Nutritive Value of *Atriplex halimus* and *Tamarix africana* in Southeastern Biskra (Algeria) and Their Importance for Ruminant Nutrition

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Abstract.
In southern Biskra (Algeria), the El Haouch area is a pastoral and fodder-producing region. Our objective was to evaluate and compare the nutritive value of the shrub *Atriplex halimus* and the tree *Tamarix africana*, and to determine the soil characteristics in the study area. Soil samples were collected near the plants along the sampling surface. Dry matter (DM), Crude protein (CP), ether extract (EE), neutral detergent fiber (NDF), acid detergent fiber (ADL), acid detergent lignin (ADL), macro and trace elements (Ca, P, Mg, Na, K, Cu, Zn, Mn, and Fe) contents were measured. The soil type is silt-clay, and its pH was slightly alkaline (7.5-8.5). Morphological effect was significant ($p<0.001$) for all nutrients concentration, except for Cu levels. Leaves showed the highest contents of EE, CP, and minerals and the lowest content of ADF. However, OM, NDF, ADL contents in stems were significantly higher than leaves ($p<0.001$). DM in *T. africana* was higher (51%) than that of *A. halimus* (24 %). The contribution of EE as fat in the whole plant does not exceed 2% for both fodders. However, Na levels in leaves can reach up to 70 g/kg DM. Nitrogen and mineral contents (Ca, Mg, Na, K and Fe) can meet the physiological needs of livestock in this region. Moreover, means of phosphorus content in whole plant were low (2.1 and 2.7 g/kg in *T. africana* and *A. halimus*, respectively). Trace element levels in both fodders ranged from sufficient to marginal. In both species, means of iron content in the leaves are almost double that of the stems.

Keywords: *Atriplex halimus*; *Tamarix africana*; arid area; soil; nutrient contents

1. Introduction

In arid area of Algeria, browse plants constitute an important source contributing to ruminant production. However, their irrational use led to a continuous degradation of these resources. El Haouch locality, situated in southeast of Biskra (south Algeria), is a pastoral and fodder area. It is characterized by a dry and alkaline soil. The vegetation is well adapted to the harsh conditions characterized by salinity, scarce and irregular precipitations, high temperatures and evapotranspiration. Local vegetation in this region is mainly composed by a various native fodder halophyte, grazed by goats, dromedaries, and sheep. Our attention is focused on the shrub *Atriplex halimus* (*Chenopodiaceae*), and the tree *Tamarix* africana (*Tamaricaceae*) due to their abundance [1], and their use as a browse by small ruminants and dromedaries, and as they remain evergreen throughout the year [2]. These halophytes exhibiting C4 photosynthesis have better water use efficiency in drought conditions and high temperatures [3], endowed with a complex root system and a considerable biomass [4].

Atriplex halimus has a deep root system that helps anchor the soil and reduce wind and water erosion. Its bushy growth habit also helps trap sand, reducing the impact of desertification [3, 4]. Moreover, *Tamarix africana* has a dense root system that stabilizes the soil and prevents erosion [2].

The objectives of this study were to assess and compare the chemical composition (major and trace elements, fiber, crude protein, organic matter, dry matter, and ether extract between *A. halimus* and *T. africana* which grow in close proximity, and to determine the soil characteristics and its chemical elements status in this area. This knowledge will lead to a better understanding whether grazing small ruminants meet their needs in terms of energy, nitrogen, and mineral nutrients to manage better the animal production and avoid possible nutritional deficits. Furthermore, to highlight the importance of these two species in arid regions.

2. Materials and Methods

2.1 Location and climat

The study was conducted in the El Haouch area, which is located 50 km southeast of Biskra in Algeria (5°N28'E30'15'). The climate is arid, with an average annual rainfall less than 100mm. The average minimum winter and maximum summer temperatures are 7°C in January and 45°C or even higher in July. The nutrition available of these grazing animals consists of native forage vegetation, natural pastures (grasses and shrubs), tree leaves and crop residues mainly straw.

