PLASMATIC IONOGRAM PROFILE OF OULED DJELLAL EWES ACCORDING TO WATER AND STRAW SALINITY AT SETIF HIGHLANDS, ALGERIA

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ABSTRACT

Salty Chotts are very common in the South Highlands of Setif Governorate (northeast of Algeria). In fact, a large part of the sheep population is eventually driven to graze in these areas. However, there is no data on the mineral status of these sheep or on the mineral content of the water and fodder they consume. The present study aims to compare the plasmatic ionogram profiles of Ouled Djellal ewes reared in the Setif Highlands. For this purpose, twenty healthy ewes, aged 2 to 3 years, were selected randomly from two semi-extensive flocks, reared in two distant regions, where they are fed exclusively with locally produced straw, and watered using water with different saltiness levels: sulfated water (S) and soft water (T). Plasmatic concentrations of macroelements (Calcium "Ca", Phosphorus " P", Magnesium "Mg", Sodium "Na", Potassium "K") and trace elements (Iron "Fe", Copper "Cu", Zinc "Zn", and Manganese "Mn") were monitored monthly for one year. Ca, P, Mg, and Fe plasmatic levels were measured using a spectrophotometer, while Na and K levels were measured using flame spectrometry. The plasmatic Cu, Zn and Mn levels were measured using Graphite furnace atomic absorption spectroscopy. Results showed that plasmatic values of mineral macro elements change within standard normal ranges, with values slightly higher in Oum Ladjoul region, where the water is sulfated. Regarding the trace elements, sheep of Oum Ladjoul region were not deficient in Cu and Fe, compared to sheep of the witness region (Smara, El-Eulma). The plasmatic Zn levels were low in both regions with regard to the species norms. The absorption of sulfated water (S) seems to have a positive effect on the plasmatic level of the studied minerals. Overall, the consumed water in the study region does not seem to have an undesirable influence on the mineral metabolism. The effect of drinking water at different physiological stages and over long-term watering need to be investigated in the study region.

Key words: Water salinity, Ouled Djellal ewes, Malnutrition, Minerals, Straw quality.

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INTRODUCTION

The southern Setif Highlands are characterized by a salty soil and the existence of Chotts or Sebkhas covering a large area. Among the most important ones; Chott El'Baida (situated between Beida Bordj and Hammam Sokhna) with a surface area of 3500 ha, Chott El'Fraim (situated between Beida Bordj and Tella), Chott Bazer (situated in Bazer Sakra), Chott El- Hmiet (situated in Ain Lahdjar) and Chott Ain Oulmane (situated in Ain Oulmane). These Chotts give the specific chemical characteristics of the water according to their geographical extension.

Previous study of Chott El Baida water chemical compositions, allowed them to be classified as of; chlorinated calcicsodic zone (region of Beida Bordj), chlorinated calcic zone (region of Beida Bordj) and sulfated calcic zone (region of Oum Ladjoul, Hammam Sokhna) (Boudoukha 1988). These three regions are situated in proximity to Chott El Baida in a way that puts them within the pasture extent of the sheep in these territories.

In addition, there were other reports related to health status, livestock management and sanitary aspects of sheep reared in Setif Governorate, showing the predominance of some reproductive disorders and several other diseases (Mamache, 1984; Meziane, 2001). Moreover, the impact of using saline water as an alternative source of fresh water to avoid water scarcity was reported to have a negative effect on the performance, carcass traits, and meat quality of farm animals (Abdelsattar *et al.,* 2020).

To maintain the best possible health status, growth, and reproduction performances in domestic animals, as well as the proper operation of the immune and endocrine systems, correct macro- and micro-element metabolism is critical to keeping them within tolerable levels (Soetan *et al*., 2010). By strengthening the body's defense mechanisms and enhancing metabolism, trace elements contribute to overall health, and a deficiency might predispose to disease. Numerous studies on the effects of mineral elements on growth and milk production have been conducted in this context, and have shown significantly improved performance after mineral supplementation of ruminants (Onjoro *et al*., 2006; Rabiee *et al*., 2010; Hession *et al*., 2022).

Sheep species are known to have a lower tolerance to chronic salinity in drinking water and feed than other animals, such as camels (Assad and El-Sherif, 2022). The lack of data at the national level regarding the influence of water and feeds' mineral compositions on the health status and mineral balance of the indigenous sheep populations was among the reasons for conducting this study. Additionally, it would be possible to highlight the eventual tolerance to salinity as expressed by sheep and the impact of the different minerals excesses on the hydro-electrolytic balance and sheep performances. Hence, the present study aims to evaluate the effects of water salinity levels during the different seasons on the plasmatic ionogram profile of Ouled Djellal sheep, reared in the Setif Highlands.

