Ethiopian Journal of
Environment and Development
EJED 2(2) 2019: 1–14

MACRO AND MICRO MINERAL STATUS OF DAIRY FEEDS IN EAST SHOA ZONE, OROMIA REGION STATE, ETHIOPIA

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Received 5th September 2019,
Accepted 22nd December 2019

Abstract

The aim of this study was to evaluate different feed types collected from two districts (Ada'a and Adama zuria) of two production systems (urban and peri-urban) based on season's (dry and wet) in East Shoa Zone, for their macro and micro mineral concentrations. Feeds in the selected districts comprised of roughages, concentrates, and non-conventional feeds. All feed samples were taken directly from the field supplied by the farmers. The feed samples were analyzed for the macro and micro minerals namely Ca, P, Mg, Cu, Fe, Zn, and Co, using atomic absorption flame emission spectrometer and P concentration was measured by the spectrophotometer. The critical level (CL) used in this article is defined as the concentration of minerals below the level considering the requirements for dairy cows. The mean calcium concentrations in roughage varied from (0.13 to 0.55%); concentrate (0.14 to 0.64%) and non-conventional feed (0.34 to 0.69%) DM respectively. Out of the total feeds analyzed only, 26.92%, 66.15% for roughage (natural grass hay, sugar cane tops, and silage) and concentrates (noug seed cake, ground maize, cotton seed cake, and lean seed cake), respectively were found to be deficient in Ca. The mean phosphorus and magnesium values were not deficient in analyzed feeds. The mean Copper concentrations varied in roughages (6.99 to 10.65 ppm); concentrate (6.67 to 8.78 ppm) and non-conventional (6.31 to 9.72 ppm) DM respectively. When those values are compared to the critical value (< 8ppm) of feeds analyzed only 19.23%, 79.92% and 65.22% for roughage (*Triticum aestivum*, *Medicago sativa*, *Pennisetum purpureum*), concentrates (wheat bran, wheat middlings, noug seed cake, cotton seed cake and concentrate mix) and non-conventional feeds (brewery by-products industrial, poultry liters) 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, *Pennisetum purpureum*), 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 but non-significant ($P > 0.05$) for Fe. Moreover, the interaction effect of feed based on sampling season was significantly different ($P < 0.05$) for Ca, P, Mg, and Zn but non-significant ($P > 0.05$) for Cu and Fe. Minerals such as Ca, Cu Zn and Co were present in inadequate amounts. Therefore, supplementation of these mineral elements is very likely to produce beneficial results in the ration of dairy. Hence, there is an urgent need for appropriate research to formulate area specific mineral mixture, and to devise supplementation packages for bio-available mineral salts.

Keywords: Dairy cows, Districts, Feed, Macro and micro-minerals, Production system, Season

1 Introduction

In Ethiopia, cattle rarely obtain mineral supplements with the exception of common salt. The use of commercial feed supplements is limited due to the cost incurred and their unavailability (Fekede *et al*., 2013). Dairy cattle are mainly fed on natural pasture (grazing and/or hay), crop residues, and different agro-industrial by products, and locally available by-products (Atela) as supplementary feeds. In the past, extensive studies were carried out in the country to explore the nutritional limitations of such feeds to improved livestock production; in this case dairy cattle cannot perform to their full genetic potential unless their mineral needs are met, even if they receive 100% of their protein and energy requirements (Prasad *et al*., 2007; Fekede *et al*., 2015). Unfortunately, forages often do not provide all of the needed minerals, which animals require throughout the year. The concentration of mineral elements in pasture forage is a function and property of soil (parent material, soil fertility, soil pH and soil drainage). Plant species and climatic factors influence the mineral concentration of pastures (Lemma *et al*., 2002). On the other hand, substantial improvements have been reported by supplementing with forage legumes and agro-industrial by-products (Alemayehu, 2003).

