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Mineral Profile of Browse Species Used as Feed by Grazing Livestock in Cholistan Rangelands, Pakistan

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Abstract: The Cholistan rangelands were observed to be degrading due to various stresses, whose effects could be seen as poor livestock production. Hence a preliminary survey was conducted in order to assess the nutrients concentration of major browses used as feed during the period of whole year for livestock grazing therein. The browse species were evaluated by their mineral composition including the macro minerals (P, K, Na, Ca and Mg) and micro minerals (Mn, Cu, Zn and Fe). The investigated species were consisting of *Calligonum polygonoides*, *Suaeda fruticosa*, *Salsola baryosma*, *Haloxylon recurvum*, *Haloxylon salicornicum*, *Capparis decidua*, *Calotropis procera*, *Tamarix aphylla*, *Prosopis cineraria* and *Acacia nilotica*. The browse samples were collected based on preferences by grazing animals, accessibility to browsing and abundance in the said area. The results of this study indicated that the concentration of almost all the minerals (micro and macro) except Na among selected browses was less than required level for ruminants grazing therein. This may be, one of the causes responsible for the pitiable health and productivity of livestock in Cholistan rangelands. The low quality forages require the attention of range manger to improve the habitat conditions and livestock breeds. It was proposed that fertilization of soil and vegetation with additional sources will not only improve the over all vegetation but also enhance the productivity of grazing animals and other wildlife. These rangelands have potential for improvement provided proper ecological management practices and with participation of local community.

Key words: Browse species, animal feed, chemical composition, macro minerals and micro minerals, cholistan rangelands

INTRODUCTION

Rangelands are very significant to the economy of many countries and still afford about 70% of feed requirements of domestic ruminants and 95% of wild ruminants (Holechek *et al.*, 1995). The daily nutrient requirement of stock fluctuates in according to the physiological functions of grazing livestock and therefore growth, gestation, lactation and fattening play key roles in determining daily nutrient demands (Cook and Harris, 1977). In contrast, the chemical composition of plants and plant communities in rangelands varies according to species, soil type, climate, phenology and abiotic factors (Greene *et al.*, 1987).

The rangelands of Pakistan show a great diversity of species composition, structure, productivity and eventually their capacity to support livestock production. Out of total area of Pakistan (80 million ha) 49 million hectare has been classified as rangelands which are almost consisting of arid to semiarid conditions (Mohammad and Naz, 1985). Rangelands of Pakistan sustain thirty million herds of grazing animals that provide 400 million US $ to annual export income (Anon,). In Pakistan, small ruminants obtain more than 60% of their feed necessities from arid and semi-arid rangelands (Khan *et al.*, 1990).

Rangelands are very important from the environmental point of view because they provide vegetation cover, protection for soil which also ensures sustainable economic production of feed for animals. Especially browse plants beside grasses compose one of the cheapest sources of feed for animals in many parts of the World. Mostly the browses have advantage of maintaining their nutritive value and greenness during the dry season when grasses dry up and decline in both quantity and quality (Kibon and Orskov, 1993). This nutritious profusion and perennial performance of browse species afford round the year provision of forage for grazing livestock (Aganga and Mosase, 2001).

Rangelands of Pakistan are degrading and facing many difficulties like short growth period, over grazing, droughts, soil erosion and marginal availability of productive perennial species. The herbaceous vegetation of these rangelands only flourishes in the monsoon season, accordingly livestock herds show pitiable health and produce very poor yield of meat and milk. These problems are common everywhere in the world where arid or semiarid rangelands exist. Therefore, developing countries like Pakistan face the similar situation in their rangelands productivity and health (Ahmad and Hasnain, 2001). These vast natural

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resources of Pakistan are not managed by scientific approaches and presently, only 10-15% of their actual potential is being documented (Ali *et al.*, 2001).

