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DAIRY FEED RESOURCES AND MINERAL ASSESSMENT IN SELECTED DISTRICTS OF EAST SHOA ZONE

EFFECTS OF DICALCIUM PHOSPHATE SUPPLEMENTATION ON MILK YIELD AND COMPOSITION IN CROSSBRED DAIRY COWS

Ph.D Dissertation

By

Wondewsen Bekele Wondater

Addis Ababa University, College of Veterinary Medicine and Agriculture

Department of Animal Production Studies

June 2020

Bishoftu, Ethiopia

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

By

Wondewsen Bekele Wondater

DVM (Animal Health)

MSc (Animal Nutrition)

June 2020

Bishoftu, Ethiopia

Addis Ababa University

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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 Wondewsen Bekele Wondater Entitled: **“**As members of the Examining Board of the final PhD open defense, we certify that we have read and evaluated the Dissertation prepared by Wondewsen Bekele Wondater entitled: **“Dairy Feed Resources and Serum Mineral Assessment in Selected Districts of East Shoa Zone: effects of dicalcium phosphate supplementation on milk yield and composition of crossbred dairy cows”**, and recommend that it be accepted as fulfilling the dissertation requirement for the degree of Philosophy in Animal Production.

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BIOGRAPHICAL SKETCH

The author was born in 1968 Tena districts of Arsi Zone of Oromia Region Ethiopia. He attended primary elementary school in Bullala and junior and comprehensive secondary education in Ticho and Robe (Didea) School, Arsi, respectively. He then joined the Addis Ababa University Natural Science College in 1987 then due to scholarship opportunity, he went to Moldova Agricultural State University, Republic of Moldova and awarded DVM (Doctor of veterinary medicine) in Animal health and stayed from 1988-1993. Soon after graduation, he employed in the Ministry of Coffee and Tea Development and worked in Wolayta zone Bolo Sore District of Southern Nation, Nationality and Peoples Regional State Ethiopia from March 1994 to May 1998 as a field veterinarian and then Head of Animal Health and Fishery Resource and then he joined Dilla Agricultural Technical and Vocational Educational Training (ATVET) and served as instructor and Department Head for six years. In the year 2005, he had the chance to join Haramaya University after which he was awarded MSc degree in Animal nutrition 2008. He was returned back to his formal career at the same Dilla Agricultural Technical and Vocational Educational Training (ATVET). Soon after he employed at Dilla University as a Senior Instructor. Over the past eight years of services in teaching, the author taught almost all animal health and Animal science courses, engaged in different community services and research activities (Effect of Substitution of Concentrate Mix With s*esbania Sesban* on Feed Intake, Digestibility, Body Weight Change and Carcass Parameters of Arsi-Bale Sheep Fed Grass Hay, Prevalence and Risk Factors Assessment of Bovine Mastitis in Dilla Town and Abaya Woreda, Prevalence and Risk of Cysticercus Bovies, Assessment of the Financial Losses Associated With Treatment of Taeniasis in Hidebu Abote Abattoirs, North Shoa Zone, Oromiya Regional State, Ethiopia). The author is married and a father of two sons and a daughter.

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I would like to acknowledge the staff members of Ada'a and Adama district dairy experts with respective dairy farm owners and farm workers, including household respondents accessible in each survey district for helping me to organize and collect the survey questioner and feed sample collection. They contributed their time and indeed, their support was vital and this work would not have been possible without their willingness.

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Last but and foremost, I would like to praise and extend my unshared thanks to Almighty God, for having presented upon me His grace and blessing, giving me endurance and strength to bring out this humble piece of work into an end.

DEDICATION

This dissertation manuscript is dedicated to my late mother Woizero Mulunesh Tessema, my father Bekele Wondater, my brother Debebe Bekele and sister Endashash Bekele who are never forgotten, and to my sons Robel Wondewsen and Dagmawi Wondewsen, daughter Nuhamine Wondewsen.

LIST OF ABBREVIATIONS

AAS	Atomic Absorption Spectroscopy
ADF	Acid detergent fiber
AFC	Age at first calving
AI	Artificial Insemination
AIA	Acid Insoluble Ash
ANOVA	Analysis of variance
AOAC	Association of Analytical Chemists
ARC	Agricultural Research Council
CP	Crude Protein
CSA	Central Statistic Agency
CV	Coefficient of variations
CVMA	College of Veterinary Medicine and Agriculture
DARC	Debreziet Agricultural Research Center
DCP	Dicalcium phosphate-18%
DHVD	1,25-dihydroxy vitamin D
DM	Dry Matter
DMI	Dry Matter Intake
DOA	District Office of Agriculture
DOMD	Digestible organic matter in the dry matter
DZARC	Debreziet Agricultural Research Institute
ELDMPS	Ethiopia Livestock Development Master Plan Study
EMDIDI	Ethiopian Meat and Dairy Industry Development Institute
FAO	Food and Agricultural Organization
GDP	Gross Domestic Product
ha	Hectare
HARC	Holetta Agricultural Research Center
HF	Holstein Friesian
HH	Household
IDARDA	International Center Agricultural Research in Dry Agriculture
ICAD-LLPI	Inter-Governmental Authority on Development-Livestock Policy Initiative
ILRI	International Livestock Research Institute
IPMS	Improving Productivity and Market Success
IVDMD	*In vitro* Dry Matter Digestibility
LSD	Least Significant Difference
masl	Meter Above Sea Level
ME	Metabolizable energy
Meclb	Methylcobalamin
MoA	Ministry of Agriculture
MY	Milk Yield
ND	Not detected

ABBREVIATIONS (Continued)

NDF	Neutral detergent fiber
OM	Organic matter
PTH	Parathyroid hormone
PA	Peasant Association
Pi	Inorganic phospherous
Po	Organic phospherous
SAS	Statistical Analysis System
SD	Standard deviation
SDDP	Smallholder Dairy Development Project
SE	Standard error
SEM	Standard error of the mean
SNV	Netherlands Development Organization
SPSS	Statistical Package for Social Sciences
25-OH	25-hydroxyvitamin D3

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Dairy Feed Resources and Serum Mineral Assessment in Selected Districts of East Shoa Zone: effects of dicalcium phosphate supplementation on milk yield and composition of crossbred dairy cows

Wondewsen Bekele Wondater
Ph.D. Dissertation
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ABSTRACT

The present study conducted to assess dairy feed resources mineral composition and dairy cow blood mineral profiles in selected districts of East Shoa Zone, and assess the effects of dicalcium phosphate supplementation on milk yield and composition in Crossbred Dairy Cows. The whole work was conducted in two major parts with sub-activities in each part. The first activity of part one was surveyed to assess the socioeconomic status of dairy farmers and feed resources available with feeding patterns in the urban and peri-urban production system of Ada'a and Adama district. The second activity of part one was minerals profile assessment both from dairy feeds resources and from dairy cow serum at different physiological status. The assessment was performed in a wet and dry season of the year. Part two was on-station mineral supplementation experimental trial to investigate the effect of mineral supplementation on blood, feed, milk, urine and feces mineral profile, feed intake, milk yield and composition of crossbred dairy cows. For part one, the sampling frame comprises farmers keeping crossbred dairy cows and a total of 250 households were purposively selected. The study districts and the production systems (urban and peri-urban) were selected purposively based on the availability of dairy farms, having crossbreed dairy cows. A total of 240 blood samples (120 at dry and 120 at wet season) and 140 feed samples were collected from the dairy farms where blood was taken. Feed samples were categorized based on the production system and seasons and were dried and grounded. The grounded feed samples and serum were stored at -20^{0}C until to be analyzed. The serum and feed samples were analyzed for Calcium (Ca), Magnesium (Mg), phosphorus (P), Copper (Cu), Iron (Fe), zinc (Zn) and Cobalt (Co). The mean value of calcium ranges from (0.13 to 0.55 %); (0.14 to 0.64 %); (0.34 to 0.69 %) respectively, in roughage, Cereal grain & oilseed cakes and non-conventional. Out of the total feeds analyzed 26.92%, roughage (natural grass hay, sugar cane tops, and silage) and 66.15% cereal grain & oilseed cakes, showed deficiency in Ca. The mean magnesium and Iron values were not deficient in analyzed feeds. The mean Copper concentrations were ranges from in (6.99 to 10.65 ppm); (6.67 to 8.78 ppm); (6.31 to 9.72 ppm) respectively, roughages, Cereal grain & oilseed cakes and non-conventional. When the Cu concentration values are compared to the critical value (<8ppm) of feeds analyzed, 19.23%, 79.92% and 65.22% for roughage concentrate and non-conventional feeds respectively, were found to be deficient in Cu. The mean Iron concentrations varied in roughages (68.5 to 176.80 ppm); concentrate (73.94 to 174.81 ppm) and non-conventional (65.92 to 157.93 ppm) DM, respectively. When those values are compared to the critical value of (50 ppm) of feeds analyzed only 48.1% and 34.8% for roughage (natural pasture, Pennisetumpurpureum), sugar cane top) and non-conventional feeds (brewery by-products industrial), respectively, were found to be deficient in Zn. The interaction effect of dairy feeds, for most analyzed feed samples, were significantly different (P<0.05) for all Ca, P, Mg, Cu, Fe, and Zn within the study districts. Similarly, the interaction effect between feed types and production systems were significantly different (P<0.05) for Ca, P, Mg, Cu, and Zn. Moreover, the interaction *effect of feed and sampling season was significantly different ($P<0.05$) for Ca, P, Mg, and Zn. Therefore, in this study minerals most widely present in inadequate amounts were Ca, P, Cu Zn and Co indifferent proportion based on seasons. Likewise, the overall mean blood serum concentration result was 0.080,0.082g/L for lactating and 0.090, 0.081g/L for dry dairy cows in the dry and wet season, respectively for Ada'a and Adama district. In lactating and dry cows, in both districts mean serum calcium concentration was very close to a critical level (CL) or close to borderline to develop clinical signs of hypocalcemia. The overall percentage of Ca deficiency based on the critical level (23.34, 29.32%); (23.34, 18.54%) for lactating cows and (7.12, 8.32%); (11.13, 6.34%) for dry cow were deficient in Ca in urban and peri-urban Ada'a and Adama districts, respectively. Likewise, seasonally Ca deficiency was (26.67, 21.67%); (31.67, 27.67%) for the dry season and (11.67, 26.67%); (34.67, 16.67%) wet season in urban and peri-urban Ada'a and Adama districts, respectively. Moreover, Ca in serum P, Cu, and Co were deficient from collected samples during the study period. Whereas, based on the mean value serum concentration of Mg, Zn, Fe was sufficient in the production system and season. Likewise, overall mean serum phosphorus was (0.037, 0.039 g/L) for lactating cows during dry and wet season whereas, (0.038, 0.037 g/L) for dry dairy cows in the dry and wet season, respectively. The difference in mean serum magnesium was significant ($P<0.05$) within the production system, the physiological state of dairy cows and seasons. Similarly, the difference in serum copper, Fe, and Zn level was statistically significant ($p<0.05$) based on the physiology of cows, production system and season. In Part II dicalcium phosphate-18% was supplemented for 120 days of feeding trial period classified into four periods which consists of 30 days each (16 days of adaptation and 14days of data collection) and at different levels (0, 0.3, 0.6, 0.9%) in lactating cows in their 1^{st}- 4^{th} lactation stage using 4X4 Latin square design. The effect of mineral supplementation was evaluated by taking blood, milk, urine, feces, feed refusals for laboratory analysis. Results of the present study revealed that supplementation of 0.3%, 0.6%, 0.9% dicalcium phosphate with the concentrate mix was improving dry matter intake, digestibility of nutrients in lactating dairy cows compared to the controls. However, increasing the level of supplementation affect milk production, and composition compared to non-supplemented groups except SNF. There was a significant difference ($P < 0.05$) between treatment groups in serum phosphorus. No difference between treatment groups was observed for serum calcium. Finally, from the current finding, it could be concluded.Ca, P, Cu, Zn, and Co was found deficient in dairy feed. Similarly, serum samples showed Ca, P, Cu, and Co to be below the critical level or close to lower borderline. While, the levels of Mg, Fe and Zn were sufficient to meet estimated nutritional requirements for dairy cows. The level of Co concentration was even not detected both on feed and blood samples, which indicate Co was below the critical level. The amount of minerals in analyzed feed significantly varies by study districts and season. Supplementation of 0.3% of 0.6%, 0.9% dicalcium phosphate with the concentrate mix was improving dry matter and nutrient intake. Supplementation of DCP-18% significantly increase milk production, and composition compared.Therefore, supplementation regimes of these mineral elements are very likely to improve production, and reproduction efficiency. However, research that covers a wider area and that asses the effect of other mineral supplementation should be conducted.*

Keywords: Dairy cows, AAS, East Shoa Zone, DCP-18%, Feed, Serum mineral, Production system

1. INTRODUCTION

The livestock sector has been contributing a considerable share to the economy of Ethiopia and still capable to rally round the economic development of the country. The total cattle population for the country is estimated to be 59.5 million cattle out of which the female cattle are found to be 55.5 percent and the remaining 44.5 percent are male cattle (CSA, 2017). About, 98.20 percent of the total cattle in the country are local breeds. Whereas, the remaining are cross and exotic breeds that accounted for about 1.62 percent and 0.18 percent, respectively (CSA, 2017). The same source indicated also that dairy cows are estimated to be around 11.83 million and milking cows are about 7.16 million heads (CSA, 2017). The estimated total cow milk produced in Ethiopia during the year 2016/17 is about 3.13 billion liters (CSA, 2017). The livestock sub-sector plays a vital role as a source of food, income, services and foreign exchange to the Ethiopian economy, and contributes to 45% of the GDP and grossly accounts for 20% of the total export value, second in order of importance (Behnke and Metaferia, 2011; Belete, 2014).

In Ethiopia, over 90% of milk is produced by smallholder producers (Staal *et al.*, 2008) as the economic potential large scale, industrial-style dairy production is much limited. In view of this, smallholder systems continue to be the major supporters to meet the ever-increasing demand for dairy products and consequently, market-oriented smallholder peri-urban and urban dairy production systems will have the marvelous potential for development. This is because dairy production is challenged with several factors which are related to genetic, environment, mineral nutrition and management practices, access to veterinary services and inputs, low adoption of improved technologies (insufficient training and extension services), marketing and absence of clear policy to support the sector (Azage *et al.*, 2013). Moreover, in Ethiopia major constraints limiting dairy productivity on cow level and are due to the inadequate supply of quality feed and the low productivity of the native cattle breeds (Ahmed *et al.*, 2004). As compared to the indigenous breed, cross-bred cattle have a higher level of production estimated at an average of 10 l/day (Kaat *et al.*, 2017; Neckermann & Kechero, 2017). From the total amount of all milk produced, 97% originates from the agro-pastoral and pastoral regions, from multipurpose indigenous livestock that also provides draught, beef, and the remaining 3% comes from improved exotic crosses (Feleke *et al*., 2010). Even though the demand for dairy and other livestock products increases with the upsurge in human population, and urbanization, there is a decrease in the amount of land and water available for dairy animals, and many grazing lands become more and more degraded, the condition aggravating feed scarcity (Kaat *et al*., 2017; Mayberry *et al.,* 2017).

However, to improve dairy development emphasis should be given towards the enhancement of certain limiting factors like seasonal inadequacy of the quantity and quality of available feed resource as well as mineral imbalances (Zegeye, 2003). Moreover, in many smallholder and commercial dairy production systems in Ethiopia, the feed being provided for dairy is believed to be imbalanced and, in many instances, deficient. Therefore, to balance the demand and supply, it is necessary to analyze how the existing smallholder dairy production systems are working so that relevant and practical strategies could be planned to alleviate challenges related to the productivity of dairy cattle in the country.

In the past, different studies have been carried out in the country to identify the nutritional limitations of dairy feeds to improve their production (Fekede *et al.,* 2015). All the nutrients (carbohydrate, proteins, fat, vitamins, minerals, and water) are equally essential as one or more of these can hinder the productivity of animals when requirements are not fulfilled because every living cell depends upon nutrients including minerals for proper functions. Energy, protein and minerals are nutrients required and should be given priority in order to optimize production, health and reproduction in dairy cattle (Bindari, *et al*., 2013). Moreover, minerals, unlike other nutrients, cannot be synthesized by a living organism (Kumar, 2006). Mineral elements exist in the cells and tissues of the animal body and their characteristic concentrations vary with the element and tissue. Minerals yield no energy but play important roles in many activities in the living body (Eruvbetine, 2003; Soetan *et al*., 2010). They are structural components of the body and play a substantial role in activities of an enzyme, hormone production, collagen formation, oxygen transport, energy production, regulators of cell replication and differentiation and other physiological processes related to growth, reproduction, and health, in general, they are considered as constituents of body fluids and tissues, (Underwood, 1981; Kumar, 2006; McDonald *et al.*, 2011). As all enzyme activities involve minerals, they are essential for the proper utilization of vitamins and other nutrients. The concentrations of essential elements must usually be maintained within the narrow limits if the functional and structural integrity of the tissues is to be sustained and the optimum growth, health, production and productivity of the animal are to be maintained. Continued intake of nutrients that are deficient, and excessively high in a mineral, induce changes in the form of concentration of that mineral in the body tissues and fluids so that it falls below or rises above the tolerable limits (Abegaze and Chopra, 2008; Suttle, 2010).

Mineral nutrition disorders range from an acute mineral deficiency or toxicity, characterized by well-marked clinical signs and pathological changes, to mild and transient conditions too difficult to diagnose and expressed as vague thriftiness or unsatisfactory growth and production (Vargas and McDowell, 1997; Soetan *et al.*, 2010). The important contributory factor for low production is mineral imbalances in soils, forages which leads to and dairy animals (McDowell, 2003). In this regard, it has long been reported as mineral imbalances in soils and forage have been responsible for low production and productivity in dairy cattle in Ethiopia (Lemma *et al.*, 2002). The concentration of mineral elements in pasture forage is a function and properties of soil (parent material, soil fertility, soil pH and soil drainage), plant species and climatic factors influence the mineral concentration of pastures (Kumar *et al.*, 2005). It is always prudent to feed dairy animals with optimum quantities of different macro and micronutrients to exploit the maximum productivity potential of dairy cows. On the other hand, substantial improvements have been reported by supplementing with mineral-rich forage legumes and agro-industrial by-products (Aschalew *et al.*, 2006; Takele *et al.*, 2014). Mineral supplementations are also known to improve the intake and digestibility of feeds thus resulting in increased animal performance (Aschalew *et al.*, 2006).

The occurrence of mineral imbalances in dairy animals, the health and productivity of the animals are greatly impaired. Consequently, it is desirable that mineral imbalances of dairy animals are recognized, and controlled in their early stages to minimize losses. A large number of dairy animals in many parts of the world consume a diet that does not meet their exact requirements, thus, necessitating the need for mineral supplementation (McDowell *et al*., 1993; 1996; Gebrehiwet, 2004). Mineral sources include natural feeds (forages, grains, and by-products) which are found to be borderline to deficient in minerals composition. Because bioavailability can be influenced by age, breed, species, level of production, physiological function, the magnitude of the previous intake of a nutrient and interactions among the dietary nutrients (Ammerman *et al*., 1995; Abegaz and Chopra, 2008). Mineral provisions are important to accomplish the increasing demands of the lactating cows for productive and reproductive functions.

Deficiencies of minerals can be primary and/or secondary sources. Primary deficiencies arise because of insufficient levels of the actual mineral element in the diet and secondary deficiencies arise when the pasture contains something else that reduces the uptake of the mineral element (e.g. pasture with high molybdenum reduces the absorption of copper). However, the most naturally occurring mineral deficiencies in dairy animals are area-specific (Garg *et al.,* 2004; Kumar, 2015), which are related to the type of soils, climate, mineral composition of soils and plants, soil pH and agronomic practices (McDowell, 2003). Consequently, a significant correlation has been observed between the mineral status of soils, forages, and dairy animals (Sharma *et al.,* 2009).To obtain improvement in dairy production, proper consideration should be given not only to macronutrient but also for micronutrition, whether the animal is in a free-ranging system or under confinement.

To obtain improvement in dairy production, proper consideration should be given not only to macronutrient but also for micro nutrition, whether the animal is in a free-ranging system or under confinement. A lack of attention to the mineral content of the total ration frequently leads to immunocompromised for different infectious diseases and reproductive problems (Harris *et al.*, 1994; Aschalew *et al*., 2006). Knowledge of the mineral composition of feeds and blood is important in determining the types and amount of minerals to be supplemented. A number of researchers have reported that a large number of forage samples fall below critical levels for different mineral elements especially Cu, Zn, Co, Na, and P (Miles and McDowell, 1983; Lemma *et al*., 2002). It has been observed that dietary minerals supplementation enhanced milk production, composition, feed intake, and fertility (Saghar, 2003). The effort to increase animal productivity maneuver genetic potentials has further emphasized the problem of mineral nutrition and also of the mineral supplements. In case of high producing animals, there is remarkable daily drainage of calcium (Ca) through the milk and adequate mineral supplements need to be planned to replenish the daily loss, in spite of the fact that internal regulatory mechanism in the animal can take care of the transient periods of enhanced needs (Abegaz and Chopra, 2008).

According to Rekhis *et al.* (2010) supplementation of di-calcium phosphate, limestone, magnesium oxide and other appropriate forms of macro and micro mineral supplementation to dairy cattle brought significant improvement to production, reproduction health condition, milk fat content and milk quantity and quality (protein and density). In tropical countries, mineral deficiency is a frequent problem regarding cattle nutrition, and it is responsible for large economic losses in livestock production (McDowell and Arthington, 2005). Dairy cattle must be provided with a balanced diet containing minerals for optimal milk production, reproductive performance, and overall health. In some parts of Ethiopia including central rift valley, Ca and P concentrations of the major feedstuffs except for some fodder trees and barley straw were deficient (Zewdi, 2010) compared to the recommendations.Moreover, mineral status of natural pastures and crop residues have low mineral status (Lemma and Smit, 2005 and Fekede *et al*., 2013,15).

According to the report of Azage (2018), cross-bred cows have higher productivity than indigenous cows. However, there is an alarming gap between the total number of dairy animals and their milk production. This is majorly due to genetic makeup and nutritional deficiencies diseases in which animal performance based on physiological functions are progressively affected the production of dairy animals. Dairy cow mineral supplementation systems, in relation to productivity and reproductive performances, are overlooked. In Ethiopia, even though information on the mineral content of some feeds of different nature in limited locality based on season’s attention should be given so far to the mineral status of feeds have been low as compared with other nutrients (Kabaija and Little, 1988; Khalili *et al*., 1993; Diriba *et al*., 2001). Moreover, huge sections of the country mineral status of feeds and dairy animals remain untouched, and detailed mineral profiles of the different available feed resources throughout the country have not organized and documented (Kabaija, & Little, 2013; Kaat *et al*., 2017). Furthermore, there is a lack of attention for mineral supplementation in ration formulations which leads to impair dairy animal production, productivity, increased disease incidence and reproductive problems (Haris *et al*., 1994; Fikadu, *et al*., 2016).

Therefore, this study was conducted to quantify the mineral content of different feeds and serum mineral concentrations to provide a basis for subsequent investigation of mineral nutrition strategies to maximize production performances of dairy cows in Ada'a and Adama district of East Shoa zone with the following general and specific objectives.

General objective

To assess minerals in feed sources and supplementation practices and characterize the mineral status of feeds, dairy cows in urban and peri-urban areas of East Shoa Zone, and determine effects of dicalcium phosphate supplementation on feed intake, milk yield and composition of lactating dairy cows.

Specific objectives

- To assess the minerals in feed resources of dairy cows in selected urban and peri-urban areas in different seasons and in Ada'a, and Adama districts of East Shewa Zone
- To assess the existing feeding practices and methods of mineral supplementation
- To determine mineral concentration of major feed stuffs seasonally collected from urban and peri-urban dairy farms
- To determine mineral concentration of blood, milk, urin and fecal samples of dairy cows managed both under on-station field conditions.
- To investigate the effect of mineral supplementation on feed intake, milk yield, and milk composition of crossbreed dairy cows.

2. LITERATURE REVIEW

2.1. Dairy Production Systems in Ethiopia

Ethiopia has a divers' topography, climate, and cultural conditions that make it difficult to generalize livestock production systems in the country (Alemayehu, 2002). Now a day different researchers used different standards to classify livestock production systems. Therefore, the dairy production systems can be defined in terms of agro-ecology, degree of integration between crop and livestock production, levels of input utilization, scale and intensity of production, location and market orientation (Tsehay, 2002; Fekede *et al*., 2013). Consequently, four major dairy production systems have been identified in the country including pastoral and agro-pastoral, mixed crop-livestock farming, urban and peri-urban and intensive dairy farming systems. The ability of the dairy enterprise to generate regular income and to contribute to the household diet on a regular basis throughout the year is an advantage over other agribusiness enterprises (SNV, 2006). The dairy industry is among the important components of the livestock sector, used as a source of animal protein, income and employment (Dereje *et al*., 2005).

The pastoral and agro-pastoral production systems are not market-oriented and the milk produced is mainly used for home consumption. The milk which is in excess of household use is traditionally processed into butter, cottage cheese, and yogurt for home use or to generate income through informal marketing systems (Tsehay, 2002; Fekede *et al*., 2013). The production system is predominantly characterized by subsistence smallholder mixed farming, with crop and livestock husbandry being practiced within similar management with varying degrees of integration, including the use of crop residues, draught power and manure (Fekede *et al*., 2013). Dairy production in Ethiopia is constrained by various factors, which generally categorized as technical and non-technical constraints. The non-technical constraints constitute the policy of environment, socioeconomic factors, and institutional-based issues. These factors in one or the other way determine access to land, access to credit and other incentives, extension service, infrastructural setups and the overall coordination, which in turn directly or indirectly affect dairy production. On the other hand, inadequate feed and nutrition, the prevalence of diseases with a lack of effective health services, and poor genetic make-up of the indigenous breeds are the major technical constraints that affecting dairy production (Fekede *et al*., 2013).

2.1.1. Urban and peri-urban dairy production system

The urban dairy production system comprising from smallholder to highly specialized, state, or businessmen owned farms, a large number of the urban dairy farmers exist in the medium and low-density areas and use their residential units as places where dairying is carried out (Shiferaw *et al.*, 2003). They rely mainly on purchased feeds like roughages and concentrates (Zegeye, 2003; Yitaye *et al*., 2007; Fekede *et al*., 2013) and they can keep exotic dairy stocks (Azage *et al*., 2000). Now a day, a number of smallholder and commercial dairy farms are emerging chiefly in the urban and peri-urban areas of the capital (Azage *et al*., 2003), and most regional towns and districts (Nigussie, 2006). The dairy production systems in the urban are relatively intensive and mainly based on stall-feeding (Fekede *et al.*, 2013). The level of milk production and reproduction of dairy cattle varies considerably within countries, and between production systems. Hence, urban farmers owned larger herds and sold a greater proportion of liquid milk than peri-urban farmers (Alemayehu *et al*., 2011).

Under this production system keeping dairy for different livelihood strategies and contributes to food security, income, and employment generation, saving, and insurance (Azage *et al*., 2006). The peri-urban dairy production system is established in areas where the population density is high and agricultural land is shrinking due to urbanization. In terms of the genotype of animals, they possess animal blood levels ranging from 50% crosses to high-grade Friesian in small to medium-sized farms. The peri-urban milk system includes smallholder and commercial dairy farmers in the proximity of cities and other regional towns (Azage *et al.*, 2000). Peri-urban dairy production systems have emerged around cities and towns, which heavily depend on purchased fodder. The term peri-urban refers to the linkage and interaction between rural and urban areas and characterized by the production, processing, and marketing of milk and milk products that are channeled to consumers in urban centers (Rey *et al*., 1993).

The peri-urban dairy farms classified into two subsystems, small-scale and medium-sized peri-urban dairy (Diriba *et al.*, 2014).

Furthermore, according to Fekede *et al*. (2013), the Peri-urban dairy production system is a crop, and livestock production is closely integrated agricultural activities other than milk production for an extra source of income. They have access to land and usually practice mixed crop-livestock farming, which produces different feeds and grazing (Azage *et al.*, 2013). Moreover, in the peri-urban production system, grazing together with purchased concentrates and roughages of conventional and non-conventional feed sources is common (Asrat *et al.*, 2013). However, production has generally been constrained by several factors including poor management, inadequate feed resources in quality and quantity, unimproved breeds, reproductive wastage, and inadequate animal health care.

2.2. Feed Resources and Dairy Production Systems

Animals derive most of their feed from natural pasture and crop residues in the tropics. However, the natural grazing lands nowadays are either being invaded by arable farming or are seriously overstocked which leads to overgrazing, low productivity, and poor nutritional quality. These will demands designing strategies to balance the supply of nutrients in deficit and to match with the requirements of the animals for production. Supplementation with agro-industrial by-products has been among the strategies used to promote the feeding values of low-quality basal diets (Yoseph *et al*. 2007). Practically in all parts of Ethiopia, the commonly used dairy cattle, feed resources are mainly natural pasture, crop residues, improved pastures, forage crops, agro-industrial by-products, non-conventional feed resources (like poultry manure, brewery by-products industrial/local) and crop aftermath with the exception of urban dairy producers (Alemayehu, 2005; Asaminew and Eyasu 2009; Yitaye *et al.*, 2009; Azage *et al*., 2013). According to Yoseph (1999) among the non-conventional feeds, *atella* (a traditional home brewery residue) and pulp hulls are utilized by 80% and 47% of the farmers, respectively. The contribution of these feed resources, however, depends upon the agro-ecology, the types of crop produced, accessibility and production system (Azage *et al*., 2013; Fekede *et al*., 2015). The crude protein (CP) content of pastures is lower than the forage CP content of 7% which would cover the maintenance requirements of ruminants (McDonald *et al*., 2002).

2.2. 1. Natural pasture and grass hay

Natural pasture refers to naturally occurring grasses, legumes, tree foliage, and herbs, which used as livestock feed. The nutrition of grazing animals is an intricate interaction of soil, plant, and animal. Natural pastures in the highlands of Ethiopia are rich in species composition, particularly indigenous grasses and legumes (Assefu, 2012). Among grass species commonly growing belongs to the genera *Andropogon, Digitaria, Panicum, Pennisetum* and *Trifolium* (Yihalem *et al.*, 2006; Endale *et al*., 2015). Natural pastures would be adequate for live weight maintenance and weight gain during wet seasons, but would not support maintenance for the rest of the year (Zinash *et al*., 1995). Lemma *et al*. (2002) indicated that despite the continued expansion of croplands into the grasslands and the consequent decline in the size of grazing areas, native pastures remain the major contributors of animal feed in the densely populated highlands of Ethiopia. Natural pastures mostly suffer from a seasonally dry periods, which is characterized by high fiber content, low digestibility, low in nitrogen, very low in protein and energy contents (Topps, 1995; Assefu, 2012; Endale *et al*., 2015). Moreover, the quality of pasture and yield is very low due to poor management and overstocking (Ashagre, 2008). In general, grazing land productivity is declining at a higher rate because of temperature stress and scarcity of rainfall, which is favored by deforestation (Yeshitila *et al.*, 2008). According to the reports of FAO (1997) and Bedru *et al*., (2019) annual and perennial grasses from natural pasture consumed during the dry season and often at the late stage of maturity together with the straw and stalk from cereal crops constitute low-quality forages, with the high lignified cell wall and poor nitrogen. The quality of hay prepared varies with grass-legume proportion, leaf to stem ratio, and physiological development of the forage upon harvest (Assefu, 2012). Mature grass, especially those that are weather leached or bleached are low in digestible energy and protein, as well as insoluble carbohydrate, carotene and some of the minerals (Ensminger *et al.*, 1990; Blair, 2011).

The soil and forages of tropical countries contain lower concentrations of minerals and thus grazing animals suffer from different mineral deficiencies (McDowell, 1985; NRC, 2001). The forages, thus, need supplementation of the minerals, because they are not meeting the mineral requirements of these grazing animals. Grazing animals with no access to adequate extra feed during the dry season, usually lose weight. Therefore, have lower total minimal requirements than during the rainy season. In the rainy season, local and crossbreed cows were found to suffer mainly from sodium (Na) and phosphorous (P) deficiency. Mineral variations may be due to the introduction of intensive crop systems and extensive fertilizer application; high yielding crop varieties; the mineral profile in soil, plants or animal feedstuffs are rapidly changing, which affect the mineral status of animals (Underwood and Suttle, 2001). Thus, different research results indicated that roughages feed that contains minerals like Cu, Mn, and Zn is below the critical level (McDowell, 1985; NRC, 2001). In general, a large number of livestock in different parts of the world consume diets including hay that do not meet these exacting requirements (McDowell *et al*., 1993; Miller, 2012).

2.2.2. Crop residues

Feed shortages and nutrient deficiencies become more acute in the dry season in both the highlands and lowlands of Ethiopia (Endale *et al*., 2015). For this purpose, crop residues are important in fulfilling feed gaps during periods of a severe shortage of other feed resources. Ethiopian smallholder farmers grow diversified crops and usually produce a mixture of crop residues including cereal straws like *teff*, wheat, barley, oats, maize, and sorghum, and different grain legume (Fekede *et al*., 2015). Crop residues consist of fibrous materials, which are the by-products of cultivated crops like the cultivation of cereals, pulses, oil plants, roots, and tubers and represent an important feed resource and contribute to about 50% of the total feed supplied in Ethiopia (Yayneshet, 2010; Adugna *et al.*, 2012).

The basic limitation in residues such as straw and stover with CP contents around the borderline level of 6 to 7% (Solomon *et al*., 2008a). Residues from leguminous crops have better quality than the residues from cereals. Legume straws contain less fiber, high digestible protein than cereal straws (Solomon, 2004). The plant species, an agronomic practice used, soil, temperature, and the stage of growth influence the chemical composition and the palatability of crop residues. Most residues are deficient in fermentable energy and minerals, as well as they have low palatability and digestibility that leads to poor intake, particularly when fed as the sole roughage (Solomon, 2004). This is because animals prosper predominantly on high-fiber feeds (straws, stovers and native pastures hay) which are deficient in nutrients (nitrogen, sulfur and phosphorous) essential for microbial fermentation. Consequently, the digestibility and intake of digestible nutrients are low.

The better productive utilization of crop residues can be attained either through appropriate supplementation (molasses, legumes, fruit pulps, poultry manure, urea) or chemical treatment (urea/ammonia treatments) or both, which facilitate the microbial break down of the cell wall of the plant. Moreover, conservation and efficient or economic use of crop residues improves and enhances their utilization (Alemu *et al.*, 1991; Getnet, 1999; Tsigie *et al.*, 2011). In feedstuff of plant origin, a high fraction of P is present in the form of phytate. Monogastrics are not able to digest phytate, but ruminants have extensive microbial activity in the rumen with a large mass of microorganisms in the possession of enzymatic phytase to break down phytate, releasing P in a form that can be absorbed along the gastrointestinal tract. Comparing different concentrates with P_0 vs. P_I sources, the P source did not seem to influence the total level of absorption in ruminants (Knowlton *et al.*, 2001; Ekelund *et al.*, 2003; Lemma and Smit, 2004).

2.2.3. Improved forage and pasture crops

Forages play a vital role in different livestock production systems. They are important as adjuncts to crop residues and natural pastures and may be used to fill the feed gaps during periods of inadequate crop residues and natural pasture supply. Even in the presence of abundant crop residues, which are often free-fed to ruminants, forage crops especially legumes are needed to improve the utilization of crop residues, crop residues often provide energy while forage legumes provide proteins (Ayenew *et al.*, 2009).

Dairy animals, because of their high requirement for a higher plane of nutrition, need more nutritious forage and will usually require feed supplementation. Improved forage yield is higher than the naturally occurring pastures and has higher nutritional value. In addition, the length of the productive season is longer for cultivated pastures than for the native pastures, which provide an opportunity to develop and use pasture and forage at a large scale for dairy production and fattening. They can also improve the feed value of the native pastures since they have more protein content than naturally occurring grasses (Yeshitila *et al.*, 2008).

