



Study of the Effect of Pastoral Areas on Mineral Levels in Goat Milk in El Oued (Algeria) Region

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Abstract

Among all foods and based on its nutritional content, goat's milk is considered one of the most complete and balanced. In fact, in recent decades, goat's milk has assumed an increasingly important role in human nutrition, not only for infants but also for adults. The problem of the presence of contaminants in milk has been widely raised by the media in recent years, so the establishment of toxicological tolerances in foodstuffs has become a necessity today. In our work, we studied the presence of metals (Cl⁻, pb, cd, Cu, So⁴⁻, Na) in some samples of Goat milk collected in different areas of the El Oued region. Analysis of Goat milk samples showed different and similar levels of these metals, for heavy metals copper content between 20-40 ug/l and lead 0.01-0.06 ug/l and cadmium 0.01-0.04 ug/l for mineral salts sodium content 0.04-0.2g/l and chlorine 0.2-0.25 g/l and sulfate 0.2-1.8 g/l with a higher concentration of sodium in goats from the Al- ZGOM region and a higher concentration of sulphates in the Al- BAYADHA region. As for the BEN GASHA region, we find a higher concentration of copper compared to other regions. The change in the proportions and concentrations of minerals in the milk of goats grazing in different regions confirms the effect of air and water pollution and changes in the type of food on the mineral components of milk, which affect human health.

Keywords: Milk; Metals; Contaminants; Poisoning, Goat.

Introduction

Algeria is the largest milk consumer in the Maghreb, with an average consumption of around 140 liters per person per year. In human nutrition, milk and its derivatives are described as a complete food containing proteins, essential fatty acids, lactose, vitamins, and minerals in balanced proportions [1]. Milk contains significant amounts of various minerals including the major element that present in large quantities (a few grams) in ionic form including sodium,



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potassium, calcium, magnesium, phosphorus, and chlorine [2]. Other minerals are known as trace elements, including iron, copper, zinc, manganese, molybdenum, aluminum, and iodine. These elements are numerous and can vary depending on the animal's diet [3]. Milk constitutes an essential part of daily nutrition, particularly for vulnerable groups such as infants and children [4]. It also highlights the high nutritional value of goat's milk, due to its high digestibility and small fat globule size, as well as its composition rich in high-quality proteins, essential fatty acids, beneficial vitamins and minerals [5,6]. However, milk can also contain harmful substances such as pesticides, medications, and heavy metals, which pose a risk to consumer health [7]. Contamination of milk by heavy metals represents a serious threat to human health, as these metals have a long lifespan in the environment and accumulate throughout the food chain. They can cause serious health problems such as cancer and neurotoxicity [8,9]. Heavy metals accumulate in the tissues of dairy animals and are excreted in milk, making them hazardous for humans who consume this milk [10,11]. These metals mainly originate from anthropogenic activities such as industrial and agricultural pollution [1,12]. Areas contaminated with heavy metals are the most vulnerable to milk contamination, which leads to adverse effects on consumer health [13–15]. Due to limited resources and logistical constraints, our study aimed to conduct research on minerals and heavy metals in goat's milk samples collected from rural areas of El-Oued city in Algeria.

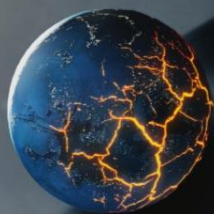
Materials and Methods :

Goat Milk Sampling

Goat milk samples were collected from different locations in each region targeted by the study (NAKHLA, ZGOM, BAYADHA and BEN GASHA). The following hygiene rules were taken into account: Wash the animal's hands and udders before milking, and discard the first stream of milk from each quarter. The milk collected was a mixture of the first milking of several lactating females belonging to herds on the same farm. For each sample, a quantity of 250 mL was collected after homogenization in previously cleaned and dried glass bottles. Each sample was then identified. The bottles were immediately placed in a cooler containing ice packs, transported, and stored in the laboratory refrigerator until analysis.

