MINERAL COMPOSITION OF LOCAL TREE LEAVES FOR FEEDING SHEEP AND GOATS IN KOHAT DISTRICT OF KHYBER PAKHTUNKHWA

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ABSTRACT

Mineral profile of tree leaves from eight local species (Acacia modesta, Albezia lebbeck, Capparis aphyla, Prosopes Juliflora, Tecoma undulata, Olea cuspidate, Ziziphus mauritiana and Ziziphus jujuba) was evaluated for feeding to sheep and goats. Leave samples were collected from three different locations (Surgul, Shakardara and Gumbat) in Kohat district of Khyber Pakhtunkhwa, Pakistan province and analyzed for total mineral matter, Ca, P, Na, K, Cu, Zn, Fe and Mn and In vitro DM digestibility. Statistical variations due to tree species and location were inconsistent for macro and micro minerals. Except Na, the contents of Ca, P and K were significantly influenced by tree species. Calcium contents were in the optimum range (1.66 to 5.14%) in all the leaves except Capparis aphyla (0.22%). Conversely, P was in the lower range (0.05-0.14%) in all samples that resulted in wide Ca:P ratio. Na in all samples was found ten times less than the required levels. Potassium was two folds higher than the recommended dietary level. Among the four micro-minerals, only Zn and Mn responded to difference in tree species and none varied due to location. Copper contents averaged 3.32 ppm across the tree species as against the required dietary levels 4 to10 ppm. The contents of Zn. Fe and Mn were found above the optimum levels and averaged 42, 186 and 94 ppm, respectively. The low in vitro DM digestibility (25.96 - 51.28%) of the tree leaves may constrain bio-availability of minerals and requires research to overcome this limitation.

***Key Words**: Tree Leaves, Mineral Composition, Sheep, Goats*

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INTRODUCTION

According to the livestock Census (2006), district Kohat habitat 174299 cattle, 27277 buffaloes, 109040 sheep and 293354 goats. Grazing land constitutes about 75% of the total reported land and is classified as sub-tropical mountain thorn type (Habib *et al.,* 2003). The range vegetation is of low species diversity and large area is covered by same species of shrubs, trees and grasses. Continuous overgrazing over the past decade has changed the vegetation diversity of the rangeland. Most of the quality grasses have vanished and the vegetation cover has shifted towards small trees and dwarf shrubs that suit browsing by sheep and goats. This is apparent from the livestock population of Kohat district predominantly represented by sheep and goats.

Trees and shrubs have provided valuable forage to herbivorous animals since the time of their domestication especially in arid regions where cultivable land is limited, fragmented and predominantly used for grain crops. Tree foliage has become a significant feed source and is considered as fodder bank that continuously supply fodder round the year and significantly contribute to filling feed gap during dry periods in feed resource limited regions of the world (Gutteridge and Shelton, 1998). Bhatta *et al.* (2005) reported that although fodder trees are often valuable sources of dietary protein and energy for livestock in semi-arid regions, maximum nutritional and economic benefits could be harvested, if used as supplement rather than as a sole feed. Ajit *et al.* (2010) found that tree leaves successfully replaced 50% concentrate in the ration of growing goats. In Kohat region, pastoral system of livestock keeping is most common. Livestock especially sheep and goats are allowed to graze freely on rangeland daily for 4 to 6 hours, thus subsisting mainly on grazing source. Tree leaves and grasses are also dried for stall feeding during feed scarcity periods.

The feeding value of fodder trees found in Kohat region with respect to mineral composition has not been investigated in the past. Research interest in the role of minerals for improving productivity of grazing animals is growing worldwide. Mineral contents in feed resources and their adequacy to meet animal requirements are always important to know, especially for sheep and goats, where tree leaves, shrubs and forbs, which have not been studied analytically, very much play a vital feeding role. Knowing the mineral profile of available local feed resources and designing mineral supplementation on this basis is supposed to bring improvement in productive performance of livestock (McDowell et al., 1983). In relevance to the above, the present study was performed to assess mineral composition of tree foliage native to Kohat district in relation to the dietary requirements of sheep and goats.

