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SHEEP PRODUCTION SYSTEMS IN URBAN AND PERI-URBAN AREAS OF DEBRE-BERHAN AND DESSIE, ETHIOPIA, AND PERFORMANCE OF LAMBS FED DIFFERENT COMBINATIONS OF WHEAT BRAN AND LENTIL SCREENING

PhD Dissertation

By

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Addis Ababa University, College of Veterinary Medicine and Agriculture
Department of Animal Production Studies
PhD Program in Animal Production,

June, 2017
Bishoftu, Ethiopia

TITLE PAGE

SHEEP PRODUCTION SYSTEMS IN URBAN AND PERI-URBAN AREAS OF DEBRE-BERHAN AND DESSIE, ETHIOPIA, AND PERFORMANCE OF LAMBS FED DIFFERENT COMBINATIONS OF WHEAT BRAN AND LENTIL SCREENING

A Dissertation Submitted to the College of Veterinary Medicine and Agriculture of Addis Ababa University in Fulfillment of the Requirements for the Degree of Doctor of Philosophy in Animal Production

By

Wude Tsega Beyene

BSc (Animal Sciences)

MSc (Animal Production)

June, 2017

Bishoftu, Ethiopia

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Addis Ababa University
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As members of the Examining Board of the final PhD open defense, we certify that we have read and evaluated the Dissertation prepared by Wude Tsega Beyene, titled: Sheep Production Systems in Urban and Peri-Urban Areas of Debre-Berhan and Dessie, Ethiopia, and Performance of Lambs Fed Different Combinations of Wheat Bran and Lentil Screening, and recommend that it be accepted as fulfilling the dissertation requirement for the degree of Philosophy in Animal Production.

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BIOGRAPHICAL SKETCH

Wude Tsega Beyene was born on 22 Augest, 1978 in Mokesh Peasant Association, Gonder, Ethiopia. She attended her elementary and secondary school education in Yibar Primary and Metehara High School, respectively. Then she joined Haramaya University (formerly Alemaya) of Agriculture in 1998 and graduated with BSc degree in Animal Sciences in 2001.

Soon after graduation, she was employed by the Ministry of Agriculture and Rural Development, in Assosa Zone Agricultural Departement office and worked as an animal production expert up to September 2004. In October 2004, she re-joined the School of Graduate Studies at Haramaya University to pursue her MSc study in Animal Production and graduated in 2006. Upon completion of her MSc study, Wude was employed by the Amhara Region Agricultural Research Institute, based at the Andassa Livestock Research Center and worked as Assistant Researcher. Then, she joined Addis Ababa University, College of Veterinary Medicine and Agriculture (Department of Animal Production Studies) in 2009 for her PhD study in Animal Production.

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DEDICATION

This dissertation manuscript is dedicated to my father Tsega Beyene, my mother Yeshi Yenenehe, my aunt Adanech Yenenesh and her husband Teshome Abebe; they helped me to reach to this level from the very remote rural area of my background.

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ABBREVIATIONS

ADFD	Acid Detergent Fiber Digestibility
ADL	Acid Detergent Lignin
A.O.A.C	Association of Official Analytical Chemists
AWI	Australian Wool Innovation
CP	Crude Protein
CPD	Crude Protein Digestibility
CSA	Central Statistics Authority
CSIRO	Commonwealth Scientific and Industrial Research Organization
CW	Carcass weight
DM	Dry Matter
DMD	Dry Matter Digestibility
EBW	Empty Body Weight
EE	Ether Extract
FAO	Food and Agricultural Organization
GDP	Growth Domestic Product
IBC	Institute of Biodiversity Conservation
IVOMD	In-vitro Organic Matter Digestibility
ME	Metabolizable Energy
m.a.s.l	Meters Above Sea Level
MJ	Mega Joule
MLA	Meat and Livestock Australia
N	Nitrogen
ND	Nitrogen Digestibility
NDF	Neutral Detergent Fiber
NDFD	Neutral Detergent Fiber Digestibility
NS	Non-Significant
SEM	Standard Error of Mean
SW	Slaughter Weight
SPSS	Statistical Package for the Social Sciences
TNR	Total Nitrogen Retained

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Sheep Production Systems in Urban and Peri-Urban Areas of Debre-Berhan and Dessie, Ethiopia, and Performance of Lambs Fed on Different Combinations of Wheat Bran and Lentil Screening

Wude Tsega Beyene (BSc in Animal Science, MSc in Animal Production)
PhD Dissertation, Addis Ababa University (2017)

ABSTRACT

This study consisting of survey and experimental parts was conducted to characterize sheep production systems in urban and peri-urban areas of Debre-Berhan and Dessie, Ethiopia, and evaluate the effect of different combinations of wheat bran and lentil screening on growth and carcass performance of Menz ram lambs. The survey was undertaken using 240 randomly selected households from Debre-Berhan and Dessie urban and peri-urban areas. Structured and pre-tested questionnaire, focus group discussions and personal observations were used to collect data. Based on the identified feed resources from the survey work, four treatment diets with different combinations of wheat bran and lentil screening were formulated. The treatments were T1 (30g wheat bran and 133g lentil screening), T2 (235g lentil screening), T3 (285g wheat bran), and T4 (227g wheat bran and 120g lentil screening). Twenty four Menz ram lambs of 8 to 10 months of age were grouped into six blocks based on their initial body weight and each block was randomly distributed to each treatment. Five lambs from each treatment were randomly picked and used for digestibility trial and carcass evaluation. According to the survey results, the average family size was greater in peri-urban Debre -Berhan (5.4) than that of Dessie (4.8). The sheep flock size per household was greater for peri-urban Debre-Berhan (16.7± 7.88) than peri-urban Dessie (9.3±7.18). Sheep producers were predominantly traders in urban (47.6 and 37.0%) and farmers (93.3 and 79.0%) in peri-urban areas of Debre-Berhan and Dessie, respectively. The major available feed resources in the study areas were pasture, hay, crop residues, wheat bran, nug seedcake, Attela and legume grain processing by-products. Grazing during the dry season and semi-grazing with stall feeding during the wet season were the major feeding practices identified. In Debre-Berhan area, more respondents (69.0% in urban and 58.9% in peri-urban) were involved in sheep fattening activity than in Dessie area (37.0% in urban and 37.1% in peri-urban). Urban and peri-urban sheep production contributed as a major household income source for 69.0 - 95.2% of the respondents and as a source of food for 4.8- 31% ones. As per ranking index, high feed cost, lack of improved sheep breeds, capital, and labour shortages were identified as major constraints of urban and peri-urban sheep production. Conducive weather conditions, access to concentrate feeds and attractive sheep market prices in urban and peri-urban areas were considered to be opportunities for sheep production. The feeding trial showed that the wheat bran and lentil screening combination affected ($P \leq 0.01$) the daily total dry matter intake (TDMI) of the lambs. The concentrate dry matter intake (CDMI) and total crude protein intake (TCPI) of lambs were different ($P \leq 0.001$) among the concentrate supplement groups. Lambs assigned to T4 diet showed higher TDMI (814.47 g) and TCPI (107.77g) than lambs on T_1, T_2 and T_3 diet categories.

Final body weight (FBW), total body weight gain (TWG) and average daily body weight gain (ADWG) of lambs on T_4 diet were higher ($P\leq 0.001$) than recorded from T_1, T_2 and T_3 diet categories. The experimental lambs showed lower ($P\leq 0.01$) feed conversion efficiency (0.06) for the diet containing 30g wheat bran and 133g lentil screening (T1) than the values recorded from T2, T3 and T4 diets. The lambs assigned to T_4 and T_3 diets showed higher ($P\leq0.05$) dry matter digestibility than were in T_1. Total nitrogen intake (TNI), nitrogen digestibility (ND) and nitrogen retention (NR) were higher ($P\leq 0.001$) for lambs in T_4 than T_2, which were then followed by T_3 and T_1 diet categories. The slaughter body weight was lower ($P\leq 0.001$) for those lambs were assigned in T_1 than in $T_{2,}$ T_3 and T_4. The higher ($P\leq 0.001$) empty body weight (19.56 g) was recorded for lambs assigned to T_4 diet than T_1 followed by T_2 and T_3 diet. The hot carcass yield of lambs was increased ($P\leq 0.01$) at 227g wheat bran and 120g lentil screening (T_4) supplemented groups than at T_1 and T_2 diets. The concentrate combination effect was non-significant ($P\geq 0.05$) on dressing percentage, and proportions of carcass lean, fat and bone. Lambs assigned to T_4 diet had higher weight of kidney fat and ureo-genital tract ($P\leq 0.01$) as well as respiratory tract and blood ($P\leq0.05$) than seen for other treatment categories. Except the dry matter percent of carcass fat ($P\leq 0.001$), all carcass quality parameters were not affected ($P\geq 0.05$) by the concentrate diet combinations. The wheat bran and lentil screening combination effect was significant ($P\leq0.001$) on feed cost per kg BWG with a lower value (42.34 Birr) recorded for T_4 than 65.80, 51.31 and 42.45 Birr for T1, T2 and T3, respectively. Thus, a concentrate supplement diet containing 227g wheat bran and 120g lentil screening can be considered as best for finishing of Menz ram lambs with higher body weight gain, dry matter digestibility, nutrient utilization, carcass yield and lower feed cost per kg weight gain. It could be also concluded that urban and peri-urban sheep production in the study areas offered economical advantages to the producers through sale of sheep and direct use for family consumption.

Keywords: Carcass; combinations, constraints, digestibility; feed; lamb; lentil screening, performance; peri-urban; production system; sheep, urban, wheat bran

1. INTRODUCTION

Sheep and goat production play a special role in providing immediate cash for the family. In Ethiopia, sheep production system has been categorized as highland sheep-barley system, mixed crop-livestock system, pastoral and agro-pastoral production system, ranching, and urban and peri-urban sheep production system (Azage *et al.,* 2010; Solomon *et al.,* 2008a). The sheep population in Ethiopia is estimated at 25.9 million and constitutes about 24% of the total livestock population (CSA, 2010). According to CSA (2008), the total sheep population of Ethiopia is 27,584.6. Although, reliable estimates of the number of animals kept in cities or urban livestock-keepers is difficult to find, it was estimated that about 87,397 sheep and goats were kept in urban areas (IGAD, 2008). According to Azage *et al.* (2002), about 64,767 sheep are found in major urban and peri-urban areas of Ethiopia.

Peri-urban areas are the midway between urban and rural spaces and subjected to strong demand pressures and multiple changes (Achamyeleh, 2014). Since, there is shortage of land and space in urban and pri-urban areas due to expansion of towns, crop production and rearing of large ruminants is likely to be more difficult than sheep. Sheep require less feed and space compared to cattle. Additionally, the feeding behaviors of sheep enables to integrate sheep production with various perennial crops with additional benefit of reduce input cost that can be allocated to eliminate weeds (Solomon *et. al.,* 2008b).Due to short reproductive cycles of sheep, there is a potential for a higher annual off take, and allows the producers for quick interval of selling part of the flock to generate cash income. In addition, sheep manure has a higher dry matter content that provides gardeners with high quality organic fertilizer, and does not cause significant pollution to the environment (Adane and Girma, 2008).

According to FAO (2009), urban and peri-urban sheep production can be an important entry point for poverty alleviation efforts including employment provider to the household. In these areas, sheep production can be undertaken either integrated with other livestock species, or integrated with non-livestock activities. The growing urban poverty, lack of formal employment and the proximity to market have lured many into pursuing livestock production within and around cities (Katongole *et al*. 2012) and animals are important physical and financial capitals for many urban households FAO (2007a).

Among urban and peri-urban areas in the central highlands of Ethiopia, Debre-Berhan and Dessie are considered to have a high potential for urban and peri-urban sheep production due to the availability of high sheep population around the surrounding areas. Firaw and Getnet (2010) reported that Basona Worana Woreda and South Wollo Zone are considered to have the highest potential for sheep production, in which Debre-Berhan and Dessie towns are located, respectively.

Although, urban and peri-urban sheep production is known to contribute to food security, research and development interventions for urban and peri-urban sheep production improvements are limited. Understanding urban and peri-urban sheep production systems can contribute towards development and implementation of sustainable sheep production programs. Moreover, since production system is dynamic, it is important to understand changes that might have taken over the past years.

Sheep production exists in a variety of environments under different production systems. However, the growth and reproduction ability of sheep in Ethiopia is low. The sheep producers may not exactly explain animal nutrient requirement related factors that contribute to low productivity of the animals. But, scientific works put nutrition to be the major determinant factor affecting productivity. In many animal production systems, approximately two-thirds of improvements in livestock productivity can be attributed to improved nutrition (Alemu, 2008). According to McDonald *et al.* (2002) and Olfaz *et al.* (2005), feed types and nutritional levels are related to carcass yield, carcass quality, and fat tissue development and composition. There are many factors affecting growth performance of lambs. Among these factors, the dietary energy and protein levels and their interaction are probably the most important ones (Haddad *et al*., 2001; Bellof and Pallauf, 2004). Energy and protein are the most required nutrients for sheep production, and their deficiency is characterized by lowered feed intake and poor feed efficiency due to alterations in the rumen function, which results in poor growth and muscular development (Suliman and Babiker, 2007; Stanton and Levalley, 2006).

Excessive protein levels in the diet impair the feed conversion efficiency of lambs (Ucel *et al*., 2009). Furthermore, currently, there is increasing understanding of the advantages of balanced feed for improved production. Skunmun *et al*. (2012) stated that nutrition can influence carcass and/or meat fatness and the energy to protein ratio influences muscle deposition and meat quality, which has implications in terms of animal feeds to improve animal performance.

Small scale lamb and ram finishing activities are being undertaken in different parts of Ethiopia including in urban and peri-urban areas. These activities can be used to improve carcass yield and producers` incomes, and reduce the length of time needed to reach slaughter weight (Alemu, 2008). Thus, identifying the best combinations of dietary energy and protein source concentrates is important in practical feeding systems to avoid under or overfeeding of the animals The best diet for feedlot lambs are based on locally available feeds and manipulation of nutrition and short term intensive feeding using locally available feedstuffs is a strategy that can be employed to increase animal live weight gain and subsequent carcass yield and economic feasibility (Chiba, 2009).

Therefore, it is worthwhile to characterize urban and peri-urban sheep production system and to identify major feed resources, feeding practices, constraints and opportunities of urban and peri-urban sheep production, and determine the best combinations of dietary energy and protein source feed for increased growth and carcass yield of Menz sheep lambs, which is the predominant sheep breed in the study areas.

The overall objective of this work was: to study sheep production system and identify major feed resources in urban and per-urban areas of Debre-Berhan and Dessie, Ethiopia and evaluate the effect of different wheat bran and lentil screening combinations on growth and carcass performance of Menz ram lambs.

The specific objectives were:

- To characterize sheep production systems, identify major feed resources, feeding practices and constraints in Debre-Berhan and Dessie urban and peri-urban areas,
- To determine feed intake, digestibility, nitrogen balance and body weight change of Menz ram lambs finished on different wheat bran and lentil screening combinations;
- To evaluate carcass characteristics of Menz ram lambs finished on wheat bran and lentil screening combinations;
- To analyze the partial budget of feeding of Menz ram lambs on different combinations of wheat bran and lentil screening.

2. LITERATURE REVIEW

2.1. Sheep Production Systems in Ethiopia

Ethiopia is second in Africa and sixth in the world in terms of sheep population, though benefit is little from this enormous resource due to multitude of problems (Biffa *et al*., 2006). Mammo and Wude (2012) reviewed that the common feature of all production system used in Ethiopia is mainly the extensive type, characterized by small flock sizes and the flock being periodically devastated by poor management. FAO (2004) reported that around 25% of the domestic meat consumption of Ethiopia is provided from sheep. According to Solomon *et al.* (2008) sheep production system can be clasfied as highland sheep-barley, mixed crop-livestock, pastoral, agro-pastoral, ranching, and urban and peri-urban sheep production system, which are clearly explained as follows:

a. Highland sheep-barley production system: This production system is found in the highlands above 3000 m.a.s.l. where the major crops grown are barley and pulses. Cropping intensity in these areas is generally low and sheep are the dominant livestock species with sheep flock sizes ranging from 30 to several hundred head. There is, therefore, a clear possibility of establishing more formal sheep production enterprises using appropriate technology packages in this production system.

b. Mixed crop–livestock sheep production system: this production system is found in areas where the altitude ranges between 1500 and 3000 m.a.s.l. Crop and cattle production are the dominant agricultural practices and sheep and goats are kept meeting small and immediate cash needs. Sheep are more dominant than goats in this production system. Sheep in this system experience year-round nutritional stress due to increases in cultivated land area that results in very high grazing pressure, excessive soil erosion and soil nutrient depletion. There is a need to intensify production in these areas because of the high population density.

c. Pastoral sheep production systems: these production systems are found at altitudes below 1500 m.a.s.l. mainly integrated with large livestock (camels, cattle, goats and donkeys) population and with little or no crop agriculture due to low rainfall. Agro-pastoral sheep production systems are also found below 1500 m.a.s.l. in areas with higher rainfall to support short season crops compared to the pastoral system.

d. Ranching sheep production system can be undertaken in high land and arid/semi-arid either intensive or extensive, in which it is possible to produce sheep that are more uniform and targeted to satisfy the increasing export and domestic market. This production system could be specialized to produce weaned lambs for fattening or finishing by other production systems.

2.1.1. Urban and peri-urban sheep production systems

Cattle and poultry are the most important of all livestock, although goats, sheep and equines make a significant contribution to the urban economy and household food security (Azage, 2004). Small ruminants are raised by people living in and around cities and towns, not only to contribute substantially to the animal protein needs of the urban community, but also benefit economically, with a resultant improvement in their standard of living (Anaeto *et al*., 2009). Muhammad (2008) found that keeping livestock, of which 48% sheep was a considerable source of additional income for civil servants and traders in urban and peri-urban areas of Nigeria. According to Baah *et al*. (2012) also, in urban areas of Ghana considerable number of sheep are produce for livelihood improvement of households.

Urban and peri -urban sheep production can be an important entry point for poverty alleviation and employment to the household family members (FAO, 2009). Sheep keeping in urban areas has little difference in management practices and flock productivity from those in rural areas (Barbara *et al*., 2006). In line with this, FAO (2007a) reported that, crop production and livestock production in urban production systems tend to be taken up by separate households, and mixed crop-livestock systems tend to be less common than in rural agriculture.

Likewise, since, sheep production is an important component of the livestock sub-sector as source of family income, meat, food and wool in Ethiopia; it is also economically important business in urban and peri-urban areas of the country. According to Solomon *et al.* (2008a), urban and peri-urban sheep production systems involve the production of sheep within and at the periphery of cities including Addis Ababa. In most cases, the types of sheep available from this system are for local consumption, being well-finished and fatty animals demanded by the local Ethiopian market. Dinksew and Girma (2000) stated that in Awassa, on average 4.6 sheep per household is kept for income generation and family consumption. Solomon *et al.* (2008a) also reported that the general characteristic of small-scale urban sheep production is small-scale sheep fattening to generate cash income or household consumption.

2.1.2. Breed and geographical distribution of sheep

Combining the morphological appearance and management systems, 18 indigenous sheep populations are identified, out of which Menz, Arsi-Bale and Dangila are found in the central highlands of Ethiopia (Markos, 2006). However, based on molecular characterization, Solomon (2008a) reported nine sheep breeds in the country (Table 1). There are also exotic sheep breeds which imported and are being utilize in Ethiopia. IBC (2007) reported that the major exotic sheep introduced for wool and mutton production and still in use are Awassi and Dorper sheep breeds.

Table 1 Sheep breeds and their distribution across agro-ecological zones of Ethiopia

Breed	Population	Tail type	Agro-ecology
Simien	Simien	Fat-tailed	Sub-alpine
Short-fat-tailed	Menz, Wollo, Sekota, Farta, Tikur	Fat-tailed	Sub-alpine
Gumz	Gumz	Thin-tailed	Humid lowland
Washera	Washera	Fat-tailed	Wet highland
Horro	Horro	Fat-tailed	Wet highland
Arsi	Adilo, Arsi-Bale	Fat-tailed	Wet highland
Bonga	Bonga	Fat-tailed	Wet highland
Afar	Afar	Fat-rumped	Arid lowland
Black-head-Somali	Black-head-Somali	Fat-rumped	Arid lowland

Source: Solomon *et al.* (2008b)

Menz sheep, numbering about 1.5 million, are indigenous to the highlands of Ethiopia and characterized as fat tailed, medium-sized (30-35 kg adult weight), predominantly black, brown or white in plain and patchy coat color pattern, and are raise for meat and coarse wool (Solomon *et al.* 2008a).

