Dissertation Ref. No. 041/04/2019

DAIRY PRODUCTION SYSTEMS CHARACTERIZATION IN URBAN AND PERI-URBAN AREAS OF CENTRAL OROMIA, ETHIOPIA, AND EFFECTS OF CONCENTRATE SUPPLEMENTATION ON PRODUCTIVE AND REPRODUCTIVE PERFORMANCES OF CROSSBRED DAIRY COWS

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

April, 2019

Bishoftu, Ethiopia

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A Thesis 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

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College of Veterinary Medicine and Agriculture

Department of Animal Production Studies

As members of the Examining Board of the final PhD open defense, we certify that we have read and evaluated the Dissertation prepared by Kiros Abebe Embaye titled: **'Dairy Production Systems Characterization in Urban and Peri-Urban Areas of Central Oromia, Ethiopia, and Effects of Concentrate Supplementation on Productive and Reproductive Performances of Crossbred Dairy Cows'** and recommend that it be accepted as fulfilling the Dissertation requirement for the Doctor of Philosophy in Animal Production.

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BIOGRAPHICAL SKETCH

The author was born in Adwa town, Central Tigray on May 29, 1987 G.C. She attended her elementary and secondary school education in Yeha town and Adwa Nigiste Saba, respectively. Then after completion of her high school education in Adwa, she joined Haramaya University in 2007 G.C and graduated with a BSc in Animal production in July 2009 G.C. Immediately after graduation, she joined the School of Graduate Studies of Haramaya University, School of Animal and Range Sciences majoring Animal Nutrition in October 2009, through the scholarship obtained from the Ethiopian Ministry of Education for outstanding students. After MSc graduation, she was employed by the Ministry of Education in Wollega University as a lecturer in the College of Agriculture and Natural Resources under the department of Animal Science. Additionally, she was serving the university as College Ethics and Anti-corruption Coordinator, as an executive member of academic staffs discipline committee and Head Department of Animal Science, respectively, for about three academic years. In November 2014/15, she joined Addis Ababa University, College of Veterinary Medicine and Agriculture to pursue a PhD study in Animal Production. In line with her PhD study, she was graduated as a Dairy Production Advisor from Dairy BISS Ethiopia by Wageningen University & Research. She also participated and certified in different professional trainings and workshops in the Netherlands, Germany, Kenya and Ethiopia. She has got about ten certificates and full membership of Organization for Women in Science for the Developing World (OWSD), Dairy Advisors Network (DAN) and Ethiopian Society of Animal Production (ESAP). She published nine scientific articles in different peer reviewed journals. Additionally, she published one proceeding and one book.

STATEMENT OF THE AUTHOR

First, I declare that this thesis is my realwork, and that all sources of materials used in this thesis have been duly acknowledged. This thesis has been submitted in fulfillment of the requirements for the PhD degree at Addis Ababa University, College of Veterinary Medicine and Agriculture and is deposited at the College library to be made available to borrowers under the rules of the library. I solemnly declare that this thesis is not submitted to any other institution anywhere for the award of any academic degree, diploma, or certificate. Brief quotations from this thesis are allowable without special permission, provided that accurate acknowledgement of the source is made. Requests for permission for extended quotation from or reproduction of this manuscript in whole or in part may be granted by the head of the major department or the Dean of the College when in his or her judgment the proposed use of the material is in the interests of scholarship. In all other instances, however permission must be obtained from the author.

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ACKNOWLEDGMENTS

First of all, I have no words to express my gratitude for the loving, kindness and faithfulness of the Almighty God and His Mother St. Mary in bestowing health, strength, patience, and protection throughout my life. Without them this work would have not come to its completion.

I would like to express my genuine and deepest gratefulness to my supervisors, Professor Berhan Tamir, Dr. Gebeyehu Goshu, Dr. Tilaye Demissie and Professor Fekadu Regassa for theirencouragement, intellectual guidance, insight, advice and regular discussions were very precious and inspiring in all processes of the proposal writing and research work. Furthermore, I want to express my sincere admiration to all staff members of the Addis Ababa University College of Veterinary Medicine and Agriculture especially Animal production department staffs for their true cooperation.

Though my words can not give me a suitable explanation for the financial research support obtained from Addis Ababa University College of Veterinary Medicine and Agriculture thematic research project *"Promotion of Improved Dairy Technology and Investigation into Reproductive Diseases of Dairy for better Health, Productivity and Development of Dairy sector in central Ethiopia*" I want to pass my admiration, appreciation and heartfelt thanks as the success of the study was impossible without the timely financial support. The financial support of Wollega University is also respected.

I am very much grateful to Assela, Bishoftu, Holetta and Sululta areas, agricultural office workers for their supports and collaboration during the survey study period. I am also very much thankful to the dairy farm owners of the respective areas for giving their farm information by honestly answering the survey questions. Without their acceptance, hospitality and enthusiasm to share their time and knowledge the primary data collection would not have been possible.

I am thankful for the Addis Ababa University College of Veterinary Medicine and Agriculture (CVMA) dairy farm for providing experimental cattle for the feeding trial. My special thanks go to Mr. Hika Waktole for facilitating and creating a smooth work environment on the farm. Genuine appreciation also goes for all dairy farm workers and particularly for Ms. Tsehay Tikuye for their wordless supports to successfully finalize the experimental study. I am very much thankful to Ethiopian Public Health Institute (EPHI), National Veterinary Institute (NVI), Ethiopian Meat and Dairy Industry Development Institute (EMDIDI) and Holetta Agricultural Research Center (HARC) for facilitating the laboratory analysis.

My sincere and deep gratitude goes to my uncle Ato Alem W/Aregaye for his unreserved supports and encouragement throughout the study. I have no special word to express him, but I can only say God bless him.

Last but not least, I would like to convey my heartfelt gratitude and thanks to my beloved father Ato Abebe Embaye and all my family members for their love, understanding, care, advice, support and encouragement in every step during the course of the study period. I also thank all my friends for their real and smooth friendship.

Generally, all of the mentioned individuals were essential for this work to come true. I could not be more thankful for all your efforts, teaching, patience and friendship with me. Thank you very much for believing in me, for all the supports, and to make this happen.

Thank You!!

DEDICATION

This dissertation work is dedicated to my beloved mother W/ro Alemtsehay Asmelash who passed away without seeing my success.

LIST OF ABBREVIATIONS

ADMY	Average Daily Milk Yield
AFC	Age at First Calving
AFS	Age at First Service
AI	ArtificialInsemination
AST	Aspartate aminotransferase
ATA	Agricultural Transformation Agency
BCS	Body Condition Score
CCI	Calving to Conception Interval
CFHI	Calving to First Heat Intervals
CFSI	Calving to First Service Interval
CI	Calving Interval
CL	Corpus Luteum
CSA	Central Statistical Agency
DIM	Days in Milk
DMI	Dry Matter Intake
FAO	Food and Agriculture Organization
FSH	Follicle Stimulating Hormone
GDP	Gross Domestic Product
GnRH	Gonadotropin-Releasing Hormone
HF	Holstein-Friesian
IGF-I	Insulin-like Growth Factor-I
LH	Luteinizing Hormone
ME	Metabolizable Energy
N	Nitrogen
NH3	Ammonia
NSC	Number of Services per Conception
SCE	Subclinical Endo-metritis
TMR	Total Mixed Ration

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Kiros Abebe Embaye
PhD Thesis
Addis Ababa University (2019)

ABSTRACT

The survey part of this study was conducted to assess urban and peri-urban dairy production systems, major constraints and opportunities, available feed resources and feeding systems in and around Assela, Bishoftu, Holetta and Sululta towns, Oromia regional state, central highlands of Ethiopia. Overall, 160 dairy farmers (40 from each site) were randomly selected for individual interviews using a pre-tested semi-structured questionnaire. The feeding trial part was carried out in Bishoftu using twelve late pregnant crossbred dairy cattle, grouped into three dietary treatments in randomized complete block design (RCBD) to evaluate the effect of different concentrate rations supplementation from late gestation to early post-partum on milk yield, milk composition, early post-partum blood plasma metabolites, reproductive performances and fertility. The treatments were T_1 (hay with noug seed cake, wheat middling, and wheat bran), T_2 (hay with noug seed cake, wheat middling plus ruminant premix) and T_3 (hay with noug seed cake, wheat middling, and ruminant premix plus commercial dairy concentrate). In all groups, feeding was started 21 days before calving and continued up to 90 days in milk and rations formulation was according to cow's requirements and stage of production. The data were analyzed using Statistical Packages for the Social Sciences software version 20. The survey results showed that, the highest educational level (diploma and above) was from Bishoftu town and the age group of most of the respondents was 40-59 years. Ninety five percent of respondents from urban Bishoftu, 90% from urban Assela, 65% from urban Sululta, 55% from peri-urban Holetta areas reported stall feeding as the primary feeding method. Artificial insemination was the main breeding system in all (100%) of peri-urban Bishoftu, 90% of urban Bishoftu, 80% of urban Assela, 65% of urban Holetta, 60% of peri-urban Holetta and 50% of urban Assela. The higher average daily milk yields were 11.7, 11.2 and 10.8 liters in urban and peri-urban Bishoftu and urban Sululta, respectively. The longest average age at first service (29.3 months) and age at first calving (38.3 months) intervals were in peri-urban Assela. The number of services per conception was 1.4 and 1.3 in urban and peri-urban Assela and these were lower than 1.65 and 1.85 in urban and peri-urban Bishoftu. The longest average calving to conception interval (168.0 days) was in peri-urban Assela. The average calving intervals 14.9 and 13.9 months from peri-urban Assela and Sululta were relatively longer than the respective urban areas.In peri-urban Bishoftu (85%), Holetta (80%) and urban Bishoftu (70%) and peri-urban Sululta (70%) less milk price relative to feed cost was the main marketing problem. High feed cost was the major constraint of peri-urban Bishoftu (55%), Sululta (55%) and urban Bishoftu (50%). In peri-urban Assela water scarcity was the main constraint following high feed cost.

Shortage of land to expand dairy and for grazing was claimed by farmers in urban Bishoftu (95%), urban Sululta (90%), urban Holetta (85%), peri-urban Bishoftu (75%) and urban Assela (55%). Dairy producers in peri-urban Assela (65%), Holetta (55%) and Sululta (50%) indicated service providers, research institutions and demand for milk consumption, respectively, as key opportunities for dairy production. Crop residues and concentrates were frequently used dairy feeds by 65% farmers in urban Bishoftu. Grass hay, crop residues and concentrates were regularly used dairy feeds in urban and peri-urban Sululta (55%). In urban Assela, Holetta and peri-urban Sululta 50%, 45% and 40%, respectively, mainly feed wheat and barley straws. The daily supplements feeding frequencies were twice in urban Sululta, peri-urban Holetta, urban Holetta, urban Bishoftu, peri-urban Bishoftu and peri-urban Sululta and three times in urban and peri-urban Assela. Results of the feeding trial showed that, total average daily DM intake during early post-calving period for T_2 (14.5 kg) was significantly ($P<0.0001$) higher than T_1 (13.2 kg) and T_3 (13.1 kg). The average daily milk yield per cow was 15.8 liters, 14.2 liters and 11.0 liters for T_2, T_3 and T_1, respectively. Milk composition did not vary ($P>0.05$) by diet and parity differences. Body condition score at 5 to 12 and 60 days after calving, calving to first heat interval, calving to first service interval, calving to conception interval and calving interval, were statistically different ($P<0.05$) among treatments and cows in T_2 and T_3 were better than T_1. The average early post-partum plasma glucose, AST and insulin were not significant ($P>0.05$). Average plasma cholesterol at calving was 116.0 mg/dl in T_1, 87.0 mg/dl in T_2 and 83.6 mg/dl in T_3 and the differences were significant ($P<0.05$). Plasma triglycerides at week one after calving was higher ($P<0.05$) in T_1 than T_2 and T_3. Furthermore, plasma total protein at day 14 after calving and plasma urea nitrogen at calving, day 7 and day 14 after calving were higher ($P<0.01$) for T_1 than T_2 and T_3. The day-21 after service plasma progesterone concentrations were 8.1±1.9 ng/ml, 6.2±1.1ng/ml and 9.7±1.9 ng/ml, respectively, for cows in T_1, T_2 and T_3 and were not different ($P>0.05$). Day-30 (ultrasound) pregnancy rate was 66.7% for cows in T_1 while all inseminated cows were pregnant in T_2 and T_3. Generally, based on the current results it might be conculuded that there were lower milk yields and longer reproductive performance indicators of crossbred dairy cattle. The feed resources used and feeding frequencies showed variation among the study areas. It could also be concluded that when formulated according to cow's requirement, and stage of production the agro-industrial by-products alone could improves milk production, body condition score and reproductive performances of crossbred dairy cows. An increase in average early post-partum plasma cholesterol, triglycerides, total protien and urea concentrations were probably due to the ration differences and might be the one that negatively affected post-partum cycling, ovulation and pregnancy rates. However, studies utilizing wider area coverages and more number of crossbred dairy cows should be conducted. Improving feeding and other management practices need attention for the improvement of urban and peri-urban dairy production. Continuous researches and provision of scientific extension services are also imperative.

Keywords**:** *Concentrate, Crossbred dairy cattle, Management practices, Milk yield, Plasma metabolites, Reproductive performances*

1. INTRODUCTION

The estimated total livestock population in Ethiopia is 59.5 million cattle, 30.7 million sheep, 30.2 million goats, 59.5 million poultry, 2.16 million horses, 8.44 million donkeys, 0.41 million mules, 1.21 million camels and 5.9 million beehives. Out of the total cattle population, the female cattle constitute about 55.5% and the remaining 44.5% are male cattle. Dairy cows are estimated to be approximately 7.16 million and milking cows are about 11.83 million heads. The estimated total cow milk produced in Ethiopia during the year 2016/17 is about 3.13 billion liters (CSA, 2017).

In Ethiopia, the introduction of high yielding dairy breeds mainly Holeistain Frisian and Jersey from abroad and crossbreeding with indigenous cattle has been pursued to improve milk production (Emebet and Zeleke, 2008; Azage *et al*., 2010). The large cattlepopulation, the suitable climate for improved and highyielding cattle breeds, and the relatively animal diseasefree environment make Ethiopia to hold a substantialpotential for dairy development (Zelalem, 2012). Regardless ofits potential for dairy development, the productive and reproductive performances of dairy cattle are low due to inadequate and low quality feed resources, poor nutritional, genotype and health care management, poor marketing system, insufficient training and extension services (Azage *et al*., 2013).

Dairy production is defined as a biologically efficient system that converts large quantities of roughage, the most abundant feed in the tropics, to milk, the most nutritious food (de Leeuw *et al*., 1996). The dairy industry also occupies a special position among theother livestock sectors (Perera, 1999). In Ethiopia, considering the potential for smallholder income and employment generation of high-value dairy products, development of the dairy sector can contribute significantly to poverty alleviation and nutrition (Mohamed *et al*., 2004).

Gündel (2006) and van Veenhuizen and Danso (2007) have tried to obviously distinguish between urban and peri-urban agriculture based on geographical location and spatial land use. Urban agriculture includes farming activities taking place within the inner cities and

major towns, utilizing vacant and under-utilized land areas not suited for construction, home and institutional gardens. On the other hand, peri-urban agriculture includes farming in the urban periphery; this type of agriculture tends to undergo dramatic changes over a given period of time, as there is an influx of people from both rural and urban areas. In Ethiopia, urban and peri-urban dairy production systems are located in towns and at the periphery, respectively, which are becoming important suppliers of milk and milk products to urban centers and contributing great role towards filling the huge demand-supply gap for milk and milk products in urban centers, where consumption of dairy products is extremely high (Azage *et al.*, 2013). Additionally, urban and peri-urban dairy production systems are the main suppliers of raw milk to processors at different scales (Zelalem *et al.*, 2011).

The performance of dairy animals depends not only on their genetic merit, but also onother factors such as nutrition and feeding, health management and other environmental factors (Lobago *et al*., 2007). Bothproduction and reproductive traits are vital issues in determining the profitability of dairyproduction.The general objective for post-partum reproductive health in dairy cattle is for the uterus to be fully involutes and free of infection, and for cows to be cyclic by the time they enter the breeding period particularly after 50 to 60 days post-partum (Plazier *et al*., 1997). Feed supplied in particular tocows' post-partum should be enough to maintain body condition, to support milkproduction, as well as to initiate ovarian cyclicity (Ghosh *et al.*,1993). The reproductive goals that one needs to follow are 12 months of calving intervals, 85 days open, 1.6 serves per conception rate and 85% of cows observed in estrous and recorded by 60 days fresh (Msangi *et al*., 2005).

Livestock and/or dairy feed resources in Ethiopia are mainly obtained from natural and improved pastures, crop residues, forage crops, agro-industrial by-products and non-conventional feeds (CSA, 2012). In Ethiopia, the supply of processed animal feedstuffs is very limited, because of the fact that there are only 11 animal feed manufacturers operating in the country (CSA, 2012). Moreover, the majority of them are working below

their designated production capacities due to, among others, low supply of raw materials, lack of commercial orientations of the farmers, poor awareness about processed feeds utilization by livestock producers, lack of tax exemptions and double taxations for individual feed ingredients in the compound feed mixtures (Adugna, 2009). With views of the emerging market-oriented livestock production (improved dairying and fattening) in the country and the corresponding supplementary feed requirement, it is obvious that the supply of processed feedstuffs falls short of the anticipated demand. Fekede *et al.* (2013) further reported that formulated rations were rarely accessed and used by smallholder peri-urban dairy farmers like in Ejere, Sululta and GirarJarsodistricts of the central highlands of Ethiopia.

Proper nutrition in the late stage of pregnancy has been very critical since nutrient demands for foetal growth, body reserve replenishment and initiation of milk synthesis are increased. However, improvement of the late pregnancy feeding is rarely practiced in most production systems in tropical Africa (Gillah *et al.*,2013). Fekede *et al.* (2015) recommended that feeding trials and animal response studies are required to generate additional information on the biological and economic advantages of using rations formulated from locally available ingredients over the industrially manufactured feeds.

Agro-industrial by-products have extraordinary value in feeding dairy cattle largely in urban and peri-urban livestock production systems as well as in conditions where the productive potential of the animals is relatively high and require high nutrient supply. The trend of the urban population has a significant effect on the establishment of agro-industries due to the corresponding increasing demand for the edible main products. Agro-industrial byproducts are rich in energy and/or protein contents or both (Zinash and Seyoum, 1991). Another study by Fekede *et al.* (2015) revealed that, in the urban and peri-urbansmallholder dairy production systems in the highland areas of Ethiopia, supplementation of dairy cattle is mainlybased on individual feed ingredients produced as byproducts of flour and oilprocessing industries and different locally available by-products. This is becausethey are relatively easily accessible to farmers and some non-

conventional by-products are also available for feeding at comparatively lower prices than manufactured feeds (Grasser *et al*., 1995). But still information on the effect of formulated homemade feed supplementation during the late stage of pregnancy on consecutive milk yield and composition, reproductive performance, blood plasma metabolitesand fertility of crossbred dairy cows is scarce in Ethiopia.

Zebu (*Bos inducus*) cattle are known to be less fertile and have lower levels of milk production than *Bos taurus*.However, *Bos taurus* are not well adapted to tropical environments and cannot maximize their potential for production in the tropics as they are less tolerance to heat stress with severe reduction in feed intake, growth rate, milk yield and reproductive function in response to heat stress (Pegorer *et al*., 2007). Various efforts have been made to improve the dairy sector through artificialinsemination or shared crossbred bull service or by distributing crossbred F_1heifers particularly to the smallholder dairy farmers in urban and peri-urban areasand to those rural farmers located in close proximity to urban areas. Among thebeneficiaries of the crossbreeding programs are the smallholder dairy farmslocated in the central highlands of Ethiopia, such as those in Bishoftu and Holetta areas.

The success of dairy production in general and crossbreeding programs in particular needs to be monitored regularly by assessing the productive and reproductive performance under the existing management systems (Lobago *et al*., 2007). The increased demand for dairy products and human population influences the importance of dairy sector in the Ethiopian economy and increased dairy productivity through good management practices is important. Furthermore, in Ethiopia dairy feed formulation neither based on scientific knowledge nor follow feeding that satisfy the nutrient requirements of dairy cows. As a result, dairy ration formulation should considerfeed intake, cows' physiology and post-partum fertility starting from late gestation through early post-partum periods in crossbred dairy cattle that have *Bos indicus* blood in Ethiopia (tropical Africa) to develop specific strategies to maximize production and reproductive performances of these dairy animals in a tropical environment.

Therefore, this study was designed to assess urban and peri-urban dairy production systems; identify available feed resources and feeding systems in the central highlands of Ethiopia and evaluating the effects of different rations fed to Holstein Friesianx Boran crossbred dairy cows starting from late pregnancy through early post-partum periods on productive and reproductive performances.

Specific Objectives:

- To assess urban and peri-urban dairy production systems in different districts in Central Oromia, Ethiopia,
- To identify major constraints and opportunities of urban and peri-urban dairy production systems,
- To identify available feed resources and feeding practices in urban and peri-urban dairy production systems.
- To investigate the effects of pre-partum and early post-partum feeding interventions on DMI, milk yield and composition, post-partum blood plasma metabolites, reproductive performances and fertility of crossbred dairy cows.

2. LITERATURE REVIEW

2.1. Dairy Production Systems in Ethiopia

Like most dairy systems found in the tropics, the Ethiopian dairy system includes a large number from small to large-sized and subsistence to market-oriented farms. Based on climate, land holdings, feed source and feeding system, herd type and size, objective of keeping animals and integration with crop production as a criterion, three major (urban, peri-urban and rural) dairy production systems were known in Ethiopia (Dereje *et al*., 2005; Sintayehu *et al*., 2008; Zelalem *et al*., 2011). Urban and peri-urban dairy production systems constitute most of the country's improved dairy stock (Sintayehu *et al*., 2008). In a review of Zelalem *et al*. (2011), the urban and peri-urban dairy production systems are market-oriented and include smallholder as well as specialized commercial dairy farms, largely concentrated in and around Addis Ababa and other regional towns.

2.1.1. Urban production system

Many countries have experienced exceptionally vast development in the dairy sector in or around the largest urban centers, responding immediately to the market demand and profiting from the lack of links between the rural producer and the urban consumers. Similarly, in Ethiopia urban and peri-urban dairy production systems are emerging as an important component of the milk production system. This system is contributing immensely towards filling in the large demand-supply gap for milk and milk products in urban centers, where consumption of milk and milk products is extremely high. Milk production is playing a vital role in the livelihoods of Ethiopian people (Belete, 2006).

The urban dairy production system is developed in towns located mostly in the highlands of Ethiopia. It comprises medium to large sized dairy farms which are capable of keeping improved dairy herds(Azage *et al.*, 2013).A number of smallholder and commercial dairy farms are emerging mainly in and around the capital, Addis Ababa (Azage, 2003) and

most regional towns and districts (Nigussie, 2006). The majority of the farmers in urban area keep their cattle in separate barn or loose house all the time, except when cleaning the barn (Derese, 2008). Generally, in Ethiopia, urban dairy farming is a system involving highly specialized, state or businessmen owned farms, which are mainly concentrated in major cities with no access to grazing land. The main feed resources are agro-industrial by-products and purchased roughage (Belete *et al.*, 2010). Fekede *et al.* (2013) also stated that urban dairy production is relatively intensive and mainly based on stall-feeding using purchased roughages and concentrates.

2.1.2. Peri-urban production system

This system is located around major cities and towns. It comprises of small sized to medium dairy farms which are also capable of keeping improved and local dairy stock. The type of housing and facilities in the barn in peri-urban dairy farms are, such that it prevents animals from hot conditions, theft and rain (Bekele *et al*., 2015). As reported by Yitaye *et al.* (2008), the farmers have small size of grazing land; they use semi-grazing systems and also practice under stall feeding conditions for improved animals. It possesses animal types ranging from 50% crosses to high grade Friesian in small to medium-sized farms. The peri-urban dairy system includes smallholder and commercial dairy farmers in the proximity of Addis Ababa and other regional towns. This sector owns most of the country's improved dairy stock (Tsehay, 2001).

The main feed resources are agro-industrial by-products, purchased roughage and in addition they use crop residue and pasture land. The primary objective of milk production is also generating additional cash income (Belete *et al.*, 2010). This production system is now expanding in the highlands among mixed crop–livestock farmers, such as those found in Selale and Holetta, and serves as the major milk supplier to the urban market (Gebre Wold *et al*., 2000).

Based on the number of animals possessed and status of farmstead structure and facilities available on farm, Diriba *et al.* (2014) classified the peri-urban dairyfarms into small-scale and medium sizedperi-urban dairy farms subsystems. In peri-urban dairy production system, crop and livestock production are closely integrated and agricultural activities other than milkproduction form additional source of income (Fekede *et al.*, 2013). For instance, peri-urban dairy farmsin the Hawassa, Shashemenne and Dilla operate at different scale ofproduction ranging from small to medium scale. They have access to land and usually practice mixed crop–livestock farming, which produces part of the feed in the form ofcrop residues and grazing (Azage *et al.*, 2013).

2.1.3. Rural production system

The rural dairy production system mainly uses indigenous breeds and includes pastoralist and mixed crop-livestock producers (Mohamed *et al.*, 2004). Most parts of the highlands are used both crop and livestock production (mixed farming) within a subsistence smallholder farming systems (Ketema and Tsehay, 1995; Belete *et al.*, 2010). Desta (2002) noted that in the rural system livestock mainly graze on natural pastures of non-arable or fallow land between crop fields and additionally fed crop residues. In this system improved concentrate feed accounts for only 0.25% (CSA, 2011).

There are two types of dairy systems in the highlands: the traditional and the market oriented system.The traditional system is based on indigenous breeds which have low production performance (Ketema and Tsehay, 1995; Desta, 2002). The milk produced is mainly used for home consumption and feed requirements are entirely satisfied, from native pasture, crop residues, stubble grazing or agricultural by-products (Falvey and Chantalakhana, 1999). As of Ahmed *et al.* (2003) the market oriented system is based on improved crossbred dairy cattle where milk is an important source of additional cash income.Only a very small part of milk is used for processing and home consumption (Desta, 2002). Farmers need to feed their cows additionally with concentrates and agro-

industrial by-products such as brewery residues, wheat bran, oil seed cakes, mineral mixtures and molasses (SNV, 2008) and keep their cattle in improved shelters.

2.2. Socio-economic Characteristics of Dairy Production Systems

The Ethiopian livestock sector has considerable economic and social importance, at both household and national levels. Livestock production is a year round activity, in comparison to crop production (which is seasonal) and therefore serves as security against the risk of crop failure while providing year-round employment to a huge workforce. It contributes in different proportions to household incomes, varying from 37% in the livelihoods of smallholder farmers in the mixed farming system to 87% in pastoralist communities (Gebremariam *et al*., 2010; Behnke and Metaferia, 2011; ATA, 2012).

Land is one of the important parameters for dairy farming activity. But due to population pressure and urbanization land size per household and communal grazing land has been decreasing. In the highland, the number of population is more densely; as a result the ratio of farm size to household is small. According to the report of (CSA, 2011), the average land size of the Ethiopian highland is 1.18 hectares. The average land holding per household (1.2 hectares) reported by Abebe *et al*. (2017) in the central highlands of Ethiopia was lower than the national average value (1.60 hectares) reported by FAO (2008). Abebe *et al*. (2017) further stated that land scarcity as one of the main constraints for dairy farmers in the central highlands of Ethiopia. A study in Bahir Dar and Gondar by Yitaye *et al*. (2011) also reported that inurban areas, 70% of the farmers do not have access to farmland, livestock farming and especially dairying isby far their main agricultural activity. Average land size perfarmer differed among farmingsystems (3.1 and 0.3 hectaresfor crop-livestock farmers' and livestock farmers, respectively). Similarly, the average farmsize was different between locations (2 and 0.6 hectares for peri-urban and urban farms, respectively).

In urban and peri-urban areas of Bahir Dar and Gondar, 27.7% of dairy farm owners were illiterate, 25.5% able to write and read and 19.6% had a higher education but there was no significant difference between locations for the respective levels of education. Farmers with diploma and above education levels were 24.5% and 18.3% in urban and peri-urban areas, respectively (Yitaye *et al*., 2011). Farmers with higher educational level adopted improved dairy management practices faster than those with low educational level (Lemma *et al*., 2012). In peri-urban farms of Bahir Dar and Gondar, North western Ethiopian highlands the family size per household was greater than urban farms which likely manipulate the labour capacity available for crop and livestock production (Yitaye*et al*., 2011). The authors further described that in urban and peri-urban farms greater percentage of males (87%) than of female household heads.

A study in Mekelle city indicated that from 180 respondents the majority (41.7%) of the dairy farms were established about 6 to 10 years ago, 7.2% of the farms were established during the last 15 and above years, 20% were established about 11-15 years ago and 31.1% were established within the last 5 years (Solomon, 2014). In Bangladesh, 280 dairy farmers' households were interviewed and the majorities of the farmers had 10 to 19 years of experiences in dairy farming and most of the highly experienced farmers reared crossbred dairy cattle (Quddus, 2017).

A study in Burkina Faso by Thys *et al*. (2005) revealed that the farmers' main objective of keeping livestock was for generating cash income. Different studies in the Ethiopian highlands stated that dairying generated 34% of the total household income of farmers in the Holleta area (Mohamed *et al*., 2003) and 48.9% of the urban farmers of Southern Ethiopia (Sintayehu *et al*., 2008). Azage *et al*. (2006) concluded that urban and peri-urban dairy production systems could contribute to overall development through income generation and employment opportunities.

2.3. Livestock Holding and Herd Structure

Livestock ownership varies depending on the type of production system, wealth status and the overall farm production objectives. Yitaye (2008) reported a larger number of cattle kept by crop-livestock farmers, like in peri-urban and rural areas, than by livestock farmers in urban areas. The average cattle herd size per household for smallholder farmers in the Highlands reported were 7.1 cattle in North West Shewa Zones (Agajie *et al.*, 2002), 17.9 cattle around Debre Birhan (Ahmed, 2006) and 4 cattle at Akaki and Lemu, Central Ethiopia (Bayush, 2008). In the mixed crop, livestock production system of the Central Rift Valley the average cattle herd size reported was 15.5 cattle per household (Lemma *et al*., 2005). Yoseph *et al*. (2003) reported an average herd size of 26.5 in urban and peri-urban production systems.

As studied by Zewdie (2010) in the Ethiopian Highland production system 95% and 4.6% of the dairy farmers reared crossbred and local cattle, respectively. Local cows are mainly kept on peri-urban crop-livestock farms in Bahir Dar and Gondar, where they constitute more than half of the cow population, while in the other locations and farming systems mainly crossbred cows are used (Yitaye *et al*., 2011). A study in Bure by Azage *et al.* (2013) described that the proportion of crossbred cattle in rural dairy production system is very low, but better in peri-urban and higher in urban dairyproduction systems.

2.4. Dairy Cattle Management Practices

2.4.1. Housing

Type of housing provided for dairy animals varied depending upon the classes of dairyanimals, agro-ecology, production system and physiological stage (Azage *etal.*, 2013). A good quality shed for dairy cattle provides comfort to the animal, decreases wastageof feedstuff and ensures better environmental control. If these basic needs cannot be met in the animal shed, then health, welfare and production of the cattle will be

compromised (Mulisa *et al.*, 2011). In Bishoftu town, 42% of dairy farms had clay floors and most of the dairy farms in all scales of production kept their dairy cows under cow shed roofed with ridged sheets of materials (Mulisa *et al.*, 2011). The authors further described that the dairy shed floor structure in the majority of small and medium dairy cattle holder was concrete floor. Cattle designs such as kraals and traditional free stalls are very common in Dire-Dawa town (Emebet and Zeleke, 2008). Zemenu *et al.* (2014) stated that in urban areas of Debre-Markos, the majority of the farms used separate enclosure houses and stone slab floor.

In Adigrat area, a study by Alemshet (2014) revealed that the main housing systems were made of stone wall with its roof being covered either by woody material (60%), corrugated metal sheet (23.3%) or plastic sheet (16.7%). The floor was mostly made of concrete, though there were few households who use toughened soil. The author further noted that, free stall with feeding trough was commonly used in the study area.

Asrat *et al*. (2013) mentioned that in the urban production system of Boditti town, South Ethiopia, housing cattle with the family was rare and was only practiced by farmers around the periphery of the town. The majority (71.6%) of the households in the town areas used cooking places (kitchen) for their animals, even though it is not advisable because of the chance of zoonotic diseases transmission to human beings. Although housing cattle in separate house have its own benefit, most dairy producers (60%) in and around Boditti town used family houses for their animals rather than sheds constructed in a suitable way. As a result, this trend should be avoided and the use of separate houses must be encouraged (Asrat *et al*., 2013).

2.4.2. Feeding

In Ethiopia, natural grazing method of animal feeding system was supplemented with natural grass hay, crop residues such as straws of cereals and agro-industrial by-products mostly from the flour/oil industries and brewery residues (CSA, 2014).As described by

Zinash *et al*. (1995) in the central highlands of Ethiopia, livestock grazing on seasonal fallow land and permanent pasture lands during cropping season and on croplands after harvest is common. Production problems common to most Ethiopian livestock feeding systems are seasonality in animal feeds supplies and of poor quality in that the quality of most harvested and conserved feedstuffs is such that when fed alone, it is often insufficient to provide even for the maintenance needs of livestock (Anderson, 1987).

In and around Awassa city, 95% of urban and 92.1% of peri-urban dairy producers use zero grazing and semi-grazing systems (Ike, 2002). The majority of the smallholder dairy farmers in Dire Dawa town practiced intensive or zero-grazing, feeding system (Emebet and Zeleke, 2008). The types of dairy cattle feeding systems identified in the East Wollega zone, Ethiopia by Misgana *et al*. (2015) were grazing (own and communal pasture), intensive feeding, combination (grazing, cut and carry and intensive) and tethering. In the same study, the majority of the interviewed households (66.7%) fed their animals through free grazing on own pasture land and only 7.6% were using communal pasture mainly in the rural areas. The authors further distinguished that Zero grazing and combinations of (grazing, cut and carry and intensive) feeding systems were mainly the characteristics of urban and peri urban areas and only 10.5% of the respondents use stall (intensive) feeding and 11.4% practice a combination of feeding systems. In Fogera district, tach abua village Getachew *et al*. (2015) described two common feeding styles (tethering and free grazing).