Mineral Determination

The destruction of organic matter by oxidation in the presence of concentrated acids allows the mineralization of the samples. A volume of 10 mL of concentrated nitric acid (HNO_3) at 68 % purity is added to 10 mL of milk. Then the mixture is transferred into a ceramic dish placed for one hour on a hot plate set at 370 °C then in a muffle furnace for four hours at 500 °C. 10 mL of distilled water with 1% nitric acid was added to the ashes obtained after the total destruction of the organic matter, the solution contained in the dish became



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white.

The mineralized solutions are then analyzed by atomic absorption spectrophotometry, in the analysis laboratory of the renewable energy research institute of El Oued. The reading is carried out against a blank (distilled water with 2 % nitric acid), and the rate of each metal is calculated from a linear calibration curve ($y = ax + b$) established with precise concentrations of each metal as a reference standard, under the same conditions as the sample. The results are expressed in (mg/L).

Statistical Analysis

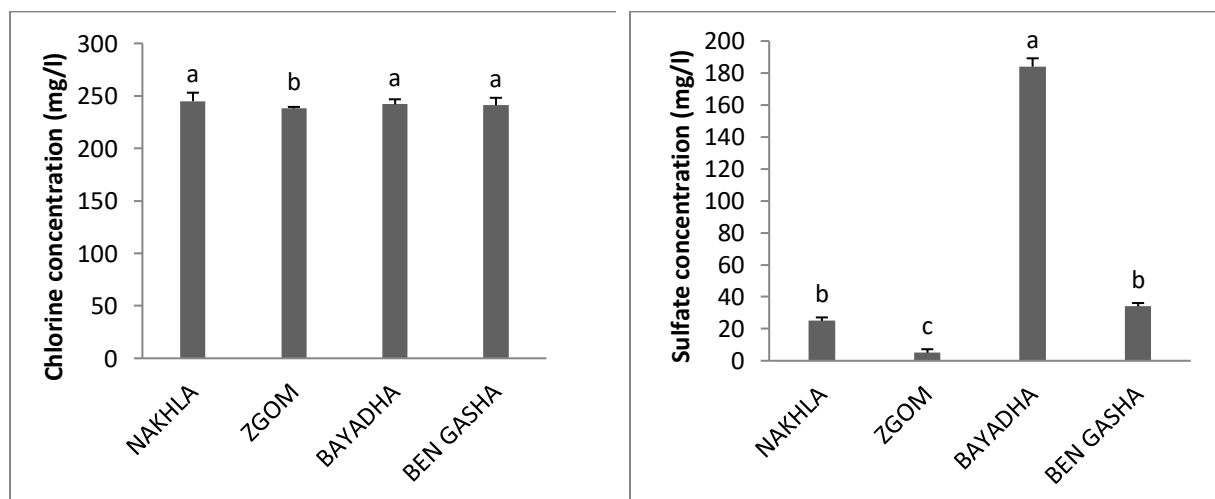
For statistical data analysis, XLSTAT version 2016 was used. Data were presented as mean \pm SE, and statistical analyses were performed using SPSS, edition 24 (2016). Analysis of variance (ANOVA) was used for comparisons between groups.

Quantitative variables with equal variances ($p > 0.05$) were compared using a one-way parametric ANOVA test, and in case of multiple comparisons, the LSD test was used. A p value < 0.05 is considered significant.

Results

Metal concentration

Figure 1 presented the concentrations of metals found in the milk of goats reared within the El-Oued region across four distinct rural locales (NAKHLA, ZGOM, BAYADHA, and BEN GASHA). The findings illustrated in these figure indicated that there is a difference in the concentrations of the studied minerals in goat milk, with a higher concentration of sodium in goats from the Al- ZGOM region and a higher concentration of sulphates in the Al-BAYADHA region. As for the BEN GASHA region, we find a higher concentration of copper compared to other regions.





