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Macro Mineral Status of Feds in the Central and Western Parts of Ethiopia

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ABSTRACT

Different feed types collected from three altitudinal ranges in the central and western parts of Ethiopia in two different seasons were evaluated for their macro mineral concentrations. Feeds in the selected parts of the country comprised of natural pasture, hay, straws of cereals and food legumes and to a lesser extent cultivated forage crops and agro-industrial by-products. All feed samples were taken directly from the field or supplied by the farmers. The feed samples were analyzed for the macro minerals namely Ca, P, Mg, Na and K. Mineral concentrations were assessed in relation to recommended dietary requirements of sheep. The results indicated a wide variation in macro minerals along with seasons, altitudes, and feed types. Regardless of seasons and altitudes, all feed types were deficient in Na. Natural pasture, cereal straws, cultivated forages and legume straws were found to be deficient in P. Among the macro minerals P, Mg and Na were found to be the most lacking. In situations where forages are fed exclusively, supplementary P, Mg and Na would be required. The insufficiency of Na is the most widespread mineral deficiency in the studied parts of the country. The levels of Ca and K were found to be sufficiently high to meet estimated nutritional requirements of sheep.

Key words: Macro minerals, season, altitude, feed, Ethiopia

INTRODUCTION

Animal production in Ethiopia is predominantly characterized by extensive grazing (Sileshi and Bediye, 1991; Khalili *et al*., 1993a). Natural pasture, hay, straws of different crops, improved pastures and agro industrial by-products comprise the feed resources (Bediye and Sileshi, 1989; Yami *et al*., 1991). Animal production in the highlands of Ethiopia is particularly constrained by shortage of feeds, which becomes severe especially during the dry and cropping seasons (Beyene and Yirga, 1989).

Animals subsist in most of the year on poor-quality pasture and hay and/or crop residues. When such kinds of low-quality feeds constitute the bulk of the feed, provision of supplementary feed is necessary to avoid sever weight losses. With the exception of common salt, the use of commercial feed supplements is limited due to the cost incurred and their unavailability (Sileshi and Bediye, 1991). On the other hand substantial improvements have been reported by supplementing with forage legumes and agro-

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industrial by-products (Yami *et al.*, 1991). Mineral supplementations are also known to improve intake and digestibility of feeds thus resulting in increased animal performance. However, the strategy must be compatible with the existing production system and should continue to have a low-input character. It is noted that mineral content of grazing pasture is influenced by botanical composition of pastures (Long *et al.*, 1970; 1972; Kabaja and Little, 1988; Jumba *et al.*, 1995 a, b), forage species (Morris, 1987; McDowell, 1997), and season of the year (McDowell, 1997; Ramirez-Perez *et al.*, 2000).

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 attention to the mineral content of the total ration frequently leads to increased disease and reproductive problems (Haris *et al.*, 1994). Knowledge of the mineral composition of feeds assists in determining the types and amount of minerals to be supplemented. In Ethiopia, even though information on the mineral content of feeds of different nature (Faye *et al.*, 1983; TDebessai, 1984; Kabaija and Little, 1988; Tolera, 1990; Khalili *et al.*, 1993a and b; Geleti *et al.*, 2001) are available, attention given so far to the mineral status of feeds has been low as compared with other nutrients. Data on the mineral content of feeds of the central and western parts of Ethiopia with particular emphasis to season and altitude are scanty. The aim of this study was to quantify the mineral content of different feeds used in the region as animal feed and to provide a basis for subsequent investigations.

MATERIALS AND METHODS

The study areas

The study was conducted in the central and western parts of Ethiopia located between the coordinates of 8° 45′ to 13° 45′N latitude and 35° to 45° 25′ E longitudes, covering an area of 170752 km^2. The study sites were selected based on their high animal population. The feed samples were collected from the three altitudinal ranges, varying from 1400 m up to 3700 m above sea level (a.s.l.) in the wet and dry seasons. The high altitudinal range comprised areas having above 2500m a.s.l., the mid-altitude areas lied between 1500-2500m a.s.l. and areas below 1500m a.s.l. were designated as lower altitudes.