Low-quality roughages are characterized by low digestibility, thus various attempts to manipulate the rumen ecology are generally aimed at enhancing roughage utilization. Topps (1995); Salem and Smith, (2008) noted that forage legumes invariably increase the digestibility of the total diet, and the digestibility would probably increase as the proportion of the forage legume is increased, which reflects the contribution of legumes to increase feed digestibility. Therefore, supplementation of poor quality roughages, like cereal crop residues, with legumes has been shown to increase their intake and digestibility (Andualem *et al*., 2015). But improved fodder production and utilization in the smallholder systems is limited due to shortage of land, lack of effective extension system, lack of adequate technical and material inputs, lack of specialization in livestock production and limited market orientation, and inadequate knowledge and awareness of the farmers about the utilization (Yitaye, 2008; Adugna *et al*., 2012; Fekede *et al*., 2013). Different research results indicated that legumes contain more minerals concentrations than would be in grass species, forage crop residues, and legumes during winter seasons, which are richer in minerals, including Ca (Kim *et al*., 2006; Aregheore, 2007; Khan *et al*., 2007). Therefore, forage Ca concentrations of 2-6 g/kg, with higher requirements for lactation have been variously recommended for cattle and sheep (ARC, 1980; NRC, 1985; Khan *et al*., 2007). The forage contained Fe contents are above the levels of 50 mg/kg proposed as adequate for grazing animals (McDowell, 1985 and Khan *et al*., 2007). Variations in the contents of Fe among grazing forages could be partly explained by forage species' differences and the influence of grazing lands on the level of Fe in the soil. Grazing pasture forages had higher levels of Fe than the critical content of Fe in animal tissues (30-50 mg kg^{-1} DM). Differences in the contents of Fe in different pastures forage values could also be related by variations in the content of Fe in the soil, and climatic conditions between localities. Forage Fe content is a function of forage species, soil Fe content, nature, and type of soil on which forages are grown (McDowell, 1992; Desalegn and Mohammed, 2012). These forages had higher levels of Fe than the normal requirements of 30-60 mg kg-1 DM of ruminants (McDowell, 1992; Aganga and Mesho, 2008).

2.2.4. Agro-industrial by-products

Agro-industrial by-products (AIBP) are fed as a supplement to roughage-based diets, particularly in the dairy production system for milking and or fattening activities in the urban and peri-urban areas. The AIBP produced in Ethiopia includes by-products from flour milling industries (wheat bran, wheat shorts, wheat middling and rice bran), breweries and sugar factories (molasses), edible oil extracting plants (noug cake, peanut cake, cottonseed cake, sesame cake, linseed cake, sunflower cake) which consist of relatively high and require high nutrient supply (Fekede *et al*., 2015). Oilseed cakes can also supply a considerable amount of protein and energy, depending upon the method of oil extraction and the amount of residual oil remaining in the cake.

The energy content varies from 2.03 to 3.7 Mcal ME/kg DM depending on the processing method. Net energy maintenance varies from 1.28 to 2.02 Mcal per kg DM and Net energy of gain varies from 0.71 to 1.36 Mcal per kg DM (Adugna, 2008). They have high protein, fat and low fiber content, high digestibility, and energy values compared with the other class of feeds. The report of Alemu *et al*. (1991) and Mengistu *et al*. (2017) indicated that more than 35% CP and 50- 70% in vitro organic matter digestibility (IVOMD) for oilseed cakes and 18-20% CP and more than 80% IVOMD for flour milling by-products. Supplementing ruminants fed low quality feeds with agro-industrial by-products enables them to perform well due to higher nutrient density to correct the nutrient deficiencies in the basal diet.

On the other hand, the report of Adugna (2008) and Zewudie (2010) agro-industrial byproducts contain more P than Ca, that indicated feeding alone likely to cause Ca deficiency. The concentrate mix is formulated to supplement a basal diet and thus it is not a balanced feed (Lukuyu *et al.*, 2012). The calcium content is usually low, which varies from 0.17 to 0.72% of DM whereas, most oilseed cakes are high in P content which ranges from 0.75-1.31% (Adugna, 2008). In general, oilseed cakes have high P, K and Mg contents and low content of Ca and Na (Adugna, 2008). However, most of the P in grains is in the form of phytates (often called phytin). Unlike monogastric animals, cattle with a functional rumen effectively utilize the phytate P.

2.2.4.1. Noug seed cake

Noug seed cake is one of the oilseed cakes commonly used as a protein supplement in the diet of farm animals in Ethiopia. Noug seed cake can be highly lignified if the seed is not dehulled before extraction. Because of its high CP content, it can be used as a protein supplement in the diet of farm animals. The report of Adugna (2008) showed that the CP content of noug seed cake varies from 28 to 38% with most values lying between 30 and 35% as well as the fat content varies from 2.1 to 12.6% with an average of 8.4% and an energy value of 2.37 Mcal ME/kg DM. Moreover, noug seed cake has high fiber (34.4% NDF and 8.4% lignin) content and relatively low digestibility (61.7% in vitro DM digestibility) compared to most other oilseed cakes. The CP and fat content of noug seed cake vary depending upon the method and efficiency of oil extraction from the noug seeds (Adugna, 2008; Nurfeta, *et al*. 2013).

2.2.4.2. Wheat bran

Wheat bran is an essential and relatively cheap and readily available source of carbohydrates, protein, minerals, and vitamins. It is quite palatable and well known for its laxative characteristics because of its swelling and water holding capacity. This is due to its high fiber and non-starch carbohydrate content (Alemu *et al*., 1989; Gebretsadik, and Kebede 2011). It is one of the energy source concentrates containing easily digestible carbohydrates (α-linked polysaccharides). Such feeds are readily digested in the rumen with high energy-yielding potential. Wheat bran also has a high CP content of about 17% and a relatively good source of most of the water-soluble vitamins except niacin. According to the report of Lonsdale (1989); Endale *et al*. (2016), CP contents of wheat bran may vary from 170 to 180 g/kg DM, respectively and its ME content may range from 10 to 11 MJ/kg DM. The crude protein in wheat bran has a relatively high digestibility of about 75%. The fiber and energy content of wheat bran may vary depending upon the quality of wheat being milled and the exact processing method used as these factors affect the overall blend of the bran components. When added to protein source feeds, wheat bran can improve feed intake, digestibility and growth performance of animals. Besides to this, wheat bran consists of high P (1%) and low Ca (0.1%) content (Adugna, 2008). *In vitro* research results of mineral availability from different animal feed resources indicated inTable 1.

Table 1. *In vitro* mineral availability from different animal feed resource

Feed resource	Macroelement (%)		Micro element (mg/kg)			
	Ca	Mg	Fe	Mn	Zn	Cu
Wheat straw	73	86	31	67	11	57
Barley straw	76	76	25	65	19	41
Teff straw	80	89	38	77	28	49
Maize stover	79	84	27	59	8	38
Oats straw	72	83	49	74	24	55
Wheat bran	83	94	45	88	62	56
Noug seed cake	11	55	22	32	27	21
Brewer's dried grain	61	93	31	52	30	29
Sorghum bran	100	77	8	55	32	28
Sunflower cake	42	77	41	48	14	37
Cottonseed cake	72	83	36	43	33	42
Groundnut cake	50	87	51	45	41	49
Linseed cake	60	43	34	26	33	27
Broiler litter	24	55	11	13	15	31
Coffee pulp	45	54	15	32	25	19

Source: Kabaija, (1989)

2.3. Mineral Elements Classification and Significance

Minerals are structural components of the body and play a substantial role in activities of the enzyme, hormone production, collagen formation, oxygen transport, energy production, regulators of cell replication and differentiation and other physiological processes related to growth, reproduction, and health, in general, they are considered as constituents of body fluids and tissues, (McDonald *et al.*, 2011). The research result of NRC (2001) indicated that 5% of the bodyweight of an animal consists of minerals, thus at least 15 mineral elements have been identified as nutritionally essential for ruminants. These are seven major(macro) minerals such as calcium (Ca), phosphorus (P), potassium (K), sodium (Na), chlorine (Cl), magnesium (Mg) and sulfur (S) and eight micro(trace) minerals - cobalt (Co), copper (Cu), iodine (I), iron (Fe), manganese (Mn), molybdenum (Mo), selenium (Se) and zinc (Zn) (NRC, 2001; McDonald *et al.*, 2002; Suttle, 2010). Moreover, mineral elements based on their valances classified as cations, including Ca, Mg, Na, K, Fe, Zn, and Mn, or anions (P, S, Cl, I, and F). Likewise, they can be classified on the basis of valence number and on their group position in the Periodic Tables of the atoms. Therefore, classifications are useful because they describe physical and chemical characteristics and importance in nutrition. For example, the monovalent cations, Na, and K have a very high absorption percentage and major interrelationships exist between them. In contrast, the absorption percentage of the divalent cations (Ca, Mg, and Zn) is much lower (Miller, 1979; Etcheverry *et al.*, 2012).

2.3.1. Macro minerals

According to the reports of Prasad and Gowda (2005); Subhash (2015), feeds that are deficient or excessively high in minerals influences in their concentration in the body tissues and fluids beyond the tolerable limits. Animal production, reproduction, and growth rates can be necessitated more attention to mineral nutrition. Mineral deficiencies, often marginal under low levels of production, which are likely to become important and previously unsuspected nutritional deficiency signs may occur as production level increases. Specific mineral requirements are difficult to identify since exact needs depend on chemical form and numerous mineral interrelationships. The chemical form of mineral elements varies greatly in the number of dietary minerals supplied and in biological availability (McDowell, 2002).

Mineral supplementation to the grazing livestock, if the main nutrients like energy and/or protein are deficient it is not economical and often of no benefit (McDowell, 1997; Abegaze and Chopra, 2008). However, in case of energy and protein supplies are adequate, mineral supplementation result a weight gain rapidly, leading to a high mineral requirements. Levels of requirements, as well as thresholds of deficiency and toxicity, vary with age, sex, production level, activity level, species and genetic strain of the animal. The age of animals can affect mineral requirements through changes in the efficiency of absorption. In general, the younger animal absorbs most minerals more efficiently than the older animal (ACA, 1990; Bezabih and Pfeffer, 2003). The sex of the animal affects susceptibility to mineral disorders probably through differences in growth rate and physiological functions. Mineral nutrition disorders range from an acute mineral deficiency to toxicity, which characterized by well-marked clinical signs and pathological changes, to mild and transient conditions too difficult to diagnose and expressed as an ambiguous unthriftiness or poor growth and production (Vargas and McDowell, 1997; Soetan *et al*., 2010).

The concentration of essential elements must usually be maintained within quite narrow limits if the functional and structural integrity of the tissues is to be protected and the growth, health, and productivity of animals to be maintained at optimum levels. Insufficiency of minerals in the diet of dairy animals mostly causes muscular weakness leading to recumbences, while mild to moderate deficiency reduces feed intake, decreases rumen and intestinal motility, causes sub minimal productivity, and increased susceptibility to other metabolic as well as infectious diseases (NRC, 2001). Mineral inadequacies in livestock are often occurred seasonally, due to increased demands of pregnancy, lactation or rapid growth of animals and reduced mineral content or availability in the pasture (Tashi *et al.*, 2005). Changes in intake of some or mobilization of certain macro mineral (Ca, P, Mg) and vitamins (vitamin D) lead to various metabolic diseases in dairy cattle. Most of the time-intensive farming with high dietary mineral requirements, dairy cattle without additional mineral supplementation may be exposed to deficiency diseases. However, mineral deficiencies or imbalances in soils and forages have long been held responsible for low production and reproductive problems among grazing tropical cattle (Radostits *et al.*, 2000).

2.3.1.1 Calcium (Ca)

Calcium is the most abundant mineral in the animal body, which estimated to be about 98 to 99 percent and is located within the skeleton with phosphate anion, which serves to provide structural strength and hardness to bone (Hall, 2005). Likewise, Ca is an important component of the skeleton and plays a crucial role in many metabolic processes like cell membrane permeability, nerve transmission, muscle contractions, blood clotting, cardiac muscle contraction, secretion of hormones, and activation and stabilization of certain enzymes (Rosol and Capen, 1997).

The concentration of Ca in blood plasma is (9 to 10 mg/dl) in an adult cow (NRC, 2001). The plasma Ca levels of dairy animals depend upon dietary Ca intake and other non-nutritional factors such as season of the year, age, weight, pregnancy, and lactation (Khan, 2003). According to the report of Chhabra (2006) higher plasma Ca levels in dairy animals in the winter season higher (8.25 $mgdl^{-1}$) than in winter season (7.99 $mgdl^{-1}$). Likewise, several researchers had observed age-related decline in plasma/serum Ca levels (Prava and Dixit, 2006), which was attributed to a progressive decline in Ca absorption with age and lactation (Payne, 1989; Sikh., 2012). Lactating animals tend to have lower serum Ca levels as compared to non-lactating cows (Mandal *et al* 1996). Based on cow age homeostatic mechanisms are slower to react to the Ca demand of lactation (Horst *et al.*, 1994; Megan, 2007).

Increased Ca concentration in the feed is associated with higher Ca content in the plasma of dairy cows if the composition is higher than 1.0% (Stevens *et al.*, 1971; Abegaze and Chopra, 2008). The research result of Black *et al.* (1973 and Wt (2012) indicated that cows with a high intake of Ca rely less on bone resorption for calcium requirements and more on intestinal absorption, as the result low Ca intake during early and mid-lactation reduced milk production. The digestibility of Ca is dependent on the diet, mainly the level of dietary Ca, and the absorption is regulated by the hormone calcitriol (Hove, 1984; Toribio, 2011). Increased incidence of parturient paresis in cows fed prepartum diets high in Ca is associated with decreased activity of chief cells of the parathyroid gland, lower parathyroid hormone (PTH) content, and decreased positive response to challenge of calcium in plasma (Black *et al*., 1973; Murray *et al*., 2008)). In other case cows consuming large quantities of calcium during prepartum have higher Ca content in the plasma due to higher thyrocalcitonin, and increased density of trabecular bone (NRC, 2001). Dietary P has been shown to negatively influence the uptake of P, and this may result from altered calcitriol production (Tanaka *et al*., 1973). The net absorption of Ca prior to the abomasum (Schroder and Breves, 2006), occurred mainly when the Ca concentration in the rumen is high (Khorasani *et al*., 1997; Kabaija and Little, 2013).

The mineral feeding of dry cows focused on providing optimum levels of Ca and P because a deficiency could affect animal health and productivity adversely. A lactating cow producing 10 kg of milk per day is required 30 g Ca/day as recommended by ARC (1994). Metabolic deficiency with the sudden loss of excess Ca in milk in high yielding dairy cows leads to milk fever, when the plasma Ca levels decline may be severe enough to produce milk fever which is characterized by circulatory collapse and depressed consciousness (Radostits *et al.,* 2007). Moreover, the reduced feed intake due to hypocalcemia could be due to reduced smooth muscle contractions leading to the reduced rumen and abomasal motility (Daniel, 1983; Goff, 2008). Whereas nutritional deficiency of Ca is associated with prolonged intake of feeds deficient in Ca which is clinically manifested by reduced feed intake, weakness, poor performance, swollen joints, lameness, and weak bones had been observed in dairy animals suffering from Ca deficiency (Schroder and Breves, 2006). In dairy animals, Ca requirement is increased greatly during the last trimester of pregnancy to meet Ca demands for proper calcification of fetal skeleton and during lactation due to drain in colostrum and milk (NRC, 2001). Therefore, deficiency of Ca is a sporadic problem occurring in a particular group of animals rather than specific geographic areas (Radostits *et al.*, 2000).

The modification of the Ca: P ratio may affect ovarian function through its blocking action on the pituitary gland. This results in elongation of first estrus and ovulation, delayed uterine involution, increased incidence of dystocia, retention of placenta, and prolapse of uterus. Moreover, low Ca level in blood is also associated with absence or irregularity of oestrus. whereas an excess of Ca can affect the reproductive status of the dairy animal by impairing absorption of P, Mn, Zn, Cu and other elements from the gastrointestinal tract. The ratios of (Ca: P) between 1.5:1 and 2.5:1 for lactating cows should not result in problems (Kumar, 2003). Milking cows should always be provided adequate amounts of calcium helps to maximize production and minimize health problems (Radostits *et al.*, 2007). Furthermore, Ca deficiency may occur in animals grazing on sandy or organic soils in humid areas where forages consist mainly of quick-growing grasses with no legumes (Underwood and Suttle, 2001). Plasma Ca concentrations are maintained more or less constant by homeostatic mechanisms through bone resorption, decreased urinary Ca excretion, and increased intestinal Ca absorption in animals on Ca deficient diets. Commonly used calcium supplements in dairy cattle are calcium chloride, calcium carbonate, bone meal, limestone, dicalcium phosphate, calcium hydroxide, calcium oxide, calcium phosphate (NRC, 2001). The bioavailability of dietary Ca is around 50-60% in cattle (NRC, 2001) as indicated in Table 2.

Table 2. Mineral supplements used in animal production

Compounds	Mineral present
Calcium carbonate	40% Ca
Limestone powder	38.5% Ca
Calcite powder	39% Ca
Dolomite stone	22.3% Ca ; 12.8 Mg
Dicalcium phosphate	23.3% Ca; 18.5% P
Magnesium carbonate	21 - 28 % Mg
Magnesium oxide	54 - 60% Mg
Magnesium sulphate	9.8 - 17% Mg
Zinc carbonate	52% Zn
Zinc chloride	48% Zn
Zinc sulphate	22 - 36 Zn
Potassium iodide	69% I
Calcium iodate	63% I
Copper sulphate	25% Cu
Cupric chloride	37.25% Cu
Cobalt sulphate	21% Co
Cobalt chloride	24.7% Co
Ferrous sulphate	26 - 30% Fe
Sodium chloride	39% Na ; 51% Cl

Source: Chopra and Kanwar (1991)

2.3.1.2 .Phosphorus (P)

Phosphorus (P) is a very essential mineral for dairy animals, and it is a component of the skeleton, as well as involved in every metabolic reaction in the body including muscle, energy, carbohydrate, amino acid, fat, nerve tissue and nucleic acid metabolism (Rosol and Capen 1997; Soetan, *et al*., 2010). It has more known biological functions compared to other essential minerals (Soetan *et al*., 2010). According to the research result of McDowell (2003), that indicated every cell of the body constitutes P and almost all transactions of energy involve formation or breaking of high energy bonds that link oxides of phosphate to carbon or to carbon-nitrogen compounds (ATP). Other major roles of P in the body include acid-base buffer system, cell differentiation, as a component of cell contents like phospholipids, phosphoproteins, and nucleic acids. Phosphorus is used to rumen microbes for cellulose digestion and the synthesis of microbial proteins (McDowell, 2003; NRC, 2001).

However, deficiency of P is the most prevalent mineral deficiency of livestock throughout the world (McDowell, 2003). Large areas of grazing land in many countries are deficient in P and need supplementation to overcome the deficiency in animals. The availability of P in soil depends upon parent rocks from which soil of the area is derived (Demelash & Stahr 2010). Moreover, excess of Ca, Fe, or aluminum in soil reduces the availability of P to plants (Melese *et al.*, 2015). Heavy leaching by rain, constant removal by cropping and drought conditions causes P deficiency (Radostits *et al*., 2000). Phosphorus deficiency primarily under field conditions is characterized in cattle by pica, poor growth, and infertility (Anestrus) while osteodystrophy develops in later stages of deficiency and post parturient hemoglobinuria (Radostits *et al*., 2000).

The reduced dietary intake of P in dairy calves had resulted in a significant decline in plasma Pi (inorganic phosphorus) levels from 8.55 $mgdl^{-1}$ on day 1 to 4.40 $mgdl^{-1}$ on day 65 (Haque and Verma 1990; Sikh., 2012). In adult dairy cattle, normal plasma Pi concentrations range from 4.0 to 6.0 $mgdl^{-1}$ (Underwood and Suttle, 2001), if it is less than 4 $mgdl^{-1}$ said to be below a critical level (Miles and Mc dowels, 1983). Moreover, lower plasma Pi levels in cows with loss of milk production (1.61 $mgdl^{-1}$) and anoestrus (1.92 $mgdl^{-1}$) than in the healthy control cows 5.71 $mgdl^{-1}$ (Samanta *et al.*, 1995; Singh, 2012). Similarly, Behera *et al.* (1993) observed lower plasma Pi concentrations in delay maturing heifers (2.91 $mgdl^{-1}$) than in the cycling heifers (5.54 $mgdl^{-1}$), suggesting that hypophosphatemia might be a contributing factor which inhibits the function of the anterior pituitary, resulting in suppression of both ovarian and genital activity.

Likewise, non-lactating cows maintained higher serum Pi levels than the lactating cows although the magnitude of differences was small. Moreover, Prava and Dixit (2006) reported that plasma Pi levels in dairy animals declined with age. Dairy feeds which is rich in Mo cause deficiency of P in plants and animals (Dhillon *et al.*, 1972; Soetan *et* *al*.,2010) The presence of Mo reduce P absorption at the intestinal level and increase urinary P excretion leading to the lowering of P contents in dairy animals (Radostits *et al*.,2007). Blood Pi homeostasis is more complicated than blood Ca because blood P is in equilibrium not only with bone Pi but also with several organic compounds produced as a result of cellular metabolism (Church and Pond, 1988; Abegaze and Chopra, 2008). Moreover, lower Pi level in animals was recorded in cool seasons than hot seasons of the year. This might be attributed to higher dietary availability of Pi during the dry season than the wet season plus the higher absorption efficiency in the drier months (Khan, 2003).

Absorption of P is in direct relation to the supply of potentially absorbable P in the lumen of the small intestine (Care *et al*., 1980; Balimane *et al*., 2000). Two mechanisms are involved in P absorption. Saturable vitamin D deficient diets help to maximize the P absorption via increased synthesis of 1, 25-dihydroxy vitamin D (Horst *et al*., 1994). The other mechanism is passive absorption which occurs when a large amount of potentially absorbable P is available in the diet. Homeostasis of P is maintained mainly by salivary recycling and endogenous fecal excretion, which are related directly to the amount of dietary P consumed and absorbed (NRC, 2001). Generally, mineral stores in bone are mobilized in late pregnancy or early lactation, irrespective of the rate of P absorption. Significance of Ca:P dietary ratio in nutritional diet formulation has been reduced over time due to the fact that sufficient dietary P, with wide ranges of the ratio can be tolerated and efficiencies of absorption of Ca and P vary greatly as per the source of the element in the diet (NRC, 2001). Several studies revealed no differences in milk yield, milk composition or reproductive performance in cows during early lactation fed diets with Ca:P ratios of 1:1, 4:1, or 8:1 (Smith *et al*., 1997) or 3:1 or 1.5:1 (Stevens *et al*., 1971), likewise, 1:1 to 2:1(ARC, 1994) with ensuring the fulfillment of the net dietary requirement of each mineral. The serum and urine Pi concentrations could aid in the diagnosis of P deficiency, but with mobilization of bone, P to maintain serum concentrations, a significant drop in serum and urinary Pi concentrations might take weeks to develop. Phosphorus requirement for cows producing 10 kg milk per day is 28 g P/day and 1.65 g recommended per additional kg of milk yield (Hall, 2006). The dietary P requirement for cattle varies according to stages of growth and production. The most used P supplements are dicalcium phosphates and defluorinated rock phosphate. Moreover, other options for supplementation used are diammonium phosphate, disodium phosphate, monosodium phosphate, mono ammonium phosphate, and sodium tripolyphosphate are sometimes utilized as sources of feed P (Radostits *et al.*, 2000). A top-dressing of pastures with superphosphate is a satisfactory method of correcting the deficiency with the added advantage of increasing the bulk and protein yield of the pastures (Radostits *et al*., 2000).

2.3.1.3. Magnesium (Mg)

Magnesium is a major intracellular cation which acts as a cofactor for several enzyme systems in every metabolic pathway, which involve in skeleton formation, energy metabolism, protein synthesis, membrane integrity, nervous tissue conduction, neuromuscular excitability, muscle contraction, hormone secretion, and intermediary metabolism (Rosol and Capen, 1997). The normal plasma Mg levels in dairy animals vary from 1.80 to 2.67 $mgdl^{-1}$ (Radostits *et al.*, 2007). Converse to Ca homeostasis, maintenance of normal plasma Mg concentration is almost very dependent on dietary Mg absorption (NRC, 2001). In dairy animals, the deficiency of Mg either can occur as a metabolic deficiency denoted as grass tetany/ Hypomagnesemia tetany, or as a true nutritional deficiency associated with a long-term dietary deficit of Mg (Radostits *et al.*, 2007). Hypomagnesemia tetany has been known under a variety of names, including magnesium tetany, lactation tetany, and grass staggers, but it is not always associated with lactation or with grazing animals. The exact cause of tetany in ruminant animals is a dietary deficiency of magnesium that may be a contributory factor. While magnesium absorption from the diet is insufficient, the cow has no possibilities to mobilize the magnesium stored in the bones and adequate absorption is thus necessary to maintain the magnesium levels in the cells and in the extracellular fluid. However, some research workers consider the condition to be caused by a cation-anion imbalance in the diet, and they believe that high intake of the element (K and Na) may interfere with the absorption and metabolism of magnesium in the animal, which may be an important factor in the etiology of hypomagnesemia tetany (Radostits *et al.*, 2007).

Grass tetany is characterized by the sudden loss of appetite, unusual alertness, muscle twitching, staggering gait, opisthotonus, and nystagmus, tetany of hind limbs, convulsions, and recumbence (Radostits *et al.*, 2007). The dietary requirement of Mg in dairy animals is suggested to be 0.18 to 0.20 percent (Mc Dowell *et al*., 1993; NRC, 2001). The leguminous fodder was reported to be rich in Mg and is not associated with hypomagnesemia in animals. But grasses contain high K reduced Mg uptake from the gut (McDowell, 2003) thereby induced hypomagnesemia in cattle grazing on immature grasses. Moreover, rapidly growing winter pastures absorb insufficient concentrations of Mg as does the potassium fertilization. Magnesium solubility decreases with an increase in ruminal pH above 6.5 which has been observed in animals grazing on pastures with high potassium content and increased salivation (which is alkaline) associated with grazing (NRC, 2001). The plasma Mg levels of dairy animals are influenced by cold windy weather may reduce serum Mg levels of the dairy animals due to poor quality and reduced intake of forages (Radostits *et al.,* 2007). Moreover, high yielding cows in a 3-5th stage of lactation are more prone to suffer from Mg deficiency due to high lactation losses and decreased ability of Mg resorption from bones in the older animals (Harris *et al.,* 1994). Serum samples are helpful in the diagnosis of hypomagnesemia in live animals (Mass, 2007). Normal serum Mg concentrations in cattle are 1.7-3 mg/dl which are often reduced (1-2 mg/dl) in seasonal subclinical hypomagnesemia (Radostits *et al.*, 2000). A magnesium requirements in pregnant animals, the fetal-placental requirement is about 0.18 g/day in Holstein cows from day 190 on wards (House and Bell, 1993; McDonald *et al*., 2004), however, the estimated requirement for the feto placental unit in late gestation was 0.33 g/day (Grace, 1983; Lain, 2007). The preventive strategy includes administration of Mg supplements in the form Mg carbonate (Magnesite), Mg sulfate, and Mg chloride, during high-risk periods, 60 g/day of Mg oxide to cattle which may be increased up to 120 g/day safely (Radostits *et al.*, 2000). Other strategies include spraying of hay with Mg, top dressing of pastures, foliar dusting and spraying, provision of Mg in drinking water, pasture management, and supplemental Mg feeding in pregnant and lactating cows as indicated (Table 2).

2.3.2. Micro-minerals

Trace minerals are found in body tissues in very low concentrations which are required for the synthesis of many proteins and activation of an enormous array of enzyme systems (Ceylan et al., 2008). Complex interrelationships exist between certain micronutrients, immune functions, and disease resistance in cattle. Trace mineral supplementation above expected requirements during times of stress may reduce oxidative damage to cells and increase disease resistance (Gressley, 2009). Inorganic forms of micro-minerals are not sufficiently absorbed and retained. However, the organic forms are absorbed and retained in the tissues to enhance performance, improve immunity and health, suggesting better bioavailability through organic/chelated sources (Pal *et al.*, 2010). The trace mineral content of roughages is not always representative of the blood levels because the presence of antagonists may reduce their absorption from feed and water (Guyot *et al.*, 2009). The absence of essential trace elements affects animal health and production, such an element exerts well-defined nutritional and biochemical roles in the body (NRC, 2001). Unlike other nutrients, minerals are not broken down intensively and rebuilt to metabolize forms. The absorption of many trace elements is carefully regulated by homeostatic control mechanisms, in an attempt to ascertain a balance between the number of elements retained from the diet and the amount inevitably lost from the body (McDonald *et al.*, 2002).

Trace elements can be secreted through sweat, milk, and digestive juices (e.g., saliva, bile). Apart from homeostatic control mechanisms, the trace element absorption in the ruminant gut is affected mainly by other compounds present in the intestinal lumen and at the absorptive site (Suttle, 2010). Excretion pathways of trace elements are feces and urine production. Even after absorption, the function of trace elements can be influenced by such compounds. These compounds can be divided into two classes: *synergistic* (positively affecting absorption) and *antagonistic* (negatively affecting absorption) (Suttle, 2010).The concentration of trace elements in forage most commonly is in inadequate for cattle nutrition, such elements are Co, Cu, I, Se, and Zn (McDowell, 1996). However, forages are also known to contain very variable amounts of trace elements (Lemma *et al.*, 2002). Those variable factors are developed from the stage of maturity of the plant, as the maturity increases, reduced the concentration of trace element content of the plants (McDowell, 1996). Moreover, generally lower trace element concentrations in the dry season (Pastrana *et al.*, 1991). However, due to the higher amounts of trace elements in soil in comparison with the plants growing on it, the soil uptake can beneficial and disadvantageous (toxicity) for the grazing animal (McDowell, 1996). For instance, soil ingestion is known to exacerbate the Cu status because of the large amount of Fe present in these particles (Suttle and Jones, 1989).

2.3.2.1 Copper (Cu)

Copper is an important trace mineral required for the normal function of cellular homeostasis, structure, and function of skeleton, cardiovascular, nervous, and immune systems (Nockels, 1994; Healy and Tipton, 2007). An increase in serum ceruloplasmin and plasma Cu which are used as a major protective role in infectious diseases (Stabel *et al.*, 1993), deficiency of Cu resulted in decreased humoral and cell-mediated immunity as well as decreased neutrophil bactericidal capability in steers. Likewise, it is an essential component of several metalloenzymes e.g. cytochrome oxidase, Cu-Zn superoxide dismutase, tyrosinase, ceruloplasmin, and dopamine beta-monooxygenase (Linder, 2002). Such enzymes are involved in protection from oxidative stress, pigmentation of hair, support hemoglobin formation, influences on iron metabolism at the cellular level and connective tissue synthesis (Gressley, 2009). It is an element involved in the synthesis of ceruloplasmin, an enzyme necessary for the oxidation of Fe and permitting it to bind with Fe transport protein transferrin (NRC, 2001). The Cu requirements vary in ruminants depending on the concentrations of other dietary components, especially S and Mo and it considered as three-way interaction between Cu, Mo, and Sulpher (NRC, 2001). In this case, thiomolybdates are formed by molybdate reacting with sulfide, which is produced by rumen microorganisms via the reduction of sulfate and also degradation of sulfur amino acids. Therefore, thiomolybdates associated with solid rumen digesta (bacteria, protozoa, and undigested feed particles) form insoluble complexes with Cu that do not release Cu even under acidic conditions (Jerry, 2003). Systemic effects on Cu metabolism that are attributed to the absorption of thiomolybdates which include: strong binding of copper to plasma albumin, results in a reduced transport of available Cu for biochemical processes; increased biliary excretion of Cu from liver stores and removal of Cu from metalloenzymes (Suttle, 1991; Clarkson *et al*., 2019).

Copper deficiency occurs in ruminants either as a primary or secondary problem (Sharma *et al*., 2003). In primary deficiency, the level of copper is low in the diet whereas, in secondary deficiency, copper absorption and utilization are inhibited by an imbalance or excess of other elements in the ration. Consequently, deficiency of copper may result in cardiovascular disorders, depigmentation and impaired keratinization of hair and wool, anemia, reduced growth, neonatal ataxia, bone abnormality, hypomyelination or demyelination and reduced levels of sphingolipids are symptomatic of copper deficiency in many animals and impaired immune response (Spears, 2000). Likewise, calves born from Cu deficient cows experience an increased incidence of death, growth rate affected, reduced immunity and poor production efficiency (Underwood and Suttle, 2001). The chemical basis for the color change is an alteration in the metabolism of tyrosine, a precursor of melanin. These symptoms are more obvious in breeds that have heavily crimped hair (Underwood, 1971). Moreover, Cu deficiency also impairs reproduction which includes decreased conception rates, increased days open, increased cases of retained placenta, delayed puberty, and increased repeat breeders in cows and decreased libido and semen quality in bulls.

The diagnosis of Cu deficiency should be based on clinical signs, history, blood/serum, and liver Cu levels (Kumar *et al*., 2005). The liver is the best measure of current Cu status, except in the fetus or newborn. The fetus stores Cu in its liver at the expense of the dam. In late pregnancy, it is normal for the cow's serum and liver Cu levels to decline drastically. The normal liver Cu level is 25–550 ppm, whereas in deficient and marginally deficient cases the levels are 0.5–10.0 and 5–25 ppm, respectively (Kumar *et al*., 2005).The serum is a more reliable and consistent measure of Cu status than the whole blood. The normal serum Cu level is 0.7–1.1 ppm whereas deficient and marginal levels are 0.2–0.4 and 0.4–0.7 ppm, respectively. However, the serum does not reflect dietary intake unless the liver is severely depleted of its Cu stores in which low serum Cu indicates that almost all of the liver Cu storage has been used. In general, reference ranges for plasma ceruloplasmin are normal >0.65 mg/l and severely deficient <0.65 mg/l (Milles and McDowell, 1983).The requirement of Cu for cattle is 10 ppm. Copper deficiency can be treated by injectable copper glycinate has been used for many years to treat and prevent Cu deficiency (NRC, 1989; Radostits *et al.*, 2000). A relatively new method of Cu supplement is the Cu oxide bolus, which is given orally and provides supplementation for up to 12 months.

2.3.2.2. Zinc (Zn)

Zinc is an important trace element required for the structural and functional integrity and involved in the metabolism of carbohydrates, nucleic acid, protein synthesis and maintenance of epithelial tissue integrity, cell repair, and division as well as membranes stabilization (Miller *et al.,* 1988; Miller and Madsen, 1992), apart from being a structural component of over 300 enzymes, it is vital for stabilization of RNA, DNA, ribosomes, hormones, and their receptors; plays a vital role to the activity of a variety of hormones including glucagon, insulin, growth hormone, and the sex hormones, antioxidant effects, maintain integrity and barrier function of skin, and is involved in the immune system (Underwood and Suttle 1999; Gressley, 2009).

Zinc influences several aspects of vitamin A metabolism, including its absorption, transport, and utilization. Two common mechanisms hypothesized to explain this dependence relation, the regulatory role of Zn in vitamin A transport mediated through protein synthesis, and the oxidative conversion of retinol to retinal that requires the action of a Zn-dependent retinol dehydrogenase enzyme (Christian and West, 1998). The normal serum Zn levels are always greater than 0.80 mg/L and if it is less than 0.8 mg/L considered to be deficient in cattle and sheep (Mc Dowell, 1985; Radostites *et al.*, 2007). However, there are factors that influence the level of Zn concentration in the blood, making serum determination as an unsuitable method for diagnosis of Zn deficiency due to hemolysis of blood the level of Zn increase, whereas stress and physical illness decrease the serum Zn levels (Underwood, 1977). However, due to low levels of Zn in soils, widespread deficiency of this element had been reported in livestock from more different areas of the world (McDowell, 2003).

The deficiency may also reduce appetite by impairing a sense of taste which is mediated through the salivary Zn dependent polypeptide gustin (Al-Saad *et al.*, 2006). Low salivary Zn concentration leads to a reduction of taste and reduced appetite. It is postulated that the reduction in enzyme activity leads to the accumulation of one or more metabolites causing a marked change in eating behavior. This extreme sensitivity of appetite to nutrient supply is unique to Zn, expressed in all species, and reflects the key role of Zn in nutrient metabolism. Likewise, parakeratosis is a common sign of Zn deprivation in all species (Kumar *et al.*, 2005). Moreover, low Zn status in dairy cattle has been implicated in poor quality milk due to an increase in the milk somatic cell count (SCC) and increased incidence of mastitis (Aguilar and Jordan, 1990; Pechova *et al.*, 2006). Zinc is critical to good hoof health in many species to improve hoof health through keratin synthesis and maturation, wound healing, and epithelium maintenance (Buragohain, 2012).

