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Mineral Contents of Browse Plants in Kweneng District in Botswana

A.A. Aganga and E.O. Mesho
Botswana College of Agriculture, P/Bag0027, Gaborone, Botswana

Abstract: The mineral composition of 22 browse species (*Acacia species* (*erubescens*, *fleckii*, *giraffae*, *karroo*, *mellifera* and *tortillis*); Grewea species (*bicolor*, *flava* and *flavascence*); Boscia species (*albutrunca* and *foetida*); *Peltophorum africanum*, *Combretum hereroscence*, *Ehretia rigida*, *Terminalia serecia*, *Ziziphus mucronata*, *Euclea undulata*, Commiphora species, *Ximania africanum*, *Ochna pulchra*, *Dichrostachys cineria* and *M. senegalensces*) from Kweneng district was evaluated. Concentration of Ca, Mg, Na, K and P varied among the species from 0.69-1.89, 0.24-0.66, 0.42-2.42, 0.41-3.03 and 0.03-0.40 g/100 g on dry matter basis, respectively. The browses contained low levels of most micro minerals. The grazing livestock in the area should be provided with mineral supplements due to the low levels of both macro and micro minerals in the browses in the sand veld of Kweneng districts.

Key words: Browse plant, micro and macro minerals, grewed and boscia species

INTRODUCTION

The tender shoots, twigs and leaves of shrubs and woody plants and also fruits and pods are referred to as browse (Aganga *et al*., 2001; Devendra, 1995, 1989). They form an important component of the diet, especially for a variety of herbivores. Devendra (1989) emphasized that the diets of small ruminants and camels consistently contain shrub and tree fodder materials much more than the diets of buffaloes and cattle. In the semi-arid and arid environment of Botswana and the rest of Africa, browses form a natural part of the diet of many ruminant animals and have been used conventionally as sources of forages for livestock (Aganga, 2003). Browse leaves and pods form a natural part of the diet of goats, which meets over 60% of the forage requirements and have been used by traditional farmers as sources of forage in Botswana (Aganga *et al*., 2000). Tree fodders are important sources of high quality feed for grazing ruminant and as supplements to improve the productivity of herbivores fed low quality feeds (Aganga, 2003). In the savanna, the availability of palatable species varies in accordance with the season. At the time when grazing offers animals only dried grass at its least palatable, of poor feed value and often present in inadequate quantities, browse plants provide fresh green stage of forage during the dry season, new shoots and buds/or flowers and fruit (Toutain, 1980).

There are several types of leguminous and non-leguminous indigenous trees in Botswana, which provide feed for both game and livestock especially during the dry season and drought years. Trees such as *Acacia species* (*erubescens*, *fleckii*, *giraffae*, *karroo*, *mellifera* and *tortilis*); *Grewea species* (*bicolor*, *flava* and *flavascence*); *Boscia species* (*albutrunca* and *foetida*); *Peltophorum africanum*, *Combretum hereronscence*, *Ehretia rigida*, *Terminalia serecia*, *Ziziphus mucronata*, *Euclea undulata*, *Ximania africanum*, *Ochna pulchra*, *Dichrostachys cineria*, *Maytenus senegslensis* and *Commiphora* species. They provide the bulk of proteins, vitamins and mineral elements, which are normally lacking in grasses during the dry seasons (Le Houérou, 1980).

Tree fodders have nutritional significance for free ranging herbivores in extensive, communal management system. According to Aganga (2003) the grazing ruminants and non-ruminants usually nibble on the young foliage of shrubs on the rangelands. The availability of a variety of these feeds and the selection process enables the herbivores especially the goats to extend as well as meet their feed preferences. Aganga and Monyatsiwa reported that many of the tree browse species have evolved in semi-arid regions alongside herbivorous animals and are often used as a buffer to overcome feed gaps that arise from seasonal fluctuations in other feed sources. During the dry season, or in times of drought, trees provide green forage rich in proteins and minerals.

The objectives of the study, were to determine some macro mineral (Ca, K, Mg, Na, and P) and some micro mineral (Fe, Mn and Zn) content of some browse plants in the rangelands in Kweneng district of Botswana.