Sample collection, preparation and analysis

Total of 176 feed samples were collected during the wet and dry seasons from the three altitudinal ranges of the central and western parts of Ethiopia. The sample comprised grazing pasture, natural pasture hay, browse species, crop residues, cultivated forage crops and agro industrial/home by-products (IHBP). Samples were kindly delivered by farmers from the feeds that were provided to animals or harvested with their cordial consent after careful observation of grazing animals. Feed samples were identified at the spot, and further confirmed at Addis Ababa University, Biology Department. From each sample, a minimum of 300g feed was dried at 60°C for 72 hours until a constant weight was obtained. The dry samples were ground to pass through a 1-mm sieve and kept in airtight cups till analysis. Analyses were done for Ca, Mg, Na, and K using atomic adsorption spectrophotometer and P was determined using an Auto Analyzer (Chemical Laboratory Instruments Method No.W2-075-01) at the International Livestock Research Institute (ILRI) Addis Ababa, Ethiopia. The macro mineral concentrations of the feeds were categorized into deficient, border line and sufficient based on the mineral requirement of sheep outlined by McDowell (1997). Minerals below, in the range and above the set standard of requirements were categorized as deficient, border line and sufficient level, respectively. The mean of macro minerals in the feeds was computed using the Statistical Analysis System (SAS, 1999). The percentage of the macro minerals was calculated based on the value obtained for each feed. Then the feeds were grouped by altitude, season, and types for comparison. In each category the number of feeds falling within each level (deficient, border line or sufficient) were counted and converted into percentage basis to indicate the magnitude of each macro mineral in its respective category.

RESULT

Mean values of the micro minerals of feeds collected from the selected sites are given in Table 1. Browse species, improved forages, straws of food legumes and grazing pasture fullfilled the minimum level of Ca (Table 1). Out of the total feeds analyzed only 4.55% were found to be deficient in Ca. The ranges of Ca concentration went from 0.13 for wheat/barley mixed straws to 4.99% for *Sesbania sesban.* This indicated the richness of browse species in their Ca content. The phosphorus level was found to be sufficient only in 11.00% of the feeds analyzed. By-products were found to be richer in P content than the other feed types. The ranges of P went from 0.06 of *Trigonella foenum-graecum* to 1.78 for *G. abyssinica* (Table 1). The ranges of Mg varied between 0.07 of wheat straws to 0.72 % of a mixture of *G. abyssinica* and *Carthamus abyssinica* cakes. Out of the tested feeds, 31.82 % were found to be deficient in Mg content. The lowest level of Mg was found in wheat straws, while relatively higher amount of Mg was found in the unimproved indigenous browse trees. Among all minerals analyzed, Na was found to be the most deficient macro mineral, the majority of the browse species, cereal straws and by-products being deficient to meet animal requirements. On the contrary, the K concentration was found to be adequate in most of the feeds analyzed (Table 1). Among the local browse species, the highest concentration of P, Mg and K were found in Cordia *africana*, and that of Ca was found in *Sicus sycommorus* species.

Comparatively, a higher number of feed samples were collected from the higher altitudes (133) as compared to mid and lower altitudinal ranges (43). This was mainly due to the inaccessibility of the areas (mid and lower) and the wide diversity of crops grown in the higher altitudes. Apart from this the highland, the farmers had a good experience in conservation and utilization of crop residues and natural pasture hay to overcome feed shortages during the dry season. To show the macro mineral status of feed resources in the study area, the feeds collected from the three altitudinal ranges were categorized into deficient, border line and sufficient in terms of their macro mineral content. The status is summarized in (Table 2).