Zinc supplementation at 50 mg/kg on a dry matter basis is normally sufficient. Treatment of the soils with Zn containing fertilizers, required to increase crop yields, usually result in significantly increased forage and grain Zn concentration (Underwood and Suttle, 1999; Riedell *et al.*, 2009). For cattle, the feeding of zinc sulfate 2-4 g daily is recommended as an emergency measure. Moreover, the creation of subcutaneous depots of zinc oxide or zinc dust has been demonstrated. However, zinc dust offers a greater delayed effect (Radostits*et al.*, 2000). Supplementation of organic Zn in lactating dairy cows revealed an increase in lactation performance and improvement of udder health with a significant reduction in SCC (Kellogg *et al.*, 2004). The concentration of Zn in plasma varies with age, stress, infections and feed restriction (Kincaid, 1999; Carroll, 2007). Different research results indicated that the plasma Zn concentration was higher in pregnant cows and lower in lactating cows followed by heifers and calves (Elnageeb and Adelatif, 2010). This could be attributed to an increased rate of Zn accumulation in the fetus and the increased demands for Zn towards the end of pregnancy.

2.3.2.3 Iron (Fe)

Iron is a component of hemoglobin, myoglobin, and several enzymes such as catalase, peroxidase, and cytochrome oxidase which performs a vital role in biochemical reactions including anti-oxidant defense mechanisms, energy and protein metabolism, oxidation-reduction reactions, and in the electron transport system (NRC, 2001). Generally, adequate Fe levels in the pasture, forage contamination from soil or direct soil intake provide excess dietary Fe to the animals. Therefore, deficiency of Fe in ruminants is uncommon under normal feeding conditions but may occur in the animals fed on poor quality roughages like straw for extended periods of time. The dietary requirement of Fe in dairy animals is reported to be 50 ppm (McDowell, 2003). The high Fe levels in forages from 250 to 500 ppm can be toxic and interfere or decrease Cu absorption (Phillippo *et al.,* 1987). Moreover, mutual antagonism exists between Fe, Mn, and Co at the absorption level due to competition for common uptake mechanisms (NRC 2001), and thus the high dietary Fe intakes can disturb Mn and Co status of the animals.

The high Fe concentration during the late pregnancy and low during early lactation this might be due to the increased transfer of this nutrient across the placenta and haemodilution during late pregnancy and at calving, together with the initiation of ovarian follicular activity postpartum, leading to high circulatory estrogen which stimulated the binding of iron with the proteins in liver and, thereby, increased concentration in plasma (NRC, 2001). The Fe in hemoglobin is essential for the proper functioning of every organ and tissue of the body. The duodenum is the main site of Fe absorption (Kaneko *et al.*, 1997; Marie Minihane and Rimbach, 2002). There is little evidence of Fe deficiency occurring in calves, lambs, and kids raised under grazing conditions, except when blood loss or disturbance in Fe metabolism due to parasitic infectious disease. Iron deficiencies are rare in cattle except in young ruminants and milk-fed calves (Matrone *et al.,* 1957; Mollerberg, 1975; Genova *et al*., 2011) because Fe is very low in the milk. Moreover, seasonal and pathological factors and acute phase response to immunological challenges affect plasma Fe levels of the dairy animals (Kushner, 1982; Genova *et al*., 2011) indicated that higher plasma Fe levels during the wet season and the plasma Fe levels decreased towards the end of the rainy season. Deficiency of Fe in farm animals is characterized by poor growth, listlessness, rough hair coat, anoxia, wrinkled skin, reduced appetite, paleness of mucous membranes, labored breathing after mild exercise, hypochromic microcytic anemia, decreased resistance to infection, enlarged heart, and spleen, enlarged fatty liver, and ascites (Kaneko *et al*., 1997; Genova *et al*., 2011). Moreover, Fe deficiency has been implicated in greater morbidity and mortality associated with depressed immune responses (Mollerberg and Moreno-Lopez, 1975; Genova *et al*., 2011). A high incidence of infectious disease especially enteric infection with *Escherichia. coli* is associated with anemia, and Streptococcal pericarditis is a well-recognized complication (Radostits *et al*., 2000).

2.3.2.4. Cobalt (Co)

Ruminants are not dependent on a dietary source of vitamin B_{12} because rumen microorganisms are capable of synthesizing vitamin B_{12} from dietary cobalt. Since Co is a constituent of vitamin B_{12}, practically Co deficiency is a vitamin B_{12} deficiency that brought about the inability of rumen micro-organisms to synthesize sufficient vitamin B_{12} when dietary Co is inadequate (McDowell, 2003). Forages consistently contain less than 0.08 ppm of Co, this level of Co concentration in dairy animals could be a prediction of deficiency (McDowell, 2003). When soils containing less than 0.25 ppm Co are likely to produce pasture containing insufficient Co, but the relationship between levels of Co in soils and pasture is not always constant (Radostits *et al.*, 2007).

The Co deficiency is considered as the most severe mineral limitation to the grazing dairy animals (McDowell, 2003). When animals are put on Co deficient diet for a considerable time, then Vit. B_{12} which stored in the liver and other tissues starts to deplete. Its deficiency signs in dairy animals are non-specific and it is often difficult to distinguish between a deficiency of Co and protein-energy malnutrition. But the deficiency characterized by fatty liver changes, anemia, decreased feed intake, lowered feed conversion, reduced growth, weight loss, hepatic lipidosis, immunosuppression, listlessness, decreased milk production and impaired reproductive functions in Co deficient animals (Puls 1994; Underwood and Suttle, 2001; Prasad and Gowda, 2005). Furthermore, with an extreme deficiency emaciation or wasting of muscles, paleness of the skin and mucous membranes, muscular incoordination, a stumbling gait, rough hair coat and high mortality rate among calves is observed (Radostits, 2000).

Assessment of Co status in dairy animals should be based upon liver Co, serum cobalamin concentrations (Kincaid, 1999). In vitamin B_{12} deficiency, methylmalonic acid (MMA) accumulates in the plasma and its elevated concentrations in plasma and urine may be used for the diagnosis of Co deficiency in ruminants (Kennedy *et al.*, 1991). However, measuring the response of treatment by supplementing Co or vitamin B_{12} is the only method of establishing a critical level of dietary Co in livestock (Underwood and Suttle, 2001). Unlike, the report of McDowell (2003) the estimation of cobalt requirements in cattle has ranged from 0.07 to 0.11 mg/kg diet, based largely on observations in grazing animals (Mills, 1981). Cobalt deficiency in grazing animals can be prevented most easily by the top dressing of affected pasture with cobalt salt at the dose of 400- 600 g/hectare every 3-4 years. The inclusion of Co in the mineral mixture containing about 1.0% Co is a satisfactory procedure (Radostits *et al*., 2000). Cobalt oxide and Co sulfate both are equally effective in raising the serum and liver Vit. B_{12} concentration (Andrews and Anderson, 1984; Soetan *et al*., 2010). Subcutaneous injection of 2 mg of vitamin as cyanocobalamin tannin complex achieves a sustained increase in serum Vit.B_{12} without improving liver storage (Judson *et al*., 1988; Soetan *et al*., 2010).

2.4. Minerals in Feed Resources

Dairy cattle normally obtain most of their minerals from the feeds that they consume and their mineral intakes are influenced by the factors that determine the mineral content of plants and their seeds. The concentration of all minerals in crop and forage plants depends on the genus, species or variety of plants the type of soil on which the plant grows; the climatic or seasonal conditions of the area where plants are grown; and the stage of maturity of the plants (Underwood and Suttle,1999; Aschalew *et al*., 2006).

They are different factors influencing the mineral concentrations in feeds which have significantly crucial importance in feeding programs and possible to identify mineral-related imbalance. These factors are interrelated in many ways. The soil where the plant is grown often has a major role in determining the content of the various minerals. One of the major factors affecting mineral availability to plants is soil pH. The pH of soils influences the level of minerals hence, low pH coupled with high soil Fe might have contributed to high P fixation (Tisdale *et al.*, 1985; Verde *et al.*, 2013). Moreover, the increase in pH of soil leads to a decrease in availability and uptake of Fe, Mn, Zn, and Co, whereas Mo and Se concentrations increase. Many minerals, including Zn, Mn, Fe, Ni, and Co are more available to plants grown on low pH soils. In contrast, others, especially Mo and Se, are more available on higher pH soils. The marked condition of leaching of minerals and weathering of soils in tropical regions under conditions of heavy rainfall and high temperature, result a mineral deficient in the plant. Poor drainage conditions often increase extractable trace elements (i.e. Mn and Co), thereby resulting in a corresponding increase in plant uptake (NRC, 2001). However, plants react to inadequate supplies of available minerals in the soil by limiting their growth, reducing the concentration of the deficient elements in their tissues or, more commonly, reducing growth and concentration simultaneously (Underwood and Suttle, 2001).

Moreover, the genetics of the plant often has a major effect on the mineral content especially, legumes plants consists more Ca, Mg, K, Zn, Fe, Cu, Co, and S than in grasses (Underwood, 1966; Aschalew *et al*., 2006). For better establishment and growth of many legumes, adequate pH and Ca level in the soil is mandatory. Moreover, the importance of a given factor varies between minerals and which is influenced by the interactions of crop or pasture husbandry, including the use of fertilizers, soil amendments, irrigation, crop rotation, intercropping and high yielding cultivars (Neville, 2010). Furthermore, the role of plant breeding may play in affecting the mineral concentration either in terms of mineral deficiency or toxicity and imbalance problems in the feeding of dairy cattle. As plant breeders become more successful in developing plant varieties and strains with superior performance under specific growing conditions, one of the adaptations may be plants containing less of any element(s) that may be low in the soil of the area. Thus, changes can be expected in the characteristic mineral composition of new "superior" strains (Graham *et al*., 1999; Bouis, 2003). This may result in unexpected mineral feeding problems for dairy cattle, especially when the changes are not considered. Just as there are interactions in mineral metabolism within animals, the same is also true in growing plants. For example, higher potassium fertilization, while increasing the potassium content of the forage, also tends to reduce Na and Mg (Aschalew *et al*., 2006). The lower Mg is sometimes associated with a higher instance of grass tetany in cattle when high K fertilization is used (Underwood, 1966; Martens and Schweigel, 2000).

As the stage of maturity of forage affects protein and usable energy composition equally, it has an important effect on the content of several minerals (Millers, 2012; Endale *et al*, 2015). Low phosphorus soils together with cattle depend on a long period's mature dry forage, is a key reason for the once very severe phosphorus deficiency over large areas of many countries of the world. Several other minerals including K, Na, Cl, Cu, Co, Ni, Zn and Mo generally decline as plant maturity (Underwood, 1966; Suttle, 2010). The mineral content of different parts of the same plant often varies and the grain or seeds generally have a characteristically different mineral content from the vegetative or forage portion (Sperotto *et al*., 2014). For example, typically grains contain much less calcium than forages. Many incidences of mineral inadequacies in forages and soils are principal causes of reproductive failure and low production rates (McDowell, 1997; Vargas and McDowell, 1997; Sperotto *et al*., 2014). Therefore, Knowledge of the mineral composition of feeds contributes in determining the types and amount of minerals to be supplemented (Aschalew *et al*., 2006).

2.5. Mineral Status of Dairy Cows

2.5.1. Assessment of mineral status in dairy cows

Minerals have been recognized as the essential dietary nutrients for the animals due to their role as structural and functional components of the body, organs, tissues, and constituents of body fluids and tissues as electrolytes. They are vital for normal growth, reproduction, health, and proper functioning of the animal's body (McDowell, 1992; Soetan *et al*., 2010; Bindari, *et al*., 2013). Moreover, they catalyze several enzymatic processes and hormone systems (Underwood and Suttle, 2001), maintain acid-base balance, water balance, and osmotic pressure in the blood and cerebral spinal fluids. Identifying cattle mineral status and meeting the NRC or ARC requirements is vital to maintaining health and at optimum concentrations can improve fertility, immunity, and overall performance (Galyean *et al*., 1999; Mee, 2004). In most of the tropical countries, mineral imbalances in soils and forages have for long been held responsible for low production and reproductive impairment of the dairy animals (Mc Dowell *et al*., 1993; Endale *et al*., 2015). Moreover, in modern dairy production, a large part of the diet consists of concentrate compounds such as cereals, oilseed residues, for their high producing cows. The mineral composition of these feeds is varied such as cereals are usually rich in phosphorus; oilseed residues are rich in P and K (Fekede *et al*., 2015).

Most naturally, occurring mineral deficiencies in livestock are associated with specific regions, and they are related to both soil mineral concentration and soil characteristics (McDowell *et al*., 1986; Endale *et al*., 2015). In an experiment of feed samples collected by Aschalew *et al.* (2006), during the wet and dry seasons from different areas of the central and western parts of Ethiopia, only 4.55% were found to be deficient in Ca. Forages that were used a mixture of grasses crop residues and legumes species that form the major portion of the diet consumed by grazing ruminants. Therefore, legumes contain more minerals concentrations than would be in grass species crop residues and legumes during wet seasons are richer in minerals, including Ca (Minson, 1990; Lemma *et al*., 2002) than stem fractions of grasses (Underwood and Suttle, 1999). The grazing pasture forages had slightly higher levels of Mg than the recommended requirement (ARC, 1980; Islam *et al*., 2003).

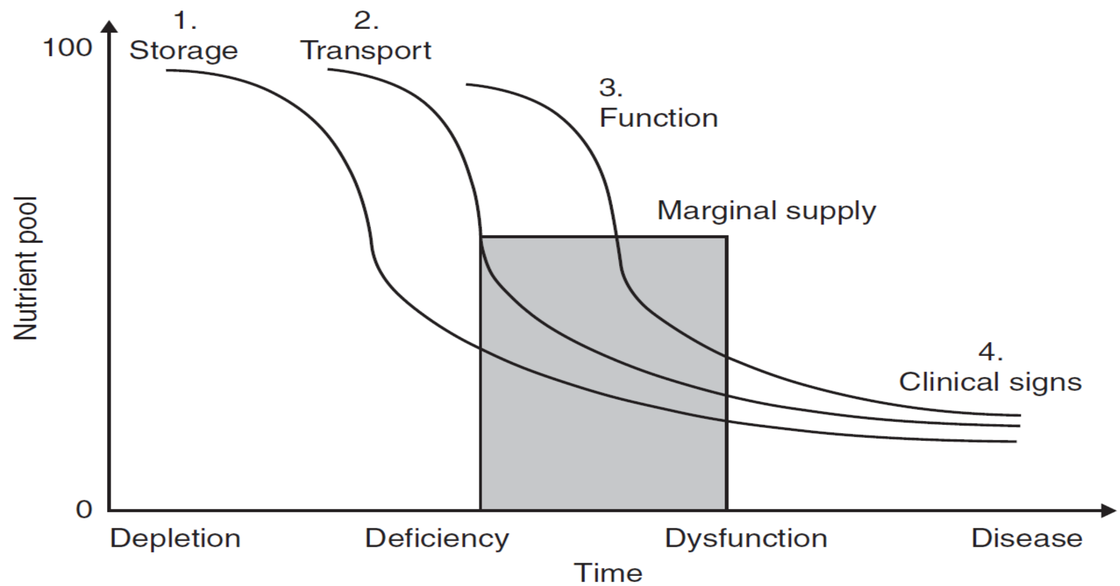
Forages often do not provide all of the needed minerals, many incidences of mineral inadequacies in forages and soils are principal causes of reproduction failure and low production rate (McDowell, 1985; McDowell *et al.*, 1993; Aschalew *et al*., 2006). These forages would, therefore, meet the theoretical requirement of Mg for beef cattle (Anon., 1996) and for lactating cows (1.2-2.1 g kg-1 DM), (Anon., 2001). Ruminants that depend on pasture forage feed as their sole feeds, especially during dry seasons, could be deficient in Cu (McDowell, 1996; Lemma *et al.*, 2002). Differences in Cu could be observed partly by genotypic differences, vegetative parts, stage of maturity, levels of available Cu in the soil, and soil pH. Forages' Cu content declines with forage maturity and is higher in leaf vs. stem fractions (McDowell 1996; Endale *et al.*, 2015). The pasture forages had lower levels of Cu than the minimum recommended requirements of ruminants for different production purposes (Spears, 2003).

High contents of Fe of the grazing land forages were comparable to high levels of Fe of most forages 100-700 mg kg^{-1} DM (McDowell, 1992; Lemma *et al*., 2002). Variations of Fe concentration in forage could be partially explicated by forage species' differences and the influence of grazing lands on the level of Fe in the soil. Therefore, grazing pasture forages had higher levels of Fe than the critical level content of Fe in animal tissues which is greater than 50 mg kg^{-1} DM (McDowell *et al.*, 1993; NRC, 2001). Forage Fe concentration is a function of forage species, soil Fe content, nature, and type of soil on which forages are grown (McDowell, 1992; Endale *et al*., 2015), whereas, the pasture forages had slightly lower levels of Zn than mean content required for ruminants (McDowell, 1985). However, the efficiency of Zn utilization of these forages would depend on Zn bioavailability and its interaction with other mineral elements.

On the other hand, the report of Fekede *et al*. (2015) indicated that commercial feeds had higher concentrations of Ca, Na, Mg, Mn, Cu and Fe than the levels recommended in dairy cattle diets (NRC, 1989, 2001). On the other hand, the concentrations of P, K, and Zn in concentrat feed rations did closely match with the NRC recommendations. Similarly, the report indicated that among the brewery by-products evaluated local liquor residue like (`*Areke attela*`) had much higher Ca content than the maximum tolerable concentration, while the P content of all the brewery by-products was fairly within the range recommended in dairy cattle diets (NRC, 1989, 2001). Moreover, concentrations of the other macro-minerals (K, S, Na, and Mg) in the brewery by-products found to be below the recommended levels in the diets of dairy cattle (Fekede *et al*., 2015). The Cu and Fe contents of the brewery by-products lied above the NRC recommendations in dairy cattle diets, but lower than the maximum tolerable concentrations (NRC, 1989, 2001). Whereas, the concentration of Zn in the industrial brewery residue and the Mn content in the traditional home-made brewery residue (*Tela attela*) lied within the recommended levels of the minerals in dairy cattle diets.

On the other hand, the report of Aschalew *et al.* (2006) indicated that the majority of the browse species, cereal straws, and by-products being deficient to meet animal requirements of macro mineral in central and western parts of Ethiopia. Among the most analyzed feeds cereal straws were found to be deficient in P, Na, and Mg, while straws of legumes were highly deficient in P. Comparatively, less percentage of straws of legume were categorized as Na deficient compared to the other feed types. Pasture grass and other feeds were found to be deficient in Na, P, and Mg in relation to dietary requirements. A large proportion of feed samples were deficient in Cu and Zn. There were wide variations in the concentrations of mineral elements among the soil and feed samples (Khalili *et al.*, 1993; Sisay *et al*., 2007). Ruminant diets based on fibrous feeds are deficient in protein, minerals, and vitamins since they are highly lignified and their digestibility is low, such characteristics affect the intake and productivity of animals (Preston, 1986; Fekede *et al*., 2015). Therefore, a supplement is a semi-concentrated source of one or more nutrients used to improve the nutritional value of a basal feed, e.g., protein supplement and mineral supplement based on the level of productivity of dairy animals (Winrock, 1989; Fekede *et al*., 2015).

To overcome severe economic losses occurring due to mineral deficiency regular assessment of animals to mineral profile is an important management strategy. Prudently mineral status of animal has been categorized in four phases according to the degree of deficiency for assessing mineral status such as i) Depletion - storage pools of minerals are reduced, ii) Deficiency - transport pools of minerals are reduced, iii) Dysfunction – mineral dependent functions become rate-limited and iv) Disorder – clinical abnormalities related to mineral deficiency become evident (Suttle, 1991, 2010). These phases are related to changes in body pools of the mineral that serve the following purposes: storage (e.g. liver), transport (e.g. plasma) or functional (e.g. muscle enzyme). For all elements, there is a marginal area where storages are all but exhausted and mineral-dependent functions begin to fail, but the animal remains outwardly healthy (Suttle, 2010) as shown in (Figure 1).



Figur 1. Phases are related to curvilinear changes in mineral elements pools responsible for storage(e.g., liver), transport (e.g., plasma) or functional (e.g., muscle enzyme) purposes. For all elements, there is a marginal area, with nearly exhausted stores and the onset of failure of mineral-dependent functions, but where animals seem healthy from outwards Suttle (2010).

Commonly, the serum mineral concentration of dairy cattle is used as a proxy for mineral deficiency assessment (Kincaid, 1999; NRC, 2001; Suttle, 2010). However, liver mineral concentration is the best indicator for mineral deficiency, so as the liver acts as a mineral storage organ, and therefore provides a more accurate mineral status of the animal (Khalili *et al*., 1993; Kincaid, 1999).

2.5.2. Calcium and phosphorous requirements for dairy cows

Minerals are required for normal functioning of all biochemical processes in the body as the result improve the function of the animal body, which continues healthy, reproduces, and produces quality and quantity of milk (NRC, 2001; Lukuyu *et al*., 2012).The dairy cow nutrient requirements mainly depend on the amount of milk production, which in turn depends on the stage of lactation. The requirement for most minerals is not constant but is affected by dietary intake, dietary antagonists, and physiological stage which influence the ultimate mineral element status and response to supply. In this case, physiological factors, which affect the requirement of certain minerals include genetics, age, sex, type of production (maintenance, growth, reproduction, and lactation), and level of production (Nielsen and Volden, 2011). Dietary factors usually affect mineral requirements by altering the absorption of mineral from the gut (Spears, 2003). Mineral mixture supplementation found positive therapeutic responses to the supplemented animals (Sharma *et al.*, 2002). Different research findings revealed that moderate to severe mineral deficiencies suggested that supplementation of the diet with the region-specific mineral elements may support in augmenting the productivity of grazing livestock (Ramana *et al.*, 2001; Garg *et al.*, 2002; Das *et al.*, 2003).

Calcium and P are the major mineral elements in respect to the quantity contained in lactating dairy cows. Some evidence suggests that Ca from inorganic sources is more available than from organic sources (Miller *et al*., 1979). There are different views on the percentage of Ca that is available from feedstuffs in which 68% of the Ca in most cattle feeds was available for absorption (ARC, 1980; Aschalew *et al*., 2006). Calcium requirements are influenced by age of the animal where in older cattle true absorption is quite variable, ranging from 22 to 55%, but averaging about 45% (Miller *et al*., 1979; Abegaz and Choppera, 2008). Young animals apparently absorb Ca more efficiently (Hansard *et al*., 1957; Abegaz and Choppera, 2008). On the other hand, the surplus of Ca intake reduces the efficiency of absorption of P in the digestive tract by decreasing the solubility of P (NRC, 2001). Calcium absorption also may be influenced by other factors including vitamin D, P intake, and acid-base balance. Moreover, high-fat diets reduce Ca availability by increasing fecal Ca losses through the formation of Ca soaps (Bowen *et al*., 2005). Ruminants are able to tolerate a broader ratio of Ca:P, either as long as dietary requirements for both minerals is met, or as long as the ratio is not critical > 7:1 or < 1:1 (Miller, 1983; Anas *et al*., 2019).

Dietary Ca requirement is dependent on the availability of Ca from the feed and the efficiency absorption which is affected by age and breed due to changes in DHVD (1, 25- dihydroxy vitamin D) receptors (Horst *et al*., 1986; Goff, 2008) in which Jerseys have fewer intestinal DHVD receptors than Holsteins which is decreasing their ability to absorb dietary Ca efficiently (Goff, 2008). However, a decrease in DHVD receptors also affects bone metabolism. It is critical to completely understand the timing of bone formation and resorption to refine Ca feeding recommendations for the lactating cow in this case of Holstein cow producing 1 kg of milk requires that 1.2 g of Ca (Horst *et al.*, 1994; NRC, 2001) to be delivered the mammary gland. When the blood Ca concentration is affected, the Ca maintaining homeostatic mechanisms are activated, but with increased age, these mechanisms have reduced activity. Calcium homeostatic mechanisms include increased intestinal Ca absorption, resorption of bone Ca, and decreased renal Ca excretion.The DHVD and parathyroid hormone (PTH) are involved in Ca regulating homeostatic mechanisms (Goff, 2008). Parathyroid hormone involved when there is low blood Ca, and low blood P can each activate mitochondria and 1α-hydroxylase in the kidney to convert 25-OH into DHVD when the body is deficient in Ca (Goff, 2008).

There are two types of vitamin D (D_3 and D_2) available to ruminants. Vitamin D_3 is formed in the skin as a result of the photochemical conversion of 7-dehydrocholesterol, and vitamin D_2 is found in forages (Mehdi *et al.*, 2013). Both forms of vitamin D can be utilized by the ruminant, but both must be converted to the biologically active DHVD (Goff, 2008). After absorption of intestinal vitamin D_2 and synthesis of D_3, these compounds are transported to the liver and converted to 25-hydroxyvitamin D3 (25-OH). The small intestine accounts for approximately 90% of dietary Ca absorption in two ways: via non- saturable diffusion related to Ca concentration in the intestine or via a saturable active mechanism driven by the demand of the animal and independent of intestinal Ca concentration (Wasserman and Taylor, 1977; Goff, 2008). Calcium freely enters the enterocyte due to the high concentration gradient between the lumen of the gut and the cell.

Table 3. Mineral requirements their critical level and maximum tolerable Concentrations of a lactating dairy cow

Minerals	Critical level*	Early lactation	Maximum tolerable %	Sources
Calcium %	<0.30	0.5-0.7	-	
Phosphorus	<0.25	0.15-0.3	-	
Magnesium	<0.20	0.2	0.4	-McDowell *et al.*1993 and NRC, 2001
Sodium %	<0.06	0.1	-	
Potassium	<0.80	0.7	3.0	
Fe(ppm)	<50.0	50	1000.0	
Cu(ppm)	<8.0	10.0	100.0	
Mn(ppm)	<40.0	40.0	1000.0	
Zn(ppm)	<30.0	30.0	500.0	

Source: **McDowell et al. (1993); NRC (2001*

A reduction in Ca content of the bone is the major change occurring when dietary Ca is inadequate (Jorgensen, 1974; Aschalew *et al*., 2006). High Ca intake during the dry period (100-125 gm/day) tends to increase the incidence of milk fever due to the delayed response of PTH and active vitamin D which makes the replenishing blood Ca inactive (Jorgensen, 1974). Although P is intimately related to Ca there are major differences in their nutrition and metabolism in which low dietary P reduces inorganic P in blood plasma much more than low Ca intake which affects plasma Ca. Phosphorus absorption is also affected by other factors such as season of the year, stage of lactation, age of the animal, and pregnancy status. Therefor, the maintenance requirement of P is 1.0 g/kg of DMI (Church and Pond, 1988; NRC, 2001). Among different ways to reduce P concentration of feces is feeding less of the recommended dose and the amount of P excreted in the feces of dairy cows is directly proportional to excess P in the diet (Wu *et al*., 2000). In chronic P deficiency, the animal sometimes develops joint stiffness, anestrus, failure to exhibit estrus or heat, and low conception rates may occur in females of breeding age with inadequate P intakes, but the P content of the milk is not affected (Wu *et al*., 2000). Generally, as a percentage of intake, absorption of P in dairy cattle is higher than Ca however, P absorption declines as animals become aged (ARC, 1965; NRC, 1978).

2.5.3. Mineral uptake in lactating dairy cows

The uptake of minerals occurs along the gastrointestinal tract and often requires the mineral to be in the dissolved and ionized form (Miller *et al*., 1979 and Endale *et al*., 2015). The site of absorption depends on the element, and several minerals are absorbed through the epithelium in different segments of the gastrointestinal tract (Khorasani *et al*., 1997; Goff, 2008). The main site for Ca absorption in ruminants occurs mainly in the small intestine, although small amounts may be absorbed from the forestomach (Schroder and Breves, 2006; Kronqvist, 2011). Absorption of Ca from the anterior part of the small intestine is both an active mediated by vitamin D_3 and a passive process. The physiologically active form of vitamin D_3 (1, 25-dihydroxy cholecalciferol) is either directly obtained from the feed or produced in the body from related compounds. In the skin, 7-dehydrocholesterol can be metabolized to cholecalciferol under ultraviolet radiation which can be vitamin D_2 is obtained from sun-cured roughages (Van den Top, 2009). Absorption of Ca from the forestomach is enhanced due to the presence of Na and phosphate whereas, it decreases in the presence of high Mg concentrations (Van den Top, 2009). Absorption of Ca is regulated by calcitriol hormone (Hove, 1984; Schroder and Breves, 2006). Dietary phosphorus has been shown to negatively influence the uptake of Ca, and this may result from altered calcitriol production (Tanaka *et al*., 1973; Veum, 2010). Parathyroid hormone secretion is sensitive to small variations in ionic Ca concentration in the extracellular fluid and, in turn, stimulates vitamin D_3 activation in the kidney. Forestomach absorption occurs mainly when the Ca concentration in the rumen is high (Martens and Schweigel, 2000; Cecilia, 2011). On the other hand, there are factors affecting the concentration of ionized Mg in the rumen fluid, which depends on the level of Mg in the diet, but also on the solubility of Mg in the rumen. Moreover, dietary K has been exist to affect the uptake of Mg in dry cows and lactating cows (Jittakhot *et al*., 2004; Weiss, 2004). This has been suggested to be due to the effect of K on the potential difference over the membrane in the epithelial cells, and thereby increased resistance for Mg transport at high K concentrations in the rumen (Schweigel *et al*., 2009; Kronqvist, 2011). As Mg is transported independently of rumen concentration of K when rumen concentrations of Mg are high, this inhibition of the uptake can be fully compensated by the addition of Mg to the diet, and K concentration has its main importance for the passage of magnesium over the epithelium at low Mg intakes (Care *et al*., 1984; Martens *et al*., 2018).

2.5.4. Determination of serum mineral

Mineral determination in the blood of animals is commonly used to assess mineral concentration status. Blood mineral composition or its functional form in circulation may not always be reliable due to large or rapid changes in dietary intake (Judson and McFarlane, 1998) whereas, serum Ca was not affected by dietary Ca concentration. During, the period of calving, cows were within or just below the normal serum of Ca which ranges from 8 to 10 mg/dl (Goff, 2000) with no clinical signs of hypocalcemia.

A severe Ca deficiency in the per parturient period might produce classical milk fever in the high yielding dairy animals (Radostits *et al.*, 2007), but mild to moderate hypocalcemia (5.0-7.9 $mgdl^{-1}$) did not result in paresis or development of pronounced clinical signs except a diminished appetite and reduced milk production (Ramberg *et al.*, 1976; Cecilia , 2011). Blood Ca is not a good indicator of Ca status due to the sensitive homeostatic mechanism of Ca and the large reserves in the bone (Herdt *et al*., 2011). However, Ca and P blood serum is a reliable indicator if and only if samples are separated from the red blood cells within 2 to 3 hours of collection due to the release of P in red blood cells (Herdt *et al*., 2011). If the P levels are below 4.50 mg/dl are indicative of P deficiency (McDowell, 2003). Similarly, if a critical level of P $<$ 4 mg/dl = $<$0.04 gm/l are indicative that dairy cows are deficient in phosphorus (Miles and McDowell, 1983). The Ca and P levels were higher in the plasma of calves (12.70 ± 0.20 mg/dl and 6.70 ± 0.16 mg/dl, respectively) and heifers (11.2 ± 0.30 mg/dl and 5.80 ± 0.12 mg/dl, respectively) compared to lactating and dry-pregnant animals. Serum Mg is another relatively reliable indicator of mineral status, the deficiency of Mg has occurred if the critical level of Mg$<$0.012g/l (Miles and McDowell, 1983). However, plasma Na only falls during terminal stages of Na deficiency, and Cl deficiency is not a common occurrence, therefore, serum concentrations may be of little diagnostic use in the determination of mineral status (Underwood and Suttle, 2001). Likewise, the critical serum Cu level has been set Cu$<$0.65ppm (Miles and McDowell, 1983). However, when the circulating Cu is decreased, the liver is responsible to release Cu into the bloodstream and only in extreme it's deficiencies serum Cu becomes depleted (Herdt *et al*., 2011). In ruminants, serum ferritin is an early indicator of Fe deficiency and serum levels can decline to 1.1µg/ml without showing signs of deficiency (McDowell, 2003). Zinc deficiency in severe instances is more evident by clinical signs, but early stages of deficiency can be assessed by determining plasma or serum (<0.6 ppm) critical levels (Miles and McDowell, 1983) and forage mineral concentrations (McDowell *et al*., 1993; NRC, 2001). Plasma Cu was lowest in calves (0.66 ± 0.05 µg/ml), whereas, it was highest in lactating animals (Cu<0.65 ppm) (Miles and McDowell, 1983).

2.6. Seasonal Influence of Mineral Concentration of Dairy Feeds

Major dairy animal producers challenge in tropical areas is suitable nutrition for their animals during the dry season when the majority of pastures and crop residues are limiting in nutritional quality (Lemma and Smit, 2004). The concentration of most mineral elements in grasses tends to change with in the season, a wet season forages having a relatively higher concentration of mineral elements (Lemma *et al.,* 2002; Endale *et al*., 2015). Therefore, most of the time dry season feeds found in the category of borderline to deficient than that of the wet season in all the macro minerals. The report of Aschalew *et al*. (2006) indicated that most of feeds found to be deficient in Ca concentration (1.22 %) in the dry season comparing to the wet season feeds (7.45%), indicating that Ca and P level was quite enough to meet the need of the animals in the wet season. Moreover, the study of (Diriba *et al*., 2001) indicated that a high level of Ca concentration was observed during the wet season than the dry season feeds. A high Ca intake, which could impair the metabolism of P, Mg whereas, Zn, Cu, Mn, Fe, and I (Alfaro *et al*., 1988; Abegaze and Chapparo, 2008) are not required. The decline in forage P concentration might be due to plant maturity or season related to translocation or leaching of P from live tissues (Pastrana *et al.,* 1991; Lemma *et al.*, 2002). Levels of P in dry season forage were clearly deficient in P for all ruminant animals (NRC 1996; Endale *et al*., 2015). On the other hand, Mg concentration of the feeds was found to be deficient in both dry and wet seasons which is seasonal change in pasture Mg concentration was not consistent (Lemma *et al.*, 2002). Likewise, high K concentration to Mg suppresses Mg absorption which induces a deficiency of Mg (Lemma *et al*., 2002).

Different studies indicated that dry season Fe concentrations in a high land native pasture higher than the wet season values, because dry season Fe pasture concentration may be associated with a high incidence of soil contamination that is common under a high intensity-grazing situation (Endale *et al*., 2005). Native pastures contained excess Fe for livestock requirement, but these concentrations were not high enough to cause toxicity in grazing cattle (NRC, 1996). Iron at the level of 250ppm to 500ppm causes Cu depletion in cattle (NRC, 1996, 2001). Wet season Cu concentration in pastures was well above the minimum 10ppm recommended for cattle (NRC 1996; Abdelrahman *et al*., 1998). The availability of Cu for grazing animals may be limited further by complex interactions with Mg, Mo and Fe in which higher levels of Cu may be needed in the presence of high concentrations of antagonists such as Fe, Mo, and S (Underwood and Suttle, 1999; Sinclair *et al*., 2013). On the other hand, high concentrations of Ca in the native pasture further aggravate a Zn deficiency (Alfaro *et al*. 1988; Lemma *et al*., 2002).

2.7. Effect of Mineral Interactions

Minerals are accountable for numerous functions in the body and interact with one another to perform various actions. Interactions between minerals are a major cause of variation in bioavailability and thus influence both the nutritive value and potential toxicity of a particular source (Greene, 1997; Holst and Williamson, 2008). Apart from homeostatic control mechanisms, absorption of mineral in the ruminant gut is affected mainly by other compounds reaction present in the intestinal lumen and at the absorptive site (Suttle, 2010). Moreover, some minerals even may interfere with the absorption, transportation, function, storage, or excretion of other nutrients. When the concentration of certain minerals increased they have negative impacts on other minerals by binding into indigestible compounds and decreasing availability e.g. increased concentrations of Mo, S, and Fe increase the requirements of Cu while K increases Mg requirements (Greene, 1997; Endale *et al*., 2015; Kleber *et al*., 2015).

However, interaction effects can be beneficial (e.g. small amounts of copper supplements can enhance iron utilization and large copper supplements can increase iron requirements (Suttle, 2010). The effects of interactions between minerals on bioavailability can sometimes be predicted, as is the case for interactions between K and Mg and between Cu, Mo, and S in ruminants (Suttle, 2010). However, the outcome is hard to predict when three mutually antagonistic elements are involved, such as Cu, cadmium(Cd), and Zn (Table 4).When each element can negatively affect the other, a supplement of any one element may have a positive net effect either by countering an antagonism against itself or neutralizing the antagonistic properties of the second element upon the third (NRC, 2001;Suttle, 2010).