The most important objective in range management is animal production that is based on nutritional composition of accessible forages (Stoddart *et al.*, 1975). Ganskopp and Bohnert (2003) projected that wildlife or livestock expert must know the nutritive properties of forage species to maintain reproduction and growth of animals and assure the reasonable importance of grazing land. Understanding of widespread nutrient ratios in forages available to livestock will support in attaining their appropriate consumption, assist to determine nutrient deficiencies and propose supplementation requirements. Especially minerals are compulsory for both animals and plants in significant amount and balance. The inadequacy of minerals greatly affects the vegetation growth and livestock development (Ulrich and Hills, 1967).

The Cholistan rangelands are degrading due multiple stresses. Sustainability of life in this hot desert rotates around the annual rainfall. During summer season, weather is tremendously severe and harsh; certain xeric browses survive but suffer high grazing pressure and leading to partial eradication. Resultantly, the palatable species are diminishing out slowly and unpalatable species with less nutritious properties are becoming abundant (Akhter and Arshad, 2006; Arshad *et al.*, 2008). Due to year round stress on browses of Cholistan rangelands, grazing animals suffer more and need detail assessment of browses with regard to their chemical composition in order to sustain livestock production. This paper will present the nutritional profile of major browse species commonly used in feeding systems of Cholistan livestock. As no such information on the mineral composition of plants of these rangelands was available, therefore present study was being planned to evaluate the mineral status of promising browses. These findings will help the range managers and stockmen to develop a strategy for improving the productivity of livestock.

MATERIALS AND METHODS

Study area: This study was conducted in Cholistan desert which is sited in southern part of Punjab Pakistan. Cholistan desert is a part of Great Indian desert that comprises of Thar desert in Sindh, Pakistan and Rajastan desert in India. It extends between longitudes 69°52' and 75°24' E and latitudes 27°42' and 29°45' N covering an area of about 2.6 million hectares (FAO, 1993; Akbar and Arshad, 2000).

It is an arid sandy desert where mean annual rainfall varies from less than 100 mm in west to 200 mm in east, mostly received in monsoon season (July to September). Rainwater is collected in locally made water pools called 'tobas'. Temperature is high in summer and mild in winter without frost. The mean summer temperature (May-July) is 34-38°C with the highest reaching over 51.6°C (FAO, 1993).

The vegetation of this desert consists of xerophytes, adjusted to low moisture, extremely high temperature and more salinity with wide variation of edaphic factors. The scarce vegetation of Cholistan commonly comprises perennial shrubs with dispersed small trees. Several ephemeral and annual species emerge after rains, complete life cycle in short duration and dry up after producing seeds. The soil of Cholistan desert is mostly alkaline, saline and gypsiferous composed of schists, gneiss, granites and slates (Baig *et al.*, 1980; Arshad and Rao, 1994).

The total human population in Cholistan desert is around 110, 000 nomadic pastoralists. Most of them live on the periphery of desert whereas interior of desert is sparsely populated. The pastoralists have smaller to large herds of cattle, camels, sheep and goats. The pastoralism in Cholistan is described by mass movement of people and animals through the year for searching of food and water. The movement pattern of nomadic herders is mostly dictated by the start and distribution of monsoon rains (Akhter and Arshad, 2006).

Procurement of samples: The samples of selected browse species were collected in spring seasons (February) 2010 from the different range sites of Cholistan desert. The collected browse samples were mostly consisting of mixture of leaves, twigs and inflorescence. The samples were air dried under shade then pooled for ground using Willey mill with 2 mm sieve for laboratory analysis. Ground samples were stored in plastic whirl-pack sample bags until put to use for further analysis. All the chemical analyses were done in triplicate.

Mineral profile: In order to determine the mineral profile the labeled ground samples were subjected to wet digestion (nitric acid and perchloric acid). Following the wet digestion the Phosphorus (P) was determined by spectrophotometer (U 1100, Hitachi), whereas the concentration of sodium (Na) and potassium (K) was determined with flame photometer (Jenway PFP7). Subsequently, concentration of Calcium (Ca), Magnesium (Mg), Manganese (Mn), Copper (Cu), Zinc (Zn) and ferrous (Fe) were calculated by Atomic absorption spectrometer (Hitachi Polarized Zeeman, Z-8200).