MATERIALS AND METHODS

Ethical statement: The studied animals were used according to the ethical principles of animal experimentation and international guidelines for animal welfare (Terrestrial Animal Health Code 2018, section 7. Art 7.5.1) and national executive decree No. 95-363 of November 11, 1995 (Algeria).

Study area: The climate of the Setif governorate is of Mediterranean type; cool and semi-arid, characterized by a cold and rainy winter and a hot, dry summer with torrential and irregular rainfall. The average annual temperature is 18.41°C. The coldest month is January with a minimum average temperature of 7.25°C. The hottest month is August, with an average maximum temperature of 32.45°C. On the thermal level, the current data reveals the presence of two contrasting seasons; a cold season extending from October to April and a hot season extending from May to September. The distribution of rainfall from one season to another, and from one month to another is marked by an obvious irregularity; so that the maximum rainfall is recorded during February (210 mm), while the minimum rainfall is recorded during June (0 mm). It is also noted that nearly 90% of rain falls occur in autumn, winter and spring. The southwest winds are hot and dry, inversely, the northwest winds blow especially in winter, and bring rain to the region (Fig. 1).

Animals: Two farms that raise sheep of the Ouled Djellal breed were chosen based on the salinity of their drinking water. The two farms are distant, although they are both located in Setif Governorate, where similar farming practices are carried out. The first farm is situated in the area of Chott El-Baida (Oum Ladjoul: sulfated water "S"), while the second one is located about 30 km to the north of Chott El-Baida (El Eulma - Smara: soft water as witness "T").

The study included 20 ewes including 10 healthy ewes selected randomly from each farm. They were aged between two and three years old, and in their first or second month of pregnancy. All ewes were dewormed, then identified with numbered tags to undergo the experimental protocol for almost a year; from October 2018 to September 2019.

Feed ration and water chemical analysis: The ewes during this experiment were reared according to a semi-extensive system. Thus, they were driven to the pasture twice a day (from about 7 a.m. to 11 a.m., and 4 p.m. to 6 p.m.). At nightfall, the sheep were housed in a barnyard. They received freshwater twice a day (once in the morning, and once in the evening). All the ewes were given the same daily supplement of 300 to 400 g of straw, at the barnyard twice a day (at 12 p.m. and 8 p.m.). The straw was brought from the same area during the previous agricultural season, and was stored in an enclosed area, thus protected from all factors that could reduce its quality.

Prior to distribution to the ewes, the straw was analysed to determine its content of key nutritional components, including the nitrogen value (Kjeldahl method Nx 6.25), the crude cellulosis (Weende cellulosis), minerals (Na, K, Ca, P, and Mg), humidity, dry matter, and organic matter. The water drunk by the sheep was also analysed, with the aim of determining its mineral composition (Cu, Zn, Fe, Mn, Na, K, Ca, P, and Mg). The drinking water was pumped from wells situated on the sampled farms..

The Kjeldahl method: The Kjeldahl method has been used for the determination of nitrogen in straw. The procedure involved three major steps. Firstly, the sample was digested in boiling concentrated sulfuric acid with a catalyst to achieve complete dissolution and oxidation, resulting in the conversion of nitrogen in the sample into Ammonium Sulfate. In the second step, an excess of sodium hydroxide solution was added to release the ammonium ions in the form of ammonia. The ammonia was then distilled and collected in a volumetric solution of sulfuric acid. Finally, the ammonia content was determined through titration using sulfuric acid standard solution as the absorbing solution. The residual sulfuric acid (the excess not reacted with NH3) was titrated with sodium hydroxide standard solution, and by difference, the amount of ammonia was calculated.