Table 4. Factors negatively affecting mineral element requirements for ruminants

Mineral	Antagonists[1]	Other factors[2]
Ca	P, Zn, Mg, F, NH_4Cl, Fe, Mo, Cu, Al, Be and Mn	Tannins[2]
P	Ca, Zn, Mg, F, NH_4Cl, Fe, Mo, Cu, Al, Be and Mn	Phytate
K	Ca, K, Fe, Mn, Mg	-
Fe	-	Oxalates,phosphates,tannins[2]
Zn	Cu, Fe, Cd, Pb, Sn, Ca	Tannins[2]
Cu	S, Mo, Fe, Zn, Ca, Cd	Tannins[2]
Mn	Ca, K, P, Fe	-

Sources*: [1]NRC (2001); [2]Karamać (2009),*

On the other hand, a high intake of K is believed to have a negative influence on the uptake of Mg in the rumen of the animal. Magnesium is transported through the ruminal wall by two active transport systems, which are inhibited by K, especially when present in high concentrations, reducing the absorbability of Mg (McDonald *et al.*, 2011; Neckermann and Kechero, 2017). Concurrent high concentrations of Mo and S in the feed limit the absorbability of dietary Cu by forming an absorbable complex (Table 4). In the rumen, microorganisms produce sulfide from sulfate or organic sulfur compounds in the feed. Sulfide then reacts with molybdate to form thiomolybdate. In turn, thiomolybdate interacts with Cu, rendering Cu absorbability by forming the insoluble copper thiomolybdate (McDonald *et al*., 2011; Dermauw *et al*., 2014). Furthermore, if an excessive amount of thiomolybdate is produced, it may be absorbed through the ruminal wall, where it could be systemically bound to Cu, thus severely affect the Cu metabolism in the animal. In addition to Mo and S, extreme amounts of dietary Zn may induce Cu deficiency (McDonald *et al.*, 2011). An excess of Fe forms insoluble Fe-Cu-S complexes, which enhances Cu deficiency by lowering Cu absorption (McDonald *et al.*, 2011; Neckermann and Kechero, 2017). Moreover, chronic Fe toxicity tends to result in P deficiency (Goff, 2000).

2.8. Milk Yield and Mineral Composition

Increase in plasma Ca, P, Mg, and Se concentration despite mineral supplementation, which might be due to higher utilization of these minerals for more milk production plus improved milk composition (Radostits *et al.*, 2009 and Begum *et al*., 2010). The most abundant mineral in milk is potassium, and calcium in second place. The calcium and magnesium concentration of milk varies with the lactation stage, and is highest soon after parturition (Tsioulpas *et al*., 2007), but the concentration is independent of mineral intake (Taylor *et al*., 2009). Fresh cows need a lot of calcium to make colostrum and milk, the availability of calcium and phosphorus improved the fat content in milk. However, the calcium concentration in milk differs among cattle breeds, with higher concentrations for Jersey cows compared with Holsteins (Cerbulis and Farrell, 1976; Lobago, 2007).

Table 5.Guide line to mineral composition in rations for high-producing cow's milk production producing equivalent to the average of 18,000 pounds of 4% fat-corrected milk

	Stage of lactation		
Mineral	Early	Mid	Late
% DM			
Calcium	0.81-0.91	0.77-0.87	0.70-0.80
Phosphorus	0.46-0.52	0.44-0.50	0.40-0.46
Magnesium	0.28-0.34	0.25-0.31	0.22-0.28
Potassium	1.20-1.50	1.20-1.50	1.20-1.50
Sulfur	0.23-0.24	0.21-0.23	0.20-0.21
Salt, or	0.45-0.50	0.45-0.50	0.45-0.50
Sodium	0.20-0.25	0.20-0.25	0.20-0.25
Chloride	0.25-0.30	0.25-0.30	0.25-0.30
PPM			
Manganese	44	44	44
Copper	11-25	11-25	11-25
Zinc	70-80	70-80	70-80
Iron	100	100	100
Addedselenium	0.30	0.30	0.30
Added cobalt	0.20	0.20	0.20
Added iodine	0.50	0.50	0.50

Source: Lammers et al., 2015

Mineral deficiency in fodder needs to be compensated by providing appropriate mineral supplements because lower daily milk yield was recorded in mineral deficient cows Bhat *et al*. (2011). It might be due to the fact that minerals are essential for metabolic pathways (Underwood and Suttle, 1999; Soetan *et al*., 2010), growth, and production performance of animals (Radostits *et al.*, 2009). The improvement of milk yield in response to mineral supplementation could be attributed to increased Cu and Zn intake as the feed consumed by the cattle contained low levels of Cu and Zn (Griffiths *et al.*, 2007; Kabaija & Little, 2013). This was achieved by the better utilization of forages, due to the adequate presence of calcium improving the buffering capacity of the rumen. The increased in fat content in milk could have been due to the production of a higher ruminal molar percentage of acetic and butyric acids due to the fermentation of fiber (Forbes, 2000; Kawas *et al*., 2007).

Higher milk yield and fat content in di-calcium phosphate supplemented group compared to the non-supplemented group (Rekhis *et al.*, 2010). Therefore supplementation of Ca and

P improves milk and composition (Table 5). The report of Begum *et al.* (2010) indicated that increased milk production, milk fat, milk total solids and reproductive performance in lactating buffaloes supplemented with 120% Ca and P as compared to 80% and 100% Ca and P supplemented buffaloes. Calcium in milk often constitutes the major part of the absorbed calcium (Taylor *et al.*, 2009), and this difference between the minerals is probably an effect of the different control of homeostasis, where calcium absorption is under hormonal control while magnesium homeostasis is regulated only by excretion, and may thus be absorbed more in excess. A large fraction of calcium is secreted into milk through exocytosis in association with the casein (Neville and Peaker, 1979; Neville, 2005).

2.8.1 Factors affecting milk yield and composition

Milk composition and production are the interaction of many elements within the cow and her external environments. The composition of milk is mutable and influenced by intrinsic factors like genetic, stage of lactation; species, parity, external factors like environmental stress, and changes in feeding. However, it is generally accepted that the milker can alter many of these factors to achieve milk production and increase profit (O'Connor, 1995; Ayza *et al.*, 2013).

2.8.1.1. Genetic factors

Genetics and inheritance account for major differences between cows' milk protein and fat content (Heinrichs *et al.*, 2005). Breed and individuality of the cow both milk yield and composition vary considerably among breeds of dairy cattle (Wiesław *et al.*, 2014). Jersey and Guernsey breeds give milk about 5% fat while the milk of Shorthorns and Friesians contains about 3.5% fat. Zebu cows can give milk containing up to 7% fat (Wiesław *et al.*, 2014). Milk of individual cows within a breed varies over a wide range in yield and the content of the various constituents. The potential fat content of milk from an individual cow is determined genetically, as are protein and lactose levels. Thus selection for breeding on the basis of individual performance is effective in improving milk compositional quality (De Marchi *et al*., 2008, Asrat *et al*., 2016).

2.8.1.2. Environmental factors

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; Hoddinott *et al*., 2015). Local dairy cows and exotic breeds (Holstein Friesian and Jersey) kept under different management in a given environment equally perform differently (McDonald *et al*., 2011; Alemu *et al*., 2013). The fat content of milk varies considerably between the morning and evening milking because there is usually a much shorter interval between morning and evening milking than between evening and morning milking. If cows were milked at 12-hour intervals most of the time variation in fat content between milkings would be negligible. Normally, SNF content does not vary with the length of time between milkings (Krovvidi *et al*., 2013; Negash *et al*., 2012).

2.8.1.3. Stage of lactation

The fat, lactose, and protein contents of milk vary with the stage of lactation. Solids-not-fat content is usually highest during the first two to three weeks, after which it decreases slightly. Fat content is high immediately after calving but soon begins to fall, and continues to do so for 10 to 12 weeks, after which it tends to rise again until the end of the lactation. The high protein content of early lactation milk is due mainly to the high globulin content (Gaucheron, 2005; Toffanin *et al*., 2015; Duguma *et al*., 2012).

2.8.1.4. Parity

The daily average milk yield is also affected by parity (Darfour-Oduro *et al*., 2010; Bitew *et al*., 2010). Milk yield of cows is low at the first parity and increases with increasing parity and a decline after the fifth to sixth parities (Hatungumukama *et al*., 2006; Afzal *et al*.; 2007; Bayou *et al*., 2015). Moreover, even as milk fat content remains relatively constant, milk protein content gradually decreases with advancing parity or age. Calcium content in plasma of periparturient cows decreases as parity increases, which leads to a higher probability of contracting milk fever in older than young cows. Magnesium and K content exhibited an opposite trend to that of Ca. Finally, plasma Na and P levels were not influenced by parity (Kume *et al*., 1998). A reduction of minerals, mainly Ca and P has been detected across parities (Toffanin *et al*., 2015b). The utilization of these minerals in the udder is lower in old than young cows. Moreover, older animals produce a great milk quantity, thus there is a milk dilution. These two phenomena can explain the lower mineral concentrations in milk of later parity cows (Kebede, 2009; Toffanin *et al*., 2015).

2.8.1.5. Age and health

As cows become older and older the fat content of their milk decreases by about 0.02 percentage units per lactation while the fall in SNF content is about 0.04 percentage units. Both fat and SNF contents can be reduced by disease, particularly mastitis (Hamann and Kromker, 1997; Kebede, 2009).

2.8.1.6. Feeding regime

Underfeeding and deficiency of minerals reduce both the fat and the SNF content of milk, although SNF content is the more sensitive to feeding level. Fat content and fat composition are influenced more by roughage (fiber) intake. The SNF content may fall if the cow is fed a low-energy diet, but is not greatly influenced by protein deficiency unless the deficiency is acute (Nega *et al*., 2006; Dehinenet *et al*., 2013).

2.8.1.7. Completeness of milking

The first milk drawn from the udder contains about 1.4% fat while the last milk or stripping contains about 8.7% fat. Thus, it is essential to milk the cow completely and thoroughly mix all the milk removed before taking a sample for analysis. The fat left in the udder at the end of milking is usually picked up during subsequent milking, so there is no net loss of fat (Jago *et al*., 2010; Fekadu *et al*., 2011).

2.9. Calcium and Phosphorous Balance

When the mineral metabolism of a dairy cow is in a steady-state, the mineral output corresponds to the inflow of minerals through the diet. Dietary Ca-binding substances like oxalate slow down accessibility of Ca in non-ruminants as well as ruminants (Ward *et al*., 1979; Horst, 1986; Martinez-Patino, 2015) and it is true for the low availability of Ca common in feeds like alfalfa hay. Likewise, nucleic acids produced by bacteria, bacterial cell walls, dietary fat, large amounts of magnesium fluoride, and low dietary P have all been associated with reduced availability of Ca for absorption (Braithwaite, 1976; Hilal *et al*.,2016). In dissimilarity to Ca, dietary P is absorbed by ruminants in direct relation to P intake (Care *et al*., 1980). Similarly, P absorption is directly related to the amount of P in the diet and also directly related to the plasma P concentrations. Eventually, feeding animals in late pregnancy and early lactation below their Ca and P requirements limited absorption and the inability to meet the Ca demand from diet alone (NRC, 2001). Calcium and P absorption can be influenced by diet (Martz *et al*., 1999; Cashman, 2002). It was further suggested to provide excess dietary Ca and P in mid-to-late lactation when the animal could absorb the minerals to replace body stores that were mobilized. If the mineral balance is negative, the cow excretes more minerals than is contained in the intake (Kronqvist, 2011). Major routes of Ca excretion are feces, urine, and milk (Horst, 1986; Castro *et al*, 2004). This is commonly the situation with Ca at the beginning of lactation, and it is compensated by a positive balance at the end of the lactation, when some of the dietary Ca is retained in the body (Taylor *et al*., 2009).

Resorption and formation are driven by changes in Ca requirements and immediate P demands do not reflect net P demands because net encompasses changes in bone (Taylor, 2007). Moreover, the P in feces is derived from three fractions: (a) unavailable dietary P, which cannot be absorbed; (b) inevitable loss, which is excreted under normal physiological conditions; and (c) excess loss where the supply of available dietary P exceeds the requirement of the animal (Spiekers *et al*., 1993; Lall, 2002). Moreover, according to the report of Morse *et al.* (1992); Reid *et al.* (2015) the amount of P excreted is dramatically affected by dietary P intake. For each gram increase in P intake, excretion of P increased by 0.80 g/d when cows were consuming a dietary P at 0.56 vs. 0.30% P. However, when cows were fed low dietary P (0.32%) for the first 4 months of lactation and then switched to high dietary P (0.43%) for the remainder of the lactation, there was no difference in P retention as compared to cows that consumed high dietary P, the entire lactation (Ekelund *et al*., 2006). Similarly, there was no difference in P or Ca retention when dietary P was fed at different levels (0.34, 0.51 or 0.67%) of the diet (Knowlton and Herbein, 2002; Weiss *et al*., 2004).

The total collection of urine, feces, and milk is used to measure Ca and P balance in the bovine (Martz *et al*., 1999; Weiss, 2004). The extent of excretion of Ca depends on the Ca content in the diet and the requirement of the animal therefore if dietary Ca is limited, the production of calcitriol increases (Wilkens *et al*., 2010). This may result in more efficient uptake of Ca in the intestine, and thus decreased fecal excretion of Ca (Hove, 1984; Schroder and Breves, 2006). The digestibility of mineral and fecal excretion is different for minerals, because of the nature of mineral solubility (Khorasani *et al*., 1997; Soetan *et al*., 2010). Therefore, the solubility of magnesium oxide is the most used inorganic source, which has a high influence on the absorption and fecal losses of magnesium (Xin *et al.*, 1989; Schonewille, 2013).

The excretion of fecal and urinary routes generally plays little part in Ca homeostasis and in determining the risk of Ca dysfunction. The extent of endogenous fecal mineral excretion differs for different minerals and depends on the feed intake of the cow (Martz *et al*., 1990; Kronqvist, 2011). However, fecal mineral output that is not of endogenous origin comes from dietary minerals that are not absorbed in the gastrointestinal tract. For magnesium, and sometimes also for Ca, the excretion of undigested minerals *via* feces constitutes the main pathway of mineral losses from the body. Major routes of P excretion are feces and milk, which vary with DM intake and milk yield (Horst, 1986; Lee *et al*., 2012). Mineral excretion with both urinary and fecal routes may correlate with either the mineral intake or mineral status of the animal, depending on the mineral feed. Furthermore, concentrations of minerals in urine and faces are influenced by dietary and animal factors such as water intake and the digestibility of the diet (Suttler, 2010).

3. MATERIALS AND METHODS

3.1. Description of the Study Areas

An assessment of feed and mineral resources of dairy farms in selected urban and peri-urban areas in Ada'a and Adama districts in East Shoa Zone was conducted. East Shewa zone extends between 7^0 33'50''N-$9^0$08'56'' N and from $38^0$24'10''E-40^0 05'34''E with a total area of approximately 10241 km^2. Two districts, namely Adama, and Ada'a which represent urban and peri-urban production systems were purposively used for the survey work (Appendix 16). The temperature in the east shoa zone varies from less than 10^0C along with high altitude to above 30^0C in Rift Valley areas. The mean annual temperature is 20^0C and rainfall varies from 600 mm to 1000 mm with a mean annual rainfall of 816 mm. According to CSA (2007), the total population of the East Shoa zone is 1.16 million, of which 0.6 million are males and 0.56 million are females and projected to be 1.48 million by 2023.

East Shoa Zone has four agro-ecological zones namely dry Dega (high altitude), dry Kola (low land), dry Woyina dega and moist Woyinadega (wet mid-altitude). The land cover is dominated by cultivation making 62%, grassland 34%, forest land 3.5%, water bodies 0.3% and 0.2%. The average landholding is estimated to be 2.75 hectares/household and the average number of farm oxen per household (HH) is 2(two). The livestock density, excluding poultry, is estimated to be about 220 cattle per square kilometer. Due to the geographical proximity of the zone to Addis Ababa, it has a great advantage for market access for both agricultural and industrial products. Currently, most parts of the East Shoa zone are delineated as industry zone.

Adama is the capital city of the East Shewa Zone. The temperature in the east Shoa zone varies from less than 10^0C along with high altitude to above 30^0C in Rift Valley areas, the mean annual temperature is 20^0C. Rainfall varies from 600 mm to 1000 mm with a mean annual rainfall of 816 mm. According to CSA (2007), the total population of the East Shoa zone is 1.16 million, of which 0.6 million are males and 0.56 million are females and projected to be 1.48 million by 2023.

Adama town is located at $8^0 33'35''$N – $8^0 36'46''$ N latitude and $39^0 11'57''$ E – 39^0 21'15" E longitude about 99 km southeast of Addis Ababa. It is one of the largest towns in Oromiya Regional State with a total population of 260,611. It is situated at an altitude ranging from 1400 to 2700 meters above sea level. The area receives an average annual rainfall ranging from about 600 to 1150 mm which is erratic in nature. There is a significant seasonal variation in the amount of rainfall. More than 67% of the mean annual rainfall occurs in the four rainy months: June, July, August and September. Some additional rains (about 23%) occur in the remaining dry months with mean monthly values of rainfall as low as zero millimeters. The minimum and maximum daily temperatures of the area are 12 and 33^oC, respectively (NMSA, 2013).

Ada'a district, is located about 45 km southeast of the capital Addis Ababa. It lies between longitudes 38^0 51' to $39^0 04'$ East and latitudes $8^0 46'$ to $8^0 59'$North and covering a land area of 1750 km^2. The district is characterized by a subtropical climate and the rainfall varies from 587 to 1122.7 mm (Lemma *et al.*, 2016). Mean annual temperatures range from about 8^0C to 28^0C (Alemayehu *et al.*, 2012). These agroecological conditions provide a favorable environment for dairy production. There are high numbers of crossbred dairy cattle (indigenous_exotic breds/mainly Holstein-Friesians) and other dairy development interventions in the district (ADARDO, 2013).

PART I (SURVEY)

3.2. Study Animals

The study consists of two districts, of two production systems (urban and peri-urban). A total of 240 high blood level crossbred dairy cows (dry and lactating) from different farms were selected purposively and included in the study. The cows were physiologically divided into dry (8-9 months of pregnancy) and lactating cows (consists of early and mid-stage of lactation) and blood samples were collected. The sample collection was held from 2017 to 2018 based on the season (dry and wet), and 120 blood samples were collected in the dry season (from January to February) and the other 120 blood samples were collected in the wet season (from July to August).

3.3. Sampling Method

In the first stage, a reconnaissance survey and discussions were held with Woreda agricultural extension offices of the zone. Moreover, information was gathered on the overall status of dairy production, feed and mineral resources, productive and reproductive performance, and health of dairy animals from the respective district offices.

Based on the secondary information obtained from the respective district offices of agriculture and individual dairy farm owners were selected by a multi-stage purposive sampling technique. The study selected based on dairy farms concentrations (high blood level and crossbreed dairy cows), dairying experience, the willingness of the farmers to participate in the study and accessibility to the farm locations. Sample units were expected to be representative of the whole population found in the study area. The two districts (Ada'a and Adama) and respective were purposively, selected based on availability of urban and peri-urban dairy farm. Multistage stage sampling method was employed to assessed dairy cattle feed resources and dairy serum mineral concentration.

3.4. Sample Size Determination

The sampling frame comprises those farmers keeping crossbred dairy cows and willing to participate in the study. Generally, a total of 250 HH (127 from Adaa and 123 from Adama district) were purposively selected according to the formula given by Arsham (2002). Dairy owners were included from 'urban' and 'peri-urban, categories within both districts (Adama and Adaa districts) (Appendex 15). A standard error of 0.032 with a 95% confidence level was taken to calculate the total hh to be involved in the questionnaire survey.

$$n = 0.25/SE2$$

Where, n= Sample size, SE= Standard error

The blood samples were collected from a total of 240 crossbred dairy cows, from the surveyed dairy farms, which were 120 dairy cows from each district per season (60 dairy cows from each district per season and 30 cows from urban and peri-urban each, the selected dairy owners/farmers that have crossbred dairy cows which were physiologically categorized into a dry cow (8-9 months of pregnancy) and lactating cows (consisted of the early stage of lactation) were selected purposively for subsequent blood mineral analysis.

Questionnaire: A structured questionnaire was used to generate survey data. In addition, personal observations and discussions were held with key informants at the district level from purposively selected HH (Appendix1). The HH's data included socio-economic characteristics (age, sex, family size, educational status and major source of incomes); farmland characteristics (regarding improved forages cultivation); feed and mineral resource (type and availability of feed and minerals sources).

3.5. Samples Collection

3.5.1. Feed sample

In the study, a total of 140 (70 composites)samples belonging to different agro-industrial by-products, forages and locally available feeds were collected to assess their mineral status based on seasonal availability (wet and dry) from the two districts (Ada'a and Adama) of urban and peri-urban production systems indicated in (Appendix 3). The samples were grouped into three categories based on the nature and relative similarities of roughage feeds (grass hay, teff straw, wheat straw, silages, cultivated forage crops, sugar cane top), cereal grain and oilseed cakes (wheat bran, wheat middling's, local concentrate mix /faba bean mixed hull X wheat bran (WB), noug seed cake, ground maize, cottonseed cake, lean seed cake) non- conventional feeds (industrial brewery by-product, *atela* (local by-product), poultry liter). Feed samples of 300g were collected from the storage place or harvested forage which was ready to be fed to dairy animals and brought, labeled, and stored in airtight self-sealing polythene bags to the laboratory for mineral analysis (Aschalew *et al*., 2006). The collected feeds were categorized based on nature and relative similarities for the sake of data analysis and result presentation and interpretations (Alemayehu, 2005; Fekede *et al*., 2015). Similarly, feed offer and refusal samples from grass hay composite pooled samples were also collected and analyzed for mineral concentration.

3.5.2. Blood samples

About 10 ml of blood was collected from the jugular vein in a sterile vacutainer test tube without anticoagulant (Charles and Fredeen, 1999). The test tubes containing blood samples were transported to the laboratory and kept for 2 to 3 hours in a slanting position at room temperature without disturbing the tubes and were centrifuged (at 3000 rpm for 10 min). Samples were separated from the red blood cells within 2 to 3 hrs of collection due to the release of P in red blood cells (Herdt *et al*., 2011).Then 2 ml serum was collected into cryovials and stored in a deep freezer (-20^{o}C) until processed (Herdt *et al*., 2000). The blood samples were collected from urban and peri-urban farms of respective districts.

3.5.3. Fecal samples

The fecal collection was performed for each period of 5 consecutive days starting from day 26th to 30th (Osuji *et al.*, 1993). To minimize errors, feces collections were performed by researchers and assistance researchers. Faecal samples for lab analysis obtained directly from a rectal grabbing taken at every six hours interval (Souza, *et al.*, 2016; Getu *et al*., 2019). Feces were collected into plastic buckets when the animals defecate. Urinal contamination was minimized by frequent washing the concrete floor with high pressure running water using a plastic water hose by research assisstance. Individual cow's feces were weighed every morning before 7:00 a.m. and before new feeds were given to the animals. After weighing, the feces from each cow were thoroughly mixed and a sample of 1% was taken and placed in a polyethylene bag (Abera *et al*., 2016). Composite samples of the daily collected samples were mixed and stored in a deep freezer (-20 ^{o}C) until the end of the collection period processed. At the end of the collection period, the pooled samples were thawed and mixed thoroughly and samples were oven-dried at 65°C for 72 hours, ground to pass a 1mm sieve and stored in sample bottles at room temperature.

3.5.4. Milk samples

The milk produced by each cow in every milking was measured using calibrated milk measuring jars and recorded, whereby the volumes of morning and evening milk yield were added together to obtain total daily milk yield per cow. Measurements of milk yield were taken by the researcher and research assistants. Milk samples were taken at different stages of the experiment using a graduated bottle every day throughout the study period. Aliquot samples of 200 ml milk from the morning and evening milking were collected in sterile plastic containers for two consecutive days at the beginning (15th and 16th day) and end of the experimental period 29th and 30th day (Getu *et al*., 2019). The 100 ml milk samples were kept at - 20^0C refrigerator for further Ca and P analysis (Cerbulis and Farrell, 1976).

3.5.5. Urine samples

During the collection of urine, cows were housed in tie stalls that contained no bedding. The urine was collected using a 75-cc Foley catheter (c. R. Bard, Covington, GA) which was placed into the bladder (Cunningham *et al*., 1955; Crutchfield, 1968; Morse *et al*., 1992). Urine was collected and stored in polyethylene containers under acidic conditions (50 ml of 50% H_2S04) for 7 days every last week of feeding trial period (24^{th} - 30^{th} days) throughout 120 days. Then sampled urine was composited by a 10% sub-sample placed in polythene bottles and stored at -20 °C until analyzed for Ca and P (Taylor *et al*., 2007).

PART II

3.6. Experimental Site Animal Selection and Management

The feeding trial was conducted at the dairy farm of Addis Ababa University, College of Veterinary Medicine and Agriculture (CVMA) located in Bishoftu town. Bishoftu is located 45 km along South East of Addis Ababa, the capital of Ethiopia at 9°N latitude and 40°E longitude and at 1850 m.a.s.l. The annual rainfall is 866 mm of which 84% is in the long rainy season from June to September. The annual average temperature ranges from 12.3^{o}C to 27.7^{o}C with an overall average of 18.7^{o}C (NMSA, 2013). The on station experimental site was selected based on its previous mineral deficiency status history and based on survey data incidence of dairy cows by a blood test that confirmed the calcium blood level to be either deficient or on borderline.

3.6.1. Experimental animal selection and management

Experimental animals were selected based on their parity. Four cross breed cow (HF× Boran) from first to fourth parity and in the mid-lactation with a range of 106.0±5 days after calving were used. The average body weight of the selected cows was 469.88±15.80 kg (mean ± SD), with average initial milk yield of 10 ± 1.05 cow^{-1} day^{-1}. Three weeks before the commencement of the experiments, all animals were treated with a broad spectrum antihelminthic (Albendazole-2500mg) and acaricides were sprayed against external parasites. The cows were tested for the presence of mastitis using the *California mastitis* Test (CMT) before the onset of the experiment.

The study was conducted during the period from October 2018 to February 2019 for a total of 120 days. Cows were individually penned and treatments were *ad libitum* feeding of natural pasture grass hay for all treatments plus on-station used dairy concentrate mix supplemented. Feed offered and refused were measured and recorded for each cow to determine the daily feed and nutrient intake. The grass hay offer was adjusted daily by allowing 10% refusal from the previous day's intake. The concentrate mix and dicalcium phosphate (DCP-18%) were offered twice per day at 8:00 AM in the morning and 4:00

PM in the afternoon. The quantity of concentrate mix offered daily was at the rate of 0.5 kg DM/liter of milk produced by each cow. Adjustments were made for concentrate offer at the end of each period and for each treatment based on the actual milk produced. Tap water was provided freely for all dairy cows. The milking cows were hand milked twice a day in the morning from 5 to 6 AM and evening from 4 to 5 PM.

3.6.2. Experimental feeds preparation

The feeds used constituted grass hay as a basal diet and concentrate consists of noug seed (*Guizotia abyssinica*) cake, wheat bran, dicalcium phosphate and common salt). Four crossbred dairy cows of 75% of Holstein Friesian plus 25% of local zebu (Boran) blood level were selected based on-farm records. The above-mentioned feeds were selected because the selected farm and most dairy farms commonly used these feed resources for dairy animals. Staal and Shapiro (1996) indicated that natural grass and legume hay, wheat bran and middling and noug seed cake are the most common dairy feeds. The roughage used in this study was grass hay (dominantly composed of *Andropogon spp.*, *Pennisetum spp, Festuca spp*. and *Hyparrhenia spp*. among the grasses and, different native *Trifolium spp*. among the legumes). Based on this and laboratory results, treatment rations were formulated using most critically deficient minerals in terms of their market availability, for instance, Ca, P, Cu and Co were deficient during the survey work but Cu and Cowere not accessible in the local market. Therefore, Ca and P were selected because these minerals are very critical in lactating dairy cows. Hence, during the feeding trial, the supplements were Ca and P in the form of DCP- 18% (ARC, 1980) as shown in Table 9.

3.6.3. Expermental design, feeding and management

The selected cows were randomly assigned to one of the four treatment supplement feeds in a 4x4 Latin square design. Total experimental periods were 120 days of which each period consisted of 30 days (16 days of adaptation and 14 days of data collection). The first 16 days were used as an adaptation period to remove the carry-over effects. The feed ingredients, NSC, wheat bran and grass hay were purchased locally. The chemical composition and mineral contents of feed ingredients were indicated in Table 10, whereas the DCP- 18% was purchased from Addis Ababa drug and medicament suppliers.

Table 6. Dicalcium phosphate treatment layout

Periods	Parity			
	1	2	3	4
1	T_0 + 0.3%	T_0 + 0.6%	T_0+ 0	T_0 + 0.9%
2	T_0 + 0.6%	T_0 + 0.9%	T_0+ 0.3%	T_0+ 0
3	T_0 +0	T_0 +0.3%	T_0 + 0.9%	T_0 + 0.6%
4	T_0+ 0.9%	T_0 + 0	To + 0.6%	T_0 +0.3%

T0=control= NSC (26%); wheat bran (72%); DCP (0.6%);1.4%Nacl; T1= T0 + 0.3% DCP;T2= T0 + 0.6% and T3= T0 + 0.9% DCP; T_0 = control; DCP=Dicalcium phosphate*

Experimental diets were individually offered to the animals throughout the period of 120 days of the experiment. The cows producing more than 10 kg milk per day were fed an additional 0.5 kg concentrate for each 1kg liter of extra milk (Ghada *et al*., 2012).

Table 7. Chemical composition of experimental feeds (%DM)

Parameters	Hay	NSC	WB	NSC+WB
DM	90.5	93.7	87.07	91.3
CP	6.15	32	15.3	27.8
OM	87.9	87.97	92.57	90.23
Ash	12.1	12.03	7.43	9.77
NDF	73.8	44.15	45.54	37.61
ADF	37.55	30.93	15.64	23.54
ADL	10.55	6.38	7.25	7.23
Hemicellols	25.75	18.42	18.9	20.31
Cellullos	31.5	17.35	5.39	8.07
Ca%	0.74	0.32	1.3	0.42
P%	0.15	0.41	0.89	0.65

DM=dry matter; CP=crude protein;OM= organic matter;NDF=Neutral detergent fibre; ADF=Acid detergent fibre, ADL=Acid detergent lignin; NSC= noug seedcake; WB= wheat bran.

The energy and protein requirements for dairy cows with about 75% Holstein blood level was calculated based on feeding standards for farm animals (ARC, 1980). Conventional used on-station dairy concentrate mix served as a base mix in the control diet which was formulated based on (ARC, 1980). Hence, during the feeding trial, the supplement was Ca and P in the form of DCP- 18%, which was 0.6% requirement (ARC, 1980).To meet the requirements, the experimental ration composed of 100%, which included wheat bran (72%), noug seed cake (26%), DCP (0.6%) and salt (1.4%). Based on the requirement (ARC, 1980), 0.6% dicalcium phosphate content was considered to meet 100% requirement, and the rest of the treatment groups received 50% above and below the recommended amount that made up 0.3, 0.6 and 0.9% for the different treatments (Table 6). The total ration roughly provides each cow daily with 9.4 MJ/kg DM, 12.3% CP to support 10±1.05 liter milk/day with 3.6% butterfat content of cows weighing 469.88±15.80 kg (ARC, 1980). Daily feed offered and the refusal was measured and recorded for each animal to determine nutrient intake by difference. Samples of refusals were taken daily and sub-sampled biweekly for chemical composition and mineral determination.

3.7. LaboratoryAnalysis

3.7.1. Digestion procedures for feeds and fecal sample

Fecal samples were thawed thoroughly and mixed. Both feed and fecal samples were dried in a forced-air oven at 60°C for 72 hours to a constant weight and ground to a 1.0 mm size using a Wiley mill and stored in plastic bags at DebreZiet Agricultural Research Center (DZARC) soil and nutrition laboratory (Bediye *et al.*, 2007). The feed and fecal samples were digested by the method of Trolson (1969), for this purpose 250 mg of previously ground and stored samples were weighed, and taken in digestion tube then 5 ml of concentrated HNO_3 and 1 ml of concentrated sulphuric acid (H_2SO_4) was added and mixed well finally filtered through a filter paper (Palma *et al.*, 2015). The mixture was heated at 120 ^{0}C over 3 hours on block digester. After digestion was completed, the clear and colorless solution was filtered out into 100 ml volumetric flask. Each digestion tube was rinsed with distilled water to collect any possible residue and added to the volumetric flask and finally, 50 mL made up to volume with distilled water. All the dilute samples were stored in 100 mL plastic bottles (high-density polyethylene) until analysis. Each feed and fecal sample were digested and analyzed in triplicate to confirm the precision of the result. The blank solution was prepared by taking a mixture of 8 mL HNO_3, 1 mL HCl and 1 mL H_2O_2 and treating similarly as that of the sample (Street, 2008).

The analysis was made for a total of seven selected minerals including three macro-minerals (Ca, P, and Mg) and four trace minerals (Cu, Fe, Zn, and Co), by using Atomic absorption spectrophotometer(AAS),usingInductively Coupled Plasma-Optical Emission Spectroscopy, Perkin Elmer Analyst 200 Atomic Absorption Spectrometer except for P. The P concentration was measured by spectrophotometer according to Murphy and Riley (1962). Except for P which was analyzed in DZARC soil lab, other minerals were analyzed at Holota Agricultural research center (HARC). For this research, only seven minerals were included, whereas other important minerals for dairy cows were missed (Na, K, Mn, and Se) this selection was because of some technical constraints (AAS capacity of reading and bulkiness of the samples as well as some results only one season result/ dry season only but wet season were not read by AAS during the time of analysis).

The concentrations of Ca, P, Mg, Cu, Fe, Zn, and Co were analyzed using the atomic absorption flame emission spectrometer. The critical level (CL) used in this article is defined as the concentration of minerals below the level considering the requirements for dairy cows (McDowell *et al*., 1993; NRC, 2001). While digesting the feed samples, simultaneous digestion of reagent blank was undertaken and the final volume was similarly made up to 10 ml to have a blank.

3.7.2. Urine digestion procedures

The representative pooled samples of urine were digested with tri acid mixture (HNO_3: HsSO4: $HClO_4$, 3:2:1) for the estimation of different mineral elements (Taylor *et al*., 2009). Calcium was estimated by the atomic absorption Spectrophotometer while P concentration was measured by spectrophotometer according to Murphy and Riley (1962).

3.7.3. Digestion procedures for serum and milk

Serum and milk samples were digested as per the procedure described by Kolmer *et al.* (1951; Aydin, (2008); Zhou *et al*. (2017). About 2 and 5ml of serum and milk respectively, with an equal volume of concentrated HNO_3, were mixed in the digestion tube. The samples were kept overnight at room temperature followed by digestion on low heat (70-80°C) using a heat bench (digestion bench) until the volume of samples was reduced to about 1 ml. Briefly, 3 ml of the double acid mixture (3 part concentrated HNO_3 and 1 part 70% $HClO_4$) was added and low heat digestion continued until the digested samples became watery clear and emitted white fumes. Further heating was continued to reduce the volume to approximately 0.5 ml (Sharma *et al*., 2003). The final volume of the filtrate was made up to 10 ml with distilled deionized water after luke warming the solution. While digesting serum and milk samples, simultaneous digestion of reagent blank was undertaken and the final volume was similarly made up to 10 ml to have blank (Shah *et al*., 2017). All sample digestion and chemical composition of feeds, milk, fecal, and urine were performed at DZARC, Nationl Veterinary Institution (NVI) and Ethiopian meat and dairy industry development institute (EMDIDI).

3.7.4. Feed offered and refused

The grass hay used for feeding the experimental animals were weighed daily using sensitive balance. Concentrates also weighed separately were offered to the animals in the morning and evening. Each morning, before feeding the feed refusals of the previous day feeding were collected and weighed using a similar sensitive balance.

3.7.5. Dry matter intake (DMI)

The daily dry matter intake by each cow was determined by taking the difference between the amount of feed offered and amount refused.

3.7.6. Nutrients intake

Daily CP intake by lactating cows was estimated by calculating the CP in feeds offered by the difference that in the refusals. The contents of Ca and P in feedstuffs were obtained from the ARC (1980). The nutrients deficit was calculated by taking the total individual nutrient offered to the animals minus the total individual nutrient requirement by the cows.

3.7.7. Milk yield, composition and mineral analysis

The milk produced by each cow in every milking was measured using calibrated milk measuring jars and recorded, whereby the volumes of morning and evening milk yield were added together to obtain total daily milk yield per cow. Measurements of milk yield were taken by the researcher and research assistants. Milk samples were taken at different stages of the experiment using a graduated bottle every day throughout the study period. Milk aliquot samples (100 ml) from the morning and evening milking were collected in sterile plastic containers for two consecutive days at the beginning (16^{th} and 17^{th} day) and end of the experimental period of 29^{th} and 30^{th} day (Getu *et al*., 2019). The milk samples were delivered to EMDIDI for milk composition analysis. 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 butyro meter 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 white ash remains. Solids-not-fat (SNF %) content of milk samples was determined by subtracting percent milk fat content from milk total solids 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 (Tola *et al*, 2007).