Calcium was found to be deficient in 6.06% of the feeds collected from the higher altitude areas while the remaining balance at least satisfied the minimum requirement set for sheep. Forty, 54.55 and 42.11% of the feeds of low, mid and high altitude areas respectively were found to be deficient in their P concentration. With regard to Mg 10.00% of the lower altitudes, 36.36% of the mid and 32.56% of the higher altitudes were found to be deficient. Livestock of the mid altitudes were more liable to Mg and P deficiencies and needs attention to fullfill the requirement of these minerals. Na was found to be the most deficient minerals. Feeds coming from the lower altitudes were absolutely deficient, and 96.97 and 84.96% of the feeds from the mid altitude and higher altitudes areas, respectively were found to be deficient. To avert this phenomenon, the tradition of common salt supplementation should be encouraged at large, till a better solution is developed. Potassium contents of the feeds were found to be deficient only in 3.03% of the feeds in mid and 9.77% of the feeds in higher altitude areas (Table 2).

Table 1 Macro mineral concentrations in different feeds (% dry matter basis).

Scientific/Common name	No sample	DM%	Ca	P	Mg	Na	K%
Erica aroborea	2	92.07	0.47	0.11	0.19	0.014	0.61
Hypericum lanceolatum	2	89.18	0.64	0.21	0.20	0.005	0.98
Zizyphus spina	3	89.34	2.21	0.24	0.30	0.003	1.09
Cordia Africana	1	88.14	3.34	0.29	0.67	0.005	3.03
Sicus sycommorus	1	88.16	4.06	0.22	0.66	0.005	1.18
Euclea spp.	2	89.26	2.01	0.21	0.56	0.003	1.51
Phalaris spp	4	89.82	0.45	0.19	0.18	0.239	2.22
Vicia spp	6	89.48	2.19	0.21	0.40	0.041	2.57
Beta vulgaries	1	94.46	0.43	0.09	0.30	0.348	2.18
Sesbaina sesban	1	89.51	4.99	0.34	0.47	0.355	1.24
Chamaecytisus palmensis	5	89.93	1.28	0.18	0.40	0.100	1.22
Avena sativa	6	89.23	0.37	0.13	0.14	0.047	1.72
Pisum sativum	4	90.69	1.13	0.12	0.17	0.027	2.13
Vicia faba	3	90.26	1.43	0.18	0.19	0.328	2.53
Trigonella foenum-graecum	3	90.07	1.97	0.06	0.16	0.110	1.62
Lens clinaris	3	90.44	1.55	0.12	0.26	0.012	1.86
V. faba+ P. sativum	1	90.65	3.90	0.12	0.08	0.159	1.18
Hordeum vulgare	20	91.00	0.43	0.17	0.09	0.414	1.56
Triticum aestivum	11	91.44	0.30	0.09	0.07	0.025	1.15
Eragrostis tef	8	91.33	0.37	0.13	0.12	0.007	1.07
H .vulgare + T. aestivum	2	90.30	0.13	0.23	0.12	0.053	0.85
Eleusin coracana	1	91.20	1.03	0.28	0.10	0.003	1.5
Korefe	10	90.67	0.39	0.34	0.17	0.014	0.43
V. faba+ P. sativum hull	2	90.25	0.51	0.15	0.18	0.033	0.76
Lens clinaris	4	89.58	0.34	0.40	0.20	0.020	0.72
Guizotia abyssinica	4	91.11	0.92	1.78	0.60	0.002	1.71
G. abyssinica + Carthamus abyssinica	1	91.47	0.58	1.31	0.26	0.002	1.13
Flour by-product	2	90.26	0.30	0.34	0.16	0.056	0.80
V. faba hull	1	90.88	0.50	0.29	0.12	0.005	1.13
P. sativum hull	1	89.75	0.41	0.37	0.13	0.003	1.21
G. abyssinica + Brassica spp.	1	91.16	1.01	1.39	0.72	0.003	1.56
Hay	20	90.60	0.71	0.23	0.17	0.033	1.76
Andropogon, Trifolium, pennistum	15	90.01	0.82	0.22	0.31	0.038	1.94
Thymus serrulatus	4	89.33	1.41	0.18	0.24	0.010	1.58
Festuca abyssinica	2	90.99	0.51	0.15	0.11	0.008	0.84
Hypernia spp.	6	90.70	0.47	0.13	0.24	0.004	1.11
Grazing pasture	13	90.94	0.67	0.15	0.18	0.070	1.76

Korefe: a by-product of home prepared brewery

Table 2 Requirement based macro mineral status of feed resources in the three altitudinal ranges[1].