2.2 Samples collection and preparation for analyses

Plant samples were randomly collected in studied area twice each month for 7 months (when available) in January, April, May, June, July, November, and December. Edible green aerial parts measuring 15 to 25 cm of length were clipped and manually separated into stems and leaves. Dry matter (DM), ash, crude protein (CP), ether extract (EE), were determined using the procedures of the Association of Official Agricultural Chemists (AOAC) [1, 5].

Calcium (Ca), magnesium (Mg), sodium (Na), potassium (K), copper (Cu), zinc (Zn), manganese (Mn) and iron (Fe) were analyzed after wet digestion in nitric-perchloric acid mixture. The photometric method was used to measure phosphorus (P) concentration [2]. The analyses of the various nutrients were performed in duplicate on the whole plant, as well as on the stems and leaves.

Moreover, soil samples were collected seasonally in a directed manner at five different points within the region, near the studied forage plants, using a soil auger at a depth of 20 cm. Samples were collected in paper bags, dried at 65°C for 72h and passed through a 2mm sieve [3]. The soil pH and the grain size distribution were determined using the technique recommended by International Soil Reference and Information Centre (ISRIC) [6]. Organic matter (OM) content was measured according to the loss of ignition method [7]. The Olsen method was utilized to determine P availability as outlined by Mathieu and Pieltain [7]. Aqua regia was used to determine chemical composition in soil [8, 9]. Mineral concentrations in forage plants and soil were measured using flame Atomic Absorption Spectrophotometry (Shimadzu model AA 6800).

2.3 Statistical analysis

The data were analyzed statistically using the XLSTAT software. Sampling period, plant species and morphological fraction were determined by one way analysis of variance. Statistical significance was set at $p<0.05$.

3. Results and discussion

3.1 Nutrient contents

Physico-chemical and mineral concentrations in the soil analysis of the study area are shown in table 1. Soil texture is silt-clay, and mean values of organic matter content were 2.7 %. High levels of OM are probably due to the method of analysis used or to the soil sampling sites selected at a depth of 20. These contents were lower than those reported by Khan *et al*. [10] in Pakistan and those noted by Bahamonde *et al*. [11] in Argentina (above 4.4 %).

Soil pH is basic (8.1 ± 0.2). These values agree with those reported by Nedjimi [3], in Djelfa (Algeria) and by Van Niekerk *et al*. [12] in South Africa. High pH is probably due to the presence of more base cations and to relatively low precipitation amounts.

Calcium concentrations in soil represent a high level (159 g/kg DM) compared to other major elements (Table 1). This high level may be a result of a high level of calcium carbonate ($CaCO_3$) and other Ca salts in soil. Ca levels in the present study differed from those recorded in Pakistan [10] and in Djelfa in Algeria [3], due to variations in climate and soil texture [9]. The mean values of available P in studied area were 78 ± 32 mg/kg DM, which is higher than those reported by Bahamonde *et al*. [11] in Argentina

(23 to 41 mg/kg). Magnesium and iron are also most abundant elements in soil, compared to other elements (Table 1). Major and trace elements levels obtained in the soil are higher than the critical levels necessary for plant growth [8, 9].

Table 1: Organic matter (%), pH and soil mineral (means ± SD) concentrations (Ca, Mg, Na, K and Fe expressed in g/kg DM and mg/ kg DM for P, Cu, Zn and Mn) in the study area (the total number (n) of soil samples was 20)

OM	pH	Ca	Mg	Na	K	P	Cu	Zn	Mn	Fe
2.7	8.1± 0.2	159 ± 37	26± 11	3.3 ± 1.1	5.3 ± 1.5	78 ±32	12± 5	95 ± 26	245 ± 14	25.3 ±4

The chemical composition in *A. halimus* and *T. africana* is presented in table 2. Generally, there was a considerable variation between both forage plants in term of nutrient contents. A significant difference was observed respectively ($p<0.001$; $p<0.01$and $p<0.05$) for DM, ash, OM and ADL. Sampling periods affect ($p<0.01$) only DM and CP levels.