Micronutrients, particularly the mineral elements though required in very small amounts are considered inevitable for the normal functioning of metabolic and physiological processes of life. In tropical countries, grazing livestock often does not receive minerals in required quantities and must depend almost exclusively upon forages for their requirements (McDowell and Valle, 2000). The essentiality of minerals for growth, health, reproduction as well as normal physiological functions of the animal's body was reported (Lemma *et al*., 2002). To obtain improvement in animal production, proper attention should be given to mineral nutrition, whether the animal is in a free-ranging system or under confinement. A lack of consideration for the mineral content of the total ration frequently leads to increased disease and reproductive problems (Radostits *et al*., 2007). Identifying and having awareness of the mineral composition of feeds contribute in determining the types and amount of minerals to be supplemented.

In Ethiopia, in spite of the fact that indication on the mineral content of feeds of various natures is accessible, but attention given so far to the mineral status of feeds has been little as related to macronutrients (Diriba *et al*., 2001; Aschalew, 2006). Some studies (Lemma *et al*., 2002; Fekede *et al*. 2015) have shown the low status of essential mineral elements in natural pastures, crop residues, and other feed resources in central and western parts of Ethiopia with particular emphasis to season and altitude. But there is no evidence of study on mineral content in dairy feeds in the rift valley of East Shoa zone with regard to importance of season and production system. Furthermore, there is very little information and organized data on important dairy mineral concentration in dairy feeds throughout Ethiopia though the problem is sever. The aim of this study was to quantify the mineral content of different feeds used in the districts as dairy cow feed and to provide a basis for subsequent investigation.

2 Materials and Mehods

2.1 Description of the Study Area

The study was conducted in urban and peri-urban production systems of Ada'a and Adama districts in East Shoa Zone. The study zone extends between 7^{o}33'50"N - 9^{o}08'56"N and 38^{o}24'10"E - 40^{o}05'34"E with a total area of approximately 10241 km^2. Ada'a district is located at 08^{o}44'E latitude and 38^{o}58'N longitude with an altitudinal range of 1540 - 3100 m a.s.l. (AWAO 2018). The largest portion (95%) of the district has mid highland agro-climate and the remaining portion (5%) has highland agro-climate. Mean annual temperature ranges from about 80 ^{o}C to 280 ^{o}C (Alemayehu *et al*., 2012).

Adama district is located at 8^{o}33'35" N - 8^{o}36'46" N latitude and 39^{o}11'57"E - 39^{o}21'15"E longitude about 99 km Southeast of Addis Ababa (CSA, 2005). It is situated at an altitude ranging from 1400 to 2700 m a.s.l. (DOA, 2013). 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 for rainfall. More than 67% of the mean annual rainfall occurs in the four rainy (Wet) months: June, July, August and September (ADARDO 2013). 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 33oC respectively (NMSA, 2013).

2.2 Study Design

A cross-sectional study involving purposive selection of study areas, but a random selection of dairy farms and farm owners from the urban and peri-urban were conducted. The study areas were purposively selected as they have high potential for dairy production. The sampling frame of Kebles and dairy farms were obtained from respective district livestock and agriculture development offices. Depending on the frame lists and information obtained, Kebles from each production system (urban- and peri-urban) of each district were purposively selected based on the availability of crossbred dairy cattle and dairy production experiences. In Ethiopia, urban dairy farming is a system involving highly specialized, businessmen owned farms, which are mainly concentrated in major cities with no access to grazing land. The main feed resources are agro-industrial by-products and purchased roughage (Belete *et al*., 2010). Moreover, according to Fekede *et al*. (2013), urban dairy production is relatively intensive and mainly based on stall-feeding using purchased roughages and concentrates. However, Peri-urban production has access to land and usually practice mixed crop–livestock farming, which produces part of the feed in the form of crop residues and grazing (Azage *et al*., 2013).

2.3 Sample Collection and Preparation

In the present study, a total of 140 samples belonging to different agro-industrial by-products 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 each production systems (urban and peri-urban). In general, the feed sample collection was season based (dry and wet), in which wet season was (from July to August) and the other was in the dry season (from January to February). These categories of feeds were purposively made for the sake of data analysis and result presentation and interpretations. Available dairy feed samples were collected from feed stores and sites of individual HH's, then labeled, and stored in airtight self-sealing polythene bags. The samples were grouped into three categories based on the nature and relative similarities according to their production system and seasonal availability in to roughage feeds natural pasture hay (*Andropogon*, *Digitaria*, *Panicum*, *Pennisetum* and *Trifolium*), teff straw, wheat straw, silages (maize), improved forage crops, sugar cane top), cereal grain and oilseed (wheat bran(*Triticum aestivum*), wheat middlings, concentrate mix (Faba bean mixed hull X wheat Bran(WB)), noug seed (*Guizotia abyssinica*) cake, ground maize, cottonseed cake, lean seed cake) non- conventional feeds (brewery by-product, Atela (traditional brewing by-product), poultry liter) Table 1.