3.7.8. Chemical composition analyses

Feed and fecal samples were thawed, thoroughly mixed, and sub-sampled per cow. Both feed and fecal samples were dried in a forced-air oven at 55°C for 72 hours to a constant weight and ground to a 1.0 mm size using a Wiley mill and stored in plastic bags. Samples from formulated treatment diets were collected into polythene bags followed by laboratory procedures for chemical composition analysis. All samples were analyzed for

DM, total ash, and CP using the procedure of AOAC (1990). Neutral detergent fiber (NDF) and acid detergent fiber (ADF) were determined by the procedures of Van Soest and Robertson (1985). The IVOMD was determined according to Tilley and Terry (1963). Metabolizable energy (ME) was estimated from the *in-vitro* organic matter in the dry matter digestibility (DOMD) as EME (MJ/kg) =0.16 x DOMD (McDonald *et al.*, 2002). Feed and fecal chemical compositions were analyzed at the NVI and DZARC laboratories.

Ca and P balance was calculated based on the formula (Hibbs & Conrad, 1983).

Mineral balance= Intake - Outgo (Milk + Feces + Urine)

3.7.8. Apparent digestibility

Apparent digestibility of total ration used in each treatment was determined using total fecal collection methods for each period of 7 consecutive days starting from day 24th to 30th. To avoid contamination feces collections were implemented by the researcher and assistance researchers. Likewise, the floor was frequently washed using tap water. Individual cow fecal was weighed every morning before 0800 hours and before fresh feeds were given to the animals. However, to avoid possible urinary contamination, fecal samples were obtained directly from rectal grabbing's taken four times a day (0800, 1400, 2000, and 0200 hours) (Getu *et al.*, 2019). Rectal grab samples from each cow were composited, 1% of the total collection was placed in a polyethylene bag, and stored at -20^{o}C until the end of the collection period. At the end of the collection period, the pooled samples were thawed and mixed thoroughly and samples were oven-dried at 65$^{o}{}_{C}$ for 72 hours, ground to pass a 1mm sieve and stored in sample bottles at room temperature. Finally, feed offer and refusal samples composite pooled samples and fecal output was analyzed for DM, Ash, CP, NDF, ADF, Ca and P. The apparent digestibility (%) of nutrients was calculated by using the following equation according to McDonald *et al.* (2002) as follows:

$$\text{Apparent digestibility (\%)} = \frac{\text{Nutrient intake} - \text{nutrient in feces}}{\text{Nutrient intake}} \times 100$$

3.8. Estimation of Minerals Using Absorption Spectrophotometer (AAS)

All the samples of feed, milk, urine, and blood were analyzed for calcium (Ca), phosphorus (P), magnesium (Mg), copper (Cu), zinc (Zn), iron (Fe), cobalt (Co), using AAS (Perkin, 1982) at Holota agricultural center (HARC) soil lab and phosphorus (P) content was determined using an auto analyzer method of (Fiske and Subbarow, 1925) at DZAC soil and nutrition laboratory. Air/Acetylene flame was used as a fuel and sample analysis was done by the attached computer and the concentrations of minerals contained in the sample were expressed in ppm. The selection for analysis of only such six minerals was made because of some technical constraints (AAS capacity of reading and bulkiness of the samples during the time of analysis).The word ‘critical’ is used in this dissertation to express a concentration of minerals in feedstuffs and blood serum below (deficiency), sufficient or borderline and above with excesses which considered the requirement for dairy cow based on (McDowell *et al.*, 1997; Miles and McDowell, 1983).

3.9. Statistical Analysis

The survey data collected from respondents were entered in the Microsoft Excel spreadsheet. The two districts, production systems, physiological status, and seasons were used as fixed factors for the various dependent variables assessed in the survey. Descriptive statistics (means, standard deviation, frequency, and percent) were used to analyze the effect of different independent variables on the dependent variables to summarize data on household characteristics; feeds and feeding systems, and dairy cows production/management systems were analyzed using the Statistical Package for Social Sciences version 20.0 (SPSS, 2002) for windows. The collected data including Phase I surveyed data (feeds and blood serum), Phase II feeding trial (experimental feeds, blood serum, fecal, urine, milk yield and compositions, DM and nutrient intakes and digestibility as well as Ca and P contents) have been subjected to analysis of variance (ANOVA) procedure for Latin Square Design using Statistical Analysis Systems (SAS, 2002). The mean mineral concentration feeds and blood from different districts, production systems, and seasons were compared statistically using the General Linear Model (GLM) procedure of SAS. When the interaction between factors was non-significant, only the main effect means were presented and discussed, otherwise simple effect means were presented. Mean separation was done using LSD test at 5% probability. The response (dependent) variable is the concentration of minerals (Ca, Mg, P, Fe, Cu, Zn, and Co) as affected by independent variables of location (Ada'a and Adama districts); production system (urban, rural), season (dry, wet) and interaction of dependent variable. Therefore, the following models were used,

- Model for feed sample lab analysis:

$$y_{ijk} = \mu + d_i + s_j + p_k + (dsp)_{ijk} + e_{ijk}$$

Where, y_{ijk} = measured data (Ca, Mg, P, Cu, Fe, Zn, Co) for feed sample,

μ= overall
d_i= effect of i^{th} district (1,2)
s_j= effect of j^{th} season (1,2)
p_k= effect of k^{th} production system (1, 2)
(dsp)ijk= Interaction effect of location, season and production system
e_{ijk}= the random error associated to the y_{ijk} observation

- Model serum sample lab analysis:

$$y_{ijlt} = \mu + \alpha_i + s_j + d_l + p_t + (\alpha sdp)ijlt + e_{ijlt}$$

Where, y_{ijlt} =measured data (Ca, Mg, P, Cu, Fe, Zn, Co) for blood

μ= overall mean

α_i= effect of j^{th} physiological state (1,2)
s_j = effect of j^{th} season (1,2)
d_l = effect of l^{th} district(1,2)
p_t = effect of t^{th} production system (1,2)
$(\alpha sdp)_{ijlt}$= interaction effect of physiological state, season, district, production system,
e_{ijlt}= the random error associated with the $_{ijlt}{}^{th}$ observation

The mathematical Design used for the feeding trials was 4X4 Latin Square

- Lactating dairy cow feeding trial model: $Y_{ijkl}=\mu + ά_i + ß_j + T_k + e_{ijkl}$

Where, Yijk is the dependent variable (intake, milk yield andcomposition),

μ = overall mean, $\acute{\alpha}_i$ = effect of period (i=1-4), $ß_j$ = effect parity (j=1-4), T_k= effect of treatment (k=1-4), ε_{ijk} = random error

4. RESULTS

The present study was classified and conducted into two parts with different sub-activities in each part. In part one, the existing dairy cow feeding practices were characterized in production systems (urban and peri-urban) of Ada'a and Adama district in the East Shoa Zone. In the second portion of part one, dairy feeds resources and the dairy cow's blood were assessed for some macro and micro minerals in dry and wet seasons. In part two, the effect of Ca and P supplementation on productive performance of lactating dairy cows was studied. Details of the results of the study were presented below.

PART I

4.1. Household Characteristics

Household (HH) characteristics of the respondents in the study areas are shown in Table 8. The current results indicated that among interviewed HH members who involved in dairy production activities 70.9% and 29.1% were male and female-headed, respectively, from Ada'a district whereas, 75.6 *vs* 24.4% were male and female-headed in Ada'a and Adama districts, respectively. The illiteracy percentage was lower (6.3 vs 0.8%) in Ada'a and Adama districts respectively, and most respondents had secondary level education. Moreover, no illiterate respondents were observed in areas of the respective districts. There were percentage differences in educational levels among the study districts. Consequently, a larger percentage of HH respondents attended primary school (37.8 %) in Ada'a whereas, junior school (43.9 %) in Adama districts.

Table 8. Scio-economic characteristics of household respondents

Variable	Adaa (n = 127), n (%)		Total n=127	Adama (n = 123),n (%)		Total n=123	Overall Total N=250	P-value
	Urban (60)	P.urban (67)		Urban(5	P.urban(68)			
Sex								
Female	13(21.7)*	24(35.8)	37(29.1)	14(25.5)	16 (23.5)	30(24.4)	67(26.8)	0.218
Male	47(78.3)	43(64.2)	90(70.9)	41(74.5)	52(76.5)	93(75.6)	183 (73.2)	
Age								
≤30	12(20.0)	7(10.4)	19(15.0)	13(81.2)	3 (18.8)	16(6.4)	35(14)	0.096
31-40	28 (46.7)	28(41.8)	56(44.1)	24(50.0)	24(50.0)	48(19.2)	104(41.6)	0.020
41-50	11 (18.3)	20 (29.9)	31(24.4)	10(35.7)	18(64.3)	28(11.2)	59(23.6)	0.036
≥51	9 (15.0)	12(17.9)	21(16.5)	8(25.8)	23(74.2)	31(12.4)	52(20.8)	0.087
Education Level								
Illiterate	-	8(11.9)	8(6.3)	-	1(1.5)	1(0.8)	9(3.6)	0.017
Basic education	3(5.0)	15(22.4)	18(14.2)	1(1.8)	4(5.9)	5(4.1)	23(9.2)	0.021
primary school**	17(28.3)	31(46.3)	48(37.8)	9(16.4)	19(27.9)	28(22.8)	76(30.4)	0.089
Junior school***	9(15.0)	7(10.4)	16(12.6)	23(41.8)	31(45.6)	54(43.9)	70(28)	0.012
high school@	18(30.0)	3(4.5)	21(16.5)	10(18.2)	8(11.8)	18(14.6)	39(15.6)	0.785
Diploma	8(13.3)	2(3.0)	10(7.9)	7(12.7)	3(4.4)	10(8.1)	20(8)	0.238
Degree and above	5(8.3)	1(1.5)	37(29.1)	5(9.1)	2(2.9)	30(24.4)	13(5.2)	0.194
Family size(person)								
1-3	28 (46.7)	29 (43.3)	57(44.9)	18(32.7)	35(51.5)	53(43.1)	110(44)	0.181
4-6	24 (40.0)	21 (31.3)	45(35.4)	26(47.3)	27(39.7)	53(43.1)	98(39.2)	0.086
≥7	8 (13.3)	17(25.4)	25 (19.7)	11(20.0)	6(8.8)	17(13.8)	42(16.8)	0.123
Marital status								
Single	3 (5.0)	2 (3.0)	5(3.9)	-	3(4.4)	3(2.4)	8(3.2)	0.465
Married	56 (93.3)	63 (94.0)	11 9(93.7)	52(94.5)	64(94.1)	116(94.3)	235(94)	0.004
Divorce	1 (1.7)	2 (3.0)	3(2.4)	3(5.5)	1 (1.5)	4(3.3)	7(2.8)	0.181

*Figures in parenthesare percentages for a given category,**1-6, ***7-8, @9-12; n= total number of respondents

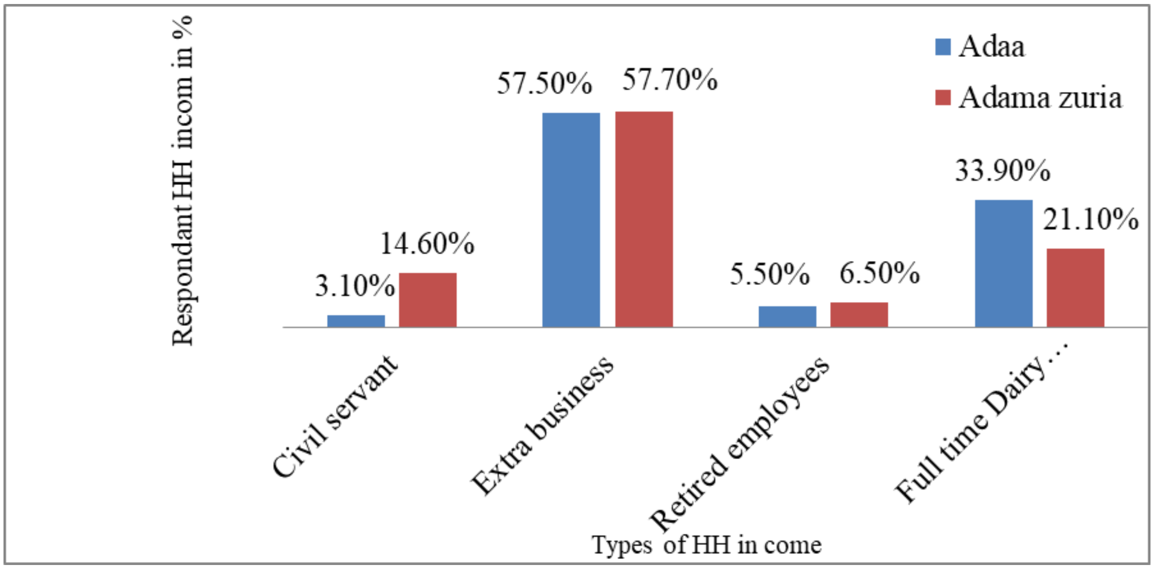
When dairy cattle breeds owned by dairy producers were considered 45.7 % from Ada’a district and 8.1%, from Adama district were pure Holistian breeds. However, the highest proportions of dairy cattle breeds were cross local breeds with Holstein Friesian (45.7% for Ada’a and 48.8% for Adama district). Details of cattle breed reared, source of income, and family income was described in Table 9.

Table 9. Source of family income of respondants in the study area

Variable	Adaa n = 127 n (%)			Adama = 123 n (%)			Overall T. N = 250	p-value
	Urban	P.urban (67)	Total	Urban(55)	P.urban(68)	Total		
Family income								
Civil servant	2(3.3)	2 (3.0)	4(3.1)	3(5.5)	15(22.1)	18 (14.6)	22(8.8)	0.037
Extrabusiness(trader)*	37(61.7	36(53.7)	73(57.5)	34(61.8)	37(54.4)	71(57.7)	144(57.6)	0.067
Retired employees	6(10.0)	1 (1.5)	7(5.5)	2(3.6)	6(8.8)	8(6.5)	15(6.0)	0.083
Full time Dairy farming	15(25.0	28(41.8)	43(33.9)	16(29.1)	10(14.7)	26(21.1)	69(27.6)	0.041
Total	60(100)	67(100)	127(100	55(100)	68(100)	123(100)	250(100)	

Extra business- it includes petty trading; Retired employees= people who were working under government or privet organization but unfortunately retire* d; *figures in parenthesis are percentages for a given category*

Among the major dairy production constraints in the study areas, disease (18.1%) was leading challenges in Ada'a district while inefficient AI service (14.6%) in Adama districts. Feed shortage 13.4 in Ada'a and 11.4% Adama district was among the most limiting factor to improve the production and productivity of dairy cattle (Table 10).



Figur 2. Farm households source of income in the study areas

Table 10. Major constraints of respondents to improve dairyng activities in the study area

Variable	Adaa n = 127 n (%)			Adama= 123 n (%)			Overall T.	P-value
	Urban (60)	Peri-urban (67)	Total	Urban (55)	Peri-urban (68)	Total	N = 250	
Shortage of land	19(31.7)	3(4.5)	22(17.3)	17(30.9)	1(1.5)	18(14.6)	40(16.0)	0.263
Feed shortage	12(20.0)	5(7.5)	17(13.4)	11(20.0)	3(4.4)	14(11.4)	31(12.4)	0.345
Diseases	6(10.0)	17(25.4)	23(18.1)	5(9.1)	9(13.2)	14(11.4)	37(14.8)	0.534
Lack of EXS	3(5.0)	7(10.4)	10(7.9)	-	10(14.7)	10(8.1)	20(8.0)	0.347
Inefficient AI service	3(5.0)	16(23.9)	19(15.0)	7(12.7)	14(20.6)	21(17.1)	40(16.0)	0014
Market problem	-	13(19.4)	13(10.2)	3(5.5)	13(19.1)	16(13.0)	29(11.6)	0.256
Shortage of labor	14(23.3)	2(3.0)	16(12.6)	10(18.2)	7(10.3)	17(13.8)	33(13.2)	0.623
InadequateV.service	3(5.0)	4(6.0)	7(5.5)	2(3.6)	11(16.2)	13(10.6)	20(8.0)	0.045

n = number of respondents; figures in parenthesis are percentages for a given category;EXS=extension service; V=veterinary

4.2. Dairy Feed Resources and Feeding System

Feed resources available in the study areas include natural pasture, crop residues, green grass, and concentrate feeds (Table 12). The most dominant feeding practices that prevailed across the study area for crossbred cattle were zero-grazing followed by partial grazing especially during the dry seasons which supplemented by indoor feeding. The survey result indicated that (40.9 *vs* 34.1%) were practiced stall feeding/ zero-grazing for crossbred dairy cows in respected Ada'a and Adama districts. Respondents who reared only local cattle breeds depend on free grazing both in Ada'a (13.4%) and Adama (16.3%) districts.

The major feed resources for dairy cows in the study area were grass hay (25.2*vs*18.7%); natural pasture (11.0 *vs* 17.1%); crop residue (15.0 *vs* 13.8%); concentrates (24.4 *vs* 30.1%); industrial brewery by-products (12.6 *vs*8.9%), and nonconventional (11.8 *vs* 8.9%) in Adaa and Adama districts, respectively.

Table 11. Dairy cattle feed sources, and feeding practices

Variables	Adaa n = 127 n (%)			Adama n = 123 n (%)			Overall N = 250	P-value
	Urban (60)	P.urban (67)	Total	Urban(55)	P.urban(68)	Total		
Type of feeding								
Free grazing	-	17(25.4)	17(13.4)	5 (9.0)	15 (22.1)	20(16.3	37(14.8)	0.406
Stall feeding	51 (85.0)	1 (1.5)	52(40.9)	25 (45.5)	17 (25.0)	42(34.1	94(37.6)	0.037
Fr and St	9 (15.0)	49 (73.1)	58 (45.7)	25 (45.5)	36 (52.9)	61(49.6	119(47.	0.564
Source of feed								
Local feed source	5(8.3)	14(20.9)	19(15.0)	15(27.3)	21(30.9)	36(29.3	55(22.0)	0.023
Purchased source	38(63.3)	21(31.3)	59(46.5)	11(20.0)	1(1.5)	12(9.8)	71(28.4)	0.045
local and purchased	17(28.3)	32(47.8)	49(38.6)	29(52.7)	46(67.6)	75(61.0	124(49.	0.018

n = number of respondentsi n the production systems; N=over all number of respondants; figures in parenthesis are percentages for a given category; Fr=free grazing;St= stall feeding

Table 12. Percentage of dairy cattle feed types and available water sources in the study area

pAvailable feeds	Ada′a n = 127 n (%)			Adama n = 123 n (%)			Overall T.	P-value
	Urban=60	P-urban =67	Total	Urban(55)	P-rban(68)	Total	N = 250	
Roughage								
Natural pasture	-	14(20.9)	14(11.0)	1(1.8)	20(29.4)	21(17.1)	35(14.0)	0.047
Grass hay	18(30.0)	14(20.9)	32(25.2)	11(20.0)	12(17.6)	23(18.7)	55(22.0)	0.037
Crop residue*	8(13.3)	11(16.4)	19(15.0)	2(3.6)	15(22.1)	17(13.8)	36(14.4)	0.068
Concentrate**	16(26.7)	15(22.4)	31(24.4)	27(49.1)	10(14.7)	37(30.1)	68(27.2)	0.016
Cereal grain and oilseed***	10(16.7)	6(9.0)	16(12.6)	9(16.4)	2(2.9)	11(8.9)	27(10.8)	0.029
Nonconventional(*atela*)	8(13.3)	7(10.4)	15(11.8)	5(9.1)	9(13.2)	14(11.4)	29(11.6)	0.976
Total	100	100	100	100	100	100	100	
Source of water								
Pipe water	53 (88.3)	12 (17.9)	65(51.2)	44(80.0)	23 (33.8)	67(54.5)	132(52.8)	0.067
Bore holes	6 (10.0)	23 (34.3)	29(22.8)	1 (1.8)	14 (20.6)	15(12.2)	44(17.6)	0.047
Pipe and Pond	1 (1.7)	18 (26.9)	19(14.9)	10 (18.2)	24 (35.3)	34(27.6)	53(21.2)	0.857
Spring water	-	10 (4.5)	10(7.9)	- -	4 (5.9)	4(3.3)	14(5.6)	0.237
Another source (rain)	-	4 (6.0)	4(3.1)	-	3 (4.4)	3(2.4)	7(2.8)	0.467
Total	100	100	100	100	100	100	100	

wheat straw, barley straw, teff straw, maize stover, sugar cane top; Concentrate= Faba bean mixed hull X WB; *** noug seed cake, cottonseed cake, wheat bran, lean seed meal, soya bean meal;n = number of respondents; figures in parenthesis are percentages for a given category*

The main source of water for dairy cows was pipe water (51.2 *vs* 54.5%) for Adaa and Adama zuria respectively. Regarding dairy feed resources, the high percentage of dairy feed was purchased feeds both in Ada'a (46.5%) and Adama districts (61%).

4.2.1. Improved forage production practices

Improved forages are variable in protein and minerals content, depending on forage type. In the current study, 67.7% of dairy farm HH's from Ada'a and, 89.4% from Adama district did not grow improved forages. The major limitations to grow improved forages included scarcity of land for forage development (45.7 *vs* 52.0%), lack of awareness (11.0 *vs* 13.0%), both scarcity of land and lack of awareness together (6.3 *vs* 8.1%) and lack of input supply (3.9 *vs* 5.7%) and (33.1 *vs* 21.1%) in Ada'a and Adama, respectively. The most commonly cultivated forges across the study areas were alfalfa, elephant grass, cowpea, and Sesbania sesban.

Dairy owners frequently establishing types of improved forages in Ada'a and Adama districts were *Medicago sativa* (17.3 *vs* 16.2%); *Pennisetum purpureum*, (11.0 *vs* 4.4%); *Vicia dasycarpa* (25.2 *vs* 10.3%); *Vigna unguiculata* (3.1 *vs* 11.4%); and mixed *Viciadasycarpa & V.unguiculata* (15.0 *vs* 19.5%) and *Sesbania sesban* (0% *vs* 4.9%) (Table 13).

Table 13. The percentage of dairy farm households planting and utilized green improved forages for dairy cattle

Variable	Adaa n = 127 n(%)			Adama n = 123 n (%)			Overall	
	Urban	P-urban (67)	Total	Urban(5	P-urban(68)	Total	N = 250	P-value
Improved Forage								
Yes	10(16.7)	31 (46.3)	41(32.3)	2(3.6)	11(16.2)	13(10.6)	54(21.6)	0.024
No	50 (83.3)	36 (53.7)	86(67.7)	53 (96.4	57(83.8)	110(89.4)	196(78.4)	0.017
Reason for not forage devt.								
Scarcity of land(SL)	42(70.0)	16(23.9)	58(45.7)	32(58.2)	32(47.1)	64(52.0)	122(48.8)	0.546
Lack of awareness	6(10.0)	8(11.9)	14(11.0)	2(3.6)	14 (20.6)	16(13.0)	30(12)	0.923
Scarcity of land & SL	1 (1.7)	7(10.4)	8(6.3)	6 (10.9)	4 (5.9)	10(8.1)	18(7.2)	0.567
Lack of input supply	1(1.7)	4(6.0)	5(3.9)	-	7(10.3)	7(5.7)	12(4.8)	0.058
Shortage of labor	10(16.7)	32(47.8)	42(33.1)	15(27.3)	11 (16.2)	26(21.1)	68(27.2)	0.026
Improved forage grown								
Alfalfa*	10(16.7)	12(17.9)	22(17.3)	10(16.7)	15(27.3)	11(16.2)	33(13.2)	0.693
Elephant grass	5(8.3)	9(13.4)	14(11.0)	5(8.3)	9(16.4)	3(4.4)	17(6.8)	0.035
Oats	12(20.0)	20(29.9)	32(25.2)	12(20.0)	7(12.7)	7(10.3)	39(15.6)	0.042
Cow pea	0.0	4(6.0)	4(3.1)	0.0	1(1.8)	5(7.4)	11(4.4)	0.058
Viciadasycarpa and *V.unguiculata*)	15(25.0)	4(6.0)	19(15.0)	15(25.0)	11(20.0)	13(19.1)	32(12.8)	0.057
Sasbaniasesban	-	-	-	6(10.9)	-	6(4.9)	6(2.4)	NA
All available forage	18(30.0)	18(50.0)	36(28.3)	18(30.0)	6(10.9)	29(42.6)	65(26)	0.035

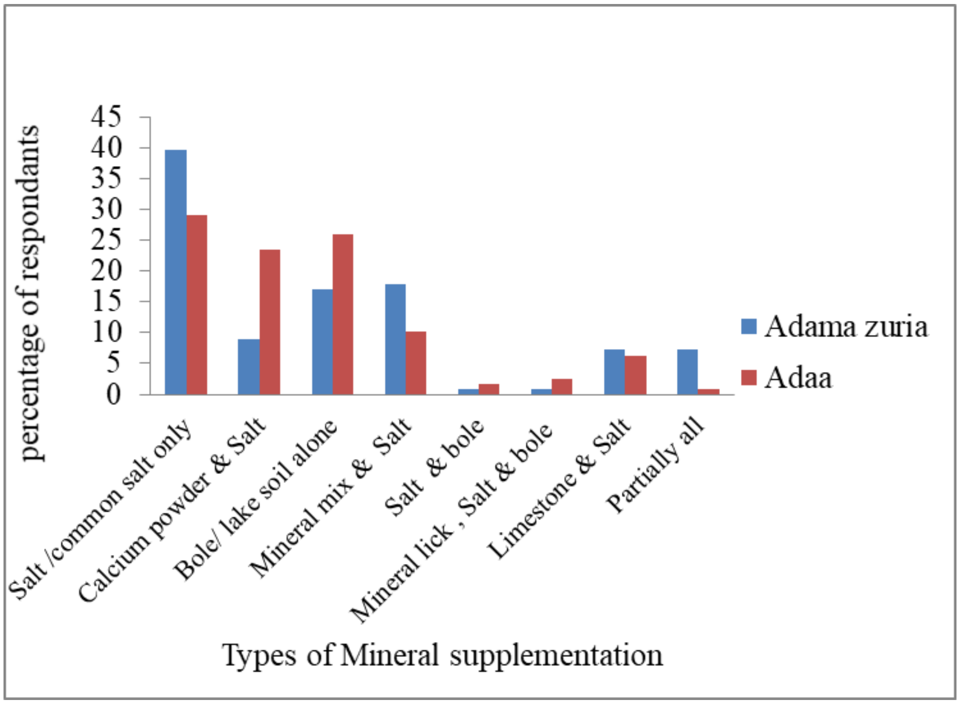
* *Alfalfa =Medicago sativaL.,Vicia dasycarpa, Pennisetum purpureum; n = number of respondents; figures in parenthesis are percentages for a given category;Elephant grass=Pennisetumpurpureum; oats=* Avena sativa *;Cow pea=Vignaunguiculata); Sesbania Sasbaniasesban;devet; NA= not applicable;SL=Scarcity of land*

The majority of dairy owners do not supplement minerals for their dairy cows (Table 14). Among the reasons of not using mineral supplements were lack of mineral source (48.8 *vs* 43.9%); followed by lack of information about minerals (31.5 *vs* 28.5%) and both lack of mineral sources and absence of awareness (19.7 *vs* 27.6%) in Ada'a and Adama districts, respectively. In those that used mineral supplements, commonly used mineral types were sodium chloride (29.1 *vs* 40.7%), and Ca powder with sodium chloride (26.0 *vs* 17.1%) in Ada'a and Adama districts, respectively. Others used undefined lake soil mineral "bole" (Figure 3).

Table 14. Source of mineral information and types of mineral supplementation in the study area

Variable	Ada'a n = 127, n (%)			Adama n= 123 (%)			Overall N = 250
	Urban(60)	Peri-urban (67)	Total	Urban(55)	Peri-urban(68)	Total	
Reason For Not Feeding M.							
Lack of mineral source*	42(70.0)	20(29.9)	62(48.8)	29(52.7)	25(36.8)	54(43.9)	116(46.4)
No information about	8(13.3)	32(47.8)	40(31.5)	22(40.0)	13(19.1)	35(28.5)	75(30.0)
Shortage	10(16.7)	15(22.4)	25(19.7)	4(7.3)	30(44.1)	34(27.6)	59(23.6)
Source of M. Knowledge							
Through education	14(23.3)	19(28.4)	33(26.0)	4 (7.3)	15(22.1)	19(15.4)	52(20.8)
Cultural knowledge	2 (3.3)	5(7.5)	7(5.5)	1(1.8)	2(2.9)	3(2.4)	10(4.0)
From friends	-	1(1.5)	1(0.8)	2(3.6)	25(36.8)	27(22.0)	28(11.2)
Through extension workers	17(28.3)	4(6.0)	21(16.5)	12(21.8)	2(2.9)	14(11.4)	35(14.0)
From different sources	7(11.7)	9(13.4)	16(12.6)	9(16.4)	4(5.9)	13(10.6)	29(11.6)
No idea	20(33.3)	29(43.3)	49(38.6)	27(49.1)	20(29.4)	47(38.2)	96(38.4)
HH's Mineral Sources							
Cultural/local source	14(23.3)	24(35.8)	38(29.9)	1(1.8)	-	1(0.8)	39(15.6)
Commercial source	40(66.7)	40(59.7)	80(63.0)	24(43.6)	25(36.8)	49(39.8)	129(51.6)
Both cultural &commercial	6 (10.0)	3(4.5)	9(7.1)	30(54.5)	43(63.2)	73(59.3)	82(32.8)

*shortage of minerals and lack of awareness; *n = number of respondents; figures in parenthesis are percentages for a given category*



Figur 3. . Dairy cow minerals sources interms of percentage

4.3. Seasonal Occurrence of Mineral Deficiency and Supplementation

The result of the current study indicated that the percentages of respondents who have awareness about the seasonal occurrence of mineral deficiency were in dry (70.1 *vs* 52.8%) ; wet (0.8 *vs* 2.4%) and in both season (3.9 *vs* 1.6%) in Ada'a and Adama districts it was based on respondent's observation. Details of farmers' awareness of the seasonal occurrence of mineral deficiency were indicated in Table 15, and the respondent's awareness of mineral deficiency-related symptoms indicated in Figure 3. During the study dairy owners indicated as a challenge was gradual increment of cost of minerals supplementation. Therefore, regarding the price of minerals different opinions were suggested (55.9 *vs* 46.3%) that even if, the price of a mineral was affordable by dairy owners, there was a problem of unavailability of some minerals in the market also (15.0 *vs* 23.6%) that the respondents suggested the the price of the mineral was unaffordable; the rest of the respondents (29.1 *vs* 30.1%) were suggested no difference in availability and price to use minerals in Ada'a and Adama districts. From the current study, it is possible to conclude that the majority of the respondents could afford to provide for their dairy cows but the challenge was the accessibility issues in the study area.

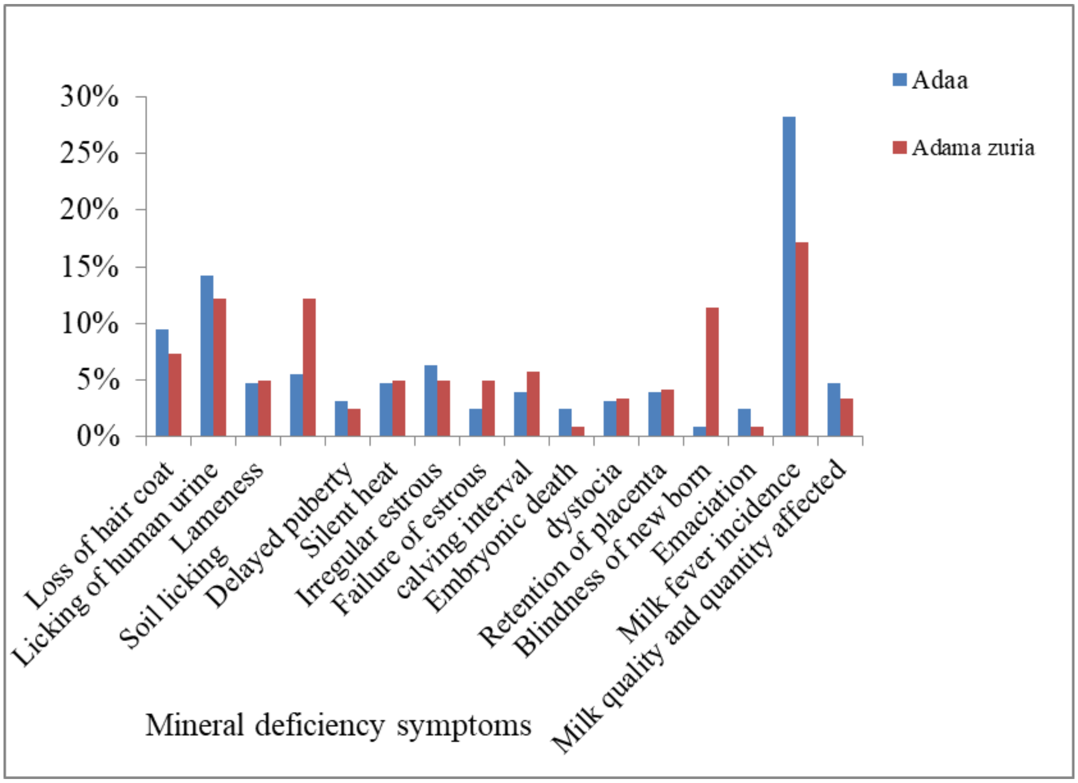
4.4. Mineral Deficiency Symptoms and Household's Observation

In the current study, the majority of the respondents were having knowledge about mineral deficiency symptoms (59.1 *vs* 44.7%), while almost half (40.9 *vs* 55.3%) of the respondants haven't idea about deficiency diseases in Ada'a and Adama districts (Appendex 5). Likewise, respondents who have knowledge about mineral deficiency symptoms were revealed different mineral deficiency symptoms on their animals which were observed like, loss of hair coat, licking of human urine, lameness, soil licking, delayed onset of puberty, silent heat, irregular estrous, failure of estrous, long period of calving interval, embryonic death, increase the incidence of dystocia, retention of placenta, blind eyes of newborn, emaciation, milk fever incidence, milk quality and quantity affected, respectively throughout the study area (Figure 4).

Table 15. Seasonal occurrence of observed mineral deficiency and infectious disease

Seasons	Adaa n = 127, n (%)			Adama = 123, n (%)			Overall	
	Urban (60)	P-urban (67)	Total	Urban(55)	P-urban(68)	Total	N = 250	P-value
Dry season	42(70.0)	47(70.1)	89(70.1)	36(65.5)	29(42.6)	65(52.8)	154(61.6)	0.0443
Wet season	1(1.7)	-	1(0.8)	1(1.8)	2(2.9)	3(2.4)	4(1.6)	NA
Both season	4(6.7)	1(1.5)	5(3.9)	2(3.6)	-	2(1.6)	7(2.8)	NA
No idea	13(21.7)	19(28.4)	32(25.2)	16(29.1)	37(54.4)	53(43.1)	85(34)	0.004

n = number of respondents; figures in parenthesis are percentages for a given category;



Figur 4. Respondent's opinion about mineral deficiency and related symptoms

4.5. Mineral Profile in Blood Serum and Dairy feeds

4.5.1. Mineral profile in blood serum of dairy cows

The details of serum macro and micro mineral profiles of lactating and dry dairy cows of the two districts, with their respective production systems in dry and wet seasons were presented in Table 16 to 20.The macro and micro mineral concentration of sampled dairy cows in two districts of respective production systems within a particular season were indicated that the mean Ca concentrations in lactating cows were (0.085 *vs* 0.080 g/L) and (0.090 vs 0.085 g/L) for dry cows in Ada'a and Adama respectively). Whereas, the mean Ca concentration (0.080 *vs* 0.075 g/L) for lactating cows and (0.080 *vs* 0.085 g/L)for dry cows in urban and peri-urban areas, respectively. The mean Ca concentration was significantly affected ($P<0.05$) by seasonal variation. Therefore, the concentration of Ca levels was affected in dairy cows between wet and dry season, the concentration was high in wet compared to the dry season. The concentration of Ca was also affected ($p<0.05$) by districts and production system (details of serum Ca concentration for the individual district, production system and season were indicated in Table 16-18). Overall the percentage of Ca deficiency in relation to their critical level value was observed (23.34 *vs* 29.32%); (23.34 *vs* 18.54%) for lactating cows in urban and peri-urban production systems of Ada'a, whereas, (7.12 *vs* 8.32%); (11.13 *vs* 6.34%) for a dry cow in urban and peri-urban production systems of Adama districts. Likewise, based on season deficiency of Ca serum concentration was (26.67 *vs* 21.67%); (31.67 *vs* 27.67%) for the dry season in urban and peri-urban production systems of Ada'a and Adama districts, whereas, the values were (11.67 *vs* 26.67%); (34.67 *vs* 16.67%) for a wet season of urban and peri-urban of Ada'a and Adama districts are shown in Table 19 and 20. Furthermore, among the sampled dairy cows almost the majority of the dairy cow's laboratory result indicated that the serum Ca level said to be found on the borderline. On the other hand, the interaction effect of the main factors did not affect the concentration of Ca.