The three types of dairy feeding systems practiced in Jimma, Ethiopia were zero-grazing/stall feeding, zero- and partial-grazingand full time-grazing, respectively (Belay and Geert, 2016). A study by Dessalegn*et al.* (2016) also mentioned that stall feeding and combinations of feeding systems were mainly practiced in Bishoftu and Akaki areas. Overall, about 74.6% of the respondents' uses stall feeding and 25.4% practiced a combination of feeding systems.

2.4.3. Breeding

In order to develop thegenetic potential of the animals, selection and breeding schemes can be used. Breeding methods distinguished into pure breeding and crossbreeding systems. Mating in the context of animal breeding means pairing of female and male animals for the purpose ofreproduction on a farm using natural or artificial insemination (AI) methods (Willam andSimianer, 2011).

The breeding objective in any livestock species is toincrease profit by improving production effectiveness (Charfeddine, 2000). Profit is a function of income and costs generated by each animal category composing the herd (Wolf *et al.*, 2011). Breeding is the first and probably most important step tobe taken in dairy cattle farming. Without it, the program could result in genetic change, butin the wrong direction. Improving the wrong traits is corresponding or even worse than noimprovement at all (Van der Werf, 2004).

In most tropical countries, both AI and natural service are practiced as breeding methods (Bebe *et al*., 2003). Most of the dairy farmers in the highland, midland and the lowland areas of Ethiopia used natural mating by using an indigenous breeding bull (Tesfa, 2009). Along with natural mating, some farmers used AI in highland and midland areas. A study by Solomon *et al.* (2014) also indicated that the majority of the farmers in Metekel zone depend on natural mating in the absence of artificial insemination (AI) facilities. Under mixedcrop-livestock production system in Boditti town, South Ethiopia most of the farmers depend on natural breeding using native bulls, while others depend on AI (Asrat *et al.*,2013). In a few cases, farmers were using both natural service and AI. According to Ayantu *et al*. (2012) and Dereje (2015) more farmers practiced natural, unplanned and uncontrolled mating system and keeping of sire was not practiced by smallholder farmers rather they use for both breeding and drought power. Communal grazing land is the primary source of breeding bulls in most part of Ethiopia (Shiferaw, 2006; Ayantu *et al.*, 2012).

A recent study in and around Mekelle city, northern Ethiopia in 177 dairy farms also described that the common breeding methods for crossbred dairy cattle were both AI and natural mating by bull 39.5% followed by AI 34.5% and natural service 26% (Alemselam *et al*., 2015). Conversely, in the East Wollega zone, Ethiopia about 45% of the interviewed farmers were using natural breeding by bull service only. Only 4% of them were using AI and the majority of the respondents (50.5%) have used both natural and AI for breeding their dairy cattle alternatively (Misgana *et al.*, 2015). As reported by Dessalegn *et al.* (2016) in Bishoftu town 50.8%, 47.8% and 6.6% of dairy cattle producers practiced AI, both AI and natural bull service and natural bull service only, respectively as breeding methods. The authors further noted that in Akaki town 47.8%, 46.4% and 5.8% of the interviewed dairy farmers used both AI and natural bull service, AI and natural bull service only, respectively, as breeding systems for their dairy cattle.

2.4.4. Culling and calf weaning practices

Reasonable economic benefits of improved reproductive performance are not easy to estimate. When reproductive performance improves, all changes in cash flow that result from the improvement must be accounted for. So for a good analysis, we need at least realistic estimates of lactation curves, feed intake, the risk of involuntary culling, and prices such as for milk, feed, labor, semen, fertility drugs, calves, replacement heifers and cull cows (De Vries *et al*., 2012).

In Fogera, Jeldu and Diga districts of the Nile Basin, Ethiopia the overall average culling age of cows was about 9 years (8-10) (Ayele, 2012). The author furthermore mentioned that in case of emergencies (both financial and agricultural) the farmers tend to sell the growing herd first and breeding females were maintained in the herd for older age until reproductive performance was nearly ceased. This is due to the significant role that cows play in the household or might be the strategy of the owners to avoid risks by maintaining the surviving adult females rather than depending on young replacement females whose survival may be low at times because of diseases (Dereje, 2005). A study by Zewdie

(2010) stated that crossbred male calves were immediately culled out at Jimma and Sebeta areas to reduce cost of production. Recently, Dessalegn *et al.* (2016) also mentioned that in Bishoftu and Akaki areas male calves were not economical to keep and farmers sold them cheaply or culled them from the herd as soon as possible.

In Tanga Region, northeast Tanzania restricted suckling (71%) and bucket feeding (29%) were the commonest form of pre-weaning calf rearing systems practiced. Many farmers in the studied area believe that mastitis can be minimized by practicing restricted suckling. The mean weaning age was 130 days and ranges 0 to 360 days (Swai *et al*., 2005).

A study by Ayele (2012) described that in Fogera; Jeldu and Diga districts of the Nile Basin about 25% of the total 207 respondents practice weaning of their calves. In and around Boditti town, South Ethiopia, 25% of households, followed early weaning (after 3 or 4 months) if there is feed availability for the calves, 14.2% wean when the cow becomes pregnant or aggressive for the calf, while the majority (51.7%) of the households wean calves when the dam/cow becomes dry. Colostrum feeding practices in the area last for 5 to 7 days as stated by the majority (65%) of the households while 35% give the colostrum to calves for 7-15 days (Asrat *et al*., 2013).

2.4.5. Record keeping

Record keeping is almost not familiar in smallholder dairy farming systems in many parts of Ethiopia. Asrat *et al.* (2013) reported that 95% of dairy farmers in and around Boditti town, South Ethiopia were not practiced record keeping. But 5% of the urban dairy producers were found to record some reproduction parameters regarding breeding/AI service using informal sheets given from development agents. The authors further mentioned that the reasons for not keeping records in the area were households do not have enough experience and lack of awareness about its benefits. A recent study by Asrat *et al*. (2016) stated that in and around Wolaita Sodo town, 42.7% (town) and 27.8%

(surroundings) of dairy producers were found to maintain breeding/AI and farm/reproduction records, respectively. But 29.4% of dairy producers have not practiced record keeping because they did not know the importance of keeping records. Lack of record keeping was reported by AI service providers and farmers which have adversely affected the national data analysis and decision making in progress and it is also highly believed to have an increased incidence of inbreeding in Ethiopia (Desalegn, 2011).

In another research conducted in the central zone of Tigray, Northern Ethiopia, 6.2% of rural farms and 19.4% of the peri-urban dairy farms practiced records keeping about input expenses and output prices. Record keeping was almost absent in all rural farms and in 80.6% of the peri-urban dairy farms which is an indicative of lack of awareness of dairy farm owners about the benefits of record keeping. The type of recorded data by farmers in the study areas were price of purchased cattle, feed cost, year of birth, medication cost, labor cost and revenues obtained from sales of bulls, male calf and milk. Therefore, to increase the practice of record keeping extension experts be supposed to give training and practically show how and what to record (Destalem, 2015).

2.5. Constraints and Opportunities of Dairy Production Systems

Ethiopia has a huge potential for increasing livestock production for both local use and export purposes. However, expansion and productivity were constrained by quantitatively and qualitatively insufficient and imbalanced nutrition, sporadic disease outbreak, water scarcity, lack of appropriate livestock extension services, insufficient and unreliable data to plan the services and inadequate information to improve animal performance, marketing, processing and integration with crop and natural resources for sustainable productivity and environmental health (Aynalem *et al*., 2011).

Earlier studies in different parts of Ethiopia also illustrated that the dairy production was constrained by inadequate supply of quality feed and its high cost, access to credit, seasonality of demand, particularly in fasting time and lack of the processing industry

(Ahmed *et al*., 2003; Sintayehu *et al*., 2008; Assaminew and Eyassu, 2009; Adebabay, 2009). Shortage of land was reported as the most limiting factor in urban dairy production systems (Belay *et al*., 2011; Azage *et al*., 2013). In Boditti town, South Ethiopia dairy production system was most challenged by factors like land shortage, availability and costs of feeds, shortage of genetically improved dairy animals, discouraging seasonal marketing systems, poor animal health services, problems related to waste disposal (for urban producers), poor extension services and knowledge gap regarding improved dairying (Asrat *et al*., 2013).

In Mekelle city, the major constraints for dairy development were shortage of feed, high costs of feeds, inadequate land for dairy expansion and preparation of feeds, seasonality of milk demand occurred due to fasting season, lack of improved breed animals with affordable price, less access to credit, AI problem, shortage of water and knowledge gap in identifying quality cross breed cattle (Solomon, 2014). Cattle productivity in Gondar town, North West Ethiopia was affected by various factors and the most important constraints associated with dairy production were land shortage, feed shortage, disease prevalence, poor government attention, poor veterinary service, lack of improved dairy breed, high cost of feed, water shortage, lack of improved forage pasture and poor transportation (Malede *et al*., 2015).

The large and diverse dairy animals genetic resources adapted to the wide and diverse agro-ecologies, establishment of several structures and service centers such as veterinary health and AI centers, high demand for consumption of dairy products, huge human population with long-standing tradition of consumption of dairy products, high rate of urbanization and income growth, availability of trained manpower, research institutions and technologies shows that Ethiopia has ample opportunities for dairy development (Azege *et al*., 2013). A recent study by Tadesse and Mengistie (2016) described that the main opportunities for dairy farm development in Ethiopia were livestock genetic resources and production system, accesses to services and land inputs, research institution opportunities, indigenous knowledge, demand for and consumption of milk, income

generation and employment opportunities and service providers. In Mekelle city, Solomon (2014) also mentioned that the rapid urbanization, extensive population growth and change in the living standard of the people, to generate income as dairy is highly demanded, highly profitable sector, accessing animal health service, AI, extension and training services were an opportunities for the development of dairy production.

2.6. Available Feed Resources inUrban and Peri-urban Dairy Production Systems

Animal feeds in Ethiopia were classified as green fodder (grazing), crop residue, improved feed, hay, industrialby-products, and other feeds. *Green fodder* is simply pasture grasses; *crop residue* includes harvested by-products (straw and chaff of cereals and pulses, etc.); *improved feed* is like alfalfa; *hay* includes any type of grass, clover, cut and dried as fodder; and finally industrial *by-products* are like oil cake (noug cake, rapeseed cake, sunflower cake), bran and brewery residue (CSA, 2013).

Feed scarcity is indicated as a factor responsible for the lower reproductive and growth performances, milk production, meat production and poor traction power output of animals especially during the dry season (Legesse, 2008). Agro-industrial by-products produced in Ethiopia and mainly used for dairy and fattening animals include; by-products from milling industries, oil processing factories, abattoirs, brewery by-products and sugar factories are the major feeds used as a supplement (Alemayehu, 2004). The farmers generally provide better feeding through supplementation of concentrate by-products such as oil cakes, wheat bran and pulse bran only to lactating cows, as they receive immediate returns through milk sales (Ranjhan, 1999).

The major roughage feed resources for dairy animals across all the different Ethiopian production systems include natural pasture/grasslands, grass hays, crop residues and non-conventional feed resources (Asaminew and Eyassu, 2009; Yitay *et al.*, 2009; Azage *et al*., 2013). In Hadiya Zone, Hosanna town of Ethiopia the major feed resources used for dairy cattle were agro-industrial products, crop residues, conserved feed, local beverages

by product atela and brint and grazing, respectively (Gezu *et al*., 2015). The major basal feed resources for cattle in the highlands of Ethiopia were natural pasture, hay and crop residues (Seyoum *et al*., 2001). Dairy farmers found in North Gonder who owned crossbred cows feed concentrate feeds like noug seed cake, sorghum bran, bean bran and wheat bran to their animals (Zewdu, 2004).

A study by Malede *et al*. (2015) explained that in Gondar town, the majority of farmers were used wet brewery grain (97%) and wheat bran (56%) followed by bean bran (39%), sorghum bran (29%) and Atela from Tella (24%), respectively, for their dairy cattle. But Noug cake was the least used feed resources. The authors also proved that there were no many improved forage feeds (like elephant grass, alfalfa white, sesibania, vetch and Rhodes grass) used in the study area. The major feed resources for dairy cattle in East Wollega zone were natural pasture, grass hay, crop-residues, improved forage plants (elephant grass or Napier grass, Rhodes grass), concentrate feeds and non-conventional feedstuffs such as mill house by product (hulls and scrubs) and '*Atela*', locally produced brewery by-product (Misgana*et al*., 2015).

2.6.1. Natural pasture and grass hay

In the majority areas of sub-Saharan Africa, the main and even the only feed source available for large parts of the year in smallholder production systems are natural pasture (Gylswyk, 1995). In most parts of the Ethiopian highlands forage is usually in good supply during the rainy season (Ensminger, 2002). Natural pastures mostly suffer from seasonal spells of dry periods during which they drop in quality, which is characterized by high fiber content, low digestibility, low nitrogen, very low protein and energy contents (Topps, 1995; Assefu, 2012). The yield as well as quality of pasture is very low due to poor management and over stocking (Ashagre, 2008). In recent times, the share of the natural grazing pasture at the national level as livestock feed resource, has become decreasedto about 57% (CSA, 2013) from aprevious level of 90% (Alemayehu, 1985).

As clarified in Zenash *et al*. (1995) natural pastures would be enough for maintenance requirement and weight gain during wet seasons, but would not support maintenance for the rest of the year. Natural pastures in the Ethiopian highlands are rich in species composition, mainly indigenous grasses and legumes (Assefu, 2012). Generally, grazing land productivity is reduced at a higher rate from time to time because of temperature stress and shortage of rainfall, which is favored by the deforestation that denies humid environment of the area. Additionally, the transfers of grazing lands to cultivation for cropping and poor grazing land management are some of the reasons for dry matter reductions from grazing lands (Yeshitila *et al*., 2008). Annual and perennial grass from natural pastures consumed during the dry season and often at late stage of maturity together with the straw and stalk from cereal crops composes low quality forages, with high lignified cell wall and poor nitrogen (FAO, 1997). Mature grass, particularly those that are weather bleached are low in digestible energy and protein, soluble carbohydrate, carotene and some minerals (Ensminger *et al*., 1990).

The urban and peri-urban dairy feedlot operations depend on the hay produced in pasturelands as a source of roughage feed in the central highlands of Ethiopia, the greater in Addis milk shed (Fekede *et al.*, 2013). The concentrations of crude protein (CP) in grass hay have often fallen even below 7% during dry seasons in the highland farming systems (Solomon *et al.*, 2008). Good grass and legume hays are adequate for maintaining most classes of livestock, particularly those in a non-productive state (Streeter *et al.*, 2006). Therefore, dairy cows depending on poor quality basal feeds will not express their full genetic potential.

2.6.2. Crop residues

Crop residues are the fibrous by-products produced from the cultivation of cereals, pulses, oil plants, roots and tubers and represent an important feed resource (Yayneshet, 2010). They are significant in fulfilling feed gaps during periods of acute scarcity of other feed resources. Crop residues are assuming greater importance as a source of roughage

than natural pasture and hay (Rehirahie and Getachew, 2011). In Ethiopia crop residues contribute to about 50% of the total feed supplied (Tolera *et al*., 2012). The availability of crop residues, as stock feed particularly in smallholder livestock production system, is possible as a result of the allocation of more land for crop production (Alemayehu, 1998). The amount of crop residue produced is intimately related to grain production, farming system, type of crops produced and intensity of cultivation. About 12 million tons of crop residues were produced yearly from 6 million hectares of farmland in Ethiopia (Daniel, 1988). A report by CSA (2008) revealed that crop residues production was increased to 31.52 million tons. Zinash and Seyoum (1989) stated that 63, 20, 10, and 7% of cereal straws are used for feed, fuel, construction and bedding purposes, respectively. Farmers in the Ethiopian highlands have a habit of conserving crop residues from teff (*Eragrostis teff*), barley, wheat and sorghum (Reed and Goe, 1989). Straws from teff, barley and wheat form the prime constituent of livestock diet in the mid and highland areas, while maize, sorghum and millet Stover's represent larger proportion of livestock feed in lower to medium altitudes (Alemayehu, 1985).

Solomon and Alemu (2009) also indicated that teff, wheat and barley straws were the main crop residues available in the highlands of Ethiopia. In southeastern parts of Ethiopia, Abate *et al.* (2010) as well noted that straw from maize, sorghum and teff was used mainly during the dry season. A recent study in Gondar town stated that crop residues such as wheat, barley, teff straws and maize thinning were used by farmers as basal diets for dairy animals (Malede *et al*., 2015).

2.6.3. Agro-industrial by-products

Agro-industrial by-products have special value in feeding livestock, mainly in urban and peri-urban livestock production systems, as well as in circumstances where the productive potential of the animals is relatively high and require high nutrient supply (Yayneshet, 2010). The same author further identified that the major agro-industrial by-products commonly used are milling by-products (wheat bran, wheat short, wheat

middling and rice bran), oil seed cakes (noug seed (*Guizotia abyssinica*)cake, cottonseed (*Gossypiumspp.*) cake, peanut (*Arachis hypogaea*) cake, linseed (*Linum usitatissimum*) cake, sesame (*Sesamum indicum*) cake, sunflower (*Helianthus annuus*) cake, breweries and molasses. The author added that the current trends of increasing urban population have a significant effect on the establishment of agro-industries due to the corresponding increasing demand for the edible main products. Additionally, Azage *et al*. (2013) mentioned that agro-industrial by-products such as bran, middling, oil seed cakes and molasses are fed as supplements to crossbred dairy cows in urban and peri-urban areas.

Though the contribution to the total animal feed resource is limited (1.45%), agro-industrial by-products are one of the important feed resources available in Ethiopia (CSA, 2003). Agro-industrial by-products have diverse nutritional characteristics and differ in their utilization as feed for livestock. However, these calls for a study evaluating and development of appropriate feeding strategies that maximize the use of the locally accessible feed resources for the different groups of animal in the varied production systems and agroecologies (Getnet *et al.*, 1999).

2.6.3.1. Milling by-products

Milling by-products include bran and related by-products of flour mills such as wheat short, wheat middling, rice bran and screening. These by-products are produced during milling of grain to produce flour for human consumption. Wheat bran is the most familiar milling by-product used for livestock feeding in Ethiopia (Adugna, 2008). It is vastly used product in formulating feed for dairy animals (Verma, 1997). Wheat middlings are alike to bran except that they have lower fiber and higher flour contents, thus they are higher in digestible energy than bran (Cheeke, 1991). Wheat screenings are broken or shriveled kernels plus any foreign materials such as cheat and weeds. The various milling by-products are of great interest as livestock feed in commercial or market oriented livestock operations. The milling by-products, molasses and grain or damaged grain predominantly serves as a source of energy. The milling by-products and grain are rich in

starch and soluble carbohydrate while molasses is mainly composed of readily fermentable soluble carbohydrates (Adugna, 2008).

2.6.3.2. Oil seed cakes

Oil seed cakes are the residue or cakes that are largely produced as by-products during the extraction of edible oil from oil seeds with the type and importance of particular seed cakes varying from place to place (Mesfin*et al*., 2014). The oil seed cakes are rich in protein and serve as a source of protein in concentrate mixtures. Their protein content may differ from 20-50%, depending upon the type of oil seed and the method of extraction of oil (mechanical Vs solvent). However, the protein content of most oil seed cakes like noug and linseed cakes lies within the range of 28-35% (Adugna, 2008). In Ethiopia, noug seed cake, linseed cake, cottonseed cake, and groundnut seed cakes are most commonly used as supplemental feeds in dairy and fattening farms.

2.7. Nutritional Value of Common Feedstuffs

The composition of the feed affects the absorption of nutrients into the blood and thereby the amount of nutrients which can be allocated to the udder. In order to increase the utilization of nutrients or to favour a certain milk composition, it is necessary to have sufficient information about the nutrient affinity of the various post absorptive tissues and regulation of mammary nutrient uptake, as well as their conversion into milk components throughout lactation. There is still a lack of knowledge concerning the interaction between supply and tissue affinity of individual nutrients (Madsen *et al*., 2005).

The crude protein (CP) content of noug seed cake (NSC) was 31.26% and 28.2% as reported by Abebaw and Solomon (2008) and Wondimagegne *et al*. (2016), respectively. The CP content of grass hay stated by Aschalew and Malede (2013) and Wondimagegne *et al*. (2016) was 6.7 and 6.5% DM, respectively. A study by Gezu *et al*. (2017) described that the Neutral Detergent Fiber (NDF) content of grass hay was 74.4% DM. The studies

of Adugna (2008) investigated that the CP content of wheat middling was 17.8% of DM basis.

Delgado and Randel (1989) recommended 15% crude protein for concentrate mixture for cows grazing tropical grass swards. Alternatively, a study by Nega *et al*. (2006) stated that in the urban and peri-urban centers of the Central Rift Valley, Ethiopia (Arsi Negelle, Ziway, Wonji Kuriftu and Lume districts) farmers were used home-mixed concentrate for their lactating crossbred dairy cows having 213 g/kg DM of CP, 10.6 MJ/kg DM of ME, 3.4 g/kg DM of calcium (Ca) and 12 g/kg DM phosphorus (P). Mesfin *et al*. (2013) further explored that home-mixed concentrate used by dairy farmers for lactating crossbred dairy cows in peri-urban smallholder dairy production systemsin West Shewa zone (Ejere, Walmera, Burayou and Ambo districts) of central Ethiopia, contained 260g/kg DM of CP and 10.8 MJ/kg DM of ME.

2.8. Nutrient Requirements for Optimum Dairy Productivity

Nutrition has a profound influence on productive and reproductive performance of dairycattle. In Ethiopia, beside the limited quantity of feed supply and intake, imbalanced nutrition is another key factor responsible for low livestock productivity (Tekalign, 2014). The utilization of feed resources is highly inefficient, with about 85% of feed intake used to meet the animal's maintenance requirements and only 15% utilized for production. As a result, lactating cows are unable to reach peak milk production during early lactation leading to low milk yields (Tesfay *et al*., 2016). Because of the high metabolic rate and requirement for milk secretion, lactating cowshave special demands for a nutrient supplement (Indetie, 2009).

Generally, cows require nutrients for maintenance, growth, production and reproduction. Nutrients required for these functions are expressed in terms of energy, protein, minerals (particularly calcium and phosphorous) and vitamins. Energy, protein, and digestibility of feeds are central in determining the nutritional adequacy and feeding levels for different

classes of livestock species (Streeter, 2006). How much energy and protein a concentrate mixture should contain will depend on the quality of the basal roughage and the level of production. In an earlier study by Tadesse *et al.* (1991) at the Holetta Agricultural Research Center, where 2, 4, 6, 8, and 10 kg of the same type of the concentrate mixture fed to lactating crossbred dairy cows per day and 6 kg/cow/day was recommended. As a rule, feeding concentrate at the rate of 0.5 kg per kg of milk yield with *ad libtum* roughages feeding was recommended (SDDP, 1999; Pandey and Voskuil, 2011).

2.8.1. Energy requirements

The energy portion of feeds is the source of fuel for all body functions and it is the major nutrient required by dairy cattle as it facilitates maintenance, growth and weight gain, reproduction and milk production (Lukuyu *et al*., 2012). Energy is usually the most important feed component needed to produce milk and depends on the composition of the milk (*i.e*. fat and protein contents). The value of a feed is clearly related to the amount of energy it can supply, since energy is usually the key limiting nutrient (Wilson and Brigstocke, 1983). Energy requirement of animals is most commonly expressed in the simplest way possible as the absolute quantities of energy gained or lost by animals (McDonald *et al*., 1988).

According to NRC (1996) energy for maintenance can be defined as the amount of feed energy required for essential metabolic processes and physical activities, which results in no net loss or gain from, or to the tissues of the animal. Demand for energy depends on live weight, sex, breed and physiological state such as pregnancy, lactation of the animal (Church and Pond, 1982). The amount of feed needed to meet maintenance requirements will vary with the typeand quality of feed available (McDonald, 1988). Friggens *et al*. (2004) suggested that a high-fat ration in the dry period primes the cow to adapt to mobilization of body fat in the following lactation period. After parturition, dairy cattle are faced with a sudden and marked increase of nutrient requirements to support milk production (Drackley, 1999). Supplementation of fat is used to increase the energy

density of the ration and this is frequently used to explain the positive response in milk yield, when fat is supplemented. The fat sources, most commonly used include oilseeds, palm oils and different variations of these (Rabiee *et al*., 2012). Damgaard *et al.* (2013) further argued that feeding oil seeds during the dry period would be a strategy for priming the cows for fat metabolism in the following early lactation. As indicated by Hans *et al*. (2008), in the tropics dairy cows generally need concentrates to produce milk and feedstuffs rich in energy such as cereals, oil seeds and their by-products, molasses and good roughage.

2.8.2. Crude protein requirements

The functions of crude protein in a dairy animal's body include: making up new tissues and muscles, repairing lost body tissues, growth and development, production and functioning of enzymes and hormones, production of milk, development of the unborn calf during pregnancy, formation of hair, horns and hooves, providing resistance against diseases and provision of energy in the case of excess protein (Pandey and Voskuil, 2011). As a result, proteins are the major components of an animal body and are continuously needed in the feedstuff. With increasing crude protein concentrations, milk yield increased by 4.0 kg/day at the same concentrate intake but tended to fall at reduced concentrate intake (Sutton *et al*., 1996). However, feeding increased level of protein to improve the productivity of the cow results in a lower efficiency of utilization of crude protein (Walker *et al*., 2005). Increased dietary protein normally elevates plasma levels of urea, indicating increased amino acid oxidation or NH3 detoxification in the liver. Total blood protein concentrations have also been shown to increase in response to increased dietary protein content, and that could be explained by an intestinal sub-absorption of amino acids (Law *et al*., 2009).

As protein is an expensive component of the ration over feeding should be avoided to minimize the cost. In addition, extra energy, which would otherwise be used for milk production, is used to remove the extra protein (nitrogen) from the animal body in the

form of urea in the urine (Lukuyu *et al*., 2012). Yan *et al.* (2006) also mentioned that nitrogen excretion in manure is highly correlated with dietary nitrogen intake and hence the key mitigation strategy to reduce manure nitrogen output is to reduce dietary nitrogen concentrations.

2.8.3. Calcium and phosphorus requirements

Calcium (Ca) and phosphorus (P) are closely correlated for building the skeletal structure. Approximately 90% of the calcium and 70% of the phosphorus can be found in the skeleton and teeth. Phosphorus in addition to its function in bone building is required in the utilization of energy and in the cell structure. Animals usually require 1.5 parts of Ca for every part of P. Phosphorus deficiency can be regarded as the most prevalent and serious mineral limitation to livestock production (McDowell, 1985). However, to meet the dietary requirements of cattle, P supplementation should be seriously considered. The dietary P concentration needed to meet dietary requirements varies widely with feed intake, breed, body weight, growth rate and physiological state (Chantiratikul *et al*., 2009). The recommended P requirements for tropical beef cattle ranging from 1.7-3.5 g kg^{-1} feed (Kearl, 1982). Feeding a calcium-deficient diet may delay uterine involution and depress fertility (Funston, 2007). Rations should be formulated to ensure that the animal consumes the desired amount of nutrients in a day (Adugna, 2008). Well balanced diets should prevent severe negative energy balance and an excess intake of specific dietary components (Leroy *et al*., 2010).

2.9. Feeding and Watering Frequencies of Dairy Cattle

Increasing the frequency of feed delivery has been shown to modulate the feeding patterns of lactating dairy cattle with cows fed more frequently, spending more time feeding, increase the distribution of feeding time over the course of the day and improve access to fresh feed for all cows (DeVries *et al*., 2005). Study on feeding management in more competitive free-stall settings indicates that frequency of delivery of fresh feed

stimulates feed bunk attendance (DeVries *et al.*, 2003) and can affect other aspects of cows' time budgets apart from feeding such as time spent standing or ruminating while standing vs. lying down (Phillips and Rind, 2001).

Gibson (1984) concluded that increasing the feeding frequency of dairy cows increased the milk fat percentage by an average of 7.3% and increased milk production by 2.7%. In the studies of Shabi *et al.* (1999), Le Liboux and Peyraud (1999) and Kudrna *et al.* (2001), increasing feeding frequency increased the DMI of the total mixed ration (TMR), but had no effect on milk production. Contrary to these results, in the study by Phillips and Rind (2001), the DMI and milk yield were higher with feeding once a day compared with 4 times a day and concluded that frequent feeding disturbed the cows and reduced milk production. Riva *et al*. (2013) concluded that the variation in the frequency of feed delivery seems to affect the cow behavioural activity, but only in a limited way and to modify only slightly the daily averages of the time spent on different activities.

Effects of feed delivery frequency on dairy cow production and metabolism depend on the farm (like housing type, milking facilities), animal and diet related factors. Therefore, because of interactions among these factors, theoretical predictions may not occur in practice. Greater feed delivery frequency of highly fermentable mixed rations and rapidly fermentable concentrates is thought to help stabilize rumen pH, and improve feed intake and milk production (Yang and Varga, 1987; NRC, 2001). Rumen fermentation patterns and cow performance have not been improved by greater feed delivery frequency (4 times or 6 times *vs*. 2 times) in non-competitive environments (Klusmeyer*et al*., 1990; Macleod *et al*., 1994; Shabi *et al*., 1998). Feed intake was increased by 4 times instead of 2 times feed delivery of a corn grain-based total mixed ration (TMR) in individual tie stalls (Shabi *et al*., 1999). Feeding 4 times for 1 time daily did not affect intake and production of mid-lactation cows in tie stalls offered a corn grain-based TMR with alfalfa hay and corn silage (Dhiman *et al*., 2002). As mentioned by Nikkhah (2011) feed delivery once per day is labor effective and more desirable for many small and mid-size

farms. Because of labor and time costs, more frequent than 4 times feed delivery is not practicable for even large dairy farms.

Dairy cows must consume large quantities of water for the production of milk. Water requirements are directly related to dry matter intake, *i.e*. increased consumption of dry matter will increase water consumption and vice versa. Milking cows require 4-5 kg of water for each kg of milk produced (Banerjee, 2009). Thokal *et al.* (2004) described that the mean value of water intake by dairy cows was significantly higher in watering thrice a day as compared to cows watering twice a day. The calculated daily water intake of every day watering group was significantly higher compared with the every 2^{nd} day, 3^{rd} day and 4^{th} day watering groups of Ethiopian Somali goats (Mengistu *et al*., 2007).

In the Highland production system (Debre Birhan, Jimma and Sebeta), dairy farmers, mostly provide water twice a day for cattle. However, in the CRV (around Ziway) 47% of the interviewed respondents watered cattle once in two days. In Debre Birhan, Jimma and around Ziway 10, 35and 13%, respectively, of the farmers were able to provide *ad libtum* water for their cattle (Zewdie, 2010). Kassahun *et al*. (2008) described that watering frequency decreased as the distance to water accessing point increased and vice versa. Azage *et al.* (2013) also revealed that the watering frequency of dairy cattle depends on access to water sources, the age structure of the dairy herd, physiological stage of animals and season. The authors further stated that in the urban and peri-urban dairy production systems in Shashemene-Dilla milkshed about 36% of the households water their dairy cattle once per day.

According the study conducted by Alemshet (2014) in Adigrat, Tigray about 25% of urban and 37.2% of peri-urban households watered their dairy cows once per day. Only 28.9% and 15.25% of urban and peri-urban respondents, respectively, provide water *ad libitum* for dairy cattle. In Mekelle city, 65.6% of the dairy producers watered their animals once a day (Tilahun and Gebregiorgis, 2016). As reported by Bernabas *et al*. (2017), in Alefa district of North Gondar zone, 66.7% of the respondents watered their

dairy cattle twice per day. About 38% of the respondents in the Quara district of North Gondar zone were watered their dairy cattle once, twice, and three times a day, respectively (Bernabas *et al*., 2017). Frequency of watering to dairy animals varies from one production system to another, which is affected by different factors, including season, accessibility, performance and/or breed of the animals and predominant feed type (dry or wet) and feeding systems (Asrat *et al*., 2016).

2.10. Prepartum and Post-partum Feed Intake in Dairy Cows

Adequate nutrition before calving and during post-partum period is essential if acceptable estrous and rebreeding performances are to be achieved (Alam *et al.*, 2001). The transition period extends from the last 3 weeks of gestation through the first 3 weeks of lactation. The term *transition* is to underscore the important physiological, metabolic and nutritional changes occurring in this time frame. Nutrition and management programs during this phase directly affect the incidence of post-partum disorders, milk production and reproduction in the subsequent lactation (Grummer, 1995; Drackley, 1999). During the transition period, the final growth of the foetus and calving occur and milk production starts. The cow is also challenged by other stressors such as separation from her calf, immune challenges when the uterus is cleared (Salasel *et al.*, 2010), increased demand for energy, nutrients and minerals (LeBlanc, 2010), and most often also exposure to a new feeding regime and regrouping (Schirmann *et al.*, 2011). Improving energy balance in the post-partum period can reduce the incidence of periparturient diseases (Duffield *et al*., 2009).

Concurrently with the dramatically increased need for nutrients, for the growing foetus, but particularly for lactation, a temporary physiological decrease in dry matter intake (DMI) leads to a shortage of glucogenic precursors from exogenous sources. Although DMI increases after calving, the increase is slow compared with the increased need for nutrients for lactation, with maximum intake reached between 5 and 7 weeks post-partum (Grummer *et al.*, 2004; Ingvartsen and Andersen, 2000).

Tetens *et al*. (2013) also described that the first weeks of lactation are critical times especially in high yielding dairy cows. During that time, an energy deficiency occurs due to a drastic increase in milk production and a physiologically restricted energy intake. In those first weeks, the cow needs to draw energy from its adipose stores and in some cases even from its muscles, leading to a loss in body weight. The nutritional status of a cow after calving affects disease resistance and reproductive performance. Lactation generates a large increase in nutrient demands, especially in dairy cows which have been bred for high milk yields. The correlation between voluntary intake and milk yield varies between less 0.2 to 0.8, and intake is often more closely related to live weight than it is to milk yield (Forbes, 1995).