MATERIALS AND METHODS

Representative plant samples of eight trees species; *Acacia modesta, Albezia lebbeck, Capparis aphyla, Prosopes Juliflora, Tecoma undulata, Olea cuspidate*, *Ziziphus mauritiana and Ziziphus jujuba* were collected at three different locations viz: Surgul, Shakardara and Gumbat in Kohat district of Khyber Pakhtunkhwa (KP). Within each sub-location samples from three randomly selected sites were collected. Leaves along young shoots (approximately 5 kg) were harvested, brought to laboratory and dried under shade. The dried leaves were separated and stored in labeled polythene bags for laboratory analysis. These were subsequently ground in a Willey hammer mill through 1mm mesh. Dry matter (DM) contents in the ground samples were determined in a drying oven at 100 Celsius for 16 hours and mineral matter (ash) was estimated by igniting the dried samples in a muffle furnace at 650 Celsius for 6 hours as described by AOAC (1995). The ground samples were digested in perchloric acid diluted to known volume with deionized water and analyzed for macro- minerals (calcium, phosphorus, sodium and potassium) using flame photometer and for micro-minerals (copper, zinc, iron and manganese) using atomic absorption spectrophotometer according to the procedures described by AOAC (1995). The *in vitro* DM digestibility of the samples was determined according to the single stage procedure of Tilley and Terry (1967). In vitro tubes in quadruplicate containing 0.5 g ground sample were added with 40 ml McDoughall's buffer as artificial saliva and 5 ml fresh rumen liquid as a microbial culture. Rumen fluid was collected from a rumen fistulated steer fed green forage. The tubes under anaerobic condition (through CO_2 flushing) were incubated for 48 hours at 38 Celsius. The incubation was stopped by freezing the tubes and subsequently the contents were filtered through sintered glass filterable crucible (porosity-1) and the residue (undigested feed) after drying was weighed for calculating DM digestibility. *In vitro* DM digestibility of the samples was completed in a series of successive batches (100 tubes /batch) at weekly intervals. Each batch included two standard samples with known DM digestibility for adjusting variation among the different batches.

The data was analyzed with the ANOVA procedure using SAS (2009). Means of tree species were compared with the Tukey's studentized range test and difference among locations were ranked with the LSD procedure at alpha 0.05 (Steel and Torrie, 1981)

RESULTS AND DISCUSSION

Macro Minerals

Results of total mineral matter and macro-elements are reported in Table 1. Total mineral contents significantly varied due to tree species (P<0.0001) and locations (P<0.0001). Total mineral matter determined after incinerating the samples at 600 Celsius was positively correlated (r^2=0.80) to sum of all mineral elements and thus provides a measure of the total amount of minerals in the samples. Except Sodium (Na), the contents of Calcium (Ca), Phosphorus (P), and Potassium (K) were largely influenced by tree species (P<0.0001). Among the macro-minerals only P contents varied due to location (P<0.05) and the remaining did not respond to difference in location. Maximum Ca (5.14%) was found in *Tecoma undulata* leaves and was lowest in *Capparis aphyla* (0.22%). Calcium contents in other tree leaves non- significantly ranged from 1.66 to 2.55 percent and were regarded adequate against the dietary levels of 0.22 to 0.40 percent for sheep and goats (NRC, 1981, 1985). All the tree leaves had low concentrations of P ranging from 0.07 to 0.14 percent and the results are consistent with several workers who reported low P contents in tree leaves (Habib *et al.*, 2012, Khanal and Subba, 2001, Inamur Rahim, 1999). Ca and P are closely inter-related and their utilization in animal body depends on the relative proportion of the two minerals in the diet. Ideally the ratio of Ca:P in ruminants diets should be 2:1 for their efficient utilization (NRC, 1981). In the present study Ca:P ratios in all the tree leaves were considerably wide and averaged 30:1. In *Tecoma undulata* leaves the highest proportion of Ca was associated with lower levels of P and represented Ca: P ratio of 114:1. These results suggest that although Ca levels in the present tree leaves were higher these would not be utilized properly due to imbalanced ratio caused by low P and may lead to occurrence of hemoglobinurea in the animals (Habib, 2005). P deficiency also causes reproductive problems and the affected animals develop depraved appetite and eat abnormal non-dietary things such as soil, debris and bones (McDowell *et al.* 1984). Na contents were same in all the eight varieties of tree leaves and averaged 0.02 percent as against 0.2% required in the sheep and goats diets and this deficiency could be attributed to low Na in the soil (Suttle, 2001). These findings agree with Khanal and Subba (2001) who also found low Na (<0.06%) in tree leaves. Our results suggest that grazing sheep and goats in Kohat region must be provided free choice salt lick on their return from grazing. Potassium contents in all the tree leaves were almost two folds higher than the recommended dietary level of 0.5 percent (NRC, 1981, 1985). Maximum level of 1.55% was found in *Capparis aphyla* leaves and remained the same (average 0.92%) in the other leaves. These results are consistent with Inamur Rahim (1999) and Habib *et al.*, (2012). Who reported high K in tree leaves and cultivated fodders. Generally, K deficiency is not common in grazing animals because it is usually present in large amount in roughage based diets.