Table 1 Types of feed samples collected based on seasonal availability from study area

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

2.4 Feed mineral analysis

The samples collected from different categories of supplementary feeds were milled through a 1mm sieve size for laboratory analysis. From each sample, a minimum of 300g feed was dried at 60 ^{o}C for 72 hours until a constant weight was obtained (Aschalew, 2006). For determination of both the macro- and trace minerals, the ground samples were dried and ashed at 450 ^{o}C for 4 hours in a furnace (Fekede *et al*., 2015). The feed samples were digested by the method of Trolson (1969) and 1g of previously ground and stored samples were taken in digestion tube and 5 ml of concentrated HNO_3 and 1ml of concentrated sulphuric acid (H_2SO_4) was added and mixed well and then was filtered through a filter paper. 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), using Inductively Coupled Plasma-Optical Emission Spectroscopy, Perkin Elmer Analyst 200 Atomic Absorption Spectrometer except P. 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 P concentration was measured by spectrophotometer according to Murphy and Riley (1962). The concentrations of Ca, P, Mg, Cu, Fe, Zn and Co were analyzed using the atomic absorption flame emission spectrometer. The critical level (CL) is 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.

2.5 Sample size determination

The sampling frame comprises those farmers keeping crossbred dairy cows and willing to participate in the study. Generally, it was made a total of 250 households (125 from each district) who were purposively selected. Dairy owners were also be designated into 'urban' and 'peri-urban', categories based on the location of the same in the town (Adama and Adaa districts) area, respectively (Table 2.). The sample size is restricted in accordance with the logistics available for laboratory analysis.

Table 2 Specific location of dairy owners used for data and sample collection with respect to localities

	Districts			
	Ada'a		Adama	
No	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 Soloke

A total of 250 households were included in the study according to the formula given by Arsham (2002). A standard error of 0.032 with a 95% confidence level was taken. From 250 dairy owners 140 feed samples were collected and made composite based on production systems of the respective districts. The difference in HH's and feed sample collected was due to involuntary of farmers and nature of similarity.

$$n = 0.25/SE^2 \quad (1)$$

Where, n= Sample size, SE= Standard error

2.6 Statistical Model and Data Analysis

Experimental data were subjected to analysis of variance using the General Linear Model procedure of the SAS program (SAS, 2002). 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 Tukey test at 5% probability. The following statistical models were used.

- **Feed experiment**: $Y_{ijk} = \mu + A_i + B_j + C_k + (ABC)_{ijk} + e_{ijk}$

Where, Y_{ijkl} = measured data (Ca, Mg, P, K, Mn, Mo, Co, Fe, Cu) for feed sample,
μ= overall
A_i= effect of ith location (1,2)
B_j= effect of jth season (1,2)
C_k= effect of kth production system (1, 2)
(ABC)= Interaction effect of location, season & production system
eijk= the random error associated to the yijk observation

3 Results

Mineral Profile Dairy Feeds

Analysis of the average of individual feeds which were available and collected from the study area was made to know the macro and micro mineral concentrations of dairy feeds (% and mg/kg dry matter basis) throughout the study area to compare with the critical values of respective minerals Table 3. The collected feed sample was analyzed individually per season and production system, but the result obtained indicated that the average of the mean of the two season and production system.

Mean values of the macro and micro minerals of dairy feed collected from the selected study areas based on seasonal availability, production system and localities is given (Table 4 to 6). Grass hay and different crop residues were found to be the major feed source in the ration of dairy cows and all feeds collected were (roughage feeds, Cereal grain & oilseed cakes and non-conventional feeds).

