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Physicochemical Analysis of Ruminant Drinking Water Quality in Some Farms in the Karaman, Kayseri, Konya, and Niğde Region

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ABSTRACT

This study, physicochemical parameters of 40 ruminant animal (large and small ruminants) drinking water samples collected from semi-open barns and pens in Karaman, Kayseri, Konya, and Niğde provinces in Turkey were evaluated. Temperature values varied between 16.85°C and 23.03°C, and while the lowest averages in Konya (18.94°C) probably originated from seasonal or groundwater-sourced coolness, the highest value in Niğde small ruminants (23.03°C) reflected the thermal exposure of surface waters. pH levels ranged between 6.92-7.80, and the highest value in Niğde small ruminants (7.80 ± 0.20) indicated slightly alkaline conditions. The electrical conductivity parameter exhibited the most pronounced regional variation; while peak values were observed in Konya large ruminant (1222.31) and small ruminant (1298.87) samples, the lowest level in Niğde small ruminants (546.27) emphasized low mineral content. Dissolved oxygen (DO, mg/ppm) concentrations were distributed across a wide spectrum from 3.87 mg/ppm in Karaman small ruminants to 19.34 mg/ppm in Niğde small ruminants; while high values in Niğde (15.86–19.34 mg/ppm) indicated good oxygenation, low levels in Karaman (3.87–4.51 mg/ppm) and values in Kayseri small ruminants (4.50 mg/ppm) fell below the recommended minimum of 5.0 mg/ppm, indicating contamination or stagnant water risks. Salinity rates varied from 0.15 ppt in Konya small ruminants to 1.13 ppt in Konya large ruminants, with the latter reflecting salt accumulation associated with intensive evaporation and evaporite dissolution under arid conditions. Total dissolved solids values followed similar trends, reaching maximum in Konya (582.54 ppm) and revealing geological-hydrological mineral richness, while the minimum in Niğde small ruminants (399.04 ppm) emphasized the relative purity of water. Most parameters were within acceptable ranges for ruminant health, and rumen acidosis, alkalosis, hypovolemia, or decrease in feed/water consumption are not expected. Physical oxygenation methods should be preferentially employed for low dissolved oxygen (DO) levels in Karaman and Kayseri provinces.

Karaman, Kayseri, Konya ve Niğde Bölgesindeki Bazı Çiftliklerde Ruminant Hayvanların İçme Suyu Kalitesinin Fizikokimyasal Analizi

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Bu çalışmada, Türkiye'de Karaman, Kayseri, Konya ve Niğde illerindeki yarı açık ahır ve ağıllardan toplanan 40 ruminant hayvan (büyük ve küçükbaş) içme suyu numunesinin fizikokimyasal parametreleri değerlendirilmiştir. Sıcaklık değerleri 16,85°C ile 23,03°C arasında değişmekte olup, Konya'daki en düşük ortalamalar (18,94°C) muhtemelen mevsimsel veya yeraltı su kaynaklı serinlikten kaynaklanırken, Niğde küçükbaş ruminantlardaki en yüksek değer (23,03) yüzey sularının termal maruziyetini yansıtmaktadır. pH seviyeleri 6,92-7,80 arasında olup, Niğde küçükbaş ruminantlardaki en yüksek değer (7,80) hafif alkali koşulları işaret etmektedir. Elektriksel iletkenlik parametresi en belirgin bölgesel varyasyonu sergilemekte; Konya büyükbaş (1222,31) ve küçükbaş (1298,87) numunelerinde zirve değerler gözlenirken, Niğde küçükbaş ruminantlardaki en düşük seviye (546,27) düşük mineral içeriğini vurgulamaktadır. Çözünmüş oksijen konsantrasyonları Karaman küçükbaş ruminantlardaki 3,87 mg/L'den Niğde küçükbaş ruminantlardaki 19,34 mg/L'ye kadar geniş bir yelpazede dağılmakta; Niğde'deki yüksek değerler (15,86–19,34 mg/L) iyi oksijenasyonu belirtirken, Karaman'daki düşük seviyeler (3,87–4,51 mg/L) ve Kayseri küçükbaş ruminantlardaki (4,50 mg/L) değerler önerilen minimum 5,0 mg/L'nin altında kalarak kontaminasyon veya durgun su risklerini işaret etmektedir. Tuzluluk oranları Konya küçükbaş ruminantlardaki 0,15 ppt'den Konya büyükbaş ruminantlardaki 1,13 ppt'ye kadar değişmekte olup, ikincisi kurak koşullardaki yoğun buharlaşma ve evaporit çözünmesiyle ilişkili tuz birikimini yansıtmaktadır. Toplam çözünmüş katı madde değerleri benzer eğilimler izleyerek Konya'da maksimuma (582,54 ppm) ulaşmakta ve jeolojik-hidrolojik mineral zenginliğini ortaya koyarken, Niğde küçükbaş ruminantlardaki minimum (399,04 ppm) suyun görece saflığını vurgulamaktadır. Çoğu parametre ruminant sağlığı açısından kabul edilebilir aralıklarda yer almakta olup, rumen asidozu, alkaloz, hipovolemi veya yem/su tüketiminde azalma beklenmemektedir. Karaman ve Kayseri illerindeki düşük çözünmüş oksijen (DO) seviyeleri için fiziksel oksijenasyon yöntemleri öncelikle tercih edilmelidir.