The morphology effect ($p<0.001$; $p<0.01$) was observed for all nutrient contents except for DM and ADL between both species and within the same forage plant (Table 2). DM levels are high ($p<0.001$) in *T. africana* compared to *A. halimus*, and as a result there is a need for additional water supply. DM concentrations in *A. halimus* ground in El Haouch area were lower (Table 2) than those obtained in the same shrub in Egypt (35 %) [13] and compared to those reported in Mediterranean shrub species collected from Tunisia with a mean annual rainfall of 900 mm [14].

The ash contents in *A. halimus* in the studied area are high especially in leaves which contain 32 %. These levels are higher than those reported by El Shaer *et al*. [13] in the same shrub and lower than those observed in the *Atriplex mixture* [15]. The ash levels in *T. africana* leaves (20 %) are low compared to those reported by Al Masri [16] in *T. aphylla* (28 %) in northeastern Syria. The high level of ash in studied forage plants is a characteristic of halophytes, which store this salt, particularly in their leaves. In both fodder, stems are characterized by a higher level of OM than leaves. These levels are lower than those observed in Mediterranean shrubs [14].

The contribution of EE as fat in both studied plants did not exceed 2 % (Table 2), and the highest levels were noted in leaves. These value ranges were similar to those reported by El Shaer [13] and Ben Salem *et al*. [17].

Crude protein means in the whole studied plants ranged from 12 to 14 %, these values are similar to those reported in different halophytes [3, 13, 15, 16]. The CP content in leaves can reach 18 % in *A. halimus* leaves (Table 2). This characteristic is inherently interesting for dry areas where herbaceous vegetation is scarce [17]. *A. halimus* stems contained a high fiber level (67%). The ADL fraction in both plants ranged from 7 to 9.4 %, with a high level in the stems of *T. africana*. NDF and ADF contents in both halophytes are within the range of that reported by authors [14, 16, 17]. Fiber levels in the studied plants were high compared to the same in Djelfa and Boussadda (Algeria) [18] and those revealed in subtropical trees from southern Africa [19].

3.2 Macrominerals

Mineral contents varied largely between *A. halimus* and *T. africana* ($p<0.05$), except for Na and Fe (Table 3). Sampling period effect is significant ($p<0.05$) only for P. In both plant species, mineral levels varied between leaves and stems. However, K and Ca/P levels were similar. The interaction between plant, sampling period and plant fraction type was significant ($p<0.05$) only for Mn.

Table 2. Chemical composition (means ± SD) in *Atriplex halimus* and *Tamarix africana* (% DM basis) and the effect of plant species, sampling period, and morphology. (The total number (n) of samples was 14 for each forage species)

Species	Plant	DM	Ash	OM	EE	CP	NDF	ADF	ADL
A. halimus	W. plant	25± 7.3	23 ± 8	77 ± 9	1.7 ± 1	13.2 ± 5	45 ± 23	26 ± 15.4	7 ± 3
	Stems	25 ± 7.6	14 ± 4	86 ± 4	1.03 ± 0.65	8.8 ± 2	67 ± 7.88	36.7 ± 13	7 ± 3,2
	Leaves	25 ± 7.6	32 ± 3	68.1 ± 3	2.3 ± 1	17.7 ± 2	23.2 ± 1,2	16 ± 8	6.8 ± 3
T. africana	W. plant	95 ± 1.3	17± 6.5	83 ± 6.5	1.64 ± 1	14.2 ± 4	45.1 ± 7	28.4 ±5.4	8.9 ± 1.6
	Stems	95 ± 1.1	13 ± 4	87 ± 4	1.4 ± 0.45	12.3 ± 3	49.2 ± 4.3	30 ± 3.6	9.4 ± 1.8
	Leaves	95 ± 1.5	21 ± 6	79 ± 6	1.9 ± 0.73	16 ± 4	41 ± 6.3	26.8 ± 7	8.3 ± 1.2
Plant species		***	**	**	ns	ns	ns	ns	*
Sampling period		**	ns	ns	ns	**	ns	ns	ns
Morphology		ns	***	***	***	***	***	**	ns
Plant*Sampling period *plant fraction		ns	ns	ns	ns	ns	*	*	ns