2.1.3. Flock sizes of sheep

Generally, about 60% of the total sheep flock is concentrated in the highlands of Ethiopia (Solomon *et al*, 2008a). The flock size of sheep is also different in different geographical areas of the country. According to Solomon *et al.* (2010), large flock size of sheep is maintained in subalpine and arid lowland areas like in Menz and Afar areas, respectively, where sheep are the main source of livelihood as crop production is unreliable. Similarly, in Lallo Mama Midir Wereda, sheep constituted 80% of the livestock production (Abebe *et al*., 2002). Getachew *et al*. (2010) reported that the mean flock size of sheep in Menz and Afar areas of Ethiopia was 31.6 and 23.0, respectively. Contrasting to this, in South Western parts, sheep production system is characterized by a small flock size, free grazing, kept on crop-livestock mixed farms, considered as a sideline business by their owners and is given marginal care (Berhanu and Aynalem, 2009). Likewise, Belete (2009) reported, 3.6 average flock sizes of sheep in Goma district.

2.1.4. Feed resources for sheep

The availability and importance of the different feed resources varies depending on the production system, farmers' livestock management practice and the production environment (Solomon *et al*., 2010). The main feed resource in highland sheep-barley production system includes wasteland grazing, stubble and sometimes straw; in mixed crop-livestock system the major feed resources are natural pasture and crop residues; in pastoral and agro-pastoral production systems rangeland is the main feed resource (Solomon *et al.,* 2008b). The same authors reported that feed resources in urban and peri-urban sheep production system are predominantly household wastes, market area wastes, byproducts and roadside grazing. Getu *et al*. (2012) also stated that though, their use is limited to urban and pre-urban livestock producers, by-products of flour mills, oil seed cakes, brewery byproducts and byproducts of the sugar factory are part of concentrate rations in Ethiopia. According to Suliman and Babiker (2007), protein concentrates originated from plants are commonly by-products of vegetable oils production such as, groundnut, sesame, cottonseed and sunflower meals are most frequently available in tropical and sub-tropical Africa.

The major feed sources for sheep in North-Western Ethiopia are natural pasture, hay, crop residues and food processing by-products (Berhanu and Aynalem, 2009; Yitaye *et al*., 2007). Food processing byproducts, which are derived in the food industry due to processing of main products are one option to utilize for livestock feeding (Abrar *et al*., 2002). As compared to non-ruminants, the ruminants, including sheep can tolerate or detoxify or at-least minimize the effect of higher concentrations of toxins from antinational factor which, may be found in byproducts (Abrar *et al*., 2002). Yenesew (2010) reported that *atella* (residue or byproduct of local beer produce) is supplemented by most of the farmers as an additional feed to their sheep. Crop residues for animal feeding are ever-increasing as more land is cropped to feed the fast-growing human population (Alemu, 2008). But, according to Kebereab *et al*. (2012) cattle can more efficiently digest roughages than sheep.

2.1.5. Management of sheep

Ann *et al*. (2000) reported that sustainable sheep production results from good management (feed and housing) and good control of diseases. Alemu (2008) stated that in feeding management it is important to avoid feed wastage, which includes overfeeding and underfeeding and ensuring that diverse types of feeds are used in the context of a balanced feeding system. Feeding management includes proper storage of feed, gradually adaptation of feeds, separate feeding and/or grazing and proper presentation of feed (Alemu, 2008). The author include that animals must be healthy and correctly handled to make the best use of feed through routine control of epizootic diseases and internal and external parasites.

There are different treatments for various diseases of sheep in Ethiopia. Traditional treatments like plants (leaves, stems and roots), water, kerosene, branding, soil and local extractions that are mixed in varying proportions and veterinary services for trans-boundary, trade sensitive and other diseases are given at various degrees in the country (Tsedeke, 2007). Markos *et al.* (2006) also reported that vaccination program, using a homologous *pestes des petits* ruminants (PPR) vaccine appeared to decrease dramatically the occurrence of the respiratory diseases.

2.1.6. Sheep productivity

In general, lambs from tropical breeds have lower birth weights and weight gains of lambs this result in lower weaning weights and consequent lower slaughter body weight. Ethiopian sheep are slaughtered on average at about 12 months of age with live weights ranging from 18–20 kg (Kassahun, 2000). Sheep finishing activities are undertaken in rural and urban areas of Ethiopia to improve the low slaughter weight of sheep. Younger growing animals utilize feed nutrients more efficiently than older and mature animals during fattening or finishing (Alemu, 2008). But not in all part of the country sheep fattening activities are undertaken. According to Berhanu and Aynalem (2009), although there is a good market price, castration and fattening are not frequently exercised in South Western part of Ethiopia. Different ram lamb fattening experiments undertaken by different authors showed that dry matter and daily body weight change of sheep are affected by feed and breed types (Table 2).

Table 2. Average dry matter intake and daily body weight gain of some Ethiopian sheep breeds

Breed	DMI	BW, %	Feed ingredients	Conc. (g)	DWG (g)	Source
Wogera	637.5	2.9	Gras hay, BDG	300	33.7	Mullu *et al.* (2008)
Washera	716.2	3.6	Millet straw, NSC, WB	300	38.4	Melese (2008)
Farta	656	3.4	Grass hay, rice bran and NSC	300	29	Abebaw (2007)

BDG = Breweries Dried Grain; NSC = Noug Seed Cake; CSC = Cotton Seed Cake; WB = Wheat Bran

Either litter size or sex or both influences initial body weight and the next growth rates of sheep; as a result, lambs born as single and male were heavier than the twin and female lambs (Berhanu and Aynalem, 2009). Annual reproduction rate of local sheep breed was 1.36 lambs per year and average litter size was 1.03 lambs per ewe per lambing, which is also affected by seasons (Abebe *et al*., 2002). The same authors reported that on average lambs weighed 1.76 kg at birth, with body weight gain range from 51.45 to70.57 g/day. According to Belete (2009), on average litter size, birth weight and weaning weight of sheep were found to be 1.37, 2.86 and 11.59 kg, respectively. As cited in Getahun (2008) age at first parturition for Menz sheep breed ranged from 423 to 474 days and the post weaning average daily gain was 50 grams.

2.1.7. Socio-economic importance of sheep

Sheep are playing important economic role in Ethiopia in the form of meat, milk, skin, hair, horns, manure and urine, cash security, gifts and religious rituals (Adane and Girma 2008; Wooster, 2005). Similarly, Abebe *et al*. (2002) pointed out that sheep provide income through the sale of live animals, wool and hides, serve as on-hand assets, and have the socio-cultural value for the resource poor farmers. In Ethiopia, especially, those sheep endowed with attractive coat-colors have always exceeded market values of their counterparts (Mammo and Wude, 2012). Dinksew and Girma (2000) reported that sheep production is becoming a viable alternative for urban production and is considered to fulfill parts of home consumption and income needs during severe shortage of cash. Solomon *et. al.* (2008b) reported that coarse wool usually used for the local carpet- making industry is produced from Menz sheep and other sheep in the central and north central highlands.

2.1.8. Constraints for sheep production

There are several factors contributing to the low productivity of sheep. This include inadequate feed, poor nutrition and lack of improved breed impair the role and productivity of sheep (Belete, 2009; Markos *et al.,* 2006). Diseases, lack of adequate veterinary service and poor housing are also the main constraints for sheep production (Anaeto *et al*., 2009; Yenesew, 2010). Diseases reduce the productivity of sheep with the mortality rate of 20-30% and causing for lamb losses before one year of age in Ethiopia (Biffa *et al*., 2006). The major causes of morbidity and mortality of sheep are fasciolosis, pneumonia, sheep pox, blackleg, anthrax, endo-parasites, ecto-parasitic and infectious diseases (Tsedeke, 2007).

Moreover, Abebe *et al.* (2002) stated that lack of capital and low price of sheep are some of the constraints of sheep production. Similarly, Adane and Girma (2008) pointed out that long marketing channels and lack of market information, low product quality, inadequate provision of credit services and low average reproductive rates are the major constraints of sheep production. Niftalem (2000) also reported that unreliable rainfall, increasing human population and landholding reduction are threats to improved sheep production in mixed farming systems.

Sheep production in Ethiopia suffers from feed shortages at all levels due to deficit in the national feed balance as a results of seasonal availability of feed in the highlands and recurrent and prolonged drought in the lowlands (Yenesew, 2010; Alemu, 2008). In Ghana, also Baah *et al*. (2012) observed that in most cases, even though, producers provided feed in *ad libitum* quantities to their animals, the quality of the feed is questionable.

2.2. Nutrition and Sheep Performance

Plane of nutrition as a factor of environment has central role to determine the body weight and carcass characteristics of lambs (Sousa *et al*., 2002; Ruzic-Muslic *et al*. 2011). The five major categories of nutrients required by sheep are water, energy, protein, vitamins and minerals (Umberger, 2009). Sheep require large quantities of energy and protein during the main period of growth between weaning and attaining mature body weight (Alemu, 2008). Intensive fattening of lambs requires monitoring of several factors, among which diet concentrations are the major ones (Ruzic-Muslic *et al*., 2011). These nutritional factors have significant effects on biochemical, structural and metabolic characteristics of muscles, and on nutritive values, organoleptic attributes and acceptability of meat from ruminants (Wood *et al*., 2003; Olfaz *et al*., 2005).

Moreover, lack of knowledge on nutrient supply through feed might lead to oversupply and severe environmental impacts (Diogo *et al*., 2010). Recently, Skunmun *et al*. (2012) reported that properly balanced diet is used to reduce methane emission from livestock and feed cost. Increasing concentrate: forage ratio in the diet can reduce the proportion of dietary intake and energy lost as methane (Kebereab *et al*., 2012).

2.2.1. Dry matter and nutrient digestibility

The nutritive value of feeds can be measured in diverse way: such as, relative proportion of nutrients, the digestibility of nutrients and the animals' voluntary intake. But, the ultimate goal of measuring the importance of the feedstuffs is performance of the animals. Protein metabolism in the rumen is the result of metabolic activity of ruminal microorganisms (Bach *et al*., 2005). Despite protein source, meals of animal products have safely and effectively used as "bypass" protein supplements while by-products from plant protein sources are mostly degraded by rumen microbes (Christoph, 2010a). Protein content in ruminant feeding should be best for growth of rumen bacteria and rate of ammonia release from protein should match the release of energy (CSIRO, 2004).

Poor efficiency of converting dietary protein into body muscles results partly from the extensive degradation of protein in the rumen with high rates of ammonia absorption and significant excretion of N in the urine (Oba *et al*., 2004). The CP should be little above the exact required quantity and proportional energy source feed is required for maintaining moderate rumen pH to avoid accumulation of ruminal ammonia (NH3-N), and to prevent N waste (Hassan and Saeed, 2012). Methane production in the rumen is an energetically wasteful process but inhibition of microbial methane concentrate can increase the efficiency of feed and have significant economic and environmental benefits (Kebereab *et al.*, 2012; Sallam *et al.,* 2010).

Though microbes play important roles for digestion process in the fore stomachs, there are also nutrients that can be digested in intestinal parts by the host secretions. After the microbes are killed by gastric juices in the abomasums and escape feed protein enter to duodenum and in it the acidity of gastric juices becomes neutralized by bile. Further the small intestine is the main site of absorption of the protein either microbial or feed protein. The Caecum also acts as a secondary fermentation chamber to breakdown any remaining protein and fiber. Finally the undigested nutrients come out in the form of faeces (CSIRO, 2004).

2.2.2. Dietary energy density and performance of lambs

Energy is the major nutrient that is responsible for the different utilization of nutrients and thereby the productivity and gain of an animal (Hosseini, 2008). Insufficient energy due to inadequate amounts of feed or from feeds of low quality probably limits performance of sheep more than any other nutritional deficiency (Kott, 2006). Supplementing animals with energy dense diet has proven to improve animal performance and profitability (Salo *et al.*, 2016). In contrast to this carbohydrate consumed more than an animal's requirements are converted and stored as fat (Alemu, 2008). So, it is important to determine best level of energy source feeds that can be results in better production.

The lowest energy density at which the sheep does not lose weight is between 8 and 10 MJ/kg DM otherwise, on the energy intake below the amount required for maintenance, the sheep loses weight since to stay alive it starts to use its tissues (Gatenby, 2002). According to Haddad and Husein (2004), finishing Awassi lambs on high- energy (2.92 Mcal kg^{-1}) diet improves ME intake, feed efficiency, average daily gain, nutrient digestibility, and carcass weight than low energy (2.40 Mcal kg^{-1}) diet. Similarly, high dietary energy (3.5 Mcal) produced the best performance, nutrient digestibility and carcass traits of lambs in addition to economic benefit than medium,3.2 and low energy, 2.9 Mcal kg^{-1} (Sayed, 2009). Increasing energy concentration of the diet from 2.3 to 2.7 Mcal ME kg^{-1}DM also resulted in increases of fat percentage but decreased the moisture and protein content of the *Longissimus dorsi* muscle (Ebrahimi *et al.,* 2007).

2.2.3. Dietary protein levels and performance of lambs

The animal industry can be defined as an industry producing proteins of higher value (meat, milk) from less expensive protein sources (Yasuhiko, 2004). Protein requirement of sheep is affected by protein to energy ratio and the environment (Ensminger, 2002). Sheep are capable of recycling more dietary and metabolic nitrogen by drawing urea from the blood and saliva, so presumably sheep can tolerate low nitrogen containing rations better than cattle (Christoph, 2010b. However, Stanton and Levalley (2006) stated that the natural proteins such as cottonseed meal and soybean meal should provide for better performance of lambs than alternative protein sources such as blood meal, feather meal or urea. Similarly, Ensminger (2002) reported that it is desirable to supplement amino acid rich feeds such as soyabean, cotton seed, linseed, peanut and sunflower meal or a commercial protein supplement to the ruminant feeds.

Literatures show that dietary crude protein levels, either under or in excess of the required amount, have significant effect on performance of lambs. Excessive protein level in the diet impairs sheep performance, as energy is required for removal of excess protein from the body of the animals (Wand, 2010). Moreover, nitrogen excretion due to animal farming is posing a serious threat to human health through ammonia or nitrate/nitrite pollution in soil and water (Christoph, 2010b). Reduction of crude protein content in a diet by 1% can yield about an eight to ten percent reduction in nitrogen excretion (Yasuhiko, 2004).

Thus, it is important to determine the level of CP requirement of lambs for specific production targets. As a rough guide, the minimum protein level required for maintenance is about 8% in the DM, while the most productive animals, such as rapidly growing lambs and lactating ewes, need about 11% CP in dry matter basis (Gatenby, 2002). Alemu (2008) also added that, a crude protein content of the feeds below 7% is inadequate for proper rumen function. Low feed intake, high average daily gain and feed efficiency were observed as protein levels in the lamb diets were increased (Ebrahimi *et al*., 2007). Increasing the dietary protein level improves the ratio of propionate to fatty acids, which improve the lamb`s energy balance and increases the body weight of lambs (Kioumarsi *et al*., 2008). The same authors reported that the protein levels have effect on feed conversion efficiency (FCR), feed cost kg^{-1} gain, carcass weight, shoulder weight, thigh weight and rib eye area of lambs. Best carcass yield and quality can be obtained by dietary crude protein levels of 12-16% for 20 kg growing lambs in tropical environments (Dove and Milne, 2006). Stanton and Levalley (2006) also reported that average daily gain and feed efficiency of lambs were improved when protein was raised from 10 to12% and further improved when it was increased.

However, beyond dietary protein, amino acids now play indispensable roles in improving the efficiency of animal protein production, and contribute to increasing protein supply to human needs (Yasuhiko, 2004). Essential amino acid deficiencies also may limit performance of lambs and the most important single factor affecting the efficiency of protein utilization for production of meat and other products is the balance of absorbed amino acids

(Nolte *et al*., 2008). The same author described that, reducing excessive protein in feed by supplementation of amino acids is the most cost-effective way to solve the problems of nitrogen pollution associated with animal feeding.

2.2.4. Nutrient concentration and carcass characteristics

Meat plays a very important role in human nutrition by contributing high quality proteins, essential minerals and vitamins. Lean meat plays a significant role in supplying such nutrients (Ponnampalam *et al*., 2001; Lombardi-Boccia, *et al*., 2005). Lean red meats with more desirable flavor are a good characteristic of lamb carcasses (Abd El-aal and Suliman, 2008). Moreover, Skunmun *et al*. (2012) stated that the level of unsaturated fatty acids in ruminant products would have implication to animal nutritionists in terms of animal feeds to improve consumers' health. The fatty acid composition and cholesterol levels in meat have received increasing attention owing to their implications in human health and product quality, which is influenced mainly by age, feeding regime and genotype (Orellana *et al*., 2009).

The characteristics of a superior lamb carcass are: high proportion of muscle (lean), low proportion of bone and an optimal level of fat cover (Kassahun, 2000). Generally, lamb meat is not marbled (fat in the meat) as is beef. Half of the fat in lamb`s meat is unsaturated, mostly monounsaturated (Steve, 2010). The same author reported that lamb can be consumed directly as part of the essential omega-6 fatty acid with high quality protein and easily absorbed iron.

According to the recommendation of Mitchell (2007), the most direct method for measuring body composition is to completely dissect it into viscera, skin, bones, muscle, and fatty tissue. Furthermore, Croker and Watt (2001) reported that color is a key issue in the eating quality of meat and nutrition is one determinant factor for the color of lamb meat. For example, if the meat is dark, it becomes less visually attractive to consumers, is tougher, has poorer keeping qualities and takes longer to cook. Acidity determines color. Acidity interacts with the pigments in meat and is a major determinant of meat color. If meat has a pH greater than 5.7, it tends to be dark. High muscle sugar (glycogen) levels before slaughter result in a low pH, around 5.5, and desirable colour. Nutrition and stress are the key determinants of muscle sugar and then, feeding high-energy diets increase stores of muscle glycogen.

Meat color is measured in terms of L*, a*, and b* values and then the L* being higher in carcass, indicates that meat is lighter in color (Croker and Watt, 2001 and MLA, 2008). Light meat tends to be more visually attractive to consumers than dark meat (MLA, 2008). Higher values of a* indicates more red meat and higher of b* values indicate an increased yellow color in the meat (Croker and Watt, 2001). Lean color and texture were more mature for carcasses from lambs on the high level of nutrition than for those on the low energy level (Maiorano *et al*., 1990).

Skins can be a valuable product in the sheep enterprise that constituting 5 to 20% of the value paid for lambs and adult sheep (AWI and MLA, 2008). It is also stated that although several management factors affect skin quality and value, best management practices, including feed in the production system improves skin quality and financial returns. Ethiopian small ruminant skins, especially sheep skins traditionally have a very good reputation for quality and in the world leather market due to their fine grain and compact structure (Tekle, 2009). The same author reported that among the factors poor nutrition is cause for smaller size of the animal, thinner skin, poorer in substance, lack of elasticity of leather, less fat deposition in the corium and finer grain. In line with this, Suliman and Babiker (2007) stated that weight and fat of skin of lambs were affected by dietary nutrient levels.

3. MATERIALS AND METHODS

3.1. Survey

3.1.1. Descriptions of the study areas

The survey was conducted from July to September 2011 in the *Kebeles* (the lowest or village-level administrative unit) of Debre-Berhan and Dessie urban and peri-urban areas, located in the central highlands of Ethiopia to characterize sheep production systems, identify major feeds, feeding practices and constraints. The peri-urban *Kebeles* were rural-urban interface areas that are administered as sub- *Kebeles* in Urban *Kebles.*

Debre-Berhan is located at about 120 km Northeast of Addis Ababa. Its altitude ranges between 2800 and 2845 m.a.s.l. The minimum and maximum monthly air temperature ranges from 2.4 ^{0}C in November to 8.5 ^{0}C in August and 18.3 ^{0}C in September to 23.3 ^{0}C in June, respectively, and the average annual rainfall is 920 mm (ILCA, 1993). Dessie is located at about 400 km North of Addis Ababa at an elevation ranging between 2470 and 2550 m.a.s.l and receives annual rainfall of 1199 mm (Gebru, 2009; Woldeamlak, 2009).

3.1.2. Survey procedures and data collection

Study *Kebeles* in urban and periur-ban areas were purposely selected based on the number of sheep population after discussions with agriculture office experts. Accordingly, eight interfacing urban and peri-urban Kebeles that is 4 kebeles from each of urban and peri-urban areas were selected from each of Debre-Berhan and Dessie towns. The *Kebeles* were found within 7 km radius for Debre-Berhan and within 10 km radius for Dessie study sites. Following the number of *Kebeles* selected, a list of sheep producers was prepared with help of the respective agriculture offices. Accordingly, the sample size of respondents was determined using the formula given by Israel (2009), as shown bellow.