Introduction

The livestock sector, as one of the cornerstones of global food security and economic stability, provides high-quality protein sources such as meat, milk, and eggs (Thornton, 2010). In this context, the efficient and healthy maintenance of ruminant animals brings the indispensable role of water to the forefront. Water functions as a vital component in ruminants in terms of body temperature regulation, digestion and metabolism processes, milk synthesis, elimination of metabolic wastes, osmotic balance, reproductive performance, and overall health (Breede, 2006; Cemek et al., 2011; Golher et al., 2021). Indeed, the change of total body water at a rate of 56-81% depending on the lactation stage emphasizes the physiological necessity of water and highlights the adverse effects of its deficiency on productivity (Breede, 2006).

Water consumption in ruminants is influenced by direct and indirect factors. Direct factors encompass breed, body size, age, physiological conditions such as lactation or pregnancy, health status, stress levels, and environmental elements such as air temperature, humidity, wind speed, precipitation, and seasonal changes, while indirect factors include rearing system, feed composition (salt and dry matter ratio), housing conditions (ventilation, shading), water accessibility (cleanliness and distance), and water quality (pH, mineral balance, microbial load) (Alkoyak, 2016; Golher et al., 2021). Contaminated or limited-access water sources, in addition to reducing water consumption, directly lead to productivity losses, and the accumulation of water-soluble contaminants in animal tissues and milk can cause a decline in milk yield and quality, as well as an increase in disease prevalence (Alkoyak, 2016; Golher et al., 2021; Giri et al., 2020). The water requirement of ruminants is met from three primary sources, and the balanced distribution of these sources determines the efficiency of digestion and metabolic processes. These sources are classified as drinking water (approximately 80%), water content in feed, and metabolic water (NRC, 2001; Göncü et al., 2008; Yaylak and Yavuz, 2016).

Individual factors shaping water needs, particularly age and gender, stand out as primary determinants of consumption levels. Calves in the growth phase require higher water intake (70-97% from drinking water) compared to adults due to metabolic and digestive development needs; insufficient consumption can disrupt nutrient absorption, leading to 10-30% growth retardation (Xu et al., 2020; Williams et al., 2017; Kamal et al., 2024; Giger-Reverdin and Gihad, 1991). Similarly, female cattle consume more water than males due to their milk production-oriented physiology; the increase in water consumption during the lactation period supports metabolic processes, milk synthesis, and hormonal regulation, thereby enhancing milk quality with components such as protein, fat, and lactose (Golher, 2021; Singh et al., 2022; Lean et al., 2019; Correa-Calderón et al., 2022). Daily water consumption in adult dairy cows varies between 80-150 L; as milk yield increases, this amount can reach up to five times, and the sufficient intake of water, which constitutes 87% of milk composition, becomes mandatory for optimal production (Araújo et al., 2010; Can and Boğa, 2025). In addition, there is a positive correlation between water consumption and dry matter intake (DMI). Sufficient and clean water supports DMI by optimizing rumen microbial activity and cellulose digestion, while high-salt feeds increase water consumption (Mesgaran et al., 2020; Iritz et al., 2025). On the other hand, insufficient or low-quality water leading to slowdowns in rumen functions, hypovolemic conditions, and metabolic stress negatively affects nutrient absorption and overall performance by disrupting this correlation (Legesse et al., 2017; Wagner and Engle, 2021).

The effect of drinking water temperature on water consumption is related to environmental factors. In hot climates, cooled water (18.3°C) increases feed intake, live weight gain, and energy efficiency compared to warm water (32.2°C); in cold climates, water at 35-40°C positively affects consumption and rumen fermentation (Lofgreen et al., 1975; Golher et al., 2014; Liu et al., 2025). For this purpose, the ideal temperature of water should be adapted according to species and season. In general, these temperatures are recommended as 15-20°C in summer months and 20-25°C in winter months for cattle, 7-13°C for sheep, and around 15°C for goats (French, 1956; Petersen et al., 2016).

Water stress arising from insufficient intake or quality deteriorations triggers dehydration and adaptation disorders in ruminants. Hot/dry climates and contaminated sources lead to intake restrictions, thereby causing intestinal infections, rumen fermentation disruptions, and metabolic imbalances. Particularly at temperatures >30°C and TDS levels >4000 mg/L, resistance in cattle is limited compared to other ruminants, with observed behavioral restlessness (rapid respiration, loss of skin elasticity), immune suppression, and 10-20% productivity loss (milk and weight) (Koluman and Göncü, 2025; Shekhar et al., 2025; French, 1956; Attia-Ismail et al., 2008; Jaber et al., 2013; Wang et al., 2020; Correa-Calderón et al., 2022). In hot weather, strategies such as cooled water provision, automatic distribution, filtration (chlorination, ozonation, UV disinfection), hygiene controls, and integration of wet feeds should be implemented to minimize stress; these methods ensure productivity optimization and health protection through an integrated approach (Thompson-Crispi et al., 2014; Umar et al., 2014; Sundrum, 2020; Bilgili et al., 2025; Kamal et al., 2025).