W: Whole, DM: dry matter; OM: organic matter; EE: ether extract; CP: crude protein; NDF: neutral d etergent fiber; ADF: acid-detergent fiber; ADL: acid detergent lignin. *: p<0,05; **: p<0,01; ***: p<0,001; ns: not significant (p>0,05).

Tamarix africana parts had a higher Ca content compared to *A. halimus*. It could be a result of adaptation in response to water stress [20]. Our results were similar to those noted in *A. halimus* ground in lovedale site in South Africa [12]. It seems that range goats consuming these halophytes could eat substantial amount of Ca to meet their requirements [20, 21, 22].

The P content is high in *A. halimus* leaves at 3 g/kg DM compared to *T. africana*. These finding seem higher than those reported by Van Niekerk *et al*. [12] in *Atriplex species* and in the foliage of various tree species from south Africa [19]. The phosphorus status of forages varied widely and is influenced by the phosphorus status of the soil. Moreover, it is reported that as of halophytes mature, phosphorus content decreases [13, 24]. P concentrations in stems and leaves were marginally above goats' requirements [20] and growing beef cattle, which ranges between1.2 to 2.7 mg P/kg DM [23] (Table 3).

The Ca/P ratio ranged from 3.6 in stems to 12. 6 in leaves. It seems that browsing small ruminants can maintain these high Ca/P ratios without affecting P metabolism [20]. Although ruminants can tolerate a relatively wide Ca/P in their diet [24], the wide range Ca: P ratios in *T. africana* (25: 2.3) may lead to a reduction in P bioavailability and its deficiency could be occur.

Atriplex halimus contain the highest level of Mg, particularly in leaves. Mg range in both studied plants was consistent with those reported in Mexico [20] and in *Atriplex species* ground in South Africa [12], but it disagreed with the finding of Lukhele *et al*. [19] and Mirzaei [25]. In this study, both forage plants had Mg contents above the range required by goats (Table 3).

Na levels in both plants ranged from 31 g/kg DM in stems to 55 g/kg DM in leaves. Studied plants are halophytes accumulating a high level of Na particular in leaves. These finding are like to those reported by Al-Shorepy *et al*. [15] in *Atriplex mixture*. Desert plants may accumulate Na in order to alleviate water and saline stress [20]. It is reported that halophytes tolerate high levels of salinity and exhibit optimal growth in saline condition [3] and accumulate Na+ in response to salinity and maintain a lower salt concentration in their tissue compared the external saline environment.

K content was highest in *T. africana* leaves (26 g/kg DM). In this study, K levels were above the requirements for ruminants as suggested in the literature (Table 3). K contents in both forage plants were higher than what has been reported in various shrubs and tree foliage by the authors [19, 20, 24]. Similar findings were reported by Ben Salem *et al***.** [17] and by Mirzaei [25] in grasses from Punjab (Pakistan). It was noted that sodium can replace certain elements like potassium, and it accumulates in high levels in its aerial parts [3].

3.3 Trace elements

Mn levels were highest in *A. halimus* particularly the leaves, with an average of 24 mg/kg DM (Table 3). Conversely, Van Niekerk *et al*. [12], and Al-Shorepy *et al*. [15] reported a high range in the same shrub (116- 395 and 38 mg/kg DM, respectively). Mn levels in both forage plants were low compared to the Mn content in the soil (Table 1). Underwood and Suttle [24] reported that Mn concentrations in plants decrease markedly as soil pH increases. The high pH and Ca content in the soil in study area were among possible causes of low levels of Mn in *A. halimus* and *T. africana* [8]. However, particular attention to Mn requirements for small ruminants should be advised in this situation.