Table 3 Summary of over all the average concentration value of individual feeds of macro and micro mineral in dairy feeds (% and mg.kg^{-1} dry matter basis) throughout the study area in relation to critical values of respective minerals

Types of Feeds N= 140	Macro minerals (%)			Micro minerals (mg/kg)			
	Ca	P	Mg	Cu	Fe	Zn	Co
Roughage feeds n=52							
Tef (*Eragrostis tef*) 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 (*Triticum aestivum*) 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
Oat vetch (*Avena sativa*) 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 (*Medicago sativa*) 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 (*Pennisetum purpureum*) 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 (*Saccharum officinarum*) 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	
Cereal grain & oilseed cakes n= 65							
Wheat bran (*Triticum aestivum*) 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 (Faba bean mixed hull x WB) 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 (*Guizotia abyssinica*) 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(*Linum usitatissimum*) 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	
Non-conventional feeds n= 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
A brewery by-products/industrial 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	
Critical level*	< 0.30%	< 0.25%	< 0.20%	< 8ppm	< 50ppm	< 30ppm	< 0.1ppm

*Concentrations below which (Ca < 0.30%; P < 0.25%; Mg < 0.20%; Cu < 8ppm; Fe < 50ppm; Zn < 30ppm; Co < 0.1ppm) Ca=calcium; P=phosphorus; Mg=magnesium; Critical level based on (McDowell *et al*., 1993; NRC, 2001); SE=standard error. This table indicated that the individual feed mineral concentration which helps to identify mineral concentration of feeds in rift valley area, WB= wheat bran.

Table 4-6 show mean values of the macro and micro minerals of dairy feed collected from the selected study areas based on seasonal availability, production system and localities. Identification of macro and micro minerals such as Ca, P, Mg, Cu, Fe, Zn, and Co were made from feeds. Grass hay and available crop residues were found to be the major feed source in the ration of dairy cows (Natural grass hay, *Triticum aestivum*, *Eragrostis tef*. The majority of milk producers use feeding as supplement. These are oilseed cake, wheat bran, wheat middlings, and ground maize, local and industrial brewery by-products. In this study, it was indicated that only general macro and micro mineral status of feed resources were collected analyzed and categorized as deficient or sufficient based on the critical values given by (McDowell *et al*., 1993; NRC, 2001) (Table 3).

The mean Calcium (Ca) concentrations in roughage varied from (0.13 to 0.55%); Cereal grain & oilseed cakes (0.14 to 0.64%) and non-conventional (0.34 to 0.69%) DM bases respectively. There was no statistically significant difference (P > 0.05) in the concentration of calcium levels in roughage, Cereal grain & oilseed cakes and non-conventional feeds in the study areas. Out of the total feeds analyzed, 12.92, 26.15% for roughage (natural grass hay, sugar cane tops and silage) and Cereal grain & oilseed cakes (noug seed cake, ground maize, cottonseed cake and lean seed cake), respectively, were found to be deficient in Ca comparing to critical level (Table 7).

Phosphorous (P) concentration was no significant difference ($p > 0.05$) between roughage feeds, but in between Cereal grain & oilseed cakes feeds as well as non-conventional feeds, P content was significantly different ($P < 0.05$) from collected samples during the study period. When P concentration levels are compared to the critical level, it was sufficient to the dairy (McDowell *et al*., 1993; NRC, 2001). Out of the total feeds analyzed, 17.0, 2.5% for roughage (natural grass hay, sugar cane tops and silage) and Cereal grain & oilseed cakes (noug seed cake, ground maize, cottonseed cake and Lean seed cake), respectively, were found to be deficient compared to critical level (Table 7), whereas the majority of sampled feeds P concentration was sufficient (Table 3).

Magnesium (Mg) concentration was no significant difference ($p > 0.05$) between roughage feeds, Cereal grain & oilseed cakes and non-conventional feeds from collected samples during the study period in the study areas. When the Mg concentration level is compared to the critical level, it was sufficient to the dairy cattle (McDowell *et al*., 1993; NRC, 2001). Out of the total feeds analyzed, Mg was deficient only for roughage feeds, but for the rest feed resource, it was not deficient compared to critical level.