Statistical analysis: The data collected regarding mineral contents was analyzed for variance analysis (ANOVA) in completely randomized design. Significance between means was tested using the Least Significance Difference (LSD) (Steel *et al.*, 1997). Significance was accepted at 5% level of probability. All the statistical procedures were performed using Statistical Analysis System Computer Package (SAS, 2000).

RESULTS

Macro minerals: The contents of macro-minerals (P, K, Na, Ca and Mg) in selected browses from Cholistan rangelands are presented in the Table. In this study, the concentration of Phosphorus (P) among browse species was varied from 0.011 to 0.024% with mean value 0.016%. The highest value of P was noted in *Calligonum polygonoides* (0.024%) and lowest in *Haloxylon recurvum* (0.011%). While mean concentration of potassium (K) in browse species was 0.30% and it was ranging from 0.22 to 0.42%. The contents of K were highest for *Salsola baryosma* (0.42%) and lowest for

Table 1: Mineral composition of selected browse species (on dm* basis)

		Macro minerals					Micro minerals			
Sr. No.	Species name	P (%)	K (%)	Na (%)	Ca (%)	Mg (%)	Mn (ppm)	Cu (ppm)	Zn (ppm)	Fe (ppm)
	Shrubs									
1	*Calligonum polygonoides*	0.024^{a}	0.34^{bc}	0.22^{d}	0.27^{bc}	0.017^{c}	3.60^{e}	1.44^{c}	2.32^{b}	9.50^{b}
2	*Suaeda fruticosa*	0.017^{cd}	0.29^{cd}	1.73^{a}	0.22^{c}	0.016^{c}	4.39^{d}	1.60^{c}	1.33^{e}	9.62^{b}
3	*Salsola baryosma*	0.019^{bc}	0.42^{a}	1.23^{b}	0.23^{c}	0.014^{c}	3.54^{e}	1.29^{c}	3.39^{a}	3.22^{e}
4	*Haloxylon recurvum*	0.011^{e}	0.25^{de}	1.82^{a}	0.25^{bc}	0.018^{c}	3.78^{de}	0.66^{d}	1.82^{cd}	3.46^{e}
5	*Haloxylon salicornicum*	0.014^{de}	0.33^{bc}	0.95^{c}	0.36^{a}	0.027^{ab}	6.61^{b}	0.66^{d}	0.81^{f}	1.42^{g}
6	*Capparis decidua*	0.014^{de}	0.29^{cd}	0.81^{c}	0.37^{a}	0.025^{b}	1.60^{g}	2.14^{ab}	3.11^{a}	2.06^{f}
7	*Calotropis procera*	0.012^{e}	0.36^{b}	0.97^{c}	0.31^{ab}	0.024^{b}	8.39^{a}	2.24^{a}	1.80^{cd}	10.41^{a}
	Trees									
8	*Tamarix aphylla*	0.021^{ab}	0.25^{de}	1.33^{b}	0.27^{bc}	0.015^{c}	2.45^{f}	0.78^{d}	1.47^{de}	6.81^{d}
9	*Prosopis cineraria*	0.018^{bc}	0.22^{e}	1.26^{b}	0.35^{a}	0.030^{a}	5.52^{c}	1.44^{c}	1.92^{bc}	8.60^{c}
10	*Acacia nilotica*	0.012^{e}	0.27^{de}	1.18^{b}	0.36^{a}	0.024^{b}	8.46^{a}	1.68^{bc}	3.44^{a}	8.65^{c}
	Mean	0.016	0.30	1.15	0.30	0.021	4.83	1.39	2.14	6.37
	SEM	1.233	0.02	0.07	0.02	1.716	0.26	0.16	0.15	0.19

Mean values based on 03 replicates. SEM: Standard error of means.
Means in same column with different superscript are significantly different P<0.05. *Dry matter.

