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Elemental Composition of Grazing Plant Species in the Eastern Province of the Kingdom of Saudi Arabia

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Abstract. The current research study was performed to contribute the knowledge in the nutritional value of grazing plant species. Mineral contents (Na, K, Ca, Mg, P, Zn, Cu, Mn and Fe) were evaluated for twenty-one species of grazing wild plants growing and scattering in the eastern region of Kingdom of Saudi Arabia. The results revealed that the contents of the estimated minerals in most of the evaluated plant species were quite enough for the sheep and camels dietary requirements. However, all plant species under study showed very high level of Na where the values rang varied between 15.5 (in Pennisetum divisum) and 17.45% in Arthrocnemum specie. Calcium content ranged between 0.7 to 5.97 % in Arthrocnemum and Halopeplis species, respectively. While, the contents of potassium, magnesium and phosphorus differed from 1.10 – 2.9%, 0.18-1.49%, 0.13-0.44%, respectively. The range of microelements Zn, Cu, Mn and Fe were 9.50 (Seidlitzia Rosmarinus)-31.22 (Atriplex halimus), 46.93 (Seidlitzia Rosmarinus)- 57.87 (Rhanterium eppaposum), 32.65 (Atriplex halimus)-175.21 (Aeluropus lagopoides) and 211.66 (Calligonum comosum)-1778.99 (Aeluropus lagopoides). The paper concluded that these halophytic plant species are good minerals sources for animals. Using these plants as alternative diets to partially replace the common dietary materials, could reduce the imported forage cost.

Keywords: Halophytes, Saudi Arabia, Mineral contents.

1. Introduction

Fe, Cu and Mn are vital for maintaining Overgrazing of rangelands in arid areas including the kingdom of Saudi Arabia (KSA), climate change and drought are threatening the sustainability of production animal production systems in KSA and the region as whole (Al-Rowaily, 1999; Hadri and Guellouz, 2012). This distressing situation attracted the interest of researchers and policy makers and encouraged them to develop feasible and sustainable plans for the promotion of animal production in the KSA for the better utilization of natural resources (mainly, rangelands). There has been an increasing awareness of the value of halophytes in animals' feed and for rehabilitation of overgrazed rangelands. The prevailing environmental conditions strongly affect plant species distribution, chemical composition and their digestibility (El-Shaer, 2010). Plant mineral contents are one of the mostly dependent on the ecosystem characteristics (Ben Salem *et al*., 2010). Al-Ani *et al*. (1991) showed significant variations in halophytes mineral content. Halophytes had higher sodium, magnesium and sulfur contents and the differences between plants species is mainly due to the ability of the various plant species to accumulate certain salts from the soil solution at low or high concentrations within their tissues (Al-Ani *et al*.,1991).

Rangelands of Saudi Arabia occur mainly in arid and hyper-arid regions that cover about 75% of the country (Al-Rowaily, 1999). These rangelands differ functionally because of differences in the spatial and temporal distribution of vegetation structure, soil and climate of each region. (Chaudhary and Le Houérou, 2006). Livestock grazing (mainly sheep, camels, and goats) is the prevalent form of land use in rangelands (Al-Rowaily, 1999, Al-Rowaily, 2003). Despite the relatively low productivity, rangeland ecosystems benefits derived from them are becoming increasingly recognized. These include watershed management (Al-Saud, 2009), wildlife conservation (Abuzinada, 2003) and eco-tourism (Seddon, 2000).

In the interior of Saudi Arabia, there were relatively very rich stands of communities of Haloxylon salicornicum and Rhanterium epapposum. The same areas now support dense stands of unpalatable shrubs or herbs such Rhazya stricta, Pulicaria undulata and Astragalus spinosus (Chaudhary and Le Houérou, 2006). Acacia woodlands cover extensive patches of wadi runnels and localized plain areas. The major species are the Acacia tortilis, Acacia ehrenbergiana and Leptadenia pyrotechnica. Woodland understory host several species of low shrubs, grasses, and annual and perennial herbs. This vegetation complex forms the major rangelands resources for livestock (Chaudhary and Le Houérou, 2006, Ghazanfar and Fisher, 2013).

The plant freshness of *Zygophyllum coccineum* and *Nitraria retusa* increased with soil dryness, but in *Haloxylon salicornicum*, *Zygophyllum album* and *Halocnemum strobilaceum* was increased by increasing water availability and soil moisture content (Girgis and Ahmed, 1985). They also claimed that plants known for their salinity and drought tolerance, the degree of freshness is more pronounced in halophytes than in xerophytes. In general, the freshness of halophytes depends mainly on the presence of (chloride) aggregation with other ions (calcium, phosphorus, potassium). The accumulation of sodium and the plant ash content was generally more in halophytes than in xerophytes, and the species known to be resistant to salinity and drought is mainly due to increased its ash content (Girgis and Ahmed, 1985).

Minerals are essential for life, to fulfil the needs of growth and production and to replace quantities lost during the course of normal metabolism. Minerals participate in a range of biochemical reactions as components of enzymes and fulfil a structural and osmotic role in a number of animal tissues (Masters and White, 1996). They added that about 19 mineral elements are essential for animals and other may be essential but the evidence is inconclusive. The essential elements as reported by both authors were calcium (Ca), phosphorus (P), magnesium (Mg), potassium (K), sodium (Na), sulphur (S), cobalt (Co), copper (Cu), iron (Fe), iodine (I), selenium (Se), zinc (Zn), molybdenum (Mo), vanadium (Va), boron (B), lithium (Li), lead (Pb), cadmium (Cd) and Tin (Sn).

Ganesh *et al*. (2018) indicated that the native flora of saline soil, halophytes has ability to salt tolerance and there are good for study the adaptation mechanism.