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

Where; n is sample size, N is the list of sheep producers that was the study population, e is the desired level of precision, 5% was taken for this study. The total study population was 600, which was 330 and 270 from Debre-Berhan and Dessie, respectively. The sheep producers were stratified based into four urban and four peri-urban areas from, each town based on the administration marks. The sample size for each stratum was determined based on probability proportional to sample size sampling technique (Israel, 2009).

Accordingly, the numbers of randomly selected respondents were 132 and 108 for Debre-Berhan and Dessie study sites, respectively. Among the total of 132 interviewed respondents, 42 were from urban *Kebeles* and 90 were from peri-urban *Kebeles* of Debre-Berhan. The numbers of respondents for Dessie urban *Kebeles* were 46, while 62 respondents were for peri-urban *Kebeles* of Dessie. Structured and pre-tested (on clarity and the variables to be gathered) questionnaire was administered to solicit information on different variables. The local Amharic language translated questionnaire was administered through trained development experts and technical assistants, and the accuracy of information gathered was closely supervised by the researcher. Group discussions and personal observations were also the methods used to gather information.

3.2. Feeding Trial

3.2.1. Experimental site

The feeding and digestibility trials was conducted from February to May 2012 at Debre-Zeit Agricultural Research Center located at about 45 km from Addis Ababa at an altitude of about 1900 meters above sea level. The mean annual rainfall and mean maximum and minimum temperatures for the area are 1100 mm, and 28.3 ^{0}C and 8.9 ^{0}C, respectively (DZARC, 2003).

3.2.2. Experimental animals

Experimental animals were 24 Menz-sheep-breed ram lambs, since this breed is predominantly available in the households` of the study areas as compared with Wello sheep breed. The age range of lambs was from 8 to 10 months and the initial body weight was 17.97 ± 0.28 kg (mean ± SE). Their age was estimated based on dentition and information obtained from the owners. The animals were bought from Debre-Berhan market and then transported to the Debre-Zeit Agricultural Research Center. Lambs were quarantined for 3 weeks during which they were treated against internal and external parasites with albendazole bolus and acarimic spray, respectively. Lambs were also vaccinated against pneumonia, sheep pox, blackleg, and anthrax diseases.

3.2.3. Feed ingredients and experimental diets

The feed ingredients used for feeding the experimental lambs were native pasture grass hay, wheat bran; lentil split (''*kik''*) screening (''*Elat''*) and salt, which were among commonly available feed ingredients for sheep around the study areas. Lentil split screening is locally called "*Elat*" and is a mixture of high amount of broken lentil, and very few lentil bran and lentil spur. The feeds were transported from Debre-Berhan to Debre-Zeit Agricultural Research Center. Experimental diets were formulated (Table 3) by reviewing of different literatures about the energy and protein requirements of dietary energy and protein for growing lambs.

Table 3 Concentrate feed ingredients used to formulate treatment diets

Treatment	Experimental feed ingredients (g)			Total (g)	Nutrients	
	Wheat bran	Lentil screening	Salt		ME (MJ/kg DM)	CP (%)
T_1	30	133	5	168	10.5	25.73
T_2	0	235	5	240	10.4	27.73
T_3	285	0	5	290	11.7	18.23
T_4	227	120	5	352	11.3	21.62

The combination of these dietary energy end protein source concentrates were determined based on nutrient recommendation guides for other breeds to contain around 8 to 9 MJ ME per kg DM and 10% to 12% CP considering the energy and protein the animals can get from grass hay *ad libitum* feeding.

3.2.4. Experimental design and layout

Randomized complete block design (RCBD) was used to undertake the experimental study. Four dietary treatments from different wheat bran and lentil screening combinations were arranged as:

T1 = diet containing 30g wheat bran 133g lentil screening

T2 = diet containing 235g lentil screening

T3 = diet containing 285g wheat bran

T4 = diet containing 227g wheat bran and 120 lentil screening

The experimental lambs were grouped into six blocks of four lambs based on their initial body weight, which was determined two weighing average after overnight fasting at the end of the adaptation period of 15 days. Four treatment diets were randomly assigned to each lamb in the block, making six lambs per treatment.

3.2.5. Feeding and feed intake of experimental lambs

Lambs were fed individually during the experimental period by offering grass hay basal diet *ad libitum* ensuring a refusal of 20%, based on previous day's intake. Concentrate supplements were offered twice a day in two equal portions at 0800 and 1600 hours. There was an adaptation period of 15 days to the experimental feeds before the commencement of data collection. Water was given *ad libitum*. Feed offered and refused was measured daily using 5 kg sensitive balance with one gram precision, and the difference between the daily total feed offered and the daily refused was considered as daily feed intake on DM basis.

3.2.6. Body weight change and feed conversion efficiency

On the first day of the commencement of the feeding trial, at the end of 15 days of adaptation period to treatment feeds the average of two weighing was taken as initial body weight of lambs. The daily feed and subsequent body weight measurements were taken at a ten-day interval after overnight fasting using a 100 kg salter fixed balance with a sensitivity of 0.5 kg. The average daily body weight change was calculated as the difference between the initial and final live weight of the lambs divided by the number of experimental days. Feed conversion efficiency (FCE) of the lambs was determined as the proportion of daily body weight gain to the daily total DM intake (Malik *et al*., 1996)

3.2.7. Digestibility and nitrogen balance evaluation

After 90 days feeding trial the digestibility and nitrogen balance evaluation was conducted. Five lambs per treatment were randomly selected and fitted with faecal collection bags and urine collection tube for three days of adaptation period followed by seven days of faeces collection period for determination of the digestibility of the total diet. The daily feed intake of each lamb was recorded. Samples of feed offered and refused as well as faeces excreted were collected every day in the morning. Total faeces voided in the harness were weighed and recorded daily during the collection period. Faeces collected from each lamb were mixed thoroughly and 10% of the mixed faeces were sub-sampled daily and bulked over the experimental period per lamb and kept in a deep freezer below -20^{o}C pending analysis. At the end of the collection period, the bulked samples of each lamb were towed and thoroughly mixed and sub-sampled for partial drying at 60^{o}C in a draft oven. Then, apparent digestibility coefficient of DM, CP, NDF, and ADF of the total feed was determined as the difference between nutrients consumed and nutrients in the faeces divided by nutrient intake (McDonald *et al*., 2002), using the following formula:

$$\text{Apparent digestibility (\%)} = \frac{\text{Nutrient intake} - \text{Faecal nutrient output}}{\text{Nutrient intake}} \text{ x } 100$$

Urine voided by each lamb was collected in a glass placed in plastic bucket under the metabolic cage. Hundred ml of sulfuric acid solution (10%) was added to each urine collection buckets daily to trap N that might escape as ammonia from the urine. The urine collected from each lamb was measured daily using graduated cylinder and 20% of urine-voided per lamb was sampled and pooled over the collection period. The urine was stored at -20^{o}C pending chemical analysis. Then, the N-excreted through urine was calculated by multiplying the total urine voided by its nitrogen content. The daily N retention then was calculated as a difference between N-intake and N-excreted through urine and faeces (McDonald *et al*., 2002).

3.2.8. Carcass evaluation

Five experimental lambs from each treatment were weighed and slaughtered after overnight fasting. The hot carcass weight was measured after about one hour from slaughter. Then, the cold carcass weight was measured after overnight chilling. The weights of different non-carcass components were measured immediately after slaughter. The blood and full reticulo-rumen were weighed using plastic buckets. The un-dissected and dissected carcass was measured for carcass yield and quality parameters.

The pH and color values of carcass were measured as described by Mitchell (2007). The pH value was measured twice (at 1 and 24 hour, after slaughter), using a pH meter equipped with a penetrating electrode (Hanna Instruments, HI–9025), which was manually inserted into the *longissimus dorsi muscle.* Then, at insertion the muscle pH was read from the equipment. In addition to calibration, ionized water was used to rinse the pH meter before and after inserting in to the muscle of another lamb. Color was measured from *longissimus dorsi muscle* using a Minolta CM-2002 colorimeter, defining color as a set of three variables: L* for brightness, a* for redness and b* for yellowness (Mitchell, 2007).

According to Mitchell (2007), the carcass was split along the dorsal middle line with a band saw after removing the tail.
Thus, components of the carcass were estimated as:
Total lean = constant x weight of lean from left half carcass,
Total fat = constant x weight of fat from left half carcass, and
Total bone = constant x weight of bone from left carcass,
Where, constant is determined as proportion of cold whole carcass to cold left half carcass.
Samples from lean meat and from visible fat were collected from the left half carcass and were retained for laboratory chemical analysis of Ether Extract and Crude Protein.

3.2.9. Partial budget analysis

The partial budget analysis was conducted according to Upton (1979) to illustrate and estimate the economic importance of feeding lambs on rations containing varied levels of dietary ME and CP in terms of feed cost per unit weight gain.

3.2.10. Laboratory analysis

The partially dried representative feed samples and faeces were milled using laboratory mill to pass through 1 mm sieve screen and analyzed for DM and ash according to the procedure of AOAC (1990). The two-stage method outlined by Tilley and Terry (1963) was followed to determine IVOMD and then metabolizable energy (ME) content was estimated using the equation: ME (MJ/kg DM) = 0.16*IVOMD (McDonald *et al.*, 2002). Nitrogen (N) was analyzed according to Kjeldhal procedure, and CP was determined as N * 6.25. Neutral detergent fiber (NDF), acid detergent fiber (ADF) and acid detergent lignin (ADL) were analyzed according to the procedure of Van Soest and Robertson (1985). Samples of meat and fat were dried at 60° C for 48 h in a forced draft oven and ground to pass through a 1 mm sieve screen and analyzed for DM, CP and EE as per AOAC (1990).

3.3. Data Analysis

Data generated from the survey such as socio economic, number of livestock species, common feed resources, management system, feeding practices, and constraints of sheep rearing were analyzed using descriptive statistics in SPSS (2011) version 20 software program. The value index was calculated for major crops grown, major feed resources, income sources and major constraint variables from ranking results of respondents according to the way Beyene *et al*. (2014) calculated as: Index = the sum of 1^{st} higher % respondent * last small % respondents +…+ last small % respondents * 1 for individual variables divided by overall sum of 1^{st} higher % respondents* last small % respondents +…+ last small % respondents * 1 for overall variables

Data on feed intake, digestibility, growth and carcass characteristics from feeding experiments were analyzed using SAS software (SAS 2002, version 9). Mean comparison was done using Duncan's multiple range test and significant differences between the treatment groups were declared at $P \leq 0.05$.

The model fitted to calculate the different response variables were:

$Y_{ij} = \mu + a_i + B_j + e_{ij}$ for feeding trial and $Y_{ij} = \mu + a_i + e_{ij}$ for digestibility and carcass evaluation

Where:

Y_{ij} = Response variables

μ = Over all mean

a_i = i^{th} Effect of wheat bran and lentil screening combinations

R_j = j^{th} replication effect due to initial body weight variation of the animals

e_{ijk} = Effect of the ij^{th} random error

4. RESULTS

4.1. Survey

4.1.1. Households` socio-economic characteristics

The proportion of respondents to household socio-economic characteristics such as religion, sex, marital status, and house ownership and occupation in urban and pri-urban areas is presented in Table 4. The number of respondents for religion was different between urban and peri-urban areas of the two study locations.

Table 4. Religion, sex, marital status and house ownership in the study locations (%)

Variables		Urban		Peri-urban	
		DB	Dessie	DB	Dessie
Religion	Orthodox	100	30.4	100	3.2
	Muslim	0	69.6	0	88.7
	Protestant	0	0	0	8.1
Sex	Male	76.2	63.0	85.6	75.8
	Female	23.8	37.0	14.4	24.2
Marital status	Married	71.4	60.9	82.2	74.2
	Single	2.4	2.2	5.6	0
	Widow	14.3	19.6	7.8	11.3
	Divorced	11.9	17.4	4.4	14.5
House ownership	Owned	81.0	84.8	98.9	98.4
	Rented	16.6	8.7	1.1	1.6
	Caretaker	2.4	6.5	0	0
Occupation	Farmer	0	19.6	93.3	79.0
	Civil servant	21.4	0	2.2	1.6
	Trader	47.6	37.0	1.1	3.2
	Pensioner	11.9	13.0	1.1	3.2
	Others	19.0	30.4	2.2	12.9

At Debre-Berhan study locations, all respondents were Orthodox Christians whereas, in Dessie areas majority of the respondents were Muslim religion followers. In both Debre-Berhan and Dessie urban and peri urban areas, majority of sheep producers were male house headed. In all study sites most household heads were married with more proportion in Debre-Berhan peri urban area. In all study areas, almost all sheep producers had their own house.

More respondents (47.6 and 37.0% in Debre-Berhan and Dessie urban areas, respectively) were traders. Apart from trading, in Dessie urban area 30.4% of sheep producers` had different occupations, such as carpentry, daily laborer, and horse cart drivers. The predominant occupation for sheep producers was crop farming in peri-urban and trade in urban areas. The higher proportion of pensioners, 13% in Dessie and 11.19% Debre-Berhan urban areas were engaged in sheep production as compared to peri-urban areas.

Educational status of the family and average family size in the study areas is presented in Table 5. In general, many of the family education were up to completion of elementary school in all study areas. Greater family members (2.8±1.31) with elementary school education were recorded in Debre-Berhan peri-urban. The average family size was more in Debre-Berhan peri-urban (5.4±1.51) area than Dessie peri-urban (4.8±1.55).

Table 5. Educational status of the family and average family size (mean ±SD)

Educational status	Urban		Peri-uban	
	DB	Dessie	DB	Dessie
Illiterate	1.2±0.41	1.2±0.42	1.4±0.79	1.5±0.60
Read and write	1.6±0.55	1.3±0.57	1.5±0.59	1.1±0.35
Elementary school	2.4±1.28	2.1±1.27	2.8±1.31	1.9±0.91
High school	1.8±1.17	1.7±0.66	1.6±0.74	1.8±1.15
Above Diploma	1.5±0.96	1.5±0.52	1.4±0.55	1.3±0.60
Family size	4.7±1.60	4.3±1.57	5.4±1.51	4.8±1.55

DB =Debre-Berhan

4.1.2. Agricultural practices and landholding

Table 6 shows the proportion of respondents regarding the type of agricultural practices in the study areas. Almost all urban respondents practiced only livestock agriculture, whereas in peri-urban areas the major agricultural practice was crop production, indicating that more time, labor, and different agricultural inputs were allocated for crop production than livestock rearing in peri-urban study areas, whereby the reverse was the case for urban areas.

Table 6. Agricultural practices and landholding of the households in the study areas (%, n)

Variables		Urban		Peri-urban	
		DB	Dessie	DB	Dessie
Agricultural practice	More livestock	4.8	0	15.6	16.1
	More crop	2.4	0	81.1	69.4
	Livestock only	92.9	97.8	2.2	1.6
	Both equal	0	2.2	1.1	12.9
LHS	<0.5 ha	50	100	18	48.4
	0.5-1 ha	0	0	19.1	41.9
	1-2 ha	50	0	39.3	6.5
	>2 ha	0	0	23.6	3.2

Note: - LHS = Land holding size; DB = Debre-Berhan.

All urban sheep producers in the study areas did not have land for crop production and grazing except 4.76 and 2.17% respondents in Debre-Berhan and Dessie, respectively. In Debre-Berhan peri-urban areas, 39.3% of the respondents had land size of 1 to 2 ha, where as 23.6% respondents had more than two hectares of land. In Dessie peri-urban areas 48.4% of respondents had land size of <0.5 ha.

4.1.3. Major crops grown

As described in Table 7, the major cultivated crops in the study areas were cereals (barley, wheat and teff), pulses (faba beans, field peas), and linseed and vegetables (carrot, salad, tomato and onion). Cereals, pulses and linseed were the 1st, 2nd and 3rd major crops grown in Debre-Berhan study area with 0.40, 0.23 and 0.20 respondent rank index, respectively. In Dessie areas, the 1st, 2nd and 3rd major grown crops were cereals, maize, and pulses with index of 0.39, 0.23 and 0.21, respectively.

Table 7. Major cultivated crops in the study areas (% and Index)

Crop	1st		2nd		3rd		4th		Index	
	DB	Dessie	DB	Dessie	DB	Dessie	DB	Dessie	DB	Dessie
N	91	63	87	58	42	44	2	7		
Cereal	97.8	88.0	1.1	10.0	0	2.3	0	0	0.40	0.39
Maize	2.2	9.5	0	34.0	0	43.2	0	0	0.01	0.23
Linseed	0	0	3.4	0	69.0	4.5	50.0	0	0.20	0.01
Pulse	0	0	90.8	41.	2.4	36.4	0	14.0	0.23	0.21
Veg.	0	1.6	4.6	13.0	28.0	13.6	50	85.0	0.12	0.16

Note: - Veg = vegetables; DB = Debre-Berhan

4.1.4. Livestock species and sheep flock structure

The number of livestock species per household in the urban and peri-urban areas of the two study sites is presented in Table 8. The number of donkeys was higher in Dessie urban area than Debre-Berhan urban area. The numbers of sheep and other livestock were higher for Debre-Berhan peri-urban than Dessie peri-urban area. The sheep flock structure for suckling, weaned, and above yearling per household was 3.8, 4.1, and 9.6, respectively for Debre-Berhan peri-urban and it was more than Dessie peri-urban area. In both urban and peri-urban areas of Dessie, farmers owned only local sheep breed. In urban and pri-urban study areas of Debre-Berhan, in addition to local sheep breed, crosses between Awassi and Menz sheep were found in very few numbers. Otherwise, the local sheep breed types were the predominant sheep breeds in both study locations, specifically dominated by Menz and Wello sheep types in Debere-Berhan and Dessie study locations, respectively.

Table 8. Livestock species, sheep flock structure and breed (mean ±SD)

Variables		Urban		Peri-urban	
		DB	Dessie	DB	Dessie
Livestock Species	Cattle	3.3±2.34	1.9±0.90	5.7±2.71	2.7±1.27
	Goat	2.11±2.98	4.2±3.49	3.4±1.44	2.5±2.38
	Chicken	6.4±5.92	3.5±1.97	5.5±4.01	3.6±2.10
	Horses	2.0±0.00	1.7±0.50	1.9±1.05	1.2±0.71
	Donkey	1.8±0.44	3.7±1.25	2.4± 0.98	1.9±2.13
	Sheep	7.5±.4.19	9.2± 5.83	16.7± 7.88	9.3±7.18
Sheep flock structure	Suckling	2.1±0.83	2.4±1.19	3.8±2.23	2.8±1.73
	Weaned	3.3±1.84	2.6±1.59	4.1±2.72	2.9±2.63
	≥ yearling	4.4±2.49	5.6±4.49	9.6±4.73	5.50±4.45
Sheep breed (%)	Local	92.9	100	88.9	100
	Cross	7.1	0	11.1	0

Note:-DB = Debre-Berhan; ≥ yearling = one year and above

4.1.5. Livestock population trends

As shown in Table 9, the amount of respondents on trends of livestock population was varying from place to place. In Dessie urban and peri-urban areas more respondents reported that cattle population was reduced within the past ten years. The cattle population in Debre-Berhan urban and peri-urban was increased as per more participants (54.5%) response. The sheep producers in all study areas reported that chicken population is decreasing, whereas, horse and donkey population was increasing over the last ten years. The higher respondents in Debre-Berhan urban and peri-urban said that sheep population was increasing during the last ten years.

Table 9. Proportion of respondents on trends of livestock population in the study areas (%)

Population trend		Urban		Peri-urban	
		DB	Dessie	DB	Dessie
Cattle	Increasing	54.5	33.3	54.7	34.0
	Decreasing	45.5	66.7	45.3	66.0
Sheep	Increasing	47.6	54.3	51.1	46.8
	Decreasing	52.4	45.7	48.9	53.2
Goats	Increasing	50	50	45.5	33.3
	Decreasing	50	50	54.5	66.7
Chicken	Increasing	38.5	46.7	47.7	47.1
	Decreasing	61.5	53.3	52.3	52.9
Horses	Increasing	100	75	77.8	75
	Decreasing	0	25	22.2	25
Donkeys	Increasing	60	71.4	75	70.6
	Decreasing	40	28.6	25	29.4

Note: - DB = Debre-Berhan

4.1.6. Common feed resources for sheep

Natural pasture, crop residues, grass hay, by-product of local brewery (*Atela*), processing by-products from legume grains (lentil, faba bean, field bean, check pea and *Lathyrus sativus*), wheat bran and noug seedcake were major feed resources in the study areas (Table 10). In Debre-Berhan urban area, crop residues, natural pasture grazing and grass hay were the three major feed resources in order of their importance with rank index of 0.25, 0.18, and 0.17%, respectively. The first three major feed resources were grass hay, natural pasture grazing and wheat bran and noug seed cake in Dessie urban area. Similarly, in peri-urban area of Debre-Berhan, natural pasture grazing, crop residues and grass hay were the first three major feed resources, whereas, grass hay, natural pasture grazing and wheat bran and noug seed cake were the first three major feed resources in Dessie peri-urban area.