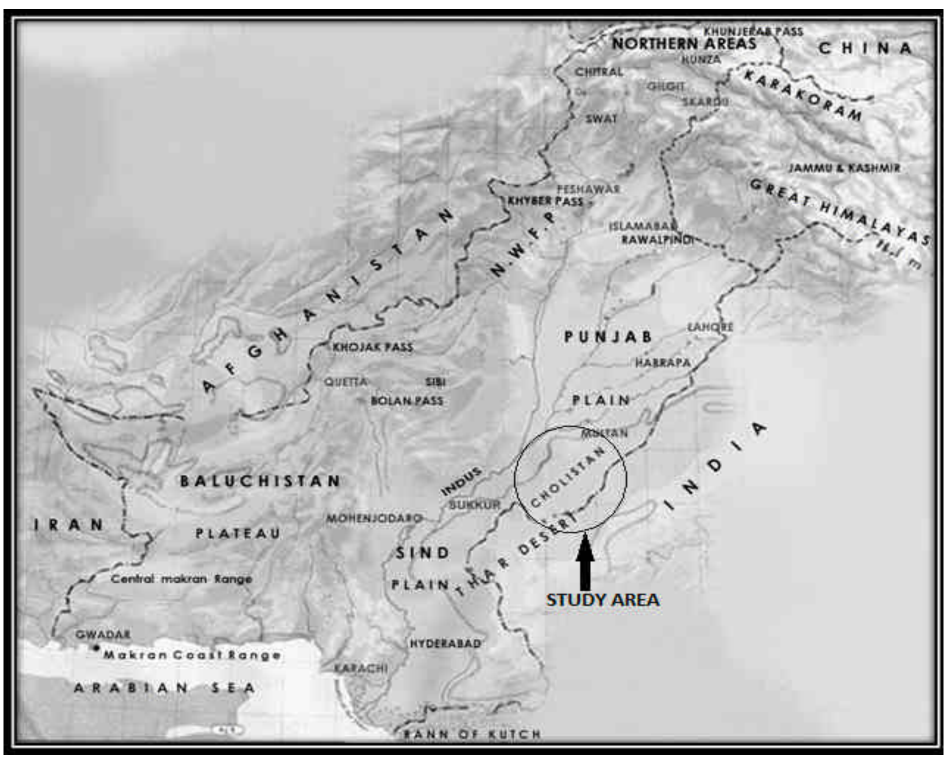

Fig. 1: Map of Pakistan showing the study area, cholistan desert

Prosopis cineraria (0.22%). Sodium (Na) was considerably varying among species from 0.22 to 1.82% and their mean value was 1.15%. Maximum Na contents were observed in *Haloxylon recurvum* (1.82%) and lowest in *Calligonum polygonoides* (0.22%). Similarly, maximum concentration of calcium (Ca) was noted in *Capparis deciduas* (0.37%) and lowest in *Suaeda fruticosa* (0.22%) with the mean value 0.30% among the selected browse species. The mean concentration of magnesium (Mg) was 0.021% that was significantly high in *Prosopis cineraria* (0.030%) and lowest in *Salsola baryosma* (0.014%).

Micro minerals: The concentration of micro minerals (Mn, Cu, Zn and Fe) in selected browses of Cholistan rangelands are presented in Table. According to results, the concentration of manganese (Mn) was highest in *Acacia nilotica* (08.46 ppm) as compare to other browse species. The contents of Mn were ranging from 01.60 to 08.46 ppm among browse species with mean value 04.83 ppm. The concentration of copper (Cu) was found to be highest in *Calotropis procera* (02.24 ppm) and lowest in *Haloxylon recurvum* (0.66 ppm) and *Haloxylon salicornicum* (0.66 ppm), with mean 01.39 ppm in the analyzed species. While the contents of zinc (Zn) were ranging from 0.81 to 03.44 ppm between the investigated species with mean value 02.14 ppm. Zn was observed to be highest in *Acacia nilotica* (03.44 ppm) and lowest in *Haloxylon salicornicum* (0.81 ppm). Similarly, concentration of ferrous (Fe) was found to be significantly high in *Calotropis procera* (10.41 ppm) and lowest in *Haloxylon salicornicum* (01.42 ppm) with mean value 06.37 ppm.