High levels of Cu were noted in *T. africana*: 27 and 35.2 mg/kg, in the whole plant and leaves, respectively. These values were similar to those reported in south Africa [19], and lower than those reported in Kenya [26]. Al-Shorepy *et al*. [15] reported a low level of Cu (4 mg/kg DM) in the *Atriplex mixture*. Cu concentrations in forage plants were considered sufficient to meet ruminants' requirements (Table 3). It is commonly suggested that the dietary requirement of ruminants for Cu ranges from 8 to 14 mg/kg DM [25]. However, high concentrations of Fe and Zn in the diet can reduce copper status and may increase copper requirements for ruminants [25, 27]. Moreover, 10 mg/kg of Cu in forage can lead to toxicity in sheep [27]. Therefore, high levels of Cu in different parts of *T. africana* (above 10 mg/kg) could be toxic for small ruminants especially sheep.

Table 3. Mean concentrations of major minerals (g/kg DM) and trace minerals (mg/kg DM) in the studied forage plants and the effects of plant species, sampling period and morphology.

Species	Plant	Ca	P	Ca/P	Mg	Na	K	Mn	Cu	Zn	Fe
A. halimus	W.	11.1	2.7	4.4	13.3	39.5	16	15.4	14.6	63	536
	Stems	10.5	2.4	5.2	8.2	31	16.3	7	14.6	57.2	391.5
	Leaves	12	3	3.6	18. 3	48	15.3	24	14.6	69	680
T. africana	W.	21	2.1	10.7	9.2	46	23.3	8.7	27	42	487
	Stems	17	1.9	8.5	6.2	36.5	21	9.8	19	37.6	368
	Leaves	25.2	2.3	12.6	12.2	55	26.1	7.6	35.2	46.2	606.3
Plant		***	**	***	**	ns	***	**	***	***	ns
Sampling period		ns	**	ns	ns	ns	ns	ns	ns	ns	ns
Plant fraction		*	*	ns	***	**	ns	***	*	*	**
Plant*Sampling period*plant fraction		ns	ns	ns	ns	ns	ns	**	ns	ns	ns
Goat requirements[a]		2.6	2.7		1.7	0.7	2.2		9	30	35
N. requirement range (minimum-maximum)[b]		1.9 -8.2	1.2 -4.8		-	0.6-1.8	5 - 10	50-60	10	50-60	50

*: p<0,05; **: p<0,01; ***: p<0,001; ns: not significant (p>0,05). [a]: Recommended requirement by Kessler [22] in Ramirez-Orduna *et al*. [20]; [b]: Recommended range of mineral elements as suggested by NRC [23]; W: whole.

Atriplex halimus leaves had a higher level of Zn (69 mg/kg DM) compared to *Tamarix africana* (46 mg/ kg). Those concentrations are marginally above the Zn requirements for goats (30 mg) [20, 22, 23] and slightly deficient for sheep and cattle (50-60 mg) [21, 28]. The deficiencies Zn in studied plants are probably due to the calcareous soil. It was noted that there was an inverse relationship between Ca and Zn [20]. According to Olsen [29], a dietary requirement of 30 mg/kg DM of Zn was deemed adequate for growing, gestating, and lactating for beef cattle. The Zn concentration in both plants varied, although it was within the range considered adequate for goats [29], but low for sheep and cattle [21, 28].