Table 10. The respondent's % and index value on major available feed resources in the study areas

Feed	Rank 1		Rank 2		Rank 3		Rank 4		Index	
	DB	Dessie	DB	Dessie	DB	Dessie	DB	Dessie	DB	Dessie
Urban										
Pasture	26.2	30.4	9.5	31.1	17.5	3.2	11.1	0	0.18	0.22
Hay	21.4	63.0	14.3	26.7	12.5	0	18.5	0	0.17	0.33
CR	33.3	0	28.6	2.2	15.0	3.2	3.7	0	0.25	0.01
WB-NSC	0	0	9.5	31.1	32.5	51.6	14.8	11.1	0.11	0.21
LGBP	16.7	6.5	7.1	6.7	2.5	35.5	29.6	44.4	0.12	0.16
Attela	2.4	0	31.0	2.2	20.0	6.5	22.2	38.9	0.16	0.06
BDG	0	0	0	0	0	0	0	5.6	0	0.01
Peri-urban										
Pasture	53.3	41.9	21.1	31.7	21.6	17.6	1.3	0	0.28	0.30
Hay	15.6	51.6	40.0	36.7	23.9	3.9	3.9	0	0.23	0.32
CR	31.1	4.8	35.6	20.0	23.9	15.7	1.3	10.3	0.28	0.12
WB-NSC	0	0	1.1	10.0	2.3	41.2	28.9	17.2	0.04	0.13
LGBP	0	1.6	1.1	3.3	5.7	13.7	23.7	55.2	0.04	0.10
*Attela**	0	0	1.1	0	22.7	0	40.8	6.9	0.09	0.01
BDG	0	0	0	0	0	7.8	0	10.3	0	0.03

Note: - DB = Debre-Berhan; WB & NSC = wheat bran and noug seedcake; LGBP = legume grains by-products; CR = crop residues; * = by-product of local brewery and BDG = Brewery dried grain.

By-products of local beer and legume grains processing were also considerable feed resources in Debre-Berhan and Dessie study locations, respectively. Brewery dried grain was used as feed resource only in Dessie area.

4.1.7. Sheep feeding and management system

4.1.7.1. Grazing systems

Table 11, shows the proportion of respondents regarding ownership pattern of grazing land and grazing practices in urban and peri-urban of the study areas. The number of respondents on grazing land ownership pattern and grazing practice were different between the two study locations. About 80.8% of the respondents in Debre-Berhan and 75.9% in Dessie urban areas used the communal grazing land. In most cases, grazing land was privately owned in Debre-Berhan (87.8%) and in Dessie peri-urban areas (71.7%). More respondents were practicing free grazing of sheep in Dessie urban (46.4%) than Debre-Berhan urban (28.0) area during dry season, whereas, semi-grazing was the grazing method during both seasons in Debre-Berhan urban areas.

Table 11. Ownership of grazing land and grazing systems in the study areas (%)

Variables		Urban		Peri-urban	
		DB	Dessie	DB	Dessie
Grazing land ownership	Communal	80.8	75.9	6.7	23.3
	Private	19.2	17.2	87.8	71.7
	Both	0	6.9	5.6	5.0
Dry season grazing	Free grazing	28.0	46.4	75.3	25
	Semi-grazing	68.0	50.0	24.7	75
	Tethering	4.0	3.6	0	0
Wet season grazing	Free grazing	30.8	41.4	31.5	28.3
	Semi-grazing	65.4	51.7	67.4	53.3
	Tethering	3.8	6.9	1.1	18.3

Note: -DB = Debre -Berhan

In most cases in Debre-Berhan peri-urban, sheep grazed freely during the dry season. Semi-grazing was widespread practice during dry (75%) and wet (53.3%) seasons in peri-urban of Dessie. Semi-grazing was a type of grazing practiced by herding the sheep for about less than 4 hours per day. In the case of free grazing, sheep stayed outside home by roaming or grazing for about 8 hrs. Tethering was also practiced during dry season by few sheep producers in both areas of urban and wet seasons in all study areas.

4.1.7.2. Feeding practices

Though it is difficult to quantify the proportion of mixtures, the amount of feed offered and the efficiency of feeding, the main feeding practice for stall feeding of sheep is summarized in Table 12. Hay was fed to sheep in all study areas without using physical or chemically treatments. Almost all sheep producers in peri-urban areas fed crop residues, mainly mixed with *Atetla* in urban areas. In Debre-Berhan peri-urban areas, 75.0% of respondents reported that pulse grain processing by-product was fed for sheep without any intervention. In Dessie peri-urban areas, 56.0% respondents fed pulse grain processing by-product mixed with salt and water.

Most respondents in urban and peri-urban of Debre-Berhan and Dessie supplemented wheat bran mixed with other feed types. Almost all sheep producers fed noug cake socked with salted water overnight and mixed up. Many of the sheep producers fed *Attela* for sheep mixed with other feeds, though; few reported that *attela c*an be offered alone for sheep. In most cases the sheep producers do supplement wheat bran and by-products of lentil split processing, which is locally called *Elate* for fattening sheep.

Table 12. Feed types and sheep feeding practices in the study areas

Feed types and form of feeding		Urban		Peri-urban	
		DB	Dessie	DB	Dessie
Hay	As it is*	100	100	100	100
CR	As it is	5.6	100	33.0	90.3
	Spray water	0	0	2.3	3.2
	Spray *atela*	91.7	0	62.5	6.5
	Mixed with *atela* and concentrates	2.8	0	2.3	0
LGPP	As it is	13.0	27.3	75.0	44.0
	Soaked in water	47.8	45.5	21.2	56.0
	Mixed with *atela*	39.1	27.3	3.8	0
WB	As it is	11.1	34.3	20.6	34.2
	Mixed with other feeds	63.0	60.0	52.9	65.8
	Mixed with *atela*	25.9	5.7	14.7	0
NSC	As it is	0	0	20.0	0
	Socked with water	100	100	80.0	100
Atela	By itself	12.8	21.4	28.8	0
	Mixed with other feeds	87.2	78.6	71.2	100

Note: WB & NSC = wheat bran and noug seedcake; LGBP = legume grains by-products; CR = crop residues; and * = feeding without any change; DB = Debre-Berhan.

4.1.7.3. Sheep fattening practices

Table 13 shows urban and pri-urban sheep fattening practices in Debre-Berhan and Dessie areas. Fattening activity could be undertaken at any time as reported by 58.6 and 88.2 urban, 46.3, and 70.8% peri-urban sheep producers of Debre-Berhan and Dessie, respectively. In Debre-Berhan peri-urban areas, 53.7 % of the respondents undertook sheep fattening targeting for Easter markets. In urban areas of Debre-Berhan, majority of respondents (65.5%) practiced castrating male sheep for fattening, while in Dessie peri-urban areas, several respondents (44.4%) fattened both castrated and intact sheep. In peri-urban areas, half (50.0%) of the respondents used both castrated and intact sheep for fattening.

Table 13. Proportion of respondents on sheep fattening activity in the study areas (%)

Measured variables		Urban		Peri-urban	
		DB	Dessie	DB	Dessie
Experience?	Yes	69.0	37.0	58.9	37.1
	No	31.0	63.0	41.1	62.9
Problems to fattening	Feed cost	38.5	28.6	14.3	35.1
	Space shortage	0	42.9	0	16.2
	Capital shortage	30.8	14.3	22.9	24.3
	Knowledge	23.1	10.7	34.3	10.8
	Labor	7.7	3.6	28.6	13.5
Fattening season	New year	3.4	0	0	25.0
	Christmas	6.9	0	0	4.20
	Easter	31.0	11.8	53.7	0
	Any time	58.6	88.2	46.3	70.8
Sheep type	Castrated	65.5	27.8	94.4	20.8
	Intact	6.9	27.8	0	29.2
	Both	27.6	44.4	5.6	50.0
Sheep source	Purchased	48.3	38.9	13.0	33.3
	Home	37.9	22.2	59.3	25.00
	Both	13.8	38.9	27.8	41.7

Note: - DB = Debre-Berhan.

The source of sheep for fattening was mainly through purchasing in Debre-Berhan urban and from home flock in pri-urban areas. About 41.7% of the respondents in Dessie peri-urban area also fattened purchased sheep and from their own flock.

The number of fattened sheep per fattening period ranged from 2.8-4.8 in the study areas and stayed indoors and feeding was for about 3.6- 5.9 months on average (Table 14). Sheep fattening activity was profitable as reported by majority of respondents from all study sites with the amount of profit earned ranging from 221±104.74 to 269±78.37 Ethiopian Birr per sheep.

Table 14. Number of fattening sheep at a time or per fattening during and profit

Measured variables	Urban		Peri- Urban	
	Debre-Berhan	Dessie	Debre-Berhan	Dessie
Number of fattening sheep	4.82±4.88	4.77±2.24	2.85±1.02	4.62±2.43
Fattening duration	4.72±2.05	5.94±3.09	3.63±1.76	5.4±1.97
Profit (Birr/sheep)	226±92.11	221±104.74	269±78.37	237±104.68

4.1.7.4. Watering and sheltering

The water source, watering frequency and shelter type for sheep is presented in Table 15. The predominant water source was tap water for 92.9 and 82.6% urban sheep producers of Debre-Berhan and Dessie areas, respectively. The main water source for sheep in Debre-Berhan peri-urban was river and tap water (hand pumped) for Desie peri-urban.

Most respondents in urban areas (92.9% in DB and 82.6% in Dessie) gave water for sheep using water buckets at home from tap, while, in peri-urban areas of DB the sheep drunk directly from the water sources (river). Either from the source or from water buckets, the daily watering frequency was mostly twice in all study areas.

The sheep shelter was predominantly house in urban and peri urban of Debre-Berhan and Dessie, kitchen in urban and peri urban of Debre-Berhan. ``*Gatta* was used for the sheep shelter in Dessie urban and in peri-urban of the two study sites by few respondents. ``*Gatta*`` is a partition or part inside the family home in which other livestock also can be sheltered. The majority of sheep producers in urban and peri-urban of Debre-Berhan and Dessie peri-urban area constructed a separate house.

Table 15. Water source and shelter for sheep in the study areas (%)

Measured variables		Urban		Peri-urban	
		Debre-Berhan	Dessie	Debre-Berhan	Dessie
Water source	Well	0	0	3.3	0
	Pond	0	2.2	2.2	3.2
	River	7.0	15.2	46.7	22.6
	Spring	0	0	24.4	1.6
	Tap	92.9	82.6	23.3	72.6
Frequency per day	Roam freely	23.8	2.2	4.4	9.70
	Once	14.3	47.8	47.8	33.9
	Twice	61.9	47.8	46.7	56.5
	Thrice	0	2.2	1.1	0
Shelter type	House	88.1	97.8	96.7	93.5
	Kitchen	11.9	0	1.1	0
	`` *Gatta*``	0	2.2	2.2	6.50
Location of shelter	Isolated	81.0	87.0	61.1	71.0
	Adjoining	19.0	6.0	13.3	24.2
	Inside	0	6.5	6.7	4.8
	Underground	0	0	18.9	0

Some respondents constructed the sheep shelter adjoining as well as inside their living house. Only in peri-urban of Debre-Berhan, the sheep were sheltered underground of the owners' house. Dominantly, the shelters for sheep were constructed in the form of house using corrugated iron, mud and wood or stone in study areas.

4.1.8. Economic contribution of sheep production

As described in Table 16, live animal sale was the first objective of sheep production as reported by urban and peri-urban respondents of Debre-Berhan and Dessie, respectively. Respondents in urban and peri-urban areas of Debre-Berhan and Dessie, respectively, did slaughter unfinished sheep during holidays aging between 6-12 months.

Table 16. Objective of sheep rearing and utilization in the study areas (%)

Measured variables		Urban		Peri-urban	
		Debre-Berhan	Dessi	Debre-Berhan	Dessie
First objective	Slaughter	31.0	8.7	18.9	4.8
	Sale	69.0	91.3	81.1	95.2
Slaughtered sheep type	Female	2.4	0	2.20	1.6
	Fattened male	35.7	9.1	12.4	3.2
	Un-fattened male	61.9	90.9	85.4	95.2
Age	6 -12 months	54.8	93.2	77.5	98.4
	1 -2 years	38.0	6.8	9.0	1.6
	>2 years	7.1	0	13.5	0
Slaughtering frequency	Holidays	40.0	38.6	60.7	29.0
	Once	11.9	13.6	2.2	17.7
	Twice	19.0	18.2	9.0	30.6
	Thrice and more	28.6	29.5	28.1	22.6

Sheep are sources of income for urban and peri-urban sheep producers complementing incomes from other livestock, crop, *Eucalyptus* tree and non-agricultural activities (Table 17). Non-agricultural sources of incomes were activities like trade, carpentry, labor, salary, hand crafts, renting house and horse cart. Sheep production was 2nd and 1st income source at Debre-Berhan and Dessie urban areas with 0.40 and 0.46 rank indices, respectively. At Debre-Berhan and Dessie peri-urban areas, sheep production was the second and first income source, respectively.

Table 17. Respondents` major income sources in the study areas (%, and index)

Income sources	1st		2nd		3rd		Index	
	DB	Dessie	DB	Dessie	DB	Dessie	DB	Dessie
Urban								
Crops	2.4	0	0	0	0	0	0.01	0
Sheep	2.4	32.6	92.7	80.6	50.0	0	0.40	0.46
Other livestock	2.4	0	7.3	2.8	25.0	100	0.08	0.19
Non-agricultural	92.9	67.4	0	16.7	25.0	0	0.51	0.36
Peri-urban								
Crops	74.4	29.0	11.2	19.0	1.8	7.7	0.41	0.22
Sheep	15.6	24.2	26.2	60.3	57.1	61.5	0.26	0.42
Other livestock	2.2	4.8	35.0	12.1	28.6	7.7	0.18	0.08
Non-agricultural	4.4	40.3	27.5	8.6	12.5	23.1	0.13	0.27
Eucalyptus tree	3.3	1.6	0	0	0	0	0.02	0.01

Note:- DB= Debre-Berhan

Average price of sheep in the study areas is shown in Table 18. The average price of ewe, fattened ram and *mesina* (infertile ewe) was different and price of lamb was similar between peri-urban areas. Prices of a lamb, fattened ram and infertile ewe were similar and ewe price was different between urban study areas. Ewes were more expensive at Dessie study areas than Debre-Berhan, while intact fattened ram was more expansive at Debre-Berhan urban areas. The price of female sheep that are not reproducing (*mesina)* was relatively cheap at Debre-Berhan peri-urban area.

The price of sheep was different from season to season. The respondents reported that the main reasons for high price of sheep were related to high demand of females for reproduction and for slaughtering at holidays. During the rainy season, transportation problems due to rains and lack of bridge to cross rivers contributed to high price for a sheep, because, during this season not too much sheep come to the market from far areas. In some cases, prices for a sheep could go down due to feed shortage, lack of labor, drought, diseases, fasting season, and increased number of sheep in markets during dry seasons. The sheep producers were selling the sheep for input purchase (fertilizer, farm labor salary), school payment, medical expenses, and others (*edir, equb*, purchase of food items, cloth, and exercise book, home rent payment etc.).

Table 18. Average price of sheep in the study areas (mean ±SD)

Flock	Urban		Peri-urban	
	Debre-Berhan	Dessie	Debre-Berhan	Dessie
Ewe	413.80±77.41	558.80±116.70	388.0±86.51	574.5±147.14
Lamb	368.20±70.79	370.10±89.04	347.4±93.00	375.9±82.09
Fattened	881.44±188.65	826.54±139.47	898.7±220.71	815.1±104.56
*Mesina**	715.0±227.48	747.10±172.82	552.6±212.27	751.8±162.49

Note: *Mesina**= not reproducing female sheep

4.1.9. Constraints of sheep production

As described in Table 19, in urban areas of Debre-Berhan and Dissie, the 1st, 2nd, 3rd and 4th ranked major constraints identified were high feed cost, lack of improved breed, lack of capital and labor shortage. Similarly, in the peri-urban area of Debre-Berhan and Dissie the 1st and 2nd major constraints were high feed cost and lack of improved breed. In the study areas, there were also other constraints like inadequate space, diseases, lack of veterinary service, theft, water shortage, and fluctuations in market prices and occurrence of accidents.

Table 19. Major constraints of sheep production as ranked by respondents in the study areas

Constraints	1st		2nd		3rd		4th		Index	
	DB	Dessie	DB	Dessie	DB	Dessie	DB	Dessie	DB	Dessie
Urban										
Breed	4.8	28.3	25.0	23.9	24.0	25.0	60.0	30.0	0.20	0.26
Feed	73.8	54.3	19.4	32.6	12.0	12.5	0	0	0.38	0.34
Labor	4.8	2.2	19.4	21.7	36.0	37.5	20.0	30.0	0.17	0.18
Capital	16.7	15.2	36.1	21.7	28.0	25.0	20.0	40.0	0.25	0.22
Peri-Urban										
Breed	32.2	12.9	25.0	31.5	13.0	42.5	19.0	37.5	0.25	0.27
Feed	53.3	51.6	30.3	37.0	13.0	12.5	4.8	0	0.33	0.34
Labor	10.0	16.1	10.5	20.4	38.9	10.0	52.4	50.0	0.20	0.20
Capital	4.4	19.4	34.2	11.1	35.2	35.0	23.8	12.5	0.21	0.19

Note: -NR= no respondents; DB = Debree-Berhan

4.1.9.1. Water related problems and poisonous plant occurrence

The response of respondents, to water related problems and the occurrence of poisonous plants in the study areas are shown in Table 20. Unavailability was the major water related problem accounting for 66.7 and 50.0% respondents in urban and peri-urban of Debre-Berhan. About 56.2 and 48.3% participants reported that impurity was the main water related problem for urban and peri-urban area of Dessie, respectively. Parasites in the water were also one of the problems for Debre-Berhan peri-urban areas, and for Dessie urban and peri-urban areas.

The occurrence of poisonous plants in the study areas was one constraint reported by respondents. In Debre -Berhan peri-urban 56.7, in Dessie urban 40.0% and in peri-urban of Dessie 88.3% respondents said that there existed poisonous plants that could cause health problems or death of sheep. In Dessie urban, 66.7 % and in Dessie peri-urban, 28.3% respondents reported that the local name of one of the poisonous plants was ``*Gudeng*. The`` local common name of poisonous plants as reported by the sheep producers from all study areas was`` *Wagema*``.

Table 20. Water related problems and poisonous plants occurrence in the study areas (%)

Variables		Urban		Peri-urban	
		DB	Dessie	DB	Dessie
Water related problems	Unavailability	66.7	31.2	50.0	20.7
	Parasites	0	12.5	20.7	31.0
	Impurity	33.3	56.2	29.3	48.3
Poisonous plants occurrence	Yes	2.4	40.0	56.7	88.3
	No	97.6	60.0	43.3	11.7
Local name	``*Gudeng*``	0	66.7	0	28.3
	``*Wagema* ``	100	33.3	100	58.5
	``*Werteb*``	0	0	0	13.2
Occurrence season	Summer	0	100	37.3	100
	End of summer	100	0	60.8	0
	Belg	0	0	2.0	0

Note: - DB = Debre-Berhan.

In Dessie peri-urban area there is also poisonous plant locally called `*Werteb*`. About 19, 18 and 53% respondents in Debre-Berhan peri-urban, Dessie urban and peri-urban reported that poisonous plants occurred during summer. In Debre-Berhan urban and peri-urban areas poisonous plants could occur at the end of summer season. Respondents in Debre-Berhan urban also reported the occurrence of poisonous plants during spring season.

4.1.9.2. Common sheep diseases reported in the study areas

The occurrence of diseases was reported by sheep producers as a constraint for sheep production (Table 21). Thus, *Faciolosis* and sheep pox were the diseases reported from all study areas. Bloating and diarrhea were the disease types reported only from Debre-Berhan urban sheep producers. Skin diseases were reported from peri-urban areas of Debre-Berhan and Dessie. The skin diseases also called tick (*Mazger*) and there is wound symptom on the body. Foot rot diseases were reported from Debre-Berhan study areas only, while Pasteurellosis was reported from all study areas except from Dessie peri-urban area.

