in to dual-purpose by considering selection criteria of cattle for both fattening and plowing purposes. Consequently, in both the study areas peri-urban cattle fatteners purchase a pair of oxen at the commencement of the farming season and they fatten them immediately after the end of tillage time through provision of home produced feed resources and purchased agro-industrial byproducts.

Peri-urban cattle fatteners experienced such practices as one measure to mitigate feed shortage. Even if the lesson came after long years of trial and error, such practices led peri-urban cattle fatteners or farmers to follow better economical approach to allocate the limited feed resources and family labor. Such approach has positive contribution for future development of the sector. Accordingly, if such dual-purpose selection criterion continues, peri-urban cattle fatteners would be additional power to supply well-fattened cattle for domestic as well as foreign market. In addition, it creates better opportunity to exploit wisely the unexploited cattle resource of the study areas.

4.1.6. Fattening cattle selection criteria

Fatteners cattle selection criteria for fattening in Dessie and Kombolcha areas are presented in Table 6. In both areas, cattle fatteners used different criteria to purchase cattle to be fattened. Among selection criteria's age, castration condition, sex, cattle breeds/ types, color, ploughing condition, anatomical and physical considerations were considered by most of the cattle fatteners.

Sex: Entirely cattle fatteners (100%) in the urban and peri-urban *kebeles* of both study areas did select male cattle for fattening purpose. This is due to the fact that male cattle fatten with in short period of time. Female cattle are not demanded due to expensive price

and cow may happen pregnancy at the middle of fattening. Moreover, the municipality slaughtering houses protect slaughtering of female cattle.

Castration condition: All the interviewed peri-urban cattle fatteners in both study areas pointed out that most of the cattle they used for fattening purpose were culled oxen from farming and they were usually castrated. Most of the time they select castrated cattle (Table 6). This is because peri-urban cattle fatteners primarily purchased oxen for farming purpose, as castration is highly correlated with the behavior and easy management of oxen while plowing and safe handling of the farming equipment. In contrast, all urban cattle fatteners in both the study towns selected and purchased both castrated and uncastrated cattle for the fattening purpose (Table 6). This is because, cattle selection mainly depends on the accessibility of cattle in the market and such selection fulfills the divergent desires of their customers. They believed that uncastrated cattle have better potential to gain and fatten with short period with less cost than the castrated oxen. Also, butcher house and hotel owners believed the meat coming from uncastrated cattle score higher carcass weight than the castrated cattle and make them more profitable when they sell the meat in kilogram basis without cooking. Conversely, the local consumers preferred fatty or '*Choma*' meat coming from castrated cattle. Such diversified selection practices will increase market opportunity via satisfying the divergent desires of customers.

Age: In Dessie and Kombolcha areas the entire peri-urban cattle fatteners selected cattle with the age ranges of 4½ to 5 years, locally called '*Yaderesse*', which means the cattle whose milk teeth (incisors) are totally replaced by the permanent ones. This was because farmers select relatively mature oxen for ploughing. Moreover, farmers explained that when oxen reach the indicated age they develop better potential to handle and pool the farming equipment's and are able to pair with other oxen in equivalent energy. Instead, in the majority of cattle fatteners in Dessie and all urban cattle fatteners in Kombolcha areas select young cattle locally called '*Hulet seber'*, which are equivalent to three years of age (Table 6). This was because they believed that such cattle finished their growth and when placed in to finishing program that will start to build fat with in short period. Cattle age

selection of urban cattle fatteners is mainly influenced by the market condition. Due to this fact, except old and emaciated cattle, they are forced to purchase the available age category in the market. Urban cattle fatteners do not select old and emaciated cattle. They reported most of the time such cattle do not fatten totally or would take much feed and long period to fatten. Moreover, the customers are not willing to purchase such cattle. Such age section practice of urban cattle fatteners is an opportunity for the sector to produce better quality meat.

As per focus group discussions and researcher observations, apart from dentition, some cattle fatteners in both the study areas determined the age of cattle based on horn ring and root. When the horn remained smooth and no ring at all, they group such cattle under younger age category. If the horns are rough, locally called '*Shakara'* with different rings and thinner horn root, they categorize such cattle under aged category. Generally, they reported horn rings are mostly observed after the animal reach five years of age. By refining such tradition horn detection could be supportive method to identify age of cattle.

Table 6. Fattening cattle selection criteria in Dessie and Kombolcha areas

Variable	Dessie town n (%)			Kombolcha town n (%)			Overall total n = 337
	PUK n = 149	UK n = 41	Total n = 190	PUK n = 81	UK n = 66	Total n = 147	
Castration condition							
Castrated	149 (100)	0 (0.0)	149 (78.4)	81 (100)	0 (0.0)	81 (55.1)	230 (68.2)
Both (castrated and uncastrated)	0 (0.0)	41 (100)	41 (21.6)	0 (0.0)	66 (100)	66 (44.9)	107 (31.8)
Age preferred							
'Yaderese'	149 (100)	9 (22.0)	158 (83.2)	80 (98.8)	0 (0.0)	80 (54.4)	232 (68.8)
'Hulet seber'	0 (0.0)	32 (78.0)	32 (16.8)	1(1.2)	66 (100)	67 (45.6)	105 (31.2)
Cattle type							
Local	149 (100)	0 (0.0)	149 (78.4)	81 (100)	0 (0.0)	81 (55.1)	230 (68.2)
Local and hybrid	0 (0.0)	41 (100)	41 (21.6)	0 (0.0)	66 (100)	66 (44.9)	107 (31.8)
Plowing condition							
Experienced in farming	149 (100)	0 (0.0)	149 (78.4)	81(100)	0 (0.0)	81 (55.1)	230 (68.2)
Both (experienced/non experienced)	0 (0.0)	41 (100)	41 (21.6)	0 (0.0)	66 (100)	66 (44.9)	107 (31.8)

PUK = Peri-urban *Kebeles;* UK = Urban *Kebeles*

Cattle type: All peri-urban cattle fatteners in both the study areas used local cattle type. This was because the peri-urban cattle fatteners believed that hybrid and exotic cattle are not manageable for ploughing purpose and take long period to train and adapt to the local environment. Due to such reasons, farmers used local cattle from their native areas and near neighbours. Instead, the entire urban cattle fatteners in both areas used both local and hybrid cattle types for fattening purpose (Table 6). As per focus group discussions, four types of cattle are reported in Wollo and adjacent areas. Namely, Raya Azebo cattle in the North, Afar Danakil cattle in the Northeast, Highland zebu in the North-west and South of the study areas and intermediate cattle type which might be a combination of the indicated cattle types in the adjacent areas.

Urban cattle fatteners used Raya Azebo and Highland zebu cattle for the fattening purpose. Particularly in Kombolcha town, cattle fatteners dominantly focus on Raya Azebo cattle type due to their better frame and large skeletal development to hold muscle and better adaptation ability to relatively hotter areas like Kombolcha. The urban cattle fatteners reported that Highland zebu cattle coming from Kutaber, Wore illu, Borena, Tenta, Ajibar, Mekane-selam and Tehuledere *woreda* were selected as a second choice next to Raya Azebo cattle because of relatively short size and less ability to hold muscle compare to Raya Azebo. As well, they stated a Highland zebu cattle looks small at the end of the fattening phase. Due to this reason, such cattle have less attracting ability in the market and less profitable because of small carcass yield.

In contrast to the above, cattle fatteners reported that the meat originating from Wollo Highland zebu cattle have better flavour, aroma and taste than Raya Azebo cattle types. Due to this fact, such cattle are highly preferred by consumers. Hotels and restaurants used the meat of Wollo highland zebu cattle as display to sell meat originating from other cattle types.

Exceptionally, Afar cattle type was not selected for fattening purpose in both the study areas due to their long horn, wild behaviour, difficulty for confined management, emaciated body condition and less adaption to the new environment particularly in Dessie

town. In addition, cattle fatteners believed that horned cattle take long time to fatten. This might be due to the difference in bloodlines that has an effect on gain performance. As per focus group discussion, urban as well as peri-urban cattle fatteners were not fattening pure exotic cattle type. This was because such cattle are not manageable at farmers' level due to their huge feed intake and energetic nature for farming. Yet again, their meat is not tasty and aromatic like that of the local and hybrid cattle. As a result, hotels and restaurants were not happy to purchase and slaughter such cattle. Generally, the presence of different cattle type in and around the study areas is used as a potential source for fattening cattle practices and to realize urban and peri-urban cattle fatteners' selection desires.

Color: All cattle fatteners' (100%) particularly urban fatteners in both the study areas give better consideration for coat color while purchasing cattle. This was due to the fact that they believe that color has impact on marketing price and consumer attraction. Accordingly, cattle fatteners did not prefer completely black, white, light brown, locally called *'Telbama'* coat color. Rather they preferred red, black and white, dusty white (*Sendema)* and different spotted colors, locally called *'Burabure or Gureza'*.

Anatomical and physical considerations: In Dessie and Kombolcha areas cattle fatteners' particularly urban cattle fatteners consider different anatomical and physical criteria for selecting cattle for fattening purpose. In addition, they have indigenous knowledge to assure that a given cattle has reached for the market after a period of feeding as described in Appendix 4 and 5. Such indigenous knowledge of cattle fatteners will be a base for further improvement.

4.1.7. Cattle fattening frequency, duration and seasonal management

Cattle fattening frequency and duration in Dessie and Kombolcha areas are presented in Table 7. All peri-urban cattle fatteners in both the study areas are dominantly fatten cattle once per year following the end of the main farming season. This was because fatteners place oxen for fattening after they finished cultivation. Such fattening practice was one

of the techniques to mitigate feed shortage. Conversely, all urban cattle fatteners in both the study areas fatten cattle twice per year. The first round commences from mid of October to January. This was due to less competition for feed resources from peri-urban cattle fatteners and rural farmers, and due to better availability and lower price of feeds and cattle in the market relative to other months. In the indicated months, rural farmers and peri-urban cattle fatteners sell their cattle to acquire cash income to cover different expenses like student cloths, exercise books and ceremony expenses, to harvest different crops and hay in the form of local tradition of labor exchange, locally called *'Debo'*. The second round of cattle fattening begin from January to June. This was due to the presence of relatively better cattle selling price, suitable (hotter) environmental condition and less competition for cattle market from rural and peri-urban cattle fatteners.

Long fattening duration was observed in peri-urban cattle fatteners (3 to 5 months and above) than urban (2 to 3 months) in both study areas (Table 7). This might be due to the management aspect particularly feed type used and feeding practices, and breed and body condition of cattle used for fattening. Moreover, urban cattle fatteners applied spread price approach rather than feed margin. Accordingly, when market opportunities and profit margin satisfied, they sell a given cattle at any time of the fattening phase irrespective of maintaining the fattening duration.

In both the study areas, peri-urban cattle fatteners predominantly undertake cattle fattening during wet/rainy season (July, August, September and October) after the end of land preparation (Table 7). Mostly they purchase oxen in the month of March to June and use them for tillage operation for main farming season, locally called '*Meher*'. Land preparation of '*Meher'* season in the study areas is undertaken between March to June. Upon finishing land preparation and sowing activities, they initiate the feeding program starting from mid-July to September to finish and sell in October, November and December. Conversely, the entire urban cattle fatteners in both the study areas commonly do not practice cattle fattening in wet, cool and rainy seasons (July, August, September and October) due to difficulty for management and environmental challenge. Besides, they reported that in the indicated months, cattle consume more feed to be fattened and

gain less. Instead, in both areas urban cattle fatteners dominantly start preparation and practice cattle fattening from mid-October to June. Such diversified fattening periods of urban and peri-urban cattle fatteners will be one solution to minimize market competition problem among rural, peri-urban and urban cattle fatteners.

Table 7. Cattle fattening frequency, duration and season in Dessie and Kombolcha areas

Variable	Dessie town n (%)			Kombolcha town n (%)			Overall total n = 337
	PUK n = 149	UK n = 41	Total n = 190	PUK n = 81	UK n = 66	Total n = 147	
Frequency of fattening							
Once/year	149 (100)	0 (0.0)	149 (78.4)	81 (100)	0 (0.0)	81 (55.1)	230 (68.2)
Twice/year	0 (0.0)	41 (100)	41 (21.6)	0 (0.0)	66 (100)	66 (44.9)	107 (31.8)
Duration (months)							
Two	0 (0.0)	31 (75.6)	31 (16.3)	0 (0.0)	0 (0.0)	0 (0.0)	31 (9.2)
Two and half	0 (0.0)	10 (24.4)	10 (5.3)	0 (0.0)	41 (62.1)	41 (27.9)	51 (15.1)
Three	37 (24.8)	0 (0.0)	37 (19.5)	27 (33.3)	25 (37.9)	52 (35.4)	89 (26.4)
Four	78 (52.4)	0 (0.0)	78 (41.0)	23 (28.4)	0 (0.0)	23 (15.6)	101 (30.0)
Five and above	34 (22.8)	0 (0.0)	34 (17.9)	31 (38.3)	0 (0.0)	31 (21.1)	65 (19.3)
Season of fattening							
Wet/ rainy season	149 (100)	0 (0.0)	149 (78.4)	81 (100)	0 (0.0)	81 (55.1)	230 (68.2)
Dry/sunny season	0 (0.0)	41 (100)	41 (21.6)	0 (0.0)	66 (100)	66 (44.9)	107 (31.8)

PUK = Peri-urban *Kebeles;* UK = Urban *Kebeles*

4.1.8. Feeding practices

Feeding practices of fattening cattle in Dessie and Kombolcha areas are presented in Table 8. Mixing different conventional and non-conventional concentrate feed resources was the only way to prepare ration for fattening cattle in both the study areas. Mixing feed ingredients using water was not a common practice in both areas. Consequently, cattle fatteners mixed the concentrate feed resources without water using shovel and hand. This was due to the presence of poultry litter in the feedstuff. When poultry litter is immersed with water, it creates a bad odor and favorable environment for diseases

causing agents and cattle refuse to take the ration due to its pungent odor. Moreover, not mixing concentrates with water might be due to difficulty to preserve the refusal and due to labor shortage.

In door/stall feeding system (100%) was the only adopted means of feeding in both the study areas. Such practice is locally called '*Majeb*'. All the urban and majority of the peri-urban cattle fatteners in both areas provide the mixed concentrate and roughage feeds separately for individual cattle. The rest peri-urban cattle fatteners provide for collective use (Table 8). Such collective feeding practices might lead to competition, have negative impacts on gain performance of individual cattle and create difficulty to estimate individual cattle profitability.

In Dessie and Kombolcha areas, majority of the peri-urban and urban cattle fatteners provide a bulk of the mixed feed once per day to save labor. The rest provided two to three times per day depending on the appetite of the cattle. Bulk feed provision increases the amount of refusals and feed cost (Table 8). All cattle fatteners in both the study areas determine the amount of feed required per cattle through guess, by observing the amount of feed left in the feeding trough. Moreover, they apply trial and error approach while feeding. This was due to the absence of practical support related to ration formulation and feeding practices from animal sciences experts. Such practices may lead to over or under supply of feed resources and will create difficulty to provide the required amount and cost estimation.

Not all cattle fatteners in both study areas had feeding procedures while feeding fattening cattle. They provided the mixed feed ingredients, roughage and water with no sequence. This might be due to lack of awareness and practical support regarding feeding procedures. This type of feeding approach makes the cattle fattening practices more traditional, as it leads to increased cost of production. Feeding is one of the important factors in planning in door/stall feeding of cattle. Besides, the feeding sequence of concentrate and roughage, affect the intake and rumen condition.

Table 8. Feeding practices of fattening cattle in Dessie and Kombolcha areas

Variable	Dessie town n (%)			Kombolcha town n (%)			Overall
	PUK	UK	Total	PUK	UK	Total	total
	n = 149	n = 41	n =190	n = 81	n = 66	n = 147	n = 337
Way of feeding							
Separately	140 (94.0)	41 (100)	181 (95.3)	63 (77.8)	66 (100)	129 (87.8)	310 (91.6)
Together	9 (6.0)	0 (0.0)	9 (4.7)	18 (22.2)	0 (0.0)	18 (12.2)	27 (8.4)
Frequency of feeding							
Once per day	124 (83.2)	33 (80.5)	157 (82.6)	81 (100)	32 (48.5)	113 (76.9)	270 (79.8)
Twice per day	0 (0.0)	8 (19.5)	8 (4.2)	0 (0.0)	14 (21.2)	14 (9.5)	22 (6.9)
Three times per day	16 (10.7)	0 (0.0)	16 (8.4)	0 (0.0)	0 (0.0)	0 (0.0)	16 (4.2)
Depend on the appetite	9 (6.1)	0 (0.0)	9 (4.8)	0 (0.0)	20 (30.3)	20 (13.6)	29 (9.1)
Feed cost/duration/ cattle							
2000 birr	0 (0.0)	1 (2.4)	1 (0.5)	0 (0.0)	3 (4.5)	3 (2.0)	4 (1.2)
2500 birr	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)	10 (15.2)	10 (6.8)	10 (3.4)
3000 birr	0 (0.0)	40 (97.6)	40 (21.1)	0 (0.0)	53 (80.3)	53 (36.1)	93 (28.6)
They don’t know	149 (100)	0 (0.0)	149 (78.4)	81(100)	0 (0.0)	81 (55.1)	230 (66.8)

PUK refers to Peri-urban *Kebeles;* UK denotes to Urban *Kebeles*

All peri-urban cattle fatteners in Dessie and Kombolcha areas were unable to estimate the amount of feed cost required for a single cattle per fattening duration. This was due to the absence of recorded information and documentation on the expense and benefit of the fattening process. Conversely, majority of urban cattle fatteners in Dessie and Kombolcha areas estimated the feed cost to be 3000 birr/cattle/fattening duration (Table 8).

Neither urban nor peri-urban cattle fatteners in both study areas were used hormone for cattle fattening process. But, as per focus group discussions, few of the peri-urban cattle fatteners in Kombolcha area use chicken eggs as feed additives and drench stirred 10 to 18 eggs at the commencement of fattening for two to three times. This was because they believe that provision of eggs at the commencement of fattening motivates the cattle to take large quantity of feed with better appetite and used to kill internal parasites.

Peri-urban and urban cattle fatteners in Dessie and Kombolcha areas had different ration formulation practice for fattening cattle (Table 9). As per focus group discussions, key informant interviews and researcher practical observations, cattle fatteners in both areas use their traditional knowledge to prepare ration for fattening cattle. Accordingly, to prepare a single ration, cattle fatteners use a minimum of 4 and maximum of 13 feed ingredients as described in Table 9. The profitability of locally formulated rations is evaluated through continuous trial and error approach. Yet, as per focus group discussions, they reported a ration that contains grass pea leftover show better result on the fattening performance of cattle. Such home-based ration preparation practices give chance to increase fattening production in the study areas where commercial rations are not available. In addition, it increase farm efficiency by using on-farm byproducts and reduce the cost of production where homemade rations are cheaper than commercial rations. As a drawback, due to variability in quality and feed availability, it is difficult to determine feeding rates and to mix homogenously; especially the ingredients used small amounts. Moreover, it is not easy to balance the ration and maintain quality up to the recommended level for some ingredients, which can be toxic or have negative effects.

Table 9. Cattle fatteners local ration formulation options for fattening cattle in Dessie and Kombolcha areas

Ration options	Amount of feed used	Feed ingredients and amount incorporated/day/cattle	Responsible	Location
Option 1	13 in 1	**(**Poultry litter + grass pea leftover + different feed leftover + oat hull + grass pea hull + wheat bran + milling house leftover + dried brewery grain + barley leftover + barley hulls + oat leftover + 200 gram salt) + unknown kg of grass hay. The amount for each feed was unknown, they provided by guess)	UCF	KT
Option 2	5 in 1	(2.5 kg wheat bran + 2.5 kg pea leftover + 2.5 kg milling house leftover + 1.5 kg corn grain + 200 gram salt) + unknown kg of grass hay	UCF	DKT
Option 3	6 in 1	(2 kg grass pea leftover + 2 kg wheat bran + 2 kg pea leftover + 2 kg bean leftover + 200 gram salt + 2 kg linseed cakes) + unknown kg of grass hay	UCF	DKT
Option 4	7 in 1	Bean leftover + linseed cakes + wheat bran + corn grain + linseed cake + available hulls + salt + grass hay (the amount was unknown, they provided by guess)	UCF	DKT
Option 5	4 in 1	Wet dried brewery grain + dried brewery grain + powdered salt + grass pea leftover + hay (the amount was unknown, they provided by guess)	UCF	KT
Option 6	5 in 1	(2 kg grass pea leftover + 2 kg poultry litter + 3 kg dried brewery grains + handful of powdered salt + 2 kg oat leftover) + unknown kg of grass hay	UCF	DKT
Option 7	4 in 1	(3 kg dried brewery grain + 2 kg grass pea leftover + 2 kg poultry litter + handful of powdered salt)+ unknown kg of grass hay	UCF	KT
Option 8	6 in 1	(1.5 kg corn grain + 1 kg barely hulls +1 kg barley leftover + 1 kg grass pea leftover + 1.5 kg poultry litter + handful of powdered salt) + unknown kg of grass hay	UCF	KT
Option 9	6 in 1	3 kg poultry litter + 3 kg grass pea leftover + molasses one litter dilute with 5 litter water + 3 kg dried brewery grain + 1 kg linseed cake + hand full of powdered salt) + unknown kg of grass hay	UCF	KT
Option 10	6 in 1	Barley grain + Barley hulls + wheat bran + grass pea leftover + maize stover + block of salt + grass hay (the amount was unknown, they provided by guess)	PUCF	DKT
Option 11	7 in 1	Different weeds locally called '*Wokiya*' + green feed + crop residues during harvesting + maize stover and /or sorghum stover + 3-4 kg wheat bran + grass hay + block of salt.	PUCF	DKT

UCF= urban cattle fatteners; PUCF= peri-urban cattle fatteners; DKT= Dessie and Kombolcha Towns; KT= Kombolcha town
Some of the ration options estimated in kilogram base by considering the cattle fatteners local estimation.

4.1.9. Water and watering practices

Water and watering practices of fattening cattle in Dessie and Kombolcha areas are presented in Table 10. All cattle fatteners in both areas provide water for fattening cattle. All urban fatteners in both the study areas and 49.4% of peri-urban cattle fatteners in Kombolcha town use pipe water as a major source, whereas, all of the peri-urban cattle fatteners in Dessie and 50.6% of peri-urban cattle fatteners in Kombolcha town use water from hand wells for fattening purpose.

Almost all of the urban cattle fatteners in both areas provide water as a free choice, whereas, more than half and majority of peri-urban cattle fatteners in Dessie and Kombolcha areas respectively provide water once per day. Urban and peri-urban cattle fatteners in both study areas provide water by taking water to the cattle through pipeline and by fetching using human labor or donkey, respectively. The entire cattle fatteners in both the study areas have no information about the amount of water provided per cattle. This might be due to lack of consideration on the cost of water.

Table 10. Water and watering practices of fattening cattle in Dessie and Kombolcha areas

Variable	Dessie town n (%)			Kombolcha town n (%)			Overall total
	PUK n = 149	UK n = 41	Total n = 190	PUK n = 81	UK n = 66	Total n =147	n = 337
Water sources							
Pipe	0 (0.0)	41 (100)	41 (21.6)	41 (50.6)	66 (100)	107 (72.8)	148 (47.2)
Hand well pipe	149 (100)	0 (0.0)	149 (78.4)	40 (49.4)	0 (0.0)	40 (27.2)	189 (52.8)
Watering gap/interval							
One day interval	107 (71.8)	41 (100)	148 (77.9)	54 (66.7)	66 (100)	120 (81.6)	268 (79.5)
Two days interval	38 (25.5)	0 (0.0)	38 (20.0)	27 (33.3)	0 (0.0)	27 (18.4)	65 (19.3)
Three days interval	4 (2.7)	0 (0.0)	4 (2.1)	0 (0.0)	0 (0.0)	0 (0.0)	4 (1.2)
Watering frequency per day							
Free choice	0 (0.0)	41 (100)	41 (21.6)	0 (0.0)	50 (75.8)	50 (34.0)	91 (27.8)
Once per day	98 (65.8)	0 (0.0)	98 (51.6)	73 (90.1)	16 (24.2)	89 (60.5)	187 (56.1)
Twice per day	51 (34.2)	0 (0.0)	51 (26.8)	8 (9.9)	0 (0.0)	8 (5.5)	59 (16.1)

PUK refers to Peri-urban *Kebeles;* UK denotes to Urban *Kebeles*

4.1.10. Salt supplementation practices

Cattle fatteners' salt provision practices for fattening cattle in Dessie and Kombolcha areas are presented in Table 11. In both the study areas, all cattle fatteners provide salt for fattening cattle that comes from market. They believe that provision of salt for fattening cattle would protect cattle from diseases, increase feed appetite and intake, improve meat quality, helps the cattle to drink ample water, and important to ease management of cattle.