El-Monayeri *et al*. (1979) found that the accumulation of potassium, sodium and calcium was increased under conditions of soil moisture deficiency while the plant content of potassium and iron decreased. They also claimed that the concentration of the different ions and plant ash content increased with increasing the soil moisture stress. The *Atriplex* genus has several plant species that grow in ecosystems with high salinity,

scarce humidity and high temperature (Ramos *et al.*, 2004). These shrubs have been used for erosion control and rangeland rehabilitation in salt-affected and degraded areas (Rani *et al.*, 2013; Souza *et al.*, 2014). These shrubs are also utilized by farmers in dry ecosystems as maintenance feed for livestock during the drought feed gap (Norman *et al.*, 2010; Pearce *et al.*, 2010) or for landscaping purposes (Panta *et al.*, 2014; Ventura *et al.*, 2015).

Halophytes plants and their environment are riches in Na constraints exerted by their natural habitat (Lutts *et al*., 2016). Na^+, Cl^- and other toxic metal ions. The species of halophytes resist several abiotic stress constraints exerted by their natural habitat (Lutts *et al*., 2016). Wang *et al*. (2013) showed that halophytes exhibit high tolerance to toxic metals and can survive under high concentration of toxic metals ions where most plants do not survive.

Al-Khateeb (1990) estimated the mineral contents (sodium, potassium, calcium, magnesium, phosphorus, zinc, cobalt, manganese and iron) of six Atriplex species under dry and saline conditions. He reported that sodium content in the leaves was more than the level necessary to feed cows, sheep and goats. Watson *et al*. (1994) found that the mean plant tissue content was 129 mg/kg dry weight for boron and 0.6 mg/kg for arsenic and that plant tissues increased their boron concentrations for all species as the plants growth progressed.

Dierenfeld *et al*. (1995) found that the concentration of mineral elements on dry matter basis differed significantly among the 26 plant species they studied. They found that calcium content was 0.55-4.29%, potassium 0.28-1.71%, magnesium 0.12-0.65%, sodium 0.001 - 0.074%, phosphorus 0.06 - 0.19%, and zinc 2.5 - 6.4 micrograms / gram, which were lower or within the dietary level required for feeding dairy animals. However, copper (3.0-12.2 μg/g), iron (2.5 - 29 μg/g) and manganese (10.9 - 269 μg / g), which were sufficient for feeding most animals. Miller *et al*. (1996) showed that zinc, copper, selenium; manganese and potassium contents of plant species within more than 100 sites in saline lands are much less, than the dietary needs of cows that were estimated in these areas. They also found that the same plants contents of sulfur, magnesium, exceeded the dietary needs of these cows. Al-Zaid *et al*. (2004) claimed that *Panicum turgidum*. Forssk. contents of sodium, potassium and magnesium was within the requirements of sheep, goats and camels, while its content of phosphorus and micro elements (zinc, copper & manganese) were low.

The aim of this study is to evaluate the mineral content of 21 halophytic plant species growing in the eastern part of the eastern province of the kingdom of Saudi Arabia.

2. Materials and Methods

Study area: Eastern Saudi Arabia consists of a broad, flat, low coastal plain that is mostly covered with sand and gravel. The entire eastern region has a desert climate, with scanty, unreliable rainfall and extremely hot diurnal temperatures for many months of the year. The daily and seasonal temperature variations are great, particularly in the areas away from the coast. In the summer, the maximum temperature usually reaches 45°C. However, in the winter, the temperatures are mild during the day (20°C) but often fall below freezing at night. 2-4 years of drought, are experienced in the region. The only source of water is that available 4-120 m below soil surface but this is highly saline. The coastal regions are notorious for their oppressive humidity as well as heat. The northern part of the region receives less than 25 mm of rain

annually, while the southern part receives even less rain falls than the north. The coastal zone consists of sandy plains, marshes and salt flats almost imperceptibly with the sea. As a result, the land surface is unstable in the places where water table reaches almost to the surface. The coastal areas are covered with salt and drought tolerant plant species. In the areas where there is little groundcover, north-westerly blown sand winds, persist during most of the summer months cause violent sandstorms (Al-Fredan, 2008). The studied region as illustration in Fig. 1 is coastal plain, rising gradually inland towards as we moved away from the coast. Its surface is covered with sand and sometime limestone mixes with sand. The area is located between 45° 30" and 52° 10" longitude (from west to east) and latitude from south to north is 24° 05" and 29° 10". Highly saline flats in coastal areas are a distinctive terrain type in this region which called sabkhahs. The surface of sabkhahs is level. Sand dunes cover parts of the studied area (Shaltout *et al*., 1997).

2.1 Sample Collection

The vegetative part of 21 plant species samples were collected from wild populations from different habitats in the eastern Saudi Arabian gulf coast, which were randomly selected. The Table 1 displays the names of plant species which collected for this study. All the plant samples were oven-dried at 65 ^{o}C for 48 h and ground in a Wiley mill (1-mm screen). The following analysis was performed in triplicate for each plant sample (5 plants per sample).

2.2 Determination of Elements

Macro and microelements were estimated using the Official AOAC methods (1997). 0.5 g of processed samples were carefully weighed in a 50 mL standard flask to which 5 ml of concentrated nitric acid was added. The mixture was left for 24 hours and then the samples were digested on a hot plate where the temperature gradually increased to 100°C. When all nitric oxide fumes were expelled, the temperature was raised to 150° C and the temperature was stabilized until the mixture became clear. The solution was then diluted using redistilled water. The wet digested solutions were transferred to plastic bottles and labelled. Sodium was estimated using Flame photometer model Jennway PFP7 (UK), while calcium, potassium, magnesium, zinc, manganese, iron and copper were determined using the Atomic Absorption Spectrophotometer (AA-6650F Shimadzu Japan). Phosphorus was estimated by using the UV-1650 (Ps) s Shimadzu Japan Spectrophotometer (Page, 1982) .The final solution for calcium and magnesium determination contained 1% of Lanthanum Chloride to reduce chemical interference. The final solution for sodium determination contained 0.1 of potassium chloride (KCl) to control the process of ionization.

Data were analysed statistically in accordance to a completely randomized design using SAS software, and means were compared using the least significant differences test (0.05%).

Microsoft Excel (Microsoft Corp., Redmond, WA, USA) was used to calculate the means and standard deviations.