MATERIALS AND METHODS

Twenty-two browse plants were randomly collected from the sandy loam soils of Kweneng district bimonthly.

Corresponding Author: A.A. Aganga, Botswana College of Agriculture, P/Bag0027, Gaborone, Botswana

The browse species included *Acacia species* (*erubescens, fleckii, giraffae, karroo, mellifera* and *tortillis*); *Grewea species* (*bicolor, flava* and *flavascence*); *Boscia species* (*albutrunca* and *foetida*); *Peltophorum africanum, Combretum hereronscence, Ehretia rigida, Terminalia serecia, Ziziphus mucronata, Euclea undulata, Commiphora species, Ximania africanum, Ochna pulchra, Dichrostachys cineria* and *Maytenus senegalensis*. The samples were dried at 70°C in a forced air oven for 48 h (AOAC) 1996. Dry samples were ground to pass through a 1mm sieve and then subjected to wet acid digestion according to AOAC (1996).

The digested plant materials were analyzed in duplicates for mineral composition using atomic absorption spectrophotometer (GBC 908 AA, Victoria, Australia) for Ca, Mg, Fe, Mn, and Zn; flame photometer (Corning Flame Photometer 410) for potassium and sodium and uv/visible spectrophotometer (Shimad zu UV-1601PC) for P .

Analysis of Variance (ANOVA) was used to analyse data collected on chemical composition.Significance between means was tested using Duncan's multiple range tests (SAS, 2004).

RESULTS AND DISCUSSION

The content of macro minerals of 22 evaluated browse plants species from Kweneng district rangelands are shown in Table 1. The chemical analysis showed that the mineral content ranged from: Ca (0.69-1.89% DM) for *Ochna pulchra* to *Ehretia rigida*; Mg (0.24-0.66 g/100 g DM) for *Acacia giraffee* to *M. senegalenses;* Na (0.42-2.42% DM) for *Acacia fleckii* to *Ehretia rigida*; K (0.41-3.03% DM) for *Dichrostachys cineria* to *Ehretia rigida* and P (0.03-0.40% DM) for *Ziziphus mucronata* to *Dichrostachys cineria*, respectively.

Livestock owners have long recognized the importance of trees and shrubs in the feeding of animals in Botswana which is an arid area where the growth of herbaceous plants is limited by lack of moisture, leaves and edible twigs of trees and shrubs constitute a large percentage of the biomass production of rangeland. Leloup and Mannatje (1996) found that there was no relationship between ash concentration and differing palatability classes of browse material or differences in crude fiber concentrations in different seasons. It seemed that the seasonality of browse consumption might be a function of a declining availability and quality of herbage (Conner *et al*., 1963) as well as a higher absolute nutritive value. This agrees with Devendra and Burns (1983) as they mentioned that the real value of browse is that it increases with the decreasing quality of browsing and feed availability.

Table 1: Content of macro minerals of 22 indigenous browse species from Kweneng district rangelands

Mineral (%)	Ca	Mg	Na	P	K
T. serecia	0.97	0.43	0.63	0.12	1.06
D. cinera	1.08	0.41	1.21	0.40	0.41
G. bicolor	1.73	0.35	1.31	0.22	1.66
G. flava	1.67	0.38	0.90	0.24	1.28
G. flavarescence	1.43	0.35	1.15	0.22	1.49
A. erubenses	1.58	0.43	0.94	0.29	1.38
A. fleckii	1.54	0.59	0.42	0.16	1.02
A. giraffee	1.10	0.24	1.26	0.32	1.50
A. karroo	0.84	0.31	0.89	0.33	1.20
A. mellifera	1.63	0.41	0.90	0.13	1.30
A. tortilis	1.45	0.26	1.29	0.20	1.55
B. albutrunca	1.21	2.04	1.05	0.18	1.27
B. foetida	1.18	0.48	0.95	0.32	1.44
E. rigida	1.89	0.61	2.42	0.26	3.03
P. africanum	1.53	0.48	0.87	0.24	1.35
X. africanum	1.11	0.44	1.36	0.19	1.81
Commiphora sp.	1.86	0.49	0.66	0.30	1.15
O. pulchra	0.69	0.31	0.51	0.16	0.82
M. senegalenses	1.39	0.66	0.87	0.13	1.54
C. herorenscence	1.82	0.53	0.87	0.16	1.40
E. undulata	1.15	0.40	0.65	0.18	0.99
Z. mucronata	1.88	0.32	1.18	0.03	1.50