The diversity of ruminant water sources, surface, groundwater, and artificial systems, supports these management strategies; parameters such as pH 6.5-8.5, TDS <3000 mg/L, and pathogens <100 CFU/mL are influenced by geological, climatic, and anthropogenic factors (Legesse et al., 2017; Khan, 2020; Refaey et al., 2025). Infrastructure optimization (automatic systems, trough maintenance) increases consumption, while contaminated troughs can cause intake declines and health risks (Araújo et al., 2010; Jaber et al., 2013; Wang et al., 2020). Water pollution (heavy metals, pesticides, nitrate/phosphate leaching) disrupts the physicochemical structure; bioremediation techniques (phytoremediation, mycoremediation) minimize toxins, thereby preserving rumen microbial balance and reinforcing sustainability (Withers and Haygarth, 2007; Rawls et al., 2003; Sönmez and Kılıç, 2021; Münzel et al., 2023; Haq et al., 2020; Puls, 1998; De Rond and van Willigen, 2012; Stettler et al., 2025).

The measurement and monitoring of water quality constitute an indispensable part of a holistic approach in ruminant farming. Water quality measurement is conducted through microbiological (E. coli, algal proliferation), chemical (pH, nitrate, hardness), and physical (color, turbidity) analyses. The standard values of water quality parameters in ruminant animals and their exceedance effects are summarized in Table 1.

This study incorporates an original approach by evaluating the physicochemical parameters (temperature, pH, EC, DO, salinity, TDS) of ruminant drinking waters in the Central Anatolia Region for the first time with an integrated approach and comparatively across four provinces (Karaman, Kayseri, Konya, Niğde). Studies on ruminant water in the literature (Higgins et al., 2008; Yaylak and Yavuz, 2016), which typically focus on a single parameter or rely on global data, are contrasted by this research, which addresses the gap in water quality in Turkish livestock by illuminating regional geological/hydrological variations (high CON in Konya). This contribution paves the way for developing sustainability models based on policy and farmer practices.

Table 1. Water quality parameters in ruminant animals
Tablo 1. Ruminant hayvanlarda su kalite parametreleri

Parameter	Appropriate Value	Effects When Value is Exceeded	Reference
pH	6.5 - 8.5	Low pH (<6.0): Decrease in feed consumption, decrease in rumen pH, acidosis risk	NRC, 2001 Stephen et al., 2008
EC, µS/cm	< 3,000	High CON (>10,000): Decrease in water and feed consumption, mild diarrhea, performance decline (growth/milk yield), adaptation difficulty, health problems	Bagley et al., 1997
DO, mg/ppm	> 5.0 (recommended minimum for surface waters)	Low DO (<5mg/ppm): Bad taste/odor, organic pollution (algal growth, pathogen risk), indirectly reduces water consumption Direct toxic effect rare in ruminants, but disrupts overall water quality	USDA, 2009
TDS, ppm	< 3,000	High TDS (>5,000): Decrease in water/feed consumption, diarrhea, decline in growth/milk yield, health problems	NRC, 2001 USDA, 2009
Salinity, ppt	< 3.0 (ideal <1.0)	High salinity (3.0-5.0 ppt): Mild diarrhea, decrease in water/feed consumption, decline in milk yield, mineral imbalances >5.0 ppt: Severe performance loss, health problems (diarrhea, weight loss)	NRC, 2001 Stephen et al., 2008

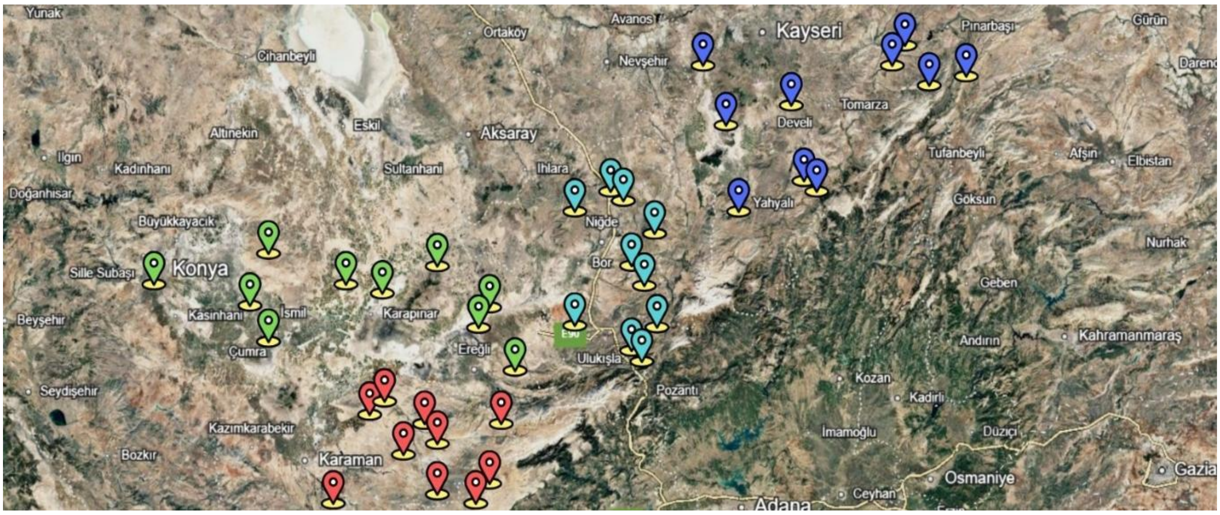
[1]EC: Electrical Conductivity, DO: Dissolved Oxygen, TDS: Total Dissolved Solids.