Minerals		Higher altitudinal range			Mid altitudinal range			Low altitudinal range		
	Requirement%	Deficient	Border line	Sufficient	Deficient	Border line	Sufficient	Deficient	Border line	Sufficient
Ca	0.20-0.82	6.06	65.15	28.79	27.27	72.73	-	-	30.00	70.00
P	0.16-0.38	42.11	48.12	9.77	54.55	42.42	3.03	40.00	60.00	-
Mg	0.12-0.18	32.56	24.81	42.64	36.36	27.27	36.36	10.00	10.00	80.00
Na	0.09-0.18	84.96	8.27	6.77	96.97	3.03	-	100.00		
K	0.50-0.80	9.77	12.78	37.44	3.03	3.03	93.94	-	30.00	70.00

[1] The figures indicate percentage of feed resources in the three altitudinal ranges that are deficient, border line or sufficient in macro minerals

Macro mineral status of different feed resources during the two seasons is given in Table 3. As shown in the table there is a distinct variation in mineral concentration of the feeds during the two seasons. The general trend indicated that most of the feeds of the dry season fell in the category of deficient to border line than that of the wet season in all the macro minerals. 7.45% of the feeds were found to be deficient in calcium concentration in the dry season as opposed to 1.22% of the wet season feeds indicating that Ca level was quite enough to meet the need of the animals in the wet season. The same held true for P content. More percentage of feeds (53.19%) was found to be deficient in the dry season as opposed to the wet season (34.15%). In Mg, 56.38 and 6.10% of the feeds were found to be deficient in dry and wet seasons respectively. This signified high deficiency of Mg in the dry season. Though Na concentration of the feeds was very low in both seasons, relatively more feeds were deficient in dry season than in wet season. About 95% and 84% of the feeds sampled in the dry and wet seasons respectively were found to be deficient in Na. Effects of season on K contents of feeds were found to be minimal when compared with the other macro minerals. Only 12.77 of the feeds in the dry season and 3.66% of those in the wet season were found to be K deficient. About 73% and 89% of the feeds during the dry and wet seasons respectively had sufficient amount of K that covered requirements ranging from 0.09-0.18%.

Table 4 indicates the percentage of different feed types that are deficient, border line or sufficient in macro mineral concentration. About 51, 17, 10, and 88% of the grazing pasture were deficient in P, Mg, K, and Na respectively. Na was found to be the most detrimental minerals for indgenious browse species and straws of forage legumes respectively. However, browse species were rich enough in Ca and none of them were deficient in Ca content (Table 1 and 4). IHBP were found to be deficient in Na (96.15%), K (34.65%),

Table 3 Status of Macro minerals of feeds sampled in dry and wet seasons[1].

Minerals		Dry Season			Wet Season		
	Requirement %	Deficient	Border line	Sufficient	Deficient	Border line	Sufficient
Ca	0.20-0.82	7.45	68.09	24.45	1.22	60.98	37.80
P	0.16-0.38	53.19	37.23	9.57	34.15	53.66	12.20
Mg	0.12-0.18	56.38	28.72	14.89	6.10	14.63	79.27
Na	0.50-0.80	95.38	3.08	1.54	83.78	9.01	7.21
K	0.09-0.18	12.77	13.83	73.40	3.66	7.32	89.02

[1] The figures indicate percentage of feeds that are deficient, border line or sufficient in macro minerals during the two seasons.

Table 4 Macro mineral status of different feed types in the study area[1].