Energy intake is a primary limitation on the milk yield of high-producing dairy cows as it is determined by the net energy content of the diet and dry matter intake. Factors affecting and regulating the feed intake of lactating dairy cows are numerous and complex and span cellular to macro-environmental levels. Some can be controlled by humans and include animal factors (age, body condition, physiological stage, milk yield level, etc.), dietary factors (ingredient and nutrient composition of diet, physical and agronomic characteristics of feeds, etc.), managerial factors (production, feeding system, housing system, etc.), and climatic factors (temperature, humidity, wind). Therefore, the determination of factors affecting DMI and quantification of their effects is important for developing new feeding strategies during the prefresh transition period (Hayirli *et al*., 2002).

Hayiril *et al*. (2002) further reported that the magnitude of DMI depression for heifer and cows was different as they approached parturition. Dry matter intake of cows gradually decreased from 2.06 to 1.36% of body weight during the final 3 weeks of gestation. The DMI of heifers' remained more constant, at about 1.8 to 1.7% of body weight from 3 to 1 weeks before parturition, and then sharply decreased to 1.23% of body weight during the final week of gestation. The greater extent of DMI depression during the prefresh transition period of cows compared with that of heifers suggests a greater decrease in

energy balance, which may relate to their greater predisposition to post-partum health problems (Curtis *et al*., 1985). Vasquez-Anon *et al*. (1994) reported a decline in dry matter intake of about 40% in the last two days before calving.

2.11. Productivity of Dairy Cows

2.11.1. Milk yield and composition

In different parts of Ethiopia the average daily milk yield of crossbred dairy cows was reported by Belay *et al*. (2012) 8.52 liters/day/cow from Jimma town, Fikrineh *et al*. (2012) 8.95 liters/day/cow in the mid rift valley and Nigusu and Yoseph (2014) 14.1 liters/day/cow in urban and secondary town dairy production systems in Adama milk shed. The average daily milk production of crossbred dairy cows was summarized and reported in Ethiopia for urban (10.21 to 15.9 liters/day/cow) and peri-urban (9.5 liters/day/cow) systems (Azage *et al*., 2013). The average milk yield in Gonder town of crossbred dairy cows was 12.6 liters/day/cow (Malede *et al*., 2015). But Anteneh (2006) reported that the average milk yield of crossbred dairy cows in the same area was 9.63 liters/day/cow which indicate the recent improvement in management systems. In Holetta Agricultural Research Center, crossbred dairy cows fed formulated concentrate mix (0.5 kg/kg of milk) and *ad libtum* native pasture hay produced a mean daily milk yield of 10.2 liters/day/cow (Getu *et al*., 2013). The overall average milk yield of crossbred dairy cattle with >50% blood levels in Bishoftu and Akaki areas were 11.6±3.1 and 10.8±2.4 liters/day/cow, respectively (Dessalegn *et al*., 2016).

Milk is composed of water, carbohydrate, fat, protein, minerals and vitamins (Heinrichs *et al*., 2005). Composition of milk varies from cow to cow and differs from the various breeds. Milk solid components include protein, fat, lactose and minerals (Schroeder, 2012). The milk protein of cows ranged from 1.57 to 4.66%, with an average of 3.05%. Furthermore, milk fat content ranged from 1.77 to 5.98%, with an average of 3.76%

(Heinrichs *et al.*, 2005). The milk from indigenous cows contains 6.1% fat, 3.3% protein, 4.5% lactose and 0.7% ash (Alganesh, 2002).

2.11.2. Lactation length

Lactation length refers to the period through which a cow starts milking and continues giving milk until dry off. The lactation length of indigenous cattle increased when crossed with exotic blood level. For example, a study conducted in the North Showa zone of Ethiopia by Mulugeta and Belayneh (2013) indicated that local breeds (273.9 days) had a shorter lactation length than crossbred (333.9 days) cows.

In most dairy units, a lactation length of 305 days (10 months) is commonly accepted as a standard. But this standard lactation length might not work for smallholder dairy cows in which the lactation length is extended considerably in most cases (Msangi *et al*., 2005). Yoseph *et al.* (2003) in Addis Ababa reported shorter (8.8 to 9.7 months) and longer (11.1 months) lactation lengths in urban and peri-urban dairy units, respectively. However, Yitaye *et al.* (2009) had different observations in which dairy cows in urban dairy units had longer (11.2 months) lactation lengths compared to cows kept in peri-urban dairy units (7.5 months). As stated by Nigusu and Yoseph (2014) the overall average lactation length in months for crossbred cows in urban and secondary town farms in the Adama milk shed was 10.9 ± 0.1 and 11.0 ± 0.1, respectively.

2.12. Factors Affecting Milk Yield and Composition

Milk composition and production are the interaction of many elements within the cow and her external environments. High milk yield of satisfactory composition is the most important factor ensuring high economic returns. If the composition of milk widely varies, its implication is that nutritive value and its availability will also vary as a raw material. Chemical composition of milk is variable and influenced by intrinsic factors like breed, species, parity, stage of lactation; external factors like environmental stress

and changes in feeding. However, it is generally accepted that the milkman can alter many of these factors to achieve milk production and increase profit (O'Connor, 1994).

A study by Pagot (1992) revealed that cattle breeds which originate from the tropics generally have limited genetic potential for milk production (500-1500 kg per lactation) even when the best possible management systems have been provided for them. However, management of dairy animals can have effects on cows' productive performance (Bee *et al*., 2005). McDonald *et al.* (2011) found that local dairy cows and exotic breeds (Holstein Friesian and Jersey) kept under different management in a given environment equally perform differently. Environment and location also play a critical role in both local cattle and exotic dairying (Ngongoni *et al.*, 2006). FAO (2013) declared that, adequate nourishment through supplementation and management in early life improves performance, health, milk production and longevity. Sufficient nutrition is required to meet cows' metabolizable energy for lactation (McDonald *et al.*, 2011). This provides benefits in twofold: less health issues and more milk production at optimum lactation period combined with equal or even lower raising costs (FAO, 2013).

The daily average milk yield is also affected by parity (Darfour-Oduro *et al.*, 2010). According to Epaphras *et al.*(2004), Hatungumukama *et al.* (2006), and Afzal *et al.* (2007) milk yield of cows is low at parity one and increase with increasing parity and a decline after the fifth to sixth parities.

Heinrichs *et al*. (2005) confirmed that genetics and inheritance account for major differences between cows' milk protein and fat content. Fifty-five percent of the variation in milk composition is due to heredity, while 45% is due to environmental factors such as feeding management (Schroeder, 2012). Milk yield per cow tends to get the most attention by dairy producers. However, milk components should not be overlooked. Genetic selection should be directed toward increasing fat, protein and non-fat solids yields. But, because component percentages tend to have negative genetic associations

with yield traits, a change in these percentages is not likely to be achieved through genetic selection alone (Looper, 2012).

Environmental factors such as nutrition and feeding management can have an impact on yield more than the actual percent composition of the major milk constituents (Looper, 2012). Nutritional strategies that optimize rumen function also maximize milk production and milk components (Varga and Ishler, 2007). As cows consume more energy than they use to be, body weight is regained, losses in body condition are minimized and cows produce milk of normal fat and protein content (Looper, 2012). As Looper (2012) parity or age can also influence fresh milk components. Even as milk fat content remains relatively constant, milk protein content gradually decreases with advancing parity/age.

2.13. Demand for Milk and Milk Products

The dairy sector in Ethiopia is expected to continue growing given the large potential for milk development in the country, increased urbanization, the expected growth in income and improved livestock policy. Human population in Ethiopia is estimated to grow at 3% annually, whereas the urban population increases at a rate of 4.4%. Consequently, an increase in population growth and consumer income in the future is expected to increase liquid milk consumption (Mohamed *et al*., 2004). The annual rate of increase in milk yield, which was estimated to be 1.2% lags behind the rapid growth in human population (CSA, 2008) and this resulted in large supply–demand inconsistency for fresh milk (MoARD, 2004).

In order to meet the growing demand for milk and milk products in Ethiopia, milk production has to grow no less than 4% per annum. Bridging this large gap calls for the design of suitable and sustainable dairy development strategies based on socioeconomic, institutional and agro-ecological circumstances that build on the demand of consumers and the needs and opportunities of producers (Azage *et al*., 2003). As reported by

Ethiopian MoA (2012) there are some improvements inper capita milk consumption with an estimated value of 19.2 kg.

2.14. Reproductive Performances of Dairy Cows

The reproductive performance of a breeding female is most likely the most important factor that is a pre-condition for sustainable dairy production system and influencing herd productivity on all forms of output such as milk, meat, traction, fuel as well as provision of replacement animals. It is influenced by feed, genetics, diseases and management practices (ILCA, 1990; Perera, 1999). Poor reproductive performance is caused by failure of the cow to become pregnant, primarily due to post-partum anoestrus, failure of the cow to maintain the pregnancy and calf losses (Perera, 1999). The parameters which describe reproductive performance in dairy cattle like age at first service, age at first calving, calving to first heat intervals, calving to first service intervals, calving to conception interval, number of services per conception and calving interval are discussed below.

2.14.1. Age at first service (AFS)

Age at first service is the age at which heifers reach sexual maturity for accepting service for the first time and influences both the productive and reproductive life of the female through its effect on her lifetime calf crop. Under small scale dairy production in urban and peri-urban areas in Gondar, Nibret (2012) reported an overall mean AFS of 15.4 months for crossbred dairy heifers. A considerable delay in the attainment of sexual maturity may mean a serious economic loss due to an additional non-lactating and unproductive period of the cow over several months (Mukasa-Mugerwa, 1989). Studies by Belay *et al.* (2012) in Jimma town and Zewdie (2010) in the highlands and central rift valley of Ethiopia stated age at first service of 24.30±8.01 and 27.5 months for crossbred dairy heifers. Habtamu *et al.* (2010) found AFS of 722.24±36.4 days for Jersey cattle at Wolaita Sodo State Dairy Farm. In Bishoftu and Akaki towns, the AFS of crossbred heifers was 18.7 months (Dessalegn*et al*., 2016). Inappropriatefeed supply and

differences in management systems may bring variations in age at first service in different areas (Gebeyehu *et al*., 2005).

2.14.2. Age at first calving (AFC)

It is the period between birth and first calving and it influences the cow lifetime productivity and cost invested for rearing (Ojango and Pollott, 2001). The estimated age at first calving for Ethiopian cattle ranges from 35-62 months (Mulugeta *et al*., 1991; Haile-Mariam and Kassa-Mersha, 1994; Ababu, 2002). Nibret (2012) stated that the overall mean AFC of crossbred dairy cows under small scale dairy production systems in urban and peri-urban areas of Gondar was 32.4 months. In Jimma town, the mean AFC was found to be 3.05±0.65 years (Belay *et al.*, 2012). Hunduma (2012) in Assela, Kumar and Tkui (2014) in Mekelle city reported AFC of 34.8±4, 36.4±1.7 months, respectively, for crossbred dairy cattle. Recently, Dessalegn *et al*. (2016) stated that the mean±SD AFC for crossbred dairy cattle in Bishoftu and Akaki areas were 27.0±3.7 and 26.9±5.4 months, respectively. A study in Wolaita Sodo State Dairy Farm indicated that the age at first calving for Jersey cattle was 1035.21±12.59 days (Habtamu *et al.*, 2010).

2.14.3. Calving to first heat interval

Calving to first estrous is an important parameter affected by feeding (Dziuk and Bellows, 1983). Cows with excessive weight loss and severe negative energy balance have irregular estrous periods and longer time to first ovulation and first breeding (Ferguson, 1991). Another study further indicated that cows that are over conditioned at calving or those that lose excess body weight are more likely to have a prolonged interval to first estrous (Roche, 2006).

In Tanzania, Msanga and Bryant (2003) found no significant differences in the interval from calving to first estrous between two crossbred genotypes (60–80% and >80% *Bos taurus* inheritance), between cows whose calves were reared by suckling or bucket.

Calving to first post-partum estrous of crossbred dairy cattle was 114.5±73.7 days in Mekelle city (Alemselam*et al*., 2015).

2.14.4. Calving to first service interval (CFSI)

Feeding significantly reduced the calving to first service interval of dairy cows (Ahmed, 2006). Similarly, Alam and Sarder (2010) stated that improved feeding significantly reduced the calving to first service interval in post-partum dairy cows. A study was investigated from 2096 records pertinent to 482 pure bred Friesian cows in Alexandria University, Egypt and the overall mean calving to first service interval was reported as 88.4 days (Hammoud *et al*., 2010). In Bukoba district, Tanzania the overall mean calving to first service interval of dairy cows was 169.9±1.8 days (Asimwe and Kifaro, 2007). The mean interval from calving to first service of crossbred dairy cows in mixed crop-livestock production, market oriented urban dairy production systems in Holetta area, Ethiopia was 141.98 days (Yoseph *et al*., 2003).

2.14.5. Calving to conception interval (CCI)

Calving to conception interval or days open is the number of days between calving to conception and influences profitability of the dairy industry. This influence is partly attributed to factors such as increased breeding cost, increased risk of culling and replacement costs and reduced milk production (de Vries and Risco, 2005).

Days open affects lifetime production and the generation interval (Ababu, 2002). Days open should not exceed 80 to 85 days, if a calving interval of 12 months is to be achieved (Enyew, 1992). This requires the re-establishment of ovarian activity soon after calving and high conception rates. Nutritional deficiencies coupled with heavy internal and external parasite load under extensive management systems, and allowing calves to suckle their dams may all interfere with ovarian function, thereby prolonging the days open (Short *et al*., 1990; Hafez, 1993). Gebreegziabher *et al.* (2005) mentioned the effect of low level of nutrition on extended post-partum period due to weight loss.

Kefena (2004) reported mean length of days open to be about 200 days for Boran crossbred cows. Generally, the average length of days open recently reported for crossbred dairy cows in Ethiopia was 85.6 to 197 days (Zewdie *et al*., 2011; Belay *et al*., 2012; Hunduma, 2012; Niraj *et al*., 2014). Extended calving to conception intervals were associated with low BCS by week +7 and greater peak milk yield (Patton *et al*., 2007; Wathes *et al*., 2007).

2.14.6. Number of services per conception (NSC)

Number of services per conception (NSC) is the number of services (natural or artificial) required for successful conception (Gidey, 2001). The number of inseminations required to produce a live calf is one of the most important parameters of reproductive efficiency, which mainly depends on the breeding system used. NSC expresses the fertility level of the dairy herds. NSC is higher under uncontrolled natural breeding than hand-mating and NSC greater than two should be considered as poor (Mukassa-Mugrewa, 1989). Many factors contribute to the differences, including poor heat detection, skills of farmers and improper timingof AI service. But cows mated naturally conceive earlier because the bulls have a natural advantage of stimulating estrous activity and detecting heat in cows.

Although several studies were conducted to estimate NSC in Ethiopia, the results were variable due to different reasons. Nuraddis *et al*. (2011) reported mean NSC of 1.29 for crossbred dairy cows' in North Gondar town. NSC values of 1.56, 1.62 and 1.73 were reported by Belay *et al*. (2012), Gebeyehu *et al*. (2005) and Demeke *et al*. (2004) for crossbred dairy cows in Jimma, Andassa ranch and Holetta Research Center, Ethiopia, respectively. On the other hand, Emebet (2006) reported higher mean NSC of 2.2 for crossbred dairy cows in a commercial farm in the Dire Dawa area. Additionally, a number of services per conception of 1.6, 1.62 and 1.67 were reported by Belayneh (2012), Yoseph *et al.* (2003) and Yifat *et al.* (2009) for Holstein crossbred dairy cows in North Shewa Zone, central Highlands and in and around Zeway, Ethiopia, respectively.

As summarized by Gillah *et al*. (2012), crossbred dairy cows kept in urban and peri-urban areas of East Africa conceive on average after 1.6-2.6 services. These values are higher than the minimum value of 1.3 NSC recommended in the tropics (Rahman *et al*., 1998). According to Cassell (2001), heritability values of NSC are low and most of the variation is related to environmental factors like quality of semen, the skill of the inseminator, proper time of insemination and cows related factors. Management, nutrition and climate conditions may also affect the success of insemination or services (Manale *et al.*, 2011).

2.14.7. Calving interval (CI)

Calving interval refers to the period between two consecutive calvings and is a function of aday's open and gestation length. Since gestation length is more or less constant for a given breed, the number of days open becomes the sole variable of calving interval. It has low heritability and can be improved through nutrition and early breeding (Mulugeta *et al.*, 1990).

A study in Dire-Dawa by Emebet and Zeleke (2007) found a mean calving interval of 17.8 months for crossbred dairy cows. But 13.6 months calving interval was reported by Yifat *et al.* (2009) in Zway for the same breed. At Bishoftu and Akaki towns, the calving intervals of crossbred dairy cows were 13.0±2.1 and 13.8±1.9 months, respectively (Dessalegn *et al*., 2016). Calving interval was shorter in crossbred than indigenous cows under proper management practices. As reported by Yifat *et al*. (2012) crossbreds of unknown exotic blood level have 622.6 days calving interval in Tatesa Cattle Breeding Center, Gurage Zone near Wolkitie town, central Ethiopia. Other results reported by (Mulugeta and Belayneh, 2013) and (Belay *et al.*, 2012) in North Showa and Jimma Zones also indicated that crossbreds of unknown exotic inheritance have calving intervals of 660 and 640.8±3.84 days, respectively. Relatively longer calving interval might be indicative of poor nutritional status, poor breeding management, lack of own bull and artificial insemination service, longer days open, diseases and poor management practices (Belay *et al.*,2012).

2.15. Body Condition Score (BCS) in Dairy Cows

Body condition score (BCS) is a subjective measure of available tissue reserves and cant herefore be used to indicate the energy balance of the dairy cow (Loker *et al*., 2010). It has been reported that increased BCS is genetically and favourably linked with health and fertility traits (Berry *et al*., 2003; Bastin *et al*., 2010). It has therefore been suggested that the BCS is moderately heritable and may be selected for without a large negative impact on milk production (Loker *et al*., 2010). It is essential to note that BCS is not genetically correlated with a fat percentage (Loker *et al*., 2010). Generally, body condition score is a moderately heritable trait across lactation and parity.

Dairy cows have the physiological ability of providing nutritional substances from their body tissues by losing "body condition" for about 40 to 100 days (Gergovska *et al*., 2011). Body condition score can be used on both heifers and cows, although primarily they are used on the lactating dairy herd. BCS greater than 3.75 at calving can reduce dry matter intake by 1.5 to 2.0% for every 0.25 BCS increase over 3.75 (Varga and Ishler, 2007). A study in Tanzania by Msangi *et al*. (2005) concluded that BCS at calving may provide a simple single indicator of the nutritional status of a cow.

Loss of the BCS after calving has a significant effect on milk yield for 305 days lactation and the highest is the milk yield of cows with the greatest loss of the BCS after calving (Gergovska *et al*., 2011). Cows from Friesian and Brown Swiss with low BCS at calving from 2 to 2.5 points have the lowest milk yield for 305 days after calving. The milk yield and lactation period of cows with low BCS (≤2.5 points) is by about 1400 kg lower than that of cows with BCS ≥3.5 points (Gergovska *et al*., 2011). It has been recommended that a cow should enter the dry period with a BCS between 3.25 and 3.75 (Watters *et al*., 2010).

Diet constraint has a negative influence on luteinizing hormone (LH) release. Animals in anoestrus showed decrease in diameter of leading follicles, and in ovulation rate to

gonado-tropin releasing hormone (GnRH) treatment. The nutritional status of an animal is reflected by body condition score (Rasby *et al*., 1992). A study conducted by D'occhio *et al*. (1990) also mentioned the negative effect of low BCS on pregnancy rates and ovarian cyclicity in beef cows. Furthermore, investigation on post-partum reproduction indicated that the BCS is a practical pointer of rebreeding potential and energy status (DeRouen *et al.*, 1994).

2.16. Roles and Methods of Early Pregnancy Diagnosis

Reproductive failure is one of the major factors affecting output in dairy herds. It is generally accepted that fertilization rates after natural service or artificial insemination are close to 90%, while calving rates to a single insemination are close to 50% (Diskin and Sreenan, 1980). The early identification of non-pregnant cows has the potential to have a direct effect on the calving to conception interval (Stevenson *et al*., 2003). Furthermore, a high cost benefit has been associated with early pregnancy detection of dairy cows (Oltenacu *et al*., 1990).

It has been demonstrated that most embryonic loss occurs between days 8 and 16 post insemination and that the embryo survival rates up to 8 days was 93%; however, the survival declined markedly to 66% and 58% by days 16 and 42 post insemination, respectively, in beef heifers (Diskin and Sreenan, 1980). Sartori *et al*. (2006) reported a much lower conception rate (29.3%) on days 60 to 66 after AI and quite high rate of pregnancy loss (18.6%) between days 25 to 32 and 60 to 66 after AI was reported in lactating Holstein cows. As a result, accurate diagnosing and monitoring pregnancy status as early as possible after service and detection of non-pregnant cows before the first expected return to estrous 18 to 24 days after service could be ideal. By different authors ultrasonographic investigations have been made to evaluate the bovine foetus by monitoring foetal heart rate and foetal growth parameters (Bertolini *et al*., 2002; Breukelman *et al*., 2004, 2005).

The most popular methods currently employed for early pregnancy diagnosis in cattle are rectal palpation, ultrasonography, hormone or pregnancy-specific antigen analysis (mainly progesterone, pregnancy-specific antigens, and oestrone sulphate). However, all these pregnancy diagnostic techniques have their own advantages and disadvantages with regard to the time interval of diagnosis after service, diagnosis accuracy and efficiency, and effect on embryonic losses (Fikre, 2007).

Manual transrectal palpation of the reproductive tract approximately 35 days post service is commonly used to determine pregnancy status. Accurate pregnancy diagnosis could be achieved based on the recognition of a proper embryo with a beating heart, at between 26 and 34 days, by using ultrasonography in cattle. The sensitivity and specificity of the ultrasound examinations between days 21 and 25 were 44.8% and 82.3%, respectively, but between days 26 and 33 the results were 97.7% and 87.8%, respectively (Pieterse *et al*., 1990). Ultrasound characteristics of the uterus and corpus luteum (CL) have been assessed as possible markers for early pregnancy diagnosis. In isolation, these markers do not appear to perform well (Badtram *et al*., 1991; Herzog *et al*., 2011). In practice, pregnancy diagnosis involves examination of the entire reproductive tract. Even when an embryonic heartbeat is detected, it is recommended that the ovaries be assessed for the presence of a CL (López-Gatius and García-Ispierto, 2010).

Zoli *et al*. (1992) reported a 95% overall accuracy of the pregnancy associated glycoprotein (PAG) radioimmunoassay as of 35 days post service, with accuracies of 93% and 98% for detecting pregnant and non-pregnant cattle, respectively. Progesterone secretion is not specific to pregnancy, so the accuracy of testing for it is influenced by different factors like pathological conditions such as pyometra, segmental aplasia of the mullerian duct system, luteal cysts, embryonic or foetal death, and the presence of macerated or mummified foetus can result in the maintenance of an active corpus luteum (persistent corpus luteum) and elevated milk or plasma progesterone levels that are suggestive of pregnancy (Lobago *et al*., 2007). In the event of non-pregnancy, progesterone may be an accurate measure of pregnancy diagnosis, as low concentrations

would indicate a non-functional corpus luteum (CL). Studies assessing the use of milk progesterone as a pregnancy diagnosis have found that it can be applied for the detection of non-pregnant cows on day 19 (Oltenacu *et al*., 1990). In general, the diagnosis of pregnant cows is difficult due to variations in progesterone concentration during early pregnancy (Mann andLamming, 1999).

2.17. Fertility in Dairy Cows

When a female is in estrous she tends to be restless and seeking a mate. If she becomes pregnant, the next estrous is postponed so the embryo has time to develop. If a female in estrous does not become pregnant new follicles start to develop on the ovaries in preparation for a new estrous (Sjaastad *et al*., 2003). Length of the estrous cycle is 21 days in dairy cows. Corpus luteum, which is formed in the ovaries after ovulation is responsible for the production of progesterone. The secretion of progesterone starts when corpora lutea starts to develop the ovaries in the luteal phase of estrous. Sjaastad *et al*. (2003) also mentioned that if the cow becomes pregnant corpora lutea continues to secrete progesterone, but progesterone secretion drops when the corpora lutea undergoes involution if the cow does not get pregnant. Because of increased progesterone concentration the uterus undergoes changes that will increase acceptance and nourishing of the embryo. The authors further stated that if the cow becomes pregnant the most important effects of progesterone are to create favorable conditions in the uterus for the embryo development. Progesterone prevents new ovulation, it stimulates growth and development of the uterus and it also contributes to growth and preparation of the mammary gland for milk synthesis.

For many years, concerns about declining dairy cow fertility were raised world-wide (Lucy, 2001). Fertility traits have a reportedly low heritability and a loss in fertility is so far mainly managed by optimizing environmental conditions (Tsuruta *et al*., 2009). Alternatively, there are also reports questioning the genetic connection between high performance and a decline of fertility (LeBlanc, 2010; Pimentel *et al*., 2011). Maintaining

a satisfactory fertility in cows is essential for successful dairying. Dairy farming is expanding with crossbred high yielding cows in urban and peri-urban areas. To achieve maximum profitability, it is very essential to increase the pregnancy rate (Rice, 1980). Poor fertility decreases the profit margin because of loss in milk yield, cost of replacing culled cows and decreased calf sale per cow (Stoat *et al.*, 1999). Ideally, optimum, economic fertility could be achieved with a pregnancy rate of 80% after the first insemination, a maximum of 1.3 services per conception and an average interval of 85 days between parturition and conception (Morrow, 1980).

2.17.1. Conception rate to artificial insemination (AI)

The conception rate to AI is the percentage of females actually pregnant after breeding or the ratio of animals confirmed pregnant after service to the number of cows bred (Mekonnen *et al*., 2010). It is a reproductive index used to determine the efficiency of AI service and the reproductive performance of the herd. Cow fertility is generally evaluated by the conception rate, defined as the proportion of cows declared pregnant following artificial insemination. This indicator is inversely related with the number of artificial inseminations per conception (Bousquet *et al*., 2004).

Delayed ovulation and insemination provides some explanation for the observed low pregnancy rate; however, as loss of BCS becomes more extensive, the reduction in conception rate to AI becomes greater (Butler, 2003; Roche *et al*., 2009). Cows losing one unit or more BCS (5 point scale) during early lactation are at greatest risk of low fertility. As a guideline, conception rate decreases about 10% per 0.5 unit BCS loss (Butler, 2001; Santos *et al*., 2009). Conception rates are generally influenced by a variety of factors. Management and environmental factors account for 96% of the variation in conception rates (Saha *et al*., 2014). Herd differences in nutrition, metabolic disorders, reproductive health, heat detection, insemination practices and climate can result in significant differences in conception rates (Kathy, 2004). The remaining 4% of variation

in conception rates is due to genetic factors with 3% of the cow and 1% for the service bull (Kathy, 2004).

The conception rate to first service in Asella town of Holstein crossbred dairy cows reported by Hunduma (2012) was 65%and Azage *et al.* (2012) reported a 61.7% for estrous synchronized cows in Adigrat and Mekelle milk shed. But 58.6% and 54.2% of the same breed in urban and rural areas of Adami Tullu and North Gondar Zone were reported by Woldu *et al.* (2011) and Haileyesus (2006), respectively. Haile (2014) revealed 75.5% conception rate to first service for Holstein Friesian dairy cows at Alage Agricultural Technical vocational training College.

As reported by Alam and Sarder (2010) parity did not significantly affect pregnancy rate. However, Hasan (2008) found significant ($P<0.01$) effect of parity on pregnancy rate. Earlier study by Biochard and Manfredi (1994) also stated that the conception rate in 1^{st} parity cows was highest (54%) and the lowest in 7^{th} parity cows (38%). Cows having BCS of 3.1 to 4.0 (very good condition) showed a better pregnancy rate (Alam and Sarder, 2010).

2.17.2. Factors affecting fertility in dairy cows

The fertility of the cow is important parameter in dairy production. If the cow does not conceive, no subsequent lactation will follow and a potential replacement heifer will be lost (Lucy, 2001). Low fertility rates of cattle in the tropics compared to temperate regions are probably related to environmental differences, including inadequate nutrition, prevalence of diseases and parasites as well as the interaction between genotype and environment (Mukasa-Mugerwa, 1989).

As indicated in Perry *et al*. (2011), increased visual observation, in addition to the use of estrous-detection aids, could improve fertility by determining the most appropriate time for insemination. Pregnancy rates were also increased when animals were detected in

standing estrous within 24 hours of fixed-time insemination regardless of follicle size induced to ovulate (Perry *et al*., 2005). Cows that initiate standing estrous around the time of fixed-time insemination had elevated preovulatory concentrations of estradiol compared to cows that did not exhibit standingestrous (Perry and Busch, 2005). Efficient transportation of sperm through the female reproductive tract requires that the female be in estrous or under the influence of estrogen (Hawk, 1983). In a review by Santos *et al*. (2004) fertilization failure in lactating beef cows ranged from 0 to 25% and in lactating dairy cows from 12 to 45%. Estrogen may influence fertilization rates through both sperm transport and fertilization efficiency by altering the uterine environment around the time of fertilization.

The reciprocal embryo transfer of embryos to and from cows induced to ovulate either a large or small follicle with GnRH revealed some interesting results about the factors affecting fertility (Atkins *et al*., 2010). While, ovulatory follicle size and serum concentrations of estradiol were highly correlated ($r = 0.49$; $P<0.0001$), both concentrations of estradiol and follicle size had independent positive effects on fertilization success, but only follicle size at time of AI had a positive independent effect on the presence of alive embryo 7 days later. Additional traits that directly increased fertilization rate included increased post-partum interval, increased cow weight, and decreased age. Younger cows also produced embryos that were better developed on day 7 than older cows. Consequently fertilization failure is greater in older cows and cows that calved later in the calving season that had lighter body weights. In addition, recipient cows that were not cycling at the onset of synchronization were less likely to become pregnant after receiving an embryo (Atkins *et al*., 2010).

2.18. Post-partum Blood Metabolic Profile in Dairy Cows

In early lactation, milk production is often believed to be limited by supply of key nutrients to the mammary gland, whereas in late lactation, mammary synthetic capacity is believed to be the main limiting factor for milk production (Wilde and Knight, 1989). It could therefore be assumed that the mammary gland would become less sensitive to

changes in nutrient supply as lactation advances. Therefore, it can be predicted that there might be a relationship between changes in the blood profile of nutrients and the milk yield, since the metabolic activity regulates the milk synthesis (Nielsen and Jakobsen, 1994), and since changes in milk yield, feed intake and energy balance of the dairy cow during lactation has been shown to be associated with characteristic changes in concentrations of plasma metabolites (Reist *et al*., 2003). If such a relationship is noticeable, the profile of different plasma metabolites potentially could provide information about the metabolic status of the cow and be used for determination of the pattern of nutrients extracted by the mammary gland.

Blood metabolites verified the energy status of dairy animals. It has been influenced by several factors, like animals dietary status, nutrients requirements and feed intake which have fluctuated mainly with parturition and advance lactation period. Glucose is a main energy source for animal tissues and is necessary metabolite for growth of tissues, preservation and used as a biochemical pathway in the animal bodies. Lactose of milk is produced from bloodglucose and it is a significant factor in organizing milk yield in dairy animals' inmammary cells (Fernandez *et al.*, 2007). Higher plasma insulin and glucose concentrations were recommended when positive indications to the reproductive axis (Gong, 2002).

Rations high in protein are positively associated with the degradation of protein in the rumen (increased NH3 concentrations) (Broderick, 2003; Hristov *et al*., 2004), increased blood urea N levels and inducing higher urinary N losses (Castillo *et al*., 2001). Ruminal N loss is the greatest single contributor to urinary N losses, but the metabolic losses, indigestible microbial N, losses in maintenance and inefficient conversion of absorbed amino acid into milk protein may cover up to 72% of the urinary N losses in the dairy cow (Hristov *et al*., 2004). By the continuous allocation of feed protein and energy it is possible to increase the synthesis of microbial protein and to reduce the NH3 concentration in the rumen, and by this improves the N efficiency in the rumen (Tamminga, 1996).

Due to enrichment of age animal tissue consumption of energy declines with low maintenance requirements and little milk production, the metabolic activities get slower and the serum concentration of triglycerides turns out to be an increase in blood (Fernandez *et al.*,2007). Liver accumulation of triglycerides delays the increases in LH and FSH necessary for stimulation of ovarian follicles, estradiol production, and ovulation (Butler *et al*., 2006). Burle *et al.* (1995) declared the lowest serum concentration of cholesterol in anoestrus than in cycling cows. Increased level of cholesterol in post-partum stimulates expansion of uterine involution (Quintela *et al*., 2003). Low blood insulin concentrations are responsible for low IGF-I production from the liver (Butler *et al*., 2003) which together reduce responsiveness of ovarian follicles to gonadotropins. Physiologically the metabolic and gonadotropin signals controlling early follicle development are interrelated: FSH stimulates granulosa cells in follicles to develop receptors for insulin, growth hormone and IGF-I; insulin and IGF-I then provide the hormonal stimulus for full development of preovulatory ovarian follicles (Kawashima *et al*., 2007; Shimizu *et al*., 2008; Sudo *et al*., 2007). The dietary effects on ovarian function were generally described through the short period influence of vigorous status on the ovary and indirect action during the system of endocrine (Scaramuzzi *et al*., 2006). Dietary supplementation for seven days from theluteal phase to the follicular phase encourages the pulsation rate of luteinizing hormone discharge and wave like discharge of follicle stimulating hormone (FSH) accompanied with raises in the plasma concentration of glucose and insulin in cyclicgoats (Haruna *et al*., 2009).

2.19. Reproductive Disorders of Dairy Cattle

Upon closer examination of reproductive processes in the dairy cattle, the post-partum period is the most varied and susceptible to problems (Radostits *etal*., 1994) which results in substantial economic loss to the dairy industry (Lobago *et al*., 2006). It is very difficult to diagnose those problems by one particular disorder or symptom, because there is interrelation between predisposing factors such as management at calving, hygiene, parity, stageof gestation, nutrition and environment (Msangi *et al*., 2005). In dairy cows

the breeding efficiency is decreased by a number of reproductive disorders such as anoestrus, repeat breeding and endometritis, which highly affects the reproductive and productive performances of cattle and cause huge financial losses to dairy farmers. Generally, the primary reasons of the reproductive difficulties in a herd are many and consist of nutritional, pathological and managemental factors (Qureshi, 2007).