Materials and Methods

Material

Research Design and Sampling Plan

This study is planned according to a descriptive cross-sectional research design, aiming to evaluate the current status of water quality in ruminant livestock operations located in the provinces of Karaman, Kayseri, Konya, and Niğde in the Central Anatolia Region. In sample selection, random sampling method (random sampling) was used, and equal number of samples were taken from each province to ensure regional representativeness. The determination of sample size targeted a total of 40 samples, with 10 samples from each province; this number was determined by considering the statistical power analyses in similar studies and the adequacy to reflect regional variation (Figure 1). The study included commercial operations with a minimum capacity of 20 heads for large ruminants, minimum 50 heads for small ruminants, applying semi-open housing systems, having regular veterinary follow-up and record-keeping systems, and accepting voluntary participation. Equal numbers of large ruminant and small ruminant operations were selected from each province, aiming for a balanced evaluation of inter-species and regional differences. During the field examinations conducted, it was observed that all operations included in the sampling scope used mains water for water supply. The sampling work was systematically carried out within July 2025 (between July 1-31, 2025) to represent the high temperature and water consumption conditions of the summer period.



Map 1. Locations of ruminant animal farms evaluated within the scope of the research from these farms on the map

Harita 1. Araştırma kapsamında değerlendirilen ruminant hayvan çiftliklerinin harita üzerindeki konumları

Method

Sample collection protocol

Water samples were collected in accordance with standard sampling protocols (TS EN ISO 5667-6:2016). Prior to the sampling process, the daily usage pattern of the trough systems was observed, and representative samples were taken from the water storage tank or trough, taking into account the animals' water consumption times. During sampling, the temperature of the water to be sampled was first measured in situ using a digital thermometer and recorded, and then 0.5 L capacity polyethylene terephthalate (PET) bottles that had undergone sterilization were used. The bottles were rinsed three times with the water to be sampled before sampling, and then immersed head-down at a 45° angle approximately 30 cm below the water surface to prevent air bubble formation. During sample collection, sterile gloves were used to prevent possible contamination, and contact of the bottle mouths with any surface was prevented. After the filling process was completed, the bottles were completely filled without leaving air space and their caps were immediately closed with airtightness ensured. Labels containing the operation code, sampling date, time, location information, and animal type (large ruminant/small ruminant) were affixed to each sample. The samples were transported while maintaining the cold chain (3±2°C) and were delivered to the laboratory of Ulukışla Vocational School at Niğde Ömer Halisdemir University within 24 hours after sampling. During transportation, the samples were stored in opaque, insulated cooler boxes to prevent light exposure, and upon arrival at the laboratory, they were immediately taken into the analysis process.

Laboratory analysis procedure

The samples delivered to the laboratory were brought to room temperature (20±2°C) before analysis and gently stirred to ensure homogenization. The AZ 86031 multi-parameter water quality measurement kit was used for the measurement of physicochemical parameters (pH, electrical conductivity, dissolved oxygen, salinity, and total dissolved solids). The device was calibrated with standard solutions (pH 4.01, 7.00, and 10.01 buffer solutions; 1413 µS/cm calibration standard) in accordance with the manufacturer's instructions before each analysis, and the accuracy of the calibration process was confirmed with control samples. During measurements, the device probes for each sample were washed with ultra-pure water and gently dried with filter paper to eliminate the risk of cross-contamination.

pH measurements were performed by completely immersing the glass electrode pH probe into the sample, waiting until the value stabilized (approximately 30-60 seconds). Electrical conductivity (EC, µS/cm) and total dissolved solids (TDS, ppm) measurements were conducted using a temperature-compensated conductivity probe, with measurements automatically normalized to a reference temperature of 25°C. Dissolved oxygen (DO, mg/L) concentration was measured after checking the cleanliness of the probe membrane beforehand and performing air calibration. Salinity (ppt) values were automatically calculated from the device's electrical conductivity data. Three replicate measurements were made for all parameters, the analysis data were entered immediately, and data integrity was ensured by the double-check method.

Quality assurance and quality control

Comprehensive quality assurance and quality control protocols were implemented to ensure the reliability of the process. On each analysis day, device performance was verified with control solutions prepared at known concentrations, and measurement accuracy was confirmed within a 95% confidence interval. For repeatability tests, 10% of randomly selected samples were analyzed in duplicate, and relative standard deviation (RSD) values were found to be below 5%. The laboratory personnel were trained in device use and sample processing, and all procedures were carried out in accordance with Standard Operating Procedures. All glassware and equipment used were washed with 10% nitric acid solution before each use and then rinsed with deionized water to minimize contamination risk.

Statistical analysis

Comparative analysis of ruminant animal drinking water quality parameters between provinces was conducted using one-way ANOVA test, and this test was determined according to the general significance level (* for $p<0.05$ and ** for $p<0.01$) based on parameters (temperature, pH, conductivity, dissolved oxygen, salinity, and total dissolved solids). Following ANOVA results, Tukey HSD test ($\alpha=0.05$) was applied for lettering to differentiate significant differences as post-hoc analysis.

Results and Discussion

Within the scope of this study, physicochemical parameters (pH, EC, TDS, and DO) of a total of 40 ruminant animal drinking water samples obtained from different farms in Niğde, Kayseri, Karaman, and Konya provinces were analyzed and are presented in Table 2.