Table 1. ***Macro-mineral composition of tree leaves (on DM basis)***

Botanical Name	Local Name	Sub Location	Mineral Matter %	Calcium %	Phosphorus %	Sodium %	Potassium %
Acacia modesta	Palosa	Surgul	8.37	3.62	0.09	0.02	0.81
		Shakardara	10.81	2.10	0.10	0.02	0.72
		Gumbat	8.76	1.94	0.13	0.02	0.88
		Mean	**9.31**[c]	**2.55**[b]	**0.11**[ab]	**0.02**	**0.80**[b]
Albezia lebbeck	Sreekh	Surgul	11.49	2.87	0.07	0.02	0.78
		Shakardara	14.26	2.30	0.06	0.02	0.79
		Gumbat	12.63	1.65	0.13	0.02	0.99
		Mean	**12.79**[b]	**2.27**[b]	**0.09**[abc]	**0.02**	**0.86**[b]
Capparis aphyla	Careeta	Surgul	9.30	0.29	0.08	0.02	1.48
		Shakardara	6.87	0.18	0.10	0.02	1.62
		Gumbat	6.97	0.20	0.16	0.02	1.55
		Mean	**7.71**[c]	**0.22**[c]	**0.11**[ab]	**0.02**	**1.55**[a]
Prosopes Juliflora	Keekar	Surgul	8.33	1.72	0.12	0.03	0.97
		Shakardara	11.13	2.58	0.12	0.02	1.17
		Gumbat	7.32	2.51	0.12	0.02	0.66
		Mean	**8.93**[c]	**2.27**[b]	**0.12**[ab]	**0.02**	**0.93**[b]
Tecoma undulata	Pleana	Surgul	41.59	5.03	0.04	0.08	0.39
		Shakardara	39.73	5.03	0.06	0.02	0.61
		Gumbat	36.19	5.36	0.04	0.02	1.10
		Mean	**39.17**[a]	**5.14**[a]	**0.05**[c]	**0.04**	**0.70**[b]
Olea cuspidata	Khona	Surgul	7.30	1.31	0.07	0.04	0.92
		Shakardara	6.17	1.94	0.06	0.02	1.21
		Gumbat	8.66	1.72	0.09	0.05	0.75
		Mean	**7.38**[c]	**1.66**[bc]	**0.07**[abc]	**0.04**	**0.96**[ab]
Ziziphus mauritiana	Watani Bera	Surgul	9.26	1.94	0.14	0.02	1.50
		Shakardara	9.84	2.36	0.13	0.02	1.07
		Gumbat	9.71	2.27	0.15	0.02	1.23
		Mean	**9.60**[c]	**2.19**[b]	**0.14**[a]	**0.02**	**1.27**[ab]
Ziziphus jujuba	Sawa beer	Surgul	7.57	2.82	0.11	0.02	1.18
		Shakardara	9.32	2.01	0.14	0.04	1.20
		Gumbat	9.54	2.41	0.13	0.03	1.19
		Mean	**8.81**[c]	**2.41**[b]	**0.13**[ab]	**0.03**	**1.19**[ab]
Tree Leaves			**P<0.0001**	**P<0.001**	**P<0.001**	**NS**	**P<0.01**
Location			**P<0.0001**	**NS**	**P<0.05**	**NS**	**NS**