McDowell (1992) suggested that livestock and humans usually derive most of their mineral nutrients from their food, but significant quantities of minerals may be obtained from water, soil or non-feed contamination. Underwood (1981) and Underwood and Suttle (2003) stated that the factors that determine the mineral content of the vegetative parts of plants and their seeds are the factors that basically determine the mineral intakes of livestock. Topps (1992) and Spears (1994) reported that factors such as soil, climate, stage of maturity and season of the year contribute to variations in the concentration in forages.

Soil and dust contamination of herbage can at times provide a further significant source of minerals to grazing animals, especially when grazing intensity is high or when pasture availability is low (Underwood, 1981).

According to Underwood (1981) the concentration of all minerals in crop and forage plants depends on four basic interdependent factors:

- The genus, species or strains (variety).
- The type of soil on which the plant grows.
- The climatic or seasonal conditions during growth.
- The stage of maturity of the plants. Mc Dowell (1992) added.
- Yield.
- Pasture management.
- Climate.

The extent to which these factors actually affect the concentration of a mineral element in the plant tissues varies with different minerals and with the treatments imposed by man in his efforts to increase crop or pasture yields.

Rubenza *et al.* (2006) in their study of six-browse sp., (*A. Sieberiana*, *Boscia* sp., *Grewia* sp., *Lonchocaprpus capassa*, *Pithecellobium dulce* and *Salvadora persica*) found that the species had high levels of Crude Protein (CP) that varied among the species from 153-231 g kg^{-1} Dry Matter (DM) in *Grewia* sp. and Boscia sp., respectively. The concentration of Ca, P, Mg and S varied among the species from 13.8-55.1, 3.2-4.9, 2.4-6.2 and 1.6-30.6 g kg^{-1} DM, respectively. The study also showed that forages contained low to moderate levels of most micro minerals. Grewia sp. had the lowest levels of Mn (44.7 vs 306 mg kg^{-1} DM; *L. capassa*) and *Boscia* sp. and *Grewia* sp. also had lowest levels of Co. (0.29 vs. 0.61 mg kg^{-1}DM; *L. capassa*. Rubenza *et al.* (2006) concluded that the species could be used as protein and mineral supplements for ruminants in the tropics due to their high levels of CP, Ca, P, S, Mn, and Co. However, the low concentrations of Cu and Zn could be limiting in ruminant feeding. The browse species had low levels Total Extractable Phenolics (TEP) (1.1-8.1) and Tannins (TET) (0.25-7.1 g kg^{-1} DM. The low levels of TEP and TET could be regarded beneficial by preventing excessive Nitrogen-loss and by promoting by-pass protein to the lower gastro-intestinal tract.

Mineral requirements define the lower limits of adequacy and are arrived at by relating to the growth, health, production, or other relevant criteria in the animal with varying dietary mineral concentrations (McDowell, 1992). Minimum mineral intakes must be sufficient to ensure the long-term maintenance of the mineral reserves of the body tissues and amounts of those minerals in the edible products of the animal. Mineral requirements are highly dependent on the level of productivity. As the amount of a mineral available to the animal becomes deficient due to inadequate intake or depletion of the body reserves, certain processes fail in the competition for the inadequate supply. The priority of demand exerted by these processes for the mineral varies among different animal species and within species, with the age of the animal and the rapidity with which the deficiency develops.

