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Seasonal and Regional Variations in Mineral Content of Some Important Plants Species Selected by Camels (*Camelus dromedaries*) in Arid and Semi-arid Lands (ASAL) of Sudan

[1]Shamat, A.M., [2]Babiker,I.A, [3]Mukhtar, A.M.S. and [1]Ahmed, F.A.

[1]Ministry of Science and Technology, ARRC, Sudan
[3]Department of Animal Nutrition, Faculty of Animal Production, University of Khartoum, Shambat, Sudan
[2]Department of Animal Production, Faculty of Agriculture, University of Zalingei, Sudan

Abstract: Twenty-nine of browse plant species that recommended by camel herders (trees and shrubs) and 24 forage types of crop residues, grasses and forbs were collected by hand plucking and clipping from Western Sudan during dry and wet seasons. Using the same procedure and seasons of the year, 26 browse samples of predominantly trees and shrubs and 27 samples of crop residues, grasses and forbs were collected from the eastern part of Sudan, to study the seasonal and regional variations in mineral content of these collected plant types selected by camel. The results revealed that, in both seasons of the year, the mineral contents in browse plants were significantly ($P<0.01$) higher than those in forages in western and eastern arid and semi-arid dry lands in Sudan, with the exception of, (Fe) and (Mn) levels which were found to be higher ($P>0.05$) in forage than in browses. Again some macro elements (Ca), (K) and (Na) and other microelements (Mn and Fe) detected in browse samples, were significantly ($P<0.05$) higher in the plants of western region than those of the eastern region of Sudan. There was no significant ($P>0.05$) effect of the season of the year on the mineral contents of the browses except for Ca, K, Zn and Co which tended to be increased in wet season. In forages samples detected, higher levels of Ca, Na, Co, Mn and Fe were detected during dry seasons while K, P, Cu, Zn and Mo levels increased during wet seasons. The interaction of effect of regions and seasons on mineral concentration of browse and forages showed variable results

Key words: macro elements, Ca, P, camel production, browse, forage

INTRODUCTION

The vital role of energy and protein of the feed to livestock maintenance and production is well known, but the optimal performance of animals is only possible when there is an adequate supply of minerals and vitamins[18]. Many researchers[43,42,6] considered that the sub-optimal mineral deficiency that affects growth and production is more serious than the manifested mineral deficiency that showing signs which could be identified and corrected. Camels depend on pasture lands to obtain their mineral requirements, but rarely forage can satisfy these requirement[24]. The importance of minerals to livestock is well known and their deficiency will be manifested by reduced milk yield, reduced water intake, increased straying in search of salty plants, chewing bones and eating soils.

Dioli and Stimellmayr[7] Bornstein[4] reported that, mineral deficiency increases the susceptibility to skin diseases, other observation claimed by camel herders that, they have seen their calves born with bent or weak legs, but recovered later. This indicates that mineral deficiency with special reference to macro elements posing more constraints to camel performance. In Sudan, the (P) content of pasture grasses drops during dry season. Tropical legumes generally contain high concentrations of most of the mineral elements except (Na)[8]. However, nutritional requirements may not always be met since availability for absorption and function varies with each element[30]. For efficient livestock production in pasture, deficient nutrients must be supplied at a minimum level to make up differences in animal daily requirements. Identification of the deficient nutrients is then the first key step in systematic or planned camel production management. Some investigations had been done to map out areas of marginal mineral deficiencies e.g. liver samples from abattoirs, soils and herbage at western Sudan to detect areas of copper deficiencies[41] but more efforts were needed in this field.

The objectives of this study is to investigate the nutrients status, with special regard to some important minerals of the browse trees, pasture grasses ,grass hay and crop residues used as camel feed in Sudan during dry and wet seasons to add some important information to the camel feed nutrient profile in Sudan.