Means of tree species across the locations in the same column with different superscripts are significantly different (P<0.05)
NS= Non significant

Micro Minerals

Micro-minerals are needed in small quantity in the animal diets but are essential elements for supporting wide range of synthesis in animal body important for maintenance of health, fertility, growth and production (NRC, 1989). Results of copper (Cu), zinc (Zn), iron (Fe) and manganese (Mn) concentrations in the tree leaves are summarized in Table 2. Zinc and Mn contents were influenced by tree species (P<0.001). None of the micro elements responded significantly to difference in the location. Copper contents across the eight species ranged from 2.4 to 4.70 ppm but did not qualify statistical significance due to high variation among the locations. Copper contents averaged 3.32 ppm and were close to 4 to 10 ppm required in forage based diets for ruminant livestock (Suttle, 2010). Copper contents in the present tree leaves were lower than those reported by Inamur Rahim (1999) who found that it averaged 21.29 ppm in 15 species of tree leaves of trans-Himalayan region. However, the present results are consistent with Habib et al. (2012) who found that Cu contents in ten species of tree leaves of Gadoon area ranged from 2 to 6 ppm. Such differences may be attributed to variation in soil profile (Khan *et al,*. 2006). Consistent with the present findings, low concentrations of Cu (3-4 ppm) in local cultivated fodders were also reported by Ashraf (1996). Our findings suggest that Cu contents in the test leaves were marginal and Cu supplementation would be required to support higher performance of sheep and goats for milk production, reproduction and accelerated growth rate. Zinc play important role in biochemical processes in the body to the extent that most of the metabolic pathways are dependent on one or more zinc-requiring proteins and there are large number of zinc-dependent enzymes of diverse structure and function (Cousins *et al.*, 2006). Zinc is important for fetal growth, fat absorption, fertility, and normal appetite (Suttle, 2010, NRC, 1989). Zinc concentrations in the present tree leaves were higher, varied from 25.53 to 131.37 ppm and were above the range of 22-50 ppm reported for pastures worldwide (Minson, 1990). Maximum Zn level of 131.37 ppm was found in *Olea cuspidate* leaves and remained the same in other seven species (29.23 ppm). These values are higher than 4-18 ppm reported by Rahim (1999) and are in close agreement to the values of Habib *et al.* (2012). Suttle (2010) reported Zn in grasses ranged from 26 to 33 ppm. Ashraf (1996) found that Zn levels in local cultivated fodder varied from 18 to 40 ppm. These observations suggest that Zn in the present tree leaves were within the optimum range required in the diets of ruminant livestock.