3. Results and Discussion

The characteristics of halophytic plant species as animals feed could be governed by the extent to which these plants have the potentiality of meeting the required animals' demands. The quality of halophytes as animals feed varies greatly among plants species. Determination of feeds for nutrient content could be used to judge the quality of feed and if it is enough to meet the animal, dietary demands in order to be used for proper animal feed supplementation. The factors that determine feed quality include palatability,

nutrient contents, plant secondary metabolites, nutritive value and animal performance as influenced by that feeding formulation. The animal feed chemical composition is the main indicator of its nutritive value for the animals. Nutritive value relies on the feed nutrient content.

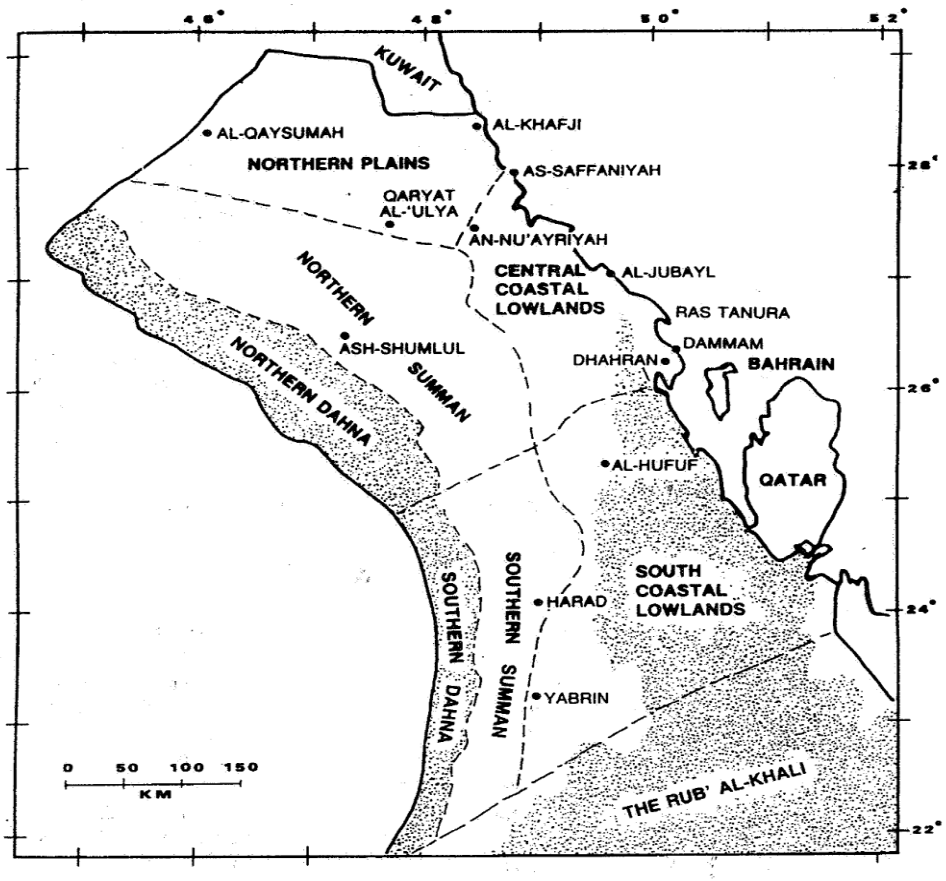

Fig. 1. Map of studied area of Eastern province of Saudi Arabia (after Shaltout *et al.*, 1997).

The results of the macroelements analysis for the 21 halophytes plant species are depicted in Fig. 2-6. The presented data indicated that the mineral contents differed among the tested halophytic plant species. The differences in mineral contents of halophytes usually depend on the plant species, stage of growth, season, soil characteristics etc. (Attia-Ismail, 2008).

- Sodium

The data in Fig. 2 shows the arithmetic mean and standard deviation of sodium (Na) in the studied plant species. The data indicated the possibility of classifying plant species in accordance to their sodium content into three groups: **Group A**: A group with a very high sodium content. Sodium content in this group ranged between 11.14 - 16.51%. This group included ***Halopeplis perfoliata (17.75±0.34),*** *Arthrocnemum (17.54±0.49), Halocnemum strobilaceum (16.71±3.15), Atriplex halimus (12.5±0.42), Salsola baryosma (12.35± 1.82), Seidlitzia rosmarinus (12.05±1.91), Anabasis setifera (11.95±3.91)* and *Suaeda vermiculata (11.14±7.15).* **Group B**: A group that contained medium to high sodium ratio ranging from 7.85 - 9.80%, which is still

relatively high to be relied on as feed source. This group included Aeluropus lagopoides (9.8±0.1%), Zygophyllum coccineum (8.95±4.02) and Calligonum comosum (7.85±7.91%). Group C: The group that had low sodium content ranging between 1.55 - 4.85%, which included most of the plant species, which could be used for feeding animals without any associated problems. This group included Panicum turgidum (4.85±0.26%), Eragrostis barrelieri (3.9±0.14), Haloxylon salicornicum (3.8±0.0), Haloxylon persicum (3.5±0.0%), Cyperus conglomerates (2.41±0.54), Rhanterium eppaposum (2.00±0.0%), Leptadenia pyrotechnica (2.00±0.37), Lasiures scindicus (1.66±0.0) and Pennisetum divisum (1.55±0.39). Sodium content in the natural plant species tested ranged between 1.55 and 17.75%. This content significantly higher than the sodium content of alfalfa where the levels ranged between 3.5 to 10% (NRC, 2000; Cornacchione *et al*., 2015) as well as greater than the basic recorded requirements of goats (0.06) (NRC, 1981), sheep (0.09-0.18%) (NRC, 1985, 2016) and milking cows (0.22%) (NRC, 2001, 2016) and dry cows (0.06 -0.08%) (NRC, 2000). According to Wardeh (1997), camels require sodium concentrations 6-8 times than other animals' needs. The rate of 0.8 - 1.44% is enough for camels to conduct their natural performance. It is clear that the sodium levels in halophytes fodder are very high, and that why the recommended amount of Salicornia in camels feed is not more than 30% (Ismail, 1998). Na toxicity to livestock was not reported and no reduction of feed intake, milk yield or toxicity were noticed (NCR, 2001).