The entire peri-urban and urban cattle fatteners in both areas provide salt in the form of block or locally called '*Ganfur*' and in powder form with a ration, respectively. Salt provision frequency of the entire urban cattle fatteners in both areas depends on the frequency of ration provision. The amount of salt provided per cattle estimated via hand of a mature person. One hand full of mature person is estimated to hold 200 gram powder salt, which is provided for a single cattle daily. In contrast, peri-urban cattle fatteners in both the study areas provide ¼, 1/2 and a block of salt once for unknown fattening days. On average, one block of salt is estimated to be 7 to 9 kg.

Table 11. Salt provision practices for fattening cattle in Dessie and Kombolcha areas

Variable	Dessie town n (%)			Kombolcha town n (%)			Overall
	PUK	UK	Total	PUK	UK	Total	total
	n = 149	n = 41	n = 190	n = 81	n = 66	n =147	n = 337
Mechanism of salt provision							
Mixing with ration	0 (0.0)	41 (100)	41 (21.6)	0 (0.0)	66 (100)	66 (44.9)	107 (31.8)
A block of salt or '*ganfur*'	149 (100)	0 (0.0)	149 (78.4)	81 (100)	0 (0.0)	81 (55.1)	230 (68.2)
Frequency of salt provision							
It depends the concentrate feed provision frequency	0 (0.0)	41 (100)	41 (21.6)	0 (0.0)	66 (100)	66 (44.9)	107 (31.8)
Once as a whole	149 (100)	0 (0.0)	149 (78.4)	81 (100)	0 (0.0)	81 (55.1)	230 (68.2)
Amount of salt provided							
One hand full powdered salt	0 (0.0)	41 (100)	41 (21.6)	0 (0.0)	66 (100)	66 (44.9)	107 (31.8)
¼ block of salt or '*ganfur*'	13 (8.7)	0 (0.0)	13 (6.8)	0 (0.0)	0 (0.0)	0 (0.0)	13 (3.9)
1/2 block of salt or '*ganfur*'	33 (22.1)	0 (0.0)	33 (17.4)	0 (0.0)	0 (0.0)	0 (0.0)	33 (9.8)
A block of salt or '*ganfur*'	103 (69.1)	0 (0.0)	103 (54.2)	81(100)	0 (0.0)	81(55.1)	184 (54.5)

PUK refers to Peri-urban *Kebeles;* UK denotes to Urban *Kebeles*

4.1.11. Housing practices

The entire urban and peri-urban cattle fatteners in Dessie and Kombolcha areas prepared a separate house for fattening cattle. As per researcher's practical observations and focus group discussions, in peri-urban *kebeles* of both the study areas, cattle fatteners prepared house that encompasses enclosed open zone, partially shed area and enclosed house used for different purposes. Enclosed house is used for night time, locally called '*Maderiya*'. Open enclosed site is used for exercising, watering, and vaccination. Partially shade area is used to tie and provide feeds by protecting cattle from hot environment in the daytime locally called '*Mewaya*'. Mostly large trees and backside of a residence house are used as a shade area in peri-urban *kebeles* of study areas. Cattle houses in peri-urban areas were made of locally available materials like corrugated metal and wood contains openings for ventilation. The floor of cattle houses was made of earth and sandy materials and roofed using grasses, plastic sheet and corrugated iron sheet.

Uniquely, all urban cattle fatteners in both areas used clustered housing system or shade, which is new housing approach constructed by Small and Micro Enterprise Offices to run the overall urban livestock production practices in a specified center. The new housing system was designed based on the master plan of the towns that has a capacity to hold 10 to 12 different associations organized under urban agriculture. Accordingly, with five-year contract agreement, the offices gave the shade for different organized associations. The housing system included half shade-enclosed area and enclosed house. The enclosed house is made from concert floor that has gutter. The wall and the roof of the house are made of corrugated iron sheet and mainly used for nighttime rest and feed store, whereas, the half shade-enclosed open area is used for daytime exercising, dry roughage storage and supplementation. Cattle fatteners used feeding and watering equipment made of plastic, concert, car tier and wooden material. As a limitation, the new housing system was not furnished with farm aids and equipment like the cattle crush. Due to this reason, during cattle vaccination and treatment the cattle owner and other individuals are expected to hold the cattle themselves. This makes the medication process very

traditional and affects the wellbeing of human and animals. Moreover, distance from the residence house need to be corrected.

4.1.12. Disease and health condition

The entire urban and peri-urban cattle fatteners in both study areas reported the presence of internal and external parasites that affect the health of fattening cattle. Nevertheless, no endemic diseases were reported. All urban and peri-urban cattle fatteners in both areas deworm fattening cattle to protect from parasites. As per focus group discussions and key informant interviews, to control intestinal parasites or worms, cattle fatteners provide *Tetraclozan* and *Albendazole*, locally called '*Keyue*' and '*Arenguadew madaberiya'*, respectively. In addition, all and more than half of urban cattle fatteners in Dessie and Kombolcha areas, respectively, have indigenous knowledge to prevent and cure different diseases and health problem of fattening cattle (Table 12).

Consequently, cattle fatteners used different plant leaves and roots to cure external parasites, particularly, to cure *tick*, they use '*Endod*'(*Phytolacca dodecandra)*. To solve Foot and Mouth Disease (FMD) problem, they use honey, which might be due to its wound healing effect and they use wheat bran as bandage or mechanical cover for wound. Moreover, they clean barn and fattening areas as disease prevention method. To inhibit the growth of microorganisms, for proper inflammation and repair the wound cattle fatteners' use smoldering using hot *Knife* for different diseases as described in Appendix 6. Cattle fatteners learned such practices from their day-to-day problems, and via trial and error medication exercises.

The entire cattle fatteners in both areas access veterinary services at agriculture office medication site and through satellite veterinary centers with a minimum price. However, cattle fatteners reported inadequacy of veterinary services and inaccessibility of governmental veterinarians. Due to this reason, particularly in Kombolcha town cattle fatteners are forced to use private veterinarians by paying 70-100 birr per cattle per single service when sudden health problem happened.

Table 12. Indigenous practices of cattle fatteners to treat sick cattle in Dessie and Kombolcha areas

Variable	Dessie town n (%)			Kombolcha town n (%)			Overall
	PUK	UK	Total	PUK	UK	Total	total
	n= 149	n = 41	n=190	n= 81	n = 66	n=147	n=337
Indigenous knowledge							
Yes	0 (0.0)	41 (100)	41 (21.8)	0 (0.0)	50 (75.8)	50 (34.0)	91 (27.0)
No	149 (100)	0 (0.0)	149 (78.2)	81 (100)	16 (24.2)	97 (66.0)	246 (73.0)

PUK refers to Peri-urban *Kebeles;* UK denotes to Urban *Kebeles*

4.1.13. Cattle marketing practices

The entire urban and peri-urban cattle fatteners in Dessie and Kombolcha areas reported the presence of ten and more cattle market (Appendix 7). As per focus group discussions, the most preferred and first choice cattle market were Hayik, Raya Kobo, Kemisse and Segno Gebeya market due to proximity, cattle supply, presence of many cattle traders and relatively affordable price. Presence of different markets in both the study towns will be an opportunity for fattening cattle marketing options.

The entire cattle fatteners in both the study areas reported their cattle marketing practices in the areas are traditional. This was because except the newly reconstructed Segno Gebeya market, none of the cattle market found in and around study the areas has market infrastructure and services except fenced area. Moreover, without adequate service, in all market centers, the municipality office charges 5-7 birr per ox. Furthermore, the marketing of all animals took place at the same open area by mixing animals together and with no shade and separation structure. Moreover, the cattle marketing system was full of risk of aggressive cattle attack. Due to this reason, market participants are dissatisfied. This might be favorable condition for disease transmission from infected to healthy cattle and even it causes human health problem and death.

All urban and majority of peri-urban cattle fatteners (96%) in Dessie town and the entire cattle fatteners in Kombolcha town use different market for selling and purchasing practices (Table 13). As per focus group discussions, while purchasing, cattle fatteners travel long distance away from the study areas for better cattle selection occasions and relatively lower purchasing price advantages, whereas, in the course of selling they use the nearest market around the towns for better selling price.

The entire cattle fatteners in both the study areas practiced cattle marketing through agreement based on visual judgment with brokers' intervention. This was due to absence of other means of marketing such as weight-based marketing.

The entire cattle fatteners in both the study areas reported the presence of serious marketing problem for fattening cattle. This was because cattle traders, hotels and restaurants found in the study areas get credit based marketing as they have limited capital to purchase fattened cattle in cash. Hence, credit-based cattle marketing approach is dominantly practiced particularly in urban areas of both the study areas. Urban cattle fatteners reported that selling cattle in credit leads to purchasing enemy by your money, for the reason that customers are not retaining their promise to give the money on time. Sometimes, they deny, locally called '*Mekad*' and/or they pay the money bit by bit. Such money transaction is carried out without official agreement, locally called '*Amana*'. The marketing systems in both the study areas are full of illegal brokers. Thus, a broker has positive and negative influence in negotiating the buyers and sellers.

Such marketing system and money transaction creates capital inability of cattle fatteners and leads to discontinuation of the fattening activities in both study areas. In addition, it creates poor linkage and social relation between purchasers and producers, which leads to animosity and termination of relationship. To minimize such challenges and conflicts, urban cattle fatteners are forced to make discount for those purchasers who pay money in cash.

Table 13. Cattle market selection practices of cattle fatteners in Dessie and Kombolcha areas

Variable	Dessie town n (%)			Kombolcha town n (%)			Overall
	PUK n = 149	UK n = 41	Total n =190	PUK n = 81	UK n = 66	Total n =147	total n =337
Market selection							
Similar market	6 (4.0)	0 (0.0)	6 (3.2)	0 (0.0)	0 (0.0)	0 (0.0)	6 (1.8)
Different market	143 (96.0)	41(100)	184 (96.8)	81 (100)	66 (100)	147 (100)	331 (98.2)

PUK refers to Peri-urban *Kebeles;* UK denotes to Urban *Kebeles*

Difficulty to compete with rural farmers and peri- urban cattle fatteners were other cattle market problems reported by group discussion participants. This was due to the tradition of the rural farmers to deliver fattened cattle to markets during festivals and other similar occasions creating over supply of cattle and leading to a low price per head. Such situations would become worst for those urban cattle fatteners who mainly depended on purchased feed resources. The occasions would obviously discourage urban cattle fatteners and lead to termination of the cattle fattening practice.

4.1.14. Means of cattle transportation and services while conveyance

Means of cattle transportation in Dessie and Kombolcha areas are presented in Table 14. In urban and peri-urban *kebeles* of both the study areas, the entire cattle fatteners practiced trekking. This was because in one marketing day, a cattle marketer, particularly urban cattle fatteners, has a capacity to purchase a maximum of 3-4 cattle. As a result, it was not economical to hire a truck and pay 3000-4000 birr per car or 300-400 birr per ox. Besides, they were fear the injury of cattle while trucking due to absence of well-designed car, poor truck shipping, limited deriver's skill, aggressive nature of cattle, and loading and unloading difficulties. Moreover, cattle fatteners believe trekking is more desirable for feedlot cattle to avoid recall of the previous management system and to adopt the new feeding practice. In addition, they reported after long trekking and fasting cattle would not be selective and take the newly offered feed with enthusiasm and adapt to the new management easily.

In Dessie and Kombolcha areas all and majority of urban cattle fatteners respectively, trekked cattle by paying 70-100 Birr per cattle for laborers, while, almost all peri-urban cattle fatteners in both areas trekked by themselves. None of the cattle fatteners in both the study areas provided services while trekking cattle. This was due to lack of reserved areas for rest, feeding and watering.

Table 14. Means of cattle transportation in Dessie and Kombolcha areas

Variable	Dessie town n (%)			Kombolcha town n (%)			Overall total N=337
	PUK n = 149	UK n = 41	Total n=190	PUK n= 81	UK n = 66	Total n=147	
Who trek cattle							
Laborers	0 (0.0)	41 (100)	41 (21.6)	2 (2.5)	50 (75.8)	52 (35.4)	93 (27.6)
Owners	149 (100)	0 (0.0)	149 (78.4)	79 (97.5)	16 (24.2)	95 (64.6)	244 (72.4)

PUK refers to Peri-urban *Kebeles;* UK denotes to Urban *Kebeles*

4.1.15. Institutional support and extension services

The entire cattle fatteners in both the study areas access cattle marketing information from marketers via personal communication. This was due to absence of governmental office or media that deliver quick and updated information for cattle fatteners. In both the study areas, all urban cattle fatteners acquire training, while, the entire peri-urban cattle fatteners did not acquire any training on cattle fattening practices (Table 15). They practice cattle fattening based on traditional experiences from model cattle fatteners and built their capacity through trial and error approach. Urban cattle fatteners criticized the quality of training and the extension services they acquired from expertise.

Table 15. Institutional support for cattle fatteners in Dessie and Kombolcha areas

Variable	Dessie town n (%)			Kombolcha town n (%)			Overall
	PUK	UK	Total	PUK	UK	Total	total
	n= 149	n = 41	n=190	n= 81	n = 66	n =147	n = 337
Training access							
No	149 (100)	0 (0.0)	149 (78.4)	81 (100)	0 (0.0)	81 (55.1)	230 (68.2)
Yes	0 (0.0)	41(100)	41 (21.6)	0 (0.0)	66 (100)	66 (44.9)	107 (31.8)

PUK refers to Peri-urban *Kebeles;* UK denotes to Urban *Kebeles*

4.1.16. Cattle fattening constraints and opportunities

Constraints of cattle fattening practices in urban and peri-urban *kebeles* of Dessie and Kombolcha areas are presented in Table 16 and 17. The data indicated limited feed resources are the major constraints for the sector in both the study areas. This was due to recurrent drought, feed shortage, unaffordability of feed price, lack of governmental feed processing factories and suppliers, poor distribution of the available feed resources, influence of illegal feed traders and transportation cost to collect different feeds from different feed suppliers. Moreover, market and market related problems are another bottleneck problem recognized. Unsuitability of environment for fattening cattle was uniquely identified constraint to Dessie town.

Table 16. Constraints of cattle fattening practices in urban and peri-urban *kebeles* of Dessie

	Constraint	Peri-urban *kebeles* (n=149)						Urban *kebeles* (n = 41)					
		Constraint priority			TW	Index	Rank	Constraint priority			TW	Index	Rank
		1st	2nd	3rd				1st	2nd	3rd			
1	Recurrent drought and feed shortage	88	40	21	365	0.408	1	12	10	6	62	0.252	2
2	Feed price increment	33	37	42	215	0.240	2	22	20	15	121	0.492	1
3	Unsuitability of environment	25	31	29	166	0.186	3	4	6	2	26	0.106	3
4	Illegal brokers	3	17	23	66	0.074	4	0	2	2	6	0.024	5
5	Inaccessibility of cattle market	0	13	20	46	0.051	5	0	0	0	0	0.000	0
6	Credit based market	0	11	14	36	0.040	6	0	0	3	3	0.012	6
7	Capital problem & limited access to credit	0	0	0	0	0.000	0	3	3	5	20	0.081	4
8	Limited brewery grain access	0	0	0	0	0.000	0	0	0	2	2	0.008	7
9	Difficulty to compare with peri-urban and rural cattle fatteners	0	0	0	0	0.000	0	0	0	2	2	0.008	7
10	Lack of cooperation with in the association members	0	0	0	0	0.000	0	0	0	2	2	0.008	7
11	Lack of processed and mixed ration feed suppliers	0	0	0	0	0.000	0	0	0	1	1	0.004	11
12	Unpredictable cattle market	0	0	0	0	0.000	0	0	0	1	1	0.004	11

TW= Total Weight

Table 17. Constraints of cattle fattening practices in urban and peri-urban *kebeles* of Kombolcha

Constraint		Peri-urban fatteners (n = 81)						Urban fatteners (n = 66)					
		Constraint priority			TW	Index	Rank	Constraint priority			TW	Index	Rank
		1st	2nd	3rd				1st	2nd	3rd			
1	Recurrent drought and feed shortage	32	27	22	172	0.354	1	18	12	8	88	0.221	2
2	Feed price increment	20	16	22	114	0.235	2	32	25	17	163	0.410	1
3	Inadequate practical training support	12	14	12	76	0.156	4	0	3	3	9	0.023	6
4	Lose of farming land	11	18	15	84	0.173	3	0	0	0	0	0.000	0
5	Illegal brokers	6	6	10	40	0.082	5	0	4	3	11	0.028	5
6	Capital problem and limited access to credit	0	0	0	0	0.000	0	14	12	13	79	0.198	3
7	Credit based market	0	0	0	0	0.000	0	2	3	4	16	0.040	4
8	Difficulty to compare with rural fatteners	0	0	0	0	0.000	0	0	3	1	7	0.018	7
9	Inadequate veterinary services	0	0	0	0	0.000	0	0	2	2	6	0.015	8
10	Lack of processed and mixed ration feed suppliers	0	0	0	0	0.000	0	0	1	3	5	0.013	9
11	Shortage of land for expansion of fattening farm	0	0	0	0	0.000	0	0	1	2	4	0.010	10
12	Feed supply organization provide for specific group	0	0	0	0	0.000	0	0	0	3	3	0.008	11
13	Lack of cooperation with in the association member's	0	0	0	0	0.000	0	0	0	2	2	0.005	12
14	Road problem to enter the fattening farm	0	0	0	0	0.000	0	0	0	2	2	0.005	12
15	Unpredictable cattle market and seasonal price variation	0	0	0	0	0.000	0	0	0	2	2	0.005	12
16	Illegal and non-licensed cattle fatteners and traders influence	0	0	0	0	0.000	0	0	0	1	1	0.003	15

TW= Total Weight

On top of the above constraints, participants of focus group discussions and key informant interviews raised different challenges of the sector that need short and long-term solutions.

Limited professional considerations while farm establishment, limited activities performed to update the skill of expertise, absence of model animal scientists, drifting of animal science experts to other field of study, dominancy of traditional cattle fattening practices, limited modern fattening experience, absence of model governmental farms, absence of weight based cattle marketing, fast expansion rate in urban land use change, absence of market linkage, lack of governmental feed processing factories, absence of cattle fattening farm that has continuous capacity to supply up to the factory demand, lack of organized and computerized recording system at offices and individual farm level and presence of old meat processing house with old infrastructure were the challenges reported by experts from different organizations as summarized in Appendix 8.

Limited practical experiences of experts, absence of manual or guide in local language, limited readiness to purchased fattened cattle by meat factories rather gather emaciated cattle, lack of cattle handling equipment like nose ring and farming aids, absence of market information from government offices and medias, lack of well-designed cattle transportation path and other means of transportation, absence of reserved area for rest, feeding and watering while trekking cattle with minimum cost and limited institutional support regarding cattle ration formulation and feeding practices were the challenges confronted by cattle fatteners in both study areas (Appendix 8).

Conversely, both the study areas have diverse promising opportunities for cattle fattening practices. The presence of clustered cattle fattening approach in specified fattening zone that makes the monitoring and guidance activities more easy and creates better media for experience sharing. Advancement of flour factories, micro and small scale human food processers, milling houses, poultry farms, crop

production of the study areas, hay preparation experience of farmers, presence of brewery and sugar factories in and around the region could be used as a feed source for cattle fattening (Appendix 9).

Centrality of the study areas, increased demand for meat due to increased number of hotels and restaurants, emerging middle-class urban dwellers with higher income and more buying power, presence of more than ten cattle markets, presence of meat processing factory and large number of cattle population in and around the study areas will create favorable atmosphere for marketable animal and animal products production (Appendix 9).

Indigenous cattle fattening skill of cattle fatteners, idea sharing, copying and adoption tradition, governmental and private veterinary services, experience of cattle fatteners to use poultry litter, presence of abattoirs, positive opinion of cattle fattener's towards the sector, assigned experts and DAs for the technical support and extension services, federal as well as regional government emphasis for urban agriculture, establishment of cattle marketing proclamation at country level, motives and interest of the educated society to be part of the sector and availability of infrastructure such as road, electric access, mobile and water will create conducive situation for improvement as summarized in Appendix 9.

4.2. Feed Resources Identification, Distribution and Marketing Price

4.2.1. Identified feed resources

The identified feed resources used for fattening cattle in Dessie and Kombolcha areas are presented in Table 18. In both the study areas, 42 types of feed resources used for cattle fattening practices were identified. Thirty-nine feeds recognized were common for both areas. The rest three feeds were uniquely documented from Kombolcha town.

Based on their significance for fattening purpose, grass hay, poultry litter coming from different chicken houses, wheat bran, corn grain, wet and dried brewers grain, grass pea leftover, pea leftover, wheat leftover, bean leftover and formulated ration obtained via aid were grouped under *1st choice* category. Under *2nd choice*, green grass, standing maize, sugar can tops, maize stover, teff straw, barley hulls, oat hulls, grass pea hulls, wheat middling, oat grain, linseed cake, mixed feeds left over, barley leftover and molasses were grouped. Different weeds, corn head and cob, pea, bean and lentil hulls, barley straw, sorghum stover, *'Atela'* and *'Korefe'* leftover, university leftover food, flour and milling factory leftover, noug seed cake and lentils leftover were categorized under *3rd choice* feed resources. The classification of feeds was similar for both towns. This might be due to sharing of similar experiences.

As per the focus group discussions, cattle fatteners explained that feed resources grouped under *1st choice* were mandatory and must be incorporated in the ration because of their significance in nutritional values and potentials to fatten cattle within short period. When the market condition was not suitable to access first choice feed resources or when some of them cannot be obtained, cattle fatteners were use *2nd choice* feed resources in the second order. Most of the time they incorporate *3rd choice* feed resources to increase the bulkiness or quantity of their ration.

Table 18. Identified feed resources used for cattle fattening in Dessie and Kombolcha areas

Feed resources		Local name (Amharic)	Category	Based on Importance	Dessie n = 190						Via Importance	Kombolcha n = 147						source town
					Feed priority based on availability & importance			Weighted value	Index	Rank		Feed priority based on availability & importance			Weighted value	Index	Rank	
					1st	2nd	3rd					1st	2nd	3rd				
Green roughage																		
1	Green grass	*Yewober sar*	C	2nd	115	34	41	454	0.398	1	2nd	82	52	13	363	0.412	1	DK
2	Standing maize	*Ertebi yebekolo ageda*	C	2nd	54	75	31	343	0.301	2	2nd	40	57	25	259	0.294	2	DK
3	Sugar can tops	*Shenkora ageda chaf*	C	2nd	11	48	77	206	0.181	3	2nd	15	34	18	131	0.149	3	DK
4	Different weeds	*Wokiya*	C	3rd	10	33	41	137	0.120	4	3rd	10	4	91	129	0.146	4	DK
Dry roughage																		
5	Grass hay	*Derkoshi*	C	1st	111	44	35	456	0.539	1	1st	82	52	13	363	0.554	1	DK
6	Maize Stover	*Yebekolo ageda*	C	2nd	37	70	24	131	0.155	2	2nd	20	31	41	92	0.140	2	DK
7	Teff straw	*Yetef chid*	C	2nd	10	24	54	88	0.104	3	2nd	3	15	17	35	0.053	4	DK
8	Wheat straw	*Yesende chid*	C	3rd	0	8	30	46	0.054	4	3rd	0	8	9	17	0.026	7	DK
9	Barley hulls	*Yegebise geleba*	C	2nd	9	5	9	23	0.027	5	2nd	3	3	9	15	0.023	8	DK
10	Oat hulls	*Yaja geleba*	C	2nd	8	7	7	22	0.026	6	2nd	3	5	4	12	0.018	9	DK
11	Grass pea hulls	*Yeguwaya geleba*	C	2nd	3	9	8	20	0.024	7	2nd	10	4	11	25	0.038	5	DK
12	Corn head and cob	*Enbut bekolo*	C	3rd	3	4	5	12	0.014	8	3rd	0	3	4	7	0.011	13	DK
13	Pea hulls	*Yater geleba*	C	3rd	3	5	4	12	0.014	8	3rd	8	3	7	18	0.027	6	DK
14	Bean hulls	*Yebakela geleba*	C	3rd	3	4	3	10	0.012	10	3rd	3	3	6	12	0.018	9	DK
15	Barley straw	*Yegebise chid*	C	3rd	0	2	5	9	0.011	11	3rd	0	4	6	10	0.015	11	DK
16	Sorghum Stover	*Yezengada ageda*	C	3rd	0	6	3	9	0.011	11	3rd	12	13	16	41	0.062	3	DK
17	Lentil hulls	*Yemeser geleba*	C	3rd	3	2	3	8	0.009	13	3rd	3	3	4	10	0.015	11	DK
Non-conventional feed																		
18	Poultry litter (layers', pullets')	*Yedoro kus (enkulal tayi and keb)*	NC	1st	115	40	35	460	0.404	1	1st	64	65	18	340	0.385	1	DK
19	Poultry litter (day old chicks')	*Yedoro kus (yechachut)*	NC	1st	51	80	36	349	0.306	2	1st	63	44	30	307	0.348	2	DK
20	Poultry litter (Broilers')	*Yedoro kus (ye sega)*	NC	1st	21	56	64	239	0.210	3	1st	20	27	41	155	0.176	3	DK
21	'Atela' leftover	*Yetela atela*	NC	3rd	3	6	25	46	0.040	4	3rd	0	3	39	45	0.051	4	DK
22	'Korefe' leftover	*Yekeorefe atela*	NC	3rd	0	6	16	28	0.025	5	3rd	0	4	13	21	0.024	5	DK
23	University leftover food	*Yemegeb treferafi*	NC	3rd	0	2	14	18	0.016	6	3rd	0	4	6	14	0.016	6	DK

C = conventional; NC = non-conventional ;DK= Dessie and Kombolcha; Scientific name of each feed attached in Appendix 13.