Table 2. ***Micro-mineral composition of tree leaves (on DM basis)***

Botanical Name	Local Name	Sub Location	Copper (Cu) ppm	Zinc (Zn) ppm	Iron (Fe) ppm	Manganese (Mn) ppm
		Surgul	3.40	25.80	204.10	84.90
Acacia modesta	Palosa	Shakardara	2.50	21.00	256.20	110.80
		Gumbat	4.18	27.68	157.40	110.25
		Mean	**3.36**	**24.83^{b}**	**205.90**	**101.98^{abc}**
		Surgul	3.40	16.80	366.80	87.50
Albezia lebbeck	Sreekh	Shakardara	2.40	26.00	229.00	134.80
		Gumbat	3.96	30.76	160.15	100.53
		Mean	**3.25**	**24.52^{b}**	**251.98**	**107.61^{ab}**
		Surgul	2.50	24.80	174.30	42.80
Capparis aphyla	Careeta	Shakardara	2.00	20.00	154.00	33.30
		Gumbat	2.90	46.20	173.90	51.90
		Mean	**2.47**	**30.33^{b}**	**167.40**	**42.67^{c}**
		Surgul	7.00	33.00	212.80	145.90
Prosopes Juliflora	Keekar	Shakardara	2.50	31.10	237.30	127.70
		Gumbat	4.60	21.50	151.90	129.70
		Mean	**4.70**	**28.53^{b}**	**200.67**	**134.43^{a}**
		Surgul	2.50	45.10	137.80	64.20
Tecoma undulate	Pleana	Shakardara	3.00	43.80	155.90	51.40
		Gumbat	3.75	33.85	162.90	90.80
		Mean	**3.08**	**40.92^{b}**	**152.20**	**68.80^{bc}**
		Surgul	4.10	127.10	178.60	53.40
Olea cuspidate	Khona	Shakardara	3.00	153.00	130.00	62.00
		Gumbat	4.00	114.00	165.00	81.00
		Mean	**3.70**	**131.37^{a}**	**157.87**	**65.47^{bc}**
		Surgul	3.50	32.80	157.50	76.00
Ziziphus mauritiana	Watani Bera	Shakardara	3.70	29.10	155.00	77.30
		Gumbat	3.00	14.70	192.60	158.60
		Mean	**3.40**	**25.53^{b}**	**168.37**	**103.97^{ab}**
		Surgul	2.20	25.90	178.00	115.20
Ziziphus jujube	Sawa beer	Shakardara	3.00	34.00	192.00	142.00
		Gumbat	2.60	29.95	185.00	128.60
		Mean	**2.60**	**29.95^{b}**	**185.00**	**128.60^{a}**
Tree Leaves			**NS**	**P<0.001**	**NS**	**P<0.001**
Location			**NS**	**NS**	**NS**	**NS**

Means of tree species across the locations in the same column with different superscripts are significantly different (P<0.05)
NS= Non significant

Both Fe and Mn in the present tree leaves were in the higher range (Table 2). Fe levels were not influenced by tree species or location and non-significantly ranged from 157.87 to 205.90 ppm. Fe contents averaged 186.17 ppm across all the tree leaves and were 3 times higher than the required dietary level of 50 ppm in ruminant rations; however it remained below the maximum tolerable level of 1000 ppm (NRC, 1989). Generally, Fe deficiency is uncommon in grazing animals due to its adequate contents in soils and forages (McDowell et al. 1984). The present results together with the findings of Ashraf (1996) who reported high levels of Fe in local varieties of fodders ranging from 69 to 438 ppm indicate that local soil in Pakistan may be rich in Fe (Khan et al., 2006) . Mn contents in the tree leaves were optimum but highly fluctuated and varied from 42.67 to 134.43 ppm apparently due to large variation between the locations (Table 2). Mn was lowest (42.67 ppm) in *Capparis aphyla* leaves and was maximum (134.43 ppm) in *Prosopes Juliflora* leaves. As compared to the present findings, lower Mn (< 19 ppm) in tree leaves of hilly region was reported by Rahim (1999). McDowell et al. (1984) reported that Mn content in feedstuffs is quite variable and influenced by soil type and soil pH and plant species. Signs of Mn deficiency include ataxia in newborn offspring, impaired reproduction and growth with skeleton abnormalities and were elicited by feeding diets low in Mn (<17 ppm) for extended period (NRC, 1989). In the present investigation, all the tree leaves showed higher concentrations of Mn than the above critical level. Nevertheless Mn requirement is not uniform and increases with high levels of Ca and P in the diets (NRC, 1989).