- *Calcium*

Calcium is critical for bones, with nearly 99% located in the skeleton. It also has roles in nerve impulses and the immune system. Large amounts are used in milk production; therefore, lactating animals have greater requirements than non-lactating animals (Kreager, 2018). The data shown in Fig. 3 showed the calcium content of plant species under study. Based on calcium content, the different plant species can be divided into three groups: **Group A**: A group of species containing high percentages of calcium (higher than 3.5%). This group included Haloxylon salicornicum (5.97±0.061%), Haloxylon persicum (4.35±0.22%), Lycium shawii (4.2±0.00%) and Leptadenia pyrotechnica (3.56±1.87%). While group B plant species containing an average range of calcium with a minimum of not less than 2%. This group included *Anabasis setifera* (3.14%±*1.18*), *Zygophyllum coccineum* (2.83±1.58%), *Calligonum comosum* Calligonum comosum (2.68±1.92%), Salsola baryosma (2.2±0.87%) Suaeda vermiculata (2.17±1.12%) and Seidlitzia rosmarinus (2.03±0.59%).

Group C: represents a group with the number of plant species that had the lowest calcium content (0.5 - 2%) and most appropriate to be used in animal nutrition. This group included the following plant species growing in the study area.Panicum turgidum (1.98±0.79), Aeluropus lagopoides (1.54±0.00), Lasiures scindicus (1.54±0.16), *Halocnemum strobilaceum* (1.51±0.31), *Cyperus conglomerates* (1.50±0.00), *Eragrostis barrelieri* (1.50±0.02), *Atriplex halimus* (1.47±0.18), *Rhanterium eppaposum* (1.33±0.28), *Halopeplis perfoliata* (0.75±0.07), *Pennisetum divisum* (0.75±0.10) and *Arthrocnemum macrostachyum* (0.70±0.04). The results also indicated that calcium content in the different plant species was in 0.5 - 5.95% range. These levels were higher than that required by beef cattle (0.18-0.44%), milk cows (0.60-0.65%), sheep (0.25-0.84%) and goats (0.138%) (NRC, 2016, 2001, 2000 & 1981). However, according to Wardeh (1997), there was no problem for calcium deficiency in camels grazing in the natural

pasture. While, Weiss (2008) indicated that the maximum tolerable levels (MTL) of Ca is 1.5% of dietary DM (approximately 2 times the NRC requirement for dairy cows). Al-Noaim *et al*. (1991) in their study of chemical composition of range plants in the Eastern Province of Saudi Arabia showed that the concentration of Ca varied from 0.84 to 2.36%.

- *Potassium*

The potassium concentration of plant species in the study area are represented in Figure 4. Generally, potassium content of the different plant species ranged between 1.1 - 2.9%. Those plant species that had relatively high potassium content of more than 2% were putted as group A: *Haloxylon persicum (2.90±0.00), Seidlitzia rosmarinus (2.88±0.32), Atriplex halimus (2.80±0.14), Rhanterium eppaposum (2.80±0.14), Haloxylon salicornicum (2.70±0.00), Lycium shawii (2.600.00), Suaeda vermiculata (2.43±0.32), Zygophyllum coccineum (2.17±0.73), Anabasis setifera (2.13±0.36).* While, group B of plant species has potassium less than 2%. However, group B include *Cyperus conglomerates* (1.96±0.51), *Pennisetum divisum* (1.78±0.33), *Salsola baryosma* (1.73±0.42), *Calligonum comosum* (1.60±0.39), *Halopeplis perfoliata* (1.50±0.00), *Lasiures scindicus* (1.5±0.00), *Halocnemum strobilaceum* (1.42±0.42), *Arthrocnemum macrostachyum* (1.35±0.08), Eragrostis barrelieri (1.30±0.28), Panicum turgidum (1.25±0.18), *Leptadenia pyrotechnica* (1.10±0.47), *Aeluropus lagopoides* (1.10±0.00). From above results, Potassium content of naturally growing plant species under study was varied from 1.1 to 2.9%. It was higher than the minimum requirement for cattle (0.6%), sheep (0.5-0.8%) and milking cows (1.0-1.05%) but lower than the highest level that could be used for dry cattle (3%) (NRC, 2000, 2001, 2016).

- *Magnesium*

Figure 5 elucidates content of magnesium in the various plant species studied. It was possible to classify the plant species in accordance to their magnesium contents into two groups: **Group A**: A group whose magnesium content was not less than 1%. This group included *Salsola baryosma (*1.49±0.12*), Seidlitzia rosmarinus (*1.47±0.21*), Haloxylon persicum (*1.46±0.04), *Haloxylon salicornicum (*1.45±0.01*), Zygophyllum coccineum (*1.44±0.43), *Halopeplis perfoliata (*1.45±0.01), *Panicum turgidum (*1.25±0.61), *Suaeda vermiculata (*1.25±0.18), *Calligonum comosum (*1.18±0.15), *Halocnemum strobilaceum (*1.18±0.00), *Anabasis setifera (*1.41±0.01) *and Aeluropus lagopoides (*1.03±0.46). *While g*roup B containing plant species with relatively low magnesium content, which was not more than 1% and ranged from 0.18 to 0.94. This group included the rest of the studied plant species i.e. *Atriplex halimus* (0.94±0.08), *Leptadenia pyrotechnica* (0.91±0.62), *Arthrocnemum macrostachyum* (0.88±0.01), *Cyperus conglomerates* (0.58±0.04*), Lasiures scindicus* (0.53±0.04), *Eragrostis barrelieri* (0.51±0.06), *Rhanterium eppaposum* (0.48±0.14), *Pennisetum divisum (*0.18±0.04). The magnesium content of naturally growing plant species was ranged between 0.18 and 1.63%. Generally, these magnesium levels were higher in most species than in alfalfa (0.3-1.0%) (NRC, 2000) and also higher than that needed for milking cows (0.18 - 0.21%), sheep (0.12 - 0.18%) and goats (-0.4% -0.8%) (NRC, 1980, 1985, 2000 & 2016).