In Meghalaya province, North-Eastern India, the reproductive disorders reported by Khan *et al*. (2016) were anoestrus (31.79%), repeat breeding (24.61%), retention of fetal membrane (14.35%), abortions (11.25%), dystocia (5.12%), prolapse (1.53%), endometritis (4.61%) and pyometra (6.66 %) irrespective of breed, age and parity of the cow.

In Ethiopia, regardless of the huge number of cattle, productivity is low due to constraints like disease, nutrition and poor management. These constraints result in poor reproductive performance of dairy cattle and lower economic benefit of the sector (Molalegn and Prased, 2011). Among the main problems that have direct impact on reproductive performance of dairy cows, abortion, dystocia, retained fetal membrane; repeat breeding and clinical endometritis are those mostly occurred which also have been classified as post-partum and pre-partum problems (Forar *et al.*,1996). The variation in management systems and environmental conditions under which cattle are maintained could greatly affect the occurrence of reproductive health problems which result in poor reproductive performance (Takele *et al*., 2005).

Repeat breeders are those cows that require three or more services to conceive (Enkhia *et al*, 1983). Post-partum anoestrus, defined as the lack of estrous until 60 days post-partum, is the major factor causing elongation of this interval and, in consequence, substantial economic losses (Schopper *et al*., 1993; Senger, 1994; Opsomer and de Kruif, 1999; Mwaanga and Janowski, 2000). Incidences of post-partum anoestrus may vary between herds from 10 to 40% (Fischer *et al*, 1998). Fischer *et al.* (1998) found a higher incidence of post-partum anoestrus of 49%. A study by Alemselam *et al*. (2015) in Mekelle city,

Ethiopia also stated that anoestrus was the most prevalent reproductive problem in crossbred dairy cattle followed by repeat-breeding. The authors further indicated the prevalence rates of reproductive problems in the area anoestrus (37.8%), repeat-breeding (21.0%), dystocia (11.6%), retained fetal membranes (11.5%), endometritis (6.6%), abortion (6.4%), prolapsed uterus/vagina (2.9%), stillbirth (2.0%) and freemartin (0.2%). Therefore, it was concluded that improvements in management systems (such as housing, feeding and health care), heat detection and proper selection of bulls for breeding taking into account the size of cows could help in minimizing reproductive health problems and hence, improve the reproductive efficiency of smallholder dairy cows (Gizaw *et al*., 2007).

The key for an optimal fertility in dairy herds is a healthy uterine environment. A healthy uterus is the basis for high submission and conception rates. The post-partum period is defined as the period after calving and lasts until the reproductive function is restored again so that another pregnancy can occur. There are four major events during this period, which, include: myometrial contractions and expulsion of secundus, endometrial repair, resumed ovarian function and elimination of bacterial contamination in the reproductive tract (Senger, 2012). Secundus begins three days post-partum and reaches its peak during the second week and all the fluid is normally expelled by 18 days post-partum (Olson *et al.*, 1986). Viscous consistency of normal secundus changes to foul smelling watery and reddish brown exudates because atonic uterus is not able to expel its content during puerperal metritis (Smith and Risco, 2002) and increases the risk of bacterial complications (Sheldon and Dobson, 2004). Uterine involution consists of the reduction in uterine size, clearing bacterial contamination, sloughing of the caruncles and regeneration of the endometrium (Sheldon *et al.*, 2008) and is completed by 28 days post-partum (Saut *et al.*, 2011). Resumption of cyclicity also occurs during this interval, with the first ovulation occurring around 40 to 45 days post-partum (Cengic *et al.*, 2012). This interval can be affected by nutrition, body condition, parity and can be extended due to uterine diseases (Sheldon *et al.*, 2002).

Bacterial contamination of the uterine lumen after parturition often hinders the uterine function (Sheldon and Dobson, 2004). Bacteria can be cultured from samples collected from the uterine lumen of dairy cattle in the first 2 weeks after parturition without the appearance of anyapparent clinical signs (Sheldon *et al.*, 2002). Polat *et al*.(2009) reported that 10-17% of cows have pathogenic bacteria two weeks post-calving while Sheldon (2007) found that intensively managed dairy cattle often have bacterial uterine contamination rates of 90 to 100% within the first two weeks post-partum. Prevalence of clinical and sub-clinical endometrits after parturition ranges between 5 to >30% and 11 to >70%, respectively (Galvao *et al.,* 2009).

In post-partum cows, endometritis continues to be a major cause of poor fertility and delayed conceptions (Couto *et al.*, 2013). Subclinical endo-metritis (SCE) is characterized by an increased proportion of polymorphonuclear (PMN) cells in uterine fluid at 35-49 DIM (days in milk). SCE is prevalent in high producing dairy cows and has been associated with delayed resumption of ovarian cyclicity (Senosy *et al*., 2009) and extended intervals to pregnancy (Gilbert *et al*., 2005; Galvao *et al*., 2009; Sheldon *et al*., 2009). Cystic ovaries contain one or more persistent fluid-filled cavities larger than a ripe follicle. This is sometimes referred to as cystic ovarian disease (Chauhan *et al.*, 1984). Estimates of the incidence of cystic ovaries in zebu cattle range from 1 to 13% (Hussain and Muniraju, 1984). According to Lopez-Diaz and Bosu (1992), ovarian cysts occur in 15% of dairy cows during the early post-partum period.

3. MATERIALS AND METHODS

In the current study, survey and feeding trial were undertaken. Consequently, the materials and methods followed during the study periods are presented below.

3.1. Survey Part

3.1.1. Description of study areas

Assessment of dairy production systems and feed resources identification was conducted in urban and peri-urban areas of Assela, Bishoftu, Holetta, and Sululta towns (Figure 1) which were considered to be the major dairy production belt areas of the central highlands of Ethiopia.

Assela town is the capital of Arsi zone. It is located at about 175 km Southeast of Addis Ababa at 7° 57' 0" N latitude and 39°7' 0" E longitude and with an altitude of 2430 meters above sea level. It is characterized by mild sub-tropical weather with the maximum and minimum temperature 18 and 5^0C, respectively. Agricultural production system in the study area is of mixed crop and livestock production. Dairy farming using improved breeds is a common practice in urban and peri-urban areas (KARC, 2008).

Bishoftu is located at 45 km along the Southeast of Addis Ababa, the capital of Ethiopia at 9°N latitude and 40°E longitude and at 1850 meters above sea level. The annual rainfall is 866 mm, of which 84% are in the long rainy season from June to September. The annual average temperature ranges from 12.3^0C to 27.7^0C with an overall average of 18.7^0C (NMSA 2010, unpublished data).

Holetta is among the places that are known to be potentially high for dairy production, located between 38.5°E longitude and 9.8°N latitude and an elevation of 2400 meters above sea level. It is situated in the central highlands of Ethiopia. The average annual rainfall and temperature is about 1200 mm and 18^0C and the average monthly relative

humidity is 60%. The seasons are classified into dry, short rainy, and long rainy, which last from October to February, March to May and June to September, respectively (Million *et al*., 2010).

Sululta district is one of the six districts of Oromia Special Zone surrounding Finfinne town of Oromia National Regional State. The districts' capital town, Chancho, is 40 kms away from Addis Ababa towards the North-west. It lies on the geographical coordinates of 9° 11' 0" N latitude, 38° 45' 0" E longitude. The area is characterized by shallow valleys with an elevation of 2500 metersabove sea level, almost completely surrounded by mountains with numerous small rivers which drain into the Muger River. The average annual temperature in Sululta is 14.7^{0}C with an average rainfall of 1119 mm (SDAO, 2012).

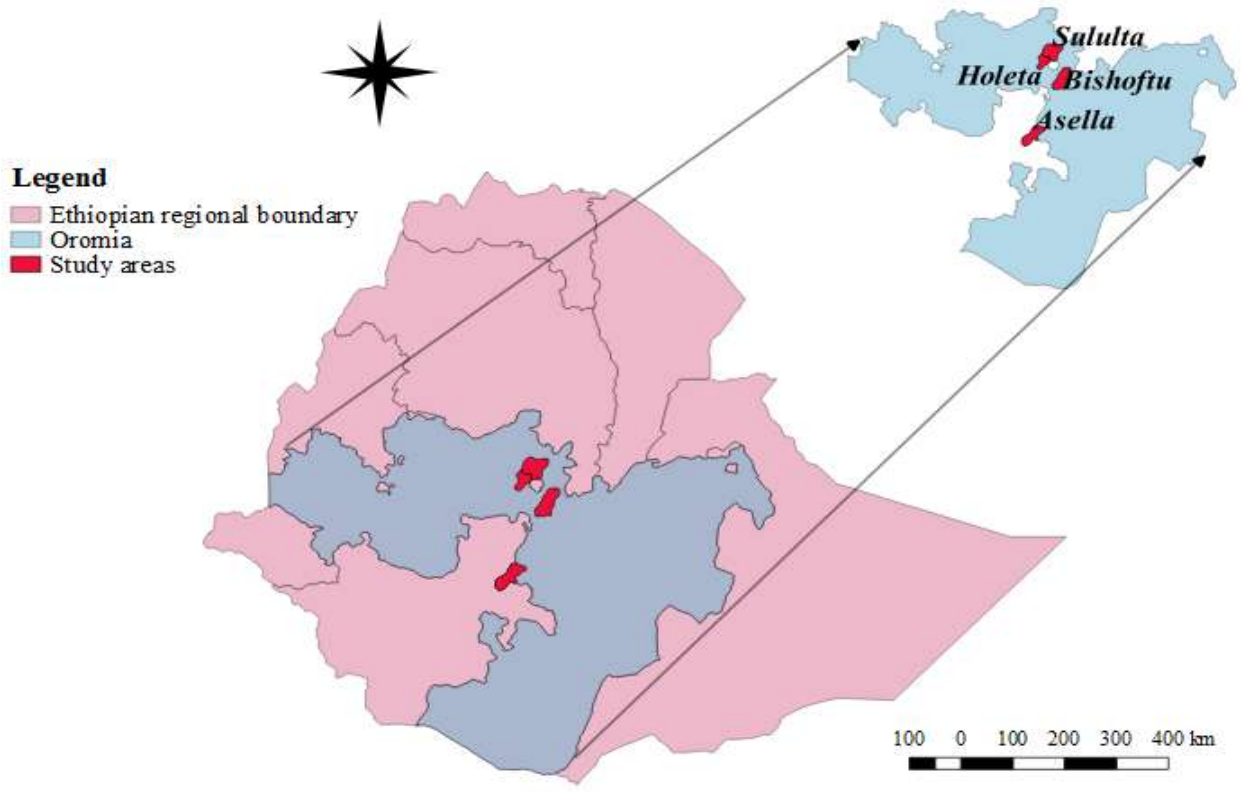

Figure 1. The geographical location of the study areas

3.1.2. Study design, sample size and sampling methodology

A cross-sectional study involving purposive selection of study areas, but a random selection of dairy farms and farm owners from the urban (town) and peri-urban (around the towns) were conducted. The study areas were purposively selected as they have high potential for dairy production. The sampling frame of Kebles and dairy farms were obtained from respective district livestock and agriculture development offices. Depending on the frame lists and information obtained, two Kebles (administrative divisions) from each production system (urban- and peri-urban) of each district were purposively selected based on the availability of crossbred dairy cattle and dairy production experiences. Ten dairy farms were then randomly selected from each Keble with a total of 40 dairy farms from each study area for the survey interviews. Before the formal survey, a pre-test survey was conducted to collect general background information about the study areas. The information that was collected in the pre-test survey helps to guide the development of the formal survey questionnaire.

The sample size was determined according the formula given by Arsham (2007) for survey studies: $N = 0.25/SE^2$ Where, N = sample size; SE = Standard error of dairy farms. Accordingly, by assuming standard error of 3.95% as follows, $N=0.25/(0.0395)^2$ = 160; a total of 160 dairy farms were selected by random sampling method from all study sites.

3.1.3. Questionnaire

A comprehensive open-ended and close-ended semi-structured questionnaire was prepared and used to collect farm information. The information that was gathered during the actual interview was supported by farm observations including records and discussions. Information on socioeconomic characteristics of urban and peri-urban dairy production systems such as household characteristics, occupation, land holding, purpose of keeping dairy cattle and livestock species and herd size; type of dairy management

practices, milk yield, dairy cattle reproductive performances, constraints and opportunities of dairy production, types of available feed resources, dairy feeding and watering systems were the main issues addressed in the survey questionnaire. Additionally, the questionnaire was also designed to obtain information on experience in dairy production, the source of crossbred cows and ways of differentiating dairy cattle. Milk yield was the only assessed productive parameter because describing lactation length, lactation milk yield and lactation length using survey data could lead to a biased information due to lack of full records. For the milk yield and reproductive performances evaluation in addition to interviewing dairy farmers, observing some recorded back history of dairy cattle, sample morning and afternoon milk yield measurements, one focus group discussion from each Kebele having elders, dairy laborer/s and dairy or livestock production experts were employed.

3.2. Feeding Experiment

The feeding trial part was conducted at the dairy farm of Addis Ababa University, College of Veterinary Medicine and Agriculture (CVMA) located in Bishoftu town which is described under 3.1.1.

3.2.1. Experimental design and feeding

Twelve late pregnant (about 3 weeks prior to calving), dry crossbred dairy cows with about 75% of Holstein Friesian blood and 25% of local zebu (Boran) and with 514.6 kg average initial body weight were selected from the dairy herd on the basis of parity (zero to third parity). The cows were then blocked by parity into four blocks of 3 cows each and then one cow from each of the four parities were randomly assigned to one of the three treatments making 4 cows per treatment in a Randomized Complete Block Design (RCBD). The three treatment combinations used in the experiment are given in Table 1.

In all groups, feeding started about 21 days before calving and continued up to 90 days in milk (DIM) post-partum. The cows in T_1 (control) fed *ad libitum* grass hay and agro-industrial by-products, according to the CVMA dairy farm ration formulation and supplementing systems. The cows in T_2 fed with *ad libitum* grass hay and agro-industrial by-products rich in energy and protein contents plus ruminant premix. The cows in T_3 fed with *ad libitum* grass hay and agro-industrial by-products rich in energy and protein contents plus ruminant premix plus super dairy concentrate (complete dairy feed having energy, protein, minerals and vitamins) mixed from different ingredients which was not specified because of commercial use. Generally, cows in T_2 and T_3 fed on formulated rations mainly for CP and ME according the dairy cattle (cows) requirements and stage of production. The individual feed ingredients were purchased from local markets, ruminant premix was purchased from Gasco Trading PLC found in Addis Ababa and super dairy concentrate was purchased from Alema Koudijs Feed PLC found in Bishoftu town.

The energy and protein requirements for dairy cows with about 75% Holstein blood level were calculated based on feeding standards for farm animals and nutrition values of animal feeds (CVB, 2012). Accordingly, for 550 kg body weight dry mature cow 90 MJ ME/day and 1680 g CP per day with 14% average protein content ration and 107 MJ ME/day and 2250 g CP per day with 15% average CP content ration for a lactating cow with 500 kg body weight (10 liter milk production per day). Furthermore, for additional milk production 5.3 MJ energy per liter was considered. The normal daily intake of roughage varies between 8 to 10 kg for a cow of 400 kg and 10 to 12 kg for a cow of 500 kg (Hans *et al*., 2008). In the current feeding trial, 8 to 13 kg hay/day/cow was offered during late pregnancy and early post-partum periods depending on the daily refusals with *ad libitum* feeding. The concentrate supplementation during the late pregnancy was 3 kg/day/cow for cows in T_2 and T_3. But for cows in T_1 (control) the amount of daily concentrate offered was according the CVMA farm feeding practices which was 6 kg/day/cow and was similar during the late pregnancy and post-partum periods. After calving the ration for (T_2 and T_3) was changed to milking ration and the concentrate supplementation was increased graduallyby 0.5 kg per day for two weeks (maximum 10

kg)to allow rumen bacteria to adjust to changes in the ration and cows pushed too fast will go off-feed. Then after two months it depended on cow's milk production (*i.e.* for 1 liter additional milk production 0.5 kg concentrate supplementation).

Table 1. Pre-partum and early post-partum ingredients proportion of experimental diets

	Treatments		
Pre-partum period-feed ingredients (%)	T_1 (Control)	T_2 (Concentrate)	T_3 (Concentrate mixture)
Hay	*Ad libitum*	*Ad libitum*	*Ad libitum*
NSc (Noug seed cake)	33.0	66.0	49.0
Wheat middling	33.0	33.0	25.0
Wheat bran	33.0	-	-
Super dairyconcentrate (19% CP/kg)	-	-	25.0
Ruminant premix/minerals	-	0.5	0.5
Salt	1.0	0.5	0.5
Total	100.0	100.0	100.0
	Treatments		
Early post-partum period-feed ingredients (%)	T_1 (Control)	T_2 (Concentrate)	T_3 (Concentrate mixture)
Hay	*Ad libitum*	*Ad libitum*	*Ad libitum*
NSc (Noug seed cake)	33.0	33.0	25.0
Wheat middling	33.0	66.0	37.0
Wheat bran	33.0	-	-
Super dairy concentrate (19% CP/kg)	-	-	37.0
Ruminant premix/minerals	-	0.5	0.5
Salt	1.0	0.5	0.5
Total	100.0	100.0	100.0

3.2.2. Feed chemical analysis

Before the start of the actual experiment, representative samples from each feed ingredient were taken for chemical composition analysis. Furthermore, feed samples from formulated treatment rations from each treatment group were collected weekly, bulked, sub-sampled into polythene bags followed by laboratory procedures for chemical

composition analysis. Feed samples were analyzed for proximate components in the National Veterinary Institute (NVI) nutrition laboratory. Dry matter (DM) and ash contents were determined by oven drying at 105^0C overnight and by igniting in a muffle furnace at 600^0C for 6 hours, respectively, using the standard procedures of AOAC (1995). Nitrogen (N) content was determined by Kjeldahl method and crude protein (CP) was then calculated as N*6.25 (AOAC, 2005). The organic matter (OM) content was calculated by subtracting the ash content from 100 as %OM = 100% DM – %ash content. Acid Detergent Fiber (ADF) and Neutral Detergent Fiber (NDF) were analyzed following the procedures of Van Soest *et al*. (1991) at the Holetta Agricultural Research Center. Calcium (Ca) content of the feeds was analyzed using atomic absorption spectrophotometer following the procedures of Perkins (1982) and phosphorus (P) content was determined using an auto analyzer according to AOAC (1995). In *vitro* organic matter digestibility (IVOMD, g/kg) was determined according to Tilley and Terry (1963). Metabolizable energy (ME) was then estimated from the IVOMD according to McDonald *et al*. (2002) as; ME (MJ/kg of DM) = 0.016 x (g/kg of IVOMD).

3.2.3. Animal management

Cows were individually penned at maternity barn and fed with native grass hay and experimental diets until the end of the trial. The feed was offered twice perday at 8:00 AM in the morning and 4:00 PM in the afternoon during late pregnancy period. Clean and fresh drinking water was offered four times daily in the morning (6 AM), afternoon (1:30 PM), late afternoon (4:30 to 5 PM) and evening (7 PM) to all experimental animals. During the post-partum phase, concentrate was offered three times a day in the morning (6 AM), afternoon (4 PM) and evening (7 to 8 PM) in the milking parlour and cows were hand milked twice a day at early morning (6 to 7 AM) and late afternoon (4 to 5 PM) starting from the 5^{th} day post-calving and daily milk yield was recorded accordingly. Any sign of estrous manifestation was visually observed and recorded three times daily at early morning, afternoon and late afternoon. Cows in heat were mated with a breeding bull after 7 to 8 hours of observed estrous.

3.2.4. Data collection

3.2.4.1. Feed and nutrient intake

The feed refusals were collected in the next morning and weighed after removing external contaminants. The amount of daily feed consumed wasdetermined as the difference between the daily feedoffered and refused on dry matter (DM) basis. The daily protein intake in gram was calculated as the daily DM intake multiplying by the protein content of the ration. Daily ME intake of hay and concentrate feeds was first determined by multiplying daily DM intake from each feed by their respective energy values. Then, total daily energy intake in MJ/kg DM was estimated as the sum energy intake from hay and concentrate feeds.

3.2.4.2. Milk yield

Milk produced by each cow at each milking was weighed separately and recorded in individual record book/card and the total daily milk yield of each cow was determined by summing up the two milkings. Similarly, the average daily milk yield of the individual lactating cow during the experimental period was determined by dividing the total milk yield of each experimental cow by the number of milking days.

3.2.4.3. Milk composition analysis

Lactation stage is one of the major factors influencing yield and composition of milk in dairy cattle (Ibeawuchi and Dangut, 1996). The milk samples were collected in mid-early lactation of the experiment on day 56 after calving for physicochemical quality analysis. Composite of 100 ml raw milk samples from the morning and afternoon milking were made from each cow into sterile bottles, kept in an ice box and transported to Ethiopian Meat and Dairy Industry Development Institute (EMDIDI) laboratoryfor analysis.

Physical examination of milk samples: The temperature of the milk samples was determined immediately after milking at each collection time using a thermometer. The pH of the milk samples was determined in the laboratory using a digital pH-meter based on the procedure described by O'Connor (1995). Specific gravity (density) of milk was calculated according (O'Connor, 1995) as Specific gravity = (L/1000) +1 Where, L = corrected lactometer reading at a given temperature. Titratable acidity (TA) of the milk samples was determined according to the method of the AOAC (1990) following the formula;

$$TA\% = \frac{N/10\ NaOH\ (ml) \times 0.009}{\text{Weight of milk sample}} \times 100$$

Chemical composition of milk samples: Milk total solids (TS) were calculated according to Richardson (1985) by the formula;

$$TS = \frac{(Cwt + \text{Oven dry sample weight}) - Cwt}{\text{Sample weight}} \times 100$$

Where, Cwt = crucible weight

The total protein content of the milk samples was determined by Kjeldahl method (AOAC, 1990). The Gerber method was used to determine the milk fat content and fat percentage was read from the butyrometer scale (O'Connor, 1995). Total ash content was determined according to the procedures of Richardson (1985) by igniting the dried milk samples used for determination of total solid content in a muffle furnace in which the temperature was slowly raised to 550^0C. The sample was ignited until carbon disappears and a white ash remains. Total ash was then calculated as;

$$Ash = \frac{\text{Residue weight}}{\text{Sample weight}} \times 100$$

Solids-not-fat (SNF%) content of milk samples was determined by subtracting percent milk fat content from milk total solids (TS) percent (O'Mahony, 1988). The lactose percentage was determined by subtracting the milk fat, protein and total ash percentages from the percentage of the milk total solids (O'Mahony, 1988).

3.2.4.4. Reproductive performance indicators

Body condition score (BCS), calving to first heat interval (CFHI), calving to first service interval (CFSI), number of services per conception (NSC), calving to conception interval (CCI) and calving interval (CI) were measured as indicators for reproductive performances of crossbred dairy cows. Body condition score of cows was measured at the start of the experiment (21 days pre-partum), 5 to 12 days after calving, 60 days after calving and at service time. The body condition score of cows was recorded by visual observation and manual assessment to score the dairy cows on a 1 to 5 scale (where 1 = emaciated, 5 = fat) following the procedures of (Edmonson *et al*., 1989). The calving to first heat interval was determined by calculating the number of days from calving to first heat sign observed. The calving to first service interval was determined as the number of days from the time a cow calved until her first service. The number of services per conception (NSC) was the number of services required for a successful conception. The calving to conception interval was determined as the interval between calving and the next successful conception. The average gestation length (GL) in dairy cattle is 280 days (Silva *et al*., 1992). The calving interval was then estimated from CCI and the gestation length (*i.e.*CCI = CI-280 and CI = CCI + 280).

3.2.4.5. Evaluation of early post-partum body weight and blood plasma metabolites

The body weight of cows after calving was determined from the heart girth measurement with a tape. About 10 ml blood was collected from the jugular vein from each post-partum cowin vacutainer tube containing EDTA at calving (day 0), day 7 after calving and day 14 after calving in the morning before feeding. The plasma was separated by centrifugation (10,000 × g for 5 minutes) and kept at -20^{0}C until biochemical analysis. Plasma concentrations of glucose, albumin, aspartate aminotransferase (AST), total cholesterol, total protein, urea and triglycerides were assayed by spectrophotometric method using automatic Cobas 6000 automated sphectrophotomter (Cobas c 501) and plasma insulin and progesterone concentrations were analyzed using Cobas e 411 (Roche

Diagnostics GmbH), immunoassay analyser which is a fully automatic run-oriented analyzer system for the determination of immunological tests using the ElectroChemiLuminescence immunoassay (ECLIA) process at Ethiopian Public Health Institute (EPHI) clinical chemistry laboratory. Globulin values were obtained from the difference between total protein and albumin concentration (*i.e*. Globulin = Total Protein – Albumin).

3.2.4.6. Evaluation of post-partum fertility

The effect of late gestation concentrates supplementation on early post-partum fertility was evaluated. Pregnancy was diagnosed by a combination of monitoring the cow for return to estrous in approximately 21 days after service, transrectal ultrasonography, plasma progesterone and rectal palpation. Transrectal ultrasonography was conducted by experienced veterinarians on the 30^{th} day after service using a portable ultrasound equipped with a trans-rectal linear-array transducer with 5-7.5-MHz (Mindray, china). The plasma progesterone test was conducted on day 21 and day 35 after service using ElectroChemiLuminescence immunoassay (ECLIA) method (Cobas Roche e 411 automated Immunoassay Chemistry Analyzer). Confirmation of pregnancy was conducted by rectal palpation on day 60^{th} by trained veterinarian. Pregnancy by transrectal ultrasonography was determined as positive based on the detection of allantoic fluid or a viable embryo (heart beat). The ovaries were also examined for the presence of the corpus luteum (CL).

3.3. Statistical Analysis

The collected survey data were analyzed using Statistical Packages for the Social Sciences (SPSS, 2011) version 20. Descriptive statistics cross-tabulation such as percentage, mean andstandard deviation were used to present the results.

The experimental data were analyzed using General Linear Model (GLM) and Chi-square test procedures of Statistical Packages for Social Sciences (SPSS, 2011) version 20. Mean comparison was done using the Least Significant Difference (LSD) for parameters with significant differences. Preliminary analysis showed that interaction effects of the fixed factors were not significant and thus not included in the model. Therefore, the statistical model used inthe data analysis was: $Y_{ijk} = \mu + T_i + P_j + e_{ijk}$

Where;

Y_{ijk} = the response variable such as feed intake, milk yield, milk composition, blood plasma composition and reproductive parameters

μ = the overall mean

T_i = effect of i^{th} treatment/diet (T_i = 1, 2, 3)

P_j = effect of the j^{th} parity (P_j = 0, 1, 2, 3 for late gestation period and 1, 2, 3, 4 for post-partum period)

e_{ijk} = random error

4. RESULTS

4.1. Survey Part

4.1.1. Socio-economic characteristics of urban and peri-urban dairy production

4.1.1.1. Household characteristics

In urban Sululta 25% of the respondents were not educated at all. In urban areas of Bishoftu 40% of the questioned household heads responded to holds diploma and above. Likewise, in urban Bishoftu and Holetta 40% responded to have secondary school education and 55% to have primary school in peri-urban areas of Assela and Sululta. Details were indicated in Table 2.

In peri-urban areas of Assela 95% of the household heads were male. In Holetta and Sululta peri-urban areas there were no female household heads involved in dairy production. But in peri-urban Bishoftu 40% of the household heads involved in dairy production were female.

Sixty five percent of the respondents in urban Holetta were in 50-59 years age group, followed by 45% respondents in peri-urban Assela and Holetta under the age group of 40-49 years. Results indicated that the age group of a majority of the dairy producers in the study areas was between 40-59 followed by 30-39 and 60-69 years old (Table 2).

Family sizes in peri-urban Assela, urban and peri-urban Bishoftu and urban Sululta were almost similar. Furthermore, the family size in urban Assela and peri-urban Holetta was also similar. Urban Holetta and peri-urban Sululta have relatively higher family size than the other study areas (Table 2).

Table 2. Educational level (%), gender of the HH head (%), age (%) and family size (Mean ± SD) of the respondents

Variables		Study areas							
		Assela		Bishoftu		Holetta		Sululta	
		U n=20	PU n=20	U n=20	PU n=20	U n=20	PU n=20	U n=20	PU n=20
Educational level of the respondents	Illiterate	15	15	15	15	0.0	0.0	25	10
	Read and write	20	0.0	0.0	5	20	5	10	25
	Primary school	20	55	5	30	15	45	40	55
	Secondary school	25	20	40	20	40	30	20	10
	Diploma and above	20	10	40	30	25	20	5	0.0
	Overall	100	100	100	100	100	100	100	100
Gender of the HH head	Male	75	95	80	60	85	100	90	100
	Female	25	5	20	40	15	0.0	10	0.0
	Overall	100	100	100	100	100	100	100	100
Age of the respondents (yrs)	20-29	0.0	5	0.0	15	5	10	5	20
	30-39	10	30	15	10	0.0	5	40	5
	40-49	25	45	15	35	15	45	25	30
	50-59	30	5	35	25	65	30	25	20
	60-69	25	10	25	10	10	5	5	20
	Above 70	10	5	10	5	5	5	0.0	5
	Overall	100	100	100	100	100	100	100	100
Family members	Mean±SD	5.1±1.6	6.1±2.2	6.0±2.2	6.0±2.2	7.2±2.2	5.4±1.7	6.0±2.2	6.9±2.9

n, number of respondents; U, Urban; PU, Peri-urban; HH, household

4.1.1.2. Occupational status and land holding

Sixty five percent fromurban Sululta and 75% in peri-urban Sululta of the interviewed dairy farm owners stated that dairy production was their main occupation. Additionally, in urban Bishoftu (60%), peri-urban Holetta (55%), peri-urban Assela (50%) and peri-urban Bishoftu (45%) of the interviewed respondents' occupational status was dairy production. But in urban Holetta, 40% of the interviewed dairy farm owners were government employees (Table 3).

As indicated in Table 3, in peri-urban Assela and Sululta, land holdings in hectares were higher than the other dairy production areas. Dairy producers in peri-urban Bishoftu have the smallest land holdings. Generally, in the current study peri-urban areas have relatively higher land holdings than urban areas.

Table 3. Occupational status (%) and land holdings (Mean ±SD) of the respondents'

Variables		Study areas							
		Assela		Bishoftu		Holetta		Sululta	
		U n=20	PU n=20	U n=20	PU n=20	U n=20	PU n=20	U n=20	PU n=20
Primary occupational status	Dairy owner	35	50	60	45	20	55	65	75
	Business man	25	20	10	25	20	20	30	20
	Non government employee	5	5	10	20	0.0	0.0	0.0	0.0
	Retired personnel	10	5	10	0.0	20	5	0.0	0.0
	Governmen t employee	20	15	10	10	40	20	5	0.0
	Daily laborer	5	5	0.0	0.0	0.0	0.0	0.0	5
	Overall	100	100	100	100	100	100	100	100
Landholding (ha)	Mean ±SD	0.64±1.2	1.9±2.0	0.03±0.1	0.19±0.4	0.16±0.5	0.9±1.6	0.19±0.7	1.7±2.0

n, number of respondents; U, Urban; PU, Peri-urban; ha, hectare

4.1.1.3. Livestock species and herd size

The average numbers of livestock owned are presented in Table 4. In peri-urban Bishoftu, the total number of local cattle per farm was higher followed by peri-urban Sululta and Assela, respectively. Local cows were mainly kept on peri-urban dairy farms, while in the other locations and production system mainly crossbred cows were kept. In peri-urban Holetta the total number of crossbred cattle per farm was higher than other peri-urban production systems. The urban areas of Bishoftu town were most dense in crossbred cows. The average number of local oxen in peri-urban Assela (1.85±1.8) and

Sululta (1.2±1.5) were higher than the other areas. The highest number of replacement heifers was in urban Bishoftu followed by urban Holetta with the smallest number in Assela area. The average number of male calves was lower than female calves due to early culling of male calves. In some of the study areas, small numbers of bulls were used for natural mating (Table 4).