Corresponding Author: Shamat, A.M., Ministry of Science and Technology, ARRC, Sudan

MATERIALS AND METHODS

The plant samples which are recommended by herders in different regions and the predominant species of plants found with each grazing area. The parts eaten (branches, leaves and fruits in the case of browse, and leaves and stems in the case of forage were collected by hand plucking and clipping or were cut with a sickle and freed from soil particles) during dry and wet season. Samples of crop residues of mechanized and traditional rain fed areas and schemes are collected using the same procedures as for natural land forages. Their local and botanical names were identified; regional plant samples were pooled according to species. After being air dried, cut into pieces (2 to 5 cm), and ground in a hammer mill to pass through (1) mm screen and mixing, 50 g sample was collected into plastic bags for subsequent chemical analysis. In this study, for plant feed of camel in eastern and western Sudan the term 'forage' refer to common crop residues, pasture grasses and forbs; whereas 'browse' for shrubs and trees (as are called hereafter). Twenty-nine browse samples of predominantly trees and shrubs and 24 forage types of crop residues, grasses and forbs were collected from western Sudan in dry and wet season. From eastern Sudan twenty-six browse samples of predominantly trees and shrubs and 27 of crop residues, grasses and forbs were collected in dry and wet seasons.

Plant Wet Digestion Method for Mineral Content Analysis: Plant samples ranges between 0.5 and 2.0 g were prepared for mineral analysis by the wet digestion method. The samples are placed into digestion vessels, kjeldhal flasks, using concentrated nitric acid and70% perchloric acid heated slowly at a low temperature. After digestion, the samples are diluted to the appropriate volume with deionized water. According to UNICMP 929 atomic absorption spectroscopy cook book manual. Working standards prepared using the extracting solution. For calcium and magnesium determination, the final sample dilution and standards should contain 1% lanthanum as a releasing agent and to overcome potential interferences e.g. from phosphorus and alkali metals. Calcium (Ca), magnesium (Mg), iron (Fe), manganese (Mn), zinc (Zn), cobalt (Co), molybdenum (MO) and copper (Cu) were determined using air/acetylene flame and D_2 corrector of the atomic absorption spectroscopy (AAS), UNICAM 929. © Unicam Limited (Division of analytical Technology Inc.), 1991, Cambridge, UK. The concentrations of potassium (K) and sodium Na) determined by flame photometer (Corning) whereas phosphorus (P) determined spectrophotometrically at 440 µm according to fertilizers and feedingstuffs regulations[17], after diluting the ash extract (1:20) and an aliquot of this reacted with ammonium vando molybdate reagent, to form the orange-yellow complex vanadium phosphomolybdate.

RESULTS AND DISCUSSION

Mineral Concentrations of Browse and Forage: The mineral contents, of the browse samples collected are presented in table (1) and that of forage in table (2). The mineral contents in browse were significantly P<0.01) higher than in forages in both season ,with the exceptions of the levels of Fe and Mn which were found to be higher(P<0.05) in forages than in browse.

Effect of Location on Mineral Concentration of Browse and Forages: The levels of the macro minerals Ca, K and Na and the micro minerals Mn and Fe detected in browse samples are significantly higher(P<0.05) in the western than the eastern region. Also in forage the levels of P, Mn and Fe detected, are significantly higher in the western than the eastern region. Only Mo levels in browse and forage, Na and K levels in forage are significantly higher in the eastern than in the western region . Levels of Cu ,Zn and Co in browse and forage, showed non significant variations between locations.

Effect of Season on Mineral Concentration of Browse and Forages: Season has no significant (P<0.05) effect on levels of minerals in browse, only, Ca, K, Zn and Co tended to increase during wet season. In forage samples, higher levels of Ca, Na, Co, Mn and Fe were detected during dry season, while higher levels of K, P, Cu, Zn and Mo, were detected during wet season .No significant variation due to season was detected on levels of Mg in forage.

The Interaction Effect of Location and Season on Mineral Concentration of Browse and Forages:
Calcium (Ca): In both seasons, location had high significant(P<0.05) effect on levels of Ca in browse and forage being higher in the western than in the eastern region In both regions, season had a significant (P<0.05)effect on Ca level of browse in the west season while Ca level of forage being higher in the dry season. Individual evaluation of plant samples based on dietary Ca requirement was 0.3% for mature cows[20] indicated adequate level of Ca in browse, whereas evaluation of forage samples indicated high percentage of deficient samples during wet season than dry season in both regions. Differences within regions, between seasons, in Ca deficient forage high percentage detected in western region than eastern region during dry season.

PhospHorus (P): Season and location had no significant(P>0.05) effects on P level of browse being higher in the eastern region during dry season and in the western region during wet season. Season and location had significant(P<0.05) effects on P level of forage, which was found to be higher in wet season than dry season in both regions . On the other hand, P higher levels detected in western region rather than the eastern region in both seasons.