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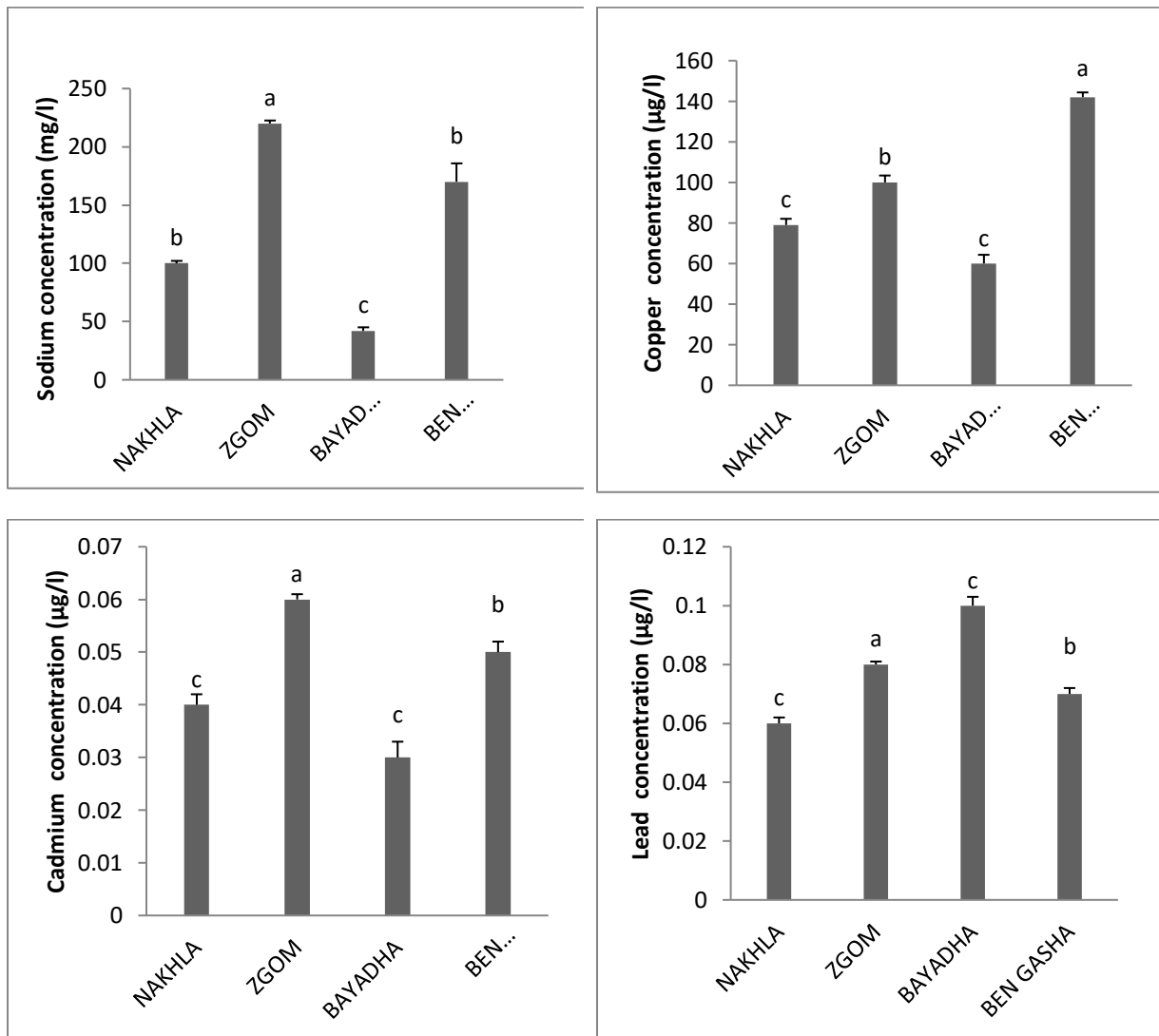


Figure 1: Metal concentration in Goat milk

Correlation between metal concentration

Figure 2 presented the correlation between the concentrations of metals found in the milk of goats reared within the El-Oued region. The findings illustrated in these figure indicated that there were statistically positive significant correlation between sodium and chlorine concentrations in Goat milk however, there were statistically negative significant correlation between sodium and Copper concentrations and between Copper and sulphate concentration in Goat milk.