Table 2. Ruminant drinking water quality of some farms in the central anatolia region
Tablo 2. İç Anadolu Bölgesi'ndeki bazı çiftliklerin ruminant içme suyu kalitesi

Province	Animal Type	Temperature °C	pH	CON, µS/cm	DO mg/ppm	Salinity ppt	TDS ppm
Karaman	Cattle	20.81± 0.12a**	6.99 ± 0.24a*	534.49 ± 3.09d**	4.51 ± 0.56d**	0.28 ± 0.17c**	468.54 ± 3.05c**
	Small Ruminants	21.35± 0.18b**	6.97 ± 0.17b**	699.12 ± 2.63c**	3.87 ± 0.72c**	0.34 ± 0.18a**	445.81 ± 3.99c**
Kayseri	Cattle	21.09± 0.18a**	6.92 ± 0.14a*	884.95 ± 2.73c**	6.55 ± 0.63c**	0.38 ± 0.21c**	466.03 ± 2.47c**
	Small Ruminants	21.20± 0.16b**	6.98 ± 0.16b**	820.00 ± 2.70b**	4.50 ± 0.70c**	0.35 ± 0.18a**	460.00 ± 3.60b**
Konya	Cattle	16.85± 0.23c**	7.08 ± 0.16a*	1222.31 ± 2.67a**	11.08 ± 0.89b**	1.13 ± 0.29a**	582.54 ± 2.80a**
	Small Ruminants	18.94± 0.13c**	6.96 ± 0.19b**	1298.87 ± 2.91a**	12.80 ± 0.89b**	0.15 ± 0.20a**	547.15 ± 2.52a**
Niğde	Cattle	18.81± 0.20b**	7.21 ± 0.21a*	1016.27 ± 3.92b**	15.86 ± 0.66a**	0.81 ± 0.21b**	556.87 ± 3.51b**
	Small Ruminants	23.03± 0.18a**	7.80 ± 0.20a**	546.27 ± 3.02d**	19.34 ± 0.73a**	0.59 ± 0.15a**	399.04 ± 3.26d**
p value		$1.34x10^{-35}$	$6.45x10^{-13}$	$8.97x10^{-68}$	$2.33x10^{-33}$	$1.27x10^{-12}$	$3.21x10^{-46}$
SE		0.06	0.06	0.94	0.23	0.06	1.01

[1]EC: Electrical Conductivity, DO: Dissolved Oxygen, TDS: Total Dissolved Solids, Means with different superscripts in the same column are statistically significantly different (** (p<0.01)), SE: Standard Error, ± Standard Deviation (SD).

Temperature values varied between 16.85-23.03°C, and while low values in Konya (up to 18.94°C) were probably due to seasonal or groundwater-sourced coolness, the high value in Niğde small ruminants (23.03 ± 0.18°C, p<0.01) reflected the thermal effects to which surface waters were exposed. pH levels ranged between 6.92 and 7.80, and the highest value in Niğde small ruminants (7.80 ± 0.20) indicated slightly alkaline conditions. The electrical conductivity (CON) parameter exhibited the most pronounced geographic variation; while the highest values were observed in Konya cattle (1222.31 ± 2.67 µS/cm) and small ruminant (1298.87 ± 2.91 µS/cm) samples, the low level in Niğde small ruminants (546.27 ± 3.02 µS/cm) indicated low mineral levels in water. Dissolved oxygen (DO) concentrations were distributed across a wide spectrum between 3.87 mg/ppm (Karaman small ruminants) and 19.34 mg/ppm (Niğde small ruminants); high values in Niğde (15.86-19.34 mg/ppm) indicated good oxygenation, whereas low levels in Karaman (3.87-4.51 mg/ppm) indicated potential contamination or stagnant water conditions. Salinity rates varied between 0.15 ppt (Konya small ruminants) and 1.13 ppt (Konya cattles), and this high level in Konya cattle husbandry reflected regional salt accumulation resulting from intensive evaporation processes prevailing in arid and semi-arid climate conditions combining with natural dissolution of evaporite deposits to increase the concentration of sodium chloride and other ions in groundwater. While high TDS concentrations recorded in Konya (582.54 ppm) revealed that the geological and hydraulic characteristics of the region reflected the dominance of mineral load, low levels in drinking water measured for small ruminants in Niğde (399.04 ppm) emphasized the relative purity of water and low ionic level.

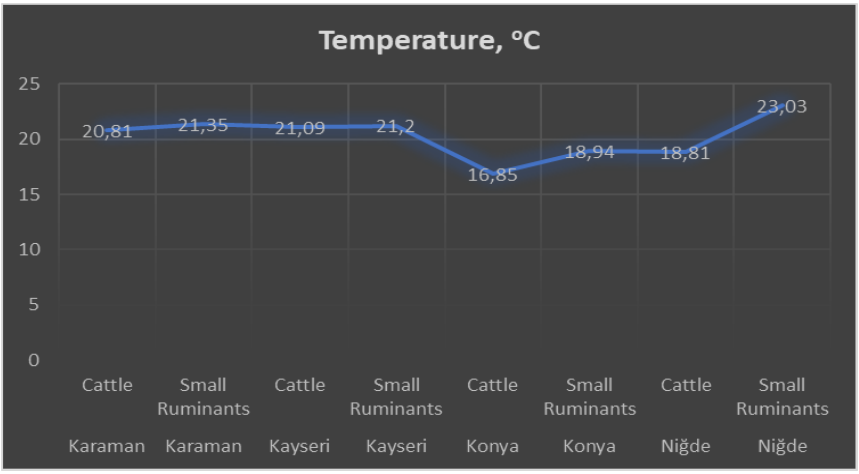


Figure 1. Drinking water temperature values of ruminant animals in the provinces of Karaman, Kayseri, Konya, and Niğde