Table 18. Identified feed resources used for cattle fattening in Dessie and Kombolcha areas (*continued*)

	Concentrate feed	Local name (Amharic)	Category	priority based on importance	Dessie n = 190						Kombolcha n = 147						Source town
					Feed priority based on availability & importance			Total weight	Index	Rank	importance	Feed priority based on availability & importance			Total weight	Index	Rank	
					1st	2nd	3rd					1st	2nd	3rd				
24	Wheat bran	*Yeferes furishika*	C	1st	36	14	16	152	0.133	1	1st	12	13	10	72	0.080	4	DK
25	Corn grain	*Bekole*	C	1st	31	22	13	150	0.132	2	1st	38	32	13	213	0.236	1	DK
26	Dried brewers grain	*Derek yebira chimaki*	NC	1st	28	23	7	137	0.120	3	1st	24	9	8	98	0.109	3	K
27	Wet brewers grain	*Ertib yebira chimaki*	NC	1st	20	22	5	109	0.096	4	1st	24	26	12	136	0.151	2	K
28	Wheat middling	*Furshikelo*	C	2nd	14	16	9	83	0.073	5	2nd	13	9	4	61	0.068	6	DK
29	Grass pea leftover	*Yeguwaya duka^*	C	1st	13	9	11	68	0.060	6	1st	13	9	6	63	0.070	5	DK
30	Oat grain	*Aja*	C	2nd	10	13	9	65	0.057	7	2nd	3	12	17	50	0.055	7	DK
31	Pea leftover	*Yater duka^*	C	1st	5	9	24	57	0.050	8	1st	7	0	2	16	0.018	14	DK
32	Wheat leftover	*Yesende duka^*	C	1st	0	8	30	46	0.040	9	1st	0	8	9	25	0.028	9	DK
33	Flour factory leftover	*Yeduket fabrica bitary*	C	3rd	9	5	9	46	0.040	9	3rd	3	3	9	24	0.027	11	DK
34	Linseed cake	*Fagulo ye telba*	C	2nd	5	7	14	43	0.038	11	2nd	0	2	0	4	0.004	18	DK
35	Different feed leftover	*Entiritaryi*	C	2nd	3	9	8	35	0.031	12	2nd	0	4	11	19	0.021	12	DK
36	Noug seed cake	*fagulo ye nuge*	C	3rd	4	5	8	30	0.026	13	3rd	0	1	0	2	0.002	19	DK
37	Milling leftover	*Yewoficho bet tiragi*	C	3rd	0	7	9	23	0.020	14	3rd	0	2	9	13	0.014	15	DK
38	Barley leftover	*Yegebise duka^*	C	2nd	3	5	4	23	0.020	14	2nd	4	3	7	25	0.028	9	DK
39	Bean leftover	*Yebakela duka^*	C	1st	3	4	5	22	0.019	16	1st	0	3	4	10	0.011	17	DK
40	Lentils leftover	*Yemeser duka^*	C	3rd	3	4	3	20	0.018	17	3rd	0	3	6	12	0.013	16	DK
41	Formulated ration	*Yetemetatene meno*	C	1st	3	2	3	16	0.014	18	1st	3	3	4	19	0.021	12	DK
42	Molasses	-	C	2nd	0	6	3	15	0.013	19	2nd	3	5	16	40	0.044	8	AR/K

Duka^= leftover and occasional surplus or damaged grain during processing; C = conventional; NC = non-conventional; DK= Dessie and Kombolcha; K= Kombolcha; AR/K= Afar Region /Kombolcha

Scientific name of each feed attached in Appendix 13.

4.2.2. Potential feed suppliers

Flour factories, poultry farms, milling houses, private micro and small food processors, local brewery houses, farmers, brewery factory, oil seed processers and oilseed byproduct supplier, governmental offices, feed traders, sugar factory, university and government aids were the identified feed sources or suppliers in Dessie and Kombolcha areas. All sources were common in both the study areas except brewery and sugar factory byproducts, which come from the nearest Afar Region via feed traders for Kombolcha town. The production capacities of the indicated feed suppliers in both areas are presented in Appendix 10. The data indicated that due to limitation of inputs, particularly the identified flour factories in Dessie and Kombolcha areas, perform respectively, at 40.9% and 39.9% of their overall production capacity. This shows that factories were operating below capacity. Since wheat flour factories are the major feed suppliers, especially for urban producers in both areas, they should be encouraged to operate with their full potential and to be part of the solution to alleviate feed resource deficiencies of the sector.

As showed in Appendix 10, flour factories have different production efficiency to produce animal feeds and pure flour for human. Their efficiency varies from 19% to 27%. This shows that factories produce different proportion of wheat bran, wheat middling, leftover feed and pure flour while processing. Such efficiency difference has significant impact on the chemical composition of wheat bran and wheat middling used for feeding cattle. This is also the major reason for the reporting of dissimilar chemical composition and nutritive value of wheat bran and wheat middling by different authors.

4.2.3. Marketing price of feed resources

Marketing prices of identified feed resources in Dessie and Kombolcha areas are presented in Appendix 11. The data revealed that similar price range for both the study areas shows. This might be due to the proximity of the study areas. As per focus

group discussions, the demand for animal feed is showing increasing trend and similarly feed prices are increasing from time to time in both the study areas. As a result, taking safety measures is needed to improve the feed marketing systems for productive cattle fattening practices.

4.2.4. Availability and seasonal distribution of feed resources

Months of availability and distribution of each identified feed resources in Dessie and Kombolcha areas are presented in Appendix 12. As a whole, in both the study areas, from September to December there was a relatively abundant feed resource with less prices. Conversely, feed scarcity and prices severely increased towards January to June (Figure 2). Availability and distribution of feeds that were common for both areas were similar. This was might be due to the proximity of study areas.

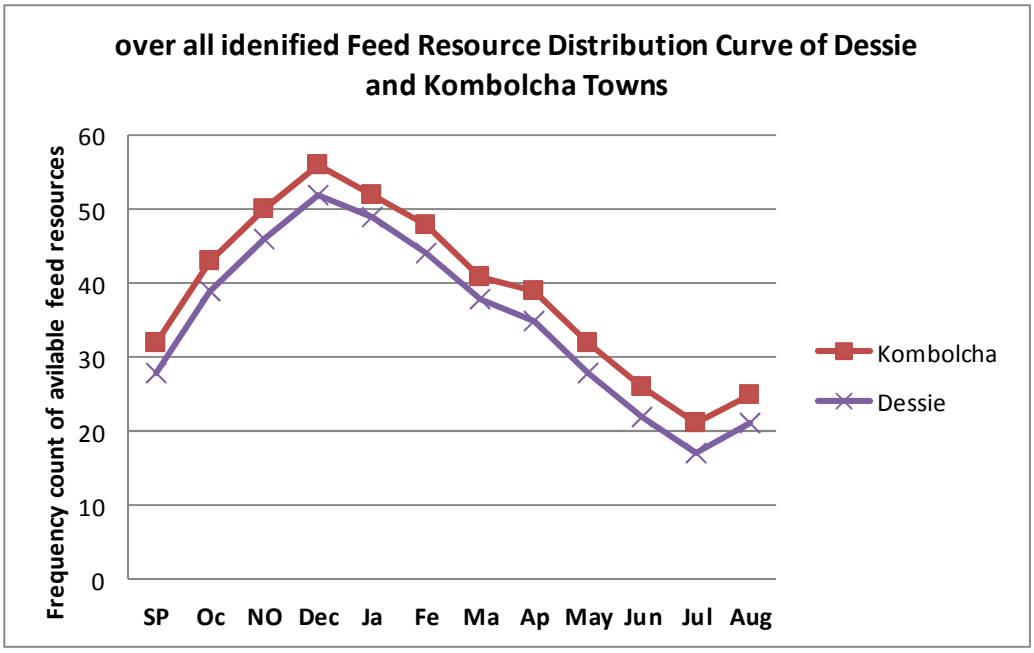

Figure 2. Identified feed resources distribution curve in Dessie and Kombolcha areas

Majority of the identified feed resources, except corn grain, poultry litter and grass pea leftover (*Yeguwaya duka*) in both the study areas, and brewery grain uniquely in

Kombolcha town showed great variability. This was might be due to variation in seasonal agronomic practices, transportation difficulties to collect from different feed suppliers, disparity in demand and supply, recurrent drought and illegal feed traders. Grass pea leftover (*Yeguwaya duka*) was relatively available. This was because small-scale food processors mostly use grass pea grain for the preparation of '*Shuro*' with a reasonable cost than pea and bean. Uniquely corn grain was available throughout the year in the market with less cost.

The identified roughage and concentrate feeds distribution show similar trend as indicated in Figure 3.

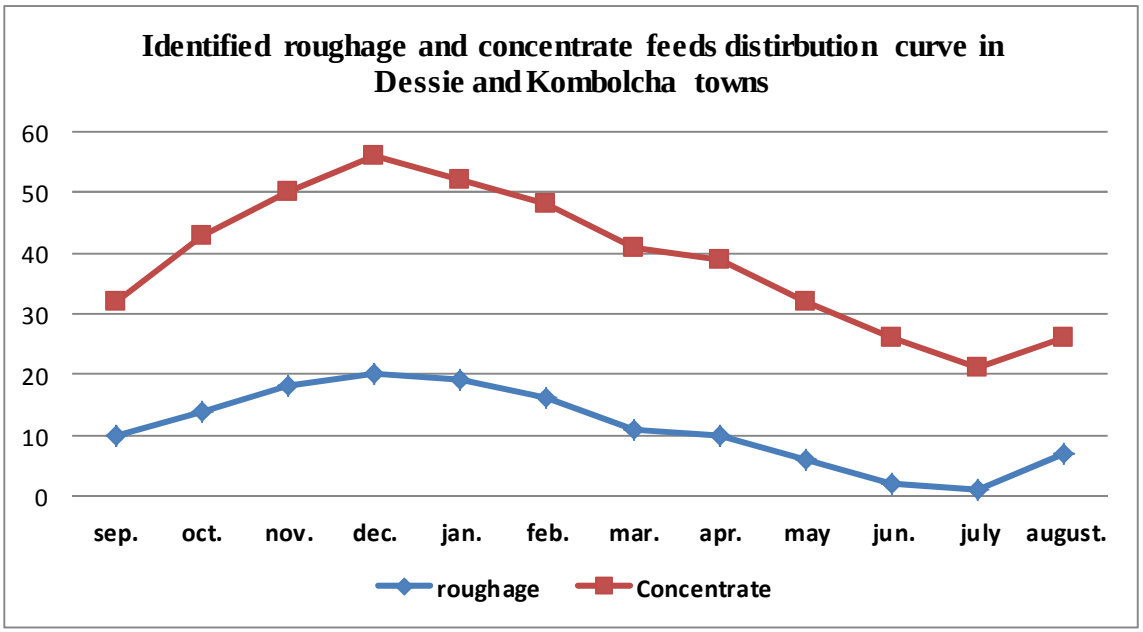

Figure 3: Identified roughage and concentrate feeds distribution curve in Dessie and Kombolcha towns.

4.3. Feeding Trial

4.3.1. Chemical composition of experimental feed ingredients

Experimental feed ingredients used to formulate treatment feeds and their chemical compositions are presented in Table 19. The DM % of all experimental ingredients used was above 90% except that of the dried breweries grain (89.69%). Crude protein content of dried breweries grain was the highest, while, it was moderate for poultry litter and wheat bran, and lowest for crushed corn grain, grass pea leftover and native grass hay. The grass hay basal diet had higher proportions of NDF, ADF and ADL while it had lower proportion of CP.

Table 19. Chemical composition of experimental feed ingredients

Feed ingredients	**Chemical composition**							
	DM (%)	**Ash**	**CP**	**NDF**	**ADF**	**ADL**	HC	C
		% DM						
Natural grass hay (NGH)	95.29	8.59	4.79	58.29	42.41	6.23	15.88	36.18
Dried brewery grain (DBG)	89.69	4.45	31.39	56.21	23.79	8.17	32.42	15.62
Poultry litter (layer) (PL)	95.86	12.56	23.33	27.19	22.7	7.65	4.49	15.05
Grass pea leftover (GPLO)	92.00	9.35	7.64	62.5	45.47	8.51	17.03	36.96
Processed corn grain (PCG)	93.70	1.61	7.59	16.16	4.77	3.41	11.39	1.36
Wheat bran (WB)	90.43	5.7	16.73	43.12	14.81	3.82	28.31	10.99

ADF=Acid detergent fiber; ADL=Acid detergent lignin; CP=Crude protein; DM=Dry matter; NDF=Neutral detergent fiber, HC = Hemicellulose, C = Cellulose

4.3.2. Chemical composition and nutrient value of experimental treatments

The chemical composition of the concentrate feeds and natural grass hay offered and refused are presented in Table 20. The CP content of the concentrate feeds offered was higher than that of the natural grass hay. When the chemical compositions of feed refusals were considered, the Ash, CP, NDF, ADF and ADL contents of the refusals of

the grass hay was similar to the contents of grass hay offered, whereas, Ash, CP, NDF, ADF and ADL of concentrate feeds shows slight numerical difference to the corresponding contents of feeds offered. This might be due to the inclusion of debris and grass hay in the refusals while feeding experimental cattle. Generally, the results indicated that experimental cattle used the concentrate feeds and grass hay with minimal selection as the offered feed was mixed thoroughly.

Table 20. Chemical composition and nutrient value of experimental treatments on DM basis

Treatments	DM (%)	Chemical composition				
		Ash	CP	NDF	ADF	ADL
		% DM				
Offered						
Grass hay	95.29	8.59	4.79	58.29	42.41	6.23
T1(WB+ PCG+ GPLO)	92.57	7.65	14. 69	33.68	14.53	4.30
T2 (WB+ PCG+ PL)	92.86	6.57	14.50	33.06	14.38	4.41
T3 (WB+ PCG + DBG)	93.06	4.54	14.59	32.75	13.86	4.30
Refused						
Grass hay	95.29	8.59	4.79	58.29	42.41	6.23
T1(WB+ PCG+ GPLO)	92.16	8.42	14.32	34.14	14.19	4.16
T2 (WB+ PCG + PL)	93.07	7.23	14.93	33.52	14.96	4.37
T3 (WB+ PCG + DBG)	92.69	5.02	14.33	33.63	13.72	4.30

Nutrients	**Grass hay**	**T1**	**T2**	**T3**
DCP (g/kg DM)	41.02	132.90	131.20	132.10
IVDMD (%)	48.68	86.84	88.51	89.18
ME (MJ/kg DM)	7.30	13.0	13.2	13.3
P (%)	0.13	1.13	1.03	0.93
Ca (%)	0.40	0.143	0.143	0.133

DM=Dry Matter; CP=Crude Protein; NDF=Neutral Detergent Fiber; ADF=Acid Detergent Fiber; ADL=Acid Detergent Lignin; DCP=Digestible Crude Protein; IVDMD=*In vitro* Dry Matter Digestibility; ME= Metabolisable Energy; P=Phosphorous; Ca=Calcium; WB= wheat bran, PCG = processed corn grain, GPLO = grass pea left over, PL= poultry litter, DBG = dried brewery grain

4.3.3. Feed and nutrient intake

The average daily dry matter intake from the treatment groups is given in Table 21. Dry matter intake (DMI), crude protein intake (CPI), neutral detergent fiber intake (NDFI), acid detergent fiber intake (ADFI) and acid detergent lignin (ADLI) were not significantly (P>0.05) varied among treatments.

Table 21. Average daily dry matter (kg)and nutrients intake (kg DM/day) of Wollo Oxen fed grass hay and concentrate supplements

Intake (kg)	Treatments (Mean±SE)			**Overall mean**	**P- value**
	T1	**T2**	**T3**		
Natural grass hay (NGH), DM	4.18±0.2	4.21±0.1	4.13±0.1	4.17±0.1	0.763
Concentrate feed (CF), DM	6.22±0.3	6.23±0.2	6.34±0.2	6.26±0.1	0.512
Total DMI	**10.40**±0.5	**10.44±0.3**	**10.47**±0.4	**10.44**±0.2	**0.927**
Nutrients intake					
CP from NGH	0.20±0.01	0.20±0.01	0.20±0.01	0.20±0.01	0.758
CP from CF	0.91±0.04	0.90±0.02	0.93±0.03	0.92±0.02	0.483
Total CPI	**1.11**±0.05	**1.10**±0.02	**1.13**±0.03	**1.12**±0.02	**0.905**
NDF from NGH	2.44±0.12	2.45±0.06	2.41±0.08	2.43±0.19	0.759
NDF from CF	2.09±0.10	2.06±0.06	2.08±0.07	2.08±0.04	0.735
Total NDFI	**4.53**±0.22	**4.51**±0.12	**4.49**±0.15	**4.51**±0.09	**0.861**
ADF from NGH	1.77±0.09	1.79±0.04	1.75±0.06	1.77±0.03	0.742
ADF from CF	0.90±0.04	0.90±0.02	0.88±0.03	0.89±0.02	0.736
Total ADFI	**2.68**±0.13	**2.68**±0.07	**2.65**±0.09	**2.67**±0.05	**0.777**
ADL from NGH	0.26±0.01	0.26±0.01	0.26±0.01	0.26±0.01	0.944
ADL from CF	0.27±0.01	0.27±0.01	0.27±0.01	0.27±0.01	0.608
Total ADLI	**0.53**±0.02	**0.54**±0.01	**0.53**±0.01	**0.53**±0.01	**0.656**

DM=Dry Matter; DMI=Dry Matter Intake; CPI=Crude Protein Intake; NDFI=Neutral Detergent Fiber Intake; ADFI=Acid Detergent Fiber Intake; ADLI=Acid Detergent Lignin Intake

4.3.4. Body weight gain

Effects of supplementation of different concentrate feeds on the final body weight (FBW), body weight gain (BWG), average daily gain (ADG), feed conversion efficiency (FCE) and feed conversion ratio (FCR) of Wollo oxen measured using fixed ground scale (FGS) and body condition score (BCS) are presented in Table 22**.**

Table 22. Effects of supplementation of different concentrate feeds on body weight gain and body condition score (BCS) of Wollo oxen

Variable	Treatments (Mean ± SE)			Overall mean	P-value
	T1	**T2**	**T3**		
	Body weight gain via Fixed Ground Scale (FGS, kg)				
IBW (kg)	304.8 ±13.2	305.0 ± 12.0	305.2 ± 13.4	305.0 ±6.9	0.967
FBW (kg)	358.6 ±15.5 ^{b}	376.0 ± 9.2 ^{a}	362.2 ± 11.9 ^{b}	365.6±6.9	0.024
$_{Overall}$BWG (kg)	53.8±3.6 ^{b}	71.0±3.3 ^{a}	57.0±3.6 ^{b}	60.6 ±2.7	0.018
ADG (kg)	0.60±0.04^{b}	0.79 ±0.04 ^{a}	0.63±0.04 ^{b}	0.67±0.03	0.018
FCE	0.058±0.003^{b}	0.076±0.005^{a}	0.061±0.005^{b}	0.065±0.003	0.009
FCR	17.5±0.81^{a}	13.4±0.98^{b}	16.8±1.34^{a}	15.9±0.74	0.012
	Body Condition Score (BCS, 1-9)				
IBCS	3.6 ± 0.4	3.6 ±0.4	3.6±0.4	3.6±0.20	0.999
FBCS	6.6±0.40	7.2±0.37	6.6±0.24	6.8±0.20	0.091
BCSC	3.0±0.00	3.6±0.24	3.0±0.31	3.2±0.14	0.091

a, b means with different superscripts in the same row differ significantly (P<0.05); IBW= initial body weight; FBW = final body weight; BWG = body weight gain; ADG = average daily gain; FCE = feed conversion efficiency; FCR = Feed conversion ratio; IBCS = Initial body condition score; FBCS = Final body condition score; BCSC = Body condition score change.

No significant difference (P > 0.05) was noted in the IBW between dietary treatments. FBW, BWG, ADG, FCE and FCR were significantly higher (P <0.05) for Wollo oxen in T2 as compared to T1 and T3. The current result revealed none significant difference (P > 0.05) for body condition score of the animals. However, the score difference support the result obtained through fixed ground scale. Moreover, as tabulated in Table 23 there was

a positive relationship between body condition score and weight gain obtained through fixed ground scale.

The pattern of body weight change and body condition score (BCS) of Wollo oxen subjected to different concentrate feeds is presented in Figure 4 and 5. Live weight change and BCS of Wollo oxen over the experimental days showed an increasing trand for the experimental animals in all treatments. The oxen gained weight with advancing feeding days. The better body weight increments were observed in T2 followed by T3 and T1, which might be due to the difference in protein feed sources.