Table 21. Major sheep diseases, symptoms and treatments in the study areas

Disease	Urban		Peri-Urban		Major Symptom	Treatment
	DB	Dessie	DB	Dessie		
Fasciolosis	*	*	*	*	Swelling of the neck	Modern
Sheep pox	*	*	*	*	Wound on the body	Modern
Bloating	*	NR	NR	NR	Swelling of stomach	Traditional and modern
Diarrhea	*	NR	NR	NR	Diarrhea	Modern
Skin disease	NR	NR	*	*	Tick	Modern
Foot rot	*	NR	*	NR	Lameness and over growth of nail	Traditional and modern
Pasteurellosis	*	NR	*	*	Coughing	Modern

Note: NR = not reported; DB = Debre-Berhan; * = reported

Faciola, a liver disease was locally called odoma or kulkult. Symptoms of Faciolosis was swelling of the neck and coughing. The disease affects all flock if they graze near the watering point. Sheep pox was locally called ``Fentata``. It occurs all year round with symptom of wound on the body. Foot rot locally called ``*choq*`` or ``*shenkef*``, and occurs at any time of the year. Pastorolosis is locally called ``*Angeb*`` and occurs during dry seasons of the year; mostly the diseases affects the ewe. Cutting off with hot knife and washing with salted water were the type of traditional treatment for ``*choq*``. The type of traditional treatment for bloating was drenching of animals with oil.

4.1.9.3. Sheep mortality and distance of veterinary clinic

As shown in Table 22, the average number of dead sheep flock per households within one year was relatively high in Dessie peri urban area. Diseases, emergency like car accident and chocked with rope, poisonous plants, and feed shortage were reported as the causes for the death sheep flocks. Feed shortage was one cause for the death of sheep, especially for lambs' death due to reduction of milk from their dams.

Veterinary services were not accessible for all sheep producers on daily basis due to distance and resource limitations. About 51.6, 36.7, 34.8, and 23.8% respondents for Dessie peri-urban, Debre-Berhan peri-urban, Dessie urban and Debre-Berhan urban areas reported that veterinary clinic was located at more than 4 km away from their residences. The veterinary technicians treat animals once per week at sheep producer's village.

Table 22. Number of dead sheep and distance of veterinary clinic

Variables	Urban		Peri-urban	
	Debre-Berhan	Dessie	Debre-Berhan	Dessie
Dead flock (number)				
Ewe	2.3±1.35	1.9±1.17	2.8±2.08	2.4±1.50
Lamb	2.2±1.47	2.7±1.67	2.9±1.49	2.8±1.33
Ram	1.0±0.00	1.7±1.50	1.4±1.26	3.0±0.00
Fattened	2.1±1.05	1.0±0.00	1.3±0.49	1.0±0.00
Veterinary Clinic Distance (% of respondents)				
<1 km	28.6	50.0	8.9	38.7
1-2 km	31.0	15.2	26.7	9.7
2-3 km	16.7	0	27.8	0
> 4km	23.8	34.8	36.7	51.6

4.2. Feeding Trial

4.2.1. Nutrient composition of feeds

The laboratory chemical analysis result of nutrients of experimental feed ingredients and refused grass hay is presented in Table 23. The dry matter (DM), metabolizable energy (ME) and crude protein (CP) contents of grass hay were 92.01%, 7.69 MJ and 6.85%, respectively. The contents of *in vitro* organic matter digestibility (IVOMD), neutral detergent fiber (NDF), acid detergent fiber (ADF) and acid detergent lignin (ADL) of grass hay were 48.09, 32.5, 36.5 and 11.8%, respectively.

Table 23. Nutrient composition of experimental feed ingredients (%)

Feed ingredient	Nutrient composition (%DM)							
	DM%	IVOMD	ME	CP	NDF	ADF	ADL	Ash
Hay	92.01	48.09	7.69	6.85	32.5	36.5	11.8	9.54
Wheat bran	91.17	74.62	11.94	18.55	35.94	10.8	2.9	17.50
Elat	91.73	66.45	10.63	28.32	30.2	8.51	3.8	15.61

Note: - DM = dry matter; IVOMD = *in vitro* organic matter digestibility; ME = metabolizable energy; CP = crude protein; NDF = neutral detergent fiber; ADF = acid detergent fiber; ADL = acid detergent lignin; ND = no data.

The chemical analysis for wheat bran showed that it contained 91.17% DM, 74.62% IVOMD, 11.94 MJ, ME, 18.55% CP, 35.94% NDF, 10.8% ADF and 2.9% ADL. The DM, IVDOM, ME, CP, NDF, ADF, and ADL values of lentil split screening, which is locally called "*Elat,* were 91.73%, 66.45%, 10.63 MJ, 28.3, 30.2, 8.51, and 3.8%, respectively.

4.2.2. Dry matter and nutrient intake

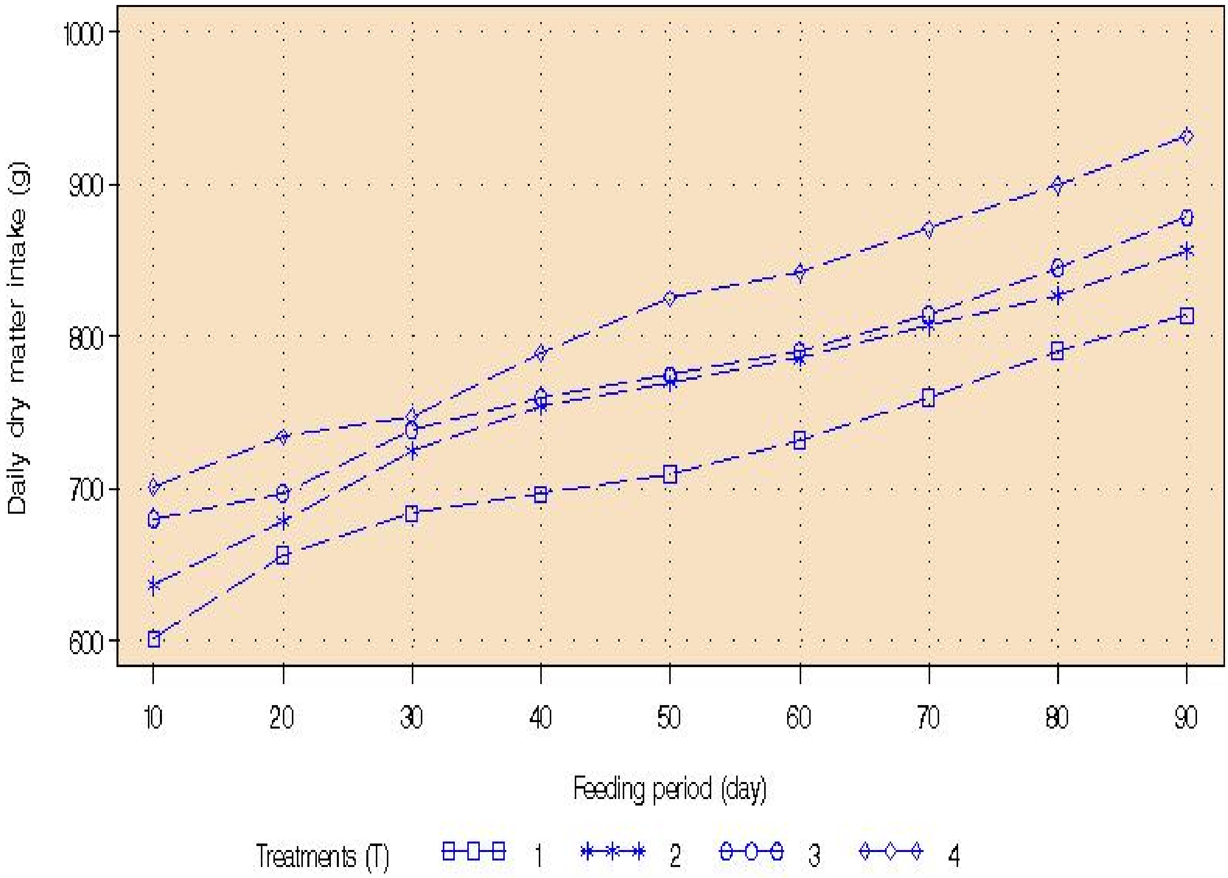
The effects of different combinations of wheat bran and lentil screening on the average daily dry matter and nutrient intake of finishing ram lambs is presented in Table 24. Wheat bran and lentil screening combinations affected ($P \leq 0.05$) the daily hay dry matter intake (HDMI), total dry matter intake (TDMI) and hay crude protein intake (HCPI). The total metabolizable energy intake (TMEI) and total crude protein intake (TCPI) of lambs were different ($P \leq 0.001$) for the concentrate combination groups. The hay dry matter intake of the lambs was highest for a combination of 30g wheat bran and 133g lentil screening (T_1) than T_3 and T_4 concentrate diet Lambs were assigned for 227g wheat bran and 120g lentil screening combination (T4) showed highest TDMI than T_1 T_2 and T_3 diet groups. The total metabolizable energy intake of lambs was higher in T_4 than T_1 and T_2 groups. Lower TCPI was recorded for lambs assigned to a concentrate diet with 30g wheat bran and 133g lentil screening combinations (T_1) than recorded for T3 followed by T2 and T4 diet groups.

Table 24. Dry matter and nutrient intakes as affected by wheat bran and lentil screening combinations (g)

Treatment	Measured Variables						
	Hay DMI	Conc. DMI	TDMI	TMEI	Hay CPI	Concentrate. CPI	Total CPI
T1	548.06^{a}	168.0^{a}	716.06^{a}	5.75^{a}	37.54^{a}	43.23^{a}	80.77^{a}
T2	520.17^{ab}	240.0^{b}	760.17^{a}	6.23^{b}	35.63^{ab}	66.55^{b}	102.18^{b}
T3	485.11^{b}	290.0c	775.11^{a}	7.09^{c}	33.23^{b}	52.87^{c}	86.10^{c}
T4	462.47^{b}	352.0^{d}	814.47^{b}	7.18^{cd}	31.68^{b}	76.09^{d}	107.77^{d}
Sig.	*	***	*	***	*	***	***

Note: - DMI = dry matter intake; TMEI= total metabolizable energy intake in MJ; CPI = crude protein intake; abc = the same column with different superscripts differ significantly; * = $P \leq 0.05$; ** = $P \leq 0.01$; *** = $P \leq 0.001$; Sig. = Significance.

The feed intake showed an increasing trend with time of feeding period (Figure 1). The dry matter intake of lambs in $T_1$was increased during the first ten days of feeding period at an increasing rate. Then, from 30th up to 60th days it was increasing at decreasing rate followed by increasing with higher rate up to the last days of the experiment period. Lambs assigned to T_2 showed higher rate of dry matter intake during the 1st, 2nd, 3rd and 4th ten-day interval but, afterwards it increased at decreasing rate and then kept increasing till the last experimental days.



Note: 1 = a diet contains 30g wheat bran and 133g lentil screening (T_1); 2 = a diet contains 235g lentil screening (T_2); 3 = a diet contains 285g wheat bran (T_3); 4 = a diet contains 227g wheat bran and 120g lentil screening (T_4).

Figure 1. Trends of dry matter intake by experimental animals as affected by wheat bran and lentil screening combinations

In a diet containing 285g wheat bran (T_3) during the 1st ten days' interval, the DMI was increased at decreased rate then became increased at higher rate till the 70th day and then the increasing rate became lower. The lambs offered a diet contained 227g wheat bran and 120g lentil screening (T_4) showed less DMI increasing rate during the 1[st] and 2[nd]ten day's intervals, then increased at increased rate up to the end of experimental days.

4.2.3. Body weight change and feed conversion efficiency

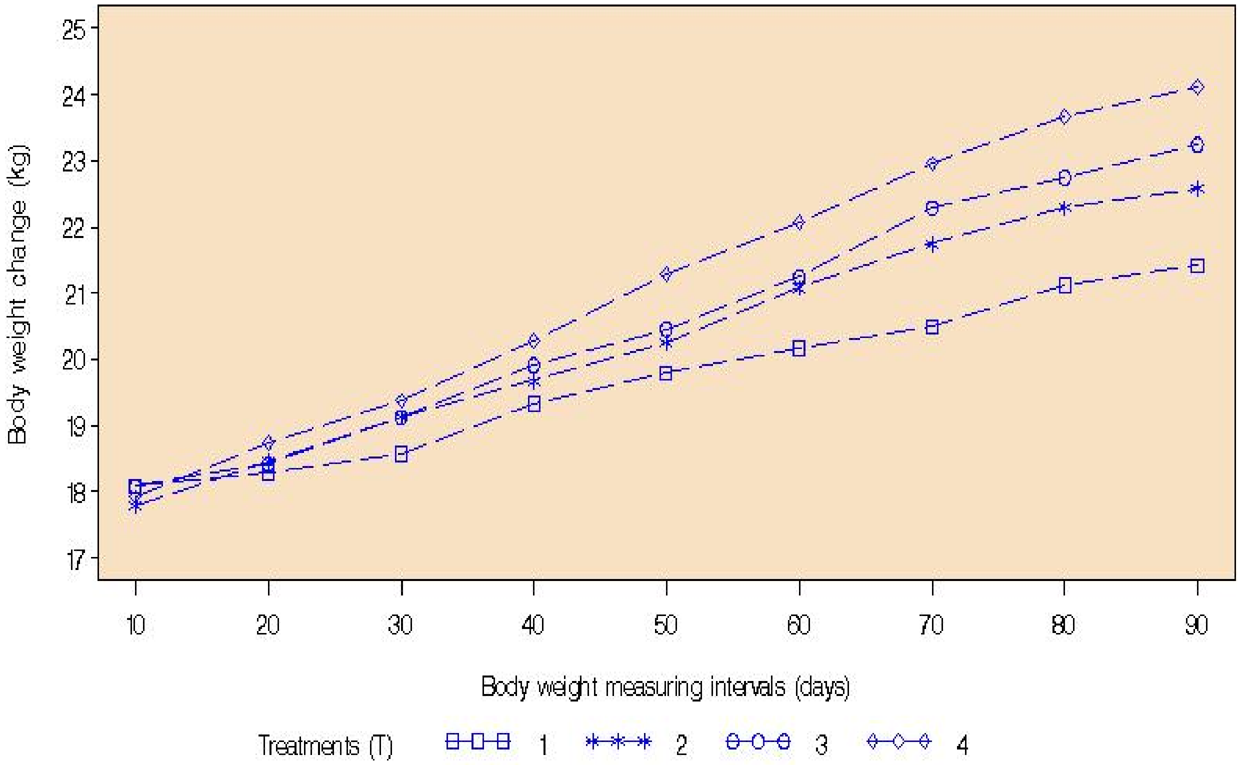
The effect of wheat bran and lentil screening combinations on body weight change and feed conversion efficiency (FCE) of finishing ram lambs is presented in Table 25. The initial body weight of the experimental animals was similar ($P \geq 0.05$) between the dietary treatment groups. Final body weight (FW) of the animals was higher ($P \leq 0.01$) for those animals fed 227g wheat bran and 120g lentil screening concentrate (T_4). Total body weight gain (BWG) and daily body weight gain (DBWG) of those animals allocated to T_4 were higher ($P \leq 0.001$) than recorded for lambs T_1 followed by T_2 then T_3 diet group. The wheat bran and lentil screening concentrate combination effect was significant ($P \leq 0.01$) for FCE in terms of kg body gain per kg dry matter intake. The experimental sheep showed superior feed efficiency (0.08) for the diet containing 227g wheat bran and 120g (T_4) lentil screening concentrate than those offered a diet containing 30g wheat bran and 133g lentil screening (T_1).

Table 25. Body weight change and feed conversion efficiency as affected by wheat bran and lentil screening combinations

Treatment	Measured variables				
	IBW (kg)	FW (kg)	TWG (kg)	DWG (g)	FCE
T1	18.08	21.42a	3.33^{a}	37.04^{a}	0.06^{a}
T2	17.79	22.58^{abc}	4.79^{b}	53.24^{b}	0.07^{b}
T3	18.08	23.25^{b}	5.17^{b}	57.41^{b}	0.07^{b}
T4	17.92	24.13^{c}	6.21^{c}	68.98^{c}	0.08^{b}
Sig.	NS	**	***	***	**

Note: IBW = Initial body weight; FW = Final body weight; TWG = Total body weight gain; DWG = Daily body weight gain; FCE = feed conversion efficiency (BWG / DMI); ** = $P \leq 0.01$; *** = $P \leq 0.001$; NS = non-significant; Sig. = Significance level.

The body weight change trend of the experimental lambs during the feeding trial is indicated in Figure 2. Lambs allocated to T_1 (30g wheat bran and 133g lentil screening) showed increased body weight gain at lower rate between 10^{th} and 30^{th} days and then increased at higher rate from the 40^{th} up to the 70^{th} days. Then, the rate slowed after wards. The body weight change for T_2 and T_3 diet groups was growing at higher increasing rate, then after 70^{th} day it continued to increase at slower rate up to the end of experimental period. Those lambs assigned to T_4 (a diet contains 227g wheat bran and 120g lentil screening) grew at increasing rate from the first 10^{th} up to 80^{th} days of experimental period, but thereafter, they grew at a slower rate.



Note: 1 = a diet contained 30g wheat bran and 133g lentil screening (T_1); 2 = a diet contained 235g lentil screening (T_2); 3 = a diet contained 285g wheat bran (T_3); 4 = a diet contained 227g wheat bran and 120g lentil screening (T_4).

Figure 2.Body weight change trends of sheep as affected by wheat bran and lentil screening combinations

4.2.4. Dry matter and nutrient digestibility

Table 26 shows the effect of wheat bran and lentil screening combinations on dry matter and nutrient digestibility. During the digestibility trial, the dry matter intake (DMI) and dry matter digestibility (DMD) of experimental lambs were different ($P \leq 0.05$) between the concentrate supplement combinations. The crude protein intake (CPI) and the, crude protein digestibility (CPD) were significantly affected ($P \leq 0.001$) by wheat bran and lentil screening combinations Neutral detergent fiber digestibility (NDFD) and acid detergent fiber digestibility (ADFD) were different ($P \leq 0.01$) between the treatment diets groups.

Table 26. Dry matter and nutrient digestibility as affected by wheat bran and lentil screening combinations

Treatments	Measured variables					
	DMI (g)	DMD (%)	CPI (g)	CPD%	NDFD (%)	ADFD (%)
T1	649.30^{a}	62.95^{a}	76.20^{a}	74.77^{a}	43.02^{a}	47.89^{a}
T2	672.02^{a}	66.75^{ab}	96.15^{b}	81.17^{b}	49.89^{ab}	48.58^{a}
T3	709.43^{ab}	74.59^{b}	81.60^{ac}	82.86^{c}	63.99^{b}	64.52^{b}
T4	791.87^{b}	75.76^{b}	106.22^{d}	86.41^{d}	66.48^{b}	66.70^{b}
Sig.	*	*	***	**	*	**

Note: DMI = dry matter intake; DMD = dry matter digestibility; CPI=Crude protein intake; CPD= crude protein digestibility; NDFD = neutral detergent fiber digestibility; ADFD =acid detergent fiber digestibility; abc = values in the same column with different superscripts differ significantly;* = P≤ 0.05; ** = P≤0.01; *** = P≤0.001.

Accordingly, higher DMI and DMD were recorded for lambs assigned to 227g wheat bran and 120g lentil screening contained concentrate supplement (T_4) than those fed 30g wheat bran and 133g lentil screening mixture (T_1) diet. The CPI was higher at a diet contained 227g wheat bran and 120g lentil screening mixture (T_4) than on a diet contained 235g lentil screening (T_2), followed by on 285g wheat bran (T_3) and 30g wheat bran and 133g lentil screening (T_1) diet group. The CPD was also higher in T_4 than T_3 followed by T_2 and T_1. Similarly, the lambs showed a higher NDFD and ADFD when fed to 227g wheat bran and 120g lentil screening contained concentrate supplement (T_4) than those lambs assigned to T1 diet categories.

4.2.5. Nitrogen balance

The effect of wheat bran and lentil screening combinations on nitrogen balance of finishing ram lambs is presented in Table 27. The effect of concentrate combinations was significant (P≤0.001) on total nitrogen intake (TNI) and nitrogen digestibility (ND) of the experimental lambs. The lambs did show significant difference (P≤0.001) in their total Nitrogen voided via feces and urine among the dietary treatment groups. The wheat bran and lentil screening combination effect was not significant (P≥ 0.05) on feces and urine nitrogen content. The N retention was significantly affected (P≤0.001) by the concentrate diet combinations.