In Vitro DM Digestibility (IVDMD)

In vitro DM digestibility results of tree leaves are summarized in Table 3. IVDMD significantly influenced by tree species (P<0.001) but did not vary due to difference in locations. Overall the IVDMD was in the lower range below the optimum level of 60% generally desired in good quality forages. Among the eight species, IVDMD was maximum (P<0.05) in *Ziziphus mauritiana* leaves (51.28 %), lowest in *Olea cuspidate* leaves (25.96%) and intermediate (32.33 – 47.90%) in the remaining leaves. In contrast to our results higher IVDMD in leaves of Ziziphus (63.20%), *Acacia* (55.90%) and *Olea* (46.40%) species were reported by Rahim (1999). Our IVDMD results of *Olea cuspidate* were close to that reported by Solorio *et al.* (2000). High variation in IVDMD results among different laboratories could be expected because of lack of adapting a uniform standardized *in vitro* fermentation technique. In the present study two standard forage samples with known digestibility were included in all *in vitro* batches to check and adjust variations. Large differences in organic matter digestibility of tree leaves (36-80%) were also reported by Khanal and Subba (2001). Nonetheless, the present results suggest that bio-availability of minerals in the tree leaves when consumed by the animals will be constrained due to low DM digestibility. The low digestibility may presumably be attributed to anti-nutritional compounds present in the leaves. Norton (1998) reported that tree foliage has a wide range of antinutritive compounds that affect their rumen digestibility and intake preference by animals. Several workers have reported that high tannins in tree leaves adversely affected digestibility, intake and N retention in animals (Habib *et al.*, 2008; Khan *et al.*, 2009; Rana *et al.* 2006; Bakhshi and Wadhwa, 2004, Kumar and Vaithiyanathan,1990). The bio-availability of minerals constrained by low DM digestibility in tree leaves need further investigations and shall be taken in to account in balancing rations for ruminant livestock.

Table 3. ***In vitro Dry Matter Digestibility (IVDMD) of tree leaves***

Botanical Name	Local Name	Sub Location	IVDMD %
Acacia modesta	Palosa	Surgul	44.24
		Shakardara	44.56
		Gumbat	43.17
		Mean	**43.99[bc]**
Albezia lebbeck	Sreekh	Surgul	30.01
		Shakardara	38.08
		Gumbat	28.90
		Mean	**32.33[d]**
Capparis aphyla	Careeta	Surgul	41.86
		Shakardara	40.27
		Gumbat	40.83
		Mean	**40.99[c]**
Prosopes Juliflora	Keekar	Surgul	47.68
		Shakardara	47.55
		Gumbat	48.47
		Mean	**47.90[ab]**
Tecoma undulate	Pleana	Surgul	41.26
		Shakardara	41.85
		Gumbat	41.94
		Mean	**41.68[bc]**
Olea cuspidate	Khona	Surgul	27.10
		Shakardara	28.31
		Gumbat	22.47
		Mean	**25.96[e]**
Ziziphus mauritiana	Watani Bera	Surgul	49.79
		Shakardara	51.03
		Gumbat	53.01
		Mean	**51.28[a]**
Ziziphus jujube	Sawa beer	Surgul	47.03
		Shakardara	46.82
		Gumbat	45.56
		Mean	**46.47[abc]**
Tree Leaves			**P<0.001**
Location			**NS**

Means of tree species across the locations in the same column with different superscripts are significantly different (P<0.05)
NS= Non significant

CONCLUSION AND RECOMMENDATIONS

Results of the present study concluded that indigenous tree leaves of Kohat region are potential source of both macro and micro minerals. Calcium levels were high but corresponding low levels of P would negatively affect utilization of both the minerals in sheep and goats. Concentrations of Na and K in the tree leaves were adequate to meet the requirements of sheep and goats. Cu contents were close to the optimum levels required by animals. However, high performance sheep and goats may require further supplementation with a Cu source. All the tree leaves had Zn, Fe and Mn contents higher than the recommended dietary levels for sheep and goats. Overall IVDMD results were in lower range suggesting that bioavailability of minerals in animals may be constrained by low digestibility of the present tree leaves and shall be taken into account during ration formulation. Research is also needed to overcome the limitation of low digestibility in the tree leaves.

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