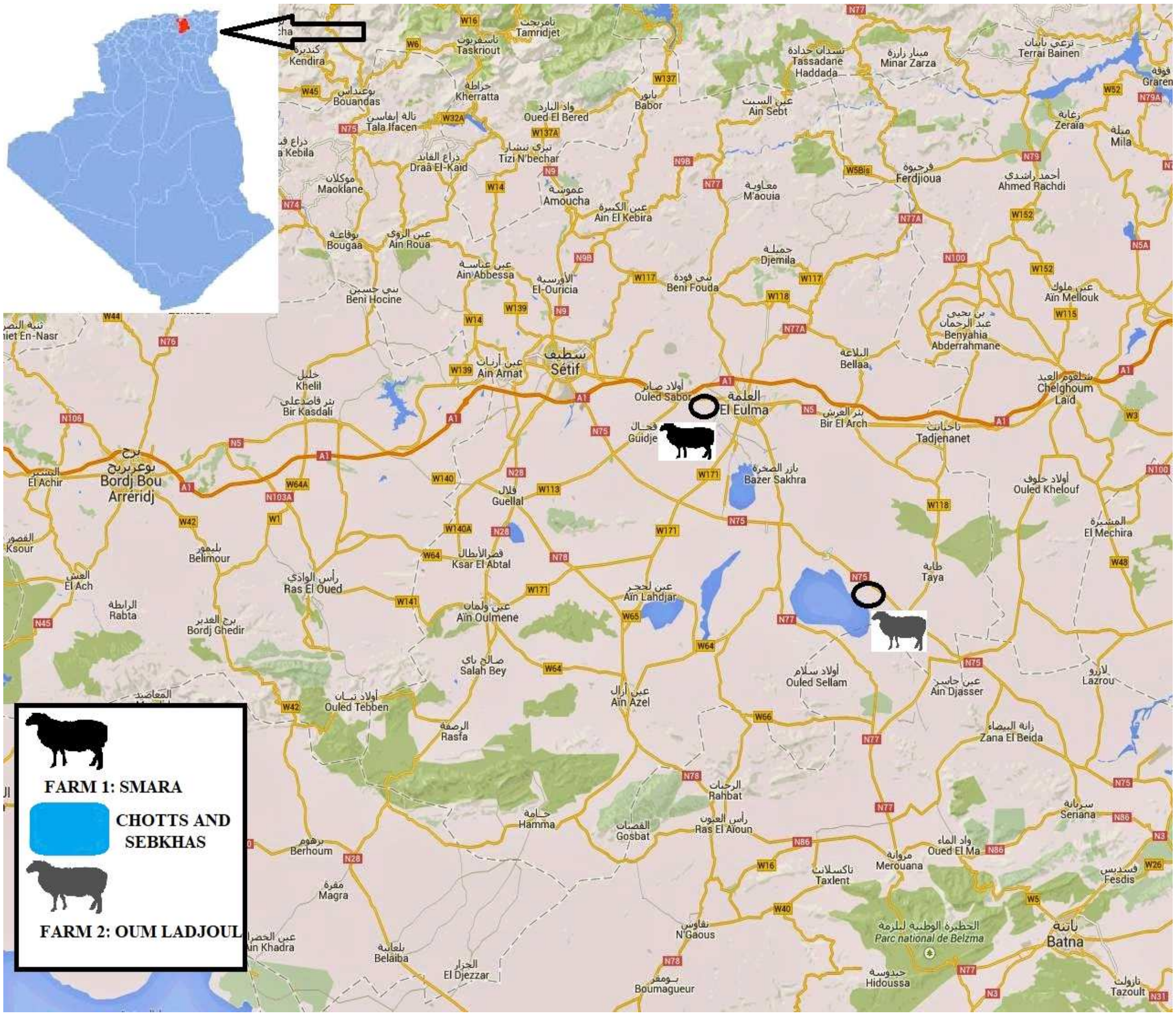

Fig. 1. Distribution of sampled farms in study area (Setif Governorate)

The Weende method: The Weende method has been widely used in nutritional analysis to determine the crude cellulosis. In this method, the sample was subjected to sequential extractions using acid and alkaline solutions. The acid treatment dissolved the hemicellulose and some pectin components, while the alkaline treatment removed proteins, lignin, and minerals. The remaining residue, primarily consisting of cellulose. The crude cellulose fraction was then quantified by weighing the residue after filtration and drying.

Essay of minerals (Na, K, Ca, P and Mg), humidity, dry matter and organic matter: The determination of minerals, including sodium (Na), potassium (K), calcium (Ca), phosphorus (P), and magnesium (Mg), in straw was performed using the Spectroscopy of Atomic Absorption (SAA) method. SAA is a widely used analytical technique that accurately measures mineral concentrations in feed samples by measuring the absorption of specific wavelengths of light by the mineral atoms. In addition to mineral analysis, other parameters such as moisture content, dry matter, and organic matter were determined. Humidity content was determined by drying the feed sample at a specified temperature to achieve a constant weight, with the weight loss representing the moisture content. Dry matter content was calculated by subtracting the moisture content from 100%. For organic matter determination, the feed sample was incinerated at high temperatures, leaving behind the inorganic content as residue. The organic matter was then calculated by subtracting the inorganic content from the total dry matter.

Plasmatic ionogram profile: Blood samples were collected monthly in vacutainer tubes containing lithium heparinate. Blood was collected from the jugular vein, then centrifuged at 3000 rpm for ten min. Plasmatic

Ca, P, Mg and Fe were determined using commercial kits "SPINREACT, Spain" according to the standard method using Spectrophotometer (UV) (UV-160A; Shimadzu Corporation, Japan), while the plasmatic Na and K by flame spectrometry using JENWAY PFP7 (detection threshold≤0.25ppm; linearity ± 5 ppm) (Table 1). The plasmatic concentrations of Cu, Zn and Mn were estimated using a Flame Atomic Absorption Spectophotometry (iCE 3300, Thermo Scientific, USA) according to previously described methods (Fick *et al.,* 1976) (Table 1).