The content of macro minerals of 22 evaluated browse plants species of Kweneng are shown in Table 1. The chemical analysis showed that the mineral content ranged from: Fe (15.00-250.00 ppm) for *Acacia karroo* to *Combretum hereroscence*; Mn (1.25-17.20 ppm) for *Acacia tortilis* to *Terminalia serecia* and Zn (1.00-2.20 ppm) for *Combretum herorenscence* to *Terminalia serecia.*

Table 2: Content of micro minerals of 22 indigenous browse species from Kweneng district rangelands

Mineral (ppm)	Fe	Mn	Zn
T. serecia	106.00	17.20	2.20
D. cinera	182.00	1.90	1.70
G. bicolour	137.05	7.75	1.42
G. flava	222.05	4.08	1.25
G. flavarescence	123.30	10.00	1.58
A. erubescens	127.50	3.56	1.31
A. fleckii	68.30	2.17	1.83
A. giraffee	105.00	-	2.00
A. karroo	15.00	-	2.00
A. mellifera	167.50	3.50	2.00
A. tortilis	90.00	1.25	2.13
B. albutrunca	70.00	3.00	1.58
B. foetida	83.03	2.33	2.00
E. rigida	110.00	4.00	1.50
P. africanum	187.50	15.62	1.38
X. africanum	92.50	7.50	-
Commiphora sp.	161.70	3.17	0.167
O. pulchra	115.00	6.75	2.00
M. senegalenses	196.70	4.17	1.00
C. herorenscence	250.00	3.50	1.00
E. undulata	80.00	15.83	2.00
Z. mucronata	120.00	1.00	1.50

Table 3: Mineral content of all analysed browse plants species in Kweneng district through the months of January, March, May and July

	Months			
Minerals	January	March	May	July
Ca (%)	1.277±0.11	1.265±0.12	1.674±0.12	1.556±0.14
Mg (%)	0.428±0.11	0.437±0.12	0.591±0.12	0.751±0.14
Na (%)	1.283±0.11	1.179±0.12	0.950±0.12	0.612±0.12
P (%)	0.305±0.11	0.150±0.12	0.179±0.12	0.305±0.12
K (%)	1.712±0.11	1.616±0.12	1.359±0.12	0.946±0.12
Fe (ppm)	80.000±1.12	160.000±1.12	110.000±1.21	170.000±1.14
Mn (ppm)	3.000±0.11	2.000±0.12	7.000±0.12	14.000±0.14
Zn (ppm)	1.000±0.11	2.000±0.12	1.000±0.12	1.000±0.14

Mean±standard error

Table 4: Tests of between-subjects effects

Source	Type III sum of squares	df	Mean square	F	Significance
Corrected model	327.509[a]	495	0.662	2.601	0.000
Intercept	166.129	1	166.129	653.067	0.000
Site	0.254(ASS)	1	0.254	0.77	0.381
Date	0.844	3	0.281	1.106	0.349
Plant	10.343	23	0.45	1.768	0.023
Mineral	168.425	7	24.061	94.584	0.000
Date*Plant	7.316	35	0.209	0.822	0.747
Date*Mineral	17.36	21	0.827	3.25	0.000
Plant*Mineral	38.797	161	0.241	0.947	0.632
Date*Plant*Mineral	32.247	245	0.132	0.517	1.000
Error	36.631	144	0.254		
Total	583.317	640			
Corrected total	364.14	639			

R Squared = 0.899 (Adjusted R Squared = 0.554), ASS = ANOVA Sum of Squares

Table 2 shows the individual mineral concentrations in all the browse plants analysed according to the months. There was no significant difference ($p<0.05$) on the site and mineral concentrations in the browse plants according to the months as shown in Table 3. However, Table 4 and Fig. 1 show that the mineral concentrations decreased as the dry season approached and intensify.