There was no significant difference ($P > 0.05$) of copper (Cu) concentration in roughage and concentrate feeds. However, a significant difference ($P < 0.05$) was observed in non-conventional feeds. When those values are compared to the critical value (< 8ppm) of feeds analyzed, 49.23, 76.92% and 65.22% for roughage (*Triticum aestivum*, *Medicago sativa*, *Pennisetum purpureum*), Cereal grain & oilseed cakes (wheat bran, wheat middling's, noug seed cake, cottonseed cake and concentrate mix) and non-conventional feeds(brewery by-products industrial and poultry liters) respectively were found to be deficient in Cu.

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

The mean zinc (Zn) concentrations varied (23.80ppm to 40.04 ppm) in roughages; Cereal grain & oilseed cakes (30.02ppm to 57.71 ppm) and non-conventional (27.53ppm to 34.30 ppm) in DM, respectively. When those values are compared to the critical value of (50 ppm), feeds analyzed were found to be deficient in Zn (48.08%, 11.45% and 34.78%) for roughage, concentrate and non-conventional feeds, respectively (Table 5).

The current study showed that except some roughages (*Avena sativa*, *Medicago sativa*, and *Pennise tumpurpureum*) feeds, totally for Cereal grain & oilseed cakes and non-conventional feeds, cobalt (Co) concentration was not detected from the sampled feeds. The value of Co level in roughages, Cereal grain & oilseed cakes and non-conventional feeds from collected feeds was below the critical level 0.1 ppm. The category of deficient or sufficient is based on the critical values of (McDowell *et al*., 1993; NRC, 2001) (Table 5 and 6).

Interaction effect of mineral concentration in dairy feeds was highly significant ($P < 0.01$) between districts, production system and sampling season (Table 4, 5, and 6).

Table 4 Effect of districts on macro and micro mineral concentration in the study districts

		Macro minerals (% DM)			Micro minerals(mg/kg DM)			
Feed type	Districts	Ca	P	Mg	Cu	Fe	Zn	Co
Roughage n=52	Ada'a	0.59^{ab}	0.49^{b}	1.02^{a}	8.91^{a}	101.78^{b}	33.16^{b}	0.07
	Adama	0.70^{a}	0.73^{a}	1.09^{a}	8.02^{a}	125.17^{ab}	32.17^{b}	0.06
Cereal grain & oilseed cakes n= 65	Ada'a	0.43^{b}	0.59^{ab}	0.58^{b}	8.68^{ab}	89.31^{b}	37.79^{a}	ND
	Adama	0.30^{b}	0.64^{ab}	0.49^{b}	7.05^{b}	142.26^{a}	42.86^{a}	ND
Non-conventional n=23	Ada'a	0.49^{b}	0.75^{a}	0.35^{b}	7.13^{b}	89.09^{b}	32.56^{b}	ND
	Adama	0.59^{ab}	0.74^{a}	0.55^{b}	7.27^{b}	124.95^{ab}	29.77^{b}	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 type		0.0001	0.0134	0.0001	0.0001	0.0013	0.6288	
Districts		0.5465	0.0131	0.3115	0.0002	0.0001	0.7335	
Feed x districts		0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	

ND= not detected; 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 not 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), Ca=calcium; P=phosphorus; Mg=magnesium; Critical level based on (McDowell *et al*., 1993; NRC, 2001)

Table 5 Effect of production system on macro and micro mineral concentration in the study districts

		Macro minerals (%)			Micro minerals (mg/kg)			
Feed type	Production system	Ca	P	Mg	Cu	Fe	Zn	Co
Roughage n=52	Urban	0.59^{ab}	0.54^{b}	0.94^{a}	7.93^{b}	100.16	33.71^{b}	ND
	per-urban	0.66^{a}	0.63^{ab}	1.07^{a}	8.41^{ab}	122.99	31.78^{b}	0.03
Cereal grain & oilseed cakes n=65	Urban	0.43^{bc}	0.61^{ab}	0.42^{b}	7.36^{b}	102.84	41.40^{a}	ND
	per-urban	0.28^{c}	0.63^{ab}	0.66^{b}	8.53^{ab}	130.81	38.46^{a}	ND
Non-conventional n=23	Urban	0.54^{ab}	0.79^{a}	0.45^{b}	9.63^{a}	95.84	33.25^{b}	ND
	per-urban	0.55^{ab}	0.75^{a}	0.44^{b}	6.51^{b}	106.84	29.62^{b}	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 type		0.0001	0.0020	0.0001	0.0533	0.2960	0.0001	
Production system		0.5816	0.4798	0.0264	0.5961	0.0074	0.0342	
Feed x Production system		0.0001	0.0058	0.0001	0.0001	0.0254	0.0001	