Table 4. Livestock species and herd size (Mean±SD) in the study areas

Variables	Study areas							
	Assela		Bishoftu		Holetta		Sululta	
	U n=20	PU n=20	U n=20	PU n=20	U n=20	PU n=20	U n=20	PU n=20
	Mean±SD	Mean±SD	Mean±SD	Mean±SD	Mean±SD	Mean±SD	Mean±SD	Mean±SD
Milking cows[a]	0.0±0.0	0.1±0.2	0.0±0.0	0.35±1.1	0.0±0.0	0.0±0.0	0.0±0.0	0.15±0.7
Milking cows[b]	1.3±0.7	1.35±0.8	5.2±3.7	2.0±1.5	2.7±2.3	4.0±1.8	3.7±2.7	2.95±1.6
Pregnant cows[b]	0.45±0.7	0.3±0.7	2.1±2.2	0.75±1.1	1.2±0.9	1.8±1.7	0.65±0.9	0.40±0.7
Dry cows[b]	0.15±0.5	0.25±0.6	0.80±1.2	0.55±0.8	0.50±0.9	0.85±1.1	0.45±0.7	0.35±0.9
Oxen[a]	0.0±0.0	1.85±1.8	0.0±0.0	0.45±1.2	0.0±0.0	0.55±1.2	0.15±0.5	1.2±1.5
Heifers[a]	0.0±0.0	0.1±0.2	0.0±0.0	0.0±0.0	0.0±0.0	0.0±0.0	0.0±0.0	0.0±0.0
Heifers[b]	0.30±0.7	0.7±0.9	2.45±1.4	1.2±1.2	1.65±1.4	1.25±1.4	1.45±1.5	1.5±1.8
Bulls[b]	0.0±0.0	0.1±0.3	0.10±0.3	0.0±0.0	0.0±0.0	0.0±0.0	0.2±0.4	0.35±0.6
Female calves[a]	0.0±0.0	0.0±0.0	0.0±0.0	0.0±0.0	0.0±0.0	0.0±0.0	0.0±0.0	0.10±0.5
Female calves[b]	0.80±0.6	0.6±0.6	1.55±1.8	0.8±1.0	1.15±1.4	1.50±1.1	1.60±1.6	1.55±1.9
Male calves[a]	0.0±0.0	0.1±0.2	0.0±0.0	0.0±0.0	0.0±0.0	0.0±0.0	0.0±0.0	0.0±0.0
Male calves[b]	0.45±0.6	0.6±0.5	0.35±0.7	0.4±0.9	0.60±0.8	1.10±1.2	0.85±1.1	1.50±1.7
Sheep	0.85±1.2	1.3±2.5	1.25±5.6	1.8±5.0	2.65±4.5	0.60±1.9	0.70±1.7	6.20±9.1
Goats	0.15±0.7	0.1±0.5	0.0±0.0	0.2±0.9	0.05±0.2	0.20±0.9	0.1±0.2	1.40±5.4
Chicken	0.50±1.7	0.8±1.5	100.2±447.2	52.4±223.1	0.65±1.95	0.75±2.5	0.95±2.7	14.2±43.7
Horses	0.1±0.5	0.2±0.5	0.0±0.0	0.0±0.0	0.1±0.2	0.1±0.2	0.0±0.0	0.1±0.2
Donkeys	0.05±0.2	0.6±1.3	0.0±0.0	0.5±1.0	0.0±0.0	0.0±0.0	0.1±0.2	1.5±2.2

n, number of respondents; U, Urban; PU, Peri-urban; a, local; b, crossbred

4.1.1.4. Experience in dairy production and source of crossbred dairy cows

Forty percent and 45% of the respondents from peri-urban Assela and urban Sululta, respectively, have dairy cattle rearing experiences of 4-7 years. In urban Bishoftu, 40% of the dairy farm owners have greater than 15 years of experiences in crossbred dairy cattle production. Ninety five percent and 100% of the respondents in urban and peri-urban Assela indicated that the source of their crossbred dairy cattle was from local market. About 60% of the respondents in urban Holetta got crossbred dairy cattle from agricultural office. Furthermore, in urban and peri-urban Sululta, 95% of the respondents' source of crossbred dairy cattle was through local market (Table 5).

Table 5. Experience in dairy production (years) and source of crossbred dairy cattle

Variables	Responses (%)	Study areas							
		Assela		Bishoftu		Holetta		Sululta	
		U n=20	PU n=20	U n=20	PU n=20	U n=20	PU n=20	U n=20	PU n=20
Experience in crossbred dairy cattle keeping (yrs)	1-3	15	20	0.0	15	5	25	25	35
	4-7	35	40	10	15	20	10	45	20
	8-11	20	35	35	35	25	35	10	25
	12-15	5	0.0	15	10	20	5	5	20
	>15	25	5	40	25	30	25	15	0.0
	Overall	100	100	100	100	100	100	100	100
Source of crossbred dairy cows	Ranch through agricultural office	0.0	0.0	25	45	60	5	0.0	5
	Gift from family	5	0.0	5	0.0	0.0	0.0	5	0.0
	Purchased from local markets	95	100	65	50	25	80	95	95
	Given from relatives and/or friends	0.0	0.0	5	0.0	0.0	0.0	0.0	0.0
	Ranch through agricultural office and purchased from local markets	0.0	0.0	0.0	5	15	15	0.0	0.0
	Overall	100	100	100	100	100	100	100	100

n, number of respondents; U, Urban; PU, Peri-urban

4.1.1.5. Purpose of keeping and ways of identifying dairy cattle

In the present study, in urban Assela, urban and peri-urban Bishoftu, Holetta and Sululta all (100%) of the interviewed respondents said that the primary purpose of keeping crossbred dairy cattle was for marketing milk and income generation. However, 80% of respondents from peri-urban Assela keept dairy cattle to generate income from milk sell as well as milk for home consumption while the remainig 20% of the respondents used milk for home consumption only (Table 6).

Results indicated that 50% of the respondents from peri-urban Holetta used ear tag to identify their dairy cattle in comparison to the other study areas. Eighty percent of respondents from urban and peri-urban Assela, 65% from urban Sululta and 60% from peri-urban Bishoftu used animals' body color to identify among their dairy cattle. In urban Bishoftu, sixty percent of the farmers named their cows and used local name to make identifications among their dairy cattle (Table 6).

Table 6. Purpose of keeping and ways of identifyingdairy cattle

Variables	Responses (%)	Study areas							
		Assela		Bishoftu		Holetta		Sululta	
		U n=20	PU n=20	U n=20	PU n=20	U n=20	PU n=20	U n=20	PU n=20
Purpose of keeping dairy cattle	Milk to generate income	100	80	100	100	100	100	100	100
	Milk for home consumption only	0.0	20	0.0	0.0	0.0	0.0	0.0	0.0
	Overall	100	100	100	100	100	100	100	100
Ways of identifyingdairy cattle in a herd	Color	80	80	15	60	35	10	65	40
	Using ear tag	0.0	15	25	10	25	50	10	30
	Using local name	15	0	60	15	30	20	5	25
	Color and local name	5	5	0.0	5	0.0	5	15	5
	Color and ear tag	0.0	0.0	0.0	2	10	2	5	0.0
	Ear tag and local name	0.0	0.0	0.0	0.0	0.0	5	0.0	0.0
	Overall	100	100	100	100	100	100	100	100

n, number of respondents; U, Urban; PU, Peri-urban

4.1.2. Dairy management practices in urban and peri-urban production systems

4.1.2.1. Housing and record keeping practices

Almost all of the interviewed respondents stated that there was a separate house for dairy cattle. Respondents in urban Bishoftu (60%), peri-urban Holetta (60%) and peri-urban Bishoftu (50%) indicated as they have records of their dairy farms. However, the dairy owners in peri-urban Assela (90%), urban Assela (75%), peri-urban Sululta (70%), urban Sululta (60%), urban Holetta (60%) and peri-urban Bishoftu (50%) were not practicing recording system. Milk yield, service and calving dates were the main parameters recorded in peri-urban Holetta, urban Sululta, urban Bishoftu, urban Holetta, peri-urban Bishoftu and peri-urban Sululta, respectively. The Dairy owners in peri-urban Assela (90%), urban Assela (75%), peri-urban Sululta (70%), urban Sululta (60%), urban Holetta (60%) and peri-urban Bishoftu (40%) stated that the reason for not practicing records was lack of awareness (Table 7).

Table 7. Housing and record keeping practices in the study areas

Variables	Responses (%)	Study areas							
		Assela		Bishoftu		Holetta		Sululta	
		U n=20	PU n=20	U n=20	PU n=20	U n=20	PU n=20	U n=20	PU n=20
Separate house for dairy cattle?	Yes	100	85	100	100	100	100	100	100
	No	0.0	15	0.0	0.0	0.0	0.0	0.0	0.0
	Overall	100	100	100	100	100	100	100	100
Record system?	Yes	25	10	60	50	40	60	40	30
	No	75	90	40	50	60	40	60	70
	Overall	100	100	100	100	100	100	100	100
Type of data recorded	Milk yield only	0.0	0.0	0.0	0.0	0.0	5	0.0	5
	Milk yield and calving dates	5	0.0	0.0	5	0.0	0.0	0.0	0.0
	Calving and service dates	15	5	5	10	0.0	5	0.0	0.0
	Milk yield, service date and calving date	5	5	35	25	35	40	40	25
	Calving date, heat sign, and service dates	0.0	0.0	10	10	5	0.0	0.0	0.0
	Milk yield, calving, heat sign, service and vaccination dates	0.0	0.0	10	0.0	0.0	10	0.0	0.0
	No record	75	90	40	50	60	40	60	70
	Overall	100	100	100	100	100	100	100	100
Reasons for notrecording	Record is available	15	0.0	60	30	40	50	40	25
	Lack of awareness	75	90	30	40	60	40	60	70
	Incomplete record	10	10	0.0	20	0.0	10	0.0	5
	No reason	0.0	0.0	10	10	0.0	0.0	0.0	0.0
	Overall	100	100	100	100	100	100	100	100

n, number of respondents; U, Urban; PU, Peri-urban

4.1.2.2. Feeding systems

As indicated in Table 8, in urban Bishoftu (95%), urban Assela (90%), urban Sululta (65%), peri-urban Assela (55%), peri-urban Holetta (55%) and peri-urban Bishoftu (50%)

the respondents revealed that stall feeding was the main feeding system. Furthermore, grazing and stall feeding were the main feeding systems in peri-urban Sululta (80%) and urban Holetta (50%) areas. Additionally, in peri-urban Bishoftu, 50% of the interviewed respondents stated that tethering and stall feeding as the primary dairy feeding management practices.

Table 8. Types of dairy cattle feeding systems in the study areas

Variables	Responses (%)	Study areas							
		Assela		Bishoftu		Holetta		Sululta	
		U n=20	PU n=20	U n=20	PU n=20	U n=20	PU n=20	U n=20	PU n=20
Types of dairy cattle feeding systems	Stall feeding	90	55	95	50	20	55	65	15
	Grazing and stall feeding	10	40	0.0	0.0	50	15	25	80
	Tethering and stall feeding	0.0	5	5	50	20	25	10	0.0
	Grazing, tethering and stall feeding	0.0	0.0	0.0	0.0	10	5	0.0	5
	Overall	100	100	100	100	100	100	100	100

n, number of respondents; U, Urban; PU, Peri-urban

4.1.2.3. Estrous detection and breeding systems

In the current study, all of the respondents indicated that they used to detect estrousbefore insemination of their cows (Table 9). Dairy owners in peri-urban Sululta (95%), urban Bishoftu (75%), peri-urban Bishoftu (70%) and peri-urban Assela (55%) stated that there was anoestrus problem in their dairy cattle.

Bull service was stated as the primary breeding system by 100% of the respondents in peri-urban and 75% in urban Sululta areas. On the other hand, artificial insemination was the main breeding system in peri-urban Bishoftu, urban Bishoftu, urban Assela, urban Holetta, peri-urban Holetta and peri-urban Assela, respectively (Table 9).

Table 9. Estrous detection and breeding systems of crossbred dairy cattle in the study areas

Variables	Responses (%)	Study areas							
		Assela		Bishoftu		Holetta		Sululta	
		U n=20	PU n=20	U n=20	PU n=20	U n=20	PU n=20	U n=20	PU n=20
Do you practice estrous detection?	Yes	100	100	100	100	100	100	100	100
	No	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	Overall	100	100	100	100	100	100	100	100
Season of the year estrous mostly detected	Summer	5	0.0	0.0	0.0	0.0	10	0.0	10
	Winter	0.0	5	5	0.0	35	20	5	10
	Not seasonal	95	95	95	100	65	70	95	80
	Overall	100	100	100	100	100	100	100	100
Is there anoestrus problem in cows or heifers?	Yes	45	55	75	70	45	35	20	95
	No	55	45	25	30	55	65	80	5
	Overall	100	100	100	100	100	100	100	100
Breeding system/s	Natural bull service	5	25	5	0.0	10	15	75	100
	AI	80	50	90	100	65	60	20	0.0
	Both AI and Natural service	15	25	5	0.0	25	25	5	0.0
	Overall	100	100	100	100	100	100	100	100

n, number of respondents; U, Urban; PU, Peri-urban; AI, Artificial Insemination

4.1.2.4. Weaning and culling systems

In Bishoftu and Holetta areas, all (100%) respondents were practicing calf weaning. Overall, in the present study, calf weaning was experienced in the study areas. Culling was also practiced by the majority of the respondents from all the study areas (Table 10).

Table 10. Practices of weaning and culling of dairy cattlein the study areas

Variables	Responses (%)	Study areas							
		Assela		Bishoftu		Holetta		Sululta	
		U n=20	PU n=20	U n=20	PU n=20	U n=20	PU n=20	U n=20	PU n=20
Do you practice calf weaning?	Yes	80	75	100	100	100	100	80	75
	No	20	25	0.0	0.0	0.0	0.0	20	25
	Overall	100	100	100	100	100	100	100	100
Do you practice culling?	Yes	70	60	100	85	100	95	80	75
	No	30	40	0.0	15	0.0	5	20	25
	Overall	100	100	100	100	100	100	100	100

n, number of respondents; U, Urban; PU, Peri-urban

4.1.3. Milk yield of crossbred dairy cows

The average daily milk yields of crossbred dairy cows in urban Bishoftu (11.7 liters), peri-urban Bishoftu (11.2 liters), urban Sululta (10.8 liters), respectively, were higher than the other areas. The relatively lower average daily milk yield was reported in peri-urban Assela (7.8 liters) and Sululta (8.5 liters) areas (Table 11).

4.1.4. Reproductive performances of crossbred dairy cattle

The survey results on estimated reproductive performances mainly age at first service, age at first calving, number of services per conception, calving interval and calving to conception interval of crossbred dairy cattle are summarized in Table 11.

4.1.4.1. Age at first service (AFS)

The shorter average age at first service were 18.8±2.2 and 19.1±5.3 months which were from urban and peri-urban Bishoftu while the longest was from peri-urban Assela (29.3±10.9 months). The details of average age at first service for individual study areas were indicated in Table 11 below.

4.1.4.2. Age at first calving (AFC)

In this study, the shortest average age at first calving were 27.8±2.2 and 28.1±5.3 months which were from urban and peri-urban Bishoftu, respectively. The longest average age at first calving was 38.3±10.9 months and was from peri-urban Assela (details in Table 11).

4.1.4.3. Number of services per conception (NSC)

In this study, the longest average numbers of services per conception were 1.85±0.61 and 1.65±0.5 which were from peri-urban and urban Bishoftu. The shortest average number of services per conception was 1.3±0.3 and that was from peri-urban Assela and urban Sululta (details in Table 11).

4.1.4.4. Calving to conception interval (CCI) and calving interval (CI)

The average calving to conception interval was shorter in urban Holetta (101.5±26.4 days), urban Bishoftu (107.6±27.3 days) and peri-urban Holetta (108.6±25.5 days) than other areas. The longest average calving to conception interval was 168.0±78.1 days which were from peri-urban Assela. The shorter average calving intervals were in urban Holetta (12.7±1.1 months), urban Bishoftu (12.9±0.8 months) and urban Sululta (13.3±1.1 months), respectively. The longest average calving intervals were in peri-urban Sululta (13.9±2.0) and peri-urban Assela (14.9±3.1 months) (details in Table 11).

Table 11. Average daily milk yieldand reproductive performances (Mean±SD) of crossbred dairy cattle

Variables	Study areas							
	Assela		Bishoftu		Holetta		Sululta	
	U n=20	PU n=20	U n=20	PU n=20	U n=20	PU n=20	U n=20	PU n=20
ADMY, liters/day	9.3±4.4	7.8±4.3	11.7±2.8	11.2±1.8	10.4±2.6	10.5±2.2	10.8±3.7	8.5±2.3
	n=19	n=10	n=20	n=20	n=20	n=20	n=20	n=17
AFS, months	21.6±4.9	29.3±10.9	18.8±2.2	19.1±5.3	21.9±6.1	21.8±5.4	25.4±7.1	25.9±7.2
AFC, months	30.6±4.9	38.3±10.9	27.8±2.2	28.1±5.3	30.5±6.2	30.5±5.4	34.4±7.1	34.9±7.2
	n=19	n=20	n=20	n=20	n=20	n=20	n=20	n=20
NSC	1.4±0.6	1.3±0.4	1.65±0.5	1.85±0.61	1.5±0.6	1.6±0.61	1.3±0.3	1.6±0.5
	n=18	n=18	n=20	n=20	n=20	n=20	n=20	n=18
CCI, days	127.5±36.7	168.0±78. 1	107.6±27.3	128.3±42.4	101.5±26.4	108.6±25.5	123.2±39.3	136.6±64.2
CI, months	13.7±1.3	14.9±3.1	12.9±0.8	13.6±4.4	12.7±1.1	13.0±1.0	13.3±1.1	13.9±2.0

n, number of respondents; U, Urban; PU, Peri-urban; ADMY, Average daily milk yield; AFS, age at first service; AFC, age at first calving; NSC, number of services per conception; CCI, calving to conception interval; CI, calving interval

4.1.5. Dairy cattle reproductive health problems and source of veterinary services

The respondents in urban Bishoftu (95%), peri-urban Holetta (90%), peri-urban Bishoftu (70%) and urban Holetta (70%) stated the occurrence of reproductive health problems in their dairy farms. The dairy farmers in urban Holetta (85%) and peri-urban Sululta (65%) mentioned that government veterinary clinics were the main source of veterinary drugs and services. However, dairy farmers in urban and peri-urban Bishoftu, peri-urban Assela, urban Sululta and Assela got veterinary drugs and services from private clinics (Table 12).

Table 12. Dairy cattle reproductive health problems and veterinary services provider/s

Variables	Responses (%)	Study areas							
		Assela		Bishoftu		Holetta		Sululta	
		U n=20	PU n=20	U n=20	PU n=20	U n=20	PU n=20	U n=20	PU n=20
Occurrence of reproductive problems	Yes	45	45	95	70	70	90	40	50
	No	55	55	5	30	30	10	60	50
	Overall	100	100	100	100	100	100	100	100
Source of veterinary services	Government	35	10	0.0	0.0	85	45	35	65
	Private	50	90	100	95	5	35	60	15
	Both government and private	15	0.0	0.0	5	10	20	5	20
	Overall	100	100	100	100	100	100	100	100

n, number of respondents; U, Urban; PU, Peri-urban

4.1.6. Milk and products marketing

All the respondents (100%) from urban and peri-urban Bishoftu, Holetta and Sululta were selling milk and milk products. However, of the owners interviewed from Assela, 95% from urban and 75% peri-urban did practice selling of milk and milk products. Details of market availability for milk and milk products were indicated in Table 13. Of the interviewed dairy farmers, 85%, 80%, 70%, 70%, 60% and 50% from peri-urban Bishoftu, Holetta, Sululta, urban Bishoftu, Holetta andAssela, respectively, complained that milk price was relatively low compared to feed cost especially during the longer fasting periods of Ethiopian Orthodox Church.

Table 13. Milk marketing practices and marketing problems in the study areas

Variables	Responses (%)	Study areas							
		Assela		Bishoftu		Holetta		Sululta	
		U n=20	PU n=20	U n=20	PU n=20	U n=20	PU n=20	U n=20	PU n=20
Milk and products selling?	Yes	95	75	100	100	100	100	100	100
	No	5	25	0.0	0.0	0.0	0.0	0.0	0.0
	Overall	100	100	100	100	100	100	100	100
Marketing prblems	Markets available	50	80	20	10	40	20	55	15
	Low milk price relative to feed cost	50	10	70	85	60	80	40	70
	Low milk price during fasting	0.0	0.0	10	0.0	0.0	10	5	15
	No milk marketing channel	0.0	10	0.0	0.0	0.0	0.0	0.0	0.0
	Delayed payments	0.0	0.0	0.0	5	0.0	0.0	0.0	0.0
	Overall	100	100	100	100	100	100	100	100

n, number of respondents U, Urban; PU, Peri-urban

4.1.7. Constraints and opportunitiesof dairy production

4.1.7.1. Constraints of dairy production

High feed cost, land shortage and space limitations, feed quality and availability as well as inadequate extension and veterinary services were the major dairy production system constraints in both urban and peri-urban areas of the study areas. High feed cost was the primary constraint in urban dairy production system of Holetta, Bishoftu, Sululta, Assela and peri-urban Sululta, Bishoftu, Holetta and Assela, respectively. The high feed cost was more serious in uban Holetta (55%), peri-urban Sululta (55%) and urban Bishoftu (50%). Thirty five percent of the repondents from peri-urban Bishoftu and peri-urban Holetta said that land scarcity and space limitation were also their main dairy production problems. Twenty percent of the dairy farmers from peri-urban Assela also complained water unavailablity for their dairy cattle (Table 14).

Table 14. Common constraints of urban and peri-urban dairy production systems

Study areas								
Variables (%)	Assela		Bishoftu		Holetta		Sululta	
Constraints	U n=20	PU n=20	U n=20	PU n=20	U n=20	PU n=20	U n=20	PU n=20
High feed costs	40	35	50	45	55	40	45	55
Land scarcity and space limitation	15	10	20	35	10	35	15	20
Feed quality and availability problems	25	15	15	10	25	10	30	10
Inadequate extension services	10	10	5	10	5	10	5	10
Inadequate veterinary service	5	5	5	0.0	5	0.0	5	0.0
Water scarcity	0.0	20	0.0	0.0	0.0	0.0	0.0	0.0
Disease problems	0.0	5	0.0	0.0	0.0	5	0.0	5
Waste removal problems	5	0.0	5	0.0	0.0	0.0	0.0	0.0
Overall	100	100	100	100	100	100	100	100

n, number of respondents U, Urban; PU, Peri-urban

4.1.7.2. Opportunitiesfor dairy production

Twenty percent of the respondents from urban Assela, 25% from urban Holetta, 25% from urban Sululta, and 50% from peri-urban Sululta indicated there was high demand for milk consumption which was a good opportunity to dairy production. Farmers in urban Holetta (40%), urban Bishoftu (45%) and peri-urban Holetta (55%) indicated the existence of research institution in their locality was a good opportunity to dairy development (details in Figure 2).

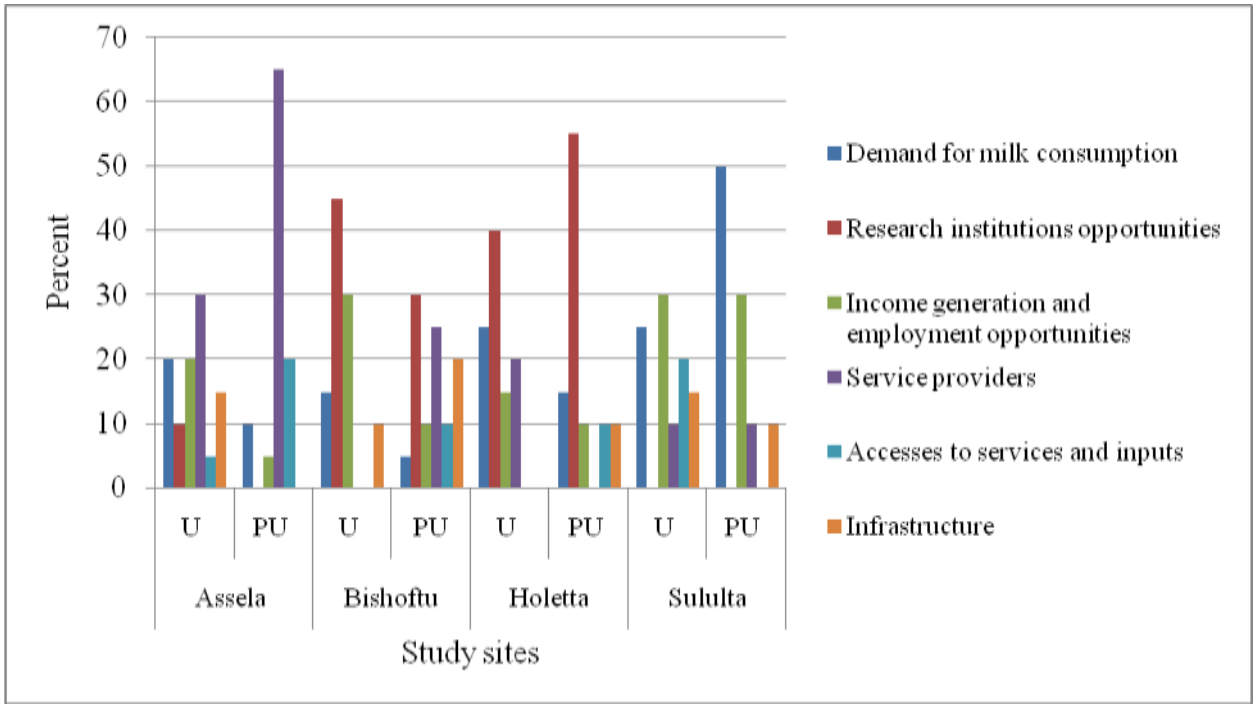

Figure 2. Graphical representation of opportunities for dairy production in urban and peri-urban production systems in the study areas

4.1.8. Available feed resources in urban and peri-urban dairy production systems

4.1.8.1. Land use and ownership

In urban Bishoftu (95%), urban Sululta (90%), urban Holetta (85%), peri-urban Bishoftu (75%), urban Assela (55%) and peri-urban Holetta (55%) respondents stated that as they totally do not have separate land for dairy production. But in peri-urban Assela (55%), urban Assela (40%) and peri-urban Bishoftu (25%) the available land was used for crop production. Furthermore, twenty five percent of the respondents in peri-urban Assela and 45% in peri-urban Sululta used the available land for crop and forage production and crop production and grazing. The dairy farmers from peri-urban Assela (80%), peri-urban Sululta (55%), urban Assela (45%) and peri-urban Holetta (35%) indicated that they have own land (Table 15).

Table 15. Land use and ownership in the study areas

Variables	Responses (%)	Study areas							
		Assela		Bishoftu		Holetta		Sululta	
		U n=20	PU n=20	U n=20	PU n=20	U n=20	PU n=20	U n=20	PU n=20
Land use	No land	55	15	95	75	85	55	90	40
	Crop production	40	55	0.0	25	15	15	0.0	15
	Forage production	0.0	0.0	5	0.0	0.0	0.0	0.0	0.0
	Crop and forage production	0.0	25	0.0	0.0	0.0	15	0.0	0.0
	Crop production and grazing	5	5	0.0	0.0	0.0	5	10	45
	Crop and forage production, grazing	0.0	0.0	0.0	0.0	0.0	10	0.0	0.0
	Overall	100	100	100	100	100	100	100	100
Land ownership	No access to land	55	15	95	75	85	55	90	40
	Own	45	80	5	10	15	35	10	55
	Lease	0.0	5	0.0	15	0.0	10	0.0	5
	Overall	100	100	100	100	100	100	100	100

n, number of respondents; U, Urban; PU, Peri-urban

4.1.8.2. Common feed resources

According to the response obtained from the respondents in urban Bishoftu (65%), peri-urban Bishoftu (45%), urban Assela (40%), peri-urban Assela (35%) as well as urban and peri-urban Sululta (55%) crop residues and concentrates and hay, crop residues and concentrates, respectively, were the commonly available dairy feed resources. Fifty percent of the respondents in urban Assela used backyard forage, crop residues and concentrates as the main dairy feed resources. Forty percent of the repondents from urban Holetta reported that communal pasture, hay, crop residues and concentrates as frequent dairy feed resources. On the other hand, private pasture, hay, crop residues and concentrates were common dairy feed resources by 30% of the respondents from peri-urban Sululta (Table 16).

Table 16. Main feed resources used for dairy cattle in urban and peri-urban areas

Variables	Responses (%)	Study areas							
		Assela		Bishoftu		Holetta		Sululta	
		U n=20	PU n=20	U n=20	PU n=20	U n=20	PU n=20	U n=20	PU n=20
Common feed resources	Crop residues and concentrates	40	35	65	45	0.0	0.0	0.0	0.0
	Hay, crop residues and concentrates	10	10	0.0	0.0	25	25	55	55
	Backyard forage (e.g. enset), crop residues and concentrates	50	5	20	25	0.0	0.0	10	0.0
	Hay during winter, crop residues and concentrates	0.0	15	5	0.0	0.0	0.0	0.0	0.0
	Improved forage during spring and summer, crop residues and concentrates	0.0	15	5	5	0.0	0.0	0.0	0.0
	Concentrates, crop residues and wet grass in the summer time	0.0	0.0	5	0.0	0.0	5	0.0	0.0
	Communal pasture, hay, crop residues and concentrates	0.0	5	0.0	15	40	0.0	0.0	0.0
	Private pasture, hay and concentrates	0.0	0.0	0.0	5	10	0	0	5
	Hay and concentrates	0.0	0.0	0.0	0.0	10	15	20	0.0
	Private pasture, hay, crop residues and concentrates	0.0	15	0.0	0.0	10	20	15	30
	Communal pasture, private pasture, crop residues and concentrates	0.0	0.0	0.0	0.0	5	5	0.0	5
	Private pasture, hay, improved forage, crop residues and concentrates	0.0	0.0	0.0	5	0.0	30	0.0	5
	Overall	100	100	100	100	100	100	100	100

n, number of respondents; U, Urban; PU, Peri-urban; Concentrates or agro-industrial by-products (mainly by-products of different agro-industries including flourmills, oil mills and industrial brewery residues)

4.1.8.3. Types of available crop residues

As summarized in Table 17, respondents from urban Assela (50%), urban Holetta (45%), and peri-urban Sululta (40%) stated that wheat and barley straws were the main crop residues used as a basal diet for dairy cattle. Additionally, dairy farmers from urban Bishoftu (50%) and peri-urban Bishoftu (40%), urban Assela (40%) and peri-urban Holetta (35%) were mainly used wheat straw as a basal diet for their dairy cattle. Wheat, barley and teff straws were the common crop residues used for feeding dairy cattle in peri-urban Assela as reported by 60% of the farmers. Wheat and teff straws were also used by 45% respondents from peri-urban Bishoftu. Fifty five percent of the respondents in urban Sululta stated that teff straw as the major crop residue used in dairy cattle feeding practices.

Table 17. Types of crop residues used by the dairy owners in each study area

Variables	Responses (%)	Study areas							
		Assela		Bishoftu		Holetta		Sululta	
		U n=20	PU n=20	U n=20	PU n=20	U n=20	PU n=20	U n=20	PU n=20
Types of crop residues	Wheat and barley straws	50	15	25	10	45	15	5	40
	Wheat straw	40	25	50	40	15	35	5	5
	Barley straw	0.0	0.0	0.0	0.0	5	10	0.0	10
	Wheat, barley and teff straws	0.0	60	10	5	0.0	20	15	20
	Wheat and teff straws	0.0	0.0	15	45	5	5	0.0	5
	Wheat straw, barley straw and bean haulms	10	0.0	0.0	0.0	5	0.0	0.0	5
	Teff straw	0.0	0.0	0.0	0.0	0.0	0.0	55	5
	No use of crop residues	0.0	0.0	0.0	0.0	25	15	20	10
	Overall	100	100	100	100	100	100	100	100

n, number of respondents; U, Urban; PU, Peri-urban

4.1.8.4. Frequency of providing feed supplements

The respondents in urban Sululta (95%), peri-urban Holetta (90%), urban Bishoftu (70%), urban Holetta (70%), peri-urban Bishoftu (65%) and peri-urban Sululta (55%) practiced feeding of feed supplements twice a day for their dairy cattle. While, farmers from urban Assela (85%), peri-urban Assela (60%), peri-urban Sululta (45%) and peri-urban Bishoftu (35%), experienced feeding of feed supplements three times per day for their dairy cattle (Table 18).

Table 18. Frequency of feeding feed supplements for dairy cattle in the study areas

Variable	Responses (%)	Study areas							
		Assela		Bishoftu		Holetta		Sululta	
		U n=20	PU n=20	U n=20	PU n=2	U n=20	PU n=20	U n=20	PU n=20
Supplements feeding frequency	Once per day	0.0	5	0.0	0.0	0.0	0.0	0.0	0.0
	Twice per day	10	25	70	65	70	90	95	55
	Three times per day	85	60	30	35	30	10	5	45
	Four times per day	5	5	0.0	0.0	0.0	0.0	0.0	0.0
	No supplements	0.0	5	0.0	0.0	0.0	0.0	0.0	0.0
	Overall	100	100	100	100	100	100	100	100

n, number of respondents; U, Urban; PU, Peri-urban

4.1.8.5. Frequency of water provision

Fifty five percent of the dairy farmers from urban Bishoftu provided water freely for their dairy cattle. In peri-urban Assela (90%), urban Assela (45%) and urban Sululta (40%) respondents provided water once per day. Furthermore, sixty five percent (65%) of the respondents from peri-urban Holetta, 65% from peri-urban Sululta, 45% from urban Sululta and 35% from peri-urban Bishoftu stated that the frequency of water provision for dairy cattle was twice per day (Table 19).

Table 19. Frequency of water provision for dairy cattlein the study areas

Variable	Responses (%)	Study areas							
		Assela		Bishoftu		Holetta		Sululta	
		U n=20	PU n=20	U n=20	PU n=20	U n=20	PU n=20	U n=20	PU n=20
Frequency of water provision	Roam freely	5	0.0	55	30	10	10	0.0	5
	Once per day	45	90	15	5	25	10	40	15
	Twice per day	15	10	20	35	30	65	45	65
	Three times per day	35	0.0	10	30	30	15	15	15
	Four times per day	0.0	0.0	0.0	0.0	5	0.0	0.0	0.0
	Overall	100	100	100	100	100	100	100	100

n, number of respondents; U, Urban; PU, Peri-urban

4.2. Feeding Experiment

4.2.1. Chemical composition of the experimental feeds

The details of chemical composition of feed ingredients and the experimental rations are given in Table 20 and 21, respectively. The grass hay had slightly lower level of crude protein (CP) content. The NDF content of hay in this study was more than 65%. On the other hand, the acid detergent fiber (ADF) content of hay in the present study was slightly below 40%. The percentage of CP used in the control diet was similar in both the feeding phases.