Individual evaluation of browse and forage samples in both regions based on dietary P requirement of 0.24% for mature cows[20] indicated high percentage of deficient samples during dry season than wet season in both regions.

Potassium (K): In both seasons, location had significant(P<0.05) effect on K level of browse and forage. Potassium level of browse being higher in the western than in the eastern region, while that of forage was found to be higher in the eastern than in the western region. Generally, season had a highly significant effect on K level of browse and forage in the wet season rather than in dry season. Individual evaluation of plant samples based on dietary K requirement of 0.8%[20] indicated negligible deficiencies in browse and forage (only 17% of forage samples were deficient in K during dry season in western region).

Magnesium (Mg): Season and location had no significant effects; the level of Mg in browse and forge were slightly higher in the eastern region during dry season and in the western region during wet season. Individual evaluation of plant samples based on dietary Mg requirement of 0.2%[20] indicated >50% of forage samples were deficient in Mg during wet season in both regions. Regarding browse, 19% were deficient in the dry season, in both regions.

Sodium (Na): Location had a significant effect on Na level of browse, high Na level detected in the western than the eastern region. Season and location had significant effect(P<0.05) on Na level of forage, high levels of Na was detected during dry season in the eastern region than in wet season. Individual evaluation of plant samples based on dietary Na requirement of 0.06%[20] indicated high levels of deficiency were detected in forage than in browse. Variation in percent deficient browse samples in Na was not significant among regions in both seasons. Variation in percent deficient forage samples in Na was significantly higher (P<0.05) in wet season than dry season in both regions and higher percent deficient samples in western region than in eastern region in both seasons.

Copper (Cu): Season and location had no significant effects(P>0.05) on levels of Cu in browse; but had significant effect(P<0.05) on Cu levels in forage, generally being higher (P<0.05) in the wet season than in dry season. In the dry season high level of Cu detected in forage in the eastern region than in the western region. Individual evaluation of plant samples based on dietary Cu requirement of 8 ppm[20] indicated only a quarter of browse samples were deficient in Cu during dry and wet season in both regions. Regarding forage, in both regions high level of deficient samples detected during dry season than in wet season.

Zinc (Zn): Season had significant effect on Zn levels in browse and forage, generally high level detected during wet season than dry season (P<0.05). Location had no significant effect on level of Zn in browse, but in forage higher levels were detected in the western region in both season. Individual evaluation of plant samples based on dietary Zn requirement of 40 ppm [20] indicated high percentage of deficient browse in Zn in dry season than in wet season. Regarding forage samples, more than 87% of all forage samples analyzed was deficient in Zn and variation in percent borderline to deficient samples was not significant among regions.

Cobalt (Co): Location had no significant effect, in both regions Co level of browse generally tended to increase in wet season, while that of forage in the dry season. Individual evaluation of plant samples based on dietary Co requirement of 0.1 ppm[20] indicated Co deficiencies in browse did not occur, only less than 5% detected in forage samples in both regions.

Manganese (Mn): Location had a significant effect on Mn level of browse and forage being higher in the western than the eastern region. Season had significant effect on Mn level of forage, higher in dry season than wet season in both regions. Individual evaluation of samples based on dietary Mn requirement of 20 ppm [20] indicated more than 15% of browse samples were deficient in Mn and variation in percent borderline to deficient samples was not significant among regions; while evaluation of forage samples indicated Mn level generally was adequate especially in the western region.

Iron (Fe): Location had a significant effect on Fe level of browse and forage tended to increase in the western than the eastern region. Season had significant effect on Fe level of forage (P<0.05, generally high levels were detected in the dry season than wet season. Fe level of forage significantly higher (P<0.01) than that of browse and individual evaluation of plant samples based on dietary Fe requirement of 50 ppm[20] indicated none of the forage samples from both regions ere Fe deficient; while evaluation of all browse samples indicated 10% were deficient in both regions.

Molybdenum (Mo): Location had a significant effect on Mo level of browse and forage higher ($P<0.05$) in the eastern than the western region. Season had significant effect on Mo level of forage, generally being higher in the wet season than dry season. Individual evaluation of browse indicated Mo level was higher that recommended in both regions. Molybdenum content of all forge samples was below the toxic level of 6 ppm[20] and ratio of Cu to Mo was not calculated because sulphur (S) was not determined in the plants.