DISCUSSION

According to results the concentration of macro minerals (P, K, Na, Ca, Mg) and micro minerals (Mn, Cu, Zn, Fe) were varying significantly ($p<0.05$) among selected browses from Cholistan rangelands. The detail discussion of minerals is discussed as below.

Phosphorus (P) has been called as "master mineral" since it is concerned in most metabolic processes (Rasby *et al.*, 1998). The recommended range of P for all classes of ruminants as suggested by National Research Council (1984) was 0.12 to 0.48%. In this study P concentration in browse species was also lower than minimum requirement (0.082%) of livestock (Anonymous, 1975). This agrees with the results of Inam-ur-Rahim (1999), Akhtar *et al.* (2007) and Sultan *et al.* (2009) who has observed P deficiency in various forages. This study also supported the results of Sprague (1979) who has observed P deficiency in rangelands soils from sub humid and semi-arid regions. Forages from savanna and semi desert areas have been described as deficient in P due to low concentration of P in soil (Minson, 1990a). According to Wilson (1969), trees and shrubs in such areas with poor or intermittent rainfall have been found to be deficient in P. On worldwide basis, P may be considered as most widespread mineral deficiency among grazing livestock (Underwood, 1981).

According to National Research Council (1984), the recommended range of potassium (K) for all classes of ruminants was 0.5-1.0%. The critical level of K was 0.60% as recommended by the NRC (1996) and 0.80% by McDowell *et al.* (1984). Results showed that concentration of K in browses was lower than these recommended ranges. Our results were almost in line with Ram'ırez-Orduna *et al.* (2005) and Ghazanfar *et al.* (2011). In certain areas of world, it can be possible that deficiency of K occur, in view of increase in forage maturity may lower the concentration of this element (McDowell and Valle, 2000). Khan (2003) had confirmed the deficiency of K for ruminants in grazing forages solely in Pakistan. The major cause for extensive K deficiency, even though forages consist of K lower than requirements, may be due to the deficiency of other nutrients (McDowell and Valle, 2000). The variation in concentration of K might be associated to availability of water, as absorption of K by root is related to soil moisture (Charley, 1977). Therefore, in our study, poor soil moisture, high Na contents and drought conditions may be the reason of low concentration K among browses of Cholistan desert. Similar, findings were reported by Barnes *et al.* (1990), Ramırez *et al.* (2001) and Moya-Rodriguez *et al.* (2002) who had studied the potassium in browses from arid and semiarid areas of world.

Sodium (Na) is an important element in order to determine the adequacy of minerals in animal feed. It has been reported that animals have an important ability to preserve Na contents but prolong deficiencies can cause weight loss or the loss of appetite, decreased growth and reduced milking (McDowell and Valle, 2000). Our results were showing higher contents than the critical value of Na 0.06% DM (National Reaserch Council, 1985). Overall, the recommended range of Na element, for all classes of ruminants, as suggested by NRC (1984) was 0.06 to 0.18%. Among all the investigated browse species, sodium level was significantly high in *Suaeda fruticosa* and *Haloxylon recurvum* because these species were halophytes and abundance of sodium make them suitable to an environment so hostile such as desert (Laudadio *et al.*, 2008). Ramýrez-Orduna *et al.* (2005) has reported that concentration of sodium tends to increase with the decrease in rainfall. Plants in desert conditions may accumulate Na contents in order to relieve water and saline stress. As soil becomes dry, the concentration of salts start to increase in soil and osmotic potential turns to be more negative. In saline environment, NaCl is very important for osmotic adjustment; but absorption of salts by plants may increase the chances of potential Na toxicity (Salisbury and Ross, 1994; Miller and Doescher, 1995). However, our findings were in agreement with Ramırez-Orduna *et al.* (2005) and Aganga and Mesho (2008) who has investigated the mineral contents in various browses.