- *Phosphorus*

Figure 6 shows the phosphorus content in the studied plant species. The different plant species could be classified according to their phosphorus content into two main groups:

Group A: The most diverse group and had the highest phosphorus content of not less than 0.2%. This group included *Seidlitzia Rosmarinus (0.44±0.11), Atriplex halimus(0.41±0.02), Zygophyllum coccineum (0.39±0.09), Lasiures scindicus (0.39±0.01), Rhanterium eppaposum (0.37±0.02), Suaeda vermiculata (0.36±0.18), Salsola baryosma (0.35±0.02), Calligonum comosum (0.34±0.05), Aeluropus lagopoides (0.30±0.01), Panicum turgidum (0.29±0.06) , Leptadenia pyrotechnica (0.29±0.01), Anabasis setifera (0.29±0.03), Pennisetum divisum (0.290.03), Lycium shawii (0.25±0.01), Cyperus conglomerates (0.23±0.05) , Arthrocnemum macrostachyum (0.20±0.01). Howvere the group* **B** included plant species that had lower phosphorus content. They could supply the minimum level of daily sheep and cattle requirements. This group included *Halopeplis perfoliata (0.19±0.04), Haloxylon salicornicum (0.18±0.01), Eragrostis barrelieri* (0.16±*0.01)* and *Haloxylon persicum (0.13±0.01).* The Phosphorus content of the different natural growing plant species ranged between 0.13 and 0.44%. This percentage is higher in most species than in alfalfa (0.28%) (NRC, 2000). According to Wardeh (1997), the calcium: phosphorus in the plant species is the same as the lower requirements of sheep (0.16-0.38) (NRC, 1985), cattle (0.18-0.5)(NRC, 2000) and milking cows (0.32-0.35)(NRC, 2000). The specific contents of plant species for phosphorus and calcium were in ranges higher than that were needed for livestock demands. Generally, calcium levels are high, so there was a need to increase the phosphorus supplement for animals that were fed halophytes fodders because the available phosphorus might not be sufficient for these animals.

3.1 Plant Species Microelements Content

- Copper

The results of Table 1 show the copper content of plant species in the study area. The results indicated that copper content of the varied in plant species studied. Copper content in *Rhanterium eppaposum* ranged between 46.93 - 58.2 ppm. While, its content in Suaeda vermiculata was in the range of 46.93- 57.87 ppm.

The copper content of plant species was close to 46.93 - 58.2 ppm. These percentages are significantly higher than that of alfalfa (5.3 ppm) (NRC, 2000, 2016) and are significantly higher than the minimum requirements for sheep (5 - 11 ppm) (NRC, 1985), cattle (10 ppm) (NRC, 2000, 2016) and milking cows (11 ppm) (NRC, 2000, 2016). However, Wardeh (1997) stated that it is difficult to determine the camels minimum copper requirements because the absorption copper rate depends mainly on its interaction with molybdenum, sulfur and possibly some other elements. In addition, Underwood (1951) noted that copper absorption is influenced by climatic factors as well. However, these levels were very high than the toxicity level for sheep (25 ppm) (NRC, 1985) but were lower than the reported toxicity for dry cows and milking cows (100 and 80 ppm) (NRC, 2000 & 2001), respectively.

- Manganese

The data in Table 1 indicated that manganese content of the studied plant species. According to their manganese content, the plant species in the study area could be classified into three groups. Group A: a group whose plants species contained in the range of 100 - 155 ppm. This group included Cyperus conglomerates, Haloxylon persicum, Haloxylon salicornicum, Suaeda vermiculata, Zygophyllum coccineum, and Aeluropus lagopoides. Group B: A group whose plants whose manganese content in the range of 50 - 100 ppm. This group included Lasiures scindicus, Panicum turgidum, Pennisetum divisum, Eragrostis

barrelieri, Calligonum comosum, Anabasis setifera, Halocnemum strobilaceum, Leptadenia pyrotechnica, Salsola baryosma.

Group C: A group of plant species that had low manganese content. Manganese content ranged between 32.6-50 ppm, which is the proper requirement for feeding livestock. This group included Atriplex halimus, Halopeplis perfoliata, Seidlitzia rosmarinus, Arthrocnemum macrostachyum, Heliotropium bacciferum, Rhanterium eppaposum.

Manganese content in the studied plant species ranged from 32.65 to 155.21 ppm. These recorded levels in natural plant species were generally higher than those of alfalfa (30.3 ppm) (NRC, 2000). They were also higher than the minimum requirements for sheep (20-40 ppm) (NRC, 1985) and dry cows (20 ppm) (NRC, 2000) and milking cows (14 ppm) (NRC, 2001). Wardeh (1997) suggested a mean level of 40 ppm as a minimum requirement for camels, but most animals could tolerate very high concentrations of manganese up to 1000 ppm for cattle, sheep and camels (NRC, 1985 & 2000) (Wardeh, 1997).

- Zinc

The data in Table 1 indicate that plant species could be classified according to their zinc content into three groups: Group A: A group of plant species that had zinc contents greater than 20 ppm, which is the lowest level of the requirement of cattle feeding. This group included Cyperus conglomerates, Lasiures scindicus, Arthrocnemum macrostachyum, Eragrostis barrelieri, Salsola baryosma, Pennisetum divisum, Rhanterium eppaposum, and Atriplex halimus. Group B: a group whose plant species that had zinc contents greater than 10 and less than 20 ppm. This group included Aeluropus lagopoides, Halopeplis perfoliata, Anabasis setifera, Leptadenia pyrotechnica, Panicum turgidum, Heliotropium bacciferum, Haloxylon persicum, Haloxylon salicornicum, Zygophyllum coccineum, Suaeda vermiculata. Group C: A group of plant species that had low zinc contents (less than 10 ppm and a minimum of 5.5 ppm) and may exhibit the effects of deficiency symptoms on animals if fed separately. This group included Calligonum comosum, Halocnemum strobilaceum, and Seidlitzia rosmarinus.