Şekil 1. Karaman, Kayseri Konya ve Niğde illerinde ruminant hayvanların içme suyu sıcaklık değerleri

The temperature and pH values of drinking water are regarded as two complementary critical parameters for the sustainability of physiological functions in ruminant animals and the optimization of milk yield. Water temperatures in the provinces of Karaman, Kayseri, Konya, and Niğde in the Central Anatolian Region vary between 16.85°C and 23.03°C. These values demonstrate similarity with the 15–20°C range recommended by Golher et al. (2014) for maximum milk production, particularly in the data from Konya (16.85°C) and Niğde cattle (18.81°C). Higgins et al. (2008) ascertained that cattle prefer waters between 4.4°C and 18.3°C, whereas temperatures exceeding 27°C markedly reduce water and feed intake; in this regard, the values below the critical temperature threshold that suppresses intake, thereby situating them within a safe zone. Göncü et al. (2008) indicated that cows consume warm water between 17–28°C with greater appetite, and the approximate 21°C measurements in Karaman and Kayseri exhibit parallelism with this finding.

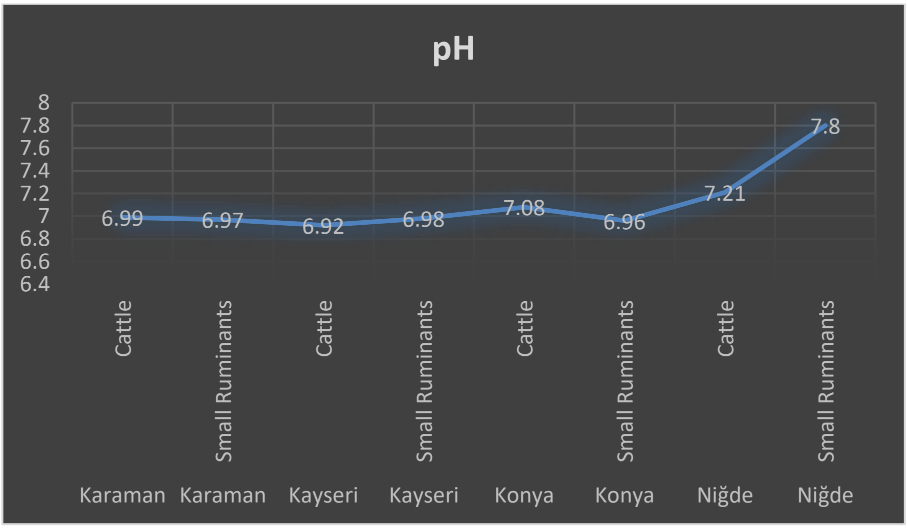


Figure 2. Drinking water ph values for ruminant animals in the provinces of Karaman, Kayseri, Konya, and Niğde

Şekil 2. Karaman, Kayseri Konya ve Niğde illerinde ruminant hayvanların içme suyu pH değerleri

The pH values of ruminant drinking water (6.92–7.80) in the provinces of Karaman, Kayseri, Konya, and Niğde in the Central Anatolian Region exhibit general conformity with the ideal limits in the literature. Yavuz (2021) deemed the 6.5–8.5 range acceptable for cattle, while ascertaining that values particularly below 6.5 and above 8.5 complicate consumption. All values in are within a safe zone in terms of animal welfare and water intake. Beede (1992) regarded the 6–9 range as generally acceptable, whereas Altunal (2010) drew attention to the potential deterioration of water taste and the reduction in mineral absorption such as calcium and magnesium when pH exceeds 8. The measured pH value of 7.80 for small ruminants in Niğde province exhibits a more alkaline character compared to the neutral values around 7 in the other provinces, thereby indicating the value closest to the critical threshold of 8 noted by Altunal (2010), which can lead to inappetence. Yaylak and Yavuz (2016) along with Görgülü (2018) indicated that pH descending below 6.0 or 5.1 may promote metabolic acidosis; even the lowest value, namely Kayseri cattle (6.92), remains well above this risk threshold. Considering the finding by Altunal (2010) regarding the advantage of slightly acidic waters in controlling pathogens such as Salmonella spp. and E. coli, it can be stated that the neutral and slightly alkaline values between 6.92 and 7.80 offer a weaker natural protection in terms of microbiological suppression compared to acidic waters. High pH levels can trigger the dissolution of certain chemical components from drainage systems, pipe networks, and various infrastructure elements into the water, thereby imparting a metallic taste and reducing animal water intake. Furthermore, the electrical conductivity level, which indicates minerals and the ionic salt content of water, when present at high levels, can cause hypovolemia, pave the way for gastrointestinal pathologies, and lead to declines in feed intake. Similarly, in dairy cattle operations located in Niğde province, animal drinking waters have generally been found within suitable ranges (electrical conductivity 803 µS/cm and pH 7.27–8.20) (Can and Boğa, 2025).