ND= not detected; value without superscript =indicated not significantly different; Means with the same superscript of each feed catagories among the production system in the same column (a, b) are not significantly different; Critical level=is concentrations below which feeds aredeficient.(Ca < 0.30%; P < 0.2%; Co < 0.1ppm); Ca=calcium; P=phosphorus; Mg=magnesium; Mg < 0.20%; Cu < 8ppm; Fe < 50ppm; Zn < 30ppm; Critical level based on (McDowell *et al*., 1993; NRC, 2001)

The interaction effect of Ca, P, Mg and Zn concentration of dairy feeds, were highly significant ($P < 0.01$) between districts, production system and sampling season (Table 4, 5, and 6). Whereas, Cu and Zn concentration of dairy feeds were not significantly different ($P > 0.05$) with seasons (Table 6).

Table 6 Effect of season on macro and micro mineral concentration in the study districts

		Macro minerals (%)			Micro minerals(mg/kg)			
Feed type	Season	Ca	P	Mg	Cu	Fe	Zn	Co
Roughage n=52	Dry	0.61^{a}	0.50^{ab}	0.86^{a}	8.47	103.25	32.46^{b}	ND
	Wet	0.63^{a}	0.64^{b}	1.09^{a}	8.49	115.26	33.41^{b}	0.06
Cereal grain & oilseed cakes n=65	Dry	0.35^{b}	0.59^{ab}	045^{b}	7.71	106.24	38.38^{ab}	ND
	Wet	0.38^{b}	0.64^{b}	0.58^{b}	8.01	122.15	41.46^{a}	ND
Non-conventional n=23	Dry	0.50^{ab}	0.65^{b}	0.34^{b}	7.54	95.27	30.15^{ab}	ND
	Wet	0.59^{a}	0.89^{a}	0.54^{b}	7.68	106.13	33.00^{b}	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 type		0.0001	0.0003	0.0001	0.079	0.408	0.0001	
Season		0.702	0.754	0.0009	0.084	0.094	0.857	
Feed x Season		0.0001	0.0001	0.0001	0.124	0.357	0.0001	

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), Ca=calcium; P=phosphorus; Mg=magnesium; Critical level based on (McDowell *et al*., 1993; NRC, 2001)

Table 7 Critical level based macro & micro mineral status of feed resources in different dairy feeds in the study districts

Minerals	Critical	Roughage %		Cereal grain & oilseed cakes %		Non-Conventional feeds%	
N=140	level*	sufficient	deficient	sufficient	deficient	sufficient	Deficient
Ca	< 0.30	87.08	12.92	73.85	26.15	100	-
P	< 0.25	83.0	17.0	97.50	2.50	100	-
Mg	< 0.20	89.10	11.0	100	-	100	-
Cu	< 8ppm	50.77	49.23	23.08	76.92	34.78	65.22
Fe	< 50ppm	100	-	100	-	100	-
Zn	< 0.30ppm	51.92	48.08	88.55	11.45	65.22	34.78
Co	< 0.1ppm	2.27	97.73	-	100	-	100

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

Table 8 Summary of seasonal variation along with production system some macro mineral status of feed resources in different dairy feeds in the study area based on critical level

		Districts N=140								
		Ada'a				Adama				
		Urban		Periurban		Urban		Periurban		Critical
Mineral	Season	Sufficient	Deficient	Sufficient	Deficient	Sufficient	Deficient	Sufficient	Deficient	level
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 feedsare deficient. (Ca < 0.30%; P < 0.25%; Mg < 0.20%; Cu < 8ppm; Fe < 50ppm; Zn < 0.30ppm; Co < 0.1ppm), Ca=calcium; P=phosphorus; Mg=magnesium; Critical level based on (McDowell *et al*., 1993; NRC, 2001); (-)=indicated that either deficient or sufficient.