	Calcium			Phosphorus			Magnesium			Sodium			Potassium		
Feed types	Deficient	Border line	Sufficient	Deficient	Border line	Sufficient	Deficient	Border line	Sufficient	Deficient	Border line	Sufficient	Deficient	Border line	Sufficient
Grazing. pasture	-	70.73	29.27	51.22	43.90	4.88	17.07	14.63	68.29	87.80	7.32	4.88	9.76	2.44	87.80
Hay	20.00	80.00	-	15.00	80.00	5.00	25.00	35.00	40.00	95.00	5.00	-	-	10.00	90.00
Cereal straws	9.52	88.10	2.38	71.43	26.19	2.38	76.19	23.81	-95.24	2.38	2.38	-	16.67	83.33	
Food legume straws	-	13.33	86.67	86.67	13.33	-	26.67	33.33	40.00	66.67	26.67	6.67	-	6.67	93.33
Agro industrial by-product	15.38	69.20	15.38	7.69	38.46	53.85	19.23	30.77	50.00	96.15	3.85	-	34.61	23.08	42.30
Browse	-	36.36	63.64	27.27	72.73	-	18.18	81.82	-100.00	-	-	9.09	27.27	63.64	
Improved forages	-	47.83	52.17	47.83	52.17	-	8.70	26.09	65.22	73.91	8.70	17.39	-	4.35	95.65

[1] The figures indicate percentage of each feed type that are deficient, border line or sufficient in that given mineral.

Mg (19.23%), Ca (15.38%) and P (7.69%). Relatively, the lower percentage of P deficiency in the IHBP as opposed to other feeds indicated that these feed resources to contain adequate P level to be used as P supplement. When ever by-products are used in animal feeds, attention should be given to correct K and Na levels.

Cereal straws were found to be deficient in P, Na and Mg, while straws of food legumes were highly deficient in P. Comparatively, less percentage of straws of food legume was categorized as Na deficient compared to the other feed types. Among all feed types, straws of cereal crops and food legume were found to be low in P, since 71.63 and 86.67% of the corresponding feeds were classified to be deficient in P level. The P level should get special consideration when ever these feeds constitute the bulk of the ration, and hence other sources of P should be incorporated to overcome the P insufficiency.

Though, 73.91% and 47.83% of the improved forages were found to be deficient in Na and P respectively, their status in terms of deficiency in other minerals was found to be better than the other feed types. Again, a considerable attention should be given to Na and P when these feeds are used. In case of grazing pasture hence, attention should be given to correct the deficiency as most of the livestock rely on grazing.

DISCUSSION

For the simplicity of discussing the levels obtained, the macro minerals were rated against the standard sets given for sheep by McDowell (1997). Sheep were used in because the selected parts of the country have high sheep populations (Annual Statistical Bulletin, 2004).

The Ca values of the feeds (Table 1) were higher than those reported by Khalili *et al*. (1993a) and Geleti *et al*. (2001) for the western and central highlands of Ethiopia, respectively, and comparable with that of TDebessai (1984) reported for the eastern part of the country. The result of Kabaija and Little (1988) was comparable for browse species and found to be less for hay and crop residues collected from southern and central parts of the country. Ogebe *et al*. (1995) reported a similar value for tree leaves and crop wastes. However, the value reported for grass was below the values obtained in this study. This disparity could be due to a difference between species (Long *et al*., 1970; 1972), as the samples were not of the same type. Geleti *et al*. (2001) reported a higher and significant level of Ca during the wet season than in the dry season. This finding was in agreement with the current study, where the percentages of feed that were found to be deficient were lower (1.22%) in the wet season as compared with of the dry season (7.45%). TDebessai (1984) also reported that out of the 86 green feeds analyzed during the wet season for Ca, none of them contained below the critical level. This finding agreed with the current study confirming that about 99% of the wet season feeds fullfilled the minimum level of Ca given by McDowell (1997) for sheep (Table 3). Since age, vitamin D level, hormonal blood level and balance, amount of calcium fed, composition of diet, calcium status of animal, and the form of calcium fed had influence on the absorption and retention of calcium, Peeler (1972) suggested that the Ca content of a feed should be evaluated based on the amount absorbed rather than on its analytical content. About 13% of the feeds were found to be deficient in K in the dry season as opposed to 4% in the wet season. This was in agreement with the findings of Kabaija and Smith (1989) who reported seasonal differences in K concentration. The K value of hay, crop residues and browse species were reported by TDebessai (1984); Kabaija and Little (1988) and Bediye and Fekadu (2000) were comparable with this finding (Table 1).