The Fe concentrations were exceptionally high in both plants. We observe that the iron content in the leaves is nearly double that of the stems. Fe levels in this study agree with those reported by authors [15, 19, 20]. High level of Fe in forage plants found in this study area aligns with the high soil Fe levels. Iron concentrations were above requirements (>35-50 mg/kg DM) (Table 3) for ruminants. The maximum tolerable level of Fe in beef cattle diets was estimated at 1000 mg/kg DM [29].

3. Conclusions

Mineral contents in the soil were higher than that recommended levels for plant growth. Generally, there was a considerable variation in nutrient contents between *Atriplex halimus* and *Tamarix africana* in particularly in their leaves and stems. CP levels were appreciable in both halophytes, especially in leaves. Moreover, leaf fiber (NDF, ADF) was less fibrous than stem, and lignin (ADL) content was abundant in different parts of *Tamarix africana*.

The mineral contents (Ca, Mg, Na, K and Fe) in both forage plants were at adequate levels to fulfill the needs of small ruminants. Whereas the concentrations of P, Cu and Zn ranged from sufficient to marginal. Supplementation of Mn should be considered for these plants in this area. Therefore, it is necessary to consider these results to formulate an adequate nutrient supplement to the ruminants consuming these halophytes, which can fill up the feed gap during drought and dormant seasons. Both species play a crucial role in stabilizing soil and preventing erosion, which is a common problem in arid regions, especially where vegetation cover is sparse. Therefore, large-scale planting of these forage plants in arid regions is a promising approach to fight against erosion, desertification, and rehabilitate degraded pastoral areas.

References

[1] Haddi M. L., Arab H., Yacoub F., Hornick J. L., Rollin F., Mehennaoui S., Seasonal changes in chemical composition and in vitro gas production of six plants from Eastern Algerian arid regions, *Livestock Research for Rural Development*, 21, pp. 1-11, 2009.

[2] Arab H., Haddi M.L., Mehennaoui S., Evaluation de la valeur nutritive par la composition chimique des principaux fourrages des zones arides et semi-arides en Algérie. *Sci. Techno*., C, 30, pp. 50-58, 2009.

[3] Nedjimi B., Seasonal variation in productivity, water relations and ion contents of *Atriplex halimus spp. Schweinfurthii* grown in Chott Zehrez wetland, Algeria, *J. Saudi Soc. Agri. Sci*., 11, pp. 43-49, 2012.

[4] Walker D. J., Lutts S., Sanchez-Garcia M., Correal E., Atriplex halimus L.: Its biology and uses. *J. Arid Environ*., 100-101, pp. 111-121, 2014.

[5] AOAC., Official Methods of Analysis 15th ed., Association of Official Analytical Chemists Washington, pp. 771, 1990.

[6] ISRIC., Procedures for soil analysis. 3rd ED, International soil reference and information center Wageningen, pp. 360, 1984.

[7] Mathieu C., Pieltain F., Analyse chimique des sols Méthodes choisies Editions Tec et DOC, 2003, pp. 239-

292.

[8] Arab H., Haddi M.L., Boudaoud A., Mehennaoui S., Seasonal variation of Cu, Zn, Mn and Fe levels in soil and *Atriplex halimus* in arid zones of South-East Algeria. *Research Journal of Pharmaceutical, Biological and Chemical*, ISSN: 0975-8585, 7 (6), pp. 1727-1733, 2016.

[9] Arab H., Mehennaoui S., Haddi M-L., Evaluation of Macro-mineral Concentration in Soil and *Atriplex halimus* from Southeast of Algeria in Relation to Ruminants Requirements. *Glob. Vet*.18 (6), pp. 399-405, 2017.

[10] Khan Z-I., Ashraf M., Valeem E-E., Ahmad K., Danish M., Pasture concentration of minerals in relation to the nutrient requirements of farm livestock. *Pak. J. Bot*., 39 (6), pp. 2183 – 2191, 2007.

[11] Bahamonde H. A., Fernández V., Mattenet F., Peri P. L., Mineral elements in grasses growing in contrasting environmental conditions in southern Patagonia. *New Zealand Journal of Agricultural Research*., 59(3), pp. 235–249, 2016.