Table 1. Analytical methods for the monitoring the blood ionogram profile of the studied ewes

Parameter	Analytical method	Coefficients of variation (%)	References
Ca	Arsenazo III. Colorimetric	Intra = 8.35-14.28 Inter = 8.58-14.57	« SPINREACT » Ref : 1001065
P	Phosphomolybdate. UV	Intra = 4.09-7.12 Inter = 4.11-7.09	« SPINREACT » Ref : 1001155
Mg	Xylidyl Blue.Colorimetric	Intra = 1.99-3.55 Inter =1.98-3.48	« SPINREACT » Ref : 1001285
Fe	Ferrozine.Colorimetric	Intra = 113-250 Inter = 111 – 249	« SPINREACT » Ref : 1001247
Na	Flame spectrometry		
P	Flame spectrometry		
Cu	Atomic Absorption Spectophotometry		
Zn	Atomic Absorption Spectophotometry		
Mn	Atomic Absorption Spectophotometry		

Statistical analysis: The statistical analysis was carried out using the repeated-measures t-test to compare the means of blood mineral components between two groups of ewes (watered with Sulfated water "S" and Soft water "T"). The analysis was performed on dependent samples using STATITCF® software. Statistical estimates were calculated at a 95% confidence interval.

RESULTS

Mineral quality of the drinking water: The recommended norms of water potability established by the Food and Agricultural Organization (FAO) and World Health Organization (WHO) (Herschy, 2012); concerning the use of saline water for watering and the concentrations of tolerable toxic inorganic substances, and the Australian Water Resources Councils for the concentrations of Mg acceptable (Ayers and Westcot, 1985). In addition, the E.E.C. admits the same norms (European Economic Community J.O /CEE/ 30.08.80 N°S L 229/21). The comparison of the thresholds of mineral levels with those of the drinking water in Oum Ladjoul locality (Farm 2) shows that it is out to be unfit for consumption, due to the Mg, K, Na, Ca, Chlorures, and especially Sulfate which are higher than potability limits. In contrast, the drinking water of El-Eulma locality (Farm 1) has a high Ca load (Table 2).

Straw mineral composition: The straw chemical composition is reported in Table 3. The straw was the unique food resource for both S and T ewes groups. The straw used to feed the S group contains lower levels of Ca, Mg, P and K compared to the straw used for the T group. Only the level of Na is higher in the straw samples from the S batch. Moreover, the Ca and Mg content in S straw is lower than the standard indicated by Bouchet and Gueguen (1981), while the P concentration in group T straw is higher than the standard levels reported by the same authors (Bouchet and Gueguen, 1981). The rest of the straw mineral composition results are within the range of recommended standards for sheep feed.

Table 2. Water minerals comparison with norms of potable water according to European Commission (2015).

Mineral elements (mg /l)	Studied localities			Norms of potable water		
	Farm 1 : Smara (control) (T)	Farm 2 : Oum Ladjoul (S)	References	Level guide	Maximal authorized concentration	References
Mg	93	93	(Khemmoudj *et al.,* 2013)	30	50	(European Commission 2015)
K	15	44		10	12	
Ca	125	500		100	200	
Chloride	775	775		/	500	
Sulfate	93	860		25	500	
Na	99.5	342.5		20	200	
Bicarbonates	180.5	360.5		/	/	
Nitrates	47.5	49		25	50	
Phosphate	44	49		/	5	
Fe	4	10	Personal results	/	0.2	
Cu	5.6	11.2		/	2	
Zn	3.4	7.4		/	5	
Mn	25	36		/	0.4	

Macro elements; Mg: magnesium, K: Potassium, Ca: Calcium, P: Phosphorus, Na: Sodium.
Micro elements; Fe: Iron, Cu: Copper, Zn: Zinc, Mn: Manganese.

Table 3.Straw mineral composition in comparison to normal ranges reported by Bouchet and Gueguen (1981).