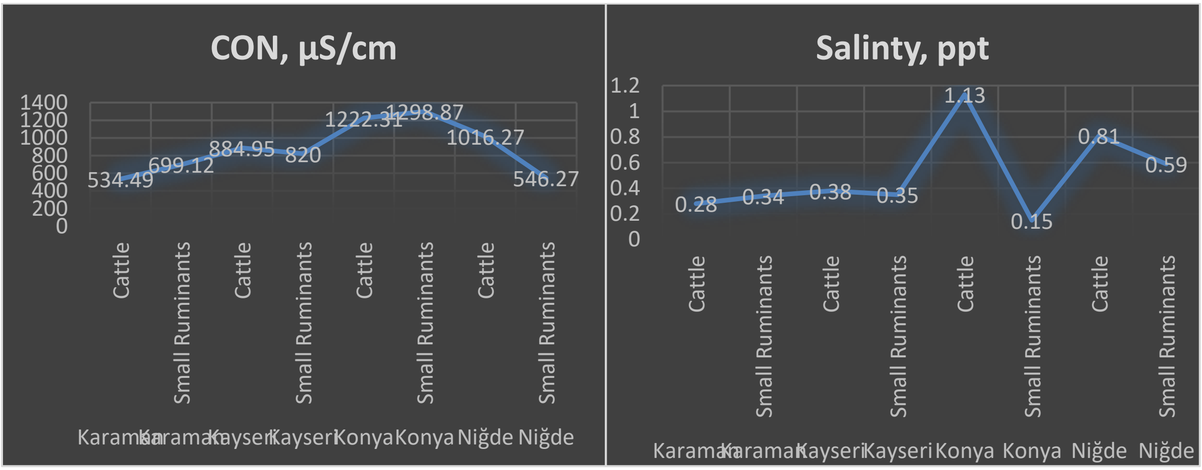


Figure 3. Drinking water electrical conductivity (CON) and salinty values for ruminant animals in the provinces of Karaman, Kayseri, Konya, and Niğde

Şekil 3. Karaman, Kayseri Konya ve Niğde illerinde ruminant hayvanların içme suyu elektriksel iletkenlik ve tuzluluk değerleri

In ruminant husbandry, the electrical conductivity (EC) of drinking water constitutes a fundamental physicochemical parameter that reflects the total amount of dissolved ions in the water and, consequently, indirectly the salinity level (Higgins et al., 2008). The measured CON values in the provinces of the Central Anatolian Region are observed to range between 534.49 µS/cm (Karaman cattle) and 1298.87 µS/cm (Konya small ruminants). Masslab (2025) considers the 250–500 µS/cm range ideal for drinking waters, whereas it is established in the academic literature that these limits can be tolerated by ruminants over a much wider scale. According to the MRCC (2013), waters between 0–800 µS/cm are of excellent quality for all farm animals, while the 800–2500 µS/cm range is also deemed "safe"; in this context, the data from Karaman and Niğde small ruminants (546.27 µS/cm) fall into the first category, whereas the data from Kayseri and Konya fall into the second category. Even the highest value in Konya province, namely 1298.87 µS/cm, remains well below this critical threshold, thereby indicating that it poses no risk to animal health and productivity (NRC, 2001). Higgins et al. (2008) along with Göncü et al. (2008) indicate that excessive salinity can restrict feed intake and suppress growth rates, and it is observed that the current values lie within the physiological adaptation limits of cattle and fall far below the thresholds that would cause productivity losses.

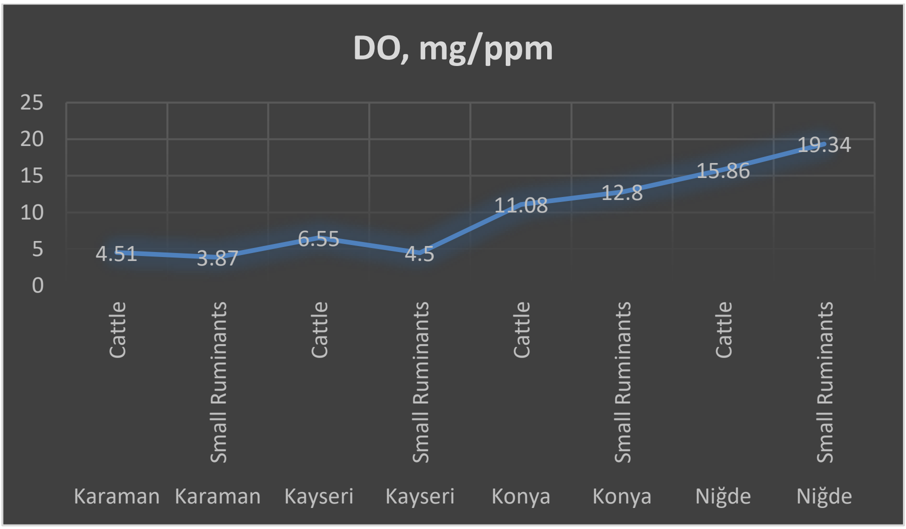


Figure 4. Drinking water dissolved oxygen (DO) values for ruminant animals in the provinces of Karaman, Kayseri, Konya, and Niğde

Şekil 4. Karaman, Kayseri Konya ve Niğde illerinde ruminant hayvanların içme suyu çözünmüş oksijen değerleri

The dissolved oxygen (DO) level in the drinking water quality of ruminants is regarded as a fundamental parameter concerning the biological stability, freshness, and life-sustaining quality of water for the animal organism (Görgülü, 2018). Examination of the dissolved oxygen values obtained from the provinces in the Central Anatolian Region reveals that the data exhibit a considerable variation between 3.87 mg/ppm (Karaman small ruminants) and 19.34 mg/ppm (Niğde small ruminants). The data from Karaman (3.87–4.51 mg/ppm) and Kayseri small ruminants (4.50 mg/ppm) indicate lower oxygen levels compared to the other provinces in the region. The high DO levels ascertained in Konya (11.08–12.80 mg/ppm) and particularly in Niğde (15.86–19.34 mg/ppm) demonstrate that the water sources are highly aerated and possess a fresher biological quality. Yaylak and Yavuz (2016) along with Higgins et al. (2008) emphasized that dissolved oxygen exerts a positive effect on the taste and drinkability of water, and that high-oxygen waters support the cattle's water drinking rates, which can reach 4 to 20 liters per minute, as well as their general appetite (Higgins et al., 2008; Yaylak and Yavuz, 2016). Considering the risk of inappetence and digestive disorders that may be observed in animals in the event of consumption of low-oxygen waters, it is concluded that the drinking waters in the Niğde and Konya regions are closer to the ideal standards anticipated in the literature for meeting the physiological needs of high-yielding ruminants compared to those in Karaman and Kayseri (Görgülü, 2018; Yaylak and Yavuz, 2016).