The zinc content in the studied plant species ranged between 5.55 and 31.22 ppm, which were higher in some plant species than that of alfalfa (18.6 ppm) (NRC, 2000), but in some species it is lower than the minimum requirement for sheep (20- 30 ppm) (NRC, 1985) and milking cows (43-55 ppm) (NRC, 2000) and camels (40 ppm) (Wardeh, 1997). However, some plant species could provide the minimum dietary requirement for cows (30 ppm) (NRC, 2000 & 2016). This content was also far from the maximum permissible limit that could cause toxicity to the animal, which is 500 and 700 ppm for cattle and sheep respectively (NRC, 2000 & 2016).

- Iron

From the data recorded in Table 1, the plant species of this group could be classified according to their iron content into four groups. Group A: A group of plant species that had iron contents above 1000 ppm. This group included Aeluropus lagopoides, Lasiures scindicus, and Cyperus conglomerates. Group B: A group of plant species that had iron contents higher than 500 ppm, which were considered high levels and could be recommended for feeding young animals. This group included Leptadenia pyrotechnica, Rhanterium eppaposum, Seidlitzia rosmarinus, Zygophyllum coccineum, Salsola baryosma,

Heliotropium bacciferum, Panicum turgidum, Atriplex halimus, Halocnemum strobilaceum, Eragrostis barrelieri. Group C: a group of plant species that had iron contents of less than 500 ppm. This group included Halopeplis perfoliata, Calligonum comosum, Avecienia marina, Pennisetum divisum, Arthrocnemum macrostachyum, Suaeda vermiculata. Group D: A group of plant species that had traces of iron or none of it. This group included Haloxylon persicum, Haloxylon salicornicum.

The iron content of naturally growing plant species ranged from not detected as in Haloxylon salicornicum and Haloxylon persicum to 124.9 ppm in Halopeplis perfoliata and 1558 in the Aeluropus lagopoides. These levels excluding Haloxylon salicornicum and Haloxylon persicum were higher than that of alfalfa (189 ppm) (NRC, 2000). They are also higher than the levels required for sheep feeding (30 - 50 ppm) (NRC, 1985), dry cows (50 ppm) (NRC, 2000), milking cows (1.8 - 12.8 ppm) (NRC, 2001) and the proposed level for feeding large and small camels (50 - 100 ppm, respectively) (Wardeh, 1997). The iron level is also lower than the level of 1000 ppm that is needed by cows (NRC, 2000) and camels (Wardeh, 1997) and the level of 500 ppm needed for sheep (NRC, 1985).

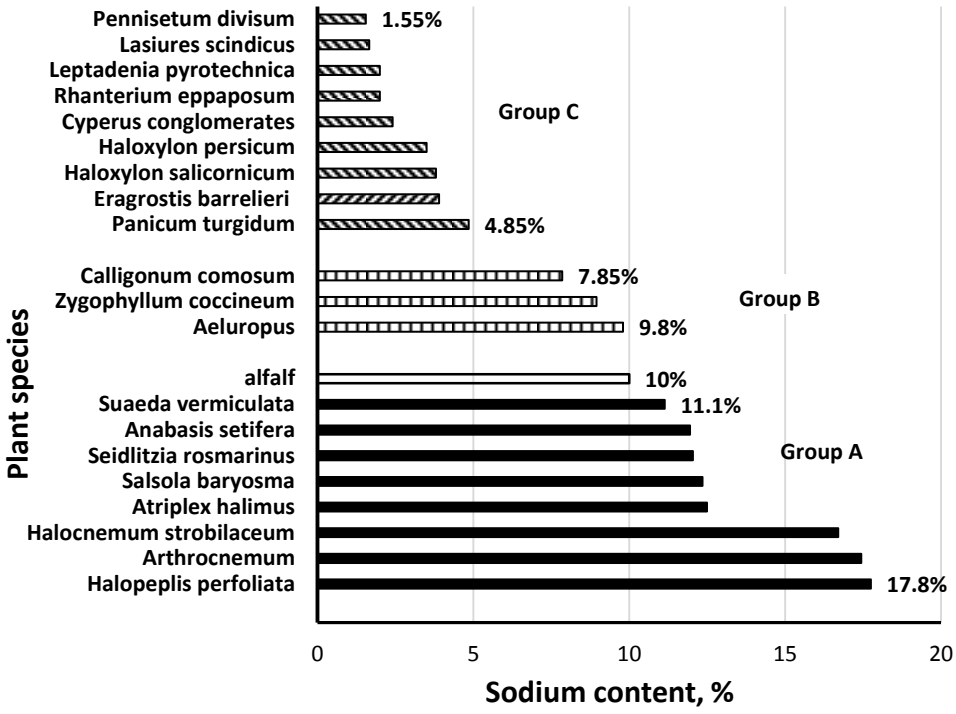

Fig. 2. Sodium content in the natural plant species under study and alfalfa as comparison.

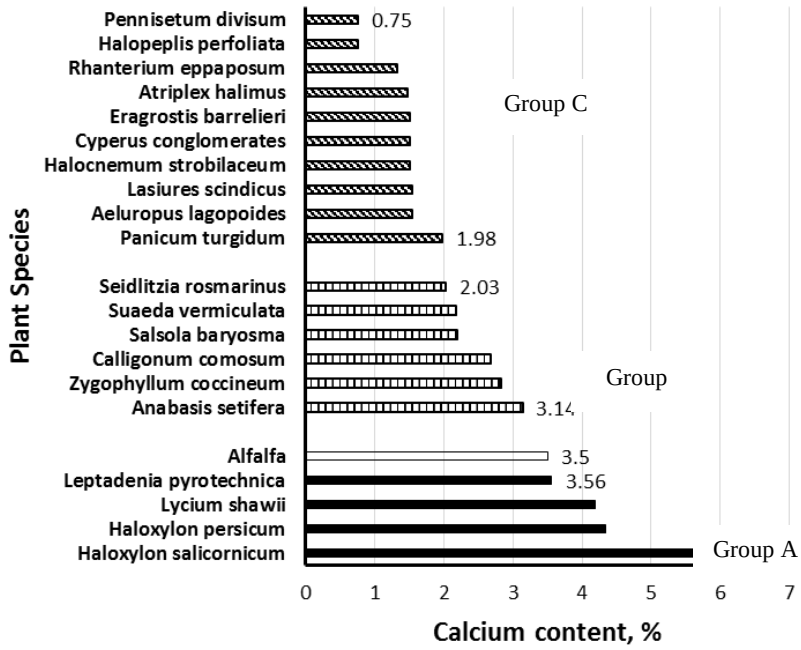

Fig. 3. Calcium content in the natural plant species under study and alfalfa as comparison.