Mineral elements (g/kg D.M)	Straw quality in the studied localities		
	Farm 1 : Smara (control) (T)	Farm 2: Oum Ladjoul (S)	Ranges of norms (Bouchet and Gueguen, 1981)
Ca	0.95 ± 0.04	0.73 ± 0.07	0.8 - 4.5
Mg	0.36 ± 0.16	0.08 ± 0.01	0.2 - 3.5
P	2.5 ± 0.09	1.4 ± 0.06	0.4 - 2.2
Na	0.5 ± 0.02	1.5 ± 0.2	0.1 - 7.0
K	14.5 ± 0.35	7.00 ± 0.4	4.0 - 37

Sheep plasmatic ionogram: Figure 2 shows the results of seasonal plasmatic microelements' concentrations in Ouled Djellal ewes, belonging to T and S groups. Overall, the level of these microelements is higher in the S group than that of the T group. This is particularly obvious for Fe during autumn ($p<0.01$), spring ($p<0.001$) and summer ($p<0.001$). Similarly for Cu; that the plasmatic concentration was significantly higher in autumn ($p<0.001$), winter ($p<0.001$) and spring ($p<0.01$) in the S group ewes' compared to those of the T group. Also, the Zn plasmatic levels showed a high concentration during the whole year in S group ewes' compared to those of the T group, however, the statistically significant difference was recorded only during the summer ($p<0.001$). The plasmatic Mn concentration was significantly higher in the S group ewes' during the autumn ($p<0.001$) and summer ($p<0.01$) (Fig.2).

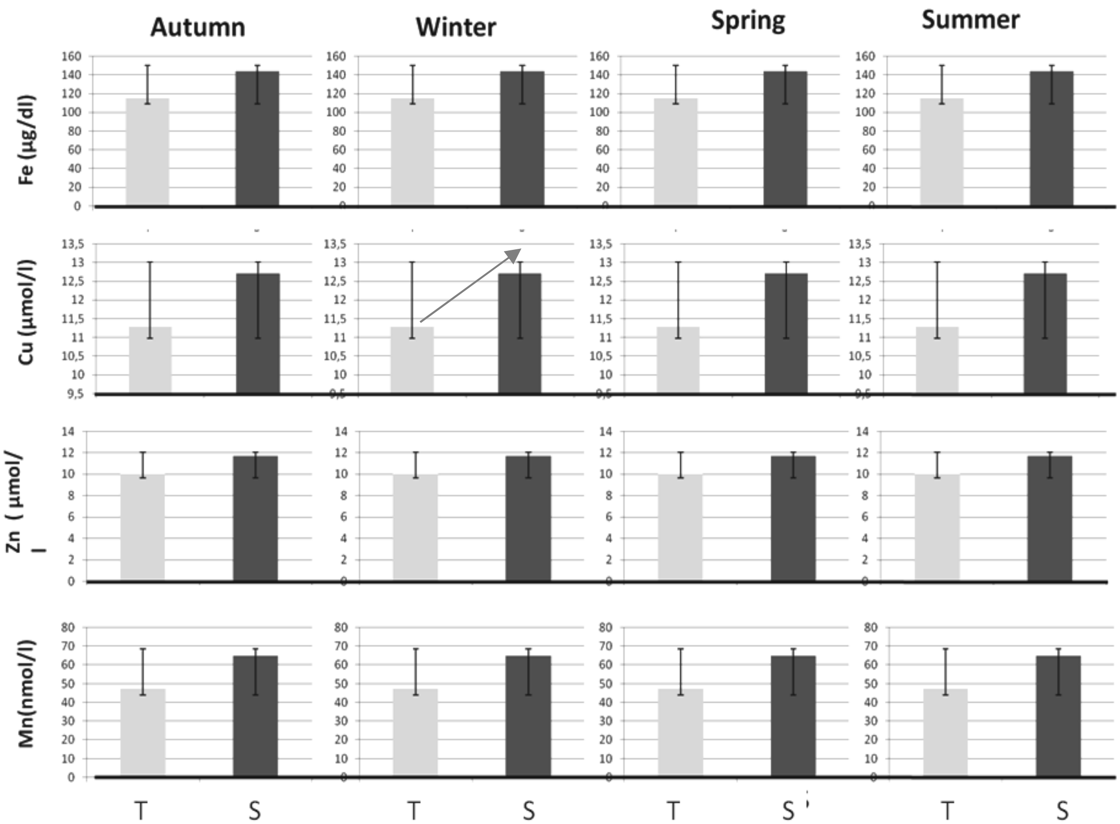

Fig. 2: Means of trace mineral elements plasmatic concentrations in Ouled Djellal ewes according to drinking water salinity (sulfated water "S" n= 10; soft water "T" n=10) and seasons.