High levels of Ca P, Mg, K, Na, Mo, and Cu in the analyzed browse samples were detected in wet and dry season than in forage samples. Forage samples studied had very low Na, P, Mo, Zn and Cu contents, but excessive concentrations of Fe and Mn. However, excessive concentrations of Fe and Mo were detected in the browses, while their contents of Cu and Zn are relatively low. Co level was higher in browse during wet season and in forage during dry season.

Discussion: Higher Ca, Mg and Na levels were detected in browse than in forge, whereas no significant variation in K and P levels. Ca level increases and P levels deceases with plant maturity[35]. Since the majority of the browse and some of the forage are legumes, these findings are in harmony with [42,34] who reported that, legumes contain higher Ca and Mg than grasses and equal amounts of K and P. This seems to agree with our findings. Forage Ca increases during dry season, from its concentration in wet season, while browse Ca concentrations did not.[34] have reported increases in calcium concentration of forge in summer. The decrease in Ca concentration in forage in rainy season is attributed to lack of mobility of Ca which tends to accumulate in old organs and stems as plants mature, hence young plants have low concentrations of calcium[38].

The Ca content of eastern and western regions browse was adequate in both seasons, >90% of browse species had higher Ca than the recommended requirements (g/kg DM diet) of growing cattle (26. – 10.8), pregnant cows (2.1 – 3.5) and lactating cows (2.9 – 5.3),[2,14]. Based on the above recommendations 40% of forage species in both regions were deficient in Ca during dry season and 50% during wet season. Although P deficiency is indisputable, there seem to be conflicting reports on availability of Ca in tropical grasses. For example, Jumba *et al*.[16] in a survey of the macro-mineral concentrations in herbage in western Kenya reported that 73% of the sampled forages would not meet the Ca requirement for maintenance of cattle and sheep. However, Minson[25] reported that most tropical grasses would satisfy the requirements of cattle and sheep. As acknowledge by Jumba *et al*.[16], the stage of growth of grasses at which the analysis was done could have affected the discrepancies observed in Ca concentrations. Browse P was not significantly affected by season in either location, while forage P level increased slightly in wet season in accordance with the general observation of P in tropical forages [44]. Phosphorus is reported to be translocated to the roots and in some cases to the soil[38]. Lower forage P concentrations, observed in the summer probably due to higher light intensity and temperature[25,16].

The majority of browse and forage species examined had lower P level than established tropical pasture (2.7 g/gkDM)[25]. Browse and forage plants had lower concentrations of P than the normal requirements of P (g/kg DM diet) of growing cattle (1.1 – 4.8), pregnant heifers and cows (0.9 – 2.0) and lactating cows (2.0 – 30), suggesting inadequacy during both seasons. The most common mineral deficiency in the world is that of phosphorus[19].

Green plants are an excellent dietary source of Mg for animals because of the presence of Mg in chlorophyll[46]. Tropical forage (grasses and legumes) contain sufficient amounts of Mg, deficiencies in animal grazing tropical pastures are likely to be rare [26]. The variation in the level of plant magnesium due to season was not significant in western region, only slight increase during wet season, may be due to the fact that magnesium like calcium is reported to be immobile implants hence is associated with old tissues [10]. Whereas in the eastern region plant Mg in dry season is significantly higher than in wet season in agreement with the observation that mineral concentrations in forage generally increased in wet season, but concentrations of calcium and magnesium decreased.

Based on Minson recommendation (2.0 g/kg DM) Mg in the diets of ruminants; browse plants had higher levels of Mg than forages. Of all the browse samples analyzed, approximately >80% in both seasons, and >70% of forage during dry season, had sufficient Mg level in agreement with[25]. Schillhorn van Veen and Loeffler (199) who reported that Mg in tropical forage was not considered to be limiting, although Jumba *et al*.[16] reported exceptionally low Mg concentrations in Kenya. During wet season, in both regions forage Mg declined to the level that more than half are deficient in agreement with Gomide[10].