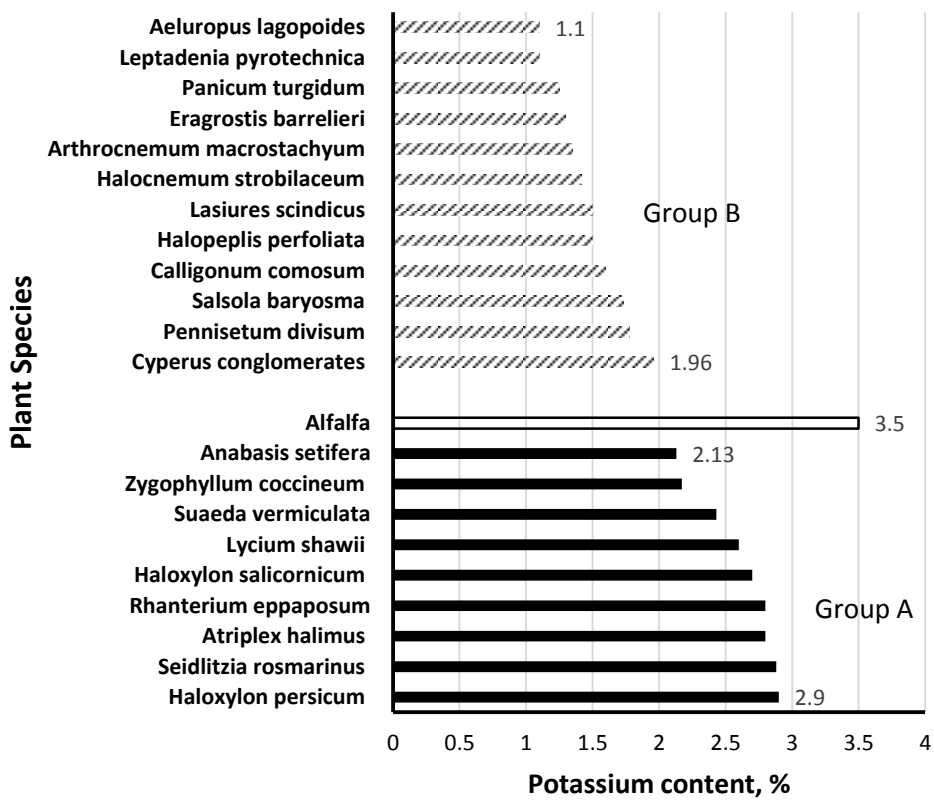

Fig. 4: Potassium content in the natural plant species under study and alfalfa as comparison.

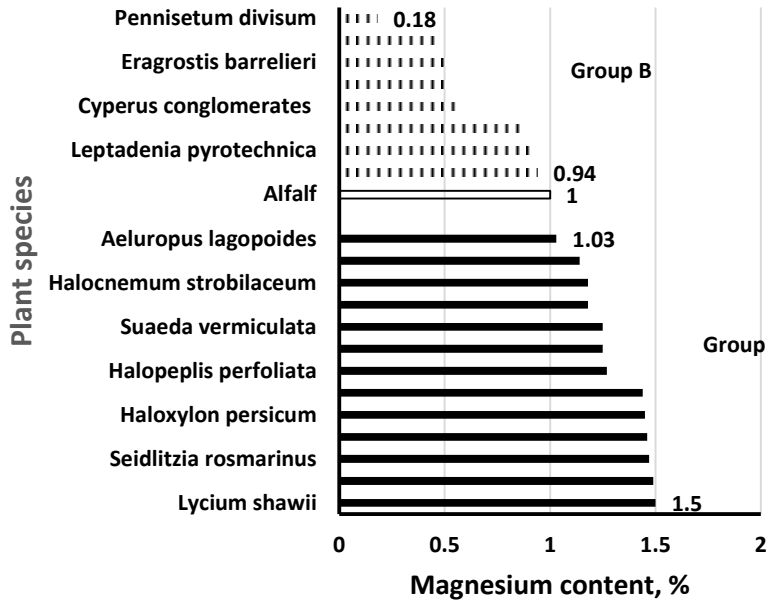

Fig. 5. Magnesium content in the natural plant species under study and alfalfa as comparison.

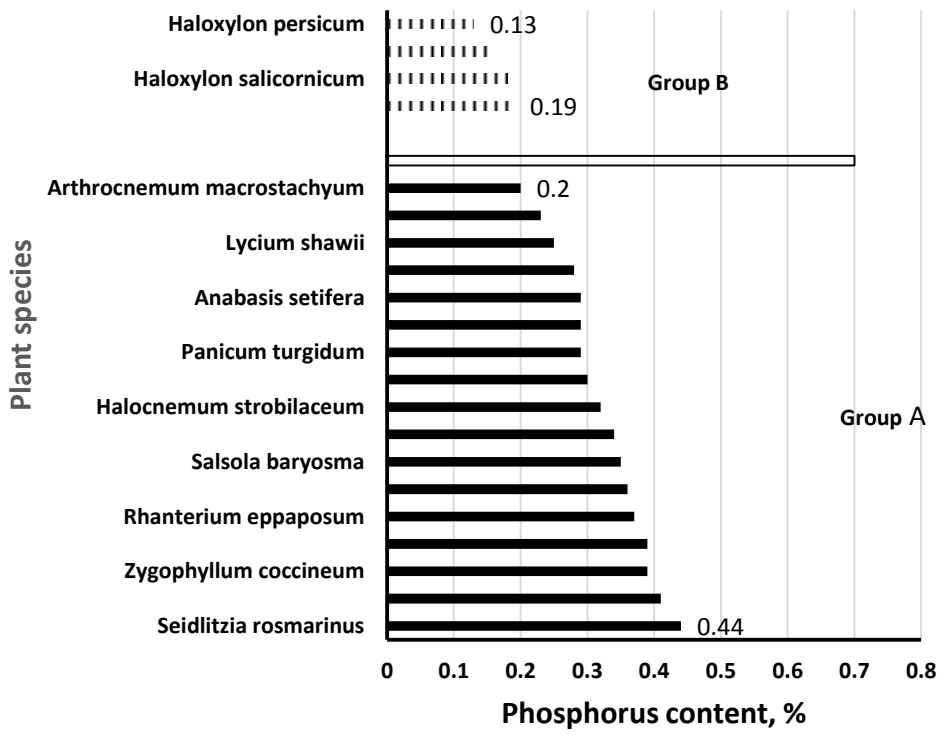

Fig. 6. Phosphorus content in the natural plant species under study and alfalfa as comparison.