*On the Y-axes, Fe, Cu, Ze and Mn stand for microelements concentrations (Fe: iron, Cu: copper, Zn: zinc and Mn: manganese). In each season, the plasmatic concentration of the microelements is reported for ewes of T group and S group. All the grey bars in the left part of each panel (T group) are lower than those of the right bars (S group). The grey arrow shows a typical example for this trend. The stars on the histograms express the significance level of means differences between the two ewes' groups; * p <0.05; ** p <0.01; *** p <0.001.*

Regarding the macro elements (Table 4), the plasma Ca concentration was the highest during the spring, especially in the S group, compared to those of T group ($p<0.05$).Similarly, ewes of the S group showed higher levels of P during winter, which decreased to their lowest levels in autumn and spring compared to T group ewes. The Mg concentrations increased significantly in summer and autumn in ewes of S group ($p<0.001$). The K level was significantly higher in S group ewes compared to those of T group, during the summer.

Table 4. Mean concentrations of plasmatic macro mineral elements in Ouled Djellal ewes according to drinking water salinity (sulfated water "S" n= 10; soft water "T" n=10) and seasons.

Minerals/Seasons		Farm 1: Smara (T)	Farm 2: Oum Ladjoul (S)	*p* -value
Ca (mg/l)	Autumn	89.33 ± 12.21	92.53 ± 8.88	>0.05
	Winter	93.89 ± 6.35	92.43 ± 9.32	>0.05
	Spring	95.30 ± 12.31	102.03 ± 10.36*	<0.05
	Summer	92.10 ± 12.59	94.40 ± 14.78	>0.05
P (mg/l)	Autumn	64.00 ±15.27	57.03 ± 15.43*	<0.05
	Winter	64.92 ± 11.43	70.80 ± 12.89*	<0.05
	Spring	73.26 ± 16.05	66.76 ± 14.61*	<0.05
	Summer	55.43 ± 11.53	53.76 ± 11.89	>0.05

Mg (mg/l)	Autumn	19.16 ± 2.16	23.33 ± 3.66***	<0.001
	Winter	26.45 ± 8.56	24.20 ± 6.88	>0.05
	Spring	21.23 ± 1.95	20.33 ± 2.60	>0.05
	Summer	20.40 ± 2.59	23.60 ± 3.37***	<0.001
Na (meq/l)	Autumn	148.31 ± 7.96	151.10 ± 26.19	>0.05
	Winter	151.40 ± 16.29	153.06 ±14.07	>0.05
	Spring	140.56 ± 7.43	142.26 ± 4.53	>0.05
	Summer	142.56 ± 12.74	145.36 ± 8.18	>0.05
K (meq/l)	Autumn	4.85 ± 0.62	4.93 ± 0.94	>0.05
	Winter	5.21 ± 0.80	5.14 ± 0.78	>0.05
	Spring	4.48 ± 0.47	4.84 ± 0.40	>0.05
	Summer	4.85 ± 0.59	5.19 ± 0.66*	<0.05

** p <0.05 ;** p<0.01 ;*** p<0.001.*

DISCUSSION

Salinity affects 954.8 million ha of the world's land area (Szabolcs, 1989; Shahid *et al*., 2018), accounting for nearly 7% of the total land area or nearly 33% of the world's potential arable land area (Gupta and Abrol, 1990). In Algeria, agricultural soils are mostly affected by salinity or are likely to be (Durand 1983). According to Berkane *et al.,* (2021); 3.2 million ha are affected to varying degrees of severity. The most common salts in arid and semi-arid regions are mainly chlorides, sodium sulfates, magnesium sulfates, and to a lesser degree, sodium carbonates (Halitim, 1988).

The mineral level of the drinking water and food salinity are often not taken into consideration when formulating animals' food rations, while water consumption is crucial for farm animals since it supports a wide range of biological processes inside their bodies. High water and food salinity levels lead to animal health issues and might alter productive and reproductive performances.

There is scarce and controversial information about how drinking water affects mineral nutrition under arid and semi-arid conditions in Algeria. However, worldwide, several studies have discussed this topic. According to Yirga *et al*., (2018), increasing the total dissolved salt concentration in drinking water had an effect on intake and digestion in various animal species, including Katahdin sheep and Boer goats.

In a study conducted by Assad and El-Sherif (2002) on the impact of saline water on Barki ewes, the activity of the acetylcholine esterase enzyme in its three sites; blood, red blood cells and plasma was significantly depressed by drinking saline water. Also, Extracellular fluids, interstitial fluids, plasma volume and blood volume in the ewes decreased (p<0.05) by increasing salinity concentration.

In a neighboring country (Tunisia), for Barbarine sheep, Yousfi *et al*., (2016) have experimentally demonstrated that serum creatinine increased (p<0.05) with the administration of sodium chloride, sodium sulfate or sodium nitrite in drinking water. Despite the fact that the same authors did not observe any effect on the Barbarine lambs' growth, they have suggested that the increased creatinine and reduced triglycerides in the blood justify the need to emphasize further investigations on the effect of these salts on lamb's health.