High proportion of Ca was deficient during dry compared to wet season. Small proportion P was deficient in Cereal grain & oilseed cakes as compared to roughages whilst relatively high deficiency in wet season as compared to dry. The result indicated that high P deficiency proportion occurred in wet season whereas, Ca deficiency occurred in dry season. Moreover, high proportion of Cu and Zn deficiencies occurred in collected feeds in all feed type and season. From the majority of feeds collected, Co was not detected in the laboratory Table 5 and 6.

4 Discussion

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) recommendations for dairy cattle (McDowell *et al*., 1993; NRC, 2001) indicated in (Table 3). The mean calcium value in different types of roughage, Cereal grain & oilseed cakes 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). This indicated that tropical forages feeds are rich in Ca. However, 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). The current results are in agreement with the report of Aschalew *et al*. (2006), which 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 in grass species and crop residues. This finding is in line with the report of Khan *et al*. (2007) that 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, soil, the season of sampling and analytical procedures and technique (McDowell, 2003).

The mean Ca concentration in the oilseed cakes was found to be below the critical level, which is 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. This result is in line with the report of NRC (2001); Fekede *et al*. (2015) reported that the brewery by-products evaluated had much higher Ca content than the maximum tolerable concentration.

The feed resources like roughage, Cereal grain & oilseed cakes, and non-conventional feeds had a high P concentration as compared to the critical level of dairy animals (Table 3). 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 (McDowell *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); 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 (Table 8). This study is in agreement with the result of Tapiwa (2012), which indicated that P was higher in the dry season than in the wet season. This may 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 aluminum 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), which indicated that during the wet season, plants will not contain an adequate amount of phosphorus due to inadequate amounts P in the soil, plant uptake of minerals is slow in the cool and wet conditions. Furthermore, the current study is in agreement with the report of (Fekede *et al*., 2015). The result showed that P content of the wheat bran, wheat middlings, and brewery by-products was fairly within the range of 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), which indicated that the recommended concentrations for dietary magnesium to range within 0.2 - 0.4% of total DMI. However, there were differences in the Mg content of feeds in this study. It may be due to differences between forage species, level of Mg in the soil, influences of locality and climate, growth stage, the proportion of leaf and stem fractions collected for mineral analysis, and season when herbage sampling was done (Radostits *et al*., 2007). Even if in the current study the availability of Mg was high in animal feeds, the dietary Mg availability markedly affected by other dietary components, especially K. High dietary levels of K and N will inhibit Mg absorption from the rumen (Dua and Care, 1995). Moreover, Ca and soluble carbohydrates may respectively increase and decrease dietary Mg requirements of dairy cows. Likewise, an increment in dietary P levels appears to lower the requirements for both Ca and Mg (Judson and McFarlane, 1998). Even though the feeding systems prevailed 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 (Michal, 1999; Garg *et al*., 2003a).

The current study revealed that copper content was below the critical level in the majority of the feed samples (roughages, concentrate and none conventional) analyzed, in all study districts, production systems and seasons. The result of this work is in line with that of Tiwary et al. (2007b) which 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 current result disagree with the report of Fekede *et al*. (2015),which indicated that the majority of feeds like wheat bran, wheat middlings, brewery by-products' Cu concentration satisfied the dairy requirements. However, the concentration of Cu obtained from such feeds was deficient. This might be because of high iron concentration and also molybdenum in the soil of the study area, which in turn reduces the copper availability in plants (Underwood, 1977; Gustavo *et al*., 2016). Moreover, the report of Sharma *et al*. (2005) showed that copper deficiency in livestock can result from low dietary Cu levels, 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). Therefore, copper contents in the majority of dairy feeds are below the critical level. As a result, copper deficiencies in forages can cause poor reproduction, broken bones, weak calves, scours and discoloration normally occur, first around the eyes and tips of the ears. Its supplementation in the ration of animals is very essential.