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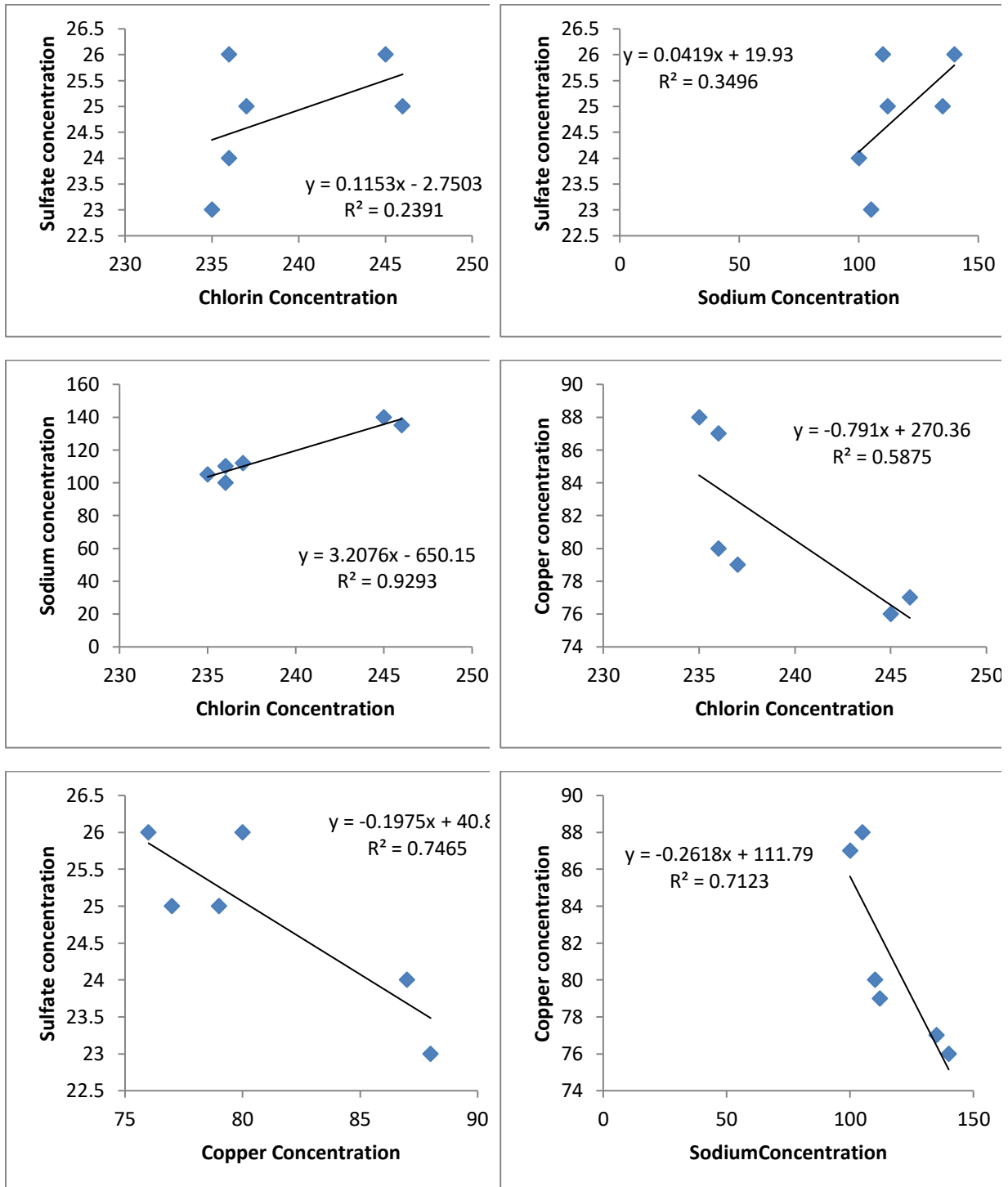