The obtained results of the present study showed a substantial effect of the mineral composition of the food intake on the blood mineral profile of a local sheep breed (Ouled Djellal). For these animals, the straw, being a very poor in energy and minerals, constitutes their main food source during periods of drought. The quantity distributed per animal (50 kg of body weight) cannot exceed 500 g of dry matter per day, and for this reason the supply is very important (Jarrige *et al.,* 1995).In addition, straw consumption cause abundant digestive secretion mainly from saliva, which leads to a significant endogenous loss of minerals; such as Ca and P.

Zn plasmatic levels were higher in S group ewes throughout the year than in T group ewes, but the difference was statistically significant only during the summer (p<0.001).The recorded Zn concentrations were significantly lower (12.24 - 27.54µmol/l: p<0.05, 12.24 -22.95µmol/l: p<0.01) than those reported by Underwood (1981). However, they were in accordance with reference ranges and are higher than the critical values cited by McDowell (2003). Zn is a mineral that is present in every cell of the body. It is a part of numerous enzymes, including those that are involved in transcription, intra- and intercellular signals, the cell transcription machinery, protein carriers, and the binding of amino acids to maintain structural integrity, among others (Hill *et al.,* 2019). In sheep, it is a crucial element for growth, immunity, wool production, and fertility. All species exhibit the effects of high Zn on Cu metabolism. It is helpful in lowering minor Cu toxicity in sheep (Hill *et al.,* 2019).

It was observed that there was a significant seasonal effect on Cu concentration; with higher levels in animals from the “S” farm compared to those of “T” farm particularly during the spring, autumn and winter. The recorded Cu plasmatic concentrations during the whole year were significantly lower than the normal ranges (12.6-18.88µmol/l) reported by Underwood (1981), meet the reference ranges and were higher than the critical values cited by Khan *et al*., (2007) and McDowell (2003). Cu deficiency in sheep can manifest as any of the following signs and symptoms: anemia (hypochromic, macrocytic), neonatal ataxia, bone disorders, poor growth and appetite, defective keratinization of wool, and infertility is frequently accompanied by small, dead fetuses (Hill *et al.,* 2019). Neonatal ataxia, sometimes referred to as "swayback" and "lamkruis", which is a neurological condition that causes incoordination and has a high mortality rate. The high Cu plasmatic levels compared to standard levels were recorded in ewes from “S” farm particularly during the autumn and spring. Chronic high dietary Cu causes an acute hemolytic crisis, resulting in the release of free, unbound Cu in the blood stream. The plasmatic assessment of Cu and Zn showed significant seasonal and individual variation. The seasonal levels of Zn and Cu were higher than those reported by EL-Gohary *et al.,* (2018). The Cu values indicate a good absorption of this element either is salty water regions or in sweet ones (spring).

The seasonal plasmatic Mn and Fe values recorded in ewes of the two studied groups (T and S) remain within the physiological limits (Runa *et al.,* 2022) with significantly higher levels in S group compared to T group. In healthy Egyptian ewes, the blood Fe concentration was slightly lower than the accepted limits reported by EL-Gohary *et al*., (2018). The increase in sideremia (Fe) during the rainy seasons (winter and spring) in the two regions could be explained by the excessively high needs of the fetus or fetuses at the end of ewes’ gestation. Unlike this study, Antunović *et al.,* (2002) found a significant difference between winter and summer, with an increase in serum Fe in lactating ewes during the summer. Yokus *et al.,* (2004) and Yokus and Cakir (2006) found no influence of the season on plasma Fe levels.

The recorded seasonal fluctuations in calcemia may be due to pregnancy, which leads to a decrease in Ca values because the need for Ca in fetuses increases in the third month of pregnancy. Except in the spring, statistical analysis revealed no seasonal effect on serum Ca between the two regions. Our results are similar to those of Yokus and Cakir (2006) and Chacha et al., (2022) who found no influence of the season on serum Ca in cows. Furthermore, Antunovic *et al.,* (2002) found a significant decrease ($p<0.05$) in ewes’ calcemia when pregnant or lactating in winter compared to summer, they correlated this decrease to the risk of hypocalcemia linked to parturition in ruminants. Yokus *et al*., (2004) also found a significant ($p<0.05$) decrease in calcemia in ewes during the winter compared to other seasons. According to Runa *et al.,* (2022), Black Bengal goats did not show significant difference in Ca between experimental groups under highly saline and normal watering.

The decrease in Mg values during spring and autumn can be explained by the low content of herbs in this mineral. However, the decrease in magnesium values during the summer may be explained by the poor quality of straw (Makhlouf *et al.,* 2020). For Boer goats, Runa *et al*., (2020) reported that increasing consumption of saline water decreased plasma concentrations of Mg (from 0.95 to a minimum of 0.80 mmol/L, $p<0.001$).