[12] Van Niekerk W. A., Sparks C. F., Rethman N. F. G., Coertze R. J., Mineral composition of certain *Atriplex species* and *Cassia sturtii*. *South African Journal of Animal Science*, 34 (Supplement 1), pp. 105-107, 2004. Available online at http://www.sasas.co.za/sajas.html.

[13] El Sher H. M., Halophytes and salt-tolerant plants as potential forage for ruminants in Near East region, *Small Rumin*. Res., 91, pp. 3- 12, 2010.

[14] Ammar, H., Lopez S., Gonzalez J.S., Assessment of the digestibility of some Mediterranean shrubs by *in vitro* techniques, *Animal Feed Sciences and Tech.*, 119, pp. 223-331, 2005.

[15] Al- Shorepy S. A., Alhadrami G. A., El Awad A.I., Development of sheep and goat production system bases on the use of salt plants and marginal resources in the United Arab Emirates, *Small Rumin. Res*., 91, pp. 39-46, 2010.

[16] Al-Masri M. R., Nutritive value and anti-nutritional components of leaves of some salt-tolerant tree species, *Livestock Research for Rural Development*, 25 (2), 2013.

[17] Ben Salem H., Norman H. C., Nefzaoui A., Mayberry D. E., Pearce K. L., Revell D. K., Potential use of oldman saltbush (*Atriplex nummularia Lindl*.) in sheep and goat feeding, *Small Rumi. Res*., 91, pp. 13- 28, 2010.

[18] Kadi S. A et Zirmi-Zembri N., Valeur nutritive des principals ressources fourragères utilisées en Algérie. 2- Les arbres et arbustes fourragers, *Livestock Research for Rural Development*, 28 (8), pp. 1- 14, 2016.

[19] Lukhele M. S and Van Ryssen J. B., The chemical composition and potential nutritive value of the foliage of four subtropical tree species in southern Africa for ruminants, *South African J.* of Ani. Sci., 33 (2), pp. 132-141, 2003.

[20] Ramirez-Orduna R., Ramirez R. G., Gonzalez-Rodriguez H., Haenlein G. F. W., Mineral content of browse species from Baja California Sur, Mexico, *Small Rumin. Res*., 57, pp.1-10, 2005. Available online at www.sciencedirect.com.

[21] INRA., Alimentation des bovins, ovins et caprins. INRA Editions, Versailles, 1988, pp. 465-471.

[22] Kessler J., Mineral nutrition of goats In Goat Nutrition, EAAP, Pudoc., 1991, pp.104-119.

[23] NRC., Nutrient requirements of domestic animals' nutrient requirements of goats, Washington DC, USA, 1981.

[24] Underwood E.J and Suttle N.F., The Mineral Nutrition of Livestock. 3rd Edition CABI, New York, 1999, pp. 283-512.

[25] Mirzaei F., Mineral's profile of forages for grazing ruminants in Pakistan, *Open Journal of Animal Sciences*, 2(3), pp.133-141, 2012.

[26] Shisia K.S., Veronica N., Hudson N., Isaac J and Fredrick O., Assessment of mineral deficiencies among grazing areas in Uasin Gishu County, Kenya, *International Journal of Nutrition and Food Sciences*, 3(2), pp. 44-48, 2014.

[27] Khan Z. I., Hussain A., Ashraf M., McDowell L. R., Mineral Status of Soils and Forages in Southwestern Punjab-Pakistan: *Micro-minerals, J. Anim Sci*., 8, pp. 1139-1147, 2006.

[28] Meschy F., Nutrition minérale des ruminants, Editions Quæ, 2010, pp 23-160.

[29] Olsen K-C., Management of Mineral Supplementation Programs for Cow-Calf Operations. *Vet. Clin. Food Anim*., 23, pp. 69-90, 2007.