Among all feed classes, K was found to be highly deficient in by-products (34.61%) as compared with 9% deficiency level of (grazing pasture and browse species), and nil for the other feed types (Table 4). This finding was in agreement with McDowell (1997) who reported a high deficiency of K in concentrate diets.

Relatively a higher amount of P was obtained from agro industrial by-products, the least amount was obtained from straws (Table 1). The lowest P was obtained from fenugreek (*Trigonella foenum-graecum*), which indicated the scanty concentration of P in food legume straws (Table 1). The value reported by Kabaija and Little (1988) for hays, crop residues and browse species was comparable with this finding. By-products contained the highest P levels with 92.31% being between border line and sufficient levels. This was by far higher than the P content of any other feed types (Tables 1 and 4). Kabaija and Little (1988); obtained a high level of P from cotton and noug (*Guizotia abyssinica*) cakes. About 51, 71, 48 and 87% of the grazing pasture, cereal residues, improved forages and legume straws were found to be deficient in P respectively (Table 4). Hence supplementation with P is likely to be beneficial in feeding systems that employ these feeds. To this end access to bone meal or licks containing phosphorus is recommended to overcome the deficiency (French, 1955).

The value obtained for Na (Table 1) was comparable with that of Khalili *et al*. (1993a) and TDebessai (1984) reported for various types of feeds and with that of Kabaija and Little (1988) given for hay and crop residues. Even though the magnitude varied, Na deficiency was observed in all feeds in both seasons, and in the three altitudinal ranges. This was in agreement with that the findings of Kemp and Guerink (1978) and McDowell *et al*. (1993) who reported Na as the most deficient mineral of free ranging animals.

The Mg value obtained for natural pasture was in line with that of Kabaija and Little, (1988) and Geleti *et al*. (2001) and was lower than that given by TDebessai (1984) and Bediye and Fekadu (2000) for forages, cereal straws and browse species. As observed in the demonstration sites of the ministry of agricultural and in the fields of 'contact farmers', there is a potential to develop improved forages in the region as intercropping, alley farming, and back yard crop. This approaches warrants encouragement as improved forages were found to be adequate in most of the minerals with the exception of Na. This was mainly due to the fact that they were cultivated for their high biomass yield and nutritional quality. However, relatively the Na content of improved forages were better than that of the other feed types (Tables 1 and 4), being preceded only by straws of food legume.

Altitude influences the mineral concentrations (Tables 2) of feeds. In the higher and mid altitude areas a considerable percentages of feeds were found to be deficient in minerals. In the higher altitudes, 6.06, 42.11, 32.56, 84.96 and 9.77% of the feeds were found to be deficient in Ca, P, Mg, Na, and K, respectively, while about 27, 55, 36, 97 and 3% of the feeds in mid altitudes were found to be deficient in Ca, P, Mg, Na, and K, respectively. Among the feeds of the mid altitudinal ranges, a mixture of wheat/barley straws contained the highest P (0.37%), Na (0.01%) and the lowest K level (0.58%) and Ca (0.12%). In the lower altitudes Na was found to be absolutely deficient in all feeds (Tabale2) as opposed to 84.96 and 96.97% of the high and medium altitudes respectively.