Table 1: Mineral concentrations in browses by region, dry and wet seasons

Mineral	Critical level[c]	Season	Region: Eastern[a]			Western[b]		
			Mean	S.E.	% Def	Mean	S.E.	% Def
Ca %	<0.3	Dry	1.24[d]	0.20	7.7	1.44[c]	0.19	3.7
		Wet	1.45[d]	0.24	0.0	1.71[c]	0.22	1.8
P %	<0.24	Dry	0.25	0.04	7.31	0.22	0.03	74.1
		Wet	0.23	0.02	61.5	0.27	0.05	55.2
K %	<0.8	Dry	1.76[d]	0.21	11.5	1.82[c]	0.26	7.4
		Wet	1.93[d]	0.27	11.5	2.05[c]	0.27	10.3
Mg %	<0.2	Dry	0.72	0.21	19.2	0.74	0.20	18.5
		Wet	0.68	0.21	11.5	0.81	0.22	6.9
Cu ppm	<8	Dry	23.20	3.19	23.1	23.24	3.27	25.9
		Wet	23.92	3.34	26.9	23.04	3.24	31.0
Zn ppm	<40	Dry	32.15	3.09	73.1	33.69	2.97	74.1
		Wet	35.64	3.75	6.54	35.12	3.58	69.0
Co ppm	<0.1	Dry	0.45	0.03	0.0	0.47	0.03	0.0
		Wet	0.49	0.04	0.0	0.49	0.03	0.0
Mn ppm	<20	Dry	33.43[d]	3.00	19.2	44.45+c	10.20	14.8
		Wet	34.03[d]	2.65	19.2	43.47+c	9.76	17.2
Na %	<0.6	Dry	0.37	0.04	15.4	0.39	0.04	14.8
		Wet	0.36	0.04	15.4	0.42	0.05	13.8
Fe ppm	<50	Dry	107.5[d]	17.95	7.7	131.08[c]	27.40	11.1
		Wet	109.88[d]	18.10	11.5	113.45[c]	17.45	10.3
Fe ppm	<50	Dry	61.43[c]	9.28	0.0	54.02[d]	10.56	0.0
		Wet	62.54[c]	9.29	0.0	54.46[d]	10.03	0.0[a]

Means are based on 26 sample; [b]Means are based on 29 samples; [c]McDowell and Conrad (1977). [c,d]Regional means within a row differ ($P<0.05$)

Table 2: Mineral concentrations in forages by region, dry and wet seasons

Mineral	Critical level[c]	Season	Region: Eastern[a]			Western[b]		
			Mean	S.E.	% Def	Mean	S.E.	% Def
Ca %	<0.3	Dry	0.89[a]	0.17	33.3	0.91[a]	0.22	43.5
		Wet	0.78	0.15	50.0	0.84	0.21	52.4
P %	<0.24	Dry	0.18[d]	0.02	77.8	0.21+c	0.03	73.9
		Wet	0.22[de]	0.03	61.5	0.26[ca]	0.04	57.1
K %	<0.8	Dry	1.62	0.13	7.4	1.42	0.13	17.4
		Wet	1.95[e]	0.11	3.8	1.84[a]	0.14	4.8
Mg %	<0.2	Dry	0.43	0.09	29.6	0.42	0.11	34.8
		Wet	0.38	0.08	57.7	0.45	0.13	52.4
Cu ppm	<8	Dry	4.03	0.54	92.6	3.15	0.41	95.7
		Wet	7.11[a]	0.86	69.2	7.11[e]	0.66	66.7
Zn ppm	<40	Dry	27.91	1.84	88.9	28.52	1.89	87.0
		Wet	30.09[e]	1.99	88.5	30.42[a]	2.12	90.5
Co ppm	<0.1	Dry	0.49[e]	0.13	3.7	0.52[e]	0.15	4.3
		Wet	0.32	0.11	3.8	0.31	0.14	4.8
Mn ppm	<20	Dry	91.25[de]	16.22	3.7	106.63[ce]	59.06	0.0
		Wet	79.75[d]	10.62	3.8	80.54+c	10.10	0.0

Table 2: Continue

Na %	<0.6	Dry	0.21[e]	0.06	55.6	0.16[e]	0.06	60.9
		Wet	0.17	0.04	69.2	0.08	0.03	81.0
Fe ppm	<50	Dry	427.59[de]	51.24	0.0	474.70[ce]	59.06	0.0
		Wet	383.88[d]	49.05	0.0	419.5[c]	57.96	0.0
Fe ppm	<50	Dry	1.55	0.35	100	1.54	0.39	100
		Wet	1.68[e]	0.39	100	1.56+e	0.42	100[a]