Table 16. Serum macro micro minerals (g/l) level in lactating and dry cows and their interaction effect in the study area.

Physiological status	Districts	Macro Minerals (g/l)			Micro Minerals(mg/l)			
		Ca	P	Mg	Cu	Fe	Zn	Co
Lactating	Ada'a	0.085a	0.040	0.155a	0.590b	2.281b	1.980	0.001
	Adama	0.080b	0.040	0.135b	0.675a	2.590a	1.890	ND
Mean		0.083	0.040	0.145	0.633	2.436	1.935	NA
Dry Cow	Ada'a	0.090a	0.042b	0.135a	0.521b	2.481a	2.406a	ND
	Adama	0.085b	0.045a	0.125b	0.641a	2.420b	2.170b	ND
Mean		0.086	0.043	0.130	0.581	2.451	2.288	NA
Over all Mean		0.085	0.042	0.138	0.607	2.443	2.112	NA
SE		0.002	0.0011	0.006	0.0013	0.5103	0.118	NA
P-Value								
Phy x districts		0.0133	0.0345	0.0427	0.0174	0.0358	0.0369	NA
Critical level		<0.08g	<0.04	<0.012	<0.65	<1.0	<0.6	<0.1

Criticallevel(Ca<0.08g/l=8mg/dl,P<0.04g/l=4mg/dl,Mg<0.012g/l=1.2mg/dl),(Cu<0.65ppm,Fe<1.0ppm,Zn<0.6ppm),Co<0.1ppm;adapted from (Miles and McDowell, 1983) cu=copper;Fe=Iron;Zn=zinc;co= cobalt; NA=data not available; ND= not detected; Means column abc indicated that significance level and season;Phys= physiological status; sn= season;M=mean

The mean P concentrations were (0.040 g/L *vs* 0.040 g/L) in lactating cows and (0.040 g/L vs 0.045 g/L) for dry cows in Ada'a and Adama districts, respectively. Whereas, the mean P concentration were (0.04 g/L *vs* 0.035 g/L) in different production systems that indicated for lactating cows in urban and peri-urban areas, respectively. The mean P serum concentration was significantly affected ($P<0.05$) in between districts, production systems, and seasons (details of serum P concentration for the individual district, production system, and the season is indicated in Table 16-18). The overall percentage of P deficiency, based on the critical level (Miles and McDowell, 1983) was (9.23 *vs* 3.33 %); (9.37 *vs* 6.12 %) for lactating cows urban and peri-urban Ada'a and Adama, whereas, P deficiency was (6.14% *vs* 0 %); (7.43% *vs* 2.44 %) for dry cows in urban and peri-urban production systems of Ada'a and Adama. Likewise, seasonally P level was (8.33% *vs* 5 %); (8.43 *vs* 7.67 %) for dry season; as well as, (3.33% *vs* 0 %); (4.33% *vs* 5 %) for wet season of urban and peri-urban in Ada'a and Adama districts (Table 19 and 20). Furthermore, the interaction effect of the main effect factors did not affect the concentration of Ca.

The mean Mg concentrations were (0.16 g/L *vs* 0.14 g/L) in lactating cows of Ada'a and Adama districts and (0.14 g/L vs 0.13 g/L) for dry cows in Ada'a and Adama districts. Whereas, the mean Mg concentration in different production systems was (0.17 g/L *vs* 0.14 g/L) in lactating cows for urban and peri-urban production systems. The mean Mg concentration was significantly affected ($P<0.05$) by the production system (details of serum Mg concentration for the individual district, production system, and the season was indicated in Table 16-18). The mean value of serum magnesium was significantly affected ($P<0.05$) within production systems. Moreover, the interaction effect Mg serum concentration was significantly affected ($p<0.05$) within the districts, production system, and season. The overall mean values of magnesium in serum were above the critical level (<0.012 g/L).

The mean Cu concentration was (0.59 mg/L *vs* 0.68 mg/L) in lactating cows and (0.52mg/L vs 0.64 mg/L) for dry cows in Ada'a and Adama districts, respectively. Whereas, the mean Cu concentration in different production systems was (0.64 mg/L *vs* 0.58 mg/L) for lactating cows in urban and peri-urban production systems of Ada'a district. The interaction effect of Cu concentration was significantly different ($p<0.05$) within districts, and season (Table 16-18). Overall the physiological status due to percentage of Cu deficiency based on the critical level of Cu was (79.54 % *vs* 54.62 %); (79. 23% *vs* 49.35 %) for lactating cows and (57.62% *vs* 67.87%); (67.62% *vs* 59.39%) for the dry cow. Moreover, based on the season it was (80.0% *vs* 58.33%); (71.67% *vs* 26.67%) for the dry season in urban and periurban production systems with the respective of Ada'a and Adama districts. Whereas, it was also (56.67% *vs* 63.33 %); (26.67% *vs* 65.0 %) for wet season in urban and periurban production systems of Ada'a and Adama districts, respectively.

Table 17. Mean serum macro (g/L) and micro minerals (mg/L) level of different categories of the cow based on production systems and their interaction effect in the study area

Physiology status	Prds	Macro Minerals (g/l)			Micro Minerals(mg/l)			
		Ca	P	Mg	Cu	Fe	Zn	Co
Lactating	Urban	0.080a	0.040a	0.170a	0.640	2.281b	2.040a	ND
	Peri-urban	0.075b	0.350b	0.135b	0.580	2.691a	1.920b	0.001
Mean		0.078	0.195	0.153	0.610	2.486	1.980	NA
Dry Cow	Urban	0.080b	0.040	0.135a	0.641	3.34b	2.140	ND
	Peri-urban	0.085	0.040	0.125b	0.580	2.72a	2.150	ND
Mean		0.0825	0.040	0.130	0.611	3.03	2.145	NA
Over all Mean		0.080	0.118	0.1415	0.611	2.758	2.063	NA
SE		0.0039	0.0011	0.0058	0.0501	0.1503	0.1176	NA
P-Value								
Phys x prds		0.0382	0.0134	0.0049	0.3273	0.0017	0.0410	NA
Critical level		<0.08g	<0.04	<0.012	<0.65	<1.0	<0.6	<0.1

Criticallevel(Ca<0.08g/l=8mg/dl,P<0.04g/l=4mg/dl,Mg<0.012g/l=1.2mg/dl),(Cu<0.65ppm,Fe<1.0ppm,Zn<0.6ppm),Co<0.1ppm;adapted from (Miles and McDowell, 1983) cu=copper;Fe=Iron;Zn=zinc;co= cobalt; NA=data not available; ND= not detected; Means column abc indicated that significance level and season;Phys= physiological status; sn= season;M=mean

The overall mean value for Fe concentration in the serum of dairy cows was shown in Table 19. Across the districts, the overall mean value of serum Fe concentration in lactating and dry cows was (2.54 mg/L *vs* 2.47 mg/L) and (2.61 mg/L *vs* 2.64 mg/L), in the dry and wet season, respectively. The result indicated that mean serum iron concentration was lower in lactating than dry cows. Also, in the dry season overall mean serum iron concentration was lower than the wet season (2.36 mg/L *vs* 2.56 mg/L), respectively. However, the value of Fe critical level (<1.0 ppm) for all the cases concentration value was above the critical level for all variables.

Table 18. Mean serum macro and micro minerals (ppm) level of different categories of the dairy cow based on seasons and their interaction effect in the study area

Physiological status	Season	Macro Minerals (g/l)			Micro Minerals(mg/l)			
		Ca	P	Mg	Cu	Fe	Zn	Co
Lactating	Dry	0.085a	0.035b	0.170a	0.570a	2.681b	2.041b	ND
	Wet	0.080b	0.040a	0.105b	0.580b	2.690a	2.190a	0.00
Mean		0.083	0.041	0.138	0.575	2.686a	2.116	NA
Dry Cow	Dry	0.075b	0.040a	0.170a	0.610a	2.281b	2.140b	ND
	Wet	0.080a	0.035b	0.155b	0.592b	3.381	2.280a	ND
Mean		0.076	0.038	0.163	0.601	2.883	2.210	NA
Over all Mean		0.080	0.0395	0.151	0.588	2.784	2.163	NA
SE		0.0037	0.0012	0.0036	0.0025	0.3123	0.1301	NA
P-Value								
Phys x Season		0.0182	0.0374	0.0236	0.0140	0.0199	0.0387	NA
Phy x dst x Prds x sn		0.9221	0.7031	<.0001	<.0001	0.0636	<.0001	NA
Critical level		<0.08g	<0.04	<0.012	<0.65	<1.0	<0.6	<0.1

Criticalevel(Ca<0.08g/l=8mg/dl,P<0.04g/l=4mg/dl,Mg<0.012g/l=1.2mg/dl),(Cu<0.65ppm,Fe<1.0ppm,Zn<0.6ppm),Co<0.1ppm;adapted from (Miles and McDowell, 1983) cu=copper;Fe=Iron;Zn=zinc;co= cobalt; NA=data not available; ND= not detected; Means column abc indicated that significance level and season;Phys= physiological status; sn= season;M=mean

The overall mean serum Zn level in lactating and dry cows was (1.71 mg/L *vs* 1.95 mg/L) and (2.02 mg/L *vs* 2.23 mg/L), in dry and wet seasons, respectively throughout the study area. Whereas, between with the production system the overall mean value was (2.41 mg/L *vs* 2.16 mg/L) for urban and per urban, respectively in Ada'a district whereas the value was (2.04 mg/L *vs* 2.17 mg/L), for urban and per urban, respectively, in Adama districts. In the study area, the p-value between districts, physiological status of dairy cows, and seasons have significantly different ($P< 0.05$) Table 20. However, based on their critical level (<0.6 ppm) in the majority of cases the value was below the critical level for all variables.

The mean values for Co concentration in the serum of dairy cows are given in (Table 20). Overall serum Co concentration throughout the study area, was not detected from serum samples Moreover, it was indicated that based on their critical level (< 0.1 ppm) in all cases, the value was below the critical level for all variables. In the current study, the interaction effect of serum minerals concentration for the different physiological status, between the districts, production systems and the season was highly significant ($P<0.01$) only for Mg, Cu, and Zn indicated in (Table 16 to 18).

Table 19. Percentage seasonal variation of some deficient macro and micro minerals status in dairy cow comparing to critical level between districts and production system

Mineral	Phys status	Ada'a				Adama				Critical level
		Urban %		Peri-urban %		Urban %		Peri-urban %		
		Sufficient	Deficient	Sufficient	Deficient	Sufficien	Deficient	Sufficient	Deficient	
Ca	Lactating	76.66	23.34	70.68	29.32	76.66	23.34	81.46	18.54	<0.08g/l
	Dry cow	92.88	7.12	91.68	8.32	88.87	11.13	93.66	6.34	
P	Lactating	90.77	9.23	97.67	3.33	90.63	9.37	93.88	6.12	<0.04g/l
	Dry cow	83.86	6.14	100	0	82.57	17.43	87.56	12.44	
Cu	Lactating	20.46	79.54	45.38	54.62	20.77	79.23	50.65	49.35	<0.65ppm
	Dry cow	42.38	57.62	32.13	67.87	32.38	67.62	40.61	59.39	
Co	Lactating	0	ND	100	0	100	0	ND	0	<0.1ppm
	Dry cow	0	ND	100	0	0	ND	0	ND	

Critical level (Ca<0.08g/l=8mg/dl, P<0.04g/l=4mg/dl,,P<Cu<0.65ppm, Fe<1.0ppm, Zn<0.6ppm) ,Co<0.1ppm; adapte from (*Miles and McDowell, 1983); ND= not detected*

Table 20. Seasonal variation of some deficient macro and micro minerals status in dairy cows compared to critical level between the districts and production systems.

Mineral N=240	Season	Ada'a				Adama				Critical level
		Urban %		Peri-urban %		Urban %		Peri-urban %		
		Sufficient	Deficient	Sufficient	Deficient	Sufficient	Deficient	Sufficient	Deficient	
Ca	Dry	73.33	26.67	78.33	21.67	68.33	31.67	72.33	27.67	<0.08g/l
	Wet	88.33	11.67	73.33	26.67	65.33	34.67	83.33	16.67	
P	Dry	91.67	8.33	95.00	5.00	91.67	8.33	92.33	7.67	<0.04g/l
	Wet	96.67	3.33	100	0	95.67	4.33	95	5.00	
cu	Dry	20.00	80.00	41.67	58.33	21.67	78.33	51.67	48.33	<0.65ppm
	Wet	43.33	56.67	36.67	63.33	73.33	26.67	35.00	65.00	
Co	Dry	ND	100	ND	100	ND	ND	ND	100	<0.1ppm
	Wet	ND	ND	100	100	ND	100	ND	100	

Critical level (Cu<0.65ppm, Fe<1.0ppm, Zn<0.6ppm) ,Co<0.1ppm; adapte from (Miles and McDowell, 1983) ; ND= not detected

4.5.2. Feeds and forages mineral profile

The macro and micro-mineral concentrations were on a dry matter basis and expressed in percent and ppm. Crop residues were found to be the major feed source in the ration of dairy cows (Natural grass hay, *Triticum aestivum*, *Eragrostis teff*). It was noticed that some of the milk producers fed dairy cows improved forages like *Pennisetum purpureum*, *Avena sativa*, *Medicago sativa*. Some milk producers feeding oilseed cake, wheat bran, wheat middlings, concentrate mix and ground maize, local and industrial brewery by-products observed in some parts of the study. Local concentrate mix (faba bean with wheat bran) and ground maize, local and industrial brewery by-products observed in the study area are given in Table 22. A total of 140 feed samples in different seasons and production systems were collected from the study area. It was mainly due to the inaccessibility of the areas (Adama peri-urban) and the wide diversity of crops grown in the periurban of Ada'a.

Table 21. Summary of average macro and micro mineral concentration values of dairy feeds (% and mg/kg dry matter basis) collected from the study areas in relation to critical values of respective minerals.

Types of Feeds N= 140	Macrominerals (%)			Micro minerals (mg/kg)			
	Ca	P	Mg	Cu	Fe	Zn	Co
Roughage feeds n=52							
Teff straw, n=10	0.39± 0.07	0.61±0.09	1.16±0.11	9 .00±0.64	68.50±15.59	39.14±1.89	ND
Wheat straw, n=7	0.35± 0.07	0.61±0.09	0.63±0.11	6.99±0.64	82.74±15.59	30.53±1.89	ND
Natural grass hay, n=14	0.13± 0.07	0.82±0.09	0.31±0.11	8.72±0.64	112.40±15.59	27.49±1.89	ND
Oats, n=4	0.54± 0.07	0.52±0.09	0.70±0.11	10.65±0.64	176.80±15.59	38.39±1.89	0.09±0.00
Alfalfa n=3	0.55± 0.07	0.70±0.09	0.85±0.11	6.96±0.64	128.39±15.59	32.56±1.89	0.05±0.00
Elephant grass, n=4	0.50± 0.08	0.44±0.09	1.32±0.12	6.96±0.69	128.05±15.59	28.82±2.04	0.06±0.00
Sugar cane tops, n=7	0.28±0.08	0.28±0.09	1.75±0.12	10.51±0.69	114.97±16.86	23.80±2.04	ND
Silage, n=3	0.14±0.08	0.67±0.09	1.39±0.12	8.97±0.69	92.92±16.86	40.04±2.04	ND
Overall mean ± SE	0.36±0.08	0.58±0.09	1.01±0.12	8.60±0.66	113.10±15.91	32.60±1.95	0.025±0.00
P-value	0.6054	0.0636	0.0396	0.9149	0.6015	0.8540	NA
C g* and oilseed cakes n= 65							
Wheat bran, n=8	0.64±0.6	0.68±0.07	0.39±0.09	7.68±0.51	73.94±14.70	48.98±2.99	ND
Wheat middling, n=5	0.38±0.6	0.51±0.07	0.32±0.09	6.67±0.51	84.39±14.70	57.71±2.99	ND
Concentrate mix*, n=11	0.48±0.6	0.41±0.07	0.54±0.09	7.90±0.51	105.81±14.70	46.06±2.99	ND
Noug seed cake, n=18	0.23±0.6	0.42±0.07	0.75±0.09	7.98±0.51	126.26±14.70	31.85±2.99	ND
Ground maize, n=10	0.27±0.6	0.64±0.06	0.41±0.08	8.59±0.48	174.81±13.74	33.61±2.79	ND
Cottonseed cake, n=8	0.14±0.6	0.59±0.07	0.54±0.09	7.74±0.5	111.15±14.70	30.02±2.99	ND
Lean seed cake, n=5	0.29±0.6	0.89±0.07	0.87±0.09	8.78±0.51	107.02±14.70	36.84±2.99	ND
Overall mean ± SE	0.35±0.6	0.60±0.07	0.54±0.09	7.91±0.51	112.02±14.56	40.72±2.96	ND
P-value	0.2103	0.0021	0.2830	0.7750	0.0573	0.0007	

Table 22. Summary of macro and micro mineral concentration value of individual dairy feeds (% and mg/kg dry matter basis) throughout the study area in relation to their critical values of respective minerals (Cont'd).

Types of Feeds N= 140	Macrominerals (%)			Micro minerals (mg/kg)			
	Ca	P	Mg	Cu	Fe	Zn	Co
Non-conventional feedsn= 23							
Atella/ local n=8	0.34±0.04	0.79±0.06	0.41±0.09	9.72±0.50	157.93±6.82	34.30±1.49	ND
Indus. brewery by-products n=8	0.69±0.04	0.81±0.06	0.51±0.08	6.31±0.47	65.92±6.37	27.53±1.40	ND
Poultry manure n=7	0.62±0.04	0.74±0.06	0.50±0.08	7.55±0.47	103.90±6.37	32.47±1.40	ND
Overall mean ± SE	0.55±0.04	0.78±0.06	0.47±0.09	7.86± 0.48	109.25±6.52	31.43±1.43	ND
P-value	0.8502	0.0281	0.0217	0.0426	0.9842	0.0035	NA
Critical level*	<0.30%	<0.25%	<0.20%	<8ppm	<50ppm	<30ppm	<0.1p

Criticallevel=isconcentrationsbelowwhichfeedsaredeficient.(Ca<0.30%;P<0.25%;Mg<0.20%;Cu<8ppm;Fe<50ppm;Zn<30ppm;Co<0.1ppm,;Critical level based on(McDowell etal.,1993; NRC, 2001); Elephant grass=Pennisetum purpureum;Teff straw =Eragrostistef; Oat vetch =Avena sativa; Alfalfa =Medicago sativa; Sugar cane tops=Saccharumofficinarum;Wheat bran=Triticumaestivum; Noug seed cake =Guizotiaabyssinica;Lean seed cake=Linumusitatissimum; n= number of samples collected; Industrial brewery by-products = Brewery spent grains

The mean Ca concentrations were ranges from (0.13 % to 0.55 %) in roughage; (0.14 % to 0.64 %) in cereal grain and oilseed cakes and non-conventional feeds (0.34 % to 0.69 %). There was a significant difference (P<0.05) in the concentration of Ca levels in roughage and concentrate feeds between Adaa and Adama districts. The overall percentage of Ca deficiency in relation to their critical level was (12.92 %, 26.15 %, and 2.8 %) for roughage; cereal grain and oilseed cakes, and non-conventional feeds, respectively. Moreover, Ca deficiency of sampled feeds in relation to the season was (26.67 % *vs* 31.67 %) in urban dry and (11.67 %, 22.67 %) for peri-urban dry season. Likewise, (29.87 % *vs* 19.67 %) in urban wet and (21.67 %, 10.67 %) in the peri-urban wet season of Ada'a and Adama districts, respectively (details of feed Ca concentration for the individual district, production system and season is indicated in Table 22 to 27.

Roughage concentration of P and Fe was significantly affected (P<0.05) between Adaa and Adama districts. Likewise, the interaction effect of roughage Ca, P and Fe concentration was significantly affected (P<0.05) between districts. Similarly, Cu and Fe concentration in concentrate feeds were significantly affected (P<0.05) within the district. Phosphorous concentration was significantly different (p<0.05) between Ada'a and Adama districts. From collected feed samples P concentration in cereal grain and oilseed cakes and non-conventional feeds, was not significantly different (P>0.05) between Adaa and Adama districts. The overall percentage of P deficiency in relation to their critical level was (17.0, 2.50, and 0 %) for roughage; cereal grain and oilseed cakes, and non-conventional feeds, respectively. Moreover, P deficiency of sampled feeds in relation to season was (11.32 *vs* 14.45%) in urban and (7.34, 9.67 %) peri-urban of the dry season in Adaa and Adama districts. Likewise, in urban wet (13.23 % *vs* 16.30 %) and in the peri-urban wet (10.69, 11.30 %) seasons of Ada'a and Adama districts, respectively (as details are shown in Table 22 to 27.

Magnesium concentration of roughage, cereal grain and oilseed cakes and non-conventional feeds were significantly different (P<0.05) between Adaa and Adama districts. Moreover, the interaction effect of Mg concentrations was significantly different (P<0.001) between collected season, districts, and production system. Out of the total feeds analyzed Mg was not deficient for all feed resources compared to a critical level during the study period (Table 27 and 28).

Table 23. Effect of districts on macro and micro mineral concentration and interaction of districts with groups of feeds in the study districts

Feed type	District	Macrominerals (% DM)			Micro minerals(mg/kg DM)			
		Ca	P	Mg	Cu	Fe	Zn	Co
Roughage(n=52)	Ada'a	0.59b	0.49b	1.02	8.91a	101.78b	33.16	0.07
	Adama	0.70a	0.73a	1.09	8.02b	125.17a	32.17	0.06
C g and oilseed cakes (n=65)	Ada'a	0.43b	0.59	0.58	8.68a	89.31b	37.79b	ND
	Adama	0.30a	0.64	0.49	7.05b	142.26a	42.86a	ND
Non-conventional n=23	Ada'a	0.49b	0.75	0.35b	7.13	89.09b	32.56	ND
	Adama	0.59a	0.74	0.55a	7.27	124.95a	29.77	ND
Overall mean (N=140)		0.52	0.66	0.68	7.84	112.09	34.72	
SEM		0.034	0.034	0.048	0.267	6.527	1.131	
P-value								
Feed x districts		0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	NA

*ND= not detected; NA=not applicable, value without superscript =indicated not significantly different; means with the same superscript of each feed catagories among the districts in the same column (a,b) are significantly different. Critical level=isconcentrations below whichfeedsaredeficient.(Ca<0.30%;P<0.25%;Mg<0.20%;Cu<8ppm;Fe<50ppm;Zn<30ppm;Co<0.1ppm),Criticallevelbasedon(*McDowell*etal.*1993;NRC2001); Feed x district(interaction effect); *C g and oilseed cakes= Cereal grain and oilseed cakes*

There was a significant difference ($P<0.05$) of Cu concentration in feeds between districts, and production system. When those values are compared to the critical value (<8ppm) of feeds analyzed 49.23%, 76.92% and 65.22% for roughage (*Triticumaestivum,Medicago sativa, Pennisetumpurpureum*), cereal grain and oilseed cakes (wheat bran, wheat middling's, noug seed cake, cottonseed cake, and local concentrate mix) and non-conventional feeds (brewery by-products industrial and poultry liters) respectively, in the majority of feeds were found to be deficient in Cu (Tables 25- 27). Moreover, the high proportion of feeds were found to be deficient in dry season except in Adama urban (26.47, 63.45%) in dry and wet respectively, which was wet season feeds were deficient (Table 27).

The mean Fe concentrations varied in roughages (68.5 to 176.80 mg/kg); cereal grain and oilseed cakes (73.94 mg/kg to 174.81 mg/kg) and non-conventional (65.92 mg/kg to 157.93 mg/kg) in DM bases, respectively. When those values are compared to the critical value of (50 mg/kg), and no sample of feeds was deficient in Fe (Table 22).

The mean Zn concentrations varied from (23.80 mg/kg to 40.04 mg/kg) in roughages; grain milling and oilseed cakes (30.02 mg/kg to 57.71 mg/kg) and non-conventional (27.53 mg/kg to 34.30 mg/kg) in DM, respectively. When those values are compared to the critical value of (50 mg/kg), feeds analyzed had 48.08 %, 11.45 % and 34.78 % for roughage, cereal grain and oilseed cakes and non-conventional feeds, respectively (Table26 and 27). Moreover, seasonally high proportion of Zn concentration in feeds was found to be deficient in wet season collected feeds except for feed samples which collected from Adama urban and peri-urban feeds (35.37 %, 31.21 %) as shown in Table27 and 28.

Table 24. Effect of macro and micro mineral concentration on production system and interaction of production system with groups of feeds in the study districts

Group feeds	Prod system	Macrominerals (%)			Micro minerals (mg/kg)			
		Ca	P	Mg	Cu	Fe	Zn	Co
Roughage	urban	0.59b	0.54b	0.94b	7.93b	100.16b	33.71	ND
n=52	per-urban	0.66a	0.63a	1.07a	8.41a	122.99a	31.78	0.03
C g & oilseed cakes n=65	urban	0.43a	0.61	0.42b	7.36b	102.84b	41.40a	ND
	per-urban	0.28b	0.63	0.66a	8.53a	130.81a	38.46b	ND
Non-conventional	urban	0.54	0.79	0.45	9.63a	95.84b	33.25	ND
n=23	per-urban	0.55	0.75	0.44	6.51b	106.84a	29.62	ND
Over all mean (N= 140)		0.51	0.65	0.66	7.73	109.91	34.70	
SEM		0.034	0.033	0.047	0.256	6.473	1.132	
p-value								
Feed x prod system		0.0001	0.0058	0.0001	0.0001	0.0254	0.0001	NA

*ND= not detected; value without superscript =indicated not significantly different; means with the same superscript in the same column(a,b) are significantly different Critical level=is concentrations below which feeds are deficient.(Ca<0.30%; P<0.25%;Mg<0.20%;Cu<8ppm;Fe<50ppm;Zn<30ppm;Co<0.1ppm);Criticallevel based on(*McDowell *et al*.,1993;NRC,2001*);Feedx district(interaction effect); C g and oilseed cakes= Cereal grain and oilseed* cakes

The current study showed that except for some roughage (*Avena sativa, Medicago sativa, and Pennisetumpurpureum),* and totally from cereal grain and oilseed cakes and non-conventional feeds, Co concentration was not detected from the sampled feed by AAS reading may be due to calibration of the apparatus. The value of Co level in roughages, cereal grain and oilseed cakes and non-conventional feeds from collected feeds were below the critical level of 0.1 ppm (McDowell *et al*. (1993); NRC (2001). They are categorized as deficient or sufficient based on the critical values of (McDowell *et al*., 1993; NRC, 2001), indicated in Table 22. The interaction effect of mineral concentration of dairy feeds, districts, and production systems highly significant (P<0.01) for all analyzed minerals is indicated in (Table 23 to 24). Whereas, the interaction effect of Ca, P, Mg, and Zn concentration in feeds were significantly different (P<0.05) between seasons. Likewise, the interaction effect of Cu and Fe concentration in feeds was a non-significant (P>0.05) between seasons (Table 25).

Table 25. Effect of season on macro and micro mineral concentration and interaction of season with groups of feeds in the study districts.

Group feeds	Season	Macrominerals (%)			Micro minerals(mg/kg)			
		Ca	P	Mg	Cu	Fe	Zn	Co
Roughage	Dry	0.61	0.50b	0.86b	8.47	103.25	32.46b	ND
n=52	Wet	0.63	0.64a	1.09a	8.49	115.26	33.41b	0.06
C. g. and oilseed cakes	Dry	0.35	0.59b	045b	7.71	106.24	38.38ab	ND
n=65	Wet	0.38	0.64a	0.58a	8.01	122.15	41.46a	ND
Nonconventional	Dry	0.50ab	0.65b	0.34b	7.54	95.27	30.15ab	ND
n=23	Wet	0.59a	0.89a	0.54a	7.68	106.13	33.00b	ND
Overall mean (n= 140)		0.51	0.65	8.07	7.98	108.05	34.81	
SEM		0.034	0.033	0.047	0.264	6.543	1.139	
P-value								
Feed X season		0.7020	0.7540	0.0009	0.0840	0.0940	0.8570	NA
Feed Xdistrict X Prods X season		0.0001	0.0001	0.0001	0.1240	0.3570	0.0001	NA

*ND= not detected; value without superscript =indicated not significantly different; Means with the same superscript of each feed catagories among the season in the same column(a, b)are not significantly different; Critical level=is below which feeds aredeficient.(Ca<0.30%;P<0.25%;Mg<0.20%;Cu<8ppm;Fe<50ppm;Zn<30ppm;Co<0.1ppm),Criticallevelbasedon(*McDowell*etal*.,1993 ;NRC,2001); X *interaction sign; C g and oilseed cakes= Cereal grain and oilseed cakes ; sn= season*

Table 26. Critical level based macro and micro mineral deficiency and sufficiency of feed resources in different dairy feeds in the study area

Minerals N=140	CV*	Feed Types					
		Roughage		*C. g and oilseed cakes*		Non-Conventional feeds	
		Sufficient	Deficient	Sufficient	Deficient	Sufficient	Deficient
Ca	<0.30%	87.08	12.92	73.85	26.15	97.2	2.8
P	<0.25%	83.0	17.0	97.50	2.50	100	-
Mg	<0.20%	89.10	11.0	100	-	100	-
Cu	<8 ppm	50.77	49.23	23.08	76.92	34.78	65.22
Fe	<50 ppm	100	-	100	-	100	-
Zn	<30 ppm	51.92	48.08	88.55	11.45	65.22	34.78
Co	<0.1 ppm	2.27	97.73	-	100	-	100

CV=Criticallevel=is concentrations below which feeds are deficient; CV*(*McDowell*etal.*,1993;NRC,2001); (-)=*indicated that either deficient or sufficient; C g and oilseed cakes= Cereal grain and oilseed* cakes

Table 27. Summary of seasonal variation along with production system for major macro and micro mineral concentration of the different dairy feeds in the study area based on a critical level

Mineral N=140	Season	Districts N=140								*Critical level
		Ada′a				Adama				
		Urban (%)		Peri-urban (%)		Urban (%)		Peri-urban (%)		
		Sufficient	Deficient	Sufficient	Deficient	Sufficient	Deficient	Sufficient	Deficient	
Ca	dry	73.37	26.67	70.13	29.87	68.33	31.67	80.33	19.67	<0.30
	wet	88.33	11.67	78.33	21.67	77.33	22.67	89.33	10.67	
P	dry	88.68	11.32	92.66	7.34	85.55	14.45	90.33	9.67	<0.25
	wet	86.77	13.23	89.31	10.69	83.70	16.30	88.70	11.30	
Cu	dry	62.11	37.89	52.44	47.56	73.53	26.47	53.66	46.34	<0.8
	wet	72.92	27.08	60.65	39.35	62.61	37.39	62.55	37.45	
Zn	dry	54.4	45.60	62.66	37.34	36.55	63.45	72.37	27.63	<0.30
	wet	46.77	53.23	53.66	46.34	64.63	35.37	68.79	31.21	
Co	dry	-	ND	-	ND	-	ND	-	ND	0.1
	wet	0.55	99.45	-	ND	-	ND	-	ND	

**Critical level=is concentrations below which feeds are deficient (Ca<0.30%;P<0.25%; Mg<0.20% ;Cu<8ppm; Fe<50ppm; Zn<0.30ppm; Co<0.1ppm), Critical level based on (McDowell et al.,1993; NRC,2001*);(-)=*indicated that either deficient or sufficient;*

PART Two

4.6. Effect of Dicalcium Phosphate (DCP-18%) Supplementation for Lactating Cows

During the survey, period to identify the concentration of some important minerals for dairy animals feed and blood serum samples were collected and subjected to laboratory analysis. Among the deficient minerals below the critical level were Ca, P, Cu, and Co that from collected blood serum samples analyzed and Ca, P, Cu, Zn, and Co from feed samples. Based on survey result feeding trial was developed to feed experimental animals with DCP-18% supplementation to dairy cows. Although Cu and Co were found deficient the present study did not include supplementation trials on these minerals and were not available in the local market. Therefore, Ca and P were used for supplementation trials for each dairy cow for 120 days. The efficacy of DCP-18% supplementation was evaluated by on-station trials in lactating cows in their 1st, 2nd, 3rd and 4th lactation stages. The effect of mineral supplementation was evaluated by observing alterations in dry matter intake, milk production and composition, digestibility, mineral status in feed, blood, fecal, urine and milk, Ca and P balance and blood Ca and P concentration.

4.6.1 Dry matter and nutrient intake

The present study showed that both basal and total DM intake increases as the level of dicalcium phosphate increase for lactating crossbred cows Table 28. The mean value for DM of lactating in T0, T1, T2, and T3 fed treatments varied from 11.46, 12.81, 14.59 and 15.68 kg DM per day were significantly different (P< 0.05). There was a significant difference (P<0.05) among nutrient intake between different treatments groups ($T_3>T_2>T_1>T_0$). Greater ME intake was encountered in T3 and T2 followed by T0 and then T1. Within the different levels of dicalcium phosphate supplemented groups, DMI and nutrient intakes increased as the level of DCP-18% in the diet increased. As the dicalcium phosphate supplementation increases there is a significant change ($P<0.05$) in the daily DM and nutrient intake between supplemented and non-supplemented groups. Total DM intake as a percentage of the live weight of experimental cows was 2.44, 2.69, 3.03, and 3.23% for T0, T1, T2, and T3, respectively. On the other hand, supplementation of DCP-18% has an effect ($P<0.05$) on estimated metabolizable energy (MJ/kg d^{-1}) of lactating cows (Table 28). However, metabolizable energy was increased linearly ($p<0.05$) as the supplementation increases T0<T1<T2<T3.

Table 28. Mean ±SEdry matter and nutrient intake (kg/d), and body weight change (kg) of cows fed with different levels of dicalcium phosphate to concentrate mix

Parameter	**Treatment**					
	T_0	T_1	T_2	T_3	SEM	P-value
Hay	6.47c	7.38b	9.44a	9.43ab	0.22	0.0229
Concentrate	4.99c	5.43b	5.15ab	6.25a	0.19	0.0149
Total DMI	11.46c	12.81b	14.59ab	15.68a	0.40	0.0248
T. Nutrient						
CP	2.1d	2.12c	2.18b	2.21a	0.07	0.0561
NDF	7.03c	7.81b	8.42a	8.37ab	0.21	0.0323
ADF	3.10c	3.34b	3.79ab	3.80a	0.11	0.0134
EME(MJ/kg DM)	11.25	11.60	11.93	12.33	0.24	0.0114
Average BWkg^{-1}	469.2	476.00	480.75	485.75	8.44	0.2100

Means with out superscripts are non significantly different (P>0.05);DMI= Dry matter intak; CP= crude protein; OM= organic matter NDF=Neutral detergent fibre; ADF=Acid detergent fibre; EME=Estimated metabolizable energy; SEM=Standard error of mean; T1=grasshay+concentrate+0.3% DCP; T2, grass hay+concentrate 0.6% DCP;T3,hay+concentrate+0.9% DCP; DCP18% average Initial body weight of experimental cows was 469.88±15.80kg (mean ± SD);T=total*

4.6.2. Apparent digestibility of dry matter and nutrients

The results of the effect of DCP-18% supplemented with concentrate mix on apparent nutrient digestibility of lactating crossbreed dairy cows were indicated in Table 29. In cows supplemented with different level of DCP-18%, result indicated that the digestibility was (70.54, 77.80, 43.31, and 28.52 %) for T0; (77.80, 78.82, 45.60 and 29.35 %) for T1; (72.40, 81.31, 48.40, and 30.23 %) for T2, and (78.97, 83.11, 48.11 and 34.93 %) for T3 of DM, CP, NDF and, ADF, respectively(Table 29).