When seasons were compared (dry and wet), the largest numbers of feeds were collected in the wet season. This was mainly because of the well established tradition of farmers in conserving feeds for dry season usage. Though the influence exerted in wet season on K and Ca seemed lighter as compared with other minerals, the influence of season was observed in all macro minerals investigated. The results indicated that the dry period feeds contain less macro minerals than the wet season feeds which was in line with McDowell (1997). Geleti *et al*. (2001) also reported that feeds of wet season contained a higher amount of minerals than the dry season feeds. McDowell (1997) stated that P% dropped from 0.3% in the early growing season to less than 0.15% after maturity. The same author further stated that mineral content to decline as plants mature (McDowell, 1985). Hence a close attention of animals is suggested to alleviate particularly the deficiency of P, Mg, and Na.

CONCLUSION

Mineral deficiencies are known to lower the performances of animals especially of those which derive their feed from natural pasture and crop residues. The results obtained in this study clearly indicated that there was mineral deficiency in the area particularly of P, Mg and Na while the level of Ca and K seemed to be adequate in most of the feeds. Attention should be given to correct the deficient minerals especially Na and P as these minerals are the most lacking minerals in the studied area. This end studies that evaluated the effect of minerals deficiency up on the productivity of animals should be carried out to come up with an applicable recommendation. Any feeding system based on those feeds should take into account minerals that are lacking and hence should go for additional supplementation to alleviate the deficiency.

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LITREATURE CITED

Bediye, S. and D. Fekadu. 2000. Potential of tef straw as livestock feed. pp.245-254. *In* H. Tefera, G. Belay and M. Sorrells (eds). Narrowing the Rift. Tef Research and Development. **Proceedings of the International Workshops on Tef Genetics and Improvement.** 16-19 October 2000. Debre Zeit, Ethiopia. of some Ethiopian feed staffs.

Bediye, S. and Z. Sileshi. 1989. Feeding value of some Ethiopian feed staffs, pp. 179-185. *In* **Proceedings of the Second National Livestock Improvement Conference.** 24-26 February, 1988. IAR. Addis Ababa, Ethiopia.

Beyene, H. and C. Yirga.1989. Initial results of informal survey Inewari, and Sendafa-Aleltu areas of northern Shewa. **Working paper No. 9**. Institute of Agricultural Research, Addis Ababa, Ethiopia. 29p.

Faye, B., C. Grillet, and A.Tessema, 1983. **Report on survey of trace element status of forages and blood of domestic ruminants in Ethiopia.** National Veterinary Institute, Debre Zeit, Ethiopia.

French, M.H. 1955. Earth eating and the mineral needs of livestock. **East Afr. Agric. J**. 20:169-175.

Geleti, D., T. Diriba, L. Gizachew and A. Hirpha. 2001. Effect of season and location on mineral concentration of natural pasture in Bako area, western Ethiopia. **EJAP.** 1:33-43.

Harris , B., Jr. A.L, Adams and H.H. Van Horn. 1994. Mineral needs of dairy cattle. University of Florida.

Jumba, I.O., N.F. Suttle, E.A. Hunter and S.O. Wandiga. 1995a. Effect of soil origin and mineral composition of forages in the Mount Elgon region of Kenya 1. Calcium, phosphorus, magnesium, and sulphur. **Trop. Grassl**. 29:40-46.

_______. 1995b. Effect of soil origin and mineral composition of forages in the Mount Elgon region of Kenya 2. Trace elements. **Trop. Grassl**. 29:47-52.

Kabaija E. and D.A.Little. 1988. Nutrient quality of forages in Ethiopia with particular reference to mineral elements, pp. 440-448. *In* African forage plant genetic resources evaluation of forage germ plasm and extensive livestock production systems. **Proceedings of the Third Pasture Network for Eastern and Southern Africa (PANESA)** workshop held at the International Conference Centre, Arusha, Tanzania, 27-30 April 1987. ILCA, Addis Ababa.

Kabaija E. and O.B. Smith 1989. Influence of season and age of regrowth on the mineral profile of *Gliricidia sepium* and *Leucaena leucocephala*. **Trop. Agric. (Trinidad)** 66: 125-128.