Table 27. Nitrogen intake and utilization of lambs as affected by wheat bran and lentil screening combinations

Treatments	Measured variables							
	TNI (g)	ND (%)	Urine N (%)	Feces N (%)	Void Nitrogen(g)		Total TNR	
					urine	feces	(g)	(%)
T1	12.19^{a}	74.77^{a}	1.96	1.30	3.42^{a}	3.06^{a}	5.72^{a}	46.26a
T2	15.38^{b}	81.17^{b}	2.44	1.30	4.92^{b}	2.87^{ab}	7.59^{a}	49.17a
T3	13.06^{a}	82.86^{b}	1.75	1.26	3.29^{a}	2.24^{b}	7.52^{a}	57.55ab
T4	16.99^{c}	86.41^{b}	2.09	1.22	3.98^{ab}	2.32^{b}	10.71^{b}	63.04bc
Sig.	***	***	NS	NS	*	**	***	*

Note: TNI = total nitrogen intake = nitrogen; ND = nitrogen digestibility; TNR = total nitrogen retained; abc = the same column with different superscripts differ significantly; * = P≤ 0.05; ** = P≤0.01; P≤0.001; NS = non-significant; Sig. = Significance level.

The experimental lambs showed a higher TNI in T_4 than T_2 followed by T_3 and T_1 diet groups. Nitrogen digestibility in a diet containing 30g wheat bran and 133g lentil screening

(T_1) was lower than recorded from T_4 T_3 and T_2 diet groups. The total nitrogen void via urin was higher from lambs were assigned for T_2 (a diet contained 235g lentil screening) than seen for T_1 and T_3. The higher amount of N was retained for the lambs that were assigned in 227g wheat bran and 120g lentil screening containing diets (T_4) than were in T_1, T_2 and T_3 groups. The nitrogen void via feces was more from lambs fed 30g wheat bran and 133g lentil screening concentrate supplement (T_1) than were in T_3 and T_4 categories.

4.2.6. Carcass evaluation

4.2.6.1. Carcass yield

The effect of wheat bran and lentil screening combinations on carcass yield is presented in Table 28. The slaughter and empty body weight, and cold carcass weight of finishing ram lambs varied ($P \leq 0.001$) between wheat bran and lentil screening combinations. The hot carcass weight was also affected ($P \leq 0.01$) by wheat bran and lentil screening combinations. The dressing percentage and carcass lean, fat and bone proportion of lambs were similar ($P \geq 0.05$) between the treatment diets groups.

Table 28. The carcass yield parameters as affected by wheat bran and lentil screening combinations

Treatments	Measured variables								
	SW (kg)	EBW (kg)	Carcass wt. (kg)		Dressing %		Carcass proportion (%)		
			Hot	Cold	SW basis	EBW basis	Lean	Fat	Bone
T1	19.20^a	15.48^a	7.88^a	7.34^a	41.20	50.17	57.69	10.78	27.83
T2	21.40^b	18.00^b	9.32^b	8.77^b	43.48	51.76	60.08	11.84	25.12
T3	22.20^b	18.76^b	9.40^b	8.89^{bc}	42.42	50.17	56.93	11.04	24.93
T4	22.60^b	19.56^c	10.06^b	9.65^c	44.61	51.64	58.62	12.28	26.31
Sig.	***	***	**	***	NS	NS	NS	NS	NS

Note: SW = Slaughter weight; EBW = Empty body weight; ** = $P \leq 0.01$; *** = $P \leq 0.001$; NS = non-significant; Sig. = significance level.

The higher slaughter and empty body weight was recorded for lambs assigned to T_4 diet categories than were in T_1, T_2 and T_3 ones. The carcass yield of lambs was increased at concentrate supplement of 227g wheat bran and 120g lentil screening mixture (T_4) than at T1 diet. Lambs assigned to T_4 diet numerically had higher dressing percentage in terms of slaughter weight than the lambs fed T_1, T_2 and T_3 diets. A bit higher fat percentage also was recorded for lambs assigned to a T_4 than T_1 followed by T_2 then T_3 group. The carcass lean proportion from lambs was better at T_2 than T_4 then followed by T_1 and T_3 categories.

4.2.6.2. Non-carcass body components

The effect of wheat bran and lentil screening combinations on non-carcass body components are presented in Table 29. Wheat bran and lentil screening combinations effect was

Table 29. Non- carcass body components as affected by wheat bran and lentil screening combinations

Measured variables	Treatments				
	T_1	T_2	T_3	T4	Sig.
Full gut (kg)	5.32	5.12	5.16	4.80	NS
Empty gut (kg)	1.60	1.72	1.76	1.80	NS
Kidney (g)	57.62	60.76	59.26	62.94	NS
Kidney fat (g)	29.68^{a}	48.30^{bc}	37.92^{ab}	51.62^{c}	**
Spleen (g)	43.74	44.46	49.26	49.64	NS
RT (g)	0.28^{a}	0.35^{b}	0.31^{ab}	0.37^{b}	*
Heart (g)	0.12	0.13	0.12	0.13	NS
Liver ^{a} (g)	0.33	0.38	0.35	0.39	NS
Blood,(kg)	0.78^{a}	0.85^{a}	0.84^{b}	0.96^{c}	*
Skin,(kg)	1.95^{a}	2.33^{ab}	2.23^{ab}	2.70^{b}	NS
Head,(kg)	1.64	1.91	1.82	1.83	NS
Testicles, (g)	0.19	0.21	0.19	0.24	NS
UGT, (g)	62.82^{a}	94.14^{b}	74.78^{ab}	125^{c}	**

Note: UGT = ureo-genital tract; a = Liver with gallbladder, RT= lung with trachea;* = P≤0.05; ** = P≤0.01; NS = non-significant; Sig. = significance level.

significant (P≤ 0.01) on kidney fat and ureo-genital tract (UGT) of the experimental lambs. Respiratory tract and blood weights were different (P≤ 0.05) between the treatment diet groups.

4.2.6.3. Carcass quality parameters

Carcass quality parameters as affected by wheat bran and lentil screening combinations are shown in Table 30. Wheat bran and lentil screening combinations effect was non-significant (P≥0.05) on all carcass quality parameters except on DM content of carcass fat. The DM% of carcass fat from lambs was higher (P≤ 0.001) for the diet contained 227g wheat bran and

Table 30. Some carcass quality parameters as affected by wheat bran and lentil screening combinations

Measured variables		Treatments				
		T_1	T_2	T_3	T4	Sig.
DM%	lean	29.08	28.70	30.80	32.96	NS
	Fat	50.86^a	53.30^b	55.12^c	55.66^c	***
Lean CP %		61.58	60.50	60.58	58.00	NS
EE %	lean	6.39	7.14	8.49	8.84	NS
	fat	90.26	80.49	83.44	90.55	NS
Carcass pH	Hot	6.61	6.86	6.91	6.68	NS
	Cold	5.68	5.71	5.94	5.80	NS
Hot carcass color	L*	33.53	33.74	32.93	31.50	NS
	a*	7.83	7.17	6.99	6.85	NS
	b*	7.42	7.26	6.63	6.56	NS
Cold carcass color	L*	34.53	34.21	32.94	34.60	NS
	a*	11.33	12.04	9.96	10.26	NS
	b*	8.11	9.97	8.59	7.08	NS

Note: DM = dry matter; CP = crude protein; EE = Ether extract; L*= bright, a*= red and b*= yellow; abc = the same column with different superscripts differ significantly; *** = P≤0.001; NS = non significant; Sig. = Significance level

120g lentil screening (T_4) than T_1 and T_2 diet. Animals assigned to T_2 diet had numerically greater value (8.59) of cold carcass b* value than 8.59, 8.11 and 7.08 recorded from T_3, T_1 and T_4 diet groups. The CP% in carcass lean of lambs was numerically higher for T1 > T3 > T2 diet. The values of cold carcass brightness (L*) was a bit higher from lambs assigned for T_4 diet.

4.2.7. Partial budget analysis

The partial budget analysis or the cost benefit analysis of feeding as affected by wheat bran and lentil screening combination is presented in Table 31. The effect of these concentrate was significant (P≤0.001) on costs of wheat bran and lentil screening. The feed cost per kg body weight gain was different (P≤0.05) between the treatment groups. The feed cost per kg body weight gain for 8 MJ ME diets was higher than was for 9MJ ME diet. Hay and total feed costs were similar (P≥0.05) between 8 and 9 MJ ME diet groups.

Table 31. Partial budget analysis as affected by wheat bran and lentil screening combinations

Treatments	Measured variables					
	Growth (Wt. gain/ head)	Cost				Feed cost/kg BW gain
		hay	wheat bran	lentil screening	Total feed	
T1	3.33^a	153.46	8.29^a	52.20^a	213.95^a	65.80^a
T2	4.79^b	145.65	0.00^b	92.23^b	237.87^{ab}	51.31^b
T3	5.17^b	135.83	78.78^c	0.00^c	214.61^a	42.45^b
T4	6.21^c	129.49	76.56^d	47.09^d	253.15^b	42.23^b
Sig.	***	NS	***	***	*	***

Note: BW = body weight; abc = the same column with different superscripts differ significantly; * = P≤ 0.05; *** = P≤ 0.001; NS = non-significant; Sig. = significance level.

5. DISCUSSION

5.1. Household Socio-economic Characteristics

The present study identified that urban and peri-urban sheep production was undertaken as a sideline practice with other agricultural and non-agricultural activities. The predominant occupation for sheep producers was farming in peri-urban and trading in urban study areas. In line with this, Okanlade and Cornelius (2011) reported that sheep producers in urban areas were engaged as traders, technician, teachers, civil servants and retired personnel.

In general, most family education was up to completion of elementary school in all study areas. It is a good opportunity to disseminate improved sheep production inputs in the areas because at least most family members can read and write. Family size in the present study areas was less than the family size previously reported by Getachew *et al*. (2010) for Menz area, but was similar with family size (5.7) of the adjacent rural areas of Debre -Berhan peri-urban reported by Hassen *et al*. (2010). In urban areas, almost all sheep producers were landless while the high proportion of respondents in peri-urban of Debre -Berhan had the landholding within the range of the previously reported land size of the adjacent rural areas (Hassen *et al*., 2010).

5.2. Landholding and Agricultural Practices

Almost all urban respondents practiced only livestock agriculture, whereas in peri-urban areas most respondents did crop production, indicating that more time, labor, and different agricultural inputs were allocated for crop production than livestock rearing in peri-urban study areas, whereby the reverse was the case for urban areas. Based on the previous research reports by Getahun (2008) and Solomon *et al.* (2008b), highland sheep production system is characterized by sheep flock sizes ranging from 30 to several hundred heads for barley production system and cattle dominant agriculture. The present study revealed that urban and peri-urban sheep production system in the study areas is dominated by sheep flock sizes of 7.5-16.7 as compared to other livestock, and integrated with crop production and small trades in peri-urban and urban areas, respectively.

FAO (2007) report also revealed that urban and peri-urban agriculture is growing and the raising of animals for food and other uses within and around cities and towns on vacant and/or under-utilized lands, including areas not suited for building, public or private uses. But, the present study revealed that almost only livestock rearing is undertaken in urban areas. It could be due to less respondents` experience for integrating crop production or unavailability of land. According to the present study almost all respondents are landless in urban areas and much of respondents in peri-urban areas have <0.5 ha land. The main crops grown in the Debre-Berhan study areas were barley, wheat, beans, peas, lentils and linseed. Among these crops, barley and beans were the most important crops. The present study was in line with the previous study in which the first three main crops grown around Debere-Berhan locations were cereals, pulses and linseed (Melese *et al*., 1996).

5.3. Livestock Species and Sheep Flock Structure

Compared to other livestock species, the existence of large number of sheep per household in the present study agreed with that reported by Firew and Getnet (2010) for Basona Worana Woreda, located surrounding Debre-Berhan pri-urban Kebeles. The number of sheep per household in the present study was less than the number of sheep in rural household reported by Getachew *et al*. (2010). In the urban and rural parts of Ethiopia, the number of sheep per household ranged from 3.6 to 6.7 (Zelealem *et al*., 2012; Shenkute *et al.,* 2010; Dinksew and Girma, 2000), which were less than the number of sheep in the present study areas. The variation in the number of sheep per household might be due to differences in agro-ecologies and production systems of the areas and the present study areas have a high potential for sheep production. Okanlade and Cornelius (2011) reported that the total flock size per household was 5-10 in urban areas of Nigeria. The total flock size in present study areas was within this range except for Debre -Berhan pri-urban study cites.

The Menz and Wollo sheep types in Debere-Berhan and Dessie study locations respectively were the dominant local sheep. According to respondents, the crossbred grew faster, but they do not tolerate diseases and feed shortages. This could be the reason for less adaptability of crossbreds. Local sheep breeds are characterized by early lambing, survival on less feed quality and quantity, diseases tolerance and twin births as compared to crossbreds. Getachew *et al*. (2010); Solomon *et al*.(2008a) and Tibbo (2006) reported that although the Menz sheep are highly adapted to the harsh environment of the area, their productivity is low and the cross-breeding program also failed due to different technical and organizational problems. So, it is better to continued improving productivity of local breeds through long term actions that could be effective breed improvement to develop appropriate one. In short term improving of feed, feeding, nutrition, housing and health could be the better options to exploit the maximum productivity improvement potential of existing local breed.

5.4. Livestock Population Trends

In most households the population of livestock was increasing. The main reasons for livestock population increment were attractive market prices of the animals and their products (milk, meat and egg) and byproducts including manure and power. As a result, animal producers are encouraged to increase their animal numbers. Animal population was also decreased due to shortage of grazing land, space and labor in some households. Increasing of feed cost, and emergency like fire and car accidents, and theft were also the reasons for decreasing of livestock. Some respondents said that to rear few improved cattle they preferred to reduce the other livestock. In Dessie, urban and peri-urban study areas, the donkey population was increasing from time to time due to their increasing importance for transportation of building materials. The population of horse was also increasing due to increasing of their importance for horse cart pulling in both study areas. Hassen *et al*. (2010) reported from adjacent rural areas of the present study cites, that horses are used mainly for transporting people and donkeys are used to transport inputs, farm equipment, and harvested grains or crop residues from the farm land and to homesteads or market places.

The other reason or increment of livestock was due to expansion of the town their crop land has been taken over by the government for urban development activities. Therefore, they were increasing their animal number on their limited available land to compensate their income source from the animal and animal products. In line with this, FAO (2011) reported that, even if keeping animals in urban and peri-urban areas is not new, the phenomenon of keeping animals in urban and peri-urban areas is increasing in many developing countries. Due to higher return per unit of land from livestock compared to crops, urban livestock keeping benefits the poor in terms of diversifying livelihoods activities but, zoonoses, environmental contamination and product safety problems should be addressed (DIFID, 2002).

5.5. Common Feed Resources for Sheep

Most of the feedstuffs found in urban and peri-urban areas of Ethiopia are household wastes; by-products from various industries, few forage plants and roadside grazing (Solomon *et al.,* 2008a). Natural pasture grazing, native pasture hay, crop residues, wheat bran and noug seed cake, legume grains processing by-products, *attela* and brewery dried grain were identified feed sources by the present study. In Debre-Berhan peri-urban area, natural pasture grazing and crop residues were dominant feed resources due to more landholding in the areas as compared to peri-urban Dessie. In agreement with the present study, Sere *et al.* (2008) reported that natural pasture and crop residues are the largest contributors to livestock feed in most developing countries.

Greater index figure for grass hay as feed resources in Dessie area supported the report of Firew and Getnet (2010), who stated that the practice of hay conservation is well adopted in Dessie areas. In Dessie town, many flour and oil pressing plants are found. As a result, many respondents use wheat bran and noug seedcake as feed for sheep. Brewery dried grain used as feed resource in Dessie study areas is related with the presence of beer factory in the nearby Combolcha town. In Debre -Berhan areas, there is more *atella* production than in Dessie area due to the tradition of people in Debre-Berhan to use local beer for home use and income. On the contrary, in Dessie local brewing is not common and consequently availability of the by-product is limited. In Debre-Berhan town, there are cooperatives engaged in legume grain processing for human food. As a result, plenty of by-products are produced. But, these by-products are transported to Adama and Mojo towns for fattening of livestock. Producers are fetching more income from selling of these by-products to livestock fatteners at Adama and Mojo towns, where the by-products are more expansive than at Debre-Berhan areas.

5.6. Sheep Feeding and Management System

Either free grazing or semi-grazing with herding or without herding plus stall feeding was the feeding method in urban and peri-urban areas of the present study areas. In urban sheep production grazing is undertaken on road sides and other vacant lands reserved for different purposes and in some cases also on rented land. In the case of stall feeding, understanding the amount of mixed feed, type of mixed feed, time of feeding; feeding based on the age and physiological stages was not considered. Due to this, it was difficult to evaluate the efficiency of feeding. It seems that could be underfeeding or overfeeding of the animals in the study areas. Similarly, Diogo *et al*. (2010) suggested that the lack of knowledge on nutrient supply through feed might lead to oversupply with severe environmental impacts. Baah *et al*. (2012) observed a similar problem, because in most cases, even though, producers provided feed *ad libitum* to their animals, the quality of the feed was questionable.

In Debere-Berhan study area mostly *attela* is mixed with crop residues, different types of legume grain processing by-products and wheat bran either mixed or independently. The way of feeding in the case of noug seed cake is by soaking in water overnight and then mixing with other feed ingredients or alone depending on availability. In Dessie areas, feeding of chopped maize stover and brewery dried grain with or without spraying of salted water is one method of feeding.

In all study areas hay is fed to sheep without physical or chemical treatment. Almost all sheep producers in peri-urban areas fed crop residue either alone or mixed with Atela. In agreement with this study, Hassen *et al*. (2010) reported that almost all farmers feed roughages as it is or do not practice any form of feed treatment, mainly due to shortage of labor for physical treatment, lack of know-how, lack of finance and inaccessibility for chemicals. Moreover, in Dessie study areas, maize is used as feed resource around

September and maize stover from December to February. In this area, barley is sown in February (the small rainy season) and harvested in June. Its residue, barley straw, is used for wet season feeding.

In both Debre-Berhan and Dessie study areas, feeding of grass hay, wheat bran, noug seedcake and legume processing by-products are prioritized for feeding of fattening sheep, followed by lactating ewes and then for the other flocks. Solomon *et al*. (2010) reported that supplementary feeds are given only for fattening sheep and goats in one of rural districts of the same study area. In Debre-Berhan peri-urban study area, cooked legumes and cereal grains are some of the feed ingredients for fattener sheep feeding. The fattener sheep are fed indoors from two to six months in most cases, but in the case of old castrated ram fattening, the fattening period may be more than six months, especially in Debre -Berhan peri-urban study area.

In Dessie peri-urban area, more respondents fatten sheep targeting the New Year market since the Dessie area is less elevated than Debre-Berhan, may be able to have convenient weather condition for fattening during rainy seasons than in Debre-Berhan areas. In Debre-Berhan area, the weather condition and availability of feed is convenient from December onwards to fatten sheep targeting the Easter (April) holiday. The major fattener sheep in Debre-Berhan area are castrated and from own flock. In Debre-Berhan area, old and extra rams are fattened. The more participants in fattening activity in Debre-Berhan area could be due to more market access for fattened sheep due to the proximity of the area to the capital city, Addis Ababa. A better profit from fattened sheep in the Debre-Berhan area also could be attributed to the better market access and higher prices fetched.

The river is main water source for sheep in Debre-Berhan peri-urban. Tap water means the water from hand pumped tap for peri-urban areas of sheep producers mainly. The watering frequency is mostly twice per day in all study areas. Some respondents think that offering of more water to fattener sheep causes less deposition of carcass fat. They thus preferred to offer water once per day. In agreement with the present study, Hassen *et al*. (2010) reported watering frequency for sheep to be mainly once per day in Debre-Berhan peri-urban adjacent rural areas. The sheep are sheltered overnight and partly during the day, predominantly using house and kitchen type shelter. Dhaba *et al*. (2012) also reported that night time sheltering of sheep is common in other parts of Ethiopia to protect them from predators, theft and unfavorable environmental condition.

5.7. Economic Contribution of Sheep Production

The present study showed that for most respondents live animal sale is the first reason of rearing sheep. In agreement with this study, Getachew *et al*. (2010) reported that income source is the first objective of the households in Menz area for sheep production. The sale of live small ruminants is considered as one of the major means income generation the highlands of Ethiopia (Niftalem, 2000). In urban areas of Ghana financial consideration was the main reason why producers kept small ruminants and the provision of animal protein to the urban community is also substantial (Baah *et al*., 2012).