Table 23. Pearson correlation (r) on effects of supplementation of different concentrate feeds on body weight gain and body condition score (BCS) of Wollo oxen

		BWG (Kg) per 15 days interval								BCS per 15 days interval (1-9 scale)					
		Initial	15 days	30 days	45 days	60 days	75 days	Final weight	Initial BCS	15 days	30 days	45 days	60 days	75 days	90 days
BWG (Kg) per 15 days interval	Initial	1													
	15 days	0.941**	1												
	30 days	0.936**	0.975**	1											
	45 days	0.932**	0.964**	0.981**	1										
	60 days	0.932**	0.963**	0.964**	0.985**	1									
	75 days	0.908**	0.944**	0.962**	0.983**	0.980**	1								
	90 days	0.923**	0.950**	0.978**	0.980**	0.970**	0.992**	1							
	Initial BCS	0.870**	0.867**	0.863**	0.845**	0.835**	0.796**	0.810**	1						
BCS per 15 days interval (1-9 scale)	15 days	0.840**	0.794**	0.867**	0.809**	0.767**	0.786**	0.835**	0.860**	1					
	30 days	0.885**	0.827**	0.836**	0.791**	0.776**	0.773**	0.807**	0.907**	0.919**	1				
	45 days	0.819**	0.768**	0.765**	0.717**	0.708**	0.722**	0.762**	0.776**	0.798**	0.887**	1			
	60 days	0.782**	0.763**	0.774**	0.737**	0.707**	0.743**	0.764**	0.795**	0.860**	0.863**	0.878**	1		
	75 days	0.879**	0.881**	0.883**	0.873**	0.860**	0.886**	0.905**	0.820**	0.839**	0.875**	0.889**	0.856**	1	
	Final BCS	0.705**	0.754**	0.780**	0.763**	0.766**	0.821**	0.822**	0.757**	0.777**	0.793**	0.830**	0.850**	0.856**	1

**. Correlation is significant at the 0.01 level; N =15; Body condition score (BCS); Body weight gain (BWG) measured via fixed ground scale

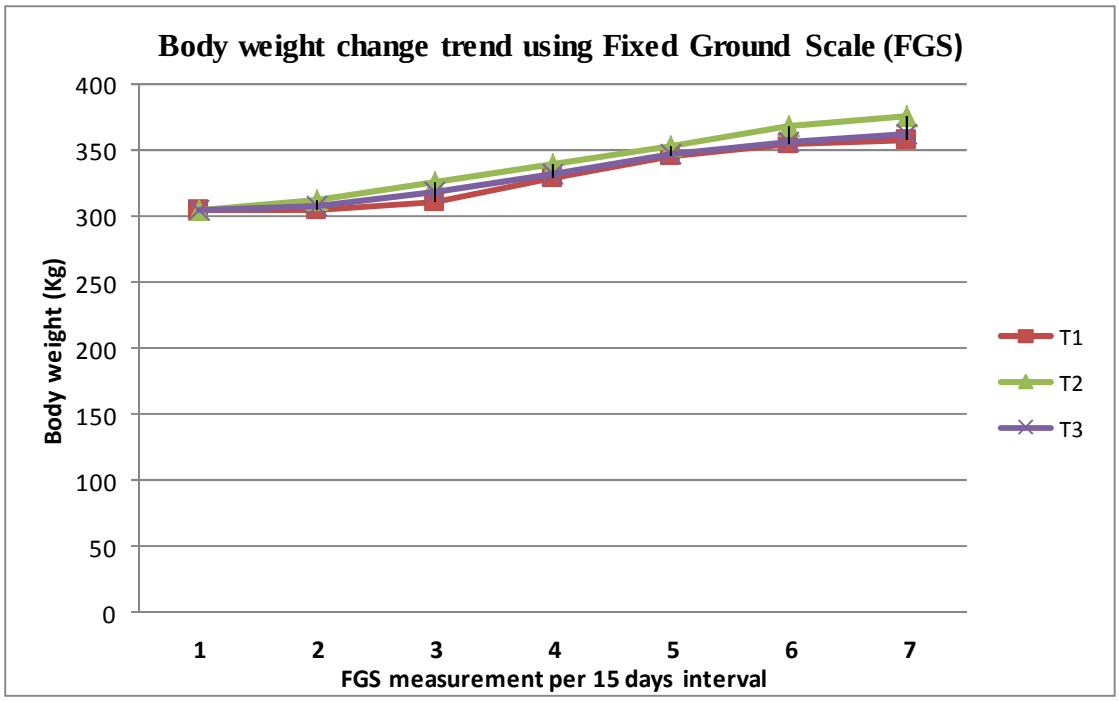

Figure 4: Body weight change pattern of Wollo oxen supplemented with different concentrates

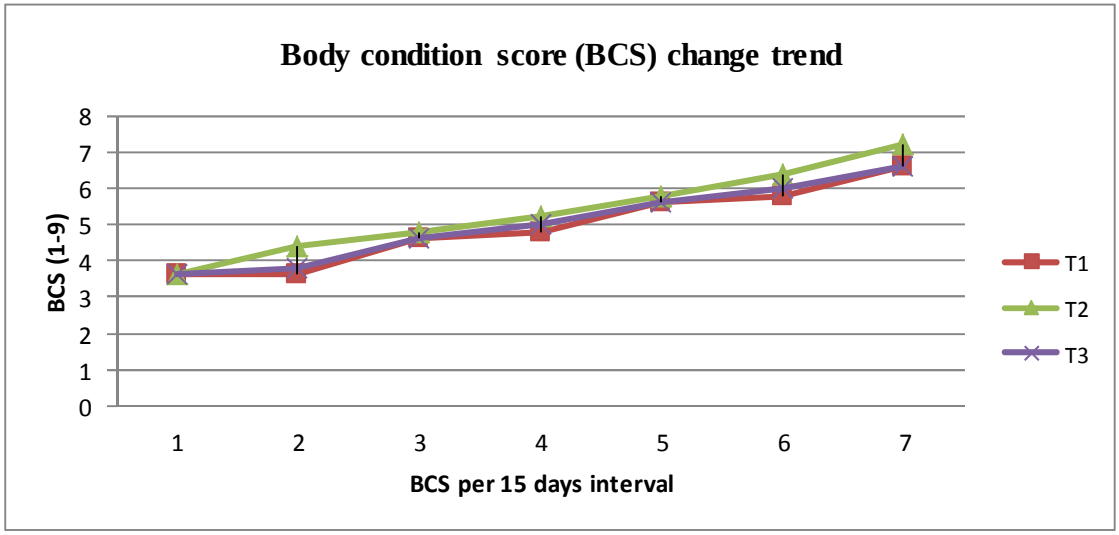

Figure 5: Body condition change pattern of Wollo oxen supplemented with different concentrates

4.3.5. Carcass characteristics

Effects of supplementation with different concentrates on dressing percentage of Wollo oxen are presented in Table 24. Significant difference ($P<0.05$) were observed in the slaughter weight (SW), empty body weight (EBW) and hot carcass weight (HCW) among Wollo oxen supplemented with poultry litter (T2), grass pea leftover (T1) and DBG (T3). Accordingly, oxen in T2 recorded higher values in the indicated parameters. The dressing percentage on slaughter body weight was significantly higher ($P<0.001$) for oxen supplemented with poultry litter (T2). This indicates that different protein sources within the concentrate might have variable impact on the indicated parameter. No significant difference in dressing percentage of oxen on empty weight basis among treatments ($P>0.05$). However, numerically, oxen supplemented with poultry litter (T2) had higher of such a dressing percentage followed by grass pea leftover (T1) and DBG (T3).

Table 24. Effects of supplementation with different concentrates on dressing percentage of Wollo oxen

Parameter	Treatment (Mean ±SE)			Overall	P - value
	T1	T2	T3		
SW (kg)	347.8±15.2[b]	369.0±7.9[a]	353.2± 10.4[b]	356.7± 6.6	0.030
EBW (kg)	296.6±14.3[b]	328.0±7.7[a]	307.3±10.5[b]	310.6± 7.0	0.002
HCW (kg)	192.8±9.8[b]	216.2±6.1[a]	198.4±7.4[b]	202.4± 5.1	0.002
DP (%)					
SWB	55.37±0.4[b]	58.55±0.5[a]	56.09±0.4[b]	56.67±0.4	0.001
EWB	64.95±0.3	65.9±0.3	64.5±0.3	65.1±0.3	0.064

SW= Slaughter weight; EBW= Empty body weight; HCW= Hot carcass weight; DP= Dressing percentage; SWB = Slaughter weight basis; EWB = Empty weight basis

Non-carcass components of Wollo oxen supplemented with different concentrates sources are presented in Table 25. No significant difference (P>0.05) was observed in the weight of total non-carcass edible components (TNCEC) and total non-edible offal components (TNEOC) among treatment diets except in gut fill. There was significant difference (P<0.001) in gut fill between treatments. The value was higher for T1 followed by T3 and T2. This might be due to grass pea left over in T1 hinders digestion due to its anti-nutritional content.

Table 25. Effects of supplementation with different concentrates on non-carcass components of Wollo oxen

Variable	Treatment (Mean ±SE)			Over all mean	P-value
	T1	T2	T3		
Total non-carcass edible offal components (kg)	**38.3±1.6**	**40.5±1.7**	**40.5±1.0**	**39.8±0.9**	**0.372**
Heart, liver, kidney, tongue, root tail and fat	16.4 ±0.5	16.6±0.8	16.5 ±0.5	16.5 ±0.3	0.971
Empty gut	21.9±1.4	23.9±1.3	24.0±0.4	23.3±0.7	0.183
Total non-edible components (kg)	**116.7±4.3**	**111.8 ±0.8**	**114.4±2.1**	**114.3±1.6**	**0.326**
Hide	27.1±1.4	29.3 ±0.4	28.2±0.5	28.2±0.6	0.123
Feet	7.4±0.4	8.0±0.2	7.9±0.3	7.8±0.2	0.330
Head without tongue	16.6±0.9	17.6±0.4	17.3±0.8	17.2±0.4	0.603
Lungs with trachea, spleen, testicles, penis, urinary and gall bladder, intestine	8.3±0.2	9.4±0.5	8.3±0.4	8.6±0.3	0.083
Blood	6.3±0.7	6.5±0.2	6.8±0.3	6.5±0.2	0.536
Gut fill	51.1±0.9[a]	41.0 ±0.7[C]	46.0±0.6[b]	46.0±1.3	0.001

4.3.6. Partial budget analysis

The result of partial budget analysis is shown in Table 26. The result of partial budget analysis revealed that T2 (supplemented with poultry litter) resulted in higher profit margin than T1 and T3 (supplemented with grass pea leftover and DBG, respectively). Oxen fed T1 and T3 had the lowest and medium net return, respectively. This indicates that feeding oxen with different quality proteins feed has an impact on weight gain, selling price and net return.

Table 26. Partial budget analysis in the 90 days of the feeding trial experiment

Ingredients	**Total price required for the whole fattening period (Birr)**			
	Price/kg	**T1**	**T2**	**T3**
Total feed cost		32266.76	28158.38	30113.25
Oxen purchase cost	5776.7 Birr/ox	28883.5	28883.5	28883.5
Cost for trek	100 Birr/ox	500.0	500.0	500.0
Service charge while oxen purchase	7 Birr/ox	35.0	35.0	35.0
Two attendant labor cost	1500 Birr/month/person	3000.0	3000.0	3000.0
Total expense	Birr	**64685.3**	**60576.9**	**62531.8**
Cost per kg live weight gain	Birr	180.4	161.1	172.6
Live estimated price / ox	Birr	13300.0	14900.0	13700.0
Number of oxen/treatment	No	5	5	5
Total income	Birr	**66500**	**74500**	**68500**
Net return	Birr/treatment	**1814.7**	**13923.1**	**5968.2**
Net return	Birr/head	**362.94**	**2784.62**	**1193.64**

The partial budget analysis showed that in cattle fattening practices feed cost and oxen purchasing cost take the largest share when compare to other expenses.

5. DISCUSSION

5.1. Survey of Cattle Fattening Practices

The dominancy of male-headed households in this study due to the fact that traditional cattle fattening practices are male dominated activities and the practice is labor intensive, making females to keep away from practicing and participating in it. Even, they focused on other job opportunities. Such circumstance creates gender disparity on the sector and limits improvement options coming from females and decrease job opportunity for them. In line with the current study Getachew *et al*. (2017) stated majority of the households (97.5%) participated in cattle fattening are male. Similarly, Zewdie (2010) reported that less number of female-headed households involved in livestock keeping due to cultural issues and/or for economic reasons.

The data indicated that in both the current study areas, the middle age category of the community involved in the cattle fattening. Particularly, in both urban areas, cattle fattening practices were handled and performed by young generation than in peri-urban *kebeles*. Such circumstance will create an opportunity to improve the sector by involving working and productive group of the community. Moreover, it creates job opportunities for youths at study town level. The minimum and maximum age of the respondents observed in this study was almost in same range of 21 and 69 years, respectively, as reported by Getachew *et al*. (2017). Likewise, the current result support Shitahun (2009) finding who reported the age groups of 15 to 64 years. These age groups are productive age and responsible for heavier agricultural activities.

The data illustrated the literacy status and level of education of the HH heads participated in cattle fattening practices in both study areas, particularly, the peri-urban cattle fatteners might not be enough and would have negative impact in the introduction of modern cattle fattening technology as well as production activities. The present result concerning education status of cattle fatteners agrees with Abdi *et al*. (2013) who reported mostly cattle fatteners education level is low and level of education is mainly associated with the

participation as well as the productivity of households in cattle fattening practices and application of technology in the sector. Similarly, this finding agrees with Bezahegn (2014) who described that farmers who are able to read and understand as compared to non-learned ones can provide better opportunity to implement improved agricultural practices, better management and effective utilization of resources. In the same way, Ofukou *et al*. (2009) stated that farmers with high education levels adopt usually new technologies more rapidly than those with lower levels education.

The current family size outcome was similar with Yitaye *et al.* (2007) who reported an average family size of 5.6 people ranging, 2-10 persons per household for urban area. Hence, the main source of labor to the farming community is the family and having many family members seems to be an asset and a security in times of retirement. Correspondingly, the overall average family size observed in the current study was almost similar with 5.42 members per household reported by Abdi *et al*. (2013). The current result supports Bezahegne (2014) who stated the family size as one of the most important characteristics of the household that determine participation of the group in different economic activities. Typically, having larger number of members with in a family gives better opportunity to use labor than having fewer members per family.

The data revealed that cattle fattening stood as a primary source of livelihood in Kombolcha town. In contrast, in Dessie town it was considered as a byproduct of mixed crop livestock production system. This was due to the influence of urban agriculture. In both areas, urban dwellers have become part of the sector by organizing themselves in different associations or enterprises depending on the number of members bounded, locally called '*Mahiber*', viz., individual/private enterprise (*Yegel*), *joint* enterprises *(Shirikina)* and cooperative enterprises *(Mahiber).* An individual or private enterprise (*Yegel*) is enterprise that has only one member. A joint enterprise (*Shirikina*) is association or enterprise that comprises two to nine members. Cooperative enterprise (*Mahiber*) is enterprise or association that comprises the largest number of participants mostly ten or more. Such condition will create additional routes to run the sector by the organized segment of the community. The current finding related to income sources is in

agreement with the work of Takele and Habtamu (2009) who reported smallholder cattle fattening under urban agriculture is emerging as an important source of income and practiced for a variety of reasons, from commercial reasons to food self-sufficiency and food security. In line with this, Amhara Regional government, in its recent comprehensive plan has given particular attention to the promotion of fattening development and its implementation has begun (Aklilu, 2004).

Cattle fattening experiences variation observed in the current study is due to the fact that peri-urban cattle fatteners commonly practice cattle fattening as a byproduct of mixed crop-livestock production system, whereas, urban cattle fatteners started the activity in recent years. Such fattening experience is used as a base line for accustomed model practices and gives clue for further improvement possibilities. The observed cattle fattening experience of cattle fatteners in this study agrees with Genet *et al*. (2017) who reported feedlot operators as having experience of about 1 to 10 years in the business. Similarly Bezahegn (2014) conveyed that more than 75% of interviewed farmers had long experience of cattle fattening greater than five years.

Based on the maximum number of cattle used for fattening, the cattle fattening practices in both the current study areas are categorized under small-scale cattle fattening category and no cattle fatteners are grouped under commercial feedlots. The observed few numbers of cattle fattened per year per person in this study disagrees with Genet *et al.* (2017) who reported that 234 cattle were fattened per year under small feedlot. Conversely, the current finding agree with Adugna (2008) who reported that commercial feedlots feed relatively large number of animals at a time and keep from as few as 20-50 animals to as many as 5000 heads of cattle at a time.

The result revealed that almost all cattle fattening activities in Dessie and Kombolcha areas were left to males. This was due to the fact that they believed cattle fattening requires, by its nature, a strong labor that makes it difficult for female regardless of the nature of cattle. Such labor allocation will create inefficient use of family labor for cattle fattening practices. The current output with reference to family labor was in agree with

Azage (2004) who reported women as being critically involved in removing and managing manure, which is made into cakes and used or sold as fuel. Again, the current outcome supports the findings of Zewdie (2010) in which larger proportion of females involved in barn cleaning at Debre Birhan. Similar to this finding Azage (2004) reported women as being usually responsible for feeding large animals, but they receive assistance of men, female children and/or other relatives. In contrast, the current finding disagrees with Shitahun (2009) and Yidnekachew *et al*. (2016) who reported that all the family members (both sexes) participate while managing the fattening cattle and livestock keeping at the household level.

The data reveled that urban cattle fatteners has no livestock. This might be due to the way of living and limitation of land. Livestock possession of peri-urban cattle fatteners is used as a main and additional source for replacement stock. This considered as an opportunity cost for urban cattle fatteners. The current result regarding livestock possession and purposes were in line with Muluwork (2014) who reported that because of reclassification program in Kombolcha town, many farmers are forced to abandon their farmlands as a result of which they hold less number of livestock. Moreover, the currently observed finding was supported by Tegaye *et al*. (2016) who indicated that livestock in Ethiopia provide power for farming, generate income generating and are means of investment, generate consumable or saleable outputs (milk and meat). Moreover, in mixed farming system of the highlands and mid-altitudes of Ethiopia where crop production is important; cattle are the most important livestock species for cultivation, threshing and manure source.

Different cattle fattening reasons observed in the current finding agree with Tegaye *et al*. (2016) who concluded that cattle fattening is one of the important strategy to improve income of the farming community and nation as a whole. Similarly, Takele and Habtamu (2009) reported fattening cattle as being one of the few agricultural commodities in Ethiopia from which the country earn foreign currency through exporting both live animals and processed commodity.

Source of fattening cattle and capital reported in this study was similar to Fikru (2015) who reported that fatteners obtained fattening cattle from farm-gate (62.2%), primary market (33.3%) and secondary market (4.5%). Similarly, Tesfaye *et al*. (2007) reported that sources of fattening cattle in Harshin *Woreda* are culled oxen due to old age or being unproductive (51%) and immediate purchase from market (49%). Regarding source of capital (finance) for cattle fattening practices, the current result was similar with Ahmed *et al*. (2010) who reported that about 90.2% cattle fatteners used their own capital and 2.3%, 4.2% and 3.3% took loan from bank, non-governmental organization and lending for individuals, respectively.

The result indicated that byproduct based cattle fattening system was dominantly being carried out in Kombolcha in than Dessie town. This is because, the town has recorded fast expansion in urbanization by changing the peripheral peri-urban agricultural farmlands into construction sites for urbanization. Due to this fact, urban cattle fattening is being practiced dominantly to secure livelihoods for the displaced farmers. Such situation will create conducive setting to scale up the small scale fattening practices.

Moreover, Kombolcha town is environmentally more suitable for cattle fattening than Dessie town. Its annual maximum and minimum temperature is 28.1^{0}C and 12.9 ^{0}C, respectively (Kombolcha Meteorology Station, 2016) which is comparable to thermal comfort zone (TCZ) for fattening cattle. Besides, Kombolcha town is located in a range of altitudes between 1500 and 1840 meter above sea level. Relatively, Dessie town is cooler and it incurs feed cost to run cattle fattening practices. Its elevation ranges between 2470 to 2550 meters. Its annual maximum and minimum temperature is 23.7 ^{0}C and 9^{0}C, respectively (Kombolcha Meteorology Station, 2016). Comparable to the current result Gaughan *et al*. (1999) who reported 15°C to 28°C temperature range provide maximum comfort or thermal comfort zone (TCZ) for fattening cattle. This study was in line with Muluwork (2014) who reported shortage of land due to population pressure pushing many farmers to either intensify the cropping system or diversify other integrated activities. The strategy applied for urban expansion in Kombolcha town is the reclassification of the six peri-urban rural *kebeles* to be count as urban settings. Urban

expansion in Kombolcha town is largely exercising expansion of territorial boundary towards the peripheral peri-urban *kebeles* and agricultural farmlands. The extent of urban land use change ranges with the radius of 5-10 Km distance from the center of the town in all directions.

The identified cattle fattening systems in the current study was in line with the three types of cattle fattening systems in Ethiopia categorized as traditional, byproduct based and the Hararghe highland type according to the Fourth Livestock Development Project MOA (1996a), cited by Belete *et al*. (2010). Moreover, the current study was introduced additional cattle fattening system, which combine the characteristics of traditional and byproduct based cattle fattening systems.

Mode of cattle fattening practices and oxen management reported in the current finding strongly agree with Harko (2015) who explained in traditional system, farmers usually sell oxen after the plowing season. The finding partially disagrees with Zewide (2010); Fikru (2015) and Andualem (2016) who stated farmers keep cattle mainly to satisfy drought power requirement.

Fattening cattle selection criteria detected in the current finding strongly agrees with Ahmed *et al*. (2010); Shewangzaw *et al*. (2014) and Genet *et al.* (2017) who described sex, age, frame size, physical appearance, castration condition, breed type, price and color as selection criteria for fattening cattle. In addition, Aklilu (2004) and Takele and Habtamu (2009) reported fatteners in Wolaita and North part of Ethiopia select fattening cattle based on tall height, good body condition, big and stand high hump, sex and color. More than eighteen different phenotypic characteristics or traits are used for cattle selection (Abdi *et al*., 2013).

Cattle sex preference for cattle fattening recognized in this finding strongly agrees with Shewangzaw *et al*. (2014) who reported that majority of cattle fatteners (86.52%) used male cattle for fattening, whereas 13.48% used both male and female. None of the cattle fatteners fattens female cattle. Similarly, Fikru (2015) reported that cattle fatteners prefer

to fatten steer (52%) and bull (48%) unless exceptional case related to disease in their reproductive organ and udder occur, cattle fatteners do not use female cattle for fattening purposes.

In line with the current finding Addisu (2016) reported castration of animals as one criterion for fattening cattle selection. Accordingly, 80% of cattle fatteners castrate their animals' before fattening whereas the remaining 20% do not recommend for castration. The current finding agrees with Bezahegn (2014) and Yidnekachew *et al.* (2016) who similarly reported that farmers select castrated cattle for farming and to simplify fattening operation. In addition, this finding strongly agrees with Shewangzaw *et al*. (2014) who reported that majority of cattle fatteners (78.5%) set castration as selection criteria, while the remaining 21.5% do not recommend. Moreover, Yidnekachew *et al.* (2016) reported farmers in South Omo Zone of SNNPR castrated animal so that they to store fat and show better feed conversion. Due to this fact, they are inclined to us the castrated one.

The observed average age of cattle used for fattening in the current finding was similar to Addisu (2016); Belete *et al*. (2010) and Shewangzaw *et al*. (2014) who reported ordinarily, farmers fattened their draught oxen and commonly fatten mature and much older animals for shorter durations.

The current finding was in line with the cattle type cluster analysis of Dereje *et al.* (2008) who concluded that, morphologically, at least three distinct cattle types are found in North western Ethiopia, specifically in South and North Wollo of Amhara Region, namely, Wollo Highland Zebu (comprising of cattle from Gimba, Were-Ilu and Kutaber sites), the Raya Sanga (Raya/Kobo site) and the Afar Sanga (Afar site). The fourth cluster is considered as intermediate cattle types that are found in the adjacent areas of Sanga and highland zebu cattle types.

Regarding color selection for fattening cattle the current finding was in agreement with Aklilu (2004), Takele and Habtamu (2009), Abdi *et al*. (2013) and Shewangzaw *et al*. (2014) who similarly reported color to be one of the selection criterion for fattening

cattle. Nevertheless, the result strongly disagrees with Belete *et al*. (2010) who reported that in Amhara region coat color as not considered as a selection criterion.

The observed cattle fattening duration and frequency in this finding agree with the conclusion of Takele and Habtamu (2009) who reported that the length of fattening period for stall-fed cattle exhibited considerable variation. Longer fattening periods tie up capital, which in turn significantly reduce profit to be realized from cattle finishing.

The current result is in line with Addisu (2016) who reported that cattle fattening is practiced starting from mid-February up to June. This is due to those facts that price of cattle for fattening is low during this period. Moreover, the fattening trend of peri-urban cattle fatteners reported in the current study was similar and strongly agrees with Takele and Habtamu (2009) who reported cattle fattening as a seasonal operation in Wolaita farmers with a peak time fattening from June to September. This is governed by seasonal pattern of feed availability and presence of main holidays. Similarly, Genet *et al.* (2017) reported that the majority of feedlot operators considered January to March and October to December to be the most suitable seasons to start fattening operation.

Experience of feed additives and feeding practices observed in the current finding agree with the findings of Tsigereda (2010) which revealed that Hararghe farmers use common baking yeast such as *Saccharomyces cerevisiae*, Abish flour (Fenugreek) and fermented dough or their combination for fattening purpose as additional feed resources. These are fed to the animals by mixing with additional fresh flour of maize or wheat bran or alone.

The data showed that cattle fatteners provide pure water for fattening cattle. Water quality and quantity may affect feed consumption and animal health. Low quality water will normally result in reduced water and feed consumption. Water transportation means of peri-urban cattle fatteners was labor intensive, it affects watering practices, and animal performance as restriction of water intake lowers weight gain. Conversely, means of water provision mechanisms (water to cattle) of urban cattle fatteners' decreases loss of energy of fattening cattle and contribute for better gain performance of cattle. Water

source and water provision practices detected in this study were in line with Genet *et al.* (2017) who reported that the majority (88.9%) of feedlot operators' uses pipe water and animals drink *ad libtum.* Fikru (2015) and Tsegay *et al.* (2016) indicated that farmers watered their fattening cattle from tape water, well, pond and rainfall sources. Similar to the current study Shitahun (2009) and Fikru (2015) reported that farmers offered drinking water for their cattle once, twice and three times per day. The current finding supports Adugna (2008) who indicated that restriction of water intake lowers feed intake. Cattle that are gaining weight require more water than those that are losing weight.