According to National Research Council (1984), the recommended range of calcium (Ca), for all classes of ruminants was 0.19 to 0.82%. While Minson (1990a) has reported that level of Ca ranged from 0.31 to 1.98% with the mean value 0.63%. In this study, concentration of Ca was lower than the recommended levels. It has been reported that Ca contents more than 1% decrease the DM intake and excess of Ca can upset the absorption of trace minerals especially Zn (NRC, 2001). According to our results, the mean contents of Ca in 50% browses were high than critical value 0.30% of DM for different classes of ruminants (NRC, 1984). The need of Ca in grazing animals is an issue of considerable debate, because requirement of Ca is influenced by type of animal, age and level of their production (Khan *et al.*, 2007). If the diet of animal is poor in Ca, then deficiency of Ca may appear in the form of broken bones, convulsions and death of animal. The area under study is sandveld, of which soil has poor texture and does not hold sufficient nutrients hence browses has low level of nutrients (Aganga and Mesho, 2008). Our findings were very close to Verscoe (1987) and Ghazanfar *et al.* (2011) who has investigated Ca in various foliages.

Green plants are remarkable source of magnesium (Mg) for animals because of its presence in chlorophyll (Wilkinson *et al.*, 1990). The recommended requirements of Mg were 0.12-0.20% DM in the feed of ruminants (National Research Council, 1980, 1985) and according to Ensminger and Olantine (1987) Mg requirements range from 0.90 to 0.21%. Our findings were lower than the recommended range and were remained fail to meet the minimum requirement of Mg for lambs (0.8-1.5% DM), lactating sheep and goats (0.9-1.8% DM) and lactating cows (1.2-2.1% DM). The deficiency of Mg was most common on sandy, acidic soils (Sultan *et al.*, 2008). Dua and Care (1995) has been reported that dietary requirement of Mg in livestock is markedly influenced by other nutrients in diet, mainly K. High concentration of N and K in animal diet will decrease the absorption of Mg from rumen. Whereas the increase in the contents of P in animals feed causes to decrease the requirements of both Ca and Mg (Judson and McFarlane, 1998). Our results were in line with Ayan *et al.* (2006) and Sultan *et al.* (2009) who have analyzed the minerals of various forages.

Among trace elements, manganese (Mn) is second most abundant element next to ferrous on earth; however, availability of Mn is decreased by draining of soil. The recommended range of Mn is 18 to 36 ppm, as suggested by the Anonymous (1981, 1985) and 20 to 50 ppm as reported by Ensminger and Olantine (1987). Our results remained fail to fulfill the recommended requirements of Mn. The maximum Mn contents in the diets of various livestock forms has been recommended as 1000 mg/kg (Anonymous, 1984) but in this investigation the level of Mn has been found below this tolerable range. The mean values of Mn in the browse species were in the range of Minson (1990b), who has reported that the contents of Mn in pastures can range from 01 to 2670 ppm. It has been reported that Mn deficiency causes the impaired growth, skeletal and infant abnormalities in livestock (Hussain and Durrani, 2008). On other hand, excessiveness of Mn decreases the appetite in animals (Danbara *et al.*, 1985). Georgievskii (1982) has described that increase in soil pH above 6.0 causes to decrease the availability of Mn. Low level of Mn contents in forages generally occur only on neutral or alkaline soils (Minson, 1990a). It has been observed that lower level in the evaluated browses may be due to high pH of soil and impact of interference with other elements. Our results are almost in range with Aganga and Mesho (2008) who has investigated minerals in various browses.