Means are based on 27 sample; [b]Means are based on 23 samples; [c]McDowell and Conrad (1977). [c,d,e]Regional means within a row or seasonal within a column with different superscripts differ (P<0.0)

During wet season there is a substantial drop in plant Na level, whereas K level generally increased in agreement with Jones[15,34] results; contrarily, extractable soil Na level increased during wet season and K during dry season. Potassium is reported to be extremely mobile in plants and is translocated from the oldest to the fastest growing tissues[10]. Losses of potassium as the plant mature was attributed to translocation of potassium to the root system and then to the soil[3] . In western and eastern regions, mean browse and forage K levels were adequate during both season. Higher Na levels were defected in browse than in forages in both seasons. Na level is adequate compared to normal levels (0.05 to 1.0%) reported by Poland and Schanabel (1980) but lower especially in forage than the ARC (1980) requirements (0.8 – 1.2%) for cattle. There seem to be a general agreement that Na is deficient in most tropical grasses, in agreement with McDwell [21] statement that many tropical regions have reported low forage sodium concentrations. Sodium deficiency can be corrected by providing common salt ad libitum which can also satisfy the requirement for chloride McDowell[18]. The need for Na is particularly pronounced in hot weather to compensate for losses due to respiration and perspiration. Individual evaluation of plants indicated high levels of deficiency were detected in forages than in browse. In the eastern region 55 and 69% and the western region60 and 81% of forage samples were deficient in Na in dry and wet season respectively. Extractable soil Na and K were higher in the Eastern than western region. Individual evaluation of plant samples based on dietary K requirement of 0.8%. McDowell and Conrad[20] indicted negligible deficiencies in browse and forage only 17% of forage samples were deficient in K during dry season in western region.

Three quarter of browse species Cu level in this study were higher than recommended Cu in ruminants' diets (7.0 – 11.0 mg/kg DM) for the normal physiological functions of the animals,[31]. Howevr4, availability of Cu from these feeds could be lowered by its low absorbability, or even due to its negative interaction with dietary S, Mo and Fe[39,40]. Forage Cu was significantly higher in wet season than dry season in both regions reflecting the non-significant increase in extractable soil copper in wet season.[38] reported similar increases and suggested that copper maybe associated with new tissues in plants and is translocated to the root system as plants mature. The Cu content of forage species was on the lower range of the normal dietary requirements in ruminants' diets during dry season, while during wet season had lower concentration than recommended.

These forage Cu concentrations were inadequate during both seasons compared to minimum recommended level of 8 mg/kg DM[32]. In Africa, Cu deficiency is common in the Rift Valleythat stretches from Ethiopia to Tanzania, and in Kenya, Zaire, Malawi, Sudan and Nigeria[36]. The browse and forage had higher level of Mo than most tropical forages (0.5 - 1.5 mg/kg DM)[22]. Browse had higher and forage lower levels of Mo than dietary requirements of ruminants (P<2.0 mg/kg DM). All forage samples from both regions were deficient in Mo in the dry and wet seasons. High levels of Mo of browse could be associated with induced Cu deficiency in camels due to this negative interaction with S on lowered Cu. Antagonistic relationships between dietary Cu and S, or with Mo, contribute to induce Cu deficiency in ruminants[39,40]. Copper combined with thiomolybdate is note available for absorption, and even that much of the thiomolybdate that is not combined with Cu in the rumen is absorbed into the blood stream, where it would be recognize to tissue Cu, leading to liver Cu-loss. Both two-way interactions between Cu and S, and three-way interaction among Cu, Mo and S, have been recognized in ruminants[23,39].

The plant species had high concentrations of Fe that were comparable to high levels of Fe (100-700mg/kg DM) of tropical grasses and legumes[22]. These species had higher levels of Fe than tabulated requirements of Fe of dairy and beef cattle (50 mg/kg DM)[14,23]. Although its availability could vary due to the fact that Fe is absorbed according to the need, and thus its absorption would depend on dietary factors, age of the animal and boy Fe status. Fe high level detected in the western region than eastern region plants, reflecting the increase in extractable soil Fe in western region. All plant species in both seasons had lower levels of Zn than mean concentration of most forages (36- 47 mg/kg DM)[25]. Individual evaluation of plant samples, in both regions, indicated that the majority meet the minimum dietary requirement of Zn (5.0 – 30 mg/kg DM) of ruminants in both seasons. According to NRC[32] recommendations of 30 mg/kg DM, in both regions, >70% of browse during dry season and >65% during wet season had inadequate Zn content whereas >85% of all forage samples were deficient in both seasons. In recent years, Zn deficiency in grazing animals has been reported in a number of tropical countries where the Zn content in the diet was less than 40 mg/kg DM[19,33]. also reported similar results of forages from different parts of Sri Lanka.