In addition to live animal sale, sheep contributed to fill the protein needs of the family mainly during holidays. New Year, Christmas, Epiphany, Easter and Assumption (Filseta) are the main holidays for Christian religion followers, on which the sheep slaughter. The holidays on which Muslim religion followers slaughter sheep are, Id Al Fater, Id Al Adha or Arafa and Mawlid. In both study areas, sheep producers slaughtered mainly male lambs with an average age of one year.

Sheep production is the first income source in Dessie urban and peri-urban areas and the second income source in Debre-Berhan urban and peri-urban areas. In line with this, Muhammad (2008) found that sheep is an important source of additional income for civil servants and traders in urban and peri-urban areas of Nigeria. Agriculture is most often not the only or even the dominant activity of urban households (FAO, 2007). In relative term, due to more crop failure and less land holding in Dessie area, income from sheep is more important than Debre-Berhan area. Moreover, in relation to crop failure due to shortage of rain and less land holding crop residue availability is lower in Dessie areas and as a result unlike sheep, it is difficult to maintain large ruminants with such very scarce feeds. In line with this, Firew and Getnet (2010) also reported that the Dessie Zuria *Woreda is* moisture deficient and has rugged topography with highly degraded soils which are not generally suitable for cropping. From both study locations, all respondents' sell skin in addition to live animal sales as a source of income.

The contribution of sheep as income source is different due to the sheep price variation from season to season as a result of variation in volume of supply. The main reasons for high price of sheep are the occurrence of holidays. In some cases the reason why high price of sheep is during rainy season there is due to lack of transportation and absence of bridges to cross rivers, the farmers can't bring their sheep to the market. These are good opportunity for urban and peri-urban sheep producers to sell their sheep at higher prices. In some seasons, sheep contributes less for their income due to cheap market price of sheep at the time of high feed shortage. The market price of sheep is also very low due to shortage of labor, drought occurrence and diseases incidence and fasting. The income from sheep rearing mainly contributes for school payment, social and cultural expenditure, clothing, filling food gaps, purchasing of household items and crop production inputs and medical expenses.

5.8. Constraints and Opportunities for Sheep Production

The major constraints identified by the present study were high feed cost, lack of improved breed, lack of capital, labor shortage and other constraints like inadequate space, disease, lack of veterinary service, theft, water shortage, low market price, road traffic accident and poisonous plants occurrence. Likewise, Guendel (2002) explained that there are various constraints to urban and peri-urban livestock production like feed cost, diseases including public health issues and environmental contamination. In rural part of central Ethiopia, the major causes of sheep mortality were worm infection during the heavy rainy season and pneumonia (Getahtun, 2008). Livestock keeping in urban areas takes place under more challenging circumstances due to different factors such as inadequate feed, lack of capital and unimproved genotype and limited space (Shenkute *et al.,* 1010; Abebe *et al.,* 2002 ; DIFID, 2002). High costs of feed, theft of the animals, availability of feed for the animals are challenges for small ruminant production in urban areas (Okanlade and Cornelius, 2011). The identified constraints by the present study have similarities with the previous reports from other areas, but feed shortage in relation with lack of grazing land makes the problem more severe.

Coping mechanisms for the constraints undertaken by sheep producers were selection of sheep from their flock for better ewes and rams, purchasing of feeds, reducing the number of animals, engaging in additional income source works, herding and indoor feeding of sheep.

The opportunities that encourage sheep production in the study areas are the good weather conditions, attractive market price of sheep, availabilities of pulse grain and local beverage distiller by-products, edible oil press and flour mill factories, and feeds for purchase. The other opportunities are natural resource conservation and zero grazing encouraging activities are being undertaken by different development organizations, which could be helpful to improve the availability of some feeds for the future.

5.9. Nutrient Composition of Feed Ingredients

In the present study, almost similar CP (6.85%) content of grass hay was observed as compared to 6.70% CP, 73.96% reported by Aschalew and Getachew (2013). Mullu *et al.* (2008) stated a higher DM (93.3 %), NDF (76.8), ADF (52.0%), and lower CP (4.2 %) contents of grass hay than the present finding. The ME value of hay in the present study (7.69 MJ Kg $^{-1}$ DM) was lower than 10 MJ Kg $^{-1}$ DM reported by Shewangzaw *et al.* (2013). In agreements with the present one, the ME value of grass hay at different harvesting seasons was 6.97-8.65 MJ ME Kg $^{-1}$ DM (Fekede *et al.*, 2014).

The higher CP (18.55%) and similar ME (11.94 MJ) content of wheat bran found in the present study as compared with 17.4% and 11.6 MJ values previously reported by Endashaw *et al.* (2013). The present study showed that lentil split (*Messer kik*) screening (''*Elat*'') had less energy value and more CP value as compared with wheat bran, indicating that it could be a reliable source of protein supplement for the animals. The CP value of *Elat* found in the present study (28.3%) was within the range of the wider varieties of lentil seed CP content (23-30%) reported by Sandhu and Sarvjeet (2007). The lentil hulls CP content was 18.9% (Kassahun *et al.*, 2012). The composition of lentil split screening used in the present study was broken lentil grain, bran (hulls) and spur. Thus, the higher CP value in lentil split screening could be due to the presence of lentil spur in it. The value differences in nutrient contents of grass hay, wheat bran and lentil split screening (*Elat*) between the present and the previous studies could be due to harvesting stage and time, storage facility, soil type and weather condition and varietal differences.

5.10. Dry Matter and Nutrient Intake

The present study showed that dry matter and nutrient intake parameters were statistically affected by energy and protein source concentrate combinations. In T_4 and T_3 diet groups, which was the higher concentrate energy contained ones, the hay dry matter intake of lambs was higher than T1 and T2 groups. It was associated with more concentrate offered for the animals assigned to higher energy contained diets. In agreement with the present findings, Sultan *et al*. (2010) reported that dietary energy levels influenced the nutrient intake of lambs. The total dry matter intake (TDMI) of the animals was higher for the diets containing higher energy concentrate supplement than was at lower level. Similarly, Haddad and Husein (2004) reported that finishing Awassi lambs on high energy diet improves DMI better than on low energy diet. The higher concentrate dry matter intake (CDMI) at 227g wheat bran and 120g lentil screening (T_4) was associated with high concentrate offered for these groups. Similarly, the more amount of CP concentrate feed offered resulted in a higher concentrate crude protein intake (CCPI) and total crude protein intake (TCPI) of the animals.

In line with the present finding, Tesfay and Solomon (2009) observed low hay dry matter intake as levels of concentrate intake increased in Afar sheep lambs. The total DMI (814.47 g) observed from T_4 diet was in agreement with 802 ± 9.35 g reported by Kassahun (2000) from one year old Menz lambs fed on hay *ad libtum* and 400 g concentrate supplement.

In disagreement with the present study, Ebrahimi *et al*. (2007) observed low total feed intake, as protein levels in the lamb's diet were increased. Dry matter intake was higher at low energy and high protein diet (Sultan *et al*., 2010). Anindo *et al.* (1998) reported 568 ± 11 g daily DM intake from 5-7 month-old Menz ram lambs on grazing and supplemented with 80 g molasses-urea-block, which was less than the DMI recorded in the present study. It could be due to the experimental animals' age and feed composition differences. The trend of DMI in the present study showed that it was decline at the last weeks of experimental period for T_2 and T_3 groups. In low energy and high protein containing concentrate diet (T_1) a slower rate of DM intake increment was observed between 30th and 60th experimental day, and then became increasing onwards till the last days. It may be due to compensatory intake for the previous slow rate of feed intake. The continuously higher DM intake at increasing rate in T_4 may be associated with those animals needing more feed to store more fat.

5.11. Body Weight Change and Feed Conversion Efficiency

The present study confirmed that FW, TWG, and DWG of lambs assigned to 227g wheat bran and 120g lentil screening mixture (T4) were higher than those fed on T_1, T_2 and T_3 diet. Similarly, the wheat bran and lentil screening combination effect was significant on FCE. Lambs assigned to a diet containing 227g wheat bran and 120g lentil screening showed higher FCE than were seen for T_1 diet groups. In agreement with the present study, Moharrery *et al*. (2012) and Yagoub and Babiker (2008) reported that daily body weight gain improved at a higher dietary energy than at a lower energy level. The final body weight of the lambs fed a diet containing 2.90 Mcal/kg DM was higher than lambs fed a diet with 2.40 Mcal/kg DM (Wandrick *et al*., 2012), which was in similar trend with the present finding. The FCE was higher in a diet containing a higher ME and CP level (Ebrahimi *et al*., 2007). Similarly, Yagoub and Babiker (2008) stated that increased dietary energy level improved FCE. Hosseini (2008) also indicated that dietary energy density has effect on performance of lambs and it is the major dietary element responsible for the variation in the utilization of nutrients.

Kassahun (2000) reported that Menz ram lambs attained 19.12 ±0.47 kg body weights at their 12 month of age with DWG of 50.62 ± 2.20 g. The 5-7 months old Menz ram lambs resulted in 4 kg extra body weight after 6 months of grazing and supplemented with 80 g molasses-urea-block (Anindo *et al.,* 1998). Indoor feeding supplementing with 227g wheat bran and 120g lentil screening mixed diet resulted in better final body weight during the 3 months feeding period seemed to be acceptable to obtain best body weight of finishing Menz ram lambs. Almost in all treatment groups, the body weight change trend was increasing with slower rate at the beginning of experimental weeks then increased at a higher rate followed by slower rate towards the last week indicated that the three months of lambs finishing time with the same age group and diet could be enough.

5.12. Dry Matter and Nutrient Digestibility and Nitrogen Balance

The present study indicated that the wheat bran and lentil screening combinations effect was significant on DM and nutrient digestibility. It was due to increasing of dietary energy level at higher concentrate combination. In agreement with this, Sultan *et al*. (2010) and Mahqoub *et al*. (2000) reported a higher digestibility of DM and N as energy levels increased in the diet. According to Haddad and Husein (2004), finishing Awassi lambs on 2.92 Mcal kg^{-1} diet improved nutrient digestibility than on 2.40 Mcal kg^{-1} diet. The total CP intake of lambs was higher at higher protein containing concentrate in the present study. .Hassan and Saeed (2012), reported that the DM and N intake and digestibility of Awassi lambs was higher at 13.5 than 11.5% CP but, it decreased at a higher (15.5%), CP diet. Higher NDF and ADF digestibility observed for higher wheat bran and lentil screening combination level could be due to a better rumen environment created for improved fiber digester microbial population. The DM intake were decreased during digestion trial than the feeding trial, which might be due to stress conditions created due to urine and feces collection materials tied to experimental animals.

The TNI during digestibility trial and nitrogen digestibility were significantly higher at 227g wheat bran and 120g lentil screening mixture (T4) diet could be indicating that positively collated with the increasing of dietary energy in the concentrate supplement. The slightly higher urine N voided from T_2 than T_1 and T_3 may be indicating that in the concentrate supplement feed, 10.4 MJ ME couldn't be enough to trap the 27.73% CP to utilize N efficiently and to retain to the body of the animals. The amount of crude protein was more than the required level in the supplement feeds. Relatively, lower urine nitrogen void from the other three treatments indicated better nitrogen utilization. The higher feces N voided from T_1 were also showed inefficient nitrogen digestibility. In agreement with the present study Vliet (2007) reported that feces produced on low-protein diet had lower amount of N than feces on a high-protein diet. The higher amount of total N retention in the animals at T_4 indicated that N utilization was improved at these concentrate combination.

5.13. Carcass Evaluation

The concentrated diet supplement combination affected the slaughter body, empty body, hot and cold carcass weights and these parameters were higher at T_4 than were at T_1, T_2 and T_3 diets. The dressing percentage and carcass proportion were not affected by energy and protein source concentrate feed combinations. Ríos-Rincón *et al.* (2014) also observed insignificant effect of dietary protein level on lamb carcass parameters.

In the present study, the dressing percentage recorded from all treatment groups disagreed with Kassahun (2000), who reported 49.1% dressing percentage, 10.78-12.36 % fat, 24.93-26.48% carcass bone and 19.5% fat proportion from the same breed slaughtered at about 17 months of age and attained 32 kg live body weight. Ewnetu *et al*. (2006) also found higher pre-slaughter weight (25 kg), empty body weight (20.4 kg) and carcass weight (10 kg), lower fat (9%) and bone (23%) proportion from 17-month-old Menz ram lambs. The difference on carcass measurements observed between the previous and the current study could be due to age and nutrition composition differences. In line with this, different scholars such as, Santos-Silva *et al*. (2002); Ruzic-Muslic *et al*. (2011) and Muhammad *et al*. (2008) stated that plane of nutrition as a factor of environment has a vital role to determine carcass characteristics of lambs.

The proportion of carcass lean was better from lambs supplemented 235g lentil screening (T2) than the rest of treatment groups. The proportion of carcass lean was also higher than the previous reports (Kassahun, 2000 and Ewnetu *et al*., 2006). This level of supplementation can be considered as best for finishing of Menz lambs, if leaner meat is the first preference. The characteristics of a superior lamb carcass are a high proportion of muscle (lean), a low proportion of bone and an optimal level of fat cover (Kassahun, 2000). However, during festivities, lambs and withers with high fat cover may be more worth. Accordingly, a supplement diet containing 227g wheat bran and 120g lentil screening may be used for feeding lambs for better carcass fat cover. A slower growth rate at a lower energy diet produced a slightly higher leaner carcass and a lower dressing percentage. In relation to this, Beauchemin *et al*. (1995) reported that to improve carcass leanness, reducing the energy content of diets fed to feedlot lambs is not an economically sound production strategy.

The effect of wheat bran and lentil screening combination was insignificant on all non-carcass body component weights except for kidney fat, blood, respiratory and ureo-genital tract weights. Higher kidney fat, blood, respiratory and ureo-genital tract weights recorded from lambs assigned to T_4 diet. In agreement with the present study, Ríos-Rincón*et al.* (2014) reported more kidney-pelvic fat percentage in the high-energy diet.

The weights of heart, head, kidney and testicles recorded from all treatments were similar with the reports of Abadi, *et al*. (2014) for heart (118- 123 g), head (1662- 1760 g), kidney (185- 212 g), and testicles (240- 254 g) of weight reported from Afar sheep. The weights of blood, kidney fat and liver were higher in the present study as compared to that reported for Washera sheep fed natural pasture grass hay supplemented with *Millettia ferruginea* leaf hay (Alemu *et al.*, 2014).

The higher lean and fat DM% value at T_4 diet group indicated that lambs fed a diet containing 227g wheat bran and 120g lentil screening resulted in a carcass yield with higher DM content as compared to that of T_1, T_2 and T_3 diet. Numerically, the protein content of lean carcass was higher from lambs supplemented 285g wheat bran (T3) than the rest treatment groups. According to FAO (2007b), the content of fat and CP in lamb`s lean meat was 9.5% and 28.5%, respectively which disagreed with the present study for all diet groups. It could be due to differences in breed, feed and age of finishing lambs.

The higher EE of lean carcass in the present study from lambs assigned for T_4 indicated that 227g wheat bran and 120g lentil screening mixture diet was better for to get high carcass fat cover than for other combination diet. A higher ether extract value (22.4%) was reported by Kasahun (2000) from lean carcass of Menz lambs, compared to the EE recorded from the present study. The EE values variation between the present and the previous ones might be a higher proportion of intra muscular fat from older lambs than young ones. The nutrient concentration variation could also be the reason for value differences between the previous and present studies. Energy to protein ratio influences muscle deposition and meat quality (Skunmun *et al*., 2012). According to Kasahun (2000), Iason and Mantecon (1993) and Cantón *et al*. (1992) reports, breed, management, environmental conditions, and nutritional level can affect carcass yield and quality, fat tissue development and composition.

The higher hot carcass yellowness (b*) numerical value for T_1 diet was in agreement with Maiorano *et al.* (1990) who reported yellowish muscles developed in animals assigned to lower ME diets than were at higher one. The pH levels of 5.8 or less after 24 hour of slaughter are recommended to avoid meat quality deteriorated (Tejeda *et al.,* 2008). Croker and Watt (2001) also reported that pH around 5.5 is desirable for carcass. Thus, the pH values recorded for cold carcass in the present study from all diet groups were within the recommended ranges.

5.14. Partial Budget Analysis

The present study indicated that weight gain per head (benefit) and cost incurred for one kg body weight gain was affected by concentrate diet combinations. The feed cost per kg body weight gain of Menz ram lambs was reduced as the level of metabolizable energy increased in the supplement concentrate diet. The results indicated that finishing of Menz ram lambs on a concentrate diet containing 227g wheat bran and 120g lentil screening mixture could be economical. In agreement with results of the present study, Beauchemin (1995) observed that feeding of lambs on lower dietary energy and protein diets reduced growth rate and increased production costs. However, contrary to this Sousa *et al.* (2012) reported a higher economical advantage obtained from lambs on a diet with low dietary energy (2.40 Mcal/kg DM) than with higher one (2.90 Mcal/kg DM).

6. CONCLUSION AND RECOMMENDATIONS

6.1. Conclusion

This study was initiated to characterize the sheep production system and identify major feed resources in selected high potential urban and per-urban areas of Debre-Berhan and Dessie, Ethiopia, and evaluate the effect of different combinations of wheat bran and lentil screening on growth and carcass performance of Menz ram lambs. The survey study provided information on sheep producers' household characteristics, livestock species and herd/flock size, available major feed resources, feeding practices, fattening activities and economic contribution of sheep, and constraints for sheep production. The study revealed that urban and peri-urban sheep production system in the central highlands of Ethiopia is characterized by a sheep flock size ranging from 7.5-16.7 heads, which was integrated to crop production and small-scale trade businesses in peri-urban and urban areas, respectively.

Except, brewery dried grain, the types of feed resources were the same. Sheep flock size was greater for Debre-Berhan than Dessie areas. The Sheep feeding system was mainly free-grazing during dry season and semi-grazing during the wet season plus stall feeding as a supplement. Urban and peri-urban sheep production in the areas is an important source of income and food through sale of sheep and direct use for family consumption. Urban and peri-urban sheep production has a potential to contribute to food security and to improve the living standard of sheep producers in the study area.

The major constraints identified in the study areas were high feed cost, lack of improved breed, lack of capital and labor shortage. However, the weather condition, market price of sheep, availability of by-product feeds, natural resource conservation activities are good opportunities for sheep production in the study areas, and could encourage an increased engagement in sheep production activity.

The feeding experiment was conducted using locally available feed resources. The objective of conducting the feeding trial was to determine the effect of different wheat bran and lentil split screening combinations on feed and nutrient intake, digestibility, growth performance and carcass yield and quality parameters of finishing Menz ram lambs. The main link between the survey study and feeding trial was to identify locally available feed resources and developing an appropriate feeding package for best production performance of finishing Menz ram lambs.

Thus, among identified locally available feed resources the grass hay, lentil split (*Messer kik*) screening (''*Elat*''), and wheat bran were used for this experimental study. Lentil split (*Messer kik*) screening (''*Elat*'') has an energy value less than wheat bran and has protein value of more than wheat bran, demonstrating that it could be a reliable source of protein supplement for finishing of lambs. The dry matter and nutrient intakes were significantly affected by wheat bran and lentil split screening combinations.

Final body weight, TWG, DWG and FCE were significantly affected by the concentrate feed combinations ME levels with the higher values recorded for the lambs assigned to T_4 diet. During the digestibility trial, the DMI and nutrient intake and their digestibility parameters were significantly affected by wheat bran and lentil split screening combinations, where higher values were recorded from lambs assigned for T_4 diet.

The concentrate feed combinations affected the slaughter body, empty body, hot and cold carcass weights and the values of these parameters were higher at T_4 than were at T_1, T_2 and T_3 diets. Except more value of kidney fat, blood respiratory and ureo-genital tract weights recorded from the animals assigned to T4 than to other diet groups, the effect of wheat bran and lentil split screening combinations was non-significant for all non- carcass components.

The wheat bran and lentil split screening combinations effects were non-significant for all carcass quality parameters except for carcass fat DM%. The feed cost per kg body weight gain was reduced at T4. The results indicated that finishing of Menz ram lambs supplemented with 227g wheat bran and 120g lentil screening mixture concentrate could be economical.

From this survey and experimental study, it could be concluded that urban and peri-urban sheep production in the study areas, give economic advantages either through sale of sheep or direct use for family consumption. This production system needs to be supported by different technologies. As one production improvement option, a supplementary diet containing 227g wheat bran and 120g lentil screening mixture can be considered as the best for finishing Menz ram lambs with higher body weight, dry matter digestibility, nutrient utilization, carcass yield and better carcass fat cover.