Copper (Cu) is vital in the formation of bones and act as key component of several enzymes in plants (Curtis and Barnes, 2000). The copper deficiencies are different in different species and problem of anemia is common along with abnormalities of bones and depressed growth (Sher *et al.*, 2011). Ensminger and Olantine (1987) has reported that requirement of Cu in ruminants can vary from 06 to 12 ppm. The Cu level in this report was lower than recommended Cu in the diet of ruminants (7.0-11.0 mg/kg DM) for common physiological functions and maintenance (NRC, 2001). Cu decline with maturity in forage species and are high in leaf parts as compare to stem (McDowell, 1996). Minson (1990b) reported that Cu values for pastures could vary from 2.50 to 13.90 ppm. In pastures, forages had low contents of Cu than minimum suggested requirements, for various production purposes in ruminants (Spears, 2003). With the exclusion of P, Cu is most common mineral deficiency for ruminants in world (McDowell, 2003). Low level of Cu in plants might be due to high level of pH in soil. Furthermore, increase in pH of soils may perhaps elevate the uptake of Se and Mo and excess of Mo could seriously increase deficiency of Cu (Spears, 1994). Akhtar *et al.* (2007) and Sher *et al.* (2011) has stated the deficiency of Cu in forage plants of Pakistan.

Zinc (Zn) is also an essential element for the activation of many enzymes (Sher *et al.*, 2011). In this study, the contents of Zn were lower in all the analyzed browses than the reported range of pastures (Minson, 1990b) and optimum value reported by Minson (l990a). Minson (1990a) stated that the amount of Zn in forages varied from 7.0 to 100.0 ppm in the DM with mean concentration of 36.0 ppm. Our results were showing the lower level of Zn than the recommended ones and investigated browses were found to be deficient with Zn. It was reported that Zinc deficiency could cause parakeratosis (inflamed skin around mouth and nose), stiffness of joints, breaks in skin around the hoof and retarded growth (Ganskopp and Bohnert, 2003). Deficiency of Zn also causes the sterility, anemia or immune system problems in animals (Hidiroglu and Knipfell, 1984). Absence of sexual maturation and dwarfism are main symptoms in case of severe Zn deficiency (Sher *et al*., 2011). Deficiencies of Zn could be improved through supplementation of this terrace element. In recent years, deficiency of Zn in grazing animals has been observed in number of tropical countries where Zn was less than recommended values in diet (McDowell *et al*., 1984). Sher *et al*. (2011) has also reported the deficiency of Zn in forages from Pakistan rangelands. Our results were almost in agreement with Aganga and Mesho (2008) who has investigated the minerals in various browse species.

Iron (Fe) is a vital component of haemoglobin, blood pigment, muscle protein, myoglobbulin and several other enzymes. The deficiency of Fe can cause anemia and decrease in the resistance to various diseases. Very high concentration of iron may cause nutritional problems in animals by lowering the absorption of phosphate (Sher *et al*., 2011). McDowell (1992) has reported that the normal requirement of iron can range from 30-60 ppm DM for ruminants. It has been observed that maximum tolerable level of Fe in forages is about 1000 mg kg^{-1} and is the least toxic of all the essential trace elements for livestock (McDowell and Arthington, 2005). The investigated species had lower level of Fe than the critical levels. The change in the conditions of soil and climate as well as physiological status of plants species may affects the absorption of iron in plants (Kabata-Pendias and Pendias, 1992). Our findings are in line with previous studies of Towhidi and Zhandi (2007) who has studied the chemical composition of various plant species in Iran. Sher *et al*. (2011) has also reported the deficiency of Fe contents (1.819 to 12 ppm) in forage from Pakistan rangelands.

Conclusion and implication: The differences in the concentration of minerals in present study with those in the previous literature could be partly described by variations between forage species, minerals level in soil, influences of climate and locality, growth stages, fractions of leaf and stem for analysis and season when forage sampling was carried. The concentration of almost all the minerals (micro and macro) except Na among selected browses was less than required level for ruminants grazing therein. The area under study was sandy and by the nature of soil type, the browse plants have low levels of both major and minor minerals. As a result, grazing animals in the area cannot obtain sufficient minerals from indigenous plants especially during dry season. Therefore, supplementation of minerals would seem most important for optimum productivity of grazing ruminants during different times of the year. Further studies are also required to assess the nutritional status of some of all the important plant species in the study area. The results of this study should be made available to educate the herders, nomadic peoples and farmers about the nutritional composition of forages that are appropriate for livestock grazing.

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