Iron is reported to be most abundant in this study, the content in different feed samples (roughages, concentrate and none conventional) analyzed, showed adequate to high levels, comparing to critical level < 50 ppm (McDowell *et al*., 1993; NRC, 2001). The current study showed a significant ($P < 0.05$) effect of districts on the concentration of Fe in the analyzed feeds items. The season had no significant effect ($P > 0.05$) on Fe concentration of analyzed feeds. On the contrary, with the current study, Lemma, *et al*. (2002) indicated that feeds 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 & oilseed cakes and none conventional 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; ZafarIq, 2006). In the current study, even roughages contained a very high concentration of Fe, which were a poor source for many other mineral elements.

The average zinc 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) which showed that Zn content was below the critical level in all the straws except some roughage feeds. This low forage Zn concentration observed in this study may be due to plant maturity and the tissue type of plants taken for analysis. However, the efficiency of Zn utilization of these forages would depend on zinc bioavailability and its interaction with other mineral elements. Metallic cations such as Ca, Fe and Mn, when found in high concentration, interfere with plant Zn uptake (Tisdale *et al*., 1985; Elisa *et al*., 2018). Excess iron inhibits the utilization of zinc and copper by plants and thus results in a secondary deficiency in plants (Underwood, 1977; Gustavo *et al*., 2016).

The mean cobalt concentration in the majority of dairy feed samples was found to be below its critical level. That was some roughage feeds were found to be fairly deficient in cobalt concentration. The result of current study when compared to previously reported study by McDowell (2003) indicated that forages consistently contain less than 0.08 ppm Co, the Co deficiency in dairy animals. In the majority of dairy feeds, it was not detected this might be due to high soil Mn content 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 Conclusions and Recommendations

The present study was carried out with the objective of assessing the status of some macro and micro-minerals in dairy feeds. In the study area based on seasons, roughages were found to be the main source of feeds in the ration of dairy cows (Natural grass hay, *Triticum aestivum*, and/or *Eragrostis tef*). It was noticed that some of the dairy producers fed improved forages like *Pennisetum purpureum*, *Avena sativa*, *Medicago sativa*. It was evident from the present study that majority of the dairy cows feeds analyzed, only 26.92%, 66.15% for roughage (natural grass hay, sugar cane tops, and silage) and concentrates (noug seed cake, ground maize, cotton seed cake, and lean seed cake), respectively, were deficient for Ca. Moreover, the concentration of Cu compared to the critical value (< 8ppm) of analyzed feeds types (19.23%, 76.92%, 65.22%) for roughage (*Triticum aestivum*, *Medicago sativa*, *Pennisetum purpureum*), Cereal grain & oilseed cakes (wheat bran, wheat middlings, noug seed cake, cottonseed cake and concentrate mix) and non-conventional feeds (brewery by-products industrial, poultry liters) respectively. Likewise, Zn concentration in feeds analyzed was only 48.08% and 34.78% deficient compared to critical levels for roughage (natural pasture, *Pennisetum purpureum*, sugar cane top) and non-conventional feeds (brewery by-products industrial), respectively. Moreover, Co was not detected from the majority of feeds implying that Co from sampled feeds was below the critical level. Due to such deficiency of minerals, production, and productivity, as well as the health of dairy cows were severely affected. However, the levels of P, Mg and Fe in all analyzed feeds were found to be sufficient to meet estimated nutritional requirements for dairy cows.

Therefore, among analyzed feeds for minerals present in inadequate amounts like Ca, Cu Zn should be supplemented to produce beneficial results on dairy production. Hence, there is an urgent need for appropriate research to develop area specific mineral mixtures that are highly bio-available for supplementation.

Conflict of interest

The authors affirm that there is no conflict of interest in the work described.

Acknowledgment

The authors would like to thank Getu Kitawu, Ms Workinesh Seid, Dr. Sofia, Dr. Diriba Geleti, and Dr. Fekede Feyissa for their technical and all-round assistance. The authors would also like to thank Debreziet and Holota Agricultural research laboratory staffs. This study was partially supported by funds from the Ethiopian Institute of Agriculture Research, AGPII and Addis Ababa University Research and Technology transfer funded thematic research entitled as "Promotion of improved dairy technology and investigation into reproductive diseases of dairy for better health, productivity, and development of the dairy sector".

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