The current survey result indicates the way of salt supplementation has an impact on the amount of salt provided per cattle and on resources usage. Provision of salt in the form of block has merits and shortcomings. As a result, it is difficult to determine the amount of salt provided per cattle per fattening and some of the portion of the block become out of use due to breakage and dirties. Conversely, it has an advantage for cattle as they to take it based on their requirement. Oppositely, powder salt provision practices of urban cattle fatteners might lead to deficit or extra provision unless otherwise cattle fatteners properly calculate and deliver.

The current finding agrees with Daniel (2008) who stated farmers in Borena Zone (94.7%) construct barn for their cattle. Similarly, Temple (2016) reported that beef cattle are housed for fattening in large outdoor pens. Outdoor feedlot housing is becoming more popular. Similar to the current study, Genet *et al.* (2017) stated that open overhead shelter with enclosures is the predominant type of housing system across all the commercial cattle fattening system. While few of the medium and small scale fattening system used no shed, but open enclosure housing system.

The current result reveled that cattle fatteners used their indigenous knowledge to treat sick cattle in addition to modern medication. Since many small scale and resource-poor livestock farmers cannot afford synthetic pharmaceutical drugs, they turn to indigenous knowledge as an alternative key to solve inadequacy of veterinary services and such indigenous knowledge will contribute to the ethno-veterinary medicinal plants to treat

animal diseases. In line with this finding bloating, diarrhea, digestive system disorder, lumpy skin disease, foot and mouth disease are different cattle health problems as reported by Abdi *et al*. (2013) and Genet *et al.* (2017). Concerning cattle fatteners' indigenous skill to treat sick cattle, the current finding was similar with Ketema *et al.* (2013) who reported that plants are traditionally used for treatment of livestock ailments in Ethiopia by different ethnic and social groups. Similarly, Khan *et al*. (2007) reported that honey has antibacterial, antifungal and antioxidant activities that make it ideal for treating wounds. Abdi *et al*. (2013) also reported that farmers have indigenous knowledge to treat their sick animals. They used different mechanisms like giving leaves and roots different trees and shrubs, garlic and spraying oil on skin, but the dosage is not known. Similar to this finding, Genet *et al.* (2017) reported that feedlot operators use both private and government animal health services and majority of the cattle fatteners prefer to use private veterinary practitioners than by services rendered government veterinarians.

The current study indicated that the cattle marketing system in both the study towns in general full of problems. Such traditional marketing practices and absence of alternative marketing mechanisms like weight-based marketing destructively affect the sector, depress the newly emerging urban fattening practices and grow into noticeable threat unless otherwise treated solemnly.

The currently observed result agrees with Shitahun (2009) and Teshager *et al*. (2013) who described that marketing system is one of the least developed activities of the livestock sub-sector. It is characterized by a large number of highly dispersed markets, which generally lack basic infrastructural facilities like perimeter fencing, cattle pens, weighting scale, watering, feeding, rest and quarantine place. Likewise, Bezahegn (2014) explained that there are many brokers either organized or individually engaging groups of intermediaries that are participating in negotiating the buyers and the sellers. In addition, buying and selling are completed through bargaining practice. In the process of cattle marketing middlemen are involved (Ahmed *et al.*, 2010).

The current study agrees with Takele and Habtamu (2009) and Shewangzaw *et al.* (2014) who explained that the majority of farmers marketed their fattened cattle during the main holidays and it is a seasonal operation. Unfavorable marketing systems and discouraging price did not stimulate producers to improve the quality. Besides, Malede and Yilkal (2014) reported that there is no strategic production of livestock for marketing except for some sales targeting to traditional Ethiopian festivals. The current result was supported by Bakhshinejad (2015) who reported finance as a major constraint to the improvement of the local beef fattening enterprises.

Similar to the current study, Eyob and Zewudu (2016) indicated that formal trading is constrained by irregular and variable quality in supply of livestock as a large proportion of sales are on credit basis and incur late payment and the feedlot industry faces severe constraints for feed, water, land, financing and markets, and formal trade competes with substantial informal cross-border trade due to weak linkages and incentives offered by the informal market. Moreover, the marketing place did not have any shade and fence. Not all producers had license to buy and sell fattened cattle but a few (5%) traders had a license (Getachew *et al.* 2017).

With respect to method of transportation, the current study showed that this is one of the limitations of the sector. Since, proper handling of meat animals can improve productivity, quality and profitability, unless properly planned and carried out, a series of handling and confinement situations such traditional means of transportation practices and perception can lead to distress, injury or death of cattle. The current finding strongly agrees with Shitahun (2009) and Tsigereda and Mengistu (2011) who reported fattening cattle are trekked on foot while purchasing and selling. Moreover, Getachew *et al.* (2017) indicated that transportation facilities are poor, inconvenient and limit the number of a farmer's market outlets. Most fattened cattle travel on foot to and from cattle market. Eyob and Zewudu (2016) reported comparable results where by live animals are either transported in trucks or herded over long distances to feedlot operators, export abattoirs or major markets. The final market destinations are far away from supply sources, and the transportation costs associated with getting live animals to markets can result in

significant weight loss and even death as stock routes are characterized by lack of adequate feed, water and resting places.

Limited institutional support has negative impact in the current both study towns to maximize benefits from the sector and affect commercial transformation of smallholder cattle fattening practice. The current outcome agrees with Samuel (2014) who reported no access for input materials and production training or consultancy. In line with the current observed result, Eyob and Zewudu (2016) indicated that there is no reliable source of information neither on export demand nor on domestic supply situations. Thus, producers, traders, exporters and support giving institutions are constrained by shortage of market information to rely on for enhancing production, marketing and exports. On the other hand, Daniel (2008), Belay (2013) and Getachew *et al*. (2017) reported that cattle fatteners obtained relevant market information before cattle sale from fellow farmers, market visit, neighbors, relatives, cooperatives, own visits and few of them from brokers prior to market days. Getting access to information on current cattle price enables the urban as well as peri-urban cattle fatteners to make rational and relevant decision, strengthen their negotiating ability during transaction with buyers and consequently prevent possible exploitation by better-informed traders.

The current finding was strongly disagree with FFILLS (2016) who reported the Ethiopian Livestock Market Information System (LMIS) provides regular livestock prices and volume information to producers, middle men and traders in most of the major livestock markets in the country. According to FFILLS, information from LMIS is available on request via text messaging, email and on the internet.

The currently identified cattle fattening constraints in urban and peri-urban areas of the study areas agreed with Belete *et al*. (2010), Abdi *et al.* (2013), Malede and Yilkal (2014) and Andualem (2016) who reported feed shortage, animal health and market problem, land shortage for expansion, lack of market information and long market chain, limited access to information, extended drought, little access to credit service, limited consumer

capital to invest, inadequate veterinary services and weak extension services as major constraints of livestock production and the fattening sector.

In line with the current study Getachew *et al.* (2017) reported that most respondents (94.8%) did not have records of cattle history during fattening period. The health status, body condition, cattle breed and other cattle information are not recorded before and after fattening. Exceptionally, most respondents (75%) have financial records but the financial record did not include the cost of labor and crop residues.

Besides, the primary and secondary constraints of cattle fattening practices identified in the current study agree with Belete *et al*. (2010), Firew and Getenet (2010), Samuel (2014) and Malede and Yilkal (2014) who found that cattle fattening in Ethiopia is challenged due to inadequate feed supply, shortage of animal feed (feed scarcity and quality deterioration of the feed during dry season) and high feed cost, poor quality and low availability of feed resources. Similarly, Shitahun (2009) stated that feed shortages are root causes for the poor performances of the livestock sector in general and the fattening enterprise in particular. Feed shortages are often highlighted as major constraint to Ethiopia's livestock and meat industry (ACDI/VOCA, 2010). Likewise, Firew and Getenet (2010) reported feed processing plants in Ethiopia are very few and still are not producing to their full capacity. Therefore, producing a high quantity and quality feeds for animals is a key factor in raising healthy and productive livestock sector (Bezahegn, 2014).

In line with the current finding Eyob and Zewudu (2016) reported that opportunities for livestock production value chain includes population growth, urbanization, rise in income in growing urban centers of developing countries, international influences (globalization and more liberal international trade), and technological changes in the production, communication and transport sectors. The rapid growth in demand for meat products in the world represents a great opportunity for livestock resource-rich countries. Likewise, Gebreegzabeher and Gebrehiwot (2011) reported the existence of different abattoirs, live animal exporters in and around towns and large cities created a favorable environment for

live animal market. The great population pressure in and around the cities has led to a tremendous increase in urban and peri-urban agriculture. The Ethiopian government has also deployed agricultural development agents in rural areas to render extension service to the rural communities and livestock development packages have been formulated to be adopted by farmers (FFILLS, 2016). Similar to this study Gizaw *et al*. (2017) stated that market oriented livestock development can only be realized once the technological, organizational and institutional opportunities and challenges are properly identified and innovative approaches are documented.

5.2. Feed Resources Identification, Distribution and Marketing Price

Since the problem of feed resources was the pronounced drawback of the sector, such of grouping indigenous feed resources would be a baseline for further research to see the effect of feeds on the fattening performance of oxen in both study towns. Moreover, it gives clue to use and provide better priority while storing feed resources for cattle fattening practices in both the study areas and in other areas where similar conditions exists. Besides, identification of the available feed types and utilization practices of cattle fatteners help for feed resource management and feed balance for study areas so that appropriate intervention strategies can be developed.

The observed feed resources classification in this study agrees with Younas and Yaqoob (2005) who showed that available feed resources can be divided into two main categories as conventional and non-conventional feed resources. Conventional resources are grouped further into three categories: viz; (i) green roughages, (ii) dry roughages and (iii) concentrates. Non-conventional feed resources have the potential to play a major role in meeting the feed shortage in the years to come. Similar to the current study, Andualem (2016) reported that agro-industrial byproducts produced in Ethiopia include byproducts from flour milling, sugar factory, oil processing factories and breweries. These products are mainly used for dairy, fattening and commercial poultry production and the scope for their wider use by smallholder producers is low due to availability and price.

Moreover, the current study was in line with Gizaw *et al*. (2017) who reported although there is an overall livestock feed shortage in the country, there are many instances where available conventional and non-conventional feeds are not properly utilized. For instance, there are byproducts that are not properly documented and efficiently utilized. Therefore, there is a justified need to pay due attention to the feed resource availability, conservation, utilization and marketing across the various agro-ecological and geographic regions.

The current finding agrees with Gebreegzabeher and Gebrehiwot (2011) who reported that urban livestock keeping offers an opportunity to make use of household wastes, agro-industrial byproducts such as molasses and brewery residues, weed and grass from public lands and crop residues from market and farmers. Similar to the current result Asrat *et al.* (2008) reported that poultry litter has been identified as one of the non-conventional feeds for ruminant production. Likewise, Zewdie (2010) reported that non-conventional feeds such as '*Atela*' are not available at large and their contribution to livestock feed supply are small, but used as a cooping strategy. The current result disagrees with report of Firew and Getenet (2010) in which the use of concentrate and agro-industrial byproducts as livestock feeds, especially for fattening and dairy is not common. Contrariwise, the current finding agrees with other report of the same author in which it is enlightened that mills are running far below their potential capacity mainly due to shortage of raw materials, particularly wheat. Small-scale local mills in one way or another have contribution in supplying varieties of grain byproducts. Pulse hulls are commonly used as feed for animals.

The current findings supports McDonald *et al.* (2002) finding in which brewers dried grains are reported as good source of protein in addition to their energy value. Because of its bulky, fibrous nature and low energy content, dried brewery grain is more suitable for ruminants than non-ruminants. Similarly, Firew and Getnet (2010) reported that farmers purchase the wet brewery spent grain dry near Kombolcha and use for their livestock.

The current result agrees with Zewdie (2010) who reported hay to be the commonly used way of feed preservation technique in Ethiopia. This is expected to mitigate problems of livestock feeding during the dry period. Likewise, Fekede *et al*. (2013) reported that hay is produced on continuously grazed pockets of pasture lands by protecting the lands from livestock for a certain period during the main rainy season to allow the pasture to grow and provide harvestable biomass.

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The currently observed result regarding feed resources distribution and availability support the idea of Aklilu (2004) according to which alternating periods of surplus and deficit result in a very low level of production for the entire year. The quantity of feed is inadequate in the dry season while there is surplus in the wet season. Seasonal variations in feed quality and quantity are the main limitations to animal production and cause fluctuation in productivity throughout the year, particularly in the dry seasons during which feed is limited.

The current finding strongly agrees with Mesfine *et al.* (2014) who indicated that, the demand for roughages, agro-industrial by-products and compound feeds is showing an increasing trend. The use of feed from commercial sources is, however, very limited due to shortage of feed supply and inefficient marketing system. The agro-industrial by-products, mainly from flour and grind mills, and oil processing plants, are in short supply and directly marketed to users or through traders. Consequently, most of the exiting feed mixers/processing enterprises are operating under capacity estimated at about 20%-30%. The main marketed roughages, which are mainly cereal straws and baled hay, are also in short supply. Feed prices are increasing from time to time.

5.3. Feeding Trial

The DM content of the basal diet in the present study was higher than the DM contents of 93.12%, 93.3%, 93.42%, and 92.13% reported by Simret (2005), Mulu (2005), Fentie (2007) and Yohannes (2011) for natural hay, respectively. The observed CP content of the natural pasture grass hay was lower than 5.6%, 7.29% and 6.7% CP reported by

Getachew (2005), Yohannes (2011) and Aschalew and Getachew (2013), respectively. However, the CP content of basal diet in the present study was higher than 4.2% and 3.56% reported by Mulu (2005) and Fentie (2007), respectively. The CP content of the basal feed, grass hay was lower than the other treatment diets as expected, its CP content was lower than the lower limit of 7% CP required for optimum rumen function (Van Soest, 1994). This is likely to be due to the fact that the grass hay was harvested from farmers grazing land used for long years for grazing purpose as a result of which the nutrient content of soil might have been depleted. As reported by Topps (1995) when the CP content of roughages is below 7%, rumen function is impaired resulting in poor digestion of feeds, low DM intake and poor animal performance. Therefore, such feed should be provided with other CP rich concentrates for effective fattening practices.

The NDF content of grass hay observed in this study, was lower than 67.2%, 72.45%, 73.96% as reported by Simachew (2009), Yohannes (2011) and Aschalew and Getachew (2013), respectively. Generally, NDF values recorded in the current hay sample was characterized as low and may had advantage on intake of basal diet, since the higher NDF content could be a limiting factor on feed intake, Voluntary feed intake and NDF content are negatively correlated.

The ADF contents of native grass hay in the present study were also lower than 45.33% and 46.68% contents reported by Fentie (2007) and Yohannes (2011) for natural pasture grass hay, respectively, but higher than 31.95% for highland and 35.09% for midland grass as reported by Mengistu *et al*. (2016). On the other hand, the result is almost comparable with 42.8% and 42.5% of ADF reported by Getachew (2005) and Yoseph *et al.* (2011), respectively.

The ADL contents of native grass hay in this study was lower than 5.60%, 8.26% and 8.51% values reported by Fentie (2007), Yohannes (2011), and Aschalew and Getachew (2013), respectively. It was higher than 3.77% for highland and 4.84% for midland grass reported by Mengistu *et al*. (2016). Almost comparable result was observed in the current study with 5.9% DM as reported by Yoseph *et al*. (2011). Differences in chemical

composition of grass hay might be related to the differences in season of harvesting, storage and duration of the harvested land used for grazing.

The DM content of the processed or crushed corn grain (PCG) was higher than the DM contents of 90.3% and 86.41% reported by Adugna (2008) and Mohammad *et al*. (2015), respectively. Its observed CP content was lower than 9.9% and 9.0% reported by Adugna (2008) and Mohammad *et al*. (2015), respectively. The NDF content of PCG in this study was higher than 13.7% reported by Adugna (2008) and lower than 34.42% reported by Amde (2015). The ADF value of PCG in this study was lower than 6.81% reported by Mohammad *et al*. (2015), respectively. The ADL value of PCG in this study was higher than 1.6% as reported by Adugna (2008), lower than 6.03% as reported by Hunegnaw (2015) and almost comparable with 3.68% reported by Amde (2015). The variations might be due to the effect of the variety and the quality of the original grain.

The DM content of the wheat bran (WB) was comparable to the DM contents of 90.43% reported by Yenesew *et al.* (2013), higher than the DM contents of 87.4% and 89% as reported by Awet (2009) and Hunegnaw (2016) and lower than 93.99% and 91.5% as reported by Yohannes (2011) and Radia (2013), respectively. Its observed CP content was almost comparable with 16.3%, 16.73%, 16.4%, and 16.9% CP reported by Hirut (2008), Adugna (2008), Awet (2009) and Yenesew *et al.* (2013), respectively, but lower than 17% reported by Tesfaye *et al.* (2001a). It was higher than 14.88% and 15.16% reported by Tsigereda (2010) and Yohannes (2011), respectively.

The NDF content of WB in this study was lower than 44.5% and 45.9% reported by Adugna (2008) and Yoseph *et al*. (2011), respectively and higher than 41.79% and 25.54% reported by Radia (2013) and Mulugeta (2015), respectively. Its ADF value was higher than 14.6%, 13.7%, 12.1%, 10.87% and 6.64% reported by Emebet (2008), Yohannes (2011), Yoseph *et al*.(2011), Radia (2013) and Mulugeta (2015), respectively. The ADL value of WB in this study was higher than 2.15% and 1.25% reported by Fentie (2007) and Mulugeta (2015) and lower with 4.95% and 6.03% with Yohannes (2011) and Hunegnaw (2016), respectively. The observed value in this study is almost comparable

with 3.4% reported by Adugna (2008). The variation might be due to the efficiency of the flour factories to produce different proportion of left over feed, wheat bran, wheat middling and flour as well due to the type of initial raw material or the variety, the quality of the original grain used in the milling industries and amount of grain in to the leftover feed.

The DM content of the grass pea left over (GPLO) was lower than the DM contents of 93.48% reported by Radia (2013) and higher than the DM contents of 90.2% reported by Adugna (2008). The observed CP content of the GPLO was lower than 11% and 16.5% CP reported by Adugna (2008) and Radia (2013), respectively. Its NDF content was lower than 71.5% and 64.37% reported by Adugna (2008) and Radia (2013), respectively, where as its ADF value was higher than 43.3% reported by Radia (2013).

The observed DM content of the poultry litter (PL) in this study was in the range of 61-95% reported by Matt *et al.* (2007). However, it was higher than the DM contents of 90.8% and 90.53% reported by Adugna (2008) and Asrat *et al*. (2008), respectively. The observed CP content of the PL was higher than 17.8% CP reported by Adugna (2008) and lower than 24.5% and 26.51% reported by Bakshi and Fontenot (1998) and Asrat *et al*. (2008), respectively. On the other hand, the CP content was within the range of 15-38% reported by Matt *et al.* (2007) and Adugna (2008). The NDF content of PL in this study was also within the range of 11 to 52 % as reported by Matt *et al.* (2007). The ADL value of PL in this study was almost comparable with 7.2% reported by Adugna (2008). Many factors could contribute to the observed differences in CP content of poultry litter, which include methods of screening, difference in the type of ration used, the poultry feeding management, poultry breed, sources of litter (from layers', boilers', day old chicks', and pullets' house), type of bedding material, the proportion of excreta in the litter and the environmental conditions under which the manure was conserved. Moreover, poultry litter comprises poultry manure, spilled from feeders, feathers, bedding materials and dirt from the floor of the poultry house (Bakshi and Fontenot, 1998).

The observed DM content of the dried brewery grain (DBG) in this study was lower than the DM contents of 93.7% and 92.9% reported by Mulu (2005) and Emebet (2008), respectively. Its observed CP content, however, was higher than 25.1% and 19.8% reported by Mulu (2005) and Emebet (2008), respectively. The current result showed increment. This variation might be due to the difference in the type of initial raw material and type of processing in the brewery manufacturing industry. These might be also a mix up with yeast while processing that might have increased the CP percentage up to 48.3% as reported by Adugna (2008).

The NDF and ADF contents of DBG in this study were within the range of 499 to 753 g/kg DM and 216 to 315 g/kg DM, respectively reported by MAFF (1990). The ADL values of DBG in this study was higher 6.3% DM reported by Emebet (2008). Generally, the chemical composition of brewers' grain mainly depends on the quality of the barley or the inputs used in the process, but it is also affected by processing method and filtration techniques used.

The current result showed a positive effect of supplementing different concentrates with dissimilar protein sources on FBW, BWG, ADG, FCE and FCR. The better FBW, BWG, ADG, FCE and FCR observed for animals supplemented with T2 (poultry litter) feeds can be explained by the nature of the protein sources. Poultry litter served as a good source of fermentable nitrogen than the protein sources in T1 and T3. Moreover, this might be due presence of anti-nutritional elements in grass pea leftover and high fibre content in dried brewer's grain. Visual estimation based on body condition of cattle is a commonly practice for cattle marketing in the current study areas. This fact may encourage cattle fatteners to practice such parameter aggressively in the monitoring of fattening cattle condition while fattening and marketing through scientific guidance.

The mean daily weight gain (0.67± 0.03 kg/day) observed for Wollo oxen in the present study was lower than the daily average gain of 829.88 g/day reported by Tsigereda (2011) for Ogaden bull fed with maize stover as basal diet and supplemented with 3 kg concentrate mixture fortified with different levels of yeast. Similarly, it was lower than

770.34 g/day as reported by Yohannes (2011) for Hararghe highland bulls fed hay as a basal diet and concentrate mixture containing *P. juliflora pod* flour as a substitute for wheat bran at different level and Arsi bulls (697 g/day) and Boran bulls (836 g/day) fed on different forage legumes and concentrate (1.5 kg noug cake and 1.5 kg maize grain per day) as reported by Nega *et al*. (2002). It was slightly higher than the daily weight gain of 0.65±0.05 kg reported by Yoseph *et al.* (2011) for Ogden bulls grazing natural pasture and supplemented with agro industrial by-products and hay at a ratio of 50:50. It was also higher than the average daily gain of 0.65 g/day observed for Adet old oxen but lower than 913 g/day observed for Fogera oxen as reported by Adebabay *et al.* (2013). Moreover, the current result was nearer to the average daily gains of 0.62 kg observed for 4 to 5 age of Ethiopian highland zebu oxen as reported by Osuji and Capper (1992).

The current finding agrees with Adugna (2008) who reported that poultry litter could serve as a good source of fermentable nitrogen and additional essential minerals. The calcium and phosphorus contents observed are around 2.1 and 1.8% of DM, respectively. The current finding strongly agrees with Grela *et al*. (2001), and Anna and Małgorzata (2010) who reported that grass pea contains anti-nutritional elements as tannins, lectins, phytate and oligosaccharides and it also contains a non-protein amino acid, ODAP (ß-n-Oxalyl- L-α, ß-Di Amino Propionic acid). According to Ngi *et al.* (2006) high fibre content of the supplemental diet might lead to a depressed use of the net efficiency of metabolisable energy. Hence, dried brewery grain is a bulky feed, low in energy and therefore seldom used for intensive beef fattening.

Similar to the current study, Tsigereda (2010) and Yohannes (2011) noted no significant difference in body condition score (BCS) between Hararghe highland bulls fed maize stover and 3 kg of concentrate feed fortified with different levels of yeast. Unlike the present study, the mean BCS was the highest ($p<0.05$) in Ogaden bulls grazing native pasture and supplemented with different proportion of agro-industrial by products and grass hay. Body condition score is an excellent indicator of the nutritional status of the animals and is an indirect reflection of the body reserve and nutritional status (Yoseph *et al*., 2011).

The overall average dressing percentage at slaughter (56.67±0.4%) and on empty weight basis (65.1±0.3%) observed in this study was almost equal to the respective values of 56.1±0.75% and 66.1±1.0% reported by Yoseph *et al* (2011) for Ogaden bulls grazed on natural pasture supplemented with agro industrial by-products and lower than 57.2% and 67.2% reported by Yohannes (2011) for Hararghe highland bulls fed hay as a basal diet and concentrate mixture containing ground *P. juliflora* pod flours 30% inclusion level as a substitute for wheat bran.

6. CONCLUSION AND RECOMMENDATIONS

6.1. Conclusion

The overall cattle fattening practices in Dessie and Kombolcha areas are structured into urban and peri-urban cattle fattening practices based on feed source, type of livestock production system and proximity of *kebeles* to the central area. Cattle fattening practices, particularly urban cattle fattening, is dominantly practiced in Kombolcha town than in Dessie.

Almost all of the cattle fatteners in Dessie and Kombolcha areas were male headed. Female participation in the sector as owner was very low. In both study areas, the middle age category of the community are involved in the cattle-fattening sector, particularly, the urban cattle fattening practices are handled and accomplished by young generation.