Table 29. Apparent dry matter and nutrient digestibility (% DM) of cows fed with diets containing concentrate mix diet supplemented with di-calcium phosphate fortified

Aparant digestibility	Treatment					
	To	T1	T2	T3	SEM	P-value
DM	70.54d	71.87c	72.40b	78.97a	1.04	0.0147
CP	77.80 d	78.82c	81.31b	83.11a	1.29	0.0215
NDF	43.31c	45.60b	48.11ab	48.40a	1.87	0.0280
ADF	28.52 d	29.35c	30.23b	34.93a	1.76	0.0118

Means without superscripts are none significantly different (P>0.05);DM= Dry matter; CP= crude protein; NDF=Neutral detergent fiber; ADF=Acid detergent fiber; SEM=Standard error of the mean. T1=grasshay+concentrate+0.3% DCP; T2, grass hay+concentrate 0.6% DCP;T3,hay+concentrate+0.9% DCP; DCP18%

4.6.3. Milk yield and compositions

Results indicated that the effect of DCP-18% supplementation affected daily milk yield and compositions. There were a significant differences (P <0.05) in milk yield and milk composition except total solid which was not significantly difference (P>0.05) between supplemented and non supplemented groups. Dairy cows in T3 produced 40.24, 10.52, and 11.l3% more milk yield per day over those cows receiving DCP-18% in relation to the rest treatment groups of T0, T1, and T2, respectively, when calculated as a percentage of the total. Likewise, the initial and average daily milk yield was significantly different (P<0.05) between supplemented and control groups. When calculated as a percentage of the final milk production difference in relation to initial milk produced due to different level of supplementation was (0.90, 18.51, 19.50, 19.83%) more daily milk yield by the difference of dairy cow received DCP-18% for

T0, T1, T2, and T3, respectively, higher percentage milk production by difference was observed in supplemented groups compared to the control group. Moreover, milk composition was variably affected by the supplementation of DCP-18%. Milk fat, protein and lactose were higher for supplementation as compared to the control (P<0.05). Total solids content did not vary among the treatment group (P > 0.05).

Table 30. Mean ±SE milk yield (l/d) and milk compositions (%) fed concentrate mix supplemented with dicalcium phosphate

Parameters	Treatment					
	To	T1	T2	T3	SE	p-value
Initial milk yield*	9.95c	10.75b	10.77ab	11.75a	0.35	0.0001
Av. Daily milk yield	10.04c	12.74b	12.87ab	14.08a	0.47	0.0161
Difference	0.09c	1.99b	2.10ab	2.33a	0.01	0.0182
Milk composition						
Fat	3.62d	4.15c	4.36b	4.73a	0.15	0.0096
Protein	2.85c	3.48b	3.72ab	4.15a	0.18	0.0127
Lactose	3.60ab	4.23ab	4.30a	4.30a	0.18	0.0211
Total solids	12.10	11.50	11.60	12.57	0.71	0.7078

[a-d] *Means with different superscripts within row are significantly different(P<0.05); T0= control;T1=grasshay+concentrate+0.3%DCP;T2,grasshay+concentrate0.6%DCP;T3,hay+concentrate+ 0.9% DCP; DCP18% initial milk yeid= average milk yeid taken during adaptation period*

4.6.4. Supplementation effect on calcium and phosphorous balance

The supplementation of DCP-18% significantly (P<0.05) increased Ca and P daily intake, Ca, and P balance. The effect of DCP-18% supplementation on total DMI, Ca, and P balance was significantly affected (P<0.05) among the treatment groups. Moreover, supplementation significantly affects (P<0.05) Ca and P intake among the treatment compared to control groups. Similarly, there was a subsequent increment between the treatment groups as the supplementation increases (T0<T1<T2<T3). When calculated as a percentage of the total T3 supplementation level, received 85.53 %, 41.41

% and 11.78 % more Ca intake over those cows in T0, T1, and T2, respectively. Calcium and P balance is significantly ($P< 0.05$) different among treatment. In this case the control group (T0) Ca balance result was negative that indicated that the cows under this treatment excrete more minerals than Ca intake from feeds.

Table 31. Mean ±SE daily intake and Ca and P balances in different group's of dairy cows (g/ head/ day)

Parameters	Treatment*					
	T0	T1	T2	T3	SEM	P-value
Hay DMI	6.47c	7.38b	9.44a	9.43a	0.22	0.0229
Conc. DMI	4.99c	5.43ab	5.15b	6.25a	0.19	0.0149
Total DMI	11.46c	12.81b	14.59ab	15.68a	0.40	0.0248
Total Ca intake	64.76d	85.29c	107.81ab	120.51a	2.23	<0.0001
Ca in feces	62.89c	73.73b	74.70b	78.87a	1.86	0.0165
Ca in urine	2.28	2.58	2.67	2.74	0.12	0.5239
Ca in milk	8.34	8.46	8.58	8.71	0.42	0.9332
T. Ca outgo	73.51c	84.77bc	85.95b	90.32a	2.01	0.037
Ca balance	-8.75c	0.52bc	21.86ab	30.19a	0.70	<0.0001
Total P intake	35.84d	52.49c	59.98b	73.14a	1.03	<0.0001
P in feces (g/d)	31.76d	41.59bc	43.83b	47.12a	2.49	0.026
P in urine (g/d)	1.51d	2.20bc	2.35b	2.71a	0.22	0.019
P in milk (g/d)	1.65d	3.68bc	3.82b	3.96a	0.31	0.018
T. P outgo	34.92d	47.47c	50.00b	53.79a	1.21	0.0139
P balance (g/d)	0.92d	05.02c	09.98b	19.35a	1.50	<0.0001

Blood serum	T0	T1	T2	T3	SEM	p-	CL(
Ca(g/l)	0.09d	0.22c	0.16b	0.35a	0.01	0.	<0.0
P(g/l)	0.06	0.06	0.06	0.05	0.00	0.	<0.0

[a-d] *Means with different superscripts in the same row significantly different; NS=nosignificant; T0,= grasshay+concentrate;T1=grasshay+concentrate+0.3%DCP;T2,grasshay+concentrate0.6%DCP;T3,hay+concentrate+0.9%DCP;DCP=Dicalciumphosphate;CL=criticallevel,Ca=<0.08g/l;P=<0.04g/l(MilesandMcDonald,1983); T0=0,T1=0.3%;T2=0.6%;T3=0.9% DCP18% ; T=total; Ca and P* balance *(Hibbs & Conrad (1983).*

Total P excretion was significantly different (P<0.05) in T3 followed by T2, T1, and To (53.79 g/d, 50.00 g/d, 47.47 g/d, and 34.92 g/d, respectively). In the case of phosphorous balance, the mean P intake from DCP-18% sources and excretion were highly significant (P<0.01). With the increase of di-calcium phosphate intake, there was significantly (p<0.05) increase P intake (35.84 g/d, 52.49 g/d, 59.98 g/d, and 73.14 g/d in T_0, T_1, T_2, and T_3, respectively). The excretion of P through milk and urine was significant different (P<0.05) in all the treatment groups in spite of different levels of supplementation used for lactating dairy cows.

4.6.5. Supplementation effect on the serum calcium and Phosphorus concentration

The mean serum Ca and P levels of crossbred dairy cows are presented in Table 31. Serum Ca concentration was affected ($p<0.05$) by different levels of DCP-18% supplementation. The mean serum Ca and P concentration in treatment groups were (0.079 *vs* 0.04 g/l); (0.22 *vs* 0.06 g/l); (0.16 *vs* 0.06 g/l) and (0.35 *vs* 0.05 g/l) for T_0, T_1, T_2 and T_3, respectively. It was evident that except the control groups, mean serum values in all treatment groups were more than critical values (0.08 and 0.04 g/l) for Ca and P, respectively, which indicated that the value of Ca and P in serum were satisfactory for lactating dairy cows in all treatment groups (Miles and McDonald, 1983) except the control one in which the balance was negative. The results suggest that there was no condition of hypocalcemia and hypophosphatemia.

5. DISCUSSION

5.1. Household Characteristics

The percentage of male HH's involved in dairy cattle production activities was higher than that of females, which was in agreement with Azage *et al.* (2003); Yitaye *et al*. (2008) in different parts of Ethiopia. This could be associated with the wealth status, where in most cases males are relatively a better in economic status than female-headed HH's. Moreover, male-headed HH's might have relatively better access to dairy technologies and information. On the contrary, the percentage of female-headed dairy farms in this study was higher as compared to reported values for Jimma town (Belay *et al*., 2012). The percentage of HH's who engaged in dairy activities varied (between 31-40 years) which was lower than 46.02±0.75 years reported by Hail *et al*. (2012) for urban dairy farmers of Hawassa town. Moreover, it was also lower compared to the previous report by Solomon *et al.* (2014), who indicated the age group of respondents was 46 years in Metekel Zone, northwestern Ethiopia. But in all cases, the age of the respondents was within the range of the productive age group.

The proportions of educated HH's involved in dairy cattle production activities in the current study were lower than those reported by Mohammed (2003) and Yitaye (2008). However, the present study was in line with the report of Fekede *et al.* (2013), who indicated that the secondary education level of dairy farmers in the urban area was higher than the peri-urban observed in Addis Ababa milk shed. In spite of location-specific, the larger percentage of dairy farm HH's heads in the study areas have basic education (at least able to read and write). The average proportions of illiterate HH heads were lower than reported by 40.05% (Tesfaye, 2016). For that reason, educating the farm HH heads is vital for the implementation and adoption of improved dairy husbandry practices in the areas. Moreover, the level of education of dairy farmers may have a significant effect on managerial capacity, affecting HH's income, as well as easily adopting technologies. Farmers with high education levels easily adopt new technologies more rapidly than lower educated farmers. The average range family size in the present study in the studied area was less than the national average family size 5.14 persons/HH (Zewdie and Yoseph, 2014), moreover, it was much lower than 9.5 and 7.3 persons/HH reported by (Diriba *et al*., 2014). In general, small family size in HH's could be a sign of better access to family planning education. The current result indicated that dairy farming is not taken as a special means of earning by the respondents which in agreement is with the report of Azage *et al*. (2006) that indicated the dairy owner's livelihood was not dependant on dairying. Thereby, dairy owners despairing to engage in daily activities due to irregularity demand and low price of milk as compared to the skyrocketing price of feed for dairy cows, to bridge the gap preferring to run extra business. The current result was in line with the work of Yitaye *et al*. (2007); Zewdie (2010); Belay, *et al*. (2012); Haile *et al*. (2012) who indicated that there are different constraints which affect dairying in different parts of Ethiopia especially in urban and peri-urban dairy production system. Therefore, the par-time engagement on the activity might influence the development and improvement of dairying in the country.

5.2. Dairy Feed Resources and Feeding System

The feed resources in the current study were obtained from purchased concentrate and crop residues it was in agreement with the report of Sintayehu *et al*. (2008) that the 76 % of urban dairy farmers in southern Ethiopia used to purchase dairy feeds and this reported result was higher than the current findings. However, the primary reason for the predominant use of purchased feeds was due to scarcity of land for on-farm forge cultivation. The observations are consistent with the reports of Tessema *et al*. (2003) and Yoseph *et al*. (2003), who reported that purchased agro-industrial by-products, commercial concentrate, and non-conventional concentrate feeds were the most important feed resources used by pre-urban and urban dairy producers in different parts of Ethiopia. Moreover, Belay *et al*. (2012) and Azage *et al*. (2013) indicated that a shortage of land is the most limiting factor for urban dairy production and improved forage production in different parts of the studied area. This condition imposed dairy owners to depend on purchased concentrate feeds. These factors may lead dairy cattle to malnourished because of irregular supply of nutrients, insufficient intake of available feeds, or inherent deficiencies in the available feeds.

5.3. Improved Forage Production Practices

One constraint for livestock production in the study area is seasonal insufficiency of quality and quantity of forage. Moreover, the nutritional quality of most crop residues is low, owing to low available protein and energy, low digestibility and intake, and poor handling practices (Adugna *et al.*, 2012). Likewise, their nutritional value is poor which needs treatment and supplementation to improve their feeding value. Therefore, these systems influence to see an alternative way to fulfill the feed requirements of animals to sustain their productivity. One way of supplementation of crop residue is with improved forage and fodder trees. In the current study, the majority of respondents, challenged for adoption and utilization of improved forage. The result of the current report is in agreement with the report of Azage *et al.* (2013), who indicated that a shortage of land in an urban production system as a major limitation to expand dairy production in urban centers that hindered to grow improved forages. Moreover, this study in line with Ahmed *et al*. (2010) who indicated that cultivated forage crops are not widely adopted due to shortage of land, lack of awareness of farmers on benefits of cultivating forage crops and shortage of availability of forage seed and planting material in other parts of the country. On the other hand, supplementation of poor quality roughages, like cereal crop residues, with legumes has been shown to increase their intake and digestibility (Mosi and Butterworth, 1985; Andualem *et al*., 2015). Moreover, legumes contain more minerals concentrations than would be in grass species, forage crop residues, and legumes during winter seasons, which are richer in minerals (Aschalew *et al.*, 2006; Khan *et al*., 2007). In general, the proportions of farmers adopting improved forage productions along the present study districts can be attributed to differences in the land and forage seed availability; the degree of attention given to promoting forage development by concerned bodies of governmental and non-governmental organizations. Likewise, the level of awareness through training towards proper fodder establishment and management skills as well as access to irrigation particularly for growing perennial fodder and improved forage crops will help to advance the dairy cattle production by satisfying the micronutrient needs as well as improve feed digestibility.

5.4. On-Farm Mineral Supplementation

The survey of the current study indicated that the majority of dairy owners do not supplement minerals for their dairy. Moreover, the mineral percentage in the diet used to feed cows is relatively low, and in addition, the phytate presence often prevents the mineral intestinal absorption. The present observation is further supported by Adugna (2008), who indicated that for animals fed in confinement for a prolonged period of time, consideration must be given for the provision of mineral and vitamin supplements. Likewise, a study by Fekede *et al*. (2015) indicated as most minerals are likely to be deficient in the ration of dairy and other animals due to very low content of the mineral in most grains, crop residue, and agro-industrial by-products. The majority of respondents provided for their dairy animals only sodium chloride and mineral soil as the main mineral source in some parts of the study area. The current study in agreement with Adugna (2008) indicated that mineral soils from different Rift Valley lakes contained an adequate amount of essential minerals like Ca (3.5- 34g/kg DM) with the exception of phosphorus (0.2-0.5g/kg DM). Furthermore, in agreement with the current finding, Yeshitila *et al*. (2008) and Addisu (2013) reported that farmers use bole soil as mineral sources for dairy supplementation. Likewise, the current study indicated that dairy farms are characterized by relatively different levels of management. However, feeds rich in energy, protein, and minerals (mainly Ca and P) are important for optimum milk production and reproductive efficiency. For the successful dairy nutrition program, a proper balance of protein, energy, vitamins and minerals is required as dairy products are the function of nutrition, genetic potential, and health status of the animal (Fekede *et al*., 2015).

5.5. Seasonal Occurrence of Mineral Deficiency

The current study indicated that the majority of mineral concentration of feeds affected by the seasonal changes which are supported by Lemma *et al*. (2002) who indicated that the concentration of mineral elements in grasses tends to change with the season. Likewise, the report of Chhabra (2006) indicated that higher (8.25 $mgdl^{-1}$) plasma Ca levels in dairy animals in the winter/wet season than in the summer dry season (7.99 $mgdl^{-1}$). The result of the current study indicated that minerals like Ca, P, Cu, Zn, and Co, were deficient, which is supported by the report of Aschalew *et al*. (2006) indicated that 7.45% of the feeds found to be deficient in Ca concentration in the dry season as contrasting to 1.22% of the wet season feeds, however, the result is lower than the current report. Moreover, the study of Geleti *et al*. (2001) and Aschalew *et al*., (2006) indicated that high Ca concentration was observed during the wet season than the dry season. This might be at the peak of the rains total exchangeable bases (Ca, Mg, K, and Na) were low and decreased down the depths of the soil.This could be attributed to the elements being utilized more minerals by plants (Hopekins, 1974). Likewise, the report of Lemma *et al*. (2002) indicated that the decline of forage P concentration due to plant maturity and season which is related to translocation or leaching of P from live tissues.

The mean Mg concentration level was sufficient compared with the critical level to the dairy cattle (McDowell *et al*., 1993; NRC, 2001). Contrary to the current finding Lemma *et al*. (2002) indicated that magnesium concentration of the feeds was found to be deficient in dry and wet seasons but in the current study among individual collected feeds (11%) of the roughage feeds were deficient. However, both decreases (Pastrana *et al*. 1991) and increases (Espinoza *et al*., 1991) in pasture Mg levels were reported with the progress of the season. This might be due to a high K to Mg ratio suppresses Mg absorption and induces a deficiency of Mg (Lemma *et al*., 2002). Even though Mg was not deficient in the current result, most of the time in dairy animals, the deficiency of Mg occurred either due to metabolic deficiency (referred to as grass tetany) or true nutritional deficiency associated with long-term dietary deficiency of Mg (Radostits *et* *al* 2007).The concentration of Fe was above the critical level in all feed types. In a similar finding with the current finding NRC (1996) reported that dry season Fe concentrations far exceeded in wet season values. However, the high Fe levels in forages from 250 to 500 ppm can be toxic and interfere or decrease Cu absorption (Phillippo *et al* 1987; Lemma, 2002).

The current study indicated that the majority of feeds samples were deficient in Cu, which is in line with the report of Minson (1990) who indicated that all grazing land forages had lower levels of Cu. This might be due to availability, which may be limited further by complex interactions with S, Mo, and Fe. Moreover, differences in Cu observed in the present study could be partly due to genotypic differences, vegetative parts, stage of maturity, levels of available Cu in the soil, and soil pH. Likewise, forage Cu content declines with forage maturity, and is higher in leaf and stem fractions (McDowell, 1996). This further supported by Spears (2003) who showed that pasture forages had lower levels of Cu than the minimum recommended requirements of ruminants for different production purposes. Likewise, ruminants that depend on pasture forage feed as their sole feeds, especially during dry seasons, could be affected by Cu deficiency (McDowell, 1996; Manyayu *et al*., 2003).

Espinoza *et al.* (1991) indicated that Zn levels in native pastures were below cattle requirements which is in agreement to the current report that indicated a high percentage of feeds were deficient in both seasons of the year. In some cases, this might be sometimes due to high concentrations of Ca in the native pasture that may aggravate a Zn deficiency (Alfaro *et al*. 1988). Moreover, deficiencies might be due to low levels of Zn in soils, cause Zn deficiency (McDowell, 2003).

5.6. Mineral deficiency and Dairy Owners Observation

During the study, respondents had tried to distinguish different signs of mineral deficiencies which were observed in their dairy farms. The observed signs in this study were in agreement with the report of Weaver (1987) and Weldegebriall, (2015) who indicated that the signs were related to milk fever, metritis, delayed uterine involution, lameness, prolapse of the uterus, retention of placenta anestrus and others. Likewise, the report of Kumar (2003) indicated that calcium-related disorders are mostly very common during parturition or within a few days following parturition. Moreover, alteration of Ca: P ratio may affect ovarian function through its blocking action on the pituitary gland which results in prolongation of estrus and ovulation, delayed uterine involution, increased incidence of dystocia, retention of placenta and prolapse of the uterus (Kumar, 2003). In a similar but related experiment by Radostits *et al*. (2000) P deficiency primarily under field, conditions is characterized in cattle by pica, poor growth, and infertility (Anestrus) while osteodystrophy develops in later stages of deficiency and post parturient hemoglobinuria.

Moreover, the current study results of various mineral deficiencies symptoms were recognized by dairy owners, including poor body conditions, slow live weight gain, and low fertility. The report is in agreement with Martinez *et al*. (2012) who observed that cows with dystocia, stillbirth, and retention of the placenta had a greater decrease in Ca and other minerals postpartum than cows without these risk factors. Furthermore, a low concentration of phosphorus in dairy feeds, supplementation of this mineral is needed because P deficiency results in reduced growth, decreased appetite, impaired reproduction, and fragile bone (NRC, 2001). Likewise, observed mineral deficiency in the study areas compared with earlier findings by Garg *et al*. (2002) and Dar *et al*. (2014) based on physiological condition and seasonal variation, animals need effective mineral supplementation. Overall when forage supply is sufficient, and mineral deficiencies can be directly related to low mineral concentration in soils concomitant to forage (Tiffany *et al*., 2000).

5.7. Mineral Profile of Dairy Cows

In the current study Ca, P, Cu, and Co were identified as a deficient mineral from sampled dairy cows. In agreement with the current study Radostitis (2007) serum Ca values were lower in lactating animals as compared to the dry cows (Table 20). The serum Ca level was lower in lactating cows, which might be due to increasing the flow of calcium in colostrum and milk (NRC, 2001). Moreover, differences in serum Ca values might be due to variations in the feed and high demand for absorbed Ca per liter of milk produced (McDowell, 2003). Similarly, most susceptible to mineral deficiencies are young growing animals and animals during their first pregnancy and lactation (Khan *et al*., 2003).Therefore, deficiency of minerals has a significant effect on the health and productivity of dairy cows (Aregheore *et al*., 2007; Gonul *et al*., 2009). Likewise, mineral insufficiencies in dairy cows are frequently seasonal, significant from increased demands of pregnancy, lactation or fast growth concurring with reduced mineral content or accessibility in the pasture (Tashi *et al*., 2005). However, the ratios of (Ca:P) between 1.5:1 and 2.5:1 for lactating cows should not result in problems (Kumar, 2003). Moreover, the plasma Ca levels of dairy animals depend upon dietary Ca intake and other non-nutritional factors such as season of the year, age, weight, pregnancy and lactation (Khan, 1995). In general, during the rainy season, when protein and energy contents of forages are at least adequate to sustain the weight gain of the animals, mineral deficiencies may be the major factors that determine the rate of animal production (McDowell and Arthington, 2005; Khan *et al*, 2008).

The mean serum P from some sampled dairy cows was below the critical value in this study. The current results were in agreement with various studies reported by (Khalili *et al.*, 1993; Abdelrahman *et al.*, 1998; Tsegahun *et al.*, 2006; McDonald *et al.*, 2011) in which East African forages were known to be low in Na and P, and it causes the most common nutritional problems in livestock. Moreover, deficiency of P is the most prevalent mineral deficiency of livestock throughout the world (McDowell, 2003). Likewise, non-lactating cows maintained higher serum Pi levels than the lactating cows, although, the magnitude of differences was small. The current P deficiencies might also be absorption reduced due to higher Ca and Fe intake (Khalili *et al.,* 1993). Furthermore, contrary to the current study Khan (2003) indicated that lower Pi level in animals was recorded in cool/wet seasons than hot seasons of the year. However, there are factors affecting the availability of P such as Ca intake reduces the efficiency of absorption of P in the digestive tract by decreasing the solubility of P (NRC, 2001) and the presence of molybdenum reduces P absorption at the intestinal level and increase excretion of urinary P leading to lowering of P contents in dairy animals (Radostits *et al.,* 2007).

The serum magnesium concentrations in different physiological status in the current study were found to be above its critical level (<0.012 gm/L) or said to be within the normal range. This study was in agreement with Tiwary *et al.* (2007) who reported that serum magnesium concentration in animals was above the critical level. However, the current result disagrees with the report of Radostits *et al.* (2007) who indicated that lower plasma Mg status of animals during the winter season could be observed. However, according to Dua and Care (1995), different minerals in the diet, especially potassium, markedly affect the dietary Mg availability to livestock due to high dietary levels of K and N which inhibited Mg absorption from the rumen. Moreover, in dairy animals, the deficiency of Mg either can occur as a metabolic deficiency referred to as grass tetany, or as a true nutritional deficiency associated with a long-term dietary deficiency of Mg (Radostits *et al.,* 2007). Likewise, a high intake of the element (K and Na) may interfere with the absorption and metabolism of Mg in the animal, which may be an important factor in the etiology of hypomagnesemia tetany (Radostits *et al.*, 2007).

The overall mean serum Cu concentration was below the critical value in both dry and lactating dairy cows in the present study. These findings are in agreement with the reports of Sharma *et al.* (2003); Tiwary *et al.* (2007); Dermauw (2013) who indicated that the concentration was below the critical level might be due to several factors such as less availability of copper in feeds, excess iron in feedstuffs which could probably interfere with Cu absorption and metabolism, and also decreased gut absorption as well as increased excretion of copper (Mc Dowell, 1985; Sharma *et al.*, 2004).

Moreover, Cu deficiency may also result due to a high intake of soluble protein from fresh pasture, which increases the amount of sulfide produced in the rumen, resulting in unavailable copper sulfide (McDowell and Conrad, 1990). Moreover, the present observations are opposed with the report of Tapiwa (2012) indicated that the concentration of Cu was relatively higher in the dry season than in the wet season, might be due to the high leaching and/or absorption of Cu, but this study indicated in the dry season-high incidence of deficiency occurred. Furthermore, a high level of iron over an extended period has an influence on copper availability (Campbell *et al.*, 1999). Therefore the deficiency in the current study may be due to either as primary (low in diet) or secondary problem (Sharma *et al.*, 2003). In secondary deficiency, copper absorption and utilization are inhibited by an imbalance or excess of other elements in the ration.

In the present study**,** the overall mean concentration of Fe in serum was higher than the critical level given by Miles and McDonald (1983), in dry and lactating cows, in wet and dry seasons, and as well in all production system of the study area. The current result agrees with the report of McDowell (2003) indicated that deficiency of Fe in ruminants is uncommon under normal feeding conditions, may be due to the abundance of Fe in the soil as well as in animal feeds but may occur in the animals fed on poor quality roughages like straw for extended periods of time. Generally, adequate Fe levels in the pasture, forage contamination from soil or direct soil intake provide excess dietary Fe to the animals. However, high Fe levels in forages from 250 to 500 ppm can be toxic and interfere or decrease Cu absorption (Phillippo *et al.,* 1987; Lemma, 2002). Moreover, mutual antagonism exists between Fe, Mn and Co at the absorption level due to competition for common uptake mechanisms (NRC, 2001), and thus the high dietary Fe intakes can disturb Mn and Co status of the animals.

The mean serum Zn concentration was found to be above its critical level (<0.6 ppm), suggested by Miles and McDonald (1983) in that the present observations are consistent with the report of Tiwary *et al.* (2007) who indicated the concentration of

Zn in dairy cows achieved the requirement in the present study. This might be due to dairy feed contained adequate Zn level to meet dairy cow's requirement. However, in the current study small protion of dairy feeds seems to be deficient or in borderline for Zn concentration this may be due to low levels of Zn in soils, contributed to deficiency in livestock (McDowell, 2003). On the other hand, Sharma *et al.* (2004) reported that plasma Zn concentrations normally decrease in dairy cows at calving, but usually return to normal within three days. Moreover, the current results indicated that the serum Zn concentration was higher in dry cows than in lactating cows. This could be attributed to an increased rate of Zn accumulation in the fetus and the increased demands for Zn towards the end of pregnancy (Elnageeb and Adelatif, 2010).

The result of this study indicated that overall mean serum cobalt was below the critical value (<0.1ppm) suggested by Miles and McDonald (1983) in both lactating and dry dairy cows in the study area. Moreover, in most cases Co concentration was not detected from serum by AAS reading that might be due to calibration. However, cobalt deficiency is the most severe mineral limitation to grazing livestock in tropical countries (McDowell and Conrad, 1990).

5.8. Mineral Profile in Dairy Feeds

5.8.1. The macro and micro mineral concentration of feeds

The mean concentrations of important macro and trace minerals in the different categories of dairy feed resources evaluated in this study in comparison to the respective critical level (CL) for dairy cattle (McDowell *et al.* 1993; NRC 2001) indicated in Table 3. The mean Ca value in different types of roughage, concentration and non-conventional feeds in both districts were majorly found to be above critical level (<0.30 percent), which is in agreement with the findings of Tiwary *et al.* (2007). However, in this study, among roughage feeds, natural grass hay, sugarcane tops, and silages are deficient in Ca in comparison to the critical levels (McDowell *et al.* 1993; NRC 2001). Likewise, the current results were in agreement with the report of

Aschalew *et al*. (2006), who indicated that tropical dry forages are deficient in Ca. This might be due to variations in forage species, plant composition, and stage of maturity, seasons, and variations in soil characteristics as well as the location of the different feed sources in the study area.

The current study revealed that from analyzed mineral samples, legume forages contained more mineral concentrations than would be in grass species and crop residues, which was in line with the report of Khan *et al*. (2007), who indicated that legume forage species are richer in Ca than grasses. The variations in different studies of mineral composition could be due to differences in the type of feeds, the soil, season of sampling and analytical procedures and technique considered (McDowell, 2003).

The mean Ca concentration in the concentrate feed was found to be below the critical level, which was in line with the report of NRC (1989, 2001); Fekede *et al*. (2015) that indicated the Ca content in oilseed cake fall below the critical level. Therefore, dairy animals need to be supplemented with other sources of minerals when oilseed cakes are used as supplementary feeds. Moreover, in the current study, non-conventional feeds, like brewery by-products (local and industrial) had higher Ca content in relation to the critical level of different minerals. Likewise, the result is in line with the report of NRC (2001) and Fekede *et al*. (2015) what indicating that the brewery by-products evaluated had much higher Ca content than the maximum tolerable concentration.

The feed resources like roughage, cereal grain and oilseed cakes, and non-conventional feeds had a high P concentration as compared to the critical level of dairy animals. The result of this study is unlike the result of Tiwary *et al*. (2007) who indicated that P was found to be deficient in different feeds based on its critical level (Mc Dowell *et al*., 1993; NRC, 2001). This difference could be due to maturity, species diversity as the samples were not of the same type. Moreover, McDowell

(1997) and Aschalew *et al*. (2006) reported that P composition dropped from 0.3% in the early growing season to less than 0.15% after maturity and management.

The concentration of P during the dry season was relatively higher than during the wet season concentration. This study was in agreement with the result of Tapiwa (2012) who indicated that P was higher in the dry season than in the wet season. This might be due to leaching or translocation of P by the flood to the root system during the rainy season, and also, due to excess of Ca, Fe or Al in soil reduces the availability of P to plants (Radostits *et al.*, 2000). Similarly, the current study is in agreement with the result of Khan *et al.* (2007) who indicated that during the wet season; plants will not contain an adequate amount of P due to inadequate amounts in the soil, plant uptake of minerals is slow in the cool and wet conditions. Furthermore, the current study in agreement with the report of (Fekede *et al.*, 2015) who showed that P content of the wheat bran, wheat middlings, and brewery by-products were fairly within the range of the recommended critical level in dairy cattle diets (NRC, 2001).

Magnesium levels in most of the sampled feeds were found above the critical level (McDowell *et al.* 1993; NRC 2001). The results of this study were in line with the result of Underwood and Suttle (1999); Goff (2000) who indicated that the recommended concentrations for dietary Mg range within 0.2-0.4% of total DMI. However, there were differences in the Mg content of feeds may be due to differences between forage species, level of Mg in the soil, influences of locality and season, growth stage, the proportion of leaf and stem fractions collected for mineral analysis (Radostits *et al.*, 2007). Even though in the current study the availability of Mg was high in animal feeds, the availability of dietary Mg markedly affected by other mineral dietary components, especially K. High dietary levels of K and N inhibit Mg absorption from the rumen (Dua and Care, 1995). Moreover, Ca and soluble carbohydrates may increase and decrease dietary Mg requirements of dairy cows, respectively. Likewise, an increment in dietary P levels appear to lower the requirements for both Ca and Mg (Judson and McFarlane, 1998). However, the feeding systems prevailed that, the requirements of Mg could be met without any supplementation, ruminant animals generally are at risk from hypomagnesemia when the forage contains less than 0.20 % of Mg and if the soil is high in K content (Garg *et al.,* 2003).

The current study revealed that Cu content was below the critical level in the majority of the feed samples collected (roughages, concentrate, and none conventional) and analyzed. The result of this work is comparable with the report of Tiwary *et al.* (2007) who indicated that animal feeds are deficient in Cu. This may be due to typical soil conditions that might be restricting its accumulation in plants and their availability (Gustavo *et al.*, 2016). Moreover, the concentration of Cu obtained from analyzed feeds was deficient, might be due to high iron concentration and also molybdenum in the soil which in turn reduces the copper availability in plants (Underwood, 1977; Gustavo *et al.*, 2016). Moreover, the report of Kumar *et al*. (2005) showed that copper deficiency in livestock can result from low dietary Cu levels, might be due to high levels of Mo, and high sulfates compound in drinking water or the feed. Moreover, low forage Cu concentration at the end of the wet season could be due to a mature stage of the forages. During this period plants lose green color and become high in fiber and lignin, similarly, mineral availability also decreases, likewise, the interaction of Cu in soil with elements like Fe and Ca that affect its absorption (McDowell *et al.*, 1996). Whereas, the current result disagrees with the report of Fekede *et al.* (2015) indicated that the majority of feeds such as wheat bran, wheat middlings, brewery by-products Cu concentration was satisfied the dairy requirements.

Therefore, Cu contents in the majority of dairy feeds are below the critical level. As a result, Cu deficiencies in forages can cause in animals poor reproduction, broken bones, weak calves, scours, and discoloration normally occurs, first around the eyes and tips of the ears. In general supplementation in the ration of dairy animals is very essential.

Iron is reported to be most abundant in this study, the content in different feed samples (roughages, cereal grain and oilseed cakes and none conventional) analyzed, showed adequate to high levels, comparing to critical level <50 ppm (McDowell *et al*. 1993; NRC 2001). In the current study, the concentration of Fe was significantly affected (P<0.05) within districts. However, Fe concentration in analyzed feeds was not significantly affected (P>0.05) by the season. On the contrary to the current study, Lemma, *et al*. (2002) indicated that feed samples collected during the dry season far exceeded the wet season values, but the difference was not significant. Forage Fe levels during the study season were sufficient for the requirements of dairy cattle for optimal performance. Variations in the contents of Fe concentration among roughages, Cereal grain and oilseed cakes and none conventional feeds could be partly due to the content of Fe in the soil, and climatic conditions between localities. Likewise, forage Fe content is a function of forage species, soil Fe content, nature, and type of soil on which forages are grown (McDowell 1992; Endale *et al*., 2015). In the current study, however, roughages samples contained a very high concentration of Fe, which were a poor source for many other mineral elements.

The average Zn concentration in the majority of feeds was found above its critical level (<30 ppm) but in some roughages had lower levels of Zn. The result agrees with the report of (McDowell, 1985; Cuesta 1993) showed that Zn content was below the critical level in all the straws except some roughage feeds, might be due to plant maturity. The high concentration of metallic cations of Ca, Fe and Mn interfered with plant Zn uptake (Tisdale *et al.* 1985; Elisa *et al*., 2018). Moreover, excess iron inhibits the utilization of Zn and copper by plants and thus results in a secondary deficiency in plants (Underwood, 1977; Gustavo *et al*., 2016).

The mean Co concentration in the majority of dairy feed samples was found to be below its critical level. The result of the current study, when compared to previous work reported by McDowell (2003), indicated that forages consistently contain less than 0.08 ppm Co, which leads to Co deficiency in dairy animals. In the majority of dairy feeds analyzed Co was not detected that might be due to high soil Mn content which depresses uptake of Co in forages which could have led to reduced Co absorption by plants and subsequently low levels in plant tissues, as it was not in detectable range in the feedstuffs analyzed. Moreover, Co concentration was not detected from the sampled feed by AAS reading may be due to calibration.

5.9. Effect of Dicalcium Phosphate Supplementation on Lactating Cows

Based on the result of Part I., which assessed the mineral profile of feed and blood of crossbred dairy cows in the different physiological states (lactating and dry cow) from two districts of a corresponding urban and periurban production system, different minerals were identified both from feed and blood serum in the laboratory. As a result, Ca, P, Cu, and Co from blood serum as well as Ca, P, Mg, Cu, Zn, and Co from different feed samples were deficient either based on the critical values or seasonal variation. Based on this laboratory result, a feeding trial was conducted. In Part II, among the deficient minerals in dairy cows, minerals were prioritized and selected based on their severity and availability of minerals in the market during the feeding trial period.

5.9.1. Dry matter and nutrient intake

The present study showed that total DM intake increases as the level of dicalcium phosphate increased for lactating crossbred cows. Dry matter and nutrient intake were significantly affected ($P<0.05$) in all treatment groups supplemented with different levels of DCP-18%. As per the recommendation of NRC (2001), that Ca and P deficiency causes reduced appetite and milk yield, poor feed utilization, lowered disease resistance, increased incidence of milk fever, reduce growth rate, osteoporosis and osteomalacia. Contrary to the current finding, Sharma *et al.* (2004) indicated that fed diets containing different levels of Ca with diverse levels of minerals to lambs, where the average value of daily DM intake was similar among the treatment groups this may be due to species and purpose of animal differences.