Table 20. Chemical composition of feed ingredients

Chemical composition	Hay	Wheat middling	Super concentrate (19% CP)	Noug seed cake (NSC)
DM (%)	90.7	90.0	91.6	93.10
Ash (%DM)	9.2	4.5	8.7	10.10
EE (%DM)	0.7	3.5	3.3	7.40
CP (%DM)	6.8	17.8	21.1	30.90
Ca (% DM)	1.8	1.9	2.4	1.10
P (%DM)	0.15	1.1	0.38	0.46
OM (%DM)	90.8	95.5	91.3	89.90
ADF (%DM)	39.5	10.0	10.3	31.70
NDF (%DM)	73.1	42.2	48.5	54.55
IVOMD (%)	48.7	70.4	75.0	70.11
IVOMD(g/kg DM)	486.8	704.0	750.0	701.10
ME (MJ/kg DM)	7.8	11.3	12.0	11.20

DM, Dry matter; EE, Ether Extract; CP, Crude protein; Ca, calcium; P, Phosphorus; OM, Organic Matter; ADF, Acid Detergent Fiber; NDF, Neutral Detergent Fiber; IVOMD, *In vitro* Organic Matter Digestibility; ME, Metabolizable Energy; MJ, *Mega joule*

Table 21. Chemical composition of experimental rations according to cows' physiology

	DM (%)	Ash (%DM)	CP (%DM)	ADF (%DM)	NDF (%DM)	Ca (%DM)	P (%DM)	OM (%DM)	IVOMD (g/kg DM)	ME (MJ/kg DM)
Treatments										
Pregnant diet										
T_1	91.0	6.1	26.5	10.3	50.5	1.1	0.4	93.9	695.0	11.1
T_2	93.1	9.9	23.0	20.1	43.4	1.7	1.9	90.1	650.0	10.4
T_3	92.1	10.3	22.2	18.7	44.2	1.8	2.4	89.7	670.0	10.7
Milking diet										
T_1	91.0	6.1	26.5	10.3	50.5	1.1	0.4	93.9	695.0	11.1
T_2	91.8	9.5	22.1	19.1	39.7	1.5	1.7	90.5	720.0	11.5
T_3	92.2	10.0	22.3	17.0	33.1	1.7	2.1	90.0	740.0	11.8

DM, Dry matter; CP, Crude protein; Ca, calcium; P, Phosphorus; OM, Organic Matter; ADF, AcidDetergent Fiber; NDF, Neutral Detergent Fiber; IVOMD, *In vitro* Organic Matter Digestibility; ME, Metabolizable Energy; MJ, *Mega joule*; T_1, treatment one (control, farm concentrate); T_2, Treatment two; T_3, Treatment three

4.2.2. Dry matter and nutrient intake of experimental cows

Daily dry matter and nutrient intakes during late pregnancy: The overall mean feed and nutrient intakes of dairy cows during late pregnancy and early post-partum periods are presented in Table 22. The average daily total dry matter intake during the late pregnancy period was statistically not significant ($P>0.05$) among treatments. But the average daily DMI was statistically significant ($P<0.0001$), ($P<0.01$) among parities with higher intake by heifers than first, second and third parity cows. Though cows in the first, second and third parties were statistically not significant ($P>0.05$) in their average daily hay, concentrate and total DM intakes. The average total ME intake of cows in first and second parities was statistically lower ($P<0.05$) than the intake of heifers. However, the average CP intake of cows with different parities was statistically not significant ($P>0.05$).

Daily dry matter and nutrient intakes during early post-calving: During the early post-calving period, the average total daily concentrate intake of cows in T_1 was statistically lower ($P<0.0001$) than the intake of cows in T_2 and T_3. The average daily concentrate intake of cows in T_2 was also statistically higher ($P<0.0001$) than the intake of cows in T_3. The average total daily DM and ME intakes of cows in T_2were statistically higher ($P<0.0001$) than the intakes of cows in T_1 and T_3. The average total daily ME intake of cows in T_1 was also statistically lower ($P<0.001$) than that of the cows in T_3. The average total daily CP intake was statistically varied ($P<0.0001$) among treatments in which the average CP intake of cows in T_1 was statistically higher ($P<0.0001$) than the intake of cows in T_2 and T_3. The average total daily CP intake of cows in T_2 was also statistically higher ($P<0.001$) than the intake of cows in T_3 (Table 22).

The average daily concentrate intake of cows was statistically significant ($P<0.0001$) with fourth parity cows having a higher intake than others. Furthermore, third parity cows were with statistically lower ($P<0.0001$) average daily concentrate intake than other parity groups. The average daily total DM intake was statistically higher ($P<0.0001$) for

fourth and third parities than other parity groups. The average total daily ME intake of cows in fourth parity was statistically higher (P<0.001) than others. The average total daily ME intake of first parity cows was statistically lower (P<0.05) than the average ME intake of third and fourth parity cows but similar to the intake of second parity cows. The average total daily CP intakes of third and fourth parity cows were statistically higher (P<0.0001) than the CP intake of the other parity groups (Table 22).

Table 22. Average daily dry matter and nutrient intakes per cow during pre and early post-partum periods of crossbred dairy cows

	Feed and nutrient intakes during pregnancy period				
Parameters	Hay (kg/day)	Concentrate (kg/day)	Total DMI (kg/day)	Total ME (MJ/day)	Total CP (g/day)
Treatments					
T_1	6.7^{c}	3.5^{a}	10.2	91.0^{a}	2699.2^{a}
T_2	7.5^{a}	2.8^{b}	10.3	88.0^{b}	1456.0^{b}
T_3	7.2^{b}	2.8^{b}	10.0	86.2^{b}	1430.8^{b}
SEM	0.1	0.03	0.1	0.8	18.6
P-value	<0.0001	<0.0001	0.064	<0.0001	<0.0001
Parity					
P_0	7.6^{a}	2.9^{b}	10.5^{a}	90.6^{a}	1896.0
P_1	6.9^{b}	3.1^{a}	10.0^{b}	87.3^{b}	1851.2
P_2	7.0^{b}	3.0^{ab}	10.0^{b}	87.2^{b}	1838.5
P_3	7.1^{b}	3.0^{ab}	10.1^{b}	88.1^{ab}	1862.2
SEM	±0.1	±0.04	±0.1	±1.0	±21.5
P-value	<0.0001	0.01	0.008	0.043	0.261
Treatments	Feed and nutrient intakes during milking period				
T_1	7.9^{a}	5.3^{c}	13.2^{b}	121.0^{c}	3499.3^{a}
T_2	6.9^{b}	7.6^{a}	14.5^{a}	141.1^{a}	2229.6^{b}
T_3	6.2^{c}	6.8^{b}	13.1^{b}	129.3^{b}	2039.3^{c}
SEM	±0.7	±0.7	±0.1	±1.0	±18.0
P-value	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001
Parity					
P_1	6.8^{b}	6.4^{c}	13.2^{b}	126.4^{c}	2534.3^{b}
P_2	6.7^{b}	6.6^{b}	13.4^{b}	128.8^{bc}	2556.0^{b}
P_3	7.8^{a}	6.0^{d}	13.8^{a}	130.2^{b}	2620.1^{a}
P_4	6.7^{b}	7.3^{a}	14.0^{a}	136.0^{a}	2647.3^{a}
SEM	±0.08	±0.08	±0.1	±1.2	±20.8
P-value	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001

^{a,b,c,d} Means followed by different superscript letters within a column are different at P<0.0001, P<0.01, P<0.05; SEM, Standard Error of the Mean; T_1,Treatment one (control, farm concentrate); T_2,Treatment two; T_3, Treatment three; DMI, Dry matter intake; g, gram; kg, kilogram; ME, Metabolizable Energy; MJ, *Mega joule*; CP, Crude protein; P_0, Heifer; P_1, first parity; P_2, second parity; P_3, third parity; P_4, fourth parity

4.2.3. Milk yield and composition

The average daily milk yield showed statistically significant differences ($P<0.0001$) between treatment groups with a higher average daily yield recorded from cows in T_2 followed by daily yield of cows in T_3 than T_1 for the three months milking period. The average daily milk yield of cows in fourth parity was statistically higher ($P<0.0001$) than the yield of the other parity groups. The average daily milk yield of first parity cows was also statistically higher ($P<0.001$) than the average yield of second parity cows, but statistically not significant ($P>0.05$) from the yield of third parity cows. The milk composition analysis results indicated that there were statistically not significant differences ($P>0.05$) among treatment and parity groups (Table 23).

4.2.4. Reproductive parameters

As indicated in Table 24, body condition score (BCS) at the start of the experiment was statistically not significant ($P>0.05$) among treatment groups. However, BCS of cows at 5 to 12 days and at day 60 after calving were statistically significant ($P<0.05$) with BCS of cows in T_1 lower than the BCS of cows in T_2 and T_3. The calving to first heat interval (CFHI) of cows in T_2 and T_3 were statistically better ($P<0.05$) than the CFHI of cows in T_1. The calving to first service interval (CFSI) of cows in T_2 and T_3 were also statistically better ($P<0.05$) than the CFSI of cows in T_1. The CCI and estimated CI were statistically significant ($P<0.05$), in which cows in T_2 and T_3 had shorter intervals than the cows in T_1. But the number of services per conception (NSC) was statistically not significant ($P>0.05$) among treatments.

The BCS at 5 to 12 days after calving for second parity cows was statistically higher ($P<0.05$) than the BCS of first and fourth parity cows but the variation in BCS of third parity cows was statistically not significant ($P>0.05$) with the other parity groups. At day 60 after calving, BCS of fourth parity cows was statistically lower ($P<0.05$) than the BCS of second and third parity cows, but the difference was statistically not significant

(P>0.05) with first parity cows. The CCI and CI of first parity cows were statistically longer (P<0.05) than the other parity groups. However, the variations in the CCI and CI were statistically not significant (P>0.05) in second, third and fourth parity cows (Table 24).

Table 23. Average daily milk yields (l/day/cow) and milk composition (%) of crossbred dairy cows fed on different diets

Measurements	ADMY	Acidity%	Fat%	Protein%	SNF%	Density (G/ML)	pH	TS%	Lactose%	Ash%	Temp.(^{o}C)
Treatments											
T_1	11.0[c]	0.19	4.2	3.2	7.7	1.028	6.7	11.6	3.7	0.70	35.8
T_2	15.8[a]	0.21	4.5	3.4	7.9	1.028	6.6	12.4	3.9	0.72	36.1
T_3	14.2[b]	0.20	4.3	3.5	7.8	1.028	6.7	12.0	3.8	0.71	35.8
SEM	±0.1	±0.01	±0.4	±0.1	±0.02	±0.01	±0.01	±0.4	±0.2	±0.01	±0.3
P-value	<0.0001	0.15	0.84	0.28	0.80	0.84	0.11	0.51	0.77	0.38	0.62
Parity											
P_1	13.2[b]	0.20	4.5	3.2	7.5	1.027	6.6	11.7	3.6	0.71	35.8
P_2	12.5[c]	0.20	4.7	3.6	8.4	1.030	6.6	12.8	4.1	0.71	35.7
P_3	12.8[bc]	0.20	3.9	3.3	7.9	1.029	6.7	11.8	3.9	0.71	36.2
P_4	15.8[a]	0.19	4.2	3.4	7.3	1.026	6.7	11.8	3.5	0.70	36.0
SEM	±0.1	±0.01	±0.4	±0.1	±0.3	±0.01	±0.01	±0.5	±0.2	±0.01	±0.3
P-value	<0.0001	0.86	0.66	0.15	0.11	0.18	0.15	0.48	0.20	0.79	0.70

[a,b,c] Means followed by different superscript letters within a column are different at P<0.0001; SEM, Standard Error of the Mean; l, liter; ADMY, Average daily milk yield; SNF, Solid not fat; TS, Total solids; T_1, Treatment one (control, farm concentrate); T_2, Treatment two; T_3,Treatment three; P_1, first parity; P_2, second parity; P_3, third parity; P_4, fourth parity

Table 24. Reproductive parameters of crossbred dairy cows fed on different diets

Measurements	BCS at start of the experiment	BCS at 5 to 12 days after calving	BCS at day 60 after calving	CFHI, days	CFSI, days	CCI, Days	NSC	CI, months
Treatments								
T_1	2.9	2.8^{b}	2.5^{b}	68.3^{a}	78.0^{a}	80.4^{a}	1.4	12.1^{a}
T_2	3.3	3.3^{a}	3.2^{a}	28.0^{b}	56.0^{b}	61.5^{b}	1.3	11.4^{b}
T_3	3.3	3.3^{a}	3.1^{a}	24.1^{b}	55.5^{b}	64.0^{b}	1.3	11.5^{b}
SEM	±0.13	±0.11	±0.13	±6.3	±5.6	±2.6	±0.01	±0.2
P-value	0.087	0.016	0.015	0.023	0.038	0.049	0.286	0.037
Parity								
P_1	2.92	2.92^{b}	2.75^{ab}	33.7	64.3	87.2^{a}	2.0	12.3^{a}
P_2	3.50	3.50^{a}	3.25^{a}	40.0	55.3	55.3^{b}	1.0	11.2^{b}
P_3	3.25	3.17^{ab}	3.17^{a}	31.1	64.6	64.9^{b}	1.0	11.5^{b}
P_4	3.00	2.92^{b}	2.42^{b}	37.6	66.7	67.1^{b}	1.0	11.5^{b}
SEM	±0.2	±0.13	±0.15	±15.3	±4.3	±3.6	±0.2	±0.07
P-value	0.112	0.047	0.026	0.894	0.222	0.027	0.633	0.017

[a,b] Means followed by different superscript letters within a column are different at P<0.05; SEM, Standard Error of the Mean; BCS, Body Condition Score; CFHI, Calving to First Heat Intervals; CFSI, Calving to First Service Interval; CCI, Calving to Conception Interval; NSC, Number of Services per Conception; CI, Calving Interval; T_1, Treatment one (control, farm concentrate); T_2, Treatment two; T_3, Treatment three; P_1, first parity; P_2, second parity; P_3, third parity; P_4, fourth parity

4.2.5. Effect of different rations on early post-partum blood plasma metabolites

Early post-partum plasma glucose, cholesterol and triglycerides concentration: The variation in average plasma glucose concentration was statistically not significant (P>0.05) among different treatment groups and parities (Table 25). The average plasma cholesterol at calving (day 0) was 116.0 mg/dl for cows in T_1, 87.0 mg/dl for those in T_2 and 83.6 mg/dl for those in T_3. The differences were statistically significant (P<0.05). The amount of average plasma triglycerides at day 7 after calving was statistically higher (P<0.05) for cows in T_1 than T_2 and T_3 (Table 25).

Early post-partum plasma total protein, albumin, globulin and urea concentration: The average plasma total protein at day 14 after calving was statistically higher (P<0.01) for cows in T_1 than T_2 and T_3. Similarly, the average plasma urea nitrogen values at calving, day 7 and day 14 after calving were statistically higher (P<0.01) for cows in T_1 than T_2

and T_3. The variationsin average plasma total protein, albumin, globulin and urea concentrations were statistically not significant (P>0.05) among parities (Table 26).

Table 25. Average early post-partum plasma glucose, cholesterol and triglycerides concentration of crossbred dairy cows

Factors	Glucose (mg/dl)			Cholesterol (mg/dl)			Triglycerides (mg/dl)		
	Wk_0	Wk_1	Wk_2	Wk_0	Wk_1	Wk_2	Wk_0	Wk_1	Wk_2
Treatments									
T_1	55.4	59.4	40.0	116.0[a]	115.0	120.0	30.6	31.2[a]	27.8
T_2	57.6	53.2	54.0	87.0[b]	106.5	115.7	23.0	24.8[b]	25.9
T_3	59.0	59.9	56.8	83.6[b]	104.1	111.0	25.3	21.5[b]	25.5
SEM	±2.7	±3.0	±7.7	±7.2	±6.7	±6.5	±3.2	±1.7	±2.7
p-value	0.65	0.287	0.321	0.037	0.53	0.47	0.30	0.019	0.819
Parity									
P_1	52.9	53.5	50.2	92.0	110.1	118.4	25.0	23.4	25.3
P_2	64.9	64.5	42.0	107.3	116.6	122.4	25.4	26.1	27.6
P_3	54.5	56.4	56.6	97.4	105.3	108.4	26.9	26.3	28.2
P_4	57.0	55.6	52.3	85.3	101.9	114.4	27.9	27.5	24.5
SEM	±3.1	±3.4	±8.8	±8.3	±7.7	±7.5	±3.7	±2.0	±3.1
P-value	0.12	0.22	0.712	0.37	0.59	0.622	0.94	0.54	0.81

[a,b] Means followed by different superscript letters within a column are different at P<0.05; T_1, Treatment one (control, farm concentrate); T_2, Treatment two; T_3, Treatment three; P_1, first parity; P_2, second parity; P_3, third parity; P_4, fourth parity; Wk_0, at calving (day 0); Wk_1, 7 days after calving; Wk_2, 14 days after calving; SEM, standard error of the mean.

Table 26. Average early post-partum plasma total protein, albumin, globulin and urea concentration of crossbred dairy cows

Factors	TP (g/dl)			Albumin (g/dl)			Globulin (g/dl)			Urea (mg/dl)		
	Wk_0	Wk_1	Wk_2	Wk_0	Wk_1	Wk_2	Wk_0	Wk_1	Wk_2	Wk_0	Wk_1	Wk_2
Treatments												
T_1	8.0	8.3	9.8[a]	3.1	3.0	2.9	4.9	5.3	5.3	42.2[a]	36.6[a]	53.3[a]
T_2	7.8	8.1	8.5[b]	3.2	3.2	3.1	4.3	4.9	5.4	23.3[b]	29.4[b]	29.2[b]
T_3	8.1	7.8	8.4[b]	3.2	3.1	2.9	4.9	4.7	5.0	24.7[b]	26.7[b]	31.3[b]
SEM	±0.5	±0.5	±0.2	±0.08	±0.1	±0.2	±0.5	±0.5	±0.5	±3.7	±1.6	±2.8
P-value	0.78	0.77	0.01	0.78	0.55	0.87	0.71	0.67	0.80	0.01	0.01	0.002
Parity												
P_1	7.0	7.0	8.3	3.3	3.1	2.8	3.7	3.9	4.2	32.0	33.9	38.8
P_2	7.8	8.2	9.1	3.3	3.4	3.2	4.5	4.8	5.3	31.0	31.4	43.1
P_3	8.8	8.5	9.2	3.1	3.0	3.1	5.7	5.5	5.4	25.2	28.0	33.3
P_4	7.9	8.6	9.0	2.9	2.8	2.9	5.0	5.7	6.1	32.0	30.2	36.6
SEM	±0.6	±0.5	±0.2	±0.1	±0.2	±0.3	±0.6	±0.5	±0.6	±4.3	±1.9	±3.2
P-value	0.33	0.25	0.13	0.06	0.14	0.72	0.21	0.20	0.26	0.65	0.26	0.28

[a,b] Means followed by different superscript letters within a column are different at $P<0.01$; T_1, Treatment one (control, farm concentrate); T_2, Treatment two; T_3, Treatment three; P_1, first parity; P_2, second parity; P_3, third parity; P4, fourth parity; TP, total protein; Wk_0, at calving (day 0); Wk_1, 7 days after calving; Wk_2, 14 days after calving; SEM, standard error of the mean

Early post-partum plasma aspartate aminotransferase (AST), insulin and progesterone concentration: The variation in average plasma AST, insulin and progesterone concentrations were statistically not significant ($P>0.05$) among the treatment groups. The average plasma progesterone concentration at day 14 after calving was statistically higher ($P<0.05$) in third parity cows than first, second and fourth parity cows, but it was less than 1 ng/ml (Table 27).

Table 27. Average early post-partum plasma AST, insulin and progesterone levels of crossbred dairy cows

Factors	AST (IU/L)			Insulin (µU/mL)			Progesterone (ng/mL)		
	Wk_0	Wk_1	Wk_2	Wk_0	Wk_1	Wk_2	Wk_0	Wk_1	Wk_2
Treatments									
T_1	64.6	65.7	69.3	1.5	1.9	2.2	0.40	0.40	0.30
T_2	67.9	76.0	69.2	1.6	1.8	1.9	0.21	0.33	0.51
T_3	62.0	61.8	65.0	1.6	1.9	2.1	0.20	0.30	0.31
SEM	±2.3	±4.8	±6.69	±0.1	±0.92	±0.3	±0.06	±0.1	±0.1
P-value	0.25	0.18	0.87	0.85	0.38	0.70	0.12	0.93	0.17
Parity									
P_1	60.0	61.6	58.1	1.5	1.6	2.1	0.26	0.2	0.24^b
P_2	61.2	64.6	70.7	1.6	2.1	2.7	0.32	0.4	0.17^b
P_3	69.0	67.2	62.9	1.5	1.8	1.9	0.25	0.3	0.71^a
P_4	68.9	77.9	79.3	1.8	1.9	1.6	0.30	0.4	0.36^b
SEM	±2.6	±5.6	±7.7	±0.1	±0.1	±0.3	±0.1	±0.1	±0.1
P-value	0.09	0.28	0.32	0.55	0.10	0.17	0.85	0.66	0.018

[a,b] Means followed by different superscript letters within a column are different at $P<0.05$; T_1, Treatment one (control, farm concentrate); T_2, Treatment two; T_3, Treatment three; AST, Aspartate aminotransferase; Wk_0, at calving (day 0); Wk_1, 7 days after calving; Wk_2, 14 days after calving; P_1, first parity; P_2, second parity; P_3, third parity; P_4, fourth parity; SEM, standard error of the mean

4.2.6. Post-partum fertility and related problems

Post-partum body condition score (BCS) at service was higher for cows in T_2 and T_3 than T_1, although the variation was statistically not significant ($P>0.05$). Furthermore, cows in first and second parities showed higher BCS than third and fourth parity cows (Table 28).

4.2.6.1. Conception and pregnancy rates

Conception rate was evaluated by plasma progesterone test on day-21 and day-35 after service and by transrectal ultrasonography at day-30 of insemination (Tables 28 and 29). At day-21 progesterone concentrations were greater than 6ng/ml in two cows out of four from T_1, three out of four from T_2 and two out of four from T_3. However, the differences in plasma progesterone values were statistically not significant ($P>0.05$) among treatments and parities.

Table 28. Mean (±SEM) age, body weight at calving, body weight and BCS at service and progesterone concentrations after serviceof crossbred dairy cows

Factors	Age of cow (yrs)	B.wt at calving (kg)	B.wt at service (kg)	BCS at service	PPD21 (ng/mL)	PPD35 (ng/mL)
Treatments						
T_1	5.5±0.4	481.3±46.7	467.3±20.8	2.5±0.2	8.1±1.9	4.5±1.7
T_2	5.1±0.3	489.3±36.2	494.3±16.1	3.3±0.2	6.2±1.1	6.9±1.0
T_3	5.1±0.5	460.0±59.1	487.0±26.4	3.2±0.2	9.7±1.9	9.9±1.7
P-value	0.72	0.92	0.63	0.07	0.41	0.27
Parity						
P_1	2.8±0.5^{c}	444.1± 55.3	462.1±24.7	3.1±0.2	9.1±1.7	10.1±1.6
P_2	4.6±0.4^{bc}	484.3±41.8	495.0±18.6	3.3±0.2	7.9±1.3	7.2±1.2
P_3	5.4±0.4^{b}	511.3±41.8	513.7±18.6	2.8±0.2	6.9±1.7	5.1±1.6
P_4	8.2±0.7^{a}	467.6± 80.9	460.6±36.1	2.6±0.3	8.1±2.5	6.2±2.3
P-value	0.02	0.81	0.46	0.39	0.86	0.40

^{a,b,c} Means followed by different superscript letters within a column are different at P<0.05; BCS, body condition score; B.wt, body weight; T_1, Treatment one (control, farm concentrate); T_2, Treatment two; T_3, Treatment three; P_1, first parity; P_2, second parity; P_3, third parity; P_4, fourth parity; SEM, standard error of the mean; PPD21, Plasma progesterone levels on day-21 post service; PPD35, Plasma progesterone levels on day-35 post service

At day-30 of insemination all cows were diagnosed by ultrasonography. The overall day-30 pregnancy rate was 88.9% (8/9) (Table 29). Two out of the inseminated three were pregnant (embryos with heart beat) from T_1, all the four were found pregnant from T_2 and similarly the two cows were pregnant from T_3. However, the differences were statistically not significant (P>0.05). The variation in pregnancy rate by parity was statistically not significant (Table 31).

Table 29. The frequency of pregnancy diagnosis (ultrasound) at day 30 after service of crossbred dairy cows

Day-30 pregnancy (Ultrasound/CL) (n=9)	Frequency	Total tested cows (%)
Positive	8	88.9
Negative	1	11.1
Total	9	100

n= number of cows

4.2.6.2. Post-partum infertility

Two cows (16.7%) remained post-partum anoestrus during the 90 days experimental period and they were diagnosed to have cystic corpus luteum (CL) on ultrasound from cows in T_1 and T_3, while one cow (8.3%) from T_1 was repeat breeder and diagnosed to have mild endometerities (Table 30). Anoestrus was observed in fourth parity cows but the difference was statistically not significant (P>0.05) from the other parities (Table 31).

Table 30. The frequency of reproductive disorders in crossbred dairy cows

Fertility parameters (n=12)	Frequency	Total tested cows (%)
No reproductive disorder	8	66.7
Anoestrus, Cystic Corpus Luteum (CL)	2	16.7
Repeat breeder	1	8.3
Mild endometerities	1	8.3
Total	12	100

n= number of cows

Table 31. Fisher's exact test for pregnancy (ultrasound) and reproductive disorders in crossbred dairy cows

	Day-30 pregnancy (Ultrasound)			Post-partum disoredrs				
	No. of examined cows	Positive	Negative	No. examined cows	No problem	Repeat breeder	Cystic CL (anoestrus)	Endometerities (slight), inactive right ovary
Treatments								
T_1	3	2(66.7%)	1(33.3%)	4	2(50%)	1(25%)	1(25%)	0.0
T_2	4	4(100%)	0.0	4	4(100%)	0.0	0.0	0.0
T_3	2	2(100%)	0.0	4	2(50%)	0.0	1(25%)	1(25%)
P- value		P>0.556					P>0.515	
Parity								
P_1	2	2(100%)	0.0	3	2(66.7%)	0.0	0.0	1(33.3%)
P_2	3	3(100%)	0.0	3	3(100%)	0.0	0.0	0.0
P_3	3	2(66.7%)	1(33.3%)	3	2(66.7%)	1(33.3%)	0.0	0.0
P_4	1	1(100%)	0.0	3	1(33.3%)	0.0	2(66.7%)	0.0
P- value		P>0.97					P>0.23	

T_1, Control (farm concentrate); T_2, Formulated concentrate; T_3, Formulated concentrate mixture; P_1, first parity; P_2, second parity; P_3, third parity; P_4, fourth parity; PD, pregnancy diagnosis; CL, Corpus Luteum; No, number

5. DISCUSSION

5.1. Survey Part

5.1.1. Socio-economic characteristics of urban and peri-urban dairy production

5.1.1.1. Household characteristics

The highest educational level of the respondents in the current study was diploma and above which might be related to the existence of different agricultural institutions and market availability. Similarly, Abebe*et al*. (2017) reported that first degree (6.58%)was the highest educational level achieved by household heads in the central highlands of Ethiopia. When farmers have a higher educational level, it helps in better understanding and adoption of new farm technologies as well as for better husbandry practices (Lemma *et al*., 2012; Gizaw *et al*., 2012).

In the current study, the highest percentages of household heads were male, which implies that higher proportions of males were occupied in dairying than the females and also most of the respondents were married. Similarly, male household heads were dominant in dairying as reported by Azage (2004) from Addis Ababa (Ethiopia), Swai *et al.* (2005) from Tanzania and Thys *et al.*(2005) from the West African situation. In the central zone of Tigray, Gebrekidan *et al*. (2012) also indicated that the proportion of male household heads were higher than female heads. The current age distribution pattern reflects that young people are less depended on urban and peri-urban dairy production, which might be due to financial and experience related problems. A study from Hawassa (Ike, 2002) indicated that 33.3% households were in the age group of 41-50 and 30% were in51-60 years, which was comparable to the present results 40-59 years old. The mean family size in urban Assela (5.1) and peri-urban Holetta (5.4) in the current study was consistent with the national average (5.2) (CACC, 2003). The larger family sizes in urban Holetta (7.2), peri-urban Sululta (6.9), peri-urban Assela (6.1), urban and peri-

urban Bishoftu (6.0) and urban Sululta (6.0) were also comparable with the 7.4 and 6.0 persons per household reported from Shashemene and Dilla (Sintayehu *et al.*, 2008) and from Jimma areas (Belay*et al.*, 2011), respectively. The relatively larger family size in the mentioned areas indicated that these households have adequate sources of family labor to use for different routine dairy farm activities such as feeding, cleaning, herding, milking and milk processing. However, the mean family size reported in the present study was slightly higher than the 4.4 persons per household from different areas of central Ethiopia (Abebe *et al.*, 2017). This might be due to data collection time and sampling differences.

5.1.1.2. Occupational status and land holding

Dairying was the major occupation for the majority of the interviewed dairy producers in the present study and it was higher than the 13.7% of farmers involvement in dairy production reported for Sebeta Awsa area (Dereje and Yoseph, 2016). Girma *et al*. (2014) also reported that 29.2% of interviewed dairy farm owners in Shashamane were dairy cow producers. The differences indicated the increasing demand for dairy production.

The overall land holdings (1.17 ha) in peri-urban areas of the present study was similar with Sintayehu *et al.* (2008) who reported land holdings of 1.1 ha in Shashemene-Dilla area. Additionally, the land holdings in peri-urban Assela (1.9 ha) and peri-urban Sululta (1.7 ha) of the present study were comparable with the national average total household land holdings of 1.77 ha in rural areas of Ethiopia (CSA, 2013). Generally, the current land holdings (0.03 to 1.9 ha) are by far less than the land holdings of 2.0 to 5 ha for 32.6% and 16.2% of the smaller farmers in the country and Southern Nations, Nationalities and People's Regional State (SNNPRS), respectively (CACC, 2003). Furthermore, the values were also inconsistent with the total land holdings of 2.5 ha reported for the Dandi district in Oromia region by Belay*et al.*(2012) and 2.12 ha reported in Metekel zone of Benishangul-Gumuz Region (Solomon *et al*., 2014). The variations could be due to rapid population growth and urbanization.

5.1.1.3. Livestock species and herd size

In the present study, crossbred milking cows comprised a relatively larger percentage of the dairy herd in all the study areas which indicates as they are playing significant role in the farmers' economy. Generally, the number of livestock owned by the respondent farmers varied between locations and the farming systems which could be related to several factors such as feed unavailability and costs, land scarcity, and objectives of livestock keeping. Similar to the results, Abebe *et al.* (2017) reported a greater percentage of milking and crossbred cows than other livestock species in different parts of central Ethiopia. The same authors further noted small proportion of male calves which was parallel to the lower average number of male than female calves of the present study. Unlike to the current results, lower numbers of milking cows (0.1-1.7 cows) per household were reported in different parts of Ethiopia (Binyam, 2008; Samson *et al*., 2012). In Bahir Dar and Hawassa also higher numbers of crossbred cows/household (5.4-11) were reported by Haile *et al.* (2012) and Dereje and Yoseph (2014). The differences could be related to variations in the dairy production potential of the areas.

5.1.1.4. Experience in dairy production and source of crossbred cows

In peri-urban Assela and in urban Sululta 40% and 45%, respectively, of the dairy producers have dairy rearing experiences of 4 to 7 years. Comparable to these results, in Mekelle city from 180 respondents the majority (41.7%) of dairy farms were established about 6 to 10 years ago (Solomon, 2014). In urban Bishoftu of the present study, about 40% of the dairy farm owners have greater than 15 years of experiences in crossbred dairy production. Similarly, in Bangladesh, 280 dairy farmers' households were questioned and the majority of the farmers had 10 to 19 years of experiences in dairy farming and most of the highly experienced farmers reared crossbred dairy cattle (Quddus, 2017).

5.1.1.5. Purpose of keeping and ways of differentiating dairy cattle

In majority of the study areas, respondents revealed that the primary purpose of keeping crossbred dairy cattle was milk to generate income. Comparable to these results, in Ethiopia market-oriented urban and peri-urban milk production systems are flourishing as the main suppliers of milk and milk products to cities (Sintayehu *et al.,* 2008). A study by Belay and Geert (2016) in Jimma town also indicated that for most of the respondents (94.4%) the primary reason for keeping dairy cattle was the milk production for income generation. The majority of the interviewed respondents in the present study areas use body color, local name and ear tag, respectively, to differentiate their dairy cattle. In Nyagatare district, Rwanda, most farmers (96.4%) stated that traditional methods of phenotypical animal identification such as names, color patterns and horn shape were dominated for identifying their cows. Accordingly, cows had different names and attributes (Eugene, 2017). The same author further reported that the use of modern methods of identification such as ear tag was very low (3.6%) which was slightly inconsistent with the present results. The variations could be due to differences in management, production system and farm type.

5.1.2. Dairy management practices in urban and peri-urban production systems

5.1.2.1. Housing and record keeping practices

In the current study, almost all dairy owners used separate housing system for their dairy cattle. Similarly, Ayalew (2017) reported that in South Wollo Zone, Dessie town of Ethiopia, all (100%) of the urban and peri-urban respondents used separate houses for their dairy cattle. Additionally, in urban and peri-urban dairy farms of Mekelle, Ethiopia, 80% in urban and 3.33% in peri-urban medium and large scale dairy farms, respectively, used separate housing systems (Hulagersh *et al*., 2017). In Bhutan, Asia, 78% of the total respondents also provided house to their crossbred dairy cattle. However, the rest 22% of the respondents did not supply houses to their dairy cattle (Wangdi *et al*., 2014).

Conflicting to the present results, Asrat *et al*. (2013) reported that 60% of dairy producers in the urban dairy production system of Boditti town, Wolaita Zone used the same house for family and animals. The differences could be attributed to variations in management systems, farm type and financial related issues.

In many of the current study areas, dairy producers were not keeping records. The main reason raised by farmers for not keeping records was lack of awareness on the benefits of keeping records. Similarly, in and around Boditti town, South Ethiopia, 95% of dairy farmers were not practicing record keeping because of inadequate experience and lack of awareness on the benefits (Asrat *et al.*, 2013). The lack of record keeping may have a negative impact on productivity, decision making in progress and also may lead to inbreeding between closely related herds (Desalegn, 2011). Milk yield, service and calving dates were the main parameters recorded by dairy producers. In line with these results, Asrat *et al.* (2016) also stated that in and around Wolaita Sodo town, 42.7% (town) and 27.8% (surroundings) of dairy farmers were found to maintain breeding/AI and reproduction records, respectively.