Kemp, A. and J.H. Guerink. 1978. Grassland farming and mineral in cattle. **Neth. J. Agric. Sci**. 26: 161-169.

Khalili M., E. Lindgren and T. Varvikko 1993a. A survey of mineral status of soils, feed and cattle in the Selale Ethiopian highlands. I. Macro elements. **Trop**. **Anim. Hlth** Prod. 25: 162-172.

_______. 1993b. A survey of mineral status of soil, feeds and cattle in the Selale Ethiopian highlands. II. Trace elements. **Trop. Anim. Hlth Prod**. 25: 193-201.

Long, M.I.E., B. Marshall, W.K. Ndyanabo, and D.D.Thornton. 1972. The mineral status of dairy farms in eastern Uganda: Nitrogen and mineral contents of grasses and some mineral contents of bovine plasma. **Trop. Agric. (Trinidad**) 49:227-234.

Long, M.I.E., D.D. Thornton, W.K. Ndyanabo, B. Marshall and H. Ssekaalo, 1970. The mineral ststus of dairy farms in the parts of Buganda and Busorga bordering Lake Victoria, Uganda. **Trop. Agric. (Trinidad)** 47:37-50.

Maynard, L.A. and J.K. Loosli, 1969. Animal Nutrition 2nd ed, McGraw Hill. New York.

McDowell, L.R. 1985. Nutrition of grazing ruminants in warm climates. Academic press, New York.

McDowell, L.R. 1997. Minerals for grazing ruminants in tropical regions. 3rd ed. University of Florida, Gainesville, Florida. 81p.

McDowell, L.R., J.H. Conorad and F.G. Hembry. 1993. Minerals for grazing ruminants in tropical regions. 2nd ed. Bulletin, University of Florida, Gainesville, Florida.

Morris, E.R. 1987. Iron, pp. 79-142. *In* W. Mertz, (ed.). **Trace elements in human and animal nutrition.** Academic Press, New York.

Ogebe P.O., J.A. Ayoade, L.R. McDowell, N.S. Wilkinson and F.G. Martin. 1995. Mineral concentrations of forages and soils in Benue State, Nigeria. I. Macro minerals and forage *in vitro* organic matter digestibility and crude protein concentrations. **Commun. Soil Sci. Plant Anal**. 26: 1989-2007.

Peeler H.T. 1972. Biological availability of nutrients in feeds: Availability of major mineral ions. **J. Anim. Sci**. 35: 695-712.

Ramirez-Perez, A.H., S.E. Buntinx, and R.Rosiles. 2000. Effect of breed and age on the voluntary intake and macro minerals status of non-pregnant sheep. II. Micro-mineral status. **Small Rumin. Res**. 37:231-242.

SAS. 1997. SAS Institute Inc, SAS user's Guide, Basics, Cary, North Carolina.

Sileshi, Z. and S. Bediye. 1991. Utilization of feed resources and feeding systems in the central zone of Ethiopia, pp. 129-132. *In* Proceedings of Third National Livestock Improvement Conference. 24-26 May 1989. Addis Ababa, Ethiopia.

TDebessai. W. 1984. **The mineral and crude protein content of some feedstuffs produced in Jijiga awraja and Gursum woreda, Eastern Ethiopia.** MSc Thesis, Addis Ababa University. Ethiopia.

Tolera, A. 1990. **Animal production and feed resource constraints in Welayta Sodo and the supplementary value of *Desmodium intortum*, *Stylosanthes guianensis* and *Macrotyloma axillare* when fed to growing sheep feeding on a basal diet of maize stover.** MSc Thesis, Agricultural University of Norway.

Yami, A. Z. Sileshi and S. Bediye 1991. The potential of crop residues and agro-ndustrial by products as animal feed, pp. 57-64. *In* the **Proceedings of the Third National Livestock Improvement Conference.** 24-26 May 1989, Addis Ababa, Ethiopia.