Regional differences were highly significant in manganese content of the plants being higher in the western reign. Manganese deficiency is not a problem in plants as only a small percentage of plants analyzed had low manganese levels. Plant Mn concentration detected were extremely variable reflecting substantial species differences[34]. The browse had intermediate while forages had high levels of Mn that were comparable to the contents of Mn of pastures and established legumes (14 – 148 mg/kg DM [25]. Although there was a slight increase in extractable soil Mn in wet season, high forage concentration of Mn in dry season was detected and attributed to low rates of Mn translocation and accumulation of Mn in order tissue [38]. All plant species had higher levels of Mn than the normal dietary requirements of 20 – 40 mg/kg DM [2,31,23], although, its supply could be lowered by its low absorbability efficiency, from forage. However Mn concentrations may interfere with the metabolism of other minerals and has been observed to result in low reproductive rates of cattle[19].

Cobalt is a serious mineral limitation to livestock because even when grazing is abundant deficiency will lead to chronic starvation or wasting which is often indistinguishable from energy and protein mal-nutrition [9,12,19]. Co level of browse generally, tended to increase in wet season, while that of forage in the dry season. It is rare for grasses to contain Co in concentrations that meet the demands of grazing animals[11]. When the content in the pastures herbage is 0.10 ppm or less[11] grazing animals are likely to suffer from Co deficiency. Content of Co observed in this study was comparable to that in most tropical grasses (<0.01 to 1.26 mg kg^{-1} DM) reported by Minson[25]. Browse and forage had higher levels of Co than the dietary recommended levels of cattle [0.06 – 0.7 mg kg^{-1} DM,[2], sheep and goats 0.11 mg kg^{-1} DM)[2,14,]. Individual evaluation of plant samples in all seasons indicated Co was adequate in both regions. Animals suffering from Co deficiency lose appetite and condition, may abort if in calf or may have difficulty to conceive again, the condition seems to affect lactating cows more than any other type of tock[13,9].

Variations in the concentration of minerals among browse and forage in this study agreed with the statement by[5] that trace minerals in plants may increase decease or show no consistent change with stage of growth, plant species, soil or seasonal conditions. Variations in the concentration also could be accounted for by genotypic differences, efficiency of mineral uptake and retention and stage of foliage maturity coupled with proportion of leaf samples (i.e. leaf vs. twigs) harvested for mineral analysis. Younger leaves and leaflets contain higher levels of minerals than older mature leaves, twigs and stem parts [25].

High levels of Ca, P, Mg, Na and Co of the browse species could be considered sufficient as mineral sources for camel maintenance. However, complete rely on these browse species as the only mineral sources for camels could be limited by their low contents of Cu and Zn, Forage species excessive concentrations of Fe and Mn and low Na coupled with excessive browse Mo that could be detrimental suggesting for low levels of inclusion of especially Mo in supplement formulation. The minerals most widely present I inadequate amounts are Na, P, Zn and Cu. Supplementation regimes involving these elements are very likely to produce beneficial results. There is an urgent need for appropriate experimentation so that soundly-based supplementation packages can be devised. It should be stressed that data of the type presented here can provide only an indication of the existence of potential mineral deficiency problems. Bearing in mind Abbas *et al*.[1] observation that dromedaries on pasture select for protein rich forage species and camel selectivity usually results in the consumption of material of somewhat higher quality than that of the total available; conclusive diagnosis must be based on the occurrence of a positive response to supplementary supply of the mineral in question. However, such data are vital in the formulation of critical supplementation experiments, upon which recommendations for practical supplementation regimes should be based. From the above analysis it may be seen that levels of nutrients in browse are sufficient for camels maintenance in both seasons while forage in the wet season only; as dry season forages are extremely deficient in protein, phosphorus and carotene cannot, alone, meet the camel maintenance requirements. It is safe to say that browse constitutes a necessary and adequate supplement to forage in the dry season, lastly but not least, the two types of plants are complementary for feed purpose.

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