5.1.2.2. Feeding systems

In most of the present study areas, stall feeding was the main dairy feeding system. But the feeding systems in peri-urban Bishoftu of the current study were tethering and stall feeding systems. Furthermore, grazing and stall feeding were the main feeding practices in peri-urban Sululta and urban Holetta, respectively (Table 8). Inline to the findings, Dessalegn *et al*. (2016) reported 74.6% and 25.4% of the dairy owners in Bishoftu and Akaki towns use stall feeding and stall feeding with limited grazing feeding systems, respectively, as the main feeding practices. Adebabay (2009) also reported that the types of feeding systems noted in the Bure district of Amhara region, Ethiopia were communal grazing and stall feeding. Parallel to the feeding managements in peri-urban Bishoftu of the current study, in and around Shashamane town, Girma *et al*. (2014) as well stated that stall feeding practiced in urban areas. Additionally, in Addis Ababa milk shed and Dire

Dawa town, grazing was not practiced by urban dairy farms (Yoseph, 1999) and (Emebet, 2006), respectively.

5.1.2.3. Estrous detection and breeding systems

Dairy respondents in peri-urban Sululta, urban Bishoftu, peri-urban Bishoftu and peri-urban Assela, respectively, stated that there was anoestrus problem in their dairy herd. Comparable to these results, Roelofs *et al.* (2010) confirmed that achieving efficient estrous detection by visual observation depends on the timing, duration and frequency of observation. In addition, discrete behavioural signs of estrous, non attendance of standing mount for up to 60% of ovulations and the shorter duration of the estrous in modern, high-yielding dairy cows make visual detection of estrous more difficult (Saint-Dizier and Chastant-Maillard, 2011; Kamphuis *et al.*, 2012). Moreover, a study at the veterinary clinic of the school of veterinary medicine in Debre Zeit town by Endris *et al*. (2014) indicated that dairy owners were mostly dependent on estrous signs like bellowing, mucus vaginal discharge and mounting. In another study it was described that long post-partum anoestrus period is a very common problem with cows reared in a tropical environment (Million *et al*., 2011).

Comparable to the natural breeding system in peri-urban Sululta and urban Sululta of the current study, Tesfa (2009) stated that along with natural mating, some farmers used AI in the highland and midland areas of Ethiopia. Similarly, Asrat *et al*. (2013) indicated that in the mixed crop/livestock production system of Boditti town, 65.4% of the households use natural mating using local bulls, 35% of the households use artificial insemination (AI) and the rest (1.7%) use both natural mating and AI service. A study by Solomon *et al.* (2014) also indicated that 100% of the dairy farmers in Metekel zone, Northwest Ethiopia depend on natural mating to inseminate their cows. In Borana zone, on average 75% and 84.2% of respondents of lowland and mid-highland areas, respectively, replied as they used natural bull service for breeding system (Dejene, 2014). In peri-urban Bishoftu, urban Bishoftu, urban Assela, urban Holetta, peri-urban Holetta and peri-urban

Assela, respectively, artificial insemination was the main breeding system. Likewise, Dessalegn *et al.* (2016) stated that in Bishoftu and Akaki towns 50.8% and 46.4% of the respondents used AI as a breeding system for their dairy cattle. However, Asrat *et al*. (2013) reported that 51.7% of the households in the urban system of Boditti town used natural mating by local bulls and the remaining 48.4% used AI. The differences could be related to access and cost of AI service, ease of getting preferred service, access of breeding bull and farmers' awareness.

A study by Misgana *et al.* (2015) in the East Wollega zone, Ethiopia stated that the majority of the dairy owners (50.5%) used both natural and artificial insemination for breeding their dairy cattle alternatively which was not consistent with the current results. The differences might be due to herd type and management variations.

5.1.2.4. Weaning and culling systems

In urban and peri-urban areas of the current study, the majority of the dairy producers experienced calf weaning in their farm. In agreement with these results, about 90.8% dairy cattle producers, both in town and the surrounding of Boditti town practiced partial suckling prior to milking and colostrum is given to calves freely (Asrat *et al*., 2013). In Bure area Adebabay (2009) stated that only 8.9% of the respondents exercise weaning, 64.3% of the respondents exercise partial weaning and the rest 26.8% employ sudden weaning.

Culling was practiced by most of the respondents in urban Holetta, urban Bishoftu, peri-urban Holetta, peri-urban Bishoftu, urban Sululta, peri-urban Sululta, urban and peri-urban Assela. In line with these results, a study in Fogera, Jeldu and Diga districts of the Nile Basin (Ethiopia) indicated that in case of emergencies of both financial and agricultural, the farmers tend to sell the growing herd first and breeding females were maintained in the herd for older age until reproductive performance was nearly stopped (Ayele, 2012). Furthermore, in Bishoftu and Akaki areas male calves were not

economical to keep and farmers sold them cheaply or culled them from the herd as soon as possible (Dessalegn *et al*., 2016).

5.1.3. Milk yield of crossbred dairy cows

The lower average daily milk yield of crossbred dairy cows in peri-urban areas might be attributed to relatively poor management practices and water availability problems. The 8.5 liters average daily milk yield in peri-urban Sululta of the present study was similar with Belay *et al*. (2012) who reported 8.52 liters/day/cow for crossbred dairy cows in Jimma town. The current average milk yield per cow was slightly lower than Nigusu and Yoseph (2014) who found 14.1 liters/day/cow in urban and secondary town dairy production systems in Adama milk shed. This difference could be resulted in lack of proper feeding and other management practices. The current average milk yield reported in urban (11.7 liters) and peri-urban (11.2 liters) Bishoftu was similar to the average daily milk yield of 11.6 liters for crossbred dairy cows with >50% blood levels in Bishoftu town (Dessalegn *et al*., 2016). Similarly, the average daily milk yield in urban (10.4 liters) and peri-urban (10.5 liters) Holetta and urban Sululta (10.8 liters) were also compatible with the average daily milk yield 10.8 liters for crossbred dairy cows in the Akaki area (Dessalegn *et al*., 2016). The overall average milk yield per cow in urban and peri-urban areas of this study was within the average daily milk production of crossbred dairy cows in urban (10.21 to 15.9 liters/day/cow) and peri-urban (9.5 liters/day/cow) systems reported in Ethiopia (Azage *et al*., 2013).

5.1.4. Reproductive performances of crossbred dairy cattle

5.1.4.1. Age at first service (AFS)

In the present study, the age at first service (AFS) in urban and peri-urban areas ranges from 18.8 to 29.3 months for crossbred dairy heifers. Under small scale dairy production in urban and peri-urban areas in Gondar, Nibret (2012) reported an overall mean AFS of

15.4 months for crossbred dairy heifers which was lower than the current results. The variation could be related to breed and management differences. However, the AFS in urban (25.4 months) and peri-urban (25.9 months) Sululta of this study were in line with Belay *et al.* (2012) in Jimma town and Zewdie (2010) in the highlands and central rift valley of Ethiopia who stated age at first service of 24.30±8.01 and 27.5 months for crossbred dairy heifers. The average age at first service in urban (18.8 months) and peri-urban (19.1 months) Bishoftu of the current study were consistent with Dessalegn *et al*. (2016) who revealed average AFS of 18.7 months for crossbred dairy heifers in Bishoftu and Akaki towns.

5.1.4.2. Age at first calving (AFC)

In urban and peri-urban Sululta as well as peri-urban Assela of the present study, the averages AFC were 34.4, 34.9 and 38.3 months for crossbred dairy heifers. Comparable to these results, Hunduma (2012) in Assela, Kumar and Tkui (2014) in Mekelle city, Belay *et al.* (2012) in Jimma and Mandefot (2017) in and around Wolaita Sodo town reported AFC of 34.8±4, 36.4±1.7, 36.6 and 37.5±0.6 months, respectively, for crossbred dairy heifers. The overall mean AFC of crossbred dairy heifers under small scale dairy productions in urban and peri-urban areas of Gondar was reported as 32.4 months (Nibret, 2012). This result was in agreement with the AFC in urban Assela (30.6 months), urban and peri-urban (30.5 months) Holetta of the present study. Dessalegn *et al*. (2016) declared that the mean AFC for crossbred dairy heifers in Bishoftu and Akaki were 27.0 and 26.9 months, respectively, which were similar with the current results in urban (27.8 months) and peri-urban (28.1 months) Bishoftu town.

5.1.4.3. Number of services per conception (NSC)

The relatively very good services per conception in this study might be indicative of the presence of fewer repeat breeder cows in the dairy farms included in the study. It might also attributed to correct timing of insemination, quality of semen, the skill of the

inseminator and cow related factors like less loss of weight before or after insemination, good body condition, absence of uterine infection and hormonal imbalances which could positively affect the success of insemination. Comparable to the number of services per conception (1.3) from peri-urban Assela and urban Sululta of the present study, Nuraddis *et al*. (2011) also reported mean NSC of 1.29 for crossbred dairy cows in North Gondar town. In Jimma, 1.56 NSC were reported by Belay*et al*. (2012) for crossbred dairy cows which was equivalent to the NSC of 1.5 from urban Holetta. The NSC 1.6 reported by Belayneh (2012) for Holstein crossbred dairy cows in North Shewa Zone was also similar with the current NSC of 1.6 in peri-urban Holetta and Sululta as well as urban Bishoftu areas. The current overall mean NSC (1.53) of all the study areas was similar with Hunduma (2012) who reported the NSC of 1.52 in Asella town for crossbred dairy cows.

5.1.4.4. Calving to conception interval (CCI) and calving interval (CI)

The average 101.5 to 168.0 days calving to conception intervals in the current study of all the study areas were longer than the 85.6 days (Hunduma, 2012) from Assela town and the 93.11 days (Niraj *et al*., 2014) from Gondar town. Belay *et al*. (2012) reported longer days open (155.7 days) from Jimma and Zewdie *et al*. (2011) even reported days open of as long as 197 and 194 days from Debre-berhan and Sebeta, respectively, and was in agreement with the higher calving to conception interval (168.0 days) from peri-urban Assela of the present study. The differences could be attributed to poor and inadequate nutrition, genetic variations, poor heat expression and detection and other management variations.

The current calving intervals in urban Holetta (12.7 months), urban Bishoftu (12.9 months), and urban Sululta (13.3 months) were comparable with the calving intervals of crossbred dairy cows reported in Bishoftu and Akaki towns which were 13.0±2.1 and 13.8±1.9 months, respectively (Dessalegn *et al*., 2016). However, studies from North Showa and Jimma Zones indicated that crossbreds of unknown exotic inheritance have calving interval of 660 days (Mulugeta and Belayneh, 2013) and 640.8±3.84 days (Belay

et al., 2012) both of which were higher than the current results. The differences might be attributed to poor nutrition and management practices, longer days open, poor breeding system and disease.

5.1.5. Reproductive health problems and source of veterinary services

As reported by Haile *et al*. (2010) the major reproductive disorders in crossbred dairy cows in different locations around Addis Ababa milk shed were 75.3%, 60.1%, 58.1% and 75.15% in Addis Ababa, Holleta, Debre-Zeit and Sululta and Muka-Turi, respectively. These values vary from the present results which might be related to feed scarcity, breeds of the animals and other management system variations among the different areas of the studies. Retrospective analysis of clinical data in central Ethiopia by Hadush *et al*. (2013) showed 44.3% of the cows had major prepartum and post-partum reproductive problems which were consistent with the occurrence of reproductive health problems reported in Assela (45%) and urban Sululta (40%) but lower than the other areas of the present study. The variations could be attributed to malnutrition and management system related factors. Comparable to the results in urban and peri-urban Assela and urban Sululta of the current study, Dawit and Ahmed (2013) and Ararsa and Wubishet (2014) reported the prevalence of 40.3% of reproductive health problems of cows in Kombolcha, Northeast Ethiopia and 51.1% of the cows were with at least one reproductive health problems in Borena Zone.

Comparable to current results, Tariku *et al*. (2015) in Ada'a district showed that veterinary service providers were classified into public and private. Private veterinary clinics were the main veterinary service providers in urban and peri-urban Bishoftu, peri-urban Assela and urban Sululta areas of the present study. However, Girma (2008) indicated that public veterinary service was the main veterinary service provider in the peri-urban and rural areas of Ada'a district, while, the urban areas receive veterinary service mainly from private veterinary service providers. This variation may be due to

inadequate budget, logistic problems, lack of basic veterinary equipments and scarcity of skilled man power in the public veterinary service providers.

5.1.6. Milk and products marketing

In all, the study areas, the majority of the respondents used to sell their milk and milk products. But low milk price relative to feed cost was their main marketing problem. Dairy products are not consumed during fasting time and most of the milk during this period is processed into cheese (locally Ayib) and butter for later sales and consumption (Tanngka *et al*., 2002). A study in Mekelle town (Solomon, 2014) revealed that the majority of the dairy producers (92%) used to sell milk and milk products and only the remaining 8% use milk for home consumption. Comparable to the marketing problem of the present study, Kassu (2016) mentioned that among the constraints of milk and butter marketing in the Bona district of Southern Nation Nationalities and People Regional States (SNNPRS), of Ethiopia were lack of training related to milk products marketing, distance to marketing points and fluctuation of prices. Studies from East Gojjam Zone, Amhara Region and North and East Showa Zones of Oromia Region of Ethiopia also indicated that the price of fresh milk was highly influenced by different external factors such as farm location, transport access, marketing system, fasting period and processors demand (Dehinenet *et al*., 2016).

5.1.7. Constraints and opportunities of dairy production

5.1.7.1. Constraints of dairy production

High feed costs, land scarcity and space limitation and feed quality and availability problems were mentioned by respondents as the primary dairy production constraints in almost all the present study areas. Comparable to these results, Sintayehu *et al*. (2008) also reported that the scarcity and costs of feeds were the major constraints in Shashemene-Dilla area, South Ethiopia. Zelalem *et al*. (2011) as well indicated that

inadequate animal feed resources as one of the important challenges of the Ethiopian dairy sector. In Boditti town, South Ethiopia land shortage and availability and costs of feeds were reported as the principal constraints of dairy production (Asrat *et al*., 2013). A recent study by Haftu (2015) described that feed scarcity and high feed cost were the main constraints of dairy production in Hossana town. The same author further mentioned that space limitaton was another dairy production constraint in the study area. Feed shortage was also identified as the key constraint of dairy production in Dale and Shebedino districts (Terefe *et al*., 2014). As reported by Malede *et al*. (2015) land shortage was the major constraint on dairy production in Gondar town. Asrat *et al*. (2016) added that land shortage and feed scarcity were the primary constraints which hamper dairy production in Wolaita Sodo town.

5.1.7.2. Opportunities for dairy production

High demand for milk consumption, the existence of the research institutions, income generation and employment creation as well as service providers were mentioned as the main opportunities for dairy production by dairy producers in different areas of the present study. Inline to these results, studies in the Ethiopian highlands indicated that dairying generated 34% of the total household income of farmers in the Holleta area (Mohamed *et al*.,2003) and 48.9% of the urban farmers of Southern Ethiopia (Sintayehu *et al*., 2008). Azage *et al*. (2006) concluded that urban and peri-urban dairy production systems could contribute to overall development through income generation and employment opportunities. Azege *et al*. (2013) also mentioned that the large and diverse dairy animals genetic resources adapted to the wide and various agro-ecologies, establishment of several structures and service centers such as veterinary health and AI centers, high demand for consumption of dairy products, huge human population with long-standing tradition of consumption of dairy products, high rate of urbanization and income growth, availability of trained manpower, research institutions and technologies shows that Ethiopia has ample opportunities for dairy development. A study by Solomon (2014) also revealed that because of the rapid urbanization, extensive population growth

and change in the living standard of the people in Mekelle city, dairying gives the opportunity for dairy producers to generate income as it is highly demanded product. The same author further mentioned other opportunities for milk producers in the same area concerning to accessing adequate land and credit for dairy cooperatives, animal health service, AI service and extension and training services. In Wolaita Sodo area, high milk demand was the main opportunity to dairy production as stated by Asrat *et al.* (2016) which was consistent with the present results. The authors added that dairying provides the opportunity for smallholder farmers to use land, labor and feed resources and generate regular income.

5.1.8. Available feed resources in urban and peri-urban dairy production systems

5.1.8.1. Land use and ownership

In urban Bishoftu (90%), urban Sululta (90%) and urban Holetta (85%) respondents stated that they do not totally have access to land. Yitaye *et al*. (2007) in Bahir Dar town and Dangla areas described that in urban areas about 75% of the farmers do not have access to land. In Bahir Dar and Gondar, Yitaye *et al*. (2011) also reported that in urban areas, 70% of the farmers do not have access to farm land which was lower than the current values in Bishoftu, urban Holetta and urban Sululta areas. The differences could be attributed to the recent rapid population growth and urbanization in urban areas. The current results highlighted that a higher proportion of the owned land in peri-urban areas were used for crop production, forage production and grazing systems. Comparable to these results, in the West Shoa zone of Oromia region, Bainesagn (2016) indicated that land holding for crop production, which was owned and rented in rural and peri-urban areas was higher than in urban areas. Similarly, the author further stated that land for grazing and forage and irrigation was higher in peri-urban and rural areas.

5.1.8.2. Common feed resources

Crop residues, concentrates (mainly from agro industrial by-products), hay, communal pasture, private pasture, improved forage and backyard forage were the commonly used dairy feed resources in the present study areas. Comparable to these results, in Bahir Dar town and Dangla areas the major sources of livestock feed resources were natural pasture, hay, crop residues and concentrates (Yitaye *et al*., 2007). Yitaye *et al.* (2009) and Azage *et al*. (2013) also noted that the major roughage feed resources for dairy animals across all the different Ethiopian production systems include natural pasture/grasslands, grass hays, crop residues and non-conventional feed resources. Sintayehu*et al*. (2008) in Shashemene area, Yitaye (2008) Northwest Ethiopia and Kechero *et al*. (2013) in Jimma Zone further reported that natural grazing lands, crop residues, pasture, forage crop and agro-industrial by-products were the main livestock feed resources. In Meta Robi district, West Showa Zone, natural pasture and crop residues such as wheat straw, barley straw were the dominant feed resources, but agro-industrial by-products such as noug seed cake, linseed cake, molasses, brewery by products, non-conventional feed and improved forage were uncommon and rarely used (Endale *et al*., 2016). These were not similar to the present results which could be due to differences in feed availability, price and management systems.

5.1.8.3. Types of available crop residues

In the present study, wheat straw, barely straw and teff straw were the mainly used crop residues. Similarly, Solomon and Alemu (2009) reported that teff, wheat and barley straws were the major crop residues available in the Ethiopian highlands. In Gondar town, crop residues such as wheat, barley, teff straws and maize thinning were used by farmers as basal diets for dairy animals (Malede *et al*., 2015). Abate *et al.* (2010) as well noted that straw from maize, sorghum and teff was used mainly during the dry season in southeastern parts of Ethiopia. In urban Assela, urban Holetta and peri-urban Sululta of the current study wheat and barley straws were the dominantly used crop residues.

However, around Ziway barley straw was the most preferred feed by dairy owners followed by maize stover (Zewdie, 2010). The differences could be attributed to the variations in availability and farmers awareness.

5.1.8.4. Frequency of providing feed supplements

In the current study, provision of feed supplements was mainly practiced twice and three times a day. As described in DeVries *et al*. (2005) increasing the frequency of feed delivery has been shown to modulate the feeding patterns of lactating dairy cattle with cows fed more frequently, spending more time feeding, increase the distribution of feeding time over the course of the day and improve access to fresh feed for all cows and this idea helps the current feeding practiced in the study areas. In Fafan town, Somali region (Ethiopia) 52.08% and 41.67% respondents were provided feed two times per day for lactating and non-lactating dairy cattle, respectively (Abdirahin and Kefyalew, 2015). The authors further revealed that 41.67% and 20.83% of the farmers in the same area provide with feed three times a day for lactating and non-lactating dairy cattle which was comparable with the present results in urban and peri-urban Assela, peri-urban Sululta, and peri-urban Bishoftu. However, 6.25% and 37.5% of respondents in Fafan town supply once a day for lactating dairy cattle and non-lactating dairy cattle, respectively. Nikkhah (2011) also mentioned that feed delivery once per day is labor effective and more desirable for many small and mid-size farms. The differences could be related to variations in feed availability, farm type, labour force and management systems.

5.1.8.5. Frequency of water provision

The water provision in peri-urban Holetta (65%), peri-urban Sululta (65%) and urban Sululta (45%) of the current study was twice a day. Similarly, in the Highland production system (Debre Birhan, Jimma and Sebeta), dairy farmers, mostly provide water twice a day for cattle (Zewdie, 2010). As reported by Bernabas *et al*. (2017) in Alefa district of North Gondar zone, 66.7% of the respondents were also watered their dairy cattle twice

per day. About 90% of the respondents in peri-urban Assela of the current study provide water once a day. Comparable to the results, a study in Mekelle city noted that 65.6% of respondents were watered their animals once a day (Tilahun and Gebregiorgis, 2016). About 38% of the respondents in the Quara district of North Gondar zone were watered their dairy animals once, twice, and three times a day, respectively, which were similar to the present results in urban Sululta (Bernabas *et al*., 2017). Overall, respondents in urban (17.5%) and peri-urban (11.3%) areas of the present study provide water *ad libitum* for dairy cattle. Inconsistent to these results, in Adigrat, Tigray Alemshet (2014) noted that 28.9% respondents in urban and 15.25% respondents in peri-urban areas provide water *ad libitum* for dairy animals. The differences might be attributed to differences in feed type and water availability.

5.2. Feeding Experiment

5.2.1. Chemical composition of the experimental feeds

The crude protein (CP) content of noug seed cake (NSC) in the present experiment (30.9%) was similar with that of 31.26% and 28.2% reported in Abebaw and Solomon (2008) and Wondimagegne *et al*. (2016), respectively. The grass hay used in the present study had slightly lower level of CP content than the minimum level of 7% required for optimum rumen microbial function (VanSoest, 1982). The CP content of grass hay (6.8%) in the current study was in agreement with Aschalew and Malede (2013) who reported 6.7%. The NDF content of grass hay (73.1%) in the present study was nearly equivalent to the 74.4% NDF value reported by Gezu *et al*. (2017). The NDF content of roughage feeds less than 45% are categorized as high quality, 45 to 65% as medium quality and those more than 65% as low quality roughages (Singh and Oosting, 1992). Therefore, grass hay used in the study might be categorized as low quality roughage that may indicate limitation on dairy cow performance. According to Kellems and Church (1998) roughage feeds with less than 40% ADF are categorized as high quality and above 40% as low quality. As a result depending on the ADF content, the grass hay used in the

present study was categorized as good quality. The CP content of wheat middling (17.8%) was within the CP range of wheat bran of 16 to 21% (McDonald, 2002) and similar to the CP contents of wheat middling 17.8% (Adugna, 2008).

The CP content (26.5%) of the concentrate ration from T_1 used in both feeding phases was similar. Similarly, Mesfin *et al*. (2013) investigated 26% CP content from farmers' home-mixed concentrate for lactating crossbred dairy cows in smallholder peri-urban dairy production systems in West Shewa zone (Ejere, Walmera, Burayou and Ambo districts) of central Ethiopia. The same authors also noted from the same study, 10.8 MJ/kg DM of ME from home-mixed concentrate for lactating crossbred dairy cows.

5.2.2. Dry matter and nutrient intake of experimental cows

Similar to the current results, Khazanehei *et al*. (2015) reported that dry matter intakes expressed as amount per day and as a percentage of body weight per day were not affected by treatment diets during the six weeks before calving feeding periods. In the current trial, the variation in average daily ME and DM intakes among parities during the late pregnancy period could be attributed to the differences in physiology, ration formulation and the amount of feed supplementation. Comparably, Hayirli *et al.* (2002) reported that transition from gestation to lactation is characterized by a dramatic decrease in DM intake and the average decrease in DM intake of heifers was less than cows during the final 3 weeks of gestation. During the early post-partum period the differences in average DM and nutrient intakes could be due to the differences in ration, milk yield and way of feeding. The lower daily average ME intake of cows in T_1 than T_2 and T_3 could be due to the high protein intake of cows in T_1 (Table 22). Similarly, increasing dietary protein concentration above the requirement reduced the daily and cumulative energy balance (Law *et al*., 2009). Assaminew and Ashenafi (2015) also reported that agro-industrial by-products used by farmers to feed lactating crossbred cows were usually mixed in similar mixtures despite milk yields. The daily ME intake during the milking period for cows in T_3 (129.3 MJ/day) was comparable with the daily ME intake of 133

MJ/day for milking crossbred cows in hay based diets (Rehrahie and Getu, 2010). But, the average daily CP intake in the current study was higher than the 1508 g/day reported by the same authors which could be related to the differences in the rations and daily DM intake. Similar to the current results, multiparous cows had a greater intake than primiparous cows (Janovick and Drackley, 2010).

5.2.3. Milk yield and composition

The differences in average daily milk yield among treatment groups in the current study could be accredited to the differences in the way the feeding was practiced, crude protein and energy contents in the feeds, which were consistent with earlier reports (Steinshamn, 2010). The ADMY of cows in T_2 15.8 liters/day/cow was consistent with the 15.5 liters/day/cow in urban dairy production systems in Adama milk shed (Nigusu and Yoseph, 2014). The higher average milk yield results of cows in T_2 (15.8 liters/day/cow) and T_3 (14.2 liters/day/cow) in the current study than the average milk yield results around Holetta (11.1 liters/day) (Assaminew and Ashenafi, 2015) and 11.6 and 10.8 liters/day in Bishoftu and Akaki towns (Dessalegn *et al*., 2016) might be related among others, to differences in the composition of the ration, feeding management and breed variations. Comparable to the current results, Jemila and Achenef (2012) mentioned that the average milk yield of primiparous cows was higher than multiparous cows. The higher average daily milk yield in fourth parity cows of the present trial might be due to the increasing development and size of the udder with a resulting increase of secretory cells and energy intake differences. Shuiep *et al*. (2016) as well highlighted order of parity were significantly ($P<0.01$) affecting the daily milk yield.

There were statistically no differences ($P>0.05$) in milk compositions of the present study. Compatible with these results, Netsanet *et al*. (2015) investigated that the milk total solids, crude protein, lactose, solid-not-fat, total ash, calcium and phosphorus contents of milk samples from cows fed diets having different ratios of roughage to concentrate were statistically not varied ($P>0.05$) due to dietary differences. Milk

compositions were also statistically not affected (P>0.05) by the parity differences which was comparable with Jemila and Achenef (2012) who indicated that milk fat, SNF, protein, lactose and pH were statistically not different (P>0.05) in primiparous and multiparous cows.

5.2.4. Reproductive parameters

Ferguson *et al*. (1994) determined that the body condition score (BCS) of an adult cow during the first two months of lactation should decrease by no more than 0.5 to 1 point which was consistent with the current results (Table 24). Hasan *et al.* (2011) found statistically significant (P<0.01) effect of pregnancy rate on different BCS groups in which cows having BCS 3.1 - 4.0 (very good condition) showed better pregnancy rate. Unlike to the current results, Tolla and Vijchulata (2006) failed to report statistical variations (P<0.05) in calving to first heat sign interval among treatment diets which could be attributed to management differences. The current results of number of services per conception (NSC) 1.3 and 1.4 were comparable with Moges (2012) who reported 1.3 services per conception in urban areas in Gonder. The CCI of the present study was lower than the CCI of 176.8 days in the urban areas of Addis Ababa (Lemma and Kebede, 2011). At Bishoftu and Akaki towns, CI was 13.0 and 13.8 months, respectively, for crossbred dairy cattle as reported by Dessalegn *et al*. (2016) which were higher than the current estimated CI values. The variations could be due to BCS and management differences. Similar to the present study, non-significant effect (P>0.05) of parity on NSC was also reported by Ibrahim *et al*. (2011). Khan *et al.* (2015) reported higher conception rate in cows at second and third parity than that of cows at zero parity, which were comparable to the current results (Table 24).

5.2.5. Effect of different rations on early post-partum blood plasma metabolites

The average plasma glucose concentration was statistically not significant (P>0.05) among different treatment groups and parities (Table 25). This finding was in agreement

with Khan *et al*. (2011) who reported non-significant differences in glucose concentration during pre- and post-partum periods in buffaloes. Similarly, Wiedemann *et al*. (2013) reported the early post-partum glucose concentration of 55.85 mg/dl, 55.85 mg/dl and 57.66 mg/dl for week 1, 2 and 3 after calving, respectively. Wiedemann *et al*. (2013) also stated that differences in weekly glucose concentration early post-partum was statistically not significant (P>0.05). Veena*et al*. (2015) as well reported that there was no statistical difference (P>0.05) in the plasma glucose values for the first three months post-partum among cows.

The average plasma cholesterol at calving was higher for cows in T_1 (116.0 mg/dl) than T_2 (87.0 mg/dl) and T_3 (83.6 mg/dl). Similarly, Gross *et al*. (2015) reported that cholesterol metabolism in dairy cows is affected by nutrient and energy deficiency depending on the stage of lactation. Guretzky *et al*. (2006) also reported an increase of blood cholesterol concentration from 1-3mM to 6-7mM from first week of lactation to 8 weeks post-partum which was comparable to current results (Table 25). In the same way, Souza and Junior (2009) and Garcia *et al*. (2011) reported a continuous increase in cholesterol concentration as days in milk increased, a result that was compatible with the present study. However, Wiedemann *et al*. (2013) stated statistically not significant differences (P>0.05) in cholesterol concentration for week 1, 2 and 3 post-calving. The variation in blood plasma cholesterol in the different studies may be related to differences in breed, environment and ration. When parity is considered average plasma cholesterol concentration was increased in both primiparous and multiparous cows in the current study. But, Colakoglu *et al.* (2017) reported that primiparous cows had lower cholesterol concentration than multiparous cows. The difference in plasma triglycerides among treatments in the present work was similar to that of Rukkwamsuk *et al*. (1999). Liver accumulates high amount of triglycerides in cows with nutritional deficiency (Rukkwamsuk *et al*., 1999). Liver accumulation of triglycerides was associated with impaired fertility (Drackley *et al*., 2001).

The average plasma urea concentration at calving (23.56 mg/dl) reported by Khan *et al*. (2011) was similar to the average plasma urea values of cows in T_2 (23.3 mg/dl) and T_3 (24.7 mg/dl) but lower than the average plasma urea values of cows in T_1 (42.2 mg/dl) of the present study which could be related to cows in T_1 received non formulated rations. Zhangrui *et al*. (2015) showed that the circulating urea concentration was highly correlated to changed expression levels of many genes in the endometrium shortly after calving. These were predominantly associated with tissue repair, innate immunity and lipid metabolism. Increased plasma or milk urea nitrogen concentrations are highly correlated with decreased fertility in cows (Wittwer *et al*., 1999). Also Butler (2001) reported that increased plasma urea concentrations may interfere with the normal inductive actions of progesterone on the micro-environment of the uterus and, thereby, causing suboptimal conditions for support of embryo development. The total protein concentration in early post-partum cows reported by Sheikh *et al*. (2017) was comparable with the average plasma total protein values of cows in T_2 and T_3 but slightly lower than the values of cows in T_1,which could be due to non formulated ration in T_1 (Table 26).

Barbara *et al*. (2016) reported comparable results of AST concentration in blood of dairy cows at day 3, 5 and 28 post-calving. The insulin concentration at week 1 after calving reported in Wiedemann *et al*. (2013) was similar to the average plasma insulin values of the current results (Table 27). But unlike the current results, the authors failed to report statistically not significant differences ($P>0.05$) in insulin concentration 1.7 mU/l, 3.0 mU/l and 6.9 mU/l for week 1, 2 and 3 post-calving, respectively, which could be related to individual factors, geographical location and ration differences. Gong *et al*. (2002) also reported that plasma insulin concentrations decreased during the first week post-partum and then increased with time during their 50 days experimental feeding period. The maintenance of progesterone synthesis requires insulin, which facilitates lipoprotein utilization in bovine luteal cells (Haq, 1992; Poff *et al*., 1998).

5.2.6. Post-partum fertility and related problems

Post-partum body condition score (BCS) at the service of cows of the present study was higher for cows from T_2 (3.3) and T_3 (3.2) than T_1 (2.5) though not significantly different (P>0.05). The BCS is linked to stored energy fat reserves which in turn related to the energy balance and fertility (Chagas *et al*., 2007). Berry *et al*. (2006) showed that cows on higher feeding levels or a balanced diet mobilized less stored fat and will have a good BCS in early lactation than cows on lower feeding levels. First and second parity cows showed higher BCS than third and fourth parity cows. Similarly, Bewley *et al.* (2008) noted that loss in BCS tends to increase with increasing parity and first-parity cows are generally managed to calve in the greater BCS than later-parity cows. Chamberlain and Wilkinson (1996) also reported that the energy status of the cow, seen by the change in the BCS, also affects fertility.

5.2.6.1. Conception and pregnancy rates

The day-21 average plasma progesterone concentrations were greater than 6 ng/ml (Table 28). Similar to these results, Dhami *et al.* (2017) reported that the mean plasma progesterone values were found to be maximum (>6 ng/ml) in pregnant cows. Lobago *et al*. (2009) also reported plasma progesterone concentrations of 1.7–8.9 ng/mL at the 4^{th} week of pregnancy that remained elevated throughout the gestation period in crossbred dairy cows.

As diagnosed by ultrasonography, the overall day-30 pregnancy rate was 88.9% (Table 29) and differences were statistically not significant (P>0.05) (Table 31). Unlike the current results, the pregnancy rate was statistically (P<0.05) affected by feeding interventions (Alam and Sarder, 2010).The authors also noted that parity did not significantly affect pregnancy rate. Stangaferro *et al*. (2017) mentioned that pregnancy per AI in primiparous cows was higher than multiparous cows. The probable reasons might be due management and/or feeding differences and uterine infections which

frequently develop in cows having repeated parities than primiparous cows. The uterine involution will be delayed in cows with post-partum endometritis (Bruun *et al*., 2002).