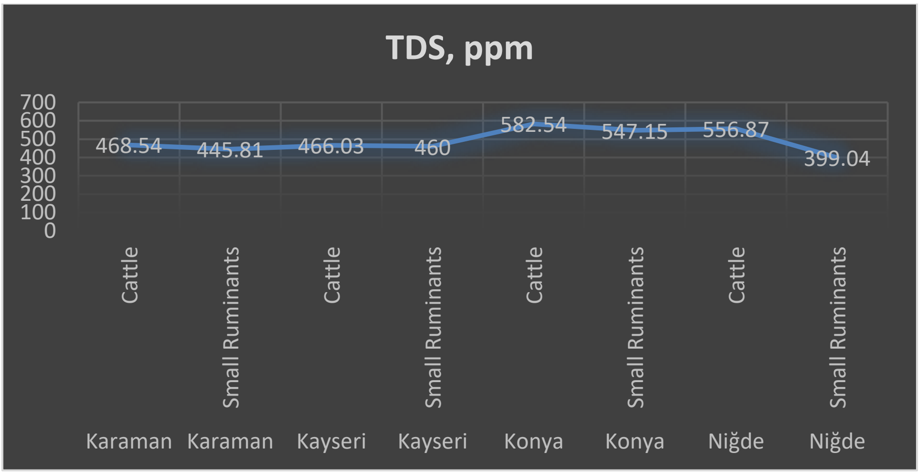


Figure 5. Drinking water total dissolved solids values (TDS) values for ruminant animals in the provinces of Karaman, Kayseri, Konya, and Niğde

Şekil 5. Karaman, Kayseri Konya ve Niğde illerinde ruminant hayvanların içme suyu çözünmüş katı madde değerleri

One of the most fundamental parameters determining the drinking water quality of ruminants, the amount of dissolved solids in water (TDS), constitutes a critical indicator reflecting the total mineral content of the water and, indirectly, the salinity level (Higgins et al., 2008). The measured TDS values in the provinces of the Central Anatolian Region are observed to range between 399.04 ppm (Niğde small ruminants) and 582.54 ppm (Konya cattle), and all of these values are situated within the safe and excellent quality limits below 1,000 ppm (Yaylak and Yavuz, 2016). Beede (2012) indicated that TDS values below 1,000 mg/L (ppm) for ruminants do not lead to any health issues; in this regard, it has been ascertained that even the highest value in the region, namely the Konya cattle data (582.54 ppm), remains considerably distant from the 3,000 ppm threshold that would disturb the animal's physiological balance or constrain water intake.

Conclusion

In this study, the physicochemical parameters of 40 ruminant drinking water samples collected from semi-open barns and pens in the provinces of Karaman, Kayseri, Konya, and Niğde were examined, with temperature values ranging between 16.85°C and 23.03°C, pH levels between 6.92 and 7.80, electrical conductivity (EC) between 546.27 µS/cm and 1298.87 µS/cm, dissolved oxygen (DO) concentrations between 3.87 mg/L and 19.34 mg/L, salinity ratios between 0.15 ppt and 1.13 ppt, and total dissolved solids (TDS) values between 399.04 ppm and 582.54 ppm. It is observed that these parameters generally remain within acceptable limits for ruminant health, whereas the low DO levels in Karaman and Kayseri (3.87–4.51 mg/L) along with the high CON (1222.31–1298.87 µS/cm) and salinity (1.13 ppt) values in

Konya may constitute potential risk factors reflecting regional geological and hydrological variations. Low DO indicates stagnant water conditions that increase the risk of microbial degradation, while high CON and salinity trigger mineral accumulation, thereby suppressing feed intake by 5–10% in the long term. Strengthening water quality monitoring programs in the Central Anatolian Region is recommended, whereby sustainable management of regional water resources can be ensured through annual mandatory physicochemical analyses and incentives for treatment infrastructure for sources below the DO <5 mg/L threshold (50% subsidized UV oxygenation systems). In parallel, individual animal farms should develop practical protocols to optimize water intake by modeling advantageous sources such as the high DO (15.86–19.34 mg/L) in Niğde, incorporating weekly physical oxygenation methods in Karaman and Kayseri operations and simple filtration filters (cost <500 TL) upon detection of CON >1000 µS/cm. In light of these findings, periodic laboratory controls of water quality in ruminant husbandry operations should be rendered mandatory, with low-cost interventions such as filtration or oxygenation rapidly implemented for detected deviations; concurrently, field-based experimental research elucidating the interactions between ruminant drinking water parameters and trough hygiene in Turkey should be encouraged, and training modules developed from the obtained data to disseminate productivity-focused awareness programs among farmers.

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