6.2. Recommendations

- Since urban and per-urban sheep production can contribute to improved household income and food supply; it should be supported with improved feeding management to reduce feed cost and to improve feeding efficiency.
- Feed resource development activities should be encouraged for improved sheep production.
- Urban and peri-urban sheep producers should be supported via financial institutions to solve capital shortages.
- As a long-term strategy, improved sheep breeding program should be expanded.
- The effect other supplementary concentrate combinations on finishing performance of Menz ram lambs should also be studied.

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8. APPENDICES

Appendix I. List of ANOVA Table

Appendix Table 1. Summary of ANOVA for dry matter and nutrient intake of Menz ram lambs fed different energy and protein levels.

Source	DF	MS					
		Hay DMI	Conc.DMI	Total DMI	Hay CPI	Con. CPI	Total CPI
Replication	5	31047.02	0	31047.02	145.68	0	145.68
Treatment	3	8569.57	36406	9917.98	40.21	1267.17	987.73
Error	15	2311.90	0	2311.90	10.85	0	10.85
CV%		9.54	0	6.27	9.54	0	3.49
MSE		48.08	0	48.08	3.29	0	3.29
F Value		9.78	Infty	10.00	9.78	Infty	42.54
Probability		<.0001	<.0001	<.0001	<.0001	<.0001	<.0001

Note: CV= Coefficient of variation; MSE = Root mean standard error. F = F value; DF = Degree of freedom; MS = Mean square; DMI = dry matter intake; Conc. = concentrate; CPI = crude protein intake.

Appendix Table 2. Summary of ANOVA on body weight change and efficiency of Menz ram lambs fed different wheat bran and lentil screening combinations

Source of variation	DF	MS				
		IBW	FW	TWG	DWG	FCE
Replication	5	8.19	5.52	1.00	123.46	0.0006
Treatment	3	0.12	7.82	8.49	1048.52	0.001
Error	15	2.12	1.74	0.54	66.49	0.000
CV%		1.81	3.05	12.72	12.72	11.94
MSE		0. 30	0.27	0.15	1.66	0.003
F Value		0.06	4.48	15.77	15.77	5.78
Probability		< .982	<..015	<.0001	<.0001	<.005

Note: CV = Coefficient of variation; MSE = Root mean standard error. DF = Degree of freedom; MS = Mean square; IBW = Initial body weight; FW = Final body weight; TWG = Total body weight gain; DWG = Daily body weight gain; FCE = feed conversion efficiency.

Appendix Table 3. Summary of ANOVA on dry matter digestibility and nutrient utilization response of Menz ram lambs fed different wheat bran and lentil screening combinations.

Source of variation	DF	MS			
		DMI	DMD	NDFD	ADFD
Treatment	3	19589.91	190.96	632.12	507.36
Error	16	5329.90	49.86	158.46	125.94
CV%		10.35	8.49	22.54	19.71
MSE		46.17	4.46	7.96	7.10
F Value		3.67	3.83	4.03	4.03
Probability		0.035	0.030	0.026	0.026

Note: CV = Coefficient of variation; MSE = Root mean standard error ; DF = Degree of freedom; MS = Mean square; DMI = dry matter intake; DMD = dry matter digestibility; NDFD = neutral detergent fiber digestibility; ADFD = acid detergent fiber digestibility.

Appendix Table 4. Summary ANOVA Table.4 ANOVA on nitrogen intake and utilization response of Menz ram lambs fed different wheat bran and lentil screening combinations.

Variation sources	DF	MS						
		TNI	ND	N void via urine	Urine N	Feces N	N void via feces	TNR
Treatment	3	23.98	18.67	2.74	0.42	0.01	0.81	296.03
Error	16	0.64	16.34	0.86	0.26	0.023	0.28	81.23
CV%		5.55	4.97	23.77	24.83	11.91	20.18	16.69
MSE		0.80	4.04	0.93	0.51	0.15	0.53	9.01
F Value		37.45	7.26	3.19	1.61	2.91	2.91	3.64
Probability		<.001	0.003	0.052	0.226	0.067	0.067	0.036

Note: CV = Coefficient of variation; MSE = Root mean standard error; DF = Degree of freedom; MS = Mean square; TNI = Total nitrogen intake; N = Nitrogen; ND = Nitrogen digestibility; TNR = Total nitrogen retained.

Appendix Table 5. Summary of ANOVA on carcass yield parameters of Menz ram lambs fed different wheat bran and lentil screening combinations.

Variation sources	DF	MS								
		SW	EBW	HCW	CCW	DPSW	DPEW	Lean	Fat	Bone
Treatment	3	11.52	15.59	4.23	4.63	10.63	2.61	9.20	4.44	8.94
Error	16	2.00	1.88	0.53	0.32	10.88	17.31	49.87	11.19	10.98
CV%		6.62	7.63	7.93	6.54	7.68	8.13	12.11	28.75	12.72
MSE		1.41	1.37	0.73	0.57	3.30	4.16	7.06	3.34	3.31
F Value		5.76	8.33	7.97	14.38	0.98	0.15	0.18	0.40	0.81
P		0.007	0.002	0.002	<.001	0.428	0.928	0.905	0.757	0.504

Note: CV = Coefficient of variation; MSE = Root mean standard error.; DF = Degree of freedom; MS = Mean square; SW = Slaughter weight; EBW = Empty body weight; HCW = Hot Carcass weight; CCW = Cold Carcass weight; DPSW = Dressing percentage based on slaughter body weight, DPEW = Dressing percentage based on empty body weight; P = Carcass Proportion.

Appendix Table 6. Summary of ANOVA on Non- carcass body components of Menz ram lambs fed different wheat bran and lentil screening combinations.

Variation sources	DF	MS												
		Full gut	Empty gut	Kidney	Kidney fat	Spleen	RT	Heart	Liver [a]	Blood	Skin	Head	Testicle	UGT
Treatment		0.24	0.24	25.58	501.01	48.26	7071.25	209.50	3664.92	0.03	0.48	0.06	0.34	3683.14
Error	16	0.63	0.02	63.42	85.92	70.82	2114.85	524.53	2082.47	0.06	0.19	0.07	0.19	520.03
CV%		15.60	8.72	13.24	22.13	17.99	14.02	18.23	12.58	9.13	18.83	14.63	20.62	25.57
MSE		0.79	0.15	7.96	9.27	8.41	45.99	22.90	45.63	0.08	0.43	0.26	43.13	22.80
F Value		0.37	1.66	0.40	5.83	0.68	3.34	0.40	1.76	4.47	2.54	0.94	1.85	7.08
P		0.772	0.216	0.753	0.007	0.576	0.046	0.75	0.195	0.018	0.093	0.446	0.178	0.003

Note CV = Coefficient of variation; MSE = Root mean standard error; DF = Degree of freedom; MS = Mean square; RT = Respiratory tract; [a]= Liver with gallbladder; UGT = Ureo-genital tract.

Appendix Table 7. Summary of ANOVA on Carcass quality parameters of Menz ram lambs fed different wheat bran and lentil screening combinations.

Variation Sources	DF	MS												
		Meat DM		Lean meat CP%	Meat EE		Carcass pH		Hot carcass color			Cold carcass color		
		Lean	Fat		Lean	Fat	Hot	Cold	L*	a*	b*	L*	a*	b*
Treatment	3	18.91	23.46	11.62	6.58	126	0.11	0.07	5.11	0.94	0.95	4.71	4.66	7.20
Error	16	9.14	1.28	18.21	7.29	85.03	0.12	0.05	4.40	0.51	0.57	4.19	3.46	4.49
CV%		9.95	2.10	7.09	35.01	10.70	5.18	3.80	6.37	9.95	10.8	5.97	17.08	25.11
MSE		3.02	1.13	4.27	2.70	9.22	0.35	0.22	2.10	0.72	0.75	2.05	1.86	2.12
F Value		2.07	18.36	0.64	0.90	1.48	0.85	1.43	1.16	1.83	1.67	1.12	1.34	1.60
Probability		0.145	<.001	0.601	0.462	0.257	0.485	0.270	0.355	0.183	0.214	0.369	0.295	0.228

Note: CV= Coefficient of variation; MSE = Root mean standard error; DF = Degree of freedom; MS = Mean square; DM = dry matter; CP = crude protein; EE = Ether extract; L* = bright, a* = red and b* = yellow

Appendix Table 8. Summary of ANOVA on Partial budget analysis of Menz ram lambs fed different wheat bran and lentil screening combinations.

Variation Source	DF	MS		
		Benefit (kg gain)	Total feed cost	Feed cost/kg BW gain
Treatment	3	8.50	2185.18	735.98
Error	16	0.54	744.46	99.75
CV%		15.05	11.87	19.79
MSE		0.73	27.28	9.98
F Value		15.77	2.94	7.38
Probability		<.001	0.058	0.002

Note: CV = Coefficient of variation; MSE = Root mean standard error; DF = Degree of freedom; MS = Mean square; BW = body weight; *Elat* = lentil split screening.

Appendix Table 9. Experimental feed ingredients and sheep initial price used for partial budget analysis.

Items	Price in birr
One kg Hay	2.8
One kg wheat bran	2.8
One kg *Elate*	4
One kg salt	4
Average price of one sheep	457.5

Appendix Table 10. Daily and weekly offered concentrate feed on as fed basis.

Feed ingredients	Treatments			
	T1	T2	T3	T4
	Daily offered concentrate			
Wheat bran (g)	30*1000/911.7=32.9	0	312.6	248.98
Elat (g)	133*1000/917.3=144.99	256.19	0	130.82
Salt (g)	5	5	5	5
Total	182.89	261.19	317.6	384.80
	Weekly offered concentrate			
Wheat bran(kg)	32.90*6*7=1.38	0*6*7=0	312.6*6*7=13.13	248.98*6*7=10.45
Elat (kg)	144.99*6*7=6.09	256.19*6*7=10.76	0*6*7= 0	132.82*6*7=5.60
Salt (g)	5*6*7=210	5 *6*7=210	5*6*7=210	5*6*7=210
Total (kg)	7.68	10.97	13.34	16.26

Appendix 2: Questionnaire

Questionnaire on Sheep Production system study in the Selected Urban and Peri-Urban Areas of Ethiopia

Zone_________Town _________ Site (Kebela) ______

Date of intervew ___________ name of enumerature ________________

I. Socio-economic characteristics (household) information

1. Name of household head __________Name of respondent ______

2. Religion of household head

01 Muslim 02 Orthodox 03 Protestant

04 Catholic 06 Other Specify_____________

3. Sex of household head 01 Male 02 Female

4. Marital status: 01 Married 02 Single 03 Widow 04 Divorced

5. Household Ownership 01 Owned 02 Rented 03 Caretakers

6. Educational status of the household

Sex	Number				
	Illiterate	Read and write	Elementary school	High school	Diploma and above
Household head					
Male other than household head					
Female other than household head					

7. Age group

Sex	Age group in years				
	<7	7-15	16-30	31-60	>60
1. Male					
2. Female					
Total					

8. Major occupation 01 Farmer 02 Civil servants 03 Trader 04 Student 05 Pensioner 06 Others

9. Household size and composition

10. Assets: 01 House 02 Machines 03 Vehicle 04 others

II Agriculture

1. What type of agriculture you practice and rank? 01 Livestock production > Crop production 02 Crop production> Livestock production 03 livestock

2. Access to land 01 owned 02 shares cropping 03 families 04 others

3. Land size? 01 <0.5 ha 02 >0.5 ha 03 others

4. Major crops grown

Crops	Rank
Cereal crops (barley, wheat and teff)	
Stalk crops (maize)	
Pulse crop ((faba beans, field peas, grass pea, lentil)	
Oil crops (noug seed, linseed etc.)	
Fruit and vegetable	
Others	

5. Distance of farm from the home 01 <1 km 02 1-2km 03 > 2km

6. Access to labor for agriculture 01 Family 02 Hired

7. Herd composition, size and ownership pattern

Species	No of heads/household
Cattle	
Sheep	
Goat	
Chicken	
Horses	
Donkeys	

8. How is the animal population for the last 10 years?

Species	Increasing	Decreasing	reason
Cattle			
Sheep			
Goat			
Chicken			
Horses			
Donkeys			

III Sheep Production, feed resources and feeding practice

1. How is the suitability of your vicinity for sheep production?

01 not suitable 02 suitable 03 very suitable

2. What is the sheep production system?

01 Traditional 02 Partially modern 03 Modern*

*Modern means feeding and housing based on age class and level of production

3. The types most frequent sheep breed and identification characteristics

Breed	Reason for preference

4. Flock demography (flock structure) and size of sheep by sex and age

Classification	Number
Suckles male	
Suckles female	
Weaned male	
Weaned female	
male above one year	
Female above one	

5. Major feed resources use for sheep, both in the dry and the wet seasons

Feed resources	Season of availability				Property
	Dry	Rank	Wet	rank	
Native pasture					Communal/ private
Hay					
Crop residue					
wheat bran and noug seed cake					
Legume grain by-products					
Attela					
brewery dried grain					

6. What is the grazing practice (method) during both the dry and the wet seasons?

	Dry	Wet
01 Free grazing	_________	__________
02 Semi-grazing	_________	__________
03 Tethering	_________	__________
04 Others	__________	________

7. What are forms of feeding for sheep?

As it is	As it is	Chopped	Spray water & salt	Treated with urea	Others
Hay					
Maize Stalks					
Cereal crop residues					
wheat bran					
noug seed cake					
Legume grain by-products					
brewery dried grain					
Attela					

8. Do you have sheep fattening experience? ______01 yes 02 No,

9. How many years' experience in sheep fattening?

10. Season of sheep fattening 01 New Year 02 x-mass 03 Easter 04 at any time

11. For how long do you fatten the sheep____, 12. Number of fattened sheep at one round __________

12. What type of animals is fattened 01 castrated 02 enacted?

13. Sources of fattened sheep 01 purchased, 02 from home

14. Is it profitable? __________, how much is profit ______________

15. If you do not have sheep fattening experience what are the reasons? _____________

16. If, you have feed shortage, specify the serious feed shortage seasons? ____________

17. Are there any poisonous plants for sheep in the area? 01 yes 02 no

If yes local name____________ season and month of occurrence_______________

18. From where do you get water for sheep during both the dry and wet season?

Source of water	dry	wet	Methods of drinking		
			Using bucket	From the source	Other
Dug well					
Pond					
River					
Spring					
Tape water					
other					

19. Frequency of water drinking for sheep 01 Roam freely 02 once per day 03 twice per day 04 three times

20. What is/are your water related problem? 01 availability 02 Parasites 03 impurity 04 others

21 How is the herding system of the sheep? 01 Male and female separately 02 the lambs herded separately 03 all sheep together 04 Village sheep in one flock 05 Mixed with other herds

22. If separately, mention season, month and reasons?

23. If herding is mixed, specify herd type, flock type, season, month and reasons?

24. Who in the family is herding the sheep? 01 husband 02 wife 03 children 04 hired labor

25. How is the housing system of your sheep? 01 house 02 open kraal 03 in the house 04 others

26. Where is the sheep house? 01 Isolated 02 adjoining house 03 in house 04 other

27. Are the lambs housed with adult flocks of sheep? 01 yes 02 no

28. Major sheep diseases (include local name) observed in the area

Diseases	Symptoms	Affected class	Rank	When occurs	Treatment	
					tradition	modern

29. Do you have access to veterinary services in the near place? 01 yes 02 no

30. If yes, from where do you get the veterinary service 01 Government 02 private 03 both?

31. Number of sheep died in the last 12 months (1yr)

Class	no of died	Cause of the death					
		diseases	Predator & theft	emergency	poisoning	feed shortage	Other
Ewe							
Lambs							
Rams							
Fattened							

V. Sheep, sheep product and by-product utilization

1. What is the main reason of practicing sheep production? Put in rank

   01 slaughtering for own 02 live animal sales 03 skins 05 other

2. Which sheep group used mostly for slaughtered?

   01 ewe average age _____ 02 lamb average age _____03 castrated age______ 04 ram age______

3. When do you slaughter sheep for home consumption 01 all festival 02 twice a year 03 three times a year 04 once a year 05 other

4. For what purpose you used the skin? 01 sale 02 other

VI. Marketing

1. Rank major item sold last year 01 crops 02 sheep 03 livestock 04 none agricultural items 05 others

2. Rank major items purchase last year 01 house 02 building materials 03 animals 04 plowing materials 05 machines 06 vehicles 07 other

3. At time of money need, which class of the sheep flock do your sale first? 01 lambs 02 ewes 03 extra ram 04 fattened sheep 05 mesina

4. What happen, the culled sheep? 01 soled 02 slaughtered

5. How is the market price status of the different sheep classes within the year?

Class	Expensive Months	Cheap months	Maximum price(birr)	Minimum price(birr)	Reason
Ewe					
Lambs more 6 month					
Indicted fattened lambs					
Castrated fattened lambs					
Mesina					

6. Reasons for sale of sheep in the study area?

01 Input purchase 02 Grain purchase 03 financial obligation 04 School expense 05 others

7. Average market age of sheep? 01 ewe _____months 02 lambs___ months 03 ram _____ months 04 mesina ____ months 06 fattened ____ months

8. Where is the market? _____________

9. For whom do you sell sheep? For consumers / for the merchant?

10. From whom do you buy sheep? From producers / from merchant?

VII. Constraints and Opportunities

1. What are the major sheep production constraints?

Constraints	Rank	Solutions you took (improvement options)
Improved genotype		
Feed shortage		
Labor scarcity		
Market problem		
Capital scarcity		
Other		

2. What are opportunities for sheep production in the study area?

3. Do you intend to expand the sheep flocks you have? 01 yes 02 if no, why

Appendixes 3: Publication from PhD dissertation

Tsega W., Tamir B., Abebe G. and Zaralis K. (2014). Characteristics of urban and peri-urban sheep production systems and economic contribution in Highlands of Ethiopia. Iranian J. Appl. Anim. Sci. *4(2), 341-349.*
http://ijas.ir/main/uploads/userfiles/files/Tsega%20%2813-108%29.pdf

Abstract

This study was initiated to characterize urban and peri-urban sheep production systems and their economic importance in and around the towns of Debre-Berhan and Dessie, Ethiopia. The study was undertaken using group discussions, structured questionnaire and personal observations. In both locations, most sheep producers were male household heads and predominantly traders in urban and farmers in peri-urban areas. The average family size was more in Debre -Berhan peri-urban (5.4) area than Dessie peri-urban (4.8). In Debre -Berhan peri-urban areas, 39.3% had a land hold size between 1 and 2 ha and in Dessie peri-urban areas 48.4% respondents had a land hold size of < 0.5 ha. The number of sheep and other livestock population was higher in Debre-Berhan peri-urban than Dessie peri-urban area. Except brewery dried grain all other types of feed used for sheep production were similar but the availability was different among the study areas. In both urban and peri-urban areas major available feed types were natural pasture grazing, hay, crop residues, wheat bran and oil seed cakes, by-products from local breweries and legume grains processing. Sheep rearing constitutes the first source of income in Dessie area and the second source of income in Debre-Berhan area. Urban and peri-urban sheep production has economic advantages as sources of in-come and food to the household. High feed cost, lack of improved breed, capital and labor shortages were major constraints. Conducive weather conditions, attractive market price, and availabilities of supplementary feed found in urban areas were considered as beneficial for sheep production. Although, there are constraints for sheep production, available opportunities are to encourage engaging in sheep production. Scientifically proven and efficient feeding packages from locally common available feed resources are required.

KEY WORDS: constraints, feed, first objective, income source, sheep production system, urban.

Appendixes 4: Other publications, trainings and work experiences

Publications

Asefa H., Tamir S., Mekuriaw S. an d **Tsega W**. 2012.Demonstration of maize and noug cake mixture supplementation for women focused small scale sheep fattening in Yilmana Denssa District. Journal of Agricultural Extension and Rural Development, 4:19-22.

Mengesha M. and **Tsega W**. 2012. Indigenous Sheep Production in Ethiopia: A Review. Iranian Journal of Applied Animal Science, 2: 311-318.

Bitew A., Abebe Y., Yitayew A., Kebede A. and **Tsega W**. 2012. On-Farm Evaluation of Mixture of Noug Seed Cake and Wheat Bran Supplementation for Fattening of Oxen in Bahir Dar Zuria District of Western Amhara. J. Life Sci. Biomed, 2: 228-230.

Tsega W., Eshetie T., Abebe G., Asefa H., Mekuriaw S. and Tamir S. 2012. On-farm Evaluation of Urea Treated fingermillet straw and Concentrate feed supplementation for sheep fattening, in Bahir Dar Zuriaworeda. Wudpecker Journal of Agricultural Research, 1: 235 - 237.

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