5.2.6.2. Post-partum infertility

Two cows (16.7%) remained post-partum anoestrus during the 90 days experimental period and they were diagnosed to have cystic corpus luteum (CL) on ultrasound, while one cow (8.3%) was repeat breeder and diagnosed to have mild endometerities which might be due to abnormal ovarian activity (Table 30). As studied by Mojtaba and Abdolah (2010), cows with abnormal ovarian activity had more days open and required more inseminations per conception compared to that of cows with normal ovarian activity and progesterone profiles. Additionally, Khan *et al*. (2016) also reported that post-partum anoestrus as the most common cause of infertility in cows followed by repeat breeding. Anoestrus was observed in fourth parity cows, but it was statistically not significant ($P>0.05$) from other parity groups (Table 31). Comparable with the present results, Khan *et al.* (2016) reported significantly higher post-partum anoestrus cases in third parity followed by 4-5th parity cows. The same authors further indicated a lower incidence of reproductive disorders in first parity cows. The variation could probably be due to cows having parity higher than 3 develop uterine infections due to the delayed involution of the uterus and chances of endometritis. Balendran *et al*. (2008) stated that lower pregnancy rate was observed in higher parity animals. Couto *et al*. (2013) revealed that in post-partum cows, endometritis was the major cause of poor fertility and delayed conceptions. Cows with high milk production have the highest incidence of infertility under some circumstances; however, epidemiological studies indicate that, in addition to milk production, other factors such as calving disorders, post-partum negative energy balance, uterine infections, heat stress, and nutrition may contribute to decreasing reproductive efficiency in dairy herds (Leroy *et al*., 2008). Similar to the present results, primiparous cows are at higher risk of clinical endometritis compared to second-parity cows (Aghamiri *et al*., 2014).

6. CONCLUSIONS AND RECOMMENDATIONS

6.1. Conclusions

Based on the results of the present study, it could be concluded that the educational level of dairy producers was diverse, most dairy farms were male headed and young people were not participating in the dairy production systems. In most of the areas, the family size was high, dairy production was the main occupation and there was high crossbred cows preference over local cows for generating income. All farmers use separate housing system to keep their dairy cattle and stall feeding was the main feeding system. Artificial insemination was described as the prime breeding system practiced in the dairy farms.

Overall, the better average daily milk yield was in Bishoftu, Holetta and urban Sululta dairy farms. The shortest and longest age at first service of dairy heifers was in Bishoftu and peri-urban Assela, respectively. The number of services per conception was greater in Bishoftu than other areas. The calving to conception interval was longer in peri-urban Assela. High feed costs, land scarcity and space limitation as well as feed quality, availability and costs were the primary constraints of dairy production. Despite the existing problems, demand for milk consumption, research institutions, income generation and employment opportunities, service providers and infrastructure were the opportunities for dairy development in the study areas. Crop residues, concentrates, hay, communal pasture, private pasture, improved forage and backyard forage were the common feed resources used for dairy cattle. Wheat straw, barely straw and teff straw were among the mainly used crop residues. The provisions of feed supplements and water were mainly practiced twice a day in the dairy farms.

Good quality agro-industrial byproducts alone can be used as suitable feed ingredients in formulating dairy ration when they are formulated according to the cows' requirements and stage of production. Appropriate and separate feeding schedule of dairy cows during pre-calving period improves post-calving milk production, body condition score,

initiation of ovarian cyclicity and calving to conception intervals. Generally, feed supplementation, in terms of providing a formulated ration with the easily available feed ingredients in the cows' diet found that increasing in milk yield and improves reproductive performances. The average plasma cholesterol at calving, triglycerides at week one after calving, total protein at week two after calving and urea concentrations at calving, week one and two after calving were varied with the ration differences. But the early post-partum average plasma glucose, albumin, globulin, AST, insulin and progesterone concentrations were not varied by the ration differences.

6.2. Recommendations

From the present study it could be recommended that

- The great potential of urban and peri-urban dairy production in sustaining food security of the farmers, generating family income and creating job opportunity would be considered and experts and different institutions should work together with the farmers to fill the existing gaps and improve production. Dairy technologies, creating awareness and knowledge transfer should be the priority areas.
- Further on farm monitoring and evaluation researches with wider area converges should be done on the proper use of available feed resources, feeding and watering practices to evaluate the productive and reproductive performances of crossbred dairy cows.
- There was laboratory equipments and expertise limitation to measure non-esterified fatty acids (NEFA) which is a good indicator of negative energy balance in dairy cows. Thus, it should be fulfilled at least at government level to improve dairy production.
- Further experiments that use large number of dairy cattle, different ration formulation, different genetics and with high quality roughage feeds should be conducted to investigate the more appropriate agro-industrial by-products for dairy ration formulation.

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8. APPENDICES

Appendix A. Questionnaire used in the study (site specific information)

Survey Site: _____Kebele Name _____Urban, Peri urban_____

Farm Type (small, medium or large)_____

Enumerator Name _____ Date of interview _____/_____/_____

1. House Hold Characteristics

1.1. Education level of the respondent

1. Illiterate 2. Read and write 3. Primary school 4. Secondary school 5. Traditional schooling 6. Diploma and above

1.2. Sex of the household head

1. Male ☐ 2. Female ☐

1.3. Age of the respondent (yrs) 1. Under 20 2. 20-293. 30-39 4. 40-49 5. 50-59 6. 60-69 7. Above 70

1.4. Number of family members in the household_____

1.4.1. Occupational status of household members 1. Business man 2. House wife 3. Farmer and/or dairy cows owner 4. Government employee 5. Non government employee 6. Investor 7. Retired personnel's 8. Other/s

_____

1.4.2. Marital status of the respondent 1. Married ☐ 2. Single ☐ 3. Divorced ☐ 4 other _____

1.5. Land holding/farm size (hectares) _____

1.5.1. Land use

1. Crop production 2. Grazing* 3. Forage production

*other than communal grazing _____

1.5.2. Land ownership

1. Own 2. Lease 3. Own and lease 4. Others_____

2. Livestock Typeand Herd Composition

Livestock type		Composition	Average Number
Cattle	Milking cows	Local	
		Crosses	
	Pregnant cows	Local	
		Crosses	
	Non-pregnant cows	Local	
		Crosses	
	Dry cows	Local	
		Crosses	
	Total cows	Local	
		Crosses	
	Oxen	Local	
	Heifers	Local	
		Crosses	
	Bull	Crosses	
	Female calves	Local	
		Crosses	
	Male calves	Local	
		Crosses	
Sheep			
Goats			
Chicken			
Horses			
Donkeys			
Mules			

3. Dairy Productionand Management Practices

3.1. Experience in keeping dairy animals (yrs)? 1. 1-3 2. 4-7 3. 8-11 4. 12-15 5. >15

3.2. Source of dairy animals

1. Ranch through Agriculture offices 2. Ranch through service cooperatives 3. Gift from family 4. Gift from NGOs 5. Purchased from local market 6. Given from relatives and/friends 7. Rearing (own source)

3.3. Currently how many crossbred dairy cows you have? 1. < 3 2. 3 - 10 3. >10

4. Others_____

3.4. Why you keep dairy cattle? 1. To produce milk for home consumption 2. To produce milk to generate income 3. To produce milk for home consumption and to generate income 4. To use for gift 5. Others _____

3.5. How do you differentiate among the different dairy cows in your flock?

1. Color 2. Size 3. Milk quantity 4. Using ear tag 5. Local name 6. Others (specify) _____

3.6. Who is mainly responsible for the dairy cattle? 1. Female head 2. Male head

3. Children 4. Other laborer 5. All family members 6. Other_____

3.7. What are the main types of dairy cattle feeding systems?

1. Grazing 2. Tethering 3. Stall feeding 4. Combination of feeding systems 5. Other ____

3.8. Is there separate house for dairy cattle? 1. Yes ☐ 2. No ☐

3.8.1. If yes what is the housing type for dairy cattle? 1. Open sided house 2. Closed sided house 3. Normal house 4. No separate house 5. Others

3.8.2. If no separate house, how you keep them? 1. Together with other animals 2. Together with family 3. Freely in the compound 4. Others _____

3.9. Dairy farm sanitation 1. Good 2. Fair or medium 3. Dirty looking 4. Difficult to judge 5. Other _____

3.10. If there recording system in the farm? 1. Yes ☐ 2. No ☐

3.10.1. If yes, what parameters are recorded?

_____

_____

_____

3.10.2. If there is no record, why?

_____

3.11. Do you wean your calf? 1. Yes ☐ 2. No ☐

3.12. System of weaning exercised by the owner? 1. Isolation and herding separately

2. Protection from suckling without isolation 3.Others _____

3.13. Do you practice culling? 1. Yes ☐ 2. No ☐

3.14. If yes, why do you cull?

1. Disease 2. Age 3. Infertility 4. Low milk yielder 5. Financial difficulties

6. Other (specify) _____

4. Feed Resources and FeedingSystems

4.1. What are the primary sources of feeds for your dairy cows in each month? Write in the table below.

Season/Month													
Source	Spring			Winter			Autumn			Summer			Specify each type of feed e.g. Teff straw, wheat straw, wheat bran, wheat short, Sesbania, oat, vetch, alfalfa, Napier grass etc.)
	S	O	N	D	J	F	M	A	M	June	July	Aug	
Communal pasture land													
Private pasture land													
Hay													
Backyard forage													
Improved forage													
Crop residues													
Supplementary feed (feed supplements)													
Others, specify													

4.2. Do you use feed supplements for your dairy cattle? 1. Yes ☐ 2. No ☐

4.3. Frequency of providing feed supplements for dairy cattle and/cows

1. Once a day 2. Twice a day 3. Three times a day 4. Four times a day 5. No supplements

4.4. When you mostly supplement your dairy cows? 1. Early pregnancy 2. Mid pregnancy 3. Late pregnancy 4. During milking period 5. During dry period 6. Other _____

4.5. How frequently do you provide water for dairy cattle and/cows?

1. Roam freely 2. Once a day 3. Twice a day 4. Three times a day 5. Every other day 6. Other _____

5. Breeding, Productiveand Reproductive Performancesof Dairy Cattle

5.1. Do you detect estrous in cows? 1. Yes ☐ 2. No ☐

5.2. In which month/season of the year you detect estrous mostly? _____

5.3. What is the average age at first service (AFS) for crossbred dairy heifer? ____months

5.4. What are the average times of services for female to become pregnant? _____times

5.5. Do you measure the amount of milk produced per cow per day? 1. Yes ☐

2. No ☐

5.6. If yes, what is the average daily milk yield (ADMY/liter/day) per crossbred cow in your farm? _____liters/day

5.7. Was there anoestrus problem in your cows or heifers? 1. Yes ☐ 2. No ☐

If yes, what do you think the reason/s?

_____

_____

_____

5.8. What is the average age at first calving (AFC) for crossbred dairy heifer?___months

5.9. Calving interval (CI) for crossbred dairy cows? _____months

5.10. Intervals from calving to conception (CCI) for crossbred dairy cows? _____days

5.11. What type of breeding system do you use for service?

1. Natural (bull service) 2. Artificial insemination 3. Both systems 4. Other_____

6. Reproductive Health Problems and Veterinary Services Provider/s

6.1. Are there reproductive health problems? 1. Yes ☐ 2. No ☐

6.2. Source of drug and veterinary service

1. Government clinic 2. Private clinic/ veterinary drug shop 3. Both 4. Others _____

7. Milk and Milk Products Marketing

7.1. Do you sell milk and milk products? 1. Yes ☐ 2. No ☐

7.2. If no, why? 1. Less production 2. Marketing problems 3. Lack of awareness

4. All 5. Other _____

7.3. Marketing problems

_____
_____
_____
_____
_____

8. Constraints and Opportunities

What are the major constraints and opportunities of dairy production in yourarea?

Major constraints

1._____
2._____
3._____
4._____
5._____
6._____
7._____

Opportunities

1._____
2._____
3._____
4._____
5._____
6._____
7._____
8._____

Appendix B 1. Sample pictures of interview with urban and peri-urban dairy producers and situation of dairy farms






Appendix B 2. Sample pictures from the feeding trial

Mixed dairy ration (formulated feed)

Experimental rations according treatments

Individual feeding

Researcher providing experimental ration

First parity cow with her calve (formulated feed)

Cows feed formulated ration

First parity cow from the control group

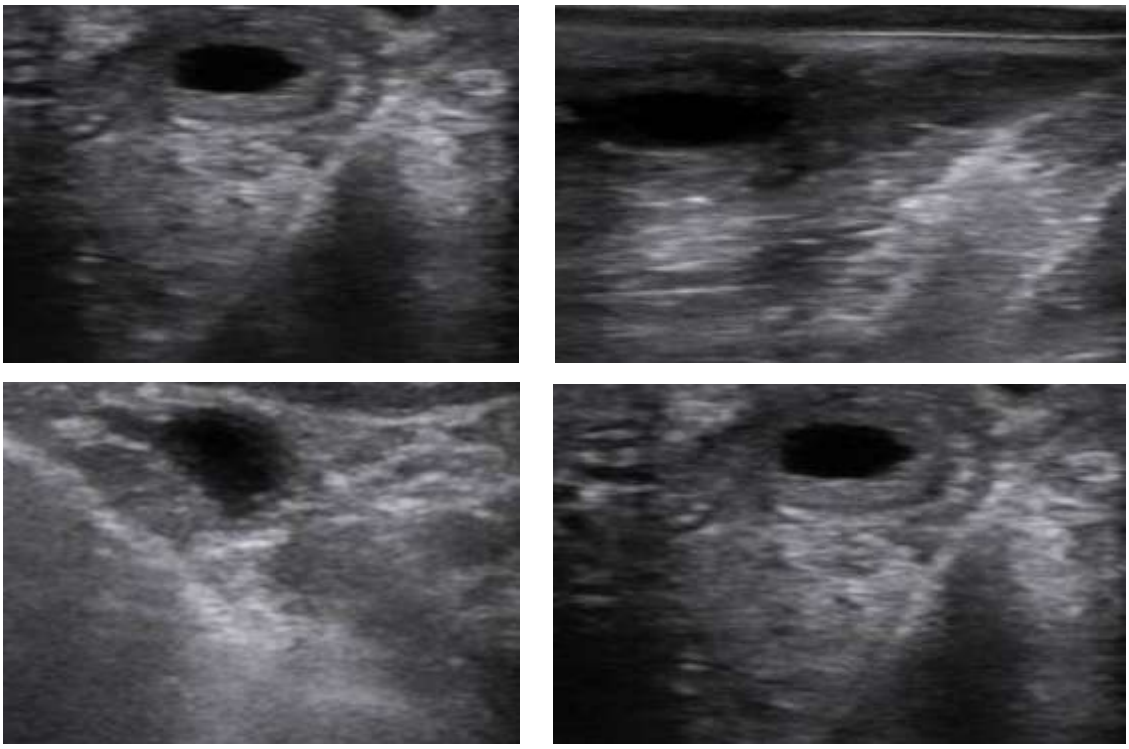
Cow from the control group (fed farm ration)

Crash done for pregnancy diagnosis

Cow on a crash (fed formulated diet)

Post-partum pregnancy diagnosis by rectal ultrasound

Sample results of day 30 pregnancy diagnosis by rectal ultrasound



Appendix C 1. Summary of ANOVA table for daily dry matter and nutrient intakes per cow during prepartum period of crossbred dairy cows fed different diets

Tests of Between-Subjects Effects							
Source of variation	Dependent Variables	df	Type III Sum of Squares (Prepartum period)	Mean Square	F-value	P-value	Sig.level
Trt	Concentrate intake on DM basis	2	28.703	14.351	150.173	0.000	***
	Hay intake on DM basis	2	32.546	16.273	21.081	0.000	***
	Total daily feed intake/cow (DM)	2	5.328	2.664	2.775	0.064	NS
	Total CP intake on DM basis	2	98417015.432	49208507.716	1467.104	0.000	***
	Total ME, MJ/day/cow on DM basis	2	1089.473	544.736	8.154	0.000	***
Parity	Concentrate intake on DM basis	3	1.114	0.371	3.886	0.010	**
	Hay intake on DM basis	3	19.332	6.444	8.348	0.000	***
	Total daily feed intake/cow (DM)	3	11.642	3.881	4.043	0.008	**
	Total CP intake on DM basis	3	134947.103	44982.368	1.341	0.261	NS
	Total ME, MJ/day/cow on DM basis	3	552.357	184.119	2.756	0.043	*
Error	Concentrate intake on DM basis	285	27.236	0.096			
	Hay intake on DM basis	285	220.006	0.772			
	Total daily feed intake/cow (DM)	285	273.559	0.960			
	Total CP intake on DM basis	285	9559255.167	33541.246			
	Total ME, MJ/day/cow on DM basis	285	19039.900	66.807			
Total	Concentrate intake on DM basis	291	2697.840				
	Hay intake on DM basis	291	15203.630				
	Total daily feed intake/cow (DM)	291	30420.710				
	Total CP intake on DM basis	291	1089694639.000				
	Total ME, MJ/day/cow on DM basis	291	2286989.940				

Appendix C 2. Summary of ANOVA table for daily dry matter and nutrient intakes per cow during early post-partum period of crossbred dairy cows fed different diets

Tests of Between-Subjects Effects							
Source of variation	Dependent Variable	df	Type III Sum of Squares (Milking period)	Mean Square	F	P-value	Sig. level
Trt	Concentrate intake on DM basis	2	981.197	490.599	278.223	0.000	***
	Hay intake on DM basis	2	502.632	251.316	141.950	0.000	***
	Total daily feed intake/cow (DM)	2	433.479	216.740	53.467	0.000	***
	Total CP intake on DM basis	2	453612436.299	226806218.150	1943.674	0.000	***
	Total ME, MJ/day/cow	2	91012.757	45506.379	98.064	0.000	***
Parity	Concentrate intake on DM basis	3	230.864	76.955	43.642	0.000	***
	Hay intake on DM basis	3	240.209	80.070	45.226	0.000	***
	Total daily feed intake/cow (DM)	3	112.205	37.402	9.227	0.000	***
	Total CP intake on DM basis	3	2283210.342	761070.114	6.522	0.000	***
	Total ME, MJ/day/cow	3	15734.611	5244.870	11.302	0.000	***
Error	Concentrate intake on DM basis	1074	1893.819	1.763			
	Hay intake on DM basis	1074	1901.464	1.770			
	Total daily feed intake/cow (DM)	1074	4353.666	4.054			
	Total CP intake on DM basis	1074	125324462.399	116689.444			
	Total ME, MJ/day/cow	1074	498389.123	464.049			
Total	Concentrate intake on DM basis	1080	49905.480				
	Hay intake on DM basis	1080	55599.310				
	Total daily feed intake/cow (DM)	1080	204218.470				
	Total CP intake on DM basis	1080	7822635680.340				
	Total ME, MJ/day/cow	1080	22526340.030				

Appendix C 3. Summary of ANOVA table for pre and post-partum body condition score of crossbred dairy cows fed different diets

Tests of Between-Subjects Effects							
Source of variation	Dependent Variables	df	Type III Sum of Squares	Mean Square	F-value	P-value	Sig. level
Trt	BCS of cows before calving	2	0.510	0.255	3.769	0.087	NS
	BCS at 5 to 12 days after calving	2	0.844	0.422	9.000	0.016	*
	BCS at day 60 after calving	2	1.292	0.646	9.300	0.015	*
Parity	BCS of cows before calving	3	0.625	0.208	3.077	0.112	NS
	BCS at 5 to 12 days after calving	3	0.688	0.229	4.889	0.047	*
	BCS at day 60 after calving	3	1.349	0.450	6.475	0.026	*
Error	BCS of cows before calving	6	0.406	0.068			
	BCS at 5 to 12 days after calving	6	0.281	0.047			
	BCS at day 60 after calving	6	0.417	0.069			
Total	BCS of cows before calving	12	121.875				
	BCS at 5 to 12 days after calving	12	119.000				
	BCS at day 60 after calving	12	103.688				

Appendix C 4. Summary of ANOVA table for reproductive parameters of crossbred dairy cows fed on different diets

Tests of Between-Subjects Effects							
Source of variation	Dependent Variable	df	Type III Sum of Squares	Mean Square	F-value	P-value	Sig. level
Trt	Intervals from calving to first heat (d)	2	921.933	460.967	7.547	0.023	*
	Calving to first service interval (CFSI) (d)	2	354.100	177.050	5.944	0.038	*
	Calving to conception interval (CCI) (d)	2	390.900	195.450	19.288	0.049	*
	Calving interval in months	2	0.416	0.208	25.979	0.037	*
	Number of services per conception (NSC)	2	2.806	1.403	1.554	0.286	NS
Parity	Intervals from calving to first heat (d)	3	106.933	35.644	0.193	0.894	NS
	Calving to first service interval (CFSI) (d)	3	159.433	53.144	3.657	0.222	NS
	Calving to conception interval (CCI) (d)	3	1091.233	363.744	35.896	0.027	*
	Calving interval in months	3	1.352	0.451	56.313	0.017	*
	Number of services per conception (NSC)	3	2.222	0.741	0.617	0.633	NS
Error	Intervals from calving to first heat (d)	2	369.067	184.533			
	Calving to first service interval (CFSI) (d)	2	29.067	14.533			
	Calving to conception interval (CCI) (d)	2	20.267	10.133			
	Calving interval in months	2	0.016	0.008			
	Number of services per conception (NSC)	2	0.000	0.000			
Total	Intervals from calving to first heat (d)	8	11036.000				
	Calving to first service interval (CFSI) (d)	8	28975.000				
	Calving to conception interval (CCI) (d)	8	36179.000				
	Calving interval in months	8	1062.630				
	Number of services per conception (NSC)	8	14.000				

Appendix C 5. Summary of ANOVA table for average daily milk yields (liters/day/cow) of crossbred dairy cows fed on different diets

Tests of Between-Subjects Effects							
Source of variation	Dependent Variable	df	Type III Sum of Squares	Mean Square	F-value	P-value	Sig. level
Trt	Total average daily milk yield (liters)	2	4769.677	2384.839	539.436	0.000	***
Parity	Total average daily milk yield (liters)	3	1883.224	627.741	141.991	0.000	***
Error	Total average daily milk yield (liters)	1074	4748.139	4.421			
Total	Total average daily milk yield (liters)	1080	210611.495				

Appendix C 6. Summary of ANOVA table for milk composition (%) of crossbred dairy cows fed on different diets

Tests of Between-Subjects Effects							
Source of variation	Dependent Variable	df	Type III Sum of Squares	Mean Square	F-value	P-value	Sig. level
Trt	Milk PH	2	0.001	0.000	3.327	0.107	NS
	Milk acidity%	2	0.001	0.000	2.612	0.153	NS
	Milk fat%	2	0.201	0.100	0.180	0.840	NS
	Milk protien%	2	0.154	0.077	1.582	0.281	NS
	Milk SNF%	2	0.104	0.052	0.229	0.802	NS
	Milk density (G/ML)	2	0.006	0.007	0.175	0.844	NS
	Milk Total Solids%	2	1.203	0.601	0.751	0.512	NS
	Milk Lactose%	2	0.062	0.031	0.273	0.770	NS
	Milk Ash%	2	0.003	0.001	2.333	0.178	NS
	Milk Temp.(^{o}C)	2	0.287	0.143	.510	0.624	NS
Parity	Milk PH	3	0.001	0.000	2.545	0.152	NS
	Milk acidity%	3	0.000	0.005	0.254	0.856	NS
	Milk fat%	3	0.952	0.317	0.569	0.656	NS
	Milk protien%	3	0.379	0.126	2.605	0.147	NS
	Milk SNF%	3	2.077	0.692	3.040	0.114	NS
	Milk density (G/ML)	3	0.005	0.006	2.256	0.182	NS
	Milk Total Solids%	3	2.241	0.747	.933	0.481	NS
	Milk Lactose%	3	0.716	0.239	2.116	0.200	NS
	Milk Ash%	3	0.016	0.005	8.333	0.015	NS
	Milk Temp.(^{o}C)	3	0.415	0.138	.493	0.700	NS
Error	Milk PH	6	0.001	0.000			
	Milk acidity%	6	0.001	0.000			
	Milk fat%	6	3.347	0.558			
	Milk protien%	6	0.291	0.049			
	Milk SNF%	6	1.366	0.228			
	Milk density (G/ML)	6	0.005	0.006			
	Milk Total Solids%	6	4.805	0.801			
	Milk Lactose%	6	0.677	0.113			
	Milk Ash%	6	0.004	0.001			
	Milk Temp. (^{o}C)	6	1.685	0.281			
Total	Milk PH	12	530.273				
	Milk acidity%	12	0.472				
	Milk fat%	12	229.140				
	Milk protien%	12	138.188				
	Milk SNF%	12	728.177				
	Milk density (G/ML)	12	12.682				
	Milk Total Solids%	12	1738.650				
	Milk Lactose%	12	170.955				
	Milk Ash%	12	6.847				
	Milk Temp. (^{o}C)	12	15453.750				

Appendix C 7. Summary of ANOVA table for blood parameters at calving of crossbred dairy cows fed on different diets

Tests of Between-Subjects Effects							
Source of variation	Dependent Variable	df	Type III Sum of Squares	Mean Square	F-value	P-value	Sig. level
Trt	Plasma albumin (g/dl) level at calving	2	0.013	0.006	0.264	0.776	NS
	Plasma globulin (g/dl) level at calving	2	0.716	0.358	0.358	0.713	NS
	Plasma AST (IU/L) level at calving	2	71.007	35.503	1.754	0.251	NS
	Plasma cholesterol (mg/dl) level at calving	2	2511.927	1255.963	6.022	0.037	*
	Plasma glucose (mg/dl) level at calving	2	26.247	13.123	0.467	0.648	NS
	Plasma total protien (g/dl) level at calving	2	0.639	0.320	0.292	0.757	NS
	Plasma urea (mg/dl) level at calving	2	889.940	444.970	8.152	0.011	**
	Plasma triglycerides (mg/dl) level at calving	2	121.722	60.861	1.483	0.300	NS
Parity	Plasma albumin (g/dl) level at calving	3	0.331	0.110	4.592	0.054	NS
	Plasma globulin (g/dl) level at calving	3	6.152	2.051	2.050	0.208	NS
	Plasma AST (IU/L) level at calving	3	212.417	70.806	3.497	0.090	NS
	Plasma cholesterol (mg/dl) level at calving	3	780.869	260.290	1.248	0.372	NS
	Plasma glucose (mg/dl) level at calving	3	254.196	84.732	3.017	0.116	NS
	Plasma total protien (g/dl) level at calving	3	4.553	1.518	1.388	0.334	NS
	Plasma urea (mg/dl) level at calving	3	94.943	31.648	0.580	0.649	NS
	Plasma triglycerides (mg/dl) level at calving	3	16.249	5.416	0.132	0.938	NS
Error	Plasma albumin (g/dl) level at calving	6	0.144	0.024			
	Plasma globulin (g/dl) level at calving	6	6.002	1.000			
	Plasma AST (IU/L) level at calving	6	121.473	20.246			
	Plasma cholesterol (mg/dl) level at calving	6	1251.353	208.559			
	Plasma glucose (mg/dl) level at calving	6	168.527	28.088			
	Plasma total protien (g/dl) level at calving	6	6.562	1.094			
	Plasma urea (mg/dl) level at calving	6	513.553	85.592			
	Plasma triglycerides (mg/dl) level at calving	6	246.258	41.043			
Total	Plasma albumin (g/dl) level at calving	12	120.759				
	Plasma globulin (g/dl) level at calving	12	280.777				
	Plasma AST (IU/L) level at calving	12	50767.460				
	Plasma cholesterol (mg/dl) level at calving	12	114006.250				
	Plasma glucose (mg/dl) level at calving	12	39905.770				
	Plasma total protien (g/dl) level at calving	12	758.937				
	Plasma urea (mg/dl) level at calving	12	12203.200				
	Plasma triglycerides (mg/dl) level at calving	12	8679.250				

Appendix C 8. Summary of ANOVA table for ealy post-partum blood plasma parameters at day 7 after calving of crossbred dairy cows fed on different diets

Tests of Between-Subjects Effects							
Source of variation	Dependent Variable	df	Type III Sum of Squares	Mean Square	F-value	P-value	Sig.level
Trt	Plasma albumin (g/dl) level at day 7 after calving	2	0.090	0.045	0.671	0.546	NS
	Plasma globulin (g/dl) level at day 7 after calving	2	0.771	0.386	0.426	0.671	NS
	Plasma AST (IU/L) level at day 7 after calving	2	429.382	214.691	2.319	0.179	NS
	Plasma cholesterol (mg/dl) level at day 7 after calving	2	254.727	127.363	0.711	0.528	NS
	Plasma glucose (mg/dl) level at day 7 after calving	2	109.832	54.916	1.549	0.287	NS
	Plasma total protien (g/dl) level at day 7 after calving	2	0.466	0.233	0.276	0.768	NS
	Plasma urea (mg/dl) level at day 7 after calving	2	210.065	105.032	9.915	0.013	**
	Plasma triglycerides (mg/dl) level at day 7 after calving	2	192.652	96.326	8.234	0.019	*
Parity	Plasma albumin (g/dl) level at day 7 after calving	3	0.551	0.184	2.727	0.137	NS
	Plasma globulin (g/dl) level at day 7 after calving	3	5.726	1.909	2.109	0.201	NS
	Plasma AST (IU/L) level at day 7 after calving	3	453.403	151.134	1.633	0.279	NS
	Plasma cholesterol (mg/dl) level at day 7 after calving	3	369.177	123.059	0.687	0.592	NS
	Plasma glucose (mg/dl) level at day 7 after calving	3	207.489	69.163	1.951	0.223	NS
	Plasma total protien (g/dl) level at day 7 after calving	3	4.583	1.528	1.808	0.246	NS
	Plasma urea (mg/dl) level at day 7 after calving	3	55.876	18.625	1.758	0.255	NS
	Plasma triglycerides (mg/dl) level at day 7 after calving	3	27.643	9.214	0.788	0.543	NS
Error	Plasma albumin (g/dl) level at day 7 after calving	6	0.404	0.067			
	Plasma globulin (g/dl) level at day 7 after calving	6	5.431	0.905			
	Plasma AST (IU/L) level at day 7 after calving	6	555.445	92.574			
	Plasma cholesterol (mg/dl) level at day 7 after calving	6	1074.313	179.052			
	Plasma glucose (mg/dl) level at day 7 after calving	6	212.748	35.458			
	Plasma total protien (g/dl) level at day 7 after calving	6	5.069	0.845			
	Plasma urea (mg/dl) level at day 7 after calving	6	63.562	10.594			
	Plasma triglycerides (mg/dl) level at day 7 after calving	6	70.195	11.699			
Total	Plasma albumin (g/dl) level at day 7 after calving	12	115.437				
	Plasma globulin (g/dl) level at day 7 after calving	12	310.730				
	Plasma AST (IU/L) level at day 7 after calving	12	56668.130				
	Plasma cholesterol (mg/dl) level at day 7 after calving	12	142921.820				
	Plasma glucose (mg/dl) level at day 7 after calving	12	40193.570				
	Plasma total protien (g/dl) level at day 7 after calving	12	793.070				
	Plasma urea (mg/dl) level at day 7 after calving	12	11768.690				
	Plasma triglycerides (mg/dl) level at day 7 after calving	12	8283.330				

Appendix C 9. Summary of ANOVA table for ealy post-partum blood plasma parameters at day 14 after calving of crossbred dairy cows fed on different diets

Tests of Between-Subjects Effects							
Source of variation	Dependent Variable	df	Type III Sum of Squares	Mean Square	F-value	P-value	Sig. level
Trt	Plasma albumin (g/dl) level at day 14 after calving	2	0.065	0.032	0.145	0.868	NS
	Plasma globulin (g/dl) level at day 14 after calving	2	0.517	0.259	0.228	0.803	NS
	Plasma AST (IU/L) level at day 14 after calving	2	52.512	26.256	0.146	0.867	NS
	Plasma cholesterol (mg/dl) level at day 14 after calving	2	292.987	146.493	0.859	0.470	NS
	Plasma glucose (mg/dl) level at day 14 after calving	2	650.912	325.456	1.383	0.321	NS
	Plasma total protien (g/dl) level at day 14 after calving	2	4.562	2.281	12.324	0.008	**
	Plasma urea (mg/dl) level at day 14 after calving	2	1420.812	710.406	23.091	0.002	**
	Plasma triglycerides (mg/dl) level at day 14 after calving	2	11.612	5.806	0.207	0.819	NS
Parity	Plasma albumin (g/dl) level at day 14 after calving	3	0.304	0.101	0.455	0.723	NS
	Plasma globulin (g/dl) level at day 14 after calving	3	5.968	1.989	1.753	0.256	NS
	Plasma AST (IU/L) level at day 14 after calving	3	779.529	259.843	1.449	0.319	NS
	Plasma cholesterol (mg/dl) level at day 14 after calving	3	322.502	107.501	0.630	0.622	NS
	Plasma glucose (mg/dl) level at day 14 after calving	3	334.867	111.622	0.474	0.712	NS
	Plasma total protien (g/dl) level at day 14 after calving	3	1.574	0.525	2.836	0.128	NS
	Plasma urea (mg/dl) level at day 14 after calving	3	151.540	50.513	1.642	0.277	NS
	Plasma triglycerides (mg/dl) level at day 14 after calving	3	27.750	9.250	0.329	0.805	NS
Error	Plasma albumin (g/dl) level at day 14 after calving	6	1.333	0.222			
	Plasma globulin (g/dl) level at day 14 after calving	6	6.810	1.135			
	Plasma AST (IU/L) level at day 14 after calving	6	1075.848	179.308			
	Plasma cholesterol (mg/dl) level at day 14 after calving	6	1023.240	170.540			
	Plasma glucose (mg/dl) level at day 14 after calving	6	1412.108	235.351			
	Plasma total protien (g/dl) level at day 14 after calving	6	1.110	0.185			
	Plasma urea (mg/dl) level at day 14 after calving	6	184.595	30.766			
	Plasma triglycerides (mg/dl) level at day 14 after calving	6	168.615	28.103			
Total	Plasma albumin (g/dl) level at day 14 after calving	12	108.385				
	Plasma globulin (g/dl) level at day 14 after calving	12	342.997				
	Plasma AST (IU/L) level at day 14 after calving	12	57002.190				
	Plasma cholesterol (mg/dl) level at day 14 after calving	12	162809.270				
	Plasma glucose (mg/dl) level at day 14 after calving	12	32718.740				
	Plasma total protien (g/dl) level at day 14 after calving	12	955.632				
	Plasma urea (mg/dl) level at day 14 after calving	12	19024.200				
	Plasma triglycerides (mg/dl) level at day 14 after calving	12	8560.940				