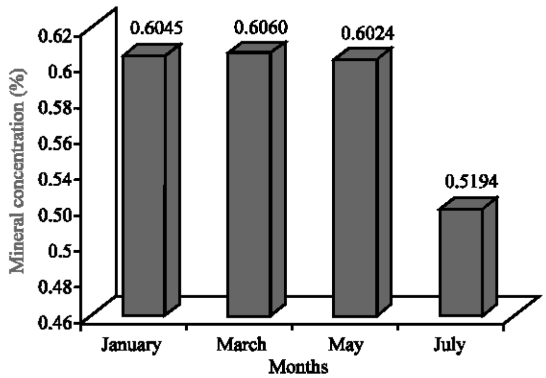

Fig. 1: Browse plants mineral concentrations during the months of January, March, May and July

This suggests that the mineral concentrations decrease as the nutritional value of the plants decrease or as the plants lose their green colour and dry off. According to Devendra (1995) the importance of browse is that its nutritive value increases with decreasing quality of browsing and feed availability. Tree fodders are important sources of high quality feed for grazing ruminants and as supplements to improve the productivity of herbivores fed on low quality feed. Tree fodders form part of the complex interaction between plants, animals and crops, the positive aspects of which help to balance a plant-animal-soil ecosystem and from which there is a sustainable source of feeds.

The maintenance needs of cattle, sheep and goats showed that browse, the nutritional value of which varies from 2.95-5.31 MJ ME kg^{-1} DM alone cannot ensure the maintenance requirement of cattle (6.02 MJ ME kg^{-1} DM). It can, however, ensure the maintenance of sheep (5.17 MJ ME kg^{-1} DM), but does not allow production, while for goats, maintenance and production may be provided on a pure browse diet (4.72 MJ M e kg^{-1} DM). The data explain why only goats, camels and some wild herbivores can survive on depleted rangelands, where browse constitutes most of the feed. It also explains why goats and camel are less affected by catastrophic droughts in the Sahel of Africa, compared with sheep and cattle.

Table 4 shows the different statistical tests and their significance. It is clear from the table that date, date*plant, plant*mineral and date*plant*mineral are not significantly different ($p>0.05$) while mineral and date*minerals are significantly different and this is because browse plants species contain different minerals and these mineral concentrations are affected by the season of the year as shown in Fig. 1.

Table 5 shows that there was no significant difference ($p>0.05$) between Zn and Mn (minor minerals) concentrations in the plants however, there was a significant difference ($p<0.05$) between these minor minerals and the major minerals (P, Mg, Na, Ca and K). There was significant difference ($p<0.05$) amongst the major minerals except between Ca and K.

Table 5: Variation between minerals concentration means

		Subset				
Mineral	N	1	2	3	4	5
Zn	80	0.0015				
Mn	80	0.0060				
P	80		0.2285			
Mg	80			0.5473		
Na	80				1.0282	
Ca	80					1.4237
K	80					1.4334
Sig.		0.892	1.000	1.000	1.000	0.903

Groups in different subset are significantly different ($p<0.05$)

Table 6: Variation between plant concentration means

	Subset		
Browse species	1	2	3
O. pulchra	0.3148		
T. serecia	0.4102	0.4102	
E. undulata	0.4125	0.4125	
A. karroo	0.4464	0.4464	
A. fleckii	0.4675	0.4675	
A. mellifera	0.5475	0.5475	
B. foetida	0.5485	0.5485	
A. giraffee	0.5543	0.5543	
Commiphora sp.	0.5598	0.5598	
P. africanum	0.5627	0.5627	
G. flava	0.564	0.564	
M. senegalense	0.5761	0.5761	
G. flavaresence	0.583	0.583	
D. cinera	0.5936	0.5936	
A. tortilis	0.596	0.596	
A. erubensence	0.599	0.599	
C. herorensence	0.6017	0.6017	
X. africanum	0.6156	0.6156	
Z. mucronata	0.6158	0.6158	
G. bicolor	0.662	0.662	
B. albutrunca	0.7183	0.7183	0.7183
E. rigida			1.0289
Significance	0.057	0.061	0.083

Groups in different subsets are significantly different ($p<0.05$)

Table 6 shows that although the browse species are different the majority of them are not significantly different ($p>0.05$) in terms of their mineral composition. Thus the browse plants in the same subsets are similar or the same in terms of their mineral concentrations, while those browse plants in different subsets are significantly different ($p<0.05$) for example *Ehretia rigida* is different from *Ochna pulchra*.