Table 1. Grazing plant species in the eastern province of the Kingdom of Saudi Arabia (on dry weight basis, mg kg^{-1}) contents of copper, manganese, zinc and iron.

Plants species	Iron	Zinc	Manganese	Copper
			mg kg^{-1}	
Aeluropus lagopoides	1778.99±104.76*	11.03±7.06	175.21±0.16	53.24±0.21
Anabasis setifera	454.94±142.01	11.70±6.84	67.53±18.00	55.48±8.62
Arthrocnemum macrostachyum	458.65±42.47	21.53±2.32	40.46±3.39	54.97±0.78
Atriplex halimus	797.42±66.777	31.22±0.46	32.65	49.75±1.17
Calligonum comosum	211.66±45.39	7.29±2.19	65.28±35.88	54.47±4.18
Cyperus conglomerates	1064.91±145.13	20.81±912	123.09±24.72	54.42±1.00
Eragrostis barrelieri	971.08±29.68	21.72±1.75	61.38±2.07	53.26±0.29
Halopeplis perfoliata	124.90±46.98	11.44±9.40	35.09±4.75	55.18±3.26
Haloxylon persicum	---	17.40±20.79	129.71±0.88	53.25±0.36
Haloxylon salicornicum	---	17.70±20.80	130.99±3.17	50.10±0.29
Heliotropium bacciferum	695.45±198.16	17.10±12.77	41.24±18.88	52.59±13.84
Lasiures scindicus	1344.50±66.2	21.21±0.55	52.14±0.52	53.39±0.10
Leptadenia pyrotechnica	550.42±111.33	13.97±14.49	78.62±2.90	56.01±4.62
Lycium shawii	355.00	20.10	140.00	50.80
Panicum turgidum	760.18±78.56	16.68±6.95	54.14±8.12	52.91±0.48
Pennisetum divisum	341.14±32.45	23.59±1.76	56.60±1.20	54.43±0.61
Rhanterium eppaposum	593.63±79.08	25.25±6.01	43.62±1.33	57.87±0.19
Salsola baryosma	684.28±90.54	21.93±9.15	93.78±5.12	54.17±2.21
Seidlitzia rosmarinus	594.39±311.12	9.50±6.125	37.47±14.11	46.93±12.21
Suaeda vermiculata	498.44±90.21	18.61±10.23	131.03±18.26	53.40±2.00
Zygophyllum coccineum	602.18±95.8	18.07±8.12	132.59±24.58	57.59±15.3

* means ± stander deviation (SD).

4. Conclusion

Some of these halophytic plant species could be valuable sources of minerals for animals' feeds. However, there is a high need for the provision of energy supplements to meet maintenance and production demands of livestock feeding on these halophytes-based diets. Using these plants as alternative diets to replace at least partially the common dietary materials, could reduce the imported forage cost. The presence of high mineral content must be considered when formulating feeds that are supplemented by halophytes for the different animals.

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تقييم المحتويات المعدنية لأنواع النباتات الرعوية في المنطقة الشرقية بالمملكة العربية السعودية

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المستخلص. تم إجراء هذه الدراسة البحثية كمحاولة للمساهمة في المعرفة القيمة الغذائية لأنواع نبات الرعي الطبيعية. تم تقدير محتويات العناصر المعدنية (Na، K، Ca، Mg، P، Zn، Cu، Mn وFe) في واحد وعشرين نوعًا من النباتات البرية التي ترعى وتنتشر في المنطقة الشرقية للمملكة العربية السعودية. أظهرت النتائج أن محتويات المعادن المقدرة في معظم الأنواع النباتية التي تم تقييمها كانت كافية للمتطلبات الغذائية للأغنام والإبل. ومع ذلك، أظهرت جميع أنواع النباتات قيد الدراسة مستوى عال جدا من Na حيث تراوحت القيم بين ١٥,٥ في (*Pennisetum divisum*) و١٧,٤٥٪ في (*Arthrocnemum*). وتراوحت نسبة الكالسيوم بين ٠,٧ إلى ٥,٩٧٪ في *Arthrocnemum* و *Halopeplis* على التوالي. بينما تختلف محتويات البوتاسيوم والمغنيسيوم والفوسفور من ١,١٠–٢,٩٪، ٠,١٨–١,٤٩٪، ٠,١٣–٠,٤٤٪، على التوالي. وكان مدى العناصر الصغرى Zn، Mn، Cu، Fe تتراوح بين ($mg\ kg^{-1}$) ٩,٥٠ (*Seidlitzia Rosmarinus*)، ٣١,٢٢ (*Atriplex halimus*)، ٤٦,٩٣ (*Seidlitzia Rosmarinus*)، ٥٧,٨٧ (*Rhanterium eppaposum*)، ٣٢,٦٥ (*Atriplex halimus*)، ١٧٥,٢١ (*Aeluropus lagopoides*)، ٢١١,٦٦ (*Calligonum comosum*)، ١٧٧٨,٩٩ (*Aeluropus lagopoides*)، على الترتيب. إن استخدام هذه النباتات كغذاء بديل لاستبدال المواد الغذائية الشائعة جزئيًا على الأقل، يمكن أن يقلل من تكلفة العلف المستوردة.

كلمات مفتاحية: النباتات الملحية، المملكة العربية السعودية، المحتويات المعدنية.