Figure 2: Correlation between variations of metal concentration



Discussion

Milk is an ideal source of macro-elements (Ca, K, and P) and micro-elements (Cu, Fe, Zn, Se). However, additional amounts of metals could enter the milk and dairy products, reaching harmful levels for humans [16]. However, contamination of this staple food with toxic heavy metals is considered a serious problem due to their toxicity and cumulative power in the food chain. Milk represents one of the pathways for metal elimination and is therefore a significant source of contamination for humans [17]. Consequently, milk and dairy products are often contaminated with heavy metals either through farming practices or manufacturing and packaging processes [18]. Heavy metals are natural constituents of the Earth's crust and are released by human activities. They enter the body through food, air, and water, where they accumulate over time [19]. Among the significant natural sources of heavy metals are volcanic eruptions, rock weathering, forest fires, and ocean evaporation [20]. The highest levels of inorganic elements found in soils are strongly linked to human activity. In our study, the copper levels in goat's milk were significantly different between the different breeding regions of Al-Nakhla, Al-Zgom, Al-Bayadha, and Ben Qasha, but there was no significant difference within the same breeding region. Copper is undoubtedly one of the most talked-about trace elements in goats, and for good reason - it is essential for healthy bone and muscle growth. When it is deficient, particularly in growing goats, the consequences can be severe. It is also important for normal immune system function and nerve conduction [21]. Large amounts of copper, typically ingested by individuals with suicidal intentions, can damage the kidneys, inhibit urine production, and cause anemia due to red blood cell rupture (hemolytic anemia) [22]. The copper content in cow's milk is 20-40 $\mu\text{g/L}$ [23]. However, this quantity varied in goat's milk, reaching up to 140 $\mu\text{g/L}$. Lead (Pb) appears in cow's milk when the animal consumes it (deposits of lead tetraethyl on pastures located near major roads), although the mammary gland slows down its passage into milk. Water stagnating in lead pipes can contaminate milk, as can containers (coated with lead paint) [24]. Cadmium can also be present in feed and water contaminated by mining, industrial, and fertilizer waste, polluted by pesticides. However, the mammary gland limits its passage into milk, where it binds to both casein and soluble proteins [25]. The levels of heavy metals, including lead and cadmium, in cow's milk are 2-10 $\mu\text{g/L}$ and approximately 1 $\mu\text{g/L}$, respectively. However, our study confirms that the levels of lead and cadmium are zero in goat's milk, which is significantly different compared to other species. These levels can fluctuate depending on variables such as the cow's feed, regional location, and exposure to environmental pollutants [26]. Chlorine is a chemical element (symbol Cl) belonging to the halogen group with an atomic mass of 35.457. In nature, chlorine is found only in the form of chloride ions (Cl^-), with a valence of -1 [27]. Chlorine is responsible for maintaining acid-base balance (pH) in the body, regulating fluids, and transmitting nerve impulses. Chloride is the main anion in the



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extracellular fluid [28]. In this scientific paper, we note that chlorine concentrations are elevated in different breeding regions, but they are roughly equal in all regions of Eloued. Increased chlorine concentrations in the body can cause severe irritation of the nose and throat, serious lung damage, and potentially life-threatening fluid accumulation in the lungs (pulmonary edema). Symptoms may include coughing, shortness of breath, respiratory difficulties, and chest tightness [29]. The chlorine content in cow's milk is 1g/L [30], but in goat's milk, it is between 0.2 -0.25 g/L. The sulfate ion SO_4 is a polyatomic ion, consisting of 1 sulfur atom and 4 oxygen atoms. Sulfates can form during the decomposition of plant and animal matter, but they can also be formed as by-products of textile, mining, steel, and petroleum industries. Sulfates can also appear as manufactured ingredients used for cleaning and personal care [22]. We note that the average concentration of sulfate in various regions is not equal, which may be linked to differences in sulfate percentage in the El Oued regions. The sulfate content in cow's milk is 0.35 g/L [30], but sulfate content in goat's milk to be between 0.2 -1.8 g/L. Sodium is the chemical element with atomic number 11, symbol Na (from the Latin natrium). On Earth and in other terrestrial bodies, it is generally bound to other elements within numerous minerals, with a silvery color. Highly reactive, it oxidizes rapidly in contact with air and reacts violently with water [31]. Hence, we say that the averages of sodium in different regions are not equal. For mineral salts (sodium), the content in cow's milk is 0.5 g/L [30]. In comparison, our study found the sodium content in goat's milk to be between 0.04-0.2 g/L.

Conclusion

The change in the proportions and concentrations of minerals in the milk of goats grazing in different regions confirms the effect of air and water pollution and changes in the type of food on the mineral components of milk, which affect human health.

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