However, the report of Abegaze and Chopra, (2008) indicated that excess Ca added to a ration or deficient P content reduced both feed consumption and growth rate. Moreover, Wise *et al*. (1963); Abegaze and Chopra (2008) observed that depression of growth ascribable to Ca: P ratio was evident at rations below 1:1 and also at the higher ratio (14.3:1).

5.9.2. Apparent digestibility of dry matter and nutrients

The values of the digestibility of DM and nutrient was significantly different ($p<0.05$) among the experimental treatment groups. Contrary to the current report feeding of Ca in excess of requirement, particularly wide Ca and P ratios may reduce the digestibility of protein and energy (Abegaze and Chopra, 2008). Likewise, Combs and Wallace (1962) also reported that the effect of 0.40 and 0.88% Ca on nutrient digestibility and observed that 0.88% Ca significantly reduced the digestibility of ether extract and CP. Moreover, Colovas *et al.* (1958); Abegaze and Chopra (2008) reported that 2% pulverized limestone when supplemented to both all roughage and mixed ration for dairy heifers decreased the digestibility of both protein and energy but a similar amount of DCP-18% did not have this effect.

The current finding indicated that supplementation was affect digestibility ($P<0.05$). In disagreement to the current finding Lall (1987); Abegaze and Chopra (2008) reported that fed different sources of Ca and P (DCP, rock phosphate and superphosphate) in the diet of calves and observed that there was no difference in the digestibility of DM, CP, OM and ADF.

5.9.3 Milk yield and composition

The mean value of milk yields significantly affected ($p<0.05$) due to the supplementation of DCP-18% compared to the control groups. The present observations are consistent with the report of Lukuyu *et al*. (2012) who indicated that minerals are nutrients required for the proper function of the animal body, which improves the health, production, productivity, and also produce quality and quantity of milk.

Likewise, supplementation of dicalcium phosphate to the dairy lactating cow had a significant effect on milk quality and quantity were significantly higher ($P<0.05$) in the supplemented group compared to control groups (Rekhis *et al*., 2001). Moreover, an increase in milk yield due to supplementation of minerals compared to the previous report by Radostits *et al.* (2009) indicated that minerals are essential to improve metabolic pathways, growth and production performance of animals. Moreover, the current result, when compared to the report of Forbes (2000) who indicated that improvement in fat content in milk was due to better utilization of energy, protein, and roughage with the adequate presence of Ca, which might have to improve the buffering capacity of the rumen due to higher percentage of acetic and butyric acids. Likewise, the current result was also supported by Rekhis *et al.* (2010); Begum *et al.* (2010) who showed that supplementation of DCP-18% to dairy cattle had a significant effect on milk fat, milk quantity and quality (protein) were higher in the supplemented group compared to the control group might be due to the availability of Ca and P which improved the fat content of milk. Moreover, the present result further supported by Mc Donalds (2011) who reported that dietary Ca requirements increase with milk yield produced and percent of milk solids. This might be due to the requirement of Ca and P which is highly dependent on the level of productivity and the physiological state of the dairy animal (NRC, 2001). The extra daily milk produced by cows under T3 may be justified by the relatively large amount of DCP-18% supplementation.

However, the report of Kayo (2019) showed that the composition of milk is also influenced by various factors, such as, stage of lactation, breed, and feeding pattern, the environmental and diseased condition of the udder which may be considered as a factor affecting the quality and quantity of milk. The result of this study showed that the mean values of lactose are significantly different ($P<0.05$) and the value is ranges from 3.60 to 4.3%. In general, inadequate and unbalanced feed and mineral supply are the major technical problem which results in low total milk output, reduce milk yield per cow and reduce replacement stock (Staal and Shapiro, 1996; Ahmed *et al.*, 2003). Might be due to Ca and P deficiencythat leads to reduced appetite and milk yield production (NRC, 2001)

5.9.4. Effect of supplementation in blood serum of calcium and phosphorous

Results of serum Ca and P concentrations of lactating cows are given in Table 31. The concentration serum Ca was significant difference ($P<0.05$) between supplemented and control groups. In line with the current result Takagi and Block (1991), showed that dietary Ca concentration had no effect on plasma concentration in ruminants fed 0.47 or 0.82% dietary Ca, that might be due to Ca within mineral supplement is generally more bioavailable for absorption than Ca in forages and common feedstuffs (NRC, 2001). Moreover, in the current study Ca: P serum ratio was (2:1; 4:1; 3:1 and 7:1) for T0, T1, T2, T3, respectively, in which serum Ca : P ratio was higher in higher supplementation of dicalcium phosphate supplemented groupit might be because mineral concentration in serum provides an indication of mineral intake by the animal (Underwood, 1977). The lower Ca : P ration in the control group might be due to dietary Ca may reduce Ca mobilization from bones for metabolism, which results in a lower Ca level in blood serum (Begum, 2010). Moreover, the result of the current study indicated that serum Ca was significantly higher ($P<0.05$) supplementation of dicalcium phosphate supplemented group. In general, the postpartum drop in blood Ca levels in cow reduces the number and amplitude of ruminal contractions (Daniel, 1983), thereby reducing feed intake which further aggravates Ca deficiency in postpartum cows by reducing the accessibility of dietary Ca.

5.9.5. Effect of supplementation on calcium and phosphorus balance

The effect of supplementation of Ca from dicalcium phosphate in lactating cows in all treatment groups was significantly different ($P<0.05$) for total Ca intake, Ca in feces, total Ca excretion and balance, whereas, none significant ($P>0.05$) different of Ca in urine and milk, as compared to control groups. In the current study numerically Ca in milk was considered to be larger in the amount as compared to Ca in the urine which is in agreement to the work of Goff (2000) who indicated that mean Ca excretion recovered from urine relatively small in dairy cows. Moreover, the current result when compared to the previous standard of ARC (1965) much lower 0.08g/d than the current result of Ca in urine which ranges (2.28-2.74g/d). However, Ca and P absorption can be influenced by diet (Martz *et al*., 1999).

Contrary to the current finding Lall (1987); Abegaze and Chopra (2008) indicated that fed Ca from different sources with similar levels and reported that neither fecal nor urinary excretion of Ca varied due to the source of Ca in the diet. However, major routes of Ca excretion are feces, urine, and milk (Horst, 1986). In agreement with the current findings Martz *et al*. (1999) reported low fecal excretion of Ca in ruminants fed small amounts of feed with low intakes of Ca. Moreover, urine output of Ca has generally been shown to be independent of Ca in the diet (Taylor *et al*., 2009), although Ramberg *et al.* (1976) observed a decreased calcium excretion in cows fed high levels of Ca. Likewise, in a similar finding to the present study Wilkens *et al*. (2010), the extent of excretion of Ca depends on the Ca content in the diet and the requirement of lactating cows. However, dietary Ca is limited, the production of calcitriol, when it increases, and this may result in more efficient uptake of ca in the intestine, and thus decreased fecal excretion of Ca (Hove, 1984). Therefore, the extent of excretion of Ca depends on the calcium content in the diet and the requirement of the animal.

The effect of supplementation results significantly ($P<0.05$) different P balances, total excretion, P in feces, and total P intake between control and supplemented groups. In agreement with the report of Hibbs and Conrad (1983); Horst (1986) who indicated that routes of P excretion are feces and milk, however, P excretion though milk was also significantly ($P<0.05$) different as compared with treatment groups this may be due to mineral excretion both through urinary and fecal routes may correlate with either the mineral intake or mineral status of the animal, depending on the mineral feed (Suttler, 2010).

It was further suggested to provide excess dietary Ca and P in mid-to-late lactation when the animal could absorb the minerals to replace body stores that were mobilized. According to the research result of Morse *et al*. (1992) which indicated that the amount of P excreted is dramatically affected by dietary P intake. For each gram of P intake, excretion increased by 0.80 g/d (Morse *et al*., 1992). In general according to the report of Suttler (2010) who indicated that the concentrations of minerals in urine and faces are influenced by dietary and animal factors such as water intake and diet digestibility. Moreover, mineral excretion both in urinary and fecal routes may be related to either the mineral intake or mineral status of the animal, depending on the mineral feed (Horst, 1986).

6. CONCLUSION AND RECOMMENDATION

6.1. Conclusion

From the survey result, it could be concluded that the major constraint of dairy production was a shortage of land, which in turn leads to the scarcity for the cultivation of improved forage, and hence feed shortage especially in the urban dairy production, in both districts.

Costs of commercial dairy feed including concentrates, minerals, and vitamins together with poor knowledge of dairy procudurs significantly affected the development of dairy production. Dairying was important employment and source of income for the majority of the urban and peri-urban population in the study area. However, dairy production and productivity were seriously affected by poor quality and quantities of nutrition, including deficiencies and mineral imbalances. Supplementations of the mineral mixture for dairy cows were not commonly practiced by producers, except few that were practiced in semi-organized dairy farms.

Feed analysis showed Ca, P, Cu, Zn, and Co deficiencies were observed. Similarly, serum samples showed Ca, P, Cu, and Co to be below the critical level or close to lower borderline while, the levels of Mg, Fe, and Zn were sufficient to meet estimated nutritional requirements for dairy cows. Moreover, the level of Co concentration was even not detected both on feed and blood samples, which indicate Co was below the critical level.

Supplementation level of 0.3%, 0.6%, 0.9% dicalcium phosphate with the concentrate mix was improving dry matter and nutrient intake. Supplementation of DCP-18% significantly increase milk production, and composition with exception of total solids.

6.2. Recommendation

On the basis of the results the possible recommendations are:

- Attention should be given to correct the deficient minerals especially Ca, P, Cu, and Co as these minerals were either below the critical level (categorized into deficient) or borderline which were detected from serum dairy cows in the study area. However, further research is needed including other vital minerals that are related to dairy production.
- Any feeding system based on mineral supplementation for dairy cows should focus on the area specific mineral mixture.
- To improve dairy production and alleviate the challenges of feeds and minerals, the development of improved forages and natural pastureland improvement measures should be taken.
- Regular evaluation of dairy animals and dairy feeds of mineral profile followed by area-based mineral supplementation may be feasible that total supplement and may improve dairy production.
- If possible large country-based research should be formulated to gather area specific mineral availability and to have nationwide dairy mineral supplementation packages based on deficiencies to that specific area.

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8. APPENDICES

Appendex 1. Survey questionnaire format for household respondents

Date of interview _______,_____,________ Code No_______ Region_________

Zone_____________woreda______________Kebele____________Urban_____Per-urban_____Largescale farm______ Medium scale farm _________ small scale farm____

Starting of time interviewed:_______________ Ending of time interviewed_____________

Signature._________________

Instruction: - explain the purpose of interview to the household

-To answer the question use pencil only, the write response precisely for open questions and encircle the numbers for closed questions.

Part-1.

1.1. Name___________________________sex_____Age_____

1.2. Family size________;No of females_________; No of Males_______

1.3. Marital status: Married_____; Single______; Divorce_______

1.4. Level of education (write "X"): Illiterate_____, BasicEducation;_____Elementary (1-6)____;Junior____;(7- 8)_____;Secondary School and Above

1.5. What is the major source of family income?___________________

1.6. What is your herd management system? _____________________

A. Intensive B. extensive C. semi intensive

Animal catagory	Breeds you posses					
	Pure HF	Pure Jursy	Cross(local x HF)	Cross(local xJersy)	Cross (HF x Jersy)	Local
Milking cows						
Pregnant cows						
Dry cow						
heifers						
Breeding Bulls						
Young bulls						
Castratedyoung males						
Male calves(<1year)						
Femalcalves(<1year)						
total						

Part. 3. General farm information

3.1. Feed resource and feeding systems

3.1.1. Do you have experience in growing improved forage species to feed your animals? A. YES B. NO

3.1.1.1. If yes, please specify the type of forage crops to grow and area allocated to it

No	Type of forage crop	Area coverage
1		
2		
3		
4		

3.1.1.2. If no, please specify your reason, why you are not growing improved forage

3.2. What are the major cattle feeding system you use/

No	Feeding scheme	Put" X" in the appropriate
1	Free grazing	
2	Rotational grazing	
3	Stall feeding /cut and carry	
4	Other specify	

3.2.1. What type of feeds do you used to feed your dairy cows based on seasonality?

No	Animal feed source	Select ("X")	Quantity(kg)/ 12months	Season(**wet**/**dry**)	Total cost paid per 12 month
	Grass hay				
	Straw/ crop residue				
	Teff straw				
	concentrate				
	Wheat bran				
	Wheat straw				
	Molasses				
	Oat-vetch				
	Silage				
	Alfalfa				
	Mineral block				
	Agriculture processing by product(Atela)				
	Feed additives				
	Grazing				
	If other specify				

Part 4. About Minerals

I. Do you have any knowledge about feeding of mineral for your dairy cows?

A. YES B. NO

II. If "YES" what type of minerals do you know? please specify

A. local/traditional mineral source

____

____

____

B. **Commercial mineral sources**

____

____

____

III. Why you feed minerals for your dairy cows?

____

____

____

IV. What is your source of information about the importance of minerals, especially for your dairy cows? Why you ask this question?

A. Through education
B. Traditionally
C. From friends
D. From concerned professionals

V. How can you proved minerals for your Dairy cows? Put "X"

A. Mineral alone ___________
B. Mixing with concentrate_____________
C. Mixing with hay_________________
D. With the others specify__________________

VI. How do you know the need of minerals by animals (any signs), Try to justify the observations your on dairy cows.

____
____
____

VII. Have you ever seen one of the following clinical sign on your animals? If "YES" put "X" and try to justify it.

A. Loss of hair coat/alopecia_____________
B. Lameness______________
C. Soil eating _______________
D. Delayed onset of puberty _______________
E. silent or irregular estrus in heifers________________
F. failure of estrus and long inter calving period in cows____________
G. still birth or weakly expelled calves_________________
H. embryonic death _________________-
I. delayed uterine involution_______________
J. increased incidence of dystocia______________
K. retention of placenta ________________
L. prolapse of uterus_________________
M. If other specify______________

VIII. For which purpose of dairy cows you feed minerals? Put "X"

A. for lactating cows___________
B. Cows at a dry period___________
C. For pregnant animals__________
D. For fatting purpose only______

E. If other specify ______________

IX. How much you cost for mineral supplementation for dairy cows

A. Cost for one dairy cows per day _______________Eth Br

B. Cost for one dairy cows per lactation period___________________Eth Br

C. Cost for total number of cows per year _____________________Eth Br

5. Animal disease

5.1. Do you know common dairy cow's diseases which are related to deficiencies of nutrition? If so please encircle for the following

A. Emaciation
B. Milk fever
C. Bloat
D. Abortion
E. retention of placental
F. Loss of milk yield
G. Decreasing milk yield
H. Still birth
I. Loss of hair coat
J. Dystocia
K. Water milk
L. If others specify_____________________________________

5.2. Do you know some infectious disease prevailing in your area?

A. Anthrax
B. Black leg
C. Brucellosis
D. Internal parasites
E. External parasites
F. Tuberculosis
G
H. Mastitis
I. Lumpy skin disease
J. Pasteurello
K. .if other specify _________

5.3. What type of treatment they are used when your animals are sick/diseased?

A. If traditional treatment specify? ________________________________

B. If the treatment is modern Specify?_______________________

C. By whom the treatment is given for your sick animals, encircle the appropriate answer

I. By professionals /private
II. By professionals/ government
III. Farmers by their own can treat their animals

5.4. During which season most of the animals are diseased specify why?______________

5.5. If most of the time, nutritional deficiency diseases observed in dairy cows? Specify why?_________________________

5.6. Do you have a habit of vaccinating for your animals, how often for specific disease

A. once times year B. Twice a year C. no vaccination

5.7. Was there an occurrence of an outbreak with in these two years period?
A. YES B. NO

5.8. If yes specify the name of the disease either by its scientific name or local name or both

---

6. Have you ever seen any none infectious disease problems in your farm. Encircle among the following

A. Bloating
B. Impaction
C. Any other specify _____________

7. What type of treatment you have been given for the above metabolic diseases, specify
____

Appendix 2. Quationary Format for Veterinary Professionals

Date of interview__________,_____,_____________

Name_________________________________educationlevel____________ ______age_______

Marital status _________ Zone _____________ Name of Vet. Clinic _____________

Signature.____________________

1. In your surrounding are there cross breed dairy farms? A. Yes B. No
2. If your answer is yes , how many farms are found?__________
3. Which type of cross breed dairy cows they keep?___________________________
4. What type of infectious and non-infectious diseases predominantly prevalent in your coverage area with in last two years? Try to

specify?____

5. What is your intervention for the occurrence of the disease?__________________________

6. Is there any dairy cow mortality case in the surrounding? specify the cause____

7. Do you have any concern about mineral deficiency diseases in your surrounding?
   A. Yes B. NO

   a. If yes which type of mineral deficiency disease and in which species of animals you come across? Try to specify about the incidence?

   ____

8. Do you know the level of awareness of dairy cow owners about minerals supplementation? Explain it?

   ____

9. If they have knowledge to use minerals, what type of minerals frequently used for their dairy cows?
   A. If they used local minerals what is the source and the local name. Specify it please?

   ____

B. If they used commercial minerals, specify about the source

   ____

10. How they provide for their dairy cow's mineral supplementation?

    ____

11. Can dairy owners distinguish the mineral deficiency disease by symptoms

A. YES B. NO

11.1. If yes how they can provide mineral treatment for their deficient cows?

____

____

12. How much morbidity incidence due to mineral deficiency disease of dairy cows?

____

____

a. What about the mortality rate due to mineral deficiency diseases with in last two years period ? specify by which mineral deficiency?______________________

____

____

13. Which mineral deficiency disease predominantly identified by you?

A. ______________________
B. ______________________
C. ______________________
D. ______________________

14. Is there any incidence of reproductive problem which is related to mineral deficiencies

A. _________________
B. _________________
C. _________________
D. _________________

15. As a professional what should your suggestion about mineral deficiency for cross breed dairy cows.

____

16. In your surrounding what local minerals are available?

Appendix 3. Types of feed samples collected based on seasonal availability from study area

Sampled feeds	No of samples	Season of coll.	Locations
A. **Roughage**			
i.Green feed			
Oats vetch	4	dry and wet	Ada urba and peri-urban
Alfalfa	3	wet	Ada urba and peri-urban
elephant grass	4	wet	Ada urba and peri-urban
Sugar can top	7	dry and wet	Adama periurban
ii. Dry feed			
Teff straw	10	dry	Both Ada and Adama
Wheat straw	7	dry	Both Ada and Adama
Natural grass hay	14	dry and wet	Both Ada and Adama
B. **Oil seed**			
Cotton seed cake	8	dry and wet	Adama urba and peri-
Concentrate mix(Faba +wheat bran)	11	dry and wet	Both Ada and Adama
Noug (Guizotia abyssinica) seed cake	18	dry and wet	Both Ada and Adama
Linseed cake	5	dry and wet	Both Ada and Adama
C. **Cereal grain mill by-products**			
Wheat bran	8	dry and wet	Both Ada and Adama
Wheat middling	5	dry and wet	Both Ada and Adama
ground maize	10	dry and wet	Both Ada and Adama
D. Brewery residues / local and industrial			
Atela	8	dry and wet	Both Ada and Adama
Brewery by products(Brewery spent grain)	8	dry and wet	Both Ada and Adama
Others			
Poultry manure	7	dry and wet	Ada urban and per urban
Silage	3	dry	Ada urban
Total	**140**		

Appendix 4. Farmer HH's perception about mineral deficiency and related symptoms in study area

Mineral deficiency S.	Adaa n = 127 n (%)			Adama = 123 n (%)			Overall
	Urban (60)	P-urban (67)	Total	Urban(5	P-urban(68)	Total	N = 250
Loss of hair coat	10(16.7)	2(3.0)	12(9.4)	3(5.5)	6(8.8)	9(7.3)	21(8.4)
Licking of human urine	11(18.3)	7(10.4)	18(14.2)	11(20.0)	4(5.9)	15(12.2	33(13.2)
Lameness	2(3.3)	4(6.0)	6(4.7)	3(5.5)	3(4.4)	6(4.9)	12(4.8)
Soil licking	1(1.7)	6(9.0)	7(5.5)	7(12.7)	8(11.8)	15(12.2	22(8.8)
Delayed onset of puberty	-	4(6.0)	4(3.1)	-	3(4.4)	3(2.4)	7(2.8)
Silent heat	2(3.3)	4(6.0)	6(4.7)	2(3.6)	4(5.9)	6(4.9)	12(4.8)
Irregular estrous	2(3.3)	6(9.0)	8(6.3)	2(3.6)	4(5.9)	6(4.9)	14(5.6)
Failure of estrous	2(3.3)	1(1.5)	3(2.4)	4(7.3)	2(2.9)	6(4.9)	9(3.6)
Long period of calving interval	2(3.3)	3(4.5)	5(3.9)	3(5.5)	4(5.9)	7(5.7)	12(4.8)
Embryonic death	2(3.3)	1(1.5)	3(2.4)	-	1(1.5)	1(0.8)	4(1.6)
Increase incidence of dystocia	2(3.3)	2(3.0)	4(3.1)	1(1.8)	3(4.4)	4(3.3)	8(3.2)
Retention of placenta	3(5.0)	2(3.0)	5(3.9)	1(1.8)	4(5.9)	5(4.1)	10(4.0)
Blind of eyes of new born	-	1(1.5)	1(0.8)	7(12.7)	7(10.3)	14(11.4	15(6.0)
Emaciation	-	3(4.5)	3(2.4)	-	1(1.5)	1(.8)	4(1.6)
Milk fever incidence	17(28.3)	19(28.4)	36(28.3)	9(16.4)	12(17.6)	21(17.1	57(22.8)
Milk quality and quantity affected	(46.7)	2(3.0)	6(4.7)	2(3.6)	2(2.9)	4(3.3)	10(4.0)

n = number of respondents; figures in parenthesis are percentages for a given category; S=syptomes

Appendix 5. Percentage knowledge of mineral deficiency and mineral types used on farm for dairy cattle and mineral sources in the study area

Parameters	Ada′a n = 127 n (%)			Adama= 123 n (%)			Overall
	Urban	P-urban	Total	Urban(55)	P-urban(68)	Total	N = 250
T. of minerals supplem.							
Salt /common salt only	18(30.0	19(28.4)	37(29.1)	10(18.2)	39(57.4)	49 (39.8)	86(34.4)
Calcium powder &Salt	9(15.0)	21(31.3)	30(23.6)	11(20.0)	-	11(8.9)	41(16.4)
Bole*/ lake soil alone	20(33.3	13(19.4)	33(26.0)	11(20.0)	10(14.7)	21(17.1)	54(21.6)
Mineral mix** & Salt	7(11.7)	6(9.0)	13(10.2)	10(18.2)	12(17.6)	22(17.9)	35(14.0)
Salt &bole	2(3.3)	8(11.9)	2(1.6)	1(1.8)	-	1(0.8)	3(1.2)
Mineral lick*** , Salt	3(5.0)	-	3(2.4)	1(1.8)	-	1(0.8)	4(1.6)
Limestone &Salt	-	-	8(6.3)	8(14.5)	1(1.5)	9(7.3)	17(6.8)
Partially all	1(1.7)	-	1(0.8)	3(5.5)	6(8.8)	9(7.3)	10(4.0)
Mineral d. knowledge							
Yes	40(66.7	35(52.2)	75(59.1)	32(58.2)	23 (33.8)	55(44.7)	130(52)
No	20(33.3	32(47.8)	52(40.9)	23(41.8)	45(66.2)	68(55.3)	120(48)

n = number of respondents; figures in parenthesis are percentages for a given category *mineral soil collected from &around lake.**different minerals together including vitamins in the form of powder. ***salt / mineral licks often occur naturally, providing sodium, calcium, iron, phosphorus and zinc;d= deficiency

Appendix II. List of ANOVA tables and others

Appendix 6. Summary of ANOVA table showing sources of variation in the effect of supplementation on calcium and phosperous balance in dairy cows

Source of variation	DF	Mean squares											
		Ca intake	Ca in feces	Ca in urine	Ca in milk	T. Ca outgo	Ca balan	**P intak**	P in feces	P in urin	P in milk	Total P ex	T. P outgo
Model	9	280.40	106.29	0.06	0.16	104.81	289.05	169.98	106.92	0.33	0.25	112.6	294.1
Error	6	6.01	32.70	0.06	0.71	29.98	10.25	4.25	9.31	0.20	0.38	9.28	20.68
Total	15												
CV%		2.58	13.02	9.45	15.27	10.94	14.28	3.56	5.40	21.88	15.51	17.25	14.42
MSE		2.45	5.72	0.25	0.84	5.47	6.46	2.06	4.98	0.45	0.62	4.57	4.54
F-value		16.66	3.25	0.94	0.23	3.50	8.20	18.69	4.31	0.65	1.31	5.39	14.22
P-value		0.0017	0.0165	0.523	0.933	0.071	0.009	0.0001	0.0261	0.019	0.018	0.013	0.0001

DF=Degree of freedom; MSE= Root mean standard error; Ca=calcium;P=Phospherous; ex=excretion; balan= balance

Appendix 7. Summary of ANOVA table showing sources of variation in the digestibility due to supplementation of different level of DCP

source	DF	Mean squares				
		ADMD	ACPD	AOMD	ANDFD	AADFD
Model	9	73.61	69.32	101.28	44.69	70.58
Error	6	4.35	6.68	9.11	13.97	12.32
Total	15	-	-			-
CV%		2.87	3.22	4.09	8.06	11.41
MSE		2.09	2.58	3.02	3.74	3.51
F-value		16.91	10.39	11.12	3.20	5.73
P-value		0.0147	0.005	0.0215	0.0280	0.0118

DF=Degree of freedom; MSE= Root mean standard error; ADMD=Apparent dry matter digestibility; ACPD=Apparent crude protein digestibility; AOMD= Apparentorganic matter digestibility;ANDFD=Apparent neutral detergent fiber digestibility; AADFD=Apparentacid detergent fibre digestibility

Appendix 8. Summary of ANOVA table showing sources of variation in the effect of supplementation of dicalcium phosphate in the concentration of Ca and P blood serum

Source of variations	DF	Mean squares	
		Ca	P
Model	9	0.054	0.000
Error	6	0.076	0.000
Total	15	-	-
CV%	12.4	12.46	2.26
MSE		0.275	0.014
F-value		0.70	0.88
P-value		0.017	0.3061

DF=Degreeoffreedom;CV=Coefficientofvariations;MSE=Rootmeanstandarderror,Ca=calcium P=phospherous

Appendix 9. Summary of ANOVA table showing sources of variation in the effect of supplementation on DM and nutrient intake in dairy animals

Source of variations	df	Mean squares						
		cDMI	hDMI	TDMI	CP	OM	NDF	ADF
Model	9	0.56	0.81	2.08	0.09	2.08	0.95	0.20
Error	6	0.14	0.19	0.14	0.02	0.21	0.17	0.05
Total	15							
CV%		7.64	5.10	2.80	6.27	3.70	4.92	5.90
MSE		0.38	0.43	0.37	0.13	0.46	0.41	0.22
F-value		3.98	4.39	14.92	5.55	9.92	5.63	4.02
P-value		0.0149	0.0229	0.002	0.0247	0.0557	0.0323	0.0134

DF=Degreeoffreedom;CV= Coefficient of variations; MSE=Root mean standard error; cDMI=concentrate dry mater intak;hay dry mater intak;TDMI=Total dry mater intak;CP=crud protein;OM=organic matter;NDF= neutral detergent fiber;ADF= acid detergent fibre

Appendix 10. Summary of ANOVA table showing sources of variation in the effect of supplementation on milk yield and composition

Sourceof variations	df	Mean squares				
		M yield	Fat	Protein	lactose	SNF
Model	9	5.67	0.34	0.44	0.54	0.56
Error	6	0.48	0.09	0.13	0.13	0.33
Total	15	-	-	-	-	-
CV%		5.75	6.99	10.25	9.49	6.69
MSE		0.69	0.29	0.37	0.37	0.57
F-value		11.77	4.01	3.30	4.03	1.70
P-value		0.0036	0.0526	0.0799	0.0520	0.2663

DF=Degree of freedom; CV= Coefficient of variations; MSE=Root mean standard error; yield; SNF=solid not fat

Appendix 11. Summary of ANOVA table showing sources of variations of analysis of blood sample based on districts, physiological status, production system, season and their interaction.

Source of variation	DF	Mean separation						
		Ca	P	Mg	Cu	Fe	Zn	Co
District	1	0.004	0.003	0.78	3.76	39.15	39.50	0.00
Ps	1	0.002	0.000	0.04	0.03	3.18	0.48	0.00
Phy	1	0.000	0.000	0.04	1.85	1.62	22.20	0.00
Sn	1	0.003	0.000	0.08	1.58	0.30	18.78	0.00
Error	1207							
Total	1211							
CV%		49.04	11.33	15.92	41.84	14.69	21.88	58.46
MSE		0.06	0.01	0.04	0.25	1.10	0.82	0.06
F-value		1.25	5.24	99.74	16.56	6.54	16.95	41.22
P-value		0.2662	<.0001	<.0001	<.0001	<.0001	<.0001	<.0001
Dst*phy	1	0.01	0.00	0.00	1.87	65.51	19.44	0.001
Ps*phy	1	0.00	0.00	0.01	0.88	19.39	10.85	0.02
Sn* phy	1	0.01	0.00	0.00	0.01	0.00	0.01	0.00
Dst*ps*phy*sn	3	0.006	0.00	0.003	0.22	4.83	2.71	0.00

Dst=districts; phy=physiological status,ps=productionsystem; sn= season;DF=degrr of freedom, CV= Coefficient of variations; MSE=Root mean standard error

Appendix 12. Summary of ANOVA table showing sources of variations of analysis of Roughage feed sample based on districts, production system, season and interaction.

Source of variation	DF	Mean separation						
		Ca	P	Mg	Cu	Fe	Zn	Co
Model	9	0.86	0.99	5.42	61.30	3435.64	861.12	0.001
Error	254							
Total	257							
CV%		27.51	35.60	42.26	23.88	22.99	33.77	35.94
MSE		0.41	0.50	0.62	3.77	91.70	11.09	0.02
F-value		23.69	4.0	14.01	4.31	4.09	7.00	20.19
P-value		<0.000	<0.0001	<0.0001	<.0001	<.0001	<.0001	<.0001
Roughage(R)	51	1.27	0.98	0.86	70.94	15525.5	903.30	0.00
R*dst	1	0.84	0.19	0.62	233.16	2937.52	33.34	0.00
R*ps	1	0.17	1.40	0.16	22.95	9.75	347.15	0.00
R*sn	1	27.51	35.60	42.26	23.88	22.99	33.77	35.94

dst=districts;phy=physiologicalstatus,ps=productionsystem;sn=season;R=roughage;DF=degrrof freedom, CV= Coefficient of variations; MSE=Root mean standard error; prs=production system

Appendix 13. Summary of ANOVA table showing sources of variations of analysis of cereal grain aznd oil seed cake feed sample based on districts, production system, season and interaction.

Source of variation	DF	Mean separation						
		Ca	P	Mg	Cu	Fe	Zn	Co
Model	9	0.86	0.79	1.44	20.89	3665.82	3091.69	0.000
Error	240							
Total	249							
CV%		81.17	62.43	67.71	38.12	75.03	43.79	35.35
MSE		0.36	0.38	0.53	3.00	86.40	17.56	0.02
F-value		6.33	5.34	5.15	2.32	4.91	10.02	3.20
P-value		<.0001	<.000	<.000	0.0162	<.0001	<.0001	0.001
C.G & oil seed cake	63	0.99	0.91	1.41	16.99	40448.66	3796.49	0.002
C.G & oil seed cake *dst	1	0.21	1.43	0.32	0.73	27244.58	3648.07	0.000
C.G & oil seed cake *ps	1	1.63	0.01	3.62	68.19	19371.63	103.93	0.000
C.G & oil seed cake *sn	1	0.24	0.48	0.33	2.30	23618.37	125.50	0.000

dst=districts; phy=physiological status,ps=productionsystem; sn= season; C.G cereal grain ;DF=degrr of freedom, CV= Coefficient of variations; MSE=Root mean standard error; prs=production system

Appendix 14. Summary of ANOVA table showing sources of variations of analysis of non-conventional feeds feed sample based on districts, production system, season and interaction.

Source of variation	DF	Mean separation						
		Ca	P	Mg	Cu	Fe	Zn	Co
Model	5	0.63	0.36	0.58	131.61	4582.71	316.23	0.00
Error	109							
Total	114							
CV%		43.18	46.94	81.94	35.99	39.41	27.64	29.63
MSE		0.23	0.35	0.49	2.92	39.77	8.71	0.020
F-value		11.48	2.80	2.38	15.36	28.96	4.17	28.21
P-value		<.0001	0.020	0.04	<.0001	<.0001	0.0017	<.0001
Non-conventional	21	1.27	0.06	0.10	109.0	78714.8	467.85	0.00
Non-conventional *dst	1	0.38	0.08	1.66	118.81	61745.7	67.01	0.00
Non-conventional	1	0.01	0.00	0.04	333.1	19244.2	351.88	0.01
Non-conventional *sn	1	0.29	1.65	0.50	71.47	1041.59	176.47	0.00

dst=districts; phy=physiological status,ps=productionsystem; sn= season;;DF=degrr of freedom, CV= Coefficient of variations; MSE=Root mean standard error; prs=production system

Appendex 15. Summary of ANOVA table showing sources of variations of analysis of concentrate feed sample based on districts, production system and season

Source of variation	DF	Mean separation						
		Ca	P	Mg	Cu	Fe	Zn	Co
Districts	1	0.22	1.44	0.33	0.74	27244.58	3648.08	0.000
Ps	1	1.64	0.01	3.63	68.20	19371.63	103.94	0.000
Sn	1	0.24	0.48	0.33	2.30	23618.38	125.50	0.000
Error	240							
Total	243							
CV%		31.18	22.44	25.09	38.13	15.04	33.79	0.000
MSE		0.37	0.39	0.53	3.00	86.40	17.56	0.000
F-value		6.33	5.34	5.15	2.32	4.91	10.02	0.000
P-value		<.0001	<.0001	<.0001	<.0.0162	<.0001	<.0001	<.0001

dst=districts; phy=physiological status,ps=productionsystem; sn= season; DF=degrr of freedom, CV= Coefficient of variations; MSE=Root mean standard error.

Appendex 16. Summary of ANOVA table showing sources of variations of analysis of non-conventional feed sample based on districts, production system, season and their interaction.

Source of variation	DF	Mean separation						
		Ca	P	Mg	Cu	Fe	Zn	Co
Districts	1	0.38	0.09	1.67	118.82	61745.70	67.01	0.000
Ps	1	0.02	0.01	0.04	333.19	19244.28	351.89	0.000
Sn	1	0.29	1.65	0.50	71.48	1041.60	176.47	0.000
Error	240							
Total	243							
CV%		43.18	46.95	41.95	36.00	39.41	27.65	0.000
MSE		0.24	0.36	0.50	2.93	3.78	2.71	0.000
F-value		11.48	2.80	2.38	15.36	28.96	4.17	0.000
P-value		<.000	0.02	0.0433	<.0.016	<.0001	0.0017	<.000

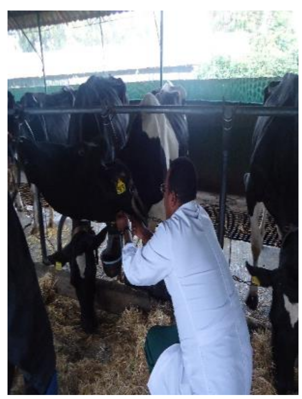
dst=districts; phy=physiological status,ps=productionsystem; sn= season; DF=degree of freedom, CV= Coefficient of variations; MSE=Root mean standard error.

Appendix 17. Specific location of category of dairy owners used for data and sample collection with respect to localities

No	Districts			
	Ada'a		Adama	
	Urban	Peri-urban	Urban	Peri-urban
1	Kebele-09 (Babogaya)	Dhankak	Kebele-01	Mormmorsa
2	Kebele-15	Gudino	Kebele-02	Guraja Furda
3	Kebele-01(Aleka Amba)	Udde	Kebele-04	Wanji kurifti
4	Kebele-03	Hidi	Kebele-13	Wonji shoa
5	Kebele-08	Wajito	Adama village	Dobe
6			Soloke	
Total	**5**	**5**	**6**	**5**
G.total		**21**		

Survey study

➢ Blood sample collection



Feed sample collection






Laboratory work









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