Almost all of the cattle fatteners in urban *kebeles* of Dessie and Kombolcha areas possessed 2nd cycle primary school (5-8) and above, whereas, the peri-urban household heads were below the indicated grade. Such educational level may not be enough for sustainable and modern cattle fattening, as the level of education is said to be directly associated with the productivity in cattle fattening practices and application of technologies by cattle fatteners.

Cattle fattening is practiced as a major job opportunity and income source for urban cattle fatteners in both study areas, whereas, it is considered as a sideline business particularly for peri-urban cattle fatteners in Dessie town. Byproduct based and a combination of traditional and byproduct based cattle fattening systems were practiced in both the study areas. Therefore, the cattle fattening system that combined the features of both traditional and byproduct based is new, and should be considered as the fourth type of cattle fattening system as diagnosed in the study areas.

Cattle fatteners have different options for ration formulation. However, while formulating rations, the type and amount of feed ingredients incorporated, the nutrient composition and the cattle requirements were not considered. Limited feed resource access due to variation in availability, distribution, price fluctuation, transportation difficulties and illegal cattle feed traders were the major limitations for the cattle-fattening sector in both areas. On the other hand, results of the current study indicated that the study areas are endowed with useful feed resources that can be utilized to productively support the sector. From the identified 42 feed resources in the study towns, corn grain, wheat middling, wheat bran, dried and wet brewer's grain, hay, poultry litter and grass pea leftover were the proposed feed resources for fattening practices.

All interviewed households in both the areas provided salt for fattening cattle and prepared a separate house for managing their cattle. Particularly, urban cattle fatteners established clustered housing system. However, the housing system needs technical corrections in internal design, distance from the residential areas and farm equipment. Internal and external parasites are the major health problems of fattening cattle, but no endemic diseases were reported that affect cattle fattening practices in both the study areas. Almost all urban and peri-urban cattle fatteners in both study areas have deworming experience. Apart from this, the cattle-fattening sector is hindered by cattle market and market related factors like poor infrastructure, broker interference, credit based marketing and poor money transaction.

As inference, the observed fattening practices in both areas have potential merits for adoption in similar areas, chiefly, in terms of involvement of young generation, indigenous ration formulation options, salt and water supplementation practices, separate house preparation and clustered housing system, deworming experience and native skills, ability to share model experience from model cattle fatteners, better consideration and involvement of urban cattle fatteners in the sector.

Though limitations were apparent in the sector, particularly, in terms of low female participation and partial family labor usage, low level of education, excess feed usage in

the course of ration preparation, bulk feed provision and salt delivery practices in the form of block, time of cattle marketing, poor means of cattle transportation and services, poor documentation at office and individual level, limited professional considerations in the course of farm establishment, lack of facilities while house construction, limitations related to institutional support, like training without demonstration, absence of information and inconsistent extension services and poor or absence of linkage between stockholders, the sector has also many promising opportunities.

As observed from the feeding trail, feeding concentrate mixture that contains poultry litter had higher effect on overall body weight gain, feed conversion efficiency/ ratio and dressing percentage on slaughter body weight basis. This implies that there is a great opportunity in utilizing poultry litter as non-conventional feed resource since it is one of the solutions to minimize feed shortage problems identified in the survey areas. Moreover, it avoids feed resources competition with monogastric animals and it could contribute to reduce environmental pollution because of waste disposal.

The difference in the net return among treatments could possibly be attributed to better protein quality in poultry litter that improved feed conversion efficiency of oxen. Moreover, the lower cost of poultry litter made the treatment group (T2) more profitable. Therefore, from the results of the study, it can be concluded that supplementation of poultry litter was potentially more feasible and economically beneficial to the cattle fatteners to efficiently utilize nutrients in combination with locally available grass hay, wheat bran and corn grain followed by dried brewery grain.

6.2. Recommendations

From this study, the following recommendations are suggested with the conviction that the implementation would help rectify perceived constraints there by improving the performance of the sector in the study areas and elsewhere having a similar scenario:

- Cattle fattening interventions should consider the identified cattle fattening systems of urban and peri-urban cattle-fattening categories.
- For proper family labor usage and to increase female participation in the sector, female oriented cattle fattening package should be promoted via organizing females in to different cattle fattening associations.
- Government and non-governmental organizations should give better emphasis to educate cattle fattening community and their children for proper technology application.
- Usage of the identified and highlighted feed resources should be the main thought considering feed price and nutritive values to minimize limitations regarding feed resources. Moreover, it is valuable to advice cattle fatteners with strong extension service to collect feed resources and enrich their feed bank before the occurrence of feed scarcity and price increment. Furthermore, government intervention is recommendable to alleviate feed cost fluctuation, transportation difficulties, illegal cattle feed traders influence, poor distribution, and limited access to the feed resources, and to initiate governmental and private feed processing enterprises to be part of the sector.
- To solve fattening cattle health problems satellite veterinary centers and private veterinarians should be strengthen.
- There is a need to facilitate the overall cattle marketing systems for sustainable market service, infrastructure development, information availability and delivery systems aimed at protecting the negative influence of the brokers.
- The government body should arrange appropriate transportation services; such as area for resting, watering and feeding site while trekking cattle. In addition, other means of

cattle transportation systems and well-structured cattle path should be considered during road construction.

- The sector in the study towns should be guided with well-trained and licensed cattle fatteners and traders with the guidance of practically equipped and educated professionals supported with practical and intensive demonstrations or training.
- Animal sciences expertise should guide the sector through accurate, well-organized, computerized and consistent documentation.
- The government needs to provide strong professional considerations, particularly, professional license in the course of cattle fattening farms establishment.
- Comprehensive awareness should be created among cattle fatteners about the significance of grass hay based fattening of oxen supplementing with low cost poultry litter within the concentrate feeds for higher economic return.
- Generally, to strengthen the cattle fattening practices it is advisable to focus on the identified opportunities and there should be a functional linkage between stakeholders such as different governmental and non-governmental bodies and private organizations. Particularly Agriculture, Micro and Small Enterprise Offices, urban and peri-urban cattle fatteners and feed suppliers should work in collaboration for sustainable and profitable cattle fattening practices and market linkage.
- As future scope to assure the cattle fattener's perception, to examine effect of agro ecology and to exploit the available local cattle potential of Wollo cattle particularly, Highland Zebu and Raya Azebo cattle types, it is advisable to undertake comparative experimental researches on their fattening performance and meat quality analysis. In addition, fattener's indigenous ration formulation options and medication practices to treat or cure sick animals or prevent disease need further scientific investigation. A study on the digestibility and degradability characteristics of different protein feed sources (poultry litter, grass pea left over and dried brewery grains) should be carried out for better understanding of the significance of supplements for large ruminants. It is worthwhile to evaluate the effect of different poultry litter collected from day old chicks, layer, pullet, and broiler house on fattening performance.

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8. APPENDICES

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Appendix 1: Structured questionnaire format

መለያ ቁጥር ,,,,,,,,,,,,

በደሴና ኮምቦልቻ ከተማ የባህላዊና ዘመናዊ የበሬ ማድለብ ተግባራቶችን እንዲሁም ተለምዳዊ የሆኑና ያልሆኑ ለማድለቢያነት የሚጠቀመባቸውን መኖዎች ለመዳሰስ የተዘጋጀ ጥናታዊ መጠይቅ

<u>የምርምሩ አላማ</u>

ካሳሁን አህመድ እባላለሁ ፡፡ የዚህ ጥናት ተመራማሪ ስሆን በአዲስ አበባ ዩኒቨርስቲ በቪተርናሪ ሜድስንና አግሪካልቸር ኮለጂ የዶክትሪት ዲግሪ ተማሪ ስሆን ከላይ በተጠቀሰው ርዕስ ዙሪያ የዳሰሳ ጥናት በማድረግ የዶክትሬት ድግሪ ማሟያ ፅሁፍ ከመፃፍ ባሻገር አዋጭነት ያለው በተግባርና በሃሳብ የታገዘ መፍትሄ ለግል አድላቢዎች ፣ለባለሃብቶች፣ለድርጅቶች ብሎም ለሃገራችን ማበርከትን አላማ ያደረገ ምርምር ነው፡፡በመሆኑም ከዚሁ ጋር ተያይዞ ከታች ያሉትን ጥያቄዎች በመመለስ ያለዎትን ባህላዊም ሆነ ዘመናዊ የተግባር ልምድ እንዲሁም ንድፍ ሃሳብ በማካፈል እንዲያስተምሩኝ በትህትና እየጠየኩኝ፣ ለሳይንሳችን መበልፀግ ብሎም የዶክትሬት ድግሪ ማሟያ ፅሁፍ መሳካት ለሚያበረክቱት አስተዋፅኦ ከልብ አመሰግናለሁ፡፡

<u>ሀ. የተጠያቂው መግለጫ የተመለከቱ ጥያቄዎች</u>

1. የቀበሌው ስምና ልዩ ቦታ ----------
2. የተጠያቂው አባወራ/እማወራ ስም ----------
3. እድሜ ---------- ፆታ ---------- የትምህርት ደረጃ ----------
4. የቤተሰብ መጠን ድምር ---------- ወንድ ---------- ሴት----------
5. የአባወራ መተዳደሪያ ስራ ----------ዋና የገቢ ምንጭ ----------

<u>ለ. ሰለከብት አርባታና ማድለብ ጥቅሞችን በተመለከተ ለመመለስ የሚጠየቁ ጥያቄዎች</u>

1. ከብቶች (ላም፣በሬ) አለዎት? ሀ፣ አለኝ ለ፣ የለኝም
2. ካለዎት ለምን ጥቅም ያረባሉ? (ዋና ዋናዎቹን ይጥቀሱ)
   - ሀ. ----------
   - ለ.----------
   - ሐ.----------
3. በሬ ያደልባሉ? ሀ፣ አደልባለሁ ለ፣ አላደልብም
4. ካደለቡ ለምን ጥቅም ያደልባሉ? (ዋና ዋና ጥቅሞችን ይግለፅ)
   - ሀ. ----------
   - ለ.----------
   - ሐ.----------
5. ለስንት ጊዜ በሬ አድልበዋል?----------

<u>ሐ. የቤተሰብ ጉልበት አጠቃቀምና ሰራ ክፍፍል ለመመለስ የሚጠየቁ ጥያቄዎች</u>

1. በሬ ለማድለብ ዋና ዋና ተግባራቶች ምን ምን ናቸዉ?
   - ሀ፣ መኖ መሰብሰብና መከመር ሠ፣ ቤት ማፅዳት
   - ለ፣ ምግብ ማዘጋጀት ረ፣ በሬ መግዛትና መሸጥ
   - ሐ፣ ምግብ መመገብ ----------
   - መ፣ ውሃና ጨው መስጠት ----------

2. በርካታዎቹ ተግባራቶች በማን ይከናወናሉ?
   ሀ፣ በወንዶች ለ፣ በሴቶች ሐ፣ በሁለቱም መ፣ በቀን ሰራተኛ ሠ፣ በሌላ
   ለምን?----------
3. በቀን ስንት ስአት በሬዎችን ለመንከባከብ ይመደባሉ?
   ሀ፣ 2-3 ለ፣ 3-4 ሐ፣ ሙሉ ቀን መ፣ ሌላ ካለ ይገለፅ

<u>መ. ከበሬ ማደለብ ዋና ዋና ተግባራቶችን ለመመለስ የሚጠየቁ ጥያቄዎች</u>

1. የአካባቢው የእንስሳት ርባታ ሁኔታ ምን አይነት ነው?
   ሀ. አርብቶ አደር ለ/ ከፊል አርብቶ አደር ሐ/ ከፊል የከተማ ግብርና መ/ ከተማ ግብርና ወይንም ሀ/ ኋለ ቀር ለ/ ዘመናዊ
2. የአካባቢው የበሬ ማድለብ አይነት ምን አይነት ነው?
   ሀ/ ባህላዊ ለ/ ተረፍ ምርት መሰረት ያደረገ ሐ/ እንደ ሃረርጌ አይነት መ/ ሌላ ካለ ይግለፁ
3. ምን አይነት እንስሳት ነው ለማድለብ የሚመርጡት?

ተ.ቁ	ዝርዝር ጉዳዬዎች	ለምን? ምክንያቱ ይገለፅ
1	ፆታ፣ ሀ፣ ወንድ ለ፣ ሴት	
2	ሀ፣ የተኮለሰ ለ፣ ያልተኮለሰ	
3	እማካይ እድሜ---------	
4	ሀ፣ የአካባቢ ዝርያ ለ፣ ድቃይ ሐ፣ የወጭ	
5	ሀ፣ እርሻ ያረሰ ለ፣ ያላረሰ ሐ፣ ሁለቱም	
6	ሀ፣ ያረጀ ለ፣ ወጣት	

4. በሬ ለማድለብ ከየት ይገዛሉ/ያገኛሉ? ሀ/ ከራስዎ በረት ለ/ ከገበያ ሐ/----------
5. በአመት ስንት ዙር ያደልባሉ? ---------- ስንት በሬ----------ለምን? ----------

Appendix 1. Structured questionnaire format *(continued)*

6. በአማካኝ የአንድ ማድለቢያ ቆይታ ስንት ጊዜ ይሆናል? ----------
7. አንድ በሬ መድለቡን እና ለገቢያ መድረሱን በምን ያውቃሉ?
8. የትኛው ወቅት በሬ ለማድለብ ይመረጣል?---------- ለምን?----------

ሠ/ ለበሬ ማድለቢያ የሚጠቀሟቸዉን መኖዎችን ለማወቅ የሚጠየቁ ጥያቄዎች

1. በሬ ለማድለብ የሚጠቀሟቸውን መኖ ስምና ምንጭ ይዘርዝሩ?

ተ ቁ	የመኖ ስም	ከየት ይገኛሉ	ዋጋ በኪ.ግ	የሚገኙበት ወቅት			አቅርቦታቸው ይገለፅ	ተፈላጊነታቸው ደረጃ
				በጋ	ክረምት	በሁለቱም		
1								

2. የሚደልቡ በሬዎች እንዴት ይመገባሉ? ሀ/ በልቅ ግጦሽ ለ/ ቤት ውስጥ በማሰር ሐ/ ሁለቱም
3. ቤት ውስጥ በማሰር የሚመግቡ ከሆነ ምን ምን መኖ ይሰጣሉ?----------
4. መኖውን እንዴት አድርገው ያዘጋጃሉ? ----------
5. ለሚደልቡ በሬዎች በቀን ስንት ጊዜ ይመገባሉ? ----------
6. ላአንድ ጊዜ በአማካይ ምን ያህል ኪ.ግ ለአንድ እንስሳት ይሰጣሉ?

ተ.ቁ	የመኖ ስም	የሚሰጠው መጠን በኪ.ግ	በቀን ስንት ጊዜ ይሠጣሉ
ሀ ለ ሐ			

7.ለሚደልቡ በሬዎች የተዘጋጀ መኖ እንዴት አድርገው ያቀርባሉ? ሀ/ ለየብቻ ለ/ በጋራ
8. ለአንድ በሬ የሚያስፈልገው የምግብ መጠን እንዴት ያውቃሉ?----------
9. ለሚደልቡ በሬዎች ሳር፣ ተጨማሪ መኖዎች እንዲሁም ውሃ የሚሰጡ ከሆነ በምን ቅደም ተከተል ይሰጣሉ?
ሀ/ ቅደም ተከል የለውም ለ/ ቅደም ተከል አለው፣----------
10. በበጋና በክረምት ለእንስሳቶች የተለያየ አመጋገብ ይከተላሉ? ሀ/ አዎ እከተላለሁ ለ/ ተመሳሳይ ነው
አዎ ከሆነ ልዩነቱ ይገለፀ?----------
11. በበጋና ክረምት እንስሳቶች የምግብ ፍላጎት ልዩነት አላቸው? ሀ/ አዎ አለ ለ/ የለም
ልዩነት ካለ ምክንያት ይግለፀ?----------
12. በአማካይ አንድ በሬ ለማድለብ የመኖ አጠቃላይ ወጭ ስንት ይሆናል ----------

ረ/ የሚደልቡ በሬዎች የውሃና የጨው ፍጆታ ለመዳሰስ የሚጠየቁ ጥያቄዎች

1. ውሃ ለሚደልቡ ከብቶች ይሰጣሉ? ሀ/አዎ ለ/ አልሰጥም
2. አልሰጥም ከሆነ መልስዎ ለምን? ----------
3. ውሃ የሚሰጡ ከሆነ
ሀ/ ውሃ ከየት ያገኛሉ? ----------
ለ/ እንዴት አድርገው ለእንስሳው ይሰጣሉ? ሀ/ እንስሳውን በመውሰድ ለ/ ውሃውን በማምጣት
ሐ/ በስንት ቀን ልዩነት ይሰጣሉ?----------
መ/ በቀን ስንት ጊዜ ይሰጣሉ? ----------
ሠ/ በአንድ ጊዜ በአማካይ አንድ በሬ ስንት ሊትር ውሃ ይፈልጋል?
በሙቀት ወቅት ----------
በቀዝቃዛ ወቅት ----------
ረ. እንስሳውን የሚያንቀሳቅሱ ከሆነ በቀን ስንት ኪ.ሜ ይጓዛሉ? ----------
4. ለሚደልቡ በሬዎች ጨው ይሰጣሉ? ሀ/ አዎ ለ/ አልሰጥም
5. የማይሰጡ ከሆነ ምክንያት ይግለፁ?-------
6. የሚሰጡ ከሆነ በምን መልኩ? ሀ/ በማላስ መልክ ለ/ ከምግብ ጋር በመቀላቀል
7. በቀን ስንት ጊዜ ጨው ይሰጣሉ?----------
8. በአማካይ አንድ በሬ በአጠቃላይ በመድለቢያ ጊዜው ምን ያህል ጨው ይፈልጋል ----------

ሰ/ ለሚደልቡ በሬዎች ቤት አዘገጃጀት ጋር ተያይዞ የሚጠየቁ ጥያቄዎች

1. ለሚደልቡ በሬዎች ቤት አዘጋጅተዋል? ሀ፣ አዎ ለ፣ የለኝም
2. ካለዎት ለሚደልቡ በሬዎች የተለየ ቤት አዘጋጅተዋል?
ሀ/ አዎ የተለየ ቤት አላቸው ለ/ ከሌሎች ጋር በጋራ ነው
3. ቤት ካዘጋጁ ቤቱ በምን መልኩ ተዘጋጅቷል በውስጡ ምን ምን ነገሮችን ያካታል?----------
4. ለሚደልቡ በሬዎች ቤት የለኝም ካሉ ለምን?----------

ሸ/ የሚደልቡ በሬዎችን የሚያጠቃ በሽታ ለመለየት የሚጠየቁየቄዎች

1. የሚደልቡ በሬዎች የሚያጠቃ የውስጥና የውጭ ጥገኛ አለ? ሀ፣ አዎ ለ፣ የለም
2. አለ ካሉ ዋና ዋና የውስጥ ጥገኛ የሚባሉትን ይዘርዝሩ? ----------
ዋና ዋና የውጭ ጥገኛ የሚባሉትን ይዘርዝሩ? ----------
አጠቃላይ የሚደልቡ በሬዎችን የሚያጠቃ በሽታ ካለ ይግለፁ?----------
3. ከላይ የጠቀሱትን በሽታ ለመካላከል ባህላዊና አካባቢያዊ የማዳኛ ዘዴ አለዎት? ሀ፣ አዎ አለኝ ለ፣ የለኝም
4. አዎ ከሆነ መልስዎ

ተ ቁ	የበሽታው ስም	የሚያሳየው ምልክት	ባህላዊ ክምና	የሚሰጡት መጠን	የሚሰጥበት ሰ
ሀ. ለ					

5. የተለየ ማወፈሪያዎችን ይጠቀማሉ /እንደ ሆርሞን ያሉ/? ሀ፣ አዎ ለ፣ አልጠቀምም
6. ከመንግስት ተቋማት የህክምና አገልግሎት ያገኛሉ? ሀ፣ አዎ ለ፣ የለም

Appendix 1. Structured questionnaire format *(continued)*

ቀ. የበሬ ገበያን በተመለከተ ለመዳሰስ የሚጠየቁ ጥያቄዎች

1. የበሬ ገበያ በአካባቢዎ አለ? ሀ፣ አዎ ለ፣ የለም
2. ካለ በስም ይግለፅ? ----------
3. የገበያዎቹ ሁኔታ ምን አይነት ነው? ሀ፣ ዘመናዊ ለ፣ ባህላዊ
4. ገበያዎቹ ምን ምን አይነት አገልግሎት ይሰጣሉ?----------
5. በገበያው ላይ የሚሳተፉት እነማን ናቸው?----------
6. በሬ ሲገዙና ሲሸጡ ተመሳሳይ ገበያ ይጠቀማሉ? ሀ፣ አልጠቀምም ለ፣ እጠቀማለሁ
   ለምን፣ ምክንያቱ ይግለፅ?----------
7. የመሸጫና የመግዣ ገበያ በአማካኝ ከአካባቢዎ የቱን ያህል ይርቃል?
   የመግዣ ----------የመሸጫ ----------
8. የእንስሳት ገበያ ዋጋ ተለዋዋጭነት ያሳያል? ሀ፣ አዎ ያሳያል ለ፣ አያሳይም
9. አዎ ከሆነ መልስዎ በየትኛው ወቅት በጣም ይወደዳል? ----------
   በየትኛው ወቅት በጣም ይረክሳል?----------
10. የሚደልቡ በሬ ሲገዙ ሲሉ ምን ምን ሁኔታዎችን ያስተውላሉ?

ተ ቁ	የሚታዩ ነገሮች	ደረጃ	የሚታዩ ነገሮች	
ሀ			ሠ	
ለ			ረ	
ሐ			ሰ	

11. የበሬ ዋጋ ሲሸጥና ሲገዛ በአማካኝ በዚህ አመት ስንት ነበር?

የበሬ ሁኔታ	የደለበ	ያልደለበ
ትንሽ በሬ		
መካከለኛ በሬ		
ከፍተኛ በሬ		

12. የበሬ ግጦና ሽያጭ በምን ሁኔታ ያከናውናሉ? ሀ/ በስምምነት ለ/ በኪሎ ግራም ሐ/ ሌላ
13. አንድ በሬ መድለቡንና ለገበያ መድረሱን በምን ያውቃሉ?----------
14. በሬ ካደለቡ በኋላ የገበያ ችግር አለ? ሀ፣ አለ ለ፣ የለም
15. ያደለቡትን በሬ ለማን ይሸጣሉ?----------
16. በበሬ ግዥና ሽያጭ ወቅት ዋጋ የሚወስነው ማን ነው? ሀ፣ ሻጭና ገዥ ለ፣ ደላላ ሐ፣ ሌላ ----------
17. የበሬ የቆዳ ቀለም ግዥና ሽያጭ ላይ ተፅዕኖ አለው? ሀ፣ አዎ ለ፣ የለውም
18. ካለው ምን አይነት የቆዳ ቀለም ተመራጭ ነው?----------
19. የበሬ ግዥ ወቅታዊ መረጃ ያገኛሉ? ሀ፣ አዎ ለ፣ አላገኝም
20. የሚያገኙ ከሆነ ከማንና እንዴት ያገኛሉ?----------
21. ከበሬ ሽያጭና ግዥ ጋር ተያይዞ ያልተነሱ መነሳት ያለባቸው ጉዳዮች ይጥቀሱ?----------

ቢ. የበሬ ትርንስፖርት በተመለከተ የሚጠየቁ ጥያቄዎች

1. የተገዙና የሚሸጡ በሬዎችን እንዴት ያጓጉዛሉ? ሀ፣ በእግር በመንዳት ለ፣ በመኪና
2. በመኪና ከሆነ ሀ/ ለበሬዎች ተብሎ የተዘጋጀ መኪና ለ/ በማንኛውም
3. በእግራቸው የሚነዱ ከሆነ
   ሀ/ ከብቶችን ማን ይነዳል? ----------
   ለ/ በቀን በእግር ስንት ኪ.ሜ ይጓዛሉ? ----------
   ሐ/ የሚያስነዱ ከሆነ ለነጂ ለአንድ ከብት ሰንት ይከፍላሉ? ----------
   መ/ በሚነዱበት ወቅት ምን አይነት እንክብካቤ ያገኛሉ? ----------
4. ከበሬ ማጓጓዣ ጋር ተያይዞ መነሳት ያለባቸው ጉዳዮች ካሉ ይጥቀሱ?----------

ተ. ከማድለብ ጋር የተያያዙ ችግሮችና ምቹ ሁኔታዎችን ለመለየት የሚጠየቁ ጥያቄዎች

1. ለበሬ ማድለብ መሰረታዊ ችግሮች ምን ምን ናቸው?