In Black Bengal goats, the blood P, K, Na and chloride levels were significantly lower in the normal salinity watered group (Runa *et al.,* 2022). The results of these authors are somewhat consistent with those recorded in our study of sheep species. However, these authors recorded lower levels of plasmatic Na and K in animal groups reared under high water salinity than our results, which corroborate the reference values reported by Tomas *et al.,* (1973), Jackson and Cockcroft (2007) for goats, and Potter (1968) for goats and sheep.

The plasmatic values of Na and K should be in a positive correlation with the dosage of these elements in saliva, which offers a crucial advantage in the diagnosis of their deficiencies. It seems that the longer period of diuresis in sheep that drank hypertonic saline water of 1 to 1.3% and were feed exclusively high salinity straw increased the blood levels of Na and K (Potter, 1968; Tomas *et al.,* 1973; Runa *et al.,* 2020). In this regard; Runa *et al.,* (2022) showed that the stepwise adaptation to saline drinking water at concentrations up to 1.5% across four weeks caused no harmful effects. The similar and concurrent changes of blood Na, K and Mg concentrations reveled how these minerals work together as complementary nutrients to keep the body's osmotic equilibrium and regulate cell signaling via the Na^+-K^+ pump. Mg is necessary for Na to enter the cell membrane, and all tissues have a positive correlation between Mg and K concentrations (Yokus and Cakir 2006).

In addition to the water salinity, according to the results of our study, it could be suggested that the straw's poor quality and the soil's poorness, allow us to propose some explanations or hypotheses that may explain the observation of Cu deficiency. It is probable that the overgrazing practiced during winter pushes the ewes to consume plants till the roots, and thus a great deal of earth is ingested. This situation leads to a decrease in the digestibility of copper and zinc (Goneratne *et al.,* 1989; Grace and Lee, 1990; Meziane*,* 2001). The presence of other mineral elements such as sulfate and molybdenum coupled with an excess of Fe and Ca could considerably reduce the digestibility of Cu leading to its plasmatic deficiency (Goneratne *et al.,* 1989; Grace and Clark, 1991; Meziane, 2001).

The low plasmatic Cu values in the studied animals from the Smara region (T) (Farm 1) during all seasons support our hypothesis. This could be explained by feeding that is composed of straw, which is very poor is Cu (Lamand, 1991). Thus, content of the order of 7 mg Cu /kg of dry matter (DM) in straw, hay and even in herbs constitutes the limit of deficiency (Goneratne *et al.,* 1989). If we consider that in our survey, ewes ingest 500 g of straw (2.3-4.7 mg Cu /kg DM), the plasmatic Cu would range from 1.15 to 2.35 mg, which represents poor feeding if compared to the minimum recommended, which is 16 mg Cu /kg DM (Underwood, 1981 and Jarrige, 1988).

Otherwise, deficiencies observed in winter could be explained by the high need of Zn and Cu during pregnancy as shown by Grace and Lee (1990), without clear evidence on the interaction among minerals.

The main clinical sign observed during our investigation was the loss of wool, especially in winter. The fodder content of Zn is below the deficiency limit (50 mg/kg DM). The excess of sulfates was very evident in the region of Oum Ladjoul "S" (Farm 2) when the water contains 885 mg of sulfate/L (Boudoukha, 1988). The excess of Ca in water and soil and the deficiency of soluble nitrogen (straw) reduce the digestibility of Zn. Cu enters into competition with Zn for the site of absorption, where it saturates the metallothinein of the intestinal cell (Goneratne *et al.,* 1989). The ewes of "S" region (Farm 2) are less deficient in most minerals. This may be due to the fodder content and source. Indeed, fodder grown on dry soils that receive less rainwater (300 mm per year) is richer in minerals, and as shown in Fig. 1, the Oum Ladjoul (Farm 2) region is located further south than the Smara (Farm 1) region.

Conclusion: This study focused on the plasmatic ionorgam of the local breed ewes, more specifically Ouled Djellal population, in relation to two different watering and food electrolytic content levels: soft in Eulma region (Farm 1) versus sulfated in Oum Ladjoul region (Farm 2). Despite the small sample size of this study, it has shown us that the ewes of Oum Ladjoul region (salty region) weren't deficient in plasmatic Cu and Fe, compared to those of El'Eulma region (soft region). In both regions, plasmatic Zn levels were low in comparison to international standards.. The plasmatic values of macroelements were somewhat elevated in the region of Oum Ladjoul where water is sulfated. The seasonal ionogram pattern changes and the evolution of the health status outcomes suggest that the Ouled Djellal sheep breed could tolerate high salt levels in food and drinking water throughout the year.

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