The evaluated browse species from Kweneng district rangelands had low levels (0.69-1.89% DM) of Ca. The variation in the levels of Ca between the findings in the current research with the values reported in the literature could be explained by botanical species composition, stage of growth and the season as well as the variations in soil characteristics due to location of the different grazing lands. The area under study is a sandveld area of which the soils have a poor texture as a result soil does hold sufficient nutrient and hence browses have low levels of Ca. The browses have a slightly lower level of Ca than the dietary requirement of growing lambs (0.9-5.3% DM) and lactating ewes (1.2-3.7% DM). But the levels in the study are within the requirements levels of goats (0.21-0.52%) (Aganga *et al.*, 2000).

The browse species had low levels (0.03-0.40% DM) of P than the mean level of 2.9% DM of most tropical grasses (Rubenza *et al.*, 2005). These levels are also lower than level of P (0.8-2.7% DM) of some browse plants, buffel grass and Lucerne carried at Botswana College of Agriculture content farm (Aganga *et al.*, 2001). Although the P levels are lower than the mean level of tropical grasses they meet the requirements for goats. The variation in the content of observed P could be due to the available soil P and soil pH, browse growth stage and proportions of leaf and stem fractions harvested for mineral analyses and sampling seasons. Contents of minerals in forages including P decrease with plant maturity (Mc Dowell, 1992).

The browse species in the study, had low levels (0.24-0.66% DM) of Mg. The difference in the content of observed Mg could be due to the available soil Mg, climate, browse growth stage and proportions of leaf and stem fractions harvested for mineral analyses and sampling seasons. These browses have low levels of Mg they would therefore, not 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), but may partially meet the requirements for beef cattle (0.2-1.2% DM).

The browse species evaluated had levels of K ranging from 0.41 B 3.03% DM which was higher than those reported by Aganga *et al.* (1999) but lower than those reported by Aganga *et al.* (2001). The difference in the content of observed K could be due to the available soil K, climate, browse growth stage and proportions of leaf and stem fractions harvested for mineral analyses. The browse species in the study had levels of Na ranging from 0.42-2.42% DM which was higher than those reported by Aganga *et al.* (1999, 2001). The variation in the levels of Na between the findings in the current study with the values reported in the literature could be explained by botanical species composition, stage of growth and the variations in soil characteristics due to location of the different grazing lands.

The browse species in the study had low levels of Fe (15.00-250.00%) compared to the high levels of most forages (100-700 ppm DM) as reported by McDowell (1992) but adequate for the critical content of Fe in animal tissues (30-50 ppm DM) as reported by Rubenza *et al.* (2006). The differences in the contents of Fe between the area of study and the literature values could be partly explained by variations in the content of Fe in the soil, and climatic conditions between localities. Forage Fe content is a function of forage species, soil Fe content, nature and type of soil on which forages are grown (McDowell, 1992). According to McDowell (1992) these browse species had adequate levels of Fe content for the normal requirements of 30-60 ppm% DM for ruminants although, Fe bioavailability in ruminants would depend on feed mixture fed together and the form of Fe in these feeds.

The difference in the content of Mn amongst the browses, could be partly explained by the herbage species, level of available Mn in the soil, soil pH and influence of soil pH on uptake by forages. The browses had lower levels (1.25-17.20 ppm) of Mn than the recommended level of 20 ppm% DM in diet and lower than the tabulated requirements of 40 ppm% DM for ruminants.

The Zn content of the browse species (1.00-2.20 ppm) were lower than the recommended requirement for sheep (24-51 ppm DM) and the efficiency of Zn utilization of these forages would depend on Zn bioavailability and its interaction with other mineral elements.

Kweneng district especially the area under study is in the sandveld and by the nature of the soil type the browse plants have low levels of both major and minor mineral content. As a result livestock in the area cannot obtain sufficient minerals from the indigenous plants especially during dry season therefore, farmers should supplement the livestock with mineral licks and blocks. Goats are recommended for the area since most of their mineral requirements, can be supplied by the browses.

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