ተ.ቁ	ችግሮች	ደረጃ	ችግሮች	ደረጃ
ሀ			ረ	
ለ			ሰ	

2. በሬ ማድለብ ጋር ተያይዞ በአካባቢው ያሉ ምቹ ሁኔታዎችን ይዘርዝሩ? ሀ፣
   ለ፣ ሐ፣ መ፣

ቸ.ከበሬ ማድለብ ጋር በተያያዘ የግለሰቡን የግል አመለካከት ለመለካት የሚጠየቁ ጥያቄዎች

1. በሬ ማድለብ ለመጀመር ምን አነሳሳዎት?----------
2. ከበሬ ማድለብ ጋር ተያይዞ ዘመናዊ ማድለብ ስልጠና ወስደዋል? ሀ፣ አዎ ለ፣ አልወሰድኩም
3. ከዚሁ ዘርፍ ጋር ተያይዞ የወደፊት ዕቅድዎ ምንድን ነው? ሀ፣ ማስፋፋት ለ፣ ማቆም
4. ከበሬ ማድለብ ጋር ተይይዞ ድጋፍ ቢደረግልዎ የሚፈልጉትን ነገር ይግለፅ?----------
5. ይህንን ዘርፍ በተሻለ ለማሳደግ በሚመለከታቸው አካላት ምን መደረግ አለበት ይላሉ?----------
6. በአጠቃላይ የበሬ ማድለብ ስራ ውጤቱን ሲመዝኑት? ሀ፣ አትራፊ ነው ለ፣ አክሳሪ ነው

ላደረጉት ታላቅ አስተዋፅኦ ከልብ አመሰግናለሁ፤፣

የመረጃ ሰብሳቢው ሰም ---------- ***ፊርማ*** ---------- ***መረጃው የተሰበሰበበት ቀን*** ----------

መረጃውን ያረጋገጠው ተመራማሪ ----------

Appendix 2: Guide questions for focus group discussion and key informant interview

To assess cattle fattening practices, common conventional and non-conventional feed resources used for cattle fattening in Dessie and Kombolcha towns, Ethiopia

My name is Kassahun. I am a PhD student in Addis Ababa University, College of Veterinary Medicine and Agriculture in the Department of Animal Production Studies. The objective of the survey is to assess cattle fattening practices and common conventional and non-conventional feed resources used for cattle fattening in Dessie and Kombolcha Town. Accordingly, the researcher is ready and enthusiastic to learn from you about cattle fattening practices, common conventional and non-conventional feed resources used for cattle fattening. Since, you are experienced person to teach and tell about the entire practical, indigenousness as well as scientific knowledge related to the topic. Therefore, kindly, I (the researcher) request you to teach him by responding the following questions mentioned below. As a remark, I assure you that, the data I will gather from you is used for the partial fulfillment of Philosophy of doctorate in Animal Production Studies. To end, in advance, I am glad to say thank you in millions for your valuable contribution.

Guide questions for group discussion and key informant interview on cattle fattening practices, common conventional and non-conventional feed resources used for cattle fattening

Target group:	**For focus group discussion (A)**	**For key informant interview (B)**	
	➢ **Model cattle fatteners**	➢ **Agricultural experts from different organization**	
	➢ **Elders and experienced fatteners**	➢ **Concerned office manager**	
		➢ **Development Agents**	
		➢ **Kebele Administrator**	
		➢ **Feed suppliers and traders**	

Points for group discussion and key informant interview		***Remark***
Question category	**Specific question**	
Gender issue	Which gender plays a great role for cattle fattening? Explain the role?	***AB***
Production system	Indicate the type of livestock production system of the area?	***B***
Fattening system	Indicate the cattle fattening systems and structure of the area?	***B***
Cattle selection	Please indicate cattle breeds/types available in your area?	***AB***
	What type/breed of cattle do fatteners used for fattening? Indicate the name of breed? Local or other	***AB***
	Indicate sex of cattle used for fattening	***A***
	Which type of cattle category prefer for fattening purpose? Eg, ox, bull, culled cow etc	***AB***
	Indicate and discuss the average age of cattle used for cattle fattening (in years)	***AB***
	Condition of cattle used for fattening (Castrated/ un-castrated) Why?	***AB***
	What type of cattle fatteners use d for fattening (Cattle never used for plowing /Cattle used for plowing)	***AB***
	Does skin color has effect on fatteners cattle purchase and selling process	*A*
	When fatteners placed cattle's for fattening? (After plowing / before plowing) Why	***AB***
Source of cattle	From where fatteners get cattle for fattening purpose (source of fattening cattle)?	***AB***
Frequency of fattening	How many times do fatteners fatten cattle per year in your area?	***AB***
	How many cattle do fatteners fatten per fattening period in your area?	***A***
	On average, in your area, for how long do fatteners supplement the cattle to finish its fattening period?	***AB***
	How do fatteners decide the end of the finishing period?	***AB***
Season of fattening	Which months/SEASON of the year fatteners prefer to practice cattle fattening activities?	***AB***
Feed and Feeding	Explain feed resources available for cattle fattening in the area?	***AB***
	Explain feeds available in Wet & Dry season? Explain feeds available year round in your area?	***AB***
	From where you get the feed / source of feed for cattle fattening? Price of feeds?	***AB***
	What type of feed fatteners offered to fattening cattle? How much they provide per day?	***A***
	How fatteners fed their fattening cattle?	***A***
	How money times fatteners provide feed for fatten cattle per day?	***A***
	Do you supplement your fattening cattle?	***A***
	If yes, in what sequence do fatteners feed their fattening cattle per day?	***A***
	Is there any variation in daily dry matter intake with in wet and dry season	***A***
	In which season fattening cattle gain more?	***A***
	How much it costs the daily, monthly, total cost of feed for one fattening cattle?	***A***
	Generally, how much cost fatteners expend for a single cattle to fatten?	*A*
	Is there feed shortage for cattle fattening in general? What do fatteners do to cope up?	***AB***

Appendix 2. Guide questions for focus group discussion and key informant interview *(continued)*

Water & watering	Do fatteners supply water for their fattening cattle? If yes, source of water?	***AB***
	How did fatteners provide water for fattening cattle?	***AB***
	If fatteners take the animal to water source, how long the cattle travel?	***AB***
	How frequently cattle are watered during dry & wet season? How much?	***A***
Salt supplementation	Do fatteners provide salt for fattening cattle?	***AB***
	How frequently fatteners provide salt for cattle? How much salt fattener provide per day per animal?	***A***
Housing practices	Do fatteners prepare house for fattening cattle?	***AB***
	If yes, type of house used for fattening cattle? What materials are used? Different structures of the house?	***AB***
	Do fatteners prepare separate pen, feeding trough, & gutter for each cattle?	***AB***
Disease and health	Is there internal and external parasites and disease which affect fatteners fattening cattle? What are they?	***AB***
	Do fatteners have indigenous knowledge to prevent & treat? Explain?	***AB***
	Do fatteners use any hormone? or feed additives?	***AB***
	Do fatteners have experience for deworming their fattening cattle?	***AB***
Cattle marketing	Explain the cattle marketing system and facilities in your area, who are the participants? Type of market?	***AB***
	Do fatteners use separate market for buying and selling?	***A***
	Indicate the average distance where marketing of fattening cattle is mostly takes place	***A***
	Do cattle prices show variation seasonally? In which season fatten cattle highly demanded	***AB***
	What criterions have fatteners considered for buying fattening cattle? (Rank in the order of importance)	***A***
	How was the price of cattle in this year? Lower/medium/ highest price?	***A***
	How do fatteners sell their fattened cattle? Who determine cattle price during buying & selling	***A***
	Where do fatteners sell their fattened cattle most of the time?	***A***
	For whom do fatteners sell their fattened cattle most of the time?	***A***
	On which months of the year, demands for fattened cattle become high and low?	***A***
	How is trend on demand/volume of customers? If decreasing or increasing? Explain the reason?	***AB***
Information accesses	Do fatteners have access to market information about supply, demand and price conditions?	***AB***
	If yes, How do fatteners get information about cattle fattening and marketing? (Rank in order)	***AB***
Cattle transportation	How do fatteners transport their cattle before and after fattening?	***AB***
	If fatteners use vehicle, what type of vehicle use?	***AB***
	If fatteners use Trekking? Who transport the animals?	***A***
	Do fatteners provide rest, feed and water during transportation?	***AB***
	How long fatteners allow cattle to travel per day (KM)?	***A***
Constraints	What are those technical and non-technical constraints that affect cattle fattening (Rank based on severity)	***AB***
	Comparative advantages and disadvantages of the sector	***AB***
	What are those challenges for fattening practices?	***AB***
Opportunities	What are those opportunities for fattening?	***AB***
Institutional support	Have fatteners taken any formal training on cattle fattening?	***AB***
	Do fatteners need any support related to cattle fattening? yes /No	***AB***
	Do fatteners have access to veterinary services?	***AB***
	What is fattener's future opinion about fattening?	***AB***
Reason of fattening	What are fattener's reasons for starting cattle fattening activity?	***AB***
Opinions'	What is fatteners general opinion about cattle fattening	***AB***
	What type of development interventions needed to enhance cattle fattening activity in your area?	***AB***
	Explain your organization future plan to improve the sector	***B***
	What is your contribution for the already started fattening program in your area	***B***
	Why people undertake fattening in your area	***AB***

Appendix 3: Feed resources identification sheet

	Feed resources identification sheet											
	Common feed resources used for cattle fattening in Dessie and Kombolcha areas											
No	Feed type	Town Dessie (1) Kombolcha(2) Both (3)	Month of availability	Price			Suppliers (Namely)	Current capacity production		Overall production capacity/day	Production efficiency	Remark
				Unit	Current price/unit	Price range/ unit		Per month	Per year			

Appendix 4: Anatomical and physical considerations of cattle fatteners to purchase cattle for fattening in Dessie and Kombolcha areas

Anatomical considerations	Physical considerations	Local expressions (Amharic)
• Frame and skeletal development	• Well framed, full and large skeleton	• *Atintu yebesele; Atintam*
• Body length	• Lengthy	• *Shintam yehone*
• Height	• Elevated	• *Zeleg yale*
• Health condition	• Health and alert	• *Tenama ena neku*
• Body condition	• Not emaciated	• *Betam yalkessa*
• Muscle	• Well-muscled	• *Belit yalew*
• Appearance	• Attractive	• *Melke-melkam*
• Back side	• Wide	• *Kitu sefi/fegaraw sefi/ kit-kifit*
• Horn size	• Medium	• *Mekekelegna kend*
• Body shape	• Rectangular	• *Yetesetekakele sewnet yalew; wot sewnet yalaw*
• Neck	• Wide and long	• *Angetu sefi,rejiem*
• Hump	• Well developed and straight up ward	• *Ket yale shagna yalew*
• Back bone	• Wide and straight	• *Ket yale ena sefi wogeb*
• Tail	• Wide and up tail	• *Jiratu yetenesa, sefi*
• Dewlap	• Well-developed dewlap	• *Dalga yalew*
• Tie and round	• Wide tie and round	• *Sefi tafa*
• Leg	• Straight leg	• *ket yale egger yalaw*
• Claw	• Wide to hold animal weight and muscle	• *Sefi kote*
• Hide	• Soft	• *Yelala koda*
• Maturity	• Matured but not young (for peri-urban fatteners)	• *Besel yale*
• Any disability	• One of the eyes not functional, broken teeth, no tail	• *Ayinu yetefa, jiratu korata, tirisu yetesebere*
• Abdomen and belly	• Small belly and gut	• *Tinish hod, zergif yalhone*

Appendix 5: Indigenous knowledge of cattle fatteners to assure a given cattle reached for market in Dessie and Kombolcha areas

Anatomical and physiological observations	Signs	Local expression in Amharic
Fattening level	Cattle become very fatty	*Yiwoferal*
Leg position	Stretched their legs when laydown, rumination and rest	*Sitegnu egrechewn yizeregalu*
Breathing condition	Pronounced and fast breathing	*Fetan atenefafes yinorachewal, Tolo tolo metenfes*
Amount of gas	Increase gas during rumination and rest	*Fes yabezalu*
Feed intake and appetite	Decrease feed intake and appetite	*Megib yikensalu*
Tail and back bone area	Tail and back bone area show border and clear division	*Jiratachew kewogebachew yileyayal*
Round, pin bone, rear side	Increased muscle around the round, pins bone and rear side	*Akofow sega yimolal* *Tafaw ser yalew gadi yisemtal*
Neck	Increased muscle deposition around neck area	*Dendesachew yimolal*
Movement	Difficulty to move fast	*Sihedu gadiw yiyizachewal*
	Difficulty to stand	*Menesat yichegeralu*
Sweat	Increased sweating	*Lab yabezalu*
Elasticity of the body	Elasticity of the body and hide increased	*Sewnetu yiletetal*
Roundness	Increase roundness at back	*Kitu yimolal*

Appendix 6: Fattening cattle health problems and therapeutic measures of cattle fatteners in Dessie and Kombolcha areas

	Common name	Local name (Amharic)	Cause	Symptoms	Cultural remedy	Recommended dose & frequency	Curability status based on cattle fatteners opinion	Side effect of the cultural remedy
1	Tick	*Mejiger*	NR	Presence of tick in the body of cattle, barn and farm	• Washing the body of cattle with *endod* water or cold water or *degita leaf* or *Ajakis* (Soap)	Once when it appear	Effective and curable	No side effect
2	Diarrhoea	*Tekimat*	Feeding excess concentrate feeds	Watery dung	• Restriction of concentrate feed particularly wheat middling and oil seed cakes • Provision of dry roughages	NR	Curable	No side effect
3	Bloat (Rumen acidosis)	*Hode menfat*	Feeding excess concentrate feeds at the commencement of fattening	Bulging out of stomach and difficulty of breathing	• Drenching of oil (hair food oil)	Once when the case occurred (1/8 litter)	Effective and more curable	No side effect
4	NR	*Mich*	Feeding oil seed cakes such as linseed and nuge seed cakes	Hair erection and un able to stand	• Bleed using knife around the tail and back bone area locally called '*jiratun mebetat'*, and wash with water • Smoking of different leaf and roots; *locally called 'Yewof gojo' and 'kebercho'* • As prevention practice, they protect cattle from hot sunlight and provision of oil seeds ingredients in the house /shade and night time	1. 2 to 3 times 2. Once	Curable	Affect hide

NR= not reported

Appendix 6. Fattening cattle health problems and indigenous measures of cattle fatteners to cure in Dessie and Kombolcha areas (*continued)*

Common name		Local name in Amharic	Cause	Symptoms	Cultural remedy	Recommended dose & frequency	Curability status based on cattle fatteners opinion	Side effect of the remedy
5	Feed toxicity	NR	Feeding excess amount of grass pea leftover in the ration	Unable to stand for long period of time and paralysis	• Decrease amount of grass pea leftover in the ration	NR	Curable	No side effect
6	FMD (Foot and Mouth Disease)	*Maz*	Muddy barn and muddy fattening site	Stamp their feet, prefer to lie down and unable to move	• Dress with honey and wheat bran • As prevention, cleaning barn and fattening area	Once when it occurred	Less curable	No side effect
7	LSD (Lumpy Skin Disease)	*Agurebereb*	Not known	Skin irritation, lesions, oedematous, inflammatory swellings of the brisket and limbs	• Smoldering locally called '*Metekos*' with hot iron (*knife)* in the diseased part • Wash using soap	Once when it occurred	Less curable	Affect hide
8	Trauma/injury	*Agodo*	Due to cattle attack	Bulged spot on the body	• Smoldering with hot iron	Once when it occurred	Less curable	Affect hide
9	NR	*Mafers*	Un able to take feed	Loss of body weight after gain	• Supplement other feeds type • Culling from the farm	NR	NR	NR

NR = not reported

Appendix 7: Available cattle market in and around Dessie and Kombolcha areas

	Market name	Location	KM from Dessie	Marketing day
1	Segno Gebeya *	Dessie	8	Monday
2	Boru Selase	Dessie	13	Saturday
3	Kutaber	Kutaber	28	Thursday
4	Hayik ***	Tehuledare	30	Friday
5	Kombolcha	Kombolcha	23	Saturday
6	Kemisse **	Kemisse	70	Thursday
7	Bati	Bati	55	Monday
8	Raya Kobo **	Kobo	170	Saturday
9	Soba	Albuko	34	Thursday
10	Checha	Akesta	79	Tuesday
11	Kabe	Worqilu	133	Saturday

* denoted to indicate first choice cattle market by cattle fatteners and more symbol (***) given for highly required market

Appendix 8: Challenges of cattle fattening practices with degree of severity in urban and peri-urban *kebeles* of Dessie and Kombolcha areas

Challenges	Kombolcha		Dessie	
	UK	PUK	UK	PUK
Challenges raised by urban and peri-urban cattle fatteners				
• Delay of working license		√		
• Limited practical experiences of experts and development agents	√√	√√	√√	√√
• Absence of manual or guide in local language	√√	√	√√	√
• Absence of readiness to purchased fattened cattle by Kombolcha Meat Processing Factory rather gather emaciated cattle	√√		√√	
• Lack of cattle handling equipment like nose ring and farming aids to protect human from aggressive cattle	√√	√√	√√	√√
• Absence of market information from governmental offices and different medias	√√	√√	√√	√√
• Lack of well-designed cattle transportation path and other means of transportation • Absence of reserved area for rest, feeding and watering with minimum cost while trekking cattle	√√	√	√√	√
• Limited institutional support regarding cattle ration formulation and feeding	√√	√√	√√	√√

Number of signs (√) increased indicates the degree of severity of the challenge

Appendix 8. Challenges of cattle fattening practices with degree of severity in urban and peri-urban *kebeles* of Dessie and Kombolcha areas (*continued*)

Challenges of cattle fattening practices	Kombolcha		Dessie	
	UCF	**PUCF**	**UCF**	**PUCF**
Challenges outstretched by Agricultural Experts and Development Agent's				
• Less consideration was given for animal science sector and profession. In addition, majority of the agricultural activities were done in-group wise, subsequently during reporting great emphasis was given for other agriculture sections. Accordingly, animal science expertise engaged and evaluated by other agriculture related activities. Moreover, other than animal scientists, other agriculture specialties assigned for the guidance of animal science activities. • Fewer activities were performed to update the skill of expertise. • Animal scientists by themselves are not practical model for the cattle-fattening sector. • Drifting of animal science experts to other field of study	√√	√√	√√	√√
• Dominancy of traditional cattle fattening practices and handling culture		√√		√√
• Absence of live-weight based cattle marketing	√√	√√	√√	√√
Challenges raised by Agricultural Experts and DA's, and cattle fatteners in common				
• Fast expansion rate in urban land use change in the peripheral agricultural farmlands and impact of urbanization which leads to farm lands allocation to investors and urban expansion	√	√√		
• Limited modern fattening experience and absence of model governmental farms for practical demonstration in the vicinity	√	√√	√	√√
• Absence of market linkage between private and governmental stockholders	√√	√	√√	√
• Lack of governmental feed processing factories	√√	√	√√	√
• Lack of cooperation within and between organized cattle fatteners	√		√	
• Poor cattle market infrastructure	√√	√√	√√	√√
• Environmental challenge			√√	√√

Number of signs (√) increased indicates the degree of severity of the challenge; UCF= urban cattle fatteners; PUCF= peri-urban cattle fatteners

Appendix 8. Challenges of cattle fattening practices with degree of severity in urban and peri-urban *kebeles* of Dessie and Kombolcha areas (*continued*)

Challenges of cattle fattening practices	Kombolcha		Dessie	
	UCF	**PUCF**	**UCF**	**PUCF**
Challenges raised by Kombolcha ELFORA meat processing factory				
▪ Absence of cattle fattening farm that has continuous capacity to supply up to the factory demand	√√	√	√√	√
Challenges raised by municipality slaughter house experts and observed by the researcher				
▪ Lack of organized and computerized recording system at offices and *kebele* level ▪ Absence of recorded information concerning overall management aspect at individual cattle fatteners' level. Particularly, peri-urban cattle fatteners' has no recording system completely. Exceptionally, urban cattle fatteners tried to record information related to marketing condition with the guidance of experts	√	√√	√	√√
▪ Individuals or groups opened cattle fattening farm without professional license	√	√√	√	√√
▪ Lack of modernized veterinary equipment and laboratory in slaughtering house ▪ Presence of old meat processing house with old infrastructure ▪ Absence of recorded data on the medication history of cattle to check and trace back for proper controlling of drug withdrawal period	√		√√	

Number of signs (√) increased indicates the degree of severity of the challenge; UCF = urban cattle fatteners; PUCF = peri-urban cattle fatteners

Appendix 9: Opportunities for cattle fattening practices in Dessie and Kombolcha areas

Opportunities	Dessie	Kombolcha
• Presence of clustered cattle fattening house or shade	Yes for urban fatteners	Yes for urban fatteners
• Suitable environment for cattle fattening	No	Yes
• Presence of flour factories	Five	Two
• Advancement of micro and small scale human food processers at individual and group wise level used as feed sources	18	36
• Advancement of milling house served as a source for different processed and leftover feeds	34	36
• Being their of governmental and newly emerging small-scale private poultry farms used as a source of poultry litter.	Yes	Yes
• Presence of Kombolcha Brewery Factory for continuous wet brewery grain supply with minimum price	No	Yes
• Establishment of sugar factory in the boundary region. The byproducts of the factory (molasses, sugarcane tops and leaf) could be used as a supplement for cattle fattening.	Less advantageous due to proximity	More advantageous due to proximity
• Hay preparation experience of the farmers in the peri-urban *kebeles* and the vicinity *Woredas*.	More practiced	Less practiced
• Centrality of the study towns for different rural and urban *Woredas* of Amhara region to access different feeds	Equally benefited	Equally benefited
• Presence of huge coverage of crop production in and around the study towns which is one possible means of byproducts	More advantageous due to large coverage	Less advantageous due to less coverage
• Increased demand for meat due to increase the number of hotels and restaurants • Emerging middle-class urban dwellers with higher income and more buying power	Equally benefited	Equally benefited
• Urbanization than before	Less advantageous	More advantageous
• Being there of ten and more cattle market in different days in and around the study towns	Equally benefited	Equally benefited

Appendix 9. Opportunities for cattle fattening practices in Dessie and Kombolcha areas (*continued*)

Opportunities	Dessie	Kombolcha
• Accessibility and central location of both towns with Afar, Tigray Region and Addis Ababa has advantage as a source of fattening cattle, feed sources and cattle market.	Equally benefited	Equally benefited
• Presence of meat processing factory in Kombolcha town will serve as a customer for marketable fatten animal for the future.	Less advantageous	More advantageous
• Presence of large number of cattle population in and around the study towns, the vicinity *Woredas* and the region.	Equally benefited	Equally benefited
• Federal as well as regional government emphasis for urban agriculture • Presence of assigned experts and DAs at *kebele* and *Woreda* level for the technical support and extension services.	Equally benefited	Equally benefited
• Establishment of cattle marketing proclamation at country level	Equally benefited	Equally benefited
• Motives and interest of the educated society to be part of the sector in both study towns	Equally benefited	Equally benefited
• Cattle fattener's indigenous cattle fattening knowledge, cultural medication, idea sharing, copying and better adoption tradition from model cattle fatteners.	Less advantageous	More advantageous
• Clustered cattle fattening approach in specified fattening zone of urban *kebeles* that makes the monitoring and guidance activities more easy and it creates better media for experience sharing.	Equally benefited	Equally benefited
• Availability of infrastructure such as road, electric access, availability of water and mobile	Equally benefited	Equally benefited
• Absence of endemic fattening cattle health problems	Equally benefited	Equally benefited
• Availability of governmental veterinary services, even if it has limitation	More advantageous	Less advantageous
• Presence of private veterinary services	Equally benefited	Equally benefited
• Better experience of cattle fatteners to use poultry litter particularly in Kombolcha town	Less advantageous	More advantageous
• Presence of abattoirs in Dessie and Kombolcha towns at municipality level	One	One
• Positive opinion of cattle fattener's towards the sector	Equally benefited	Equally benefited

Appendix 10: Feed suppliers and production potentials in Dessie and Kombolcha areas

	Flour factory	Type of feed produced	Production efficiency of the apparatus to produce animal feed	Current production capacity (quintals/ year)	Daily production capacity (quintals/ day)	Yearly production capacity (quintals /year)	Factory site
1	Fowa Bel	Wheat bran, Wheat middling and factory left over	27%	4212	450	31590	Dessie
2	Fabry		20%	27560	600	31200	Dessie
3	Kenean		24%	22464	360	22464	Dessie
4	Wollo		22%	14300	1180	67496	Dessie
5	Jama Degollo		27%	17550	820	57564	Jama
6	Nur Selam		-	-	-	-	Dessie
Dessie Total				**86086 (40.9%)**	**3410**	**210314**	
7	Flower		19%	12350	660	32604	Kombolcha
8	Hussen & his sons		23%	14950	600	35880	Kombolcha
Kombolcha Total				**27300 (39.9%)**	**1260**	**68484**	
Overall Total				**113386**	**4,670**	**278798**	

Appendix 10. Feed suppliers and production potentials in Dessie and Kombolcha areas (*continued*)

Feed Supplier	Feed type Produced	Production capacity/month	Production capacity/year	Location
Poultry farms				
Kombolcha	Poultry litter	126.3 quintals	1515.31 quintals	KT
Gerado	Poultry litter	150 quintals	1800 quintals	DT
Bishoftu	Poultry litter	Access via traders	Access via traders	BT
Private small-scale poultry farms	Poultry litter	NR	NR	DKT
Small scale oil seed processers				
Seid Ali	Noug seed & linseed cake	NR	NR	DT
Huda	Noug seed & linseed cake	10 quintals	120 quintals	DT
Lemma	Noug seed & linseed cake	NR	NR	KT
Brewery factory				
Kombolcha BGI ETHIOPIA	Wet brewers grain	130-150 truck	1560-1800 truck	KT
	Dried brewers grain	6110-9600 sacks	99840-115200 sacks	KT
Milling house (Mh)				
34 mill houses (15 quintals/Mh/month)	Different leftover and hulls	510 quintals	5100 quintals	DT
36 mill houses (15 quintals/Mh/month)	Different leftover and hulls	540 quintals	5400 quintals	KT
Small scale food processer at micro level (SSFP)				
18 (12 quintals/SSFP/ month)	Different leftover and hulls	216 quintals	2160 quintals	DT
36 (12 quintals/SSFP/month)	Different leftover and hulls	432 quintals	432 quintals	KT
Local home brewing houses	'*Atella*' and '*Korefe*'	NR	NR	DKT
Wollo University	Food left over	NR	NR	DKT
Farmers	Green and dry roughage	NR	NR	DKT
Feed traders	Sugar can tops and crops	NR	NR	DKT
Government aid	Formulated rations	NR	NR	DKT
Sugar factories via traders	Molasses	NR	NR	KT

BT= Bishoftu Town; KT= Kombolcha Town; DT= Dessie Town; NR= not reported; one car/truck has a capacity to hold 16 m^3 wet brewery grain; one quintal equivalent to 100kg; one sack has capacity to hold 20kg dried brewers grain

Appendix 11: Marketing price of identified feed resources in Dessie and Kombolcha areas

Feed resource		Unit	Current price (Birr per unit measurment)	Price range (Birr)	Location
1	Day old chicks' poultry litter	kg	2.0	2.0 - 4.5	DKT
2	Layers' and pullets' poultry litter	kg	2.0	2.0 - 4.5	DKT
3	Broilers' poultry litter	kg	2.0	2.0 - 4.5	DKT
4	*'Atela'*	25 litters	15.0	10.0 - 20.0	DKT
		Monthly rent	250.0	200.0 - 300.0	DKT
5	*'Korefe'*	25 litters	12.5	12.0 - 20.0	DKT
		Monthly rent	200.0	150.0 - 250.0	DKT
6	University leftover food	NR	NR	NR	DKT
7	Green grass	*'Besew shekim'*	65.0	50.0 - 80.0	DKT
8	Green maize Stover	*'Besew shekim'*	NR	NR	DKT
9	Sugar can tops	Single top	0.25	0.25-1.00	DKT
10	Different weeds	*'Besew shekim'*	NR	NR	DKT
11	Hay	Donkey load or '*chinet'* (40kg)	100.0	90.0 - 120.0	DKT
		Mule/Horse load or '*chinet'* (50kg)	120.0	120.0 - 160.0	DKT
		Car (Isuzu)	3000.0	2500.0 - 3000.0	DKT
		Piled (17-18 kg)	55.0	50.0 - 60.0	DKT
12	Maize stover	Pile or '*Kemer'*	300.0	300.0 - 500.0	DKT
13	Teff straw	Donkey load or *'chinet'*(40kg)	170.0	150.0 - 200.0	DKT
		Pile (15-20 kg)	85.0	47.0 - 85.0	DKT
14	Wheat straw	Donkey load or '*chinet'* (40 kg)	160.0	140.0 - 200.0	DKT
15	Barley hulls	kg	4.0	4.0 - 5.0	DKT
16	Oat hulls	kg	5.0	4.0 - 5.0	DKT
17	Grass pea hulls	kg	5.0	4.5 - 5.0	DKT
18	Corn head and cob	NR	NR	NR	DKT
19	Pea hulls	kg	5.0	4.5 - 5.0	DKT
20	Bean hulls	kg	5.0	4.0 - 5.0	DKT

'Besew shekim' means measured or quantified based on a matured person ability to carry;'Kemer' or pile means a given amount of deposited feed resources; NR= not reported; DKT= Dessie and Kombolcha Towns; KT= Kombolcha Town

Appendix 11. Identified feed resources marketing price and users in Dessie and Kombolcha areas (*continued*)

Feed resource		Unit	Current price (Birr per unit measurment)	Price range (Birr)	Location
21	Barely straw	Donkey load or 'chinet' (40 kg)	160.0	140.0 - 200.0	DKT
22	Sorghum Stover	Pile or*'Kemer'*	250.0	250.0 - 450.0	DKT
23	Lentil hulls	kg	5.0	5.0 - 5.5	DKT
24	Grass pea leftover	kg	6.50	6.0 - 8.0	DKT
25	Corn grain	kg (non-processed)	5.30	4.0 - 5.40	DKT
	Processed corn grain	kg (processed)	6.0	5.20 - 6.10	DKT
26	Dried brewers grain	Truck	2700.0	2700.0	KT
		Sack (20kg)	125.0	120.0 - 130.0	KT
27	Wheat bran	kg	4.70	3.80 - 5.20	DKT
28	Wet brewers grain	Truck	2000.0	2000.0	KT
29	Oat grain	kg	32.0	26.0 - 34.0	DKT
30	Wheat middling	kg	5.50	5.0 - 5.50	DKT
31	Molasses	Litter	NR	NR	KT
32	Wheat leftover	kg	7.0	6.50 - 7.50	DKT
33	Flour factory leftover	kg	5.0	2.0 - 5.0	DKT
34	Linseed cake	kg	8.0	6.0 - 8.0	DKT
35	Different feed leftover	kg	5.0	4.0 - 5.0	DKT
36	Noug seedcake	kg	8.0	6.0 - 8.0	DKT
37	Milling leftover	kg	5.0	3.0 - 5.0	DKT
38	Barley leftover	kg	5.0	5.0 - 6.0	DKT
39	Bean leftover	kg	7.0	6.5 - 7.0	DKT
40	Lentils leftover	kg	7.0	6.5 - 7.0	DKT
41	Formulated ration	kg	5.40	5.0 - 8.0	DKT
42	Pea leftover	kg	7.0	6.5 - 7.0	DKT

Pile or'Kemer'or pile means a given amount of stored feed resources; NR= not reported; DKT= Dessie and Kombolcha Towns; KT= Kombolcha Town

Appendix 12: Month of availability and distribution of identified feed resources in Dessie and Kombolcha areas

Feed resource		Month of availability and distribution												Area
		Sept.	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	April	May	June	July	Aug.	
Green roughage														
1	Green grass	***	***	**									**	DKT
2	Standing maize	**	***	*									*	DKT
3	Sugar can tops					*	*	**	**	**	*			DKT
4	Different weeds	**										*	**	DKT
Dry roughage														
5	Hay			***	***	***	***	**	**	*				DKT
6	Maize Stover	*	***	***	*								*	DKT
7	Teff straw		*	*	**	**	*							DKT
8	Wheat straw			**	**	**	**	*						DKT
9	Barley hulls				**	**	**	*	*					DKT
10	Oat hulls				*	*	*	*	*					DKT
11	Grass pea hulls	*	**	**	**	**	*	*	*	*	*			DKT
12	Corn head & cob	*	*										*	DKT
13	Pea hulls			*	*	*	*	*	*	*				DKT
14	Bean hulls			*	*	*	*	*	*	*				DKT
15	Barley straw				**	**	**	*	*					DKT
16	Sorghum Stover		*	**	**	*								DKT
17	Lentil hulls				*	*	*							DKT
Non-conventional feed														
18	Poultry litter (Day old chicks')	**	**	**	**	**	**	**	**	**	**	**	**	DKT
19	Poultry litter (Layers', Pullets')	**	**	**	**	**	**	**	**	**	**	**	**	DKT
20	Poultry litter (Broilers')	**	**	**	**	**	**	**	**	**	**	**	**	DKT
21	'Atela' leftover	*	*	*	*	*	*	*	*	*	*			DKT
22	'Korefe' leftover	*	*	*	*	*	*	*	*	*	*			DKT
23	Leftover food	*	*	*	*	*	*	*	*	*	*	*	*	DKT

***= abundantly available **= moderately available *= less available; DKT= Dessie and Kombolcha Towns; KT= Kombolcha Town

Appendix 12. Month of availability and seasonal distribution of identified feed resources in Dessie and Kombolcha areas (*continued*)

	Feed resource	Month of availability and distribution												Area
		Sept.	Oct.	Nov.	De.	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	
24	Grass pea leftover	*	**	**	**	**	**	**	**	*	*			DKT
25	Corn grain	**	**	***	***	***	***	**	**	**	**	**	**	DKT
26	Dried brewers grain	**	**	**	**	**	**	**	**	**	**	**	**	KT
27	Wheat bran	*	***	***	***	**	**	*	*	*	*	*	*	DKT
28	Wet brewers grain	**	**	**	**	***	**	***	**	**	**	**	**	KT
29	Oat grain				*	*	*	*	*					DKT
30	Wheat middling	*	***	***	***	**	**	*	*	*	*	*	*	DKT
31	Molasses	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	KT
32	Wheat leftover	*	*	*	*	*	*	*	*	*	*	*	*	DKT
33	Flour factory leftover	*	*	*	*	*	*	*	*	*	*	*	*	DKT
34	Lin seedcake		*	*	*									DKT
35	Different feed leftover	*	*	*	*	*	*	*	*	*	*	*	*	DKT
36	Noug seedcake		*	*	*									DKT
37	Milling leftover	*	*	*	*	*	*	*	*	*	*	*	*	DKT
38	Barley leftover				**	**	**	*	*					DKT
39	Bean leftover			*	*	*	*	*	*	*				DKT
40	Lentils leftover				*	*	*							DKT
41	Formulated ration							**	**	**	**	*		DKT
42	Pea leftover			*	*	*	*	*	*	*				DKT

***= abundantly available **= moderately available *= less available; leftover = occasional surplus or damaged grain during processing, NR= not reported; DKT= Dessie and Kombolcha Towns; KT= Kombolcha Town

Appendix 13: Identified feed resource used for cattle fattening in Dessie and Kombolcha towns and their scientific name

	Feed resource	Scientific name
1	Green grass	*Cynodon dactylon*
2	Standing maize	*Zea mays*
3	Sugar can tops	*Saccharum officinarum* tops
4	Different weeds	-
5	Grass hay	*Cynodon dactylon* hay
6	Maize Stover	*Zea mays* stover
7	Teff straw	*Eragrostis* tef straw
8	Wheat straw	*Triticum Aestivum/ Triticum Durum* straw
9	Barley hulls	*Hordeum vulgare* hulls
10	Oat hulls	*Avena sativa* hulls
11	Grass pea hulls	*Lathyrus sativus L.* hulls
12	Corn head and cob	*Zea mays* head and cob
13	Pea hulls	*Pisum sativum* hulls
14	Bean hulls	*Phaseolus vulgaris* hulls
15	Barley straw	*Hordeum vulgare L.* straw
16	Sorghum Stover	*Sorghum bicolor* stover
17	Lentil hulls	*Lens culinaris* hulls
18	Poultry litter (layers', pullets')	-
19	Poultry litter (day old chicks')	-
20	Poultry litter (Broilers')	-
21	'Atela' leftover	-
22	'Korefe' leftover	-
23	University leftover food	-
24	Wheat bran	*Triticum Aestivum barn*
25	Corn grain	*Zea mays*
26	Dried brewers grain	-
27	Wet brewers grain	-
28	Wheat middling	*Triticum spelta*
29	Grass pea leftover	*Lathyrus sativus* leftover
30	Oat grain	*Avena sativa*
31	Pea leftover	*Pisum sativum* leftover
32	Wheat leftover	*Triticum aestivum* leftover
33	Flour factory leftover	-
34	Linseed cake	*Linum usitatissimum*
35	Different feed leftover	-
36	Noug seed cake	*Guizotia abissynica*
37	Milling leftover	-
38	Barley leftover	*Hordeum vulgare* leftover
39	Bean leftover	*Phaseolus vulgaris* leftover
40	Lentils leftover	*Lens culinaris* leftover
41	Formulated ration	-
42	Molasses	-

Appendix 14: Analysis of Variance (ANOVA) of feeding trial variables

	DF	Sum of Squares	Mean Square	F Value	Pr > F
Initial weight					
Trt	2	0.400000	0.200000	0.03	0.9666
Block	4	9918.666667	2479.666667	422.67	<.0001
Error	8	46.933333	5.866667		
Corrected Total	14	9966.000000			

R-Square	Coeff Var	Root MSE	initial Mean
0.995291	0.794138	2.422120	305.0000

	DF	Sum of Squares	Mean Square	F Value	Pr > F
Final weight					
Trt	2	843.600000	421.800000	6.19	0.0237
Block	4	8744.933333	2186.233333	32.09	<.0001
Error	8	545.06667	68.13333		
Corrected Total	14	10133.60000			

R-Square	Coeff Var	Root MSE	BWp6 Mean
0.946212	2.257738	8.254292	365.6000

	DF	Sum of Squares	Mean Square	F Value	Pr > F
FCE (feed conversion efficiency)					
Trt	2	0.00098093	0.00049047	8.78	0.0096
Block	4	0.00074293	0.00018573	3.32	0.0697
Error	8	0.00044707	0.00005588		
Corrected Total	14	0.00217093			

R-Square	Coeff Var	Root MSE	FCE Mean
0.794067	11.51260	0.007476	0.064933

	DF	Sum of Squares	Mean Square	F Value	Pr > F
FCR (feed conversion ratio)					
Trt	2	48.63652000	24.31826000	8.07	0.0121
Block	4	44.82857333	11.20714333	3.72	0.0539
Error	8	24.1211467	3.0151433		
Corrected Total	14	117.5862400			

R-Square	Coeff Var	Root MSE	FCR Mean
0.794864	10.90166	1.736417	15.92800

	DF	Sum of Squares	Mean Square	F Value	Pr > F
BWG (overall body weight gain)					
Trt	2	836.8000000	418.4000000	6.91	0.0181
Block	4	226.2666667	56.5666667	0.93	0.4909
Error	8	484.533333	60.566667		
Corrected Total	14	1547.600000			

R-Square	Coeff Var	Root MSE	BWG Mean
0.686913	12.84234	7.782459	60.60000

Appendix 14. Analysis of variance (ANOVA) of feeding trial variables (continued)

	DF	Sum of Squares	Mean Square	F Value	Pr > F
DG (daily gain)					
Trt	2	0.10330864	0.05165432	6.91	0.0181
Block	4	0.02793416	0.00698354	0.93	0.4909
Error	8	0.05981893	0.00747737		
Corrected Total	14	0.19106173			

R-Square	Coeff Var	Root MSE	DG Mean
0.686913	12.84234	0.086472	0.673333

	DF	Sum of Squares	Mean Square	F Value	Pr > F
BCSI (body condition score initial)					
Trt	2	0.00000000	0.00000000	0.00	.
Block	4	9.60000000	2.40000000	0.00	<.0001
Error	8	0.00000000	0.00000000		
Corrected Total	14	9.60000000			

R-Square	Coeff Var	Root MSE	BCSI Mean
1.000000	0	0	3.600000

	DF	Sum of Squares	Mean Square	F Value	Pr > F
BCSF (body condition score final)					
Trt	2	1.20000000	0.60000000	3.27	0.0915
Block	4	5.73333333	1.43333333	7.82	0.0072
Error	8	1.46666667	0.18333333		
Corrected Total	14	8.40000000			

R-Square	Coeff Var	Root MSE	BCSF Mean
0.825397	6.296683	0.428174	6.800000

	DF	Sum of Squares	Mean Square	F Value	Pr > F
BCSC (body condition score change)					
Trt	2	1.20000000	0.60000000	3.27	0.0915
Block	4	1.73333333	0.43333333	2.36	0.1397
Error	8	1.46666667	0.18333333		
Corrected Total	14	4.40000000			

R-Square	Coeff Var	Root MSE	BCSC Mean
0.666667	13.38045	0.428174	3.200000

	DF	Sum of Squares	Mean Square	F Value	Pr > F
SW (slaughter body weight)					
Trt	2	973.166667	486.583333	6.60	0.0305
Block	3	4375.333333	1458.444444	19.79	0.0016
Error	6	442.166667	73.694444		
Corrected Total	11	5790.666667			

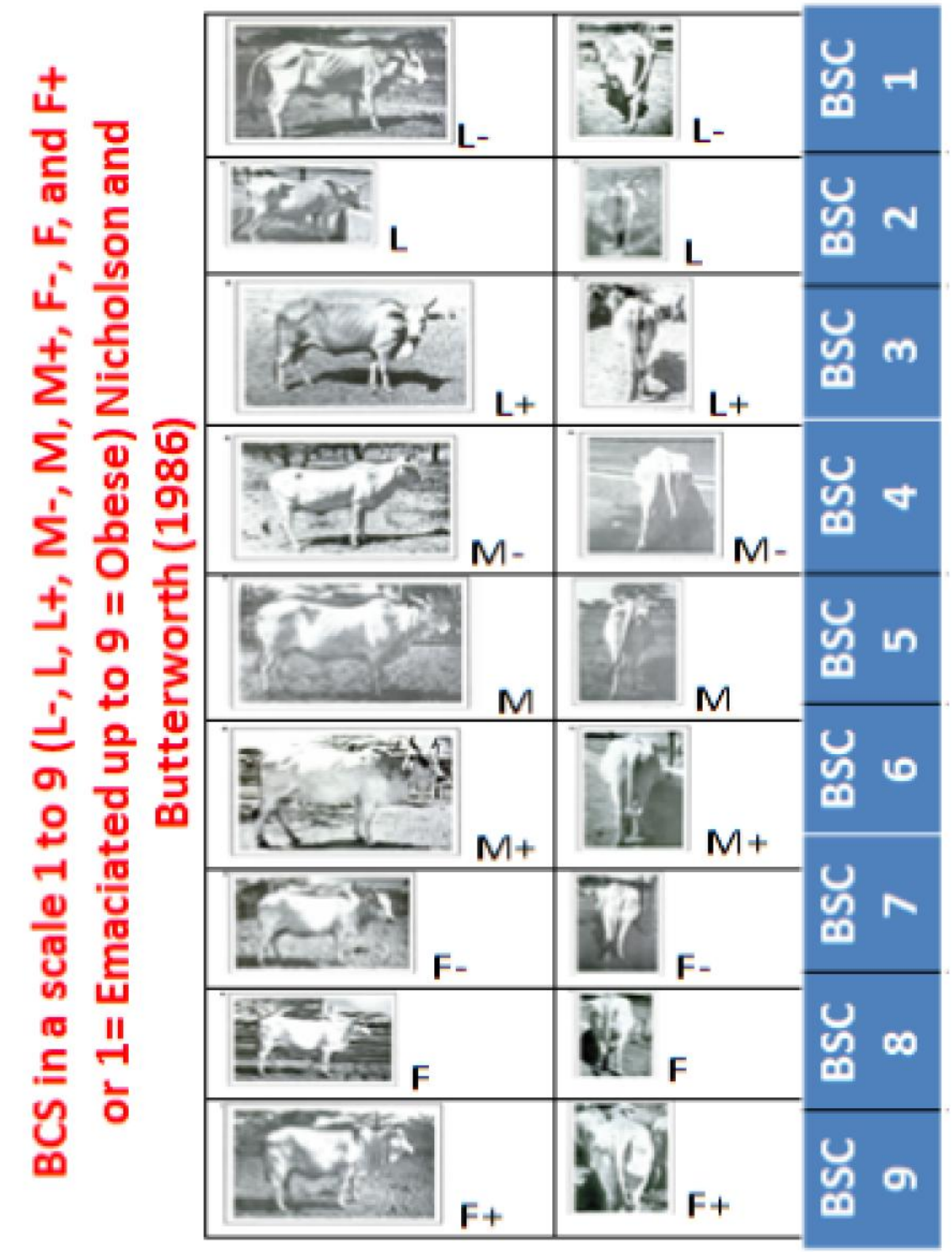
R-Square	Coeff Var	Root MSE	SW Mean
0.923641	2.406882	8.584547	356.6667

	DF	Sum of Squares	Mean Square	F Value	Pr > F
EBW (empty body weight)					
Trt	2	2037.125000	1018.562500	18.67	0.0027
Block	3	4164.562500	1388.187500	25.44	0.0008
Error	6	327.375000	54.562500		
Corrected Total	11	6529.062500			

R-Square	Coeff Var	Root MSE	EBW Mean
0.949859	2.377994	7.386643	310.6250

Appendix 14. Analysis of variance (ANOVA) of feeding trial variables (continued)

		Sum of			
	DF	Squares	Mean Square	F Value	Pr > F
HC (hot carcass)					
Trt	2	1204.541667	602.270833	20.27	0.0021
Block	3	2094.895833	698.298611	23.50	0.0010
Error	6	178.291667	29.715278		
Corrected Total	11	3477.729167			
R-Square	Coeff Var	Root MSE	HC Mean		
0.948733	2.692491	5.451172	202.4583		
DPEWB (dressing percentage empty weight based)					
Trt	2	3.94461667	1.97230833	4.50	0.0641
Block	3	1.93535833	0.64511944	1.47	0.3139
Error	6	2.63111667	0.43851944		
Corrected Total	11	8.51109167			
R-Square	Coeff Var	Root MSE	DPEWB Mean		
0.690860	1.016735	0.662208	65.13083		
DPSWB (dressing percentage at slaughter weight base)					
Trt	2	22.29526667	11.14763333	29.24	0.0008
Block	3	6.55635833	2.18545278	5.73	0.0340
Error	6	2.28726667	0.38121111		
Corrected Total	11	31.13889167			
R-Square	Coeff Var	Root MSE	DPSWB Mean		
0.926546	1.089394	0.617423	56.67583		



Appendix Figure 1: Body Condition Score (BCS)

PUBLISHED ARTICLES

Kassahun Ahmed, Berhan Tamir and Ashenafi Mengistu (2017). Fattening cattle feeding practices of urban and peri-urban cattle fatteners in Dessie and Kombolcha towns, Ethiopia. *World Applied Sciences Journal*, **35** (3): 370-376.

Kassahun Ahmed, **Berhan Tamir and Ashenafi Mengistu (2017**). Fattening cattle health problems and fatteners indigenous measures in Dessie and Kombolcha towns, Ethiopia. *Agriculture and Biology Journal of North America*, **8** (3):85-93.

Kassahun Ahmed, Berhan Tamir and Ashenafi Mengistu (2017). Fattening cattle salt supplementation and watering practices of urban and peri-urban cattle fatteners in Dessie and Kombolcha towns, Ethiopia. *European Scientific Journal,* **13** (9): 22-30.

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Kassahun Ahmed, Berhan Tamir and Ashenafi Mengistu (2017). Means of transportation of fattening cattle, services while shipping and institutional support in Dessie and Kombolcha towns, Ethiopia. *Advances in Biological Research* **11** (1): 35-40

Kassahun Ahmed, Berhan Tamir and Ashenafi Mengistu (2017). Identification of feed resources for cattle fattening and chemical composition determination in Dessie and Kombolcha towns, Ethiopia. *European Scientific Journal*, **13** (9): 456-484.

Kassahun Ahmed, Berhan Tamir and Ashenafi Mengistu (2017). Cattle Selection Criteria and Fattening Practices in Urban and Peri-Urban *Kebeles* of Dessie and Kombolcha Towns, Ethiopia.*Online Journal of Animal and Feed Research,* **7**(2): 29-37.