Journal of Animal Science and Products (JASP)
International peer-reviewed journal

6 (2): 123-136, 2023

Comparison of Blood Mineral Levels of Norduz Goats of Different Ages Fed on Pasture at the End of the Lactation Period

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ARTICLE INFO

Research Article

This study was presented as a poster with the same name at 3nd International Congress of Engineering and Natural Sciences Studies, 24-25 May 2023, Ankara/Türkiye

Received : 22.08.2023
Accepted : 14.09.2023

Keywords

Norduz goat
Blood mineral
ICP-OES
Reference values

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ABSTRACT

This study was carried out to determine some makro and micro mineral levels in the blood of a total of 26 Norduz goats (at the end of 1st lactation (n=10), at the end of 2nd lactation (n=8), at the end of 3rd lactation (n=8)) fed in pasture at Van Yuzuncu Yil University, Research and Application Farm (Van, Turkiye). For this purpose, blood samples were duly taken from goats that had completed the lactation period at the beginning of June. Some macro mineral's levels (potassium (K), magnesium (Mg), calcium (Ca), sodium (Na)) and some micro mineral's levels (cobalt (Co), copper (Cu), iron (Fe), nickel (Ni), manganese (Mn), selenium (Se), zinc (Zn), lead (Pb)) in samples of serum obtained from blood samples collected from goats were determined by inductively coupled plasma optical emission spectrometry (ICP-OES). Results were subjected to all statistical analysis using SPSS 24.0 version (IBM SPSS Inc, Chicago, USA) (SPSS, 2016). All statistically significant differences ($P<0.05$) were compared and ranked with Duncan's Multiple Range Test. Later, the relationships between minerals were revealed by Pearson Correlation Coefficient ($P\leq0.05$). In addition, in this study, the ranking of macro and micro minerals and the rates of some of these minerals (Ca/Mn, Ca/Mg, Ca/Zn, Cu/Fe, Cu/Zn, Fe/Mn, Fe/Zn, K/Mg, K/Na, K/Mn) were also presented.

Laktasyon Döneminin Sonunda Merada Beslenen Farklı Yaşlardaki Norduz Keçilerinin Kan Mineral Seviyelerinin Karşılaştırılması

MAKALE BİLGİSİ

Araştırma Makalesi

Bu çalışma, 3. Uluslararası Mühendislik ve Doğa Bilimleri Çalışmaları Kongresinde poster olarak sunulmuştur. 24-25 Mayıs 2023, Ankara/Türkiye.

Geliş: 22.08.2023
Kabul: 14.09.2023

ÖZ

Bu çalışma Van Yüzüncü Yıl Üniversitesi Araştırma ve Uygulama Çiftliği'nde (Van, Türkiye) merada beslenen toplam 26 Norduz keçisinin (1. laktasyon sonunda (n=10), 2. laktasyon sonunda (n=8) ve 3. laktasyon sonunda (n=8)) kanındaki bazı makro ve mikro mineral düzeylerinin belirlenmesi amacıyla yapıldı. Bu amaçla Haziran ayı başında laktasyon dönemini tamamlamış keçilerden usulüne uygun olarak kan örnekleri alındı. Keçilerden toplanan kan örneklerinden elde edilen bazı makro minerallerin düzeyleri (potasyum (K), magnezyum (Mg), kalsiyum (Ca), sodyum (Na)) ve bazı mikro minerallerin düzeyleri (cobalt (Co), bakır (Cu), demir (Fe), nikel (Ni), manganez

Lütfen aşağıdaki şekilde atıf yapınız / Please cite this paper as following;
Demir, A.Ö., Akkol, S., 2023. Comparison of blood mineral levels of Norduz Goats of different ages fed on pasture at the end of the lactation period, Journal of Animal Science and Products (JASP) 6 (2):123-136. DOI: 10.51970/jasp.1347793

Anahtar Kelimeler

Norduz keçisi
Kan minerali
ICP-OES
Referans değerler

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(Mn), selenyum (Se), çinko (Zn), kurşun (Pb),) keçilerden toplanan kan örneklerinden elde edilen serum örnekleri endüktif olarak eşleşmiş plazma optik emisyon spektrometresi (ICP-OES) ile belirlendi. Sonuçlar SPSS 24.0 versiyonu (IBM SPSS Inc, Chicago, ABD) kullanılarak tüm istatistiksel analizlere tabi tutuldu (SPSS, 2016). İstatistiksel olarak anlamlı tüm farklılıklar ($P<0.05$) Duncan'ın Çoklu Aralık Testi ile karşılaştırıldı ve sıralandı. Daha sonra mineraller arasındaki ilişkiler Pearson Korelasyon Katsayısı ($P\leq0.05$) ile ortaya konuldu. Ayrıca bu çalışmada makro ve mikro minerallerin sıralaması ve bu minerallerden bazılarının oranları da (Ca/Mn, Ca/Mg, Ca/Zn, Cu/Fe, Cu/Zn, Fe/Mn, Fe/Zn, K/Mg, K/Na, K/Mn) sunuldu.

Introduction

Many of the minerals required in livestock (especially sheep, goat and cow) breeding are responsible for the healthy and regular functioning of the living organisms. Minerals greater than 100 ppm (parts per million) in healthy animal organisms are referred to as macro minerals, while minerals less than 100 ppm are classified as micro minerals (Anonymous, 2023a). On the other hand, those that are above 50 ppm (mg/kg) per kilogram of lean body weight are defined as macro minerals and those that are found in lower amounts are defined as microminerals. Macro minerals can be expressed as a percentage of the diet, while microminerals are expressed in ppm or sometimes ppb (parts per billion) (Anonymous, 2023b). The most well-known main 7 macro minerals (Na, K, Ca, Mg, S, P, Cl etc.) in the classification is always more than the micro minerals (Cu, Fe, Zn, Se, Mn, Fl, As, Br, Co, Cr, Li, Mo, Ni, Pb, Si, V, I etc…) are more. These minerals are in a certain amount in the body and are responsible for ensuring that the organism works in a balanced and healthy way like a machine. When the levels of minerals in the circulatory system of the organism and stored decrease; immune system, functions of enzymes, growth and fertility gradually decrease (Anonymous, 2020a). When there is a large decrease in mineral levels, clinical symptoms begin to appear. These clinical signs can sometimes reach the level that requires treatment.

Goats, which are the most used animals, especially in mountainous and unproductive lands, it comes to the forefront with the aspect of reducing the negative effects of animal husbandry on natural resources (Mutlukoca and Keskin, 2021). Also, all of analized minerals interaction of Norduz goats was presented in this study as described Jacobson et all. (1971).

Materials and Methods

26 Norduz goats, which were determined to be healthy in clinical examination that were regularly given antiparasitic drugs and vaccinated for prevent possible diseases that may occur, constituted the living material of this study. Goats that at the end of 1st lactation (n=10), at the end of 2nd lactation (n=8), at the end of 3rd lactation (n=8)) were breed at Van Yuzuncu Yil University, Small Ruminant Breeding Unit of Research and Application Farm lies on 38° 575’ North and 43° 287’ East coordinates (Van, Türkiye). The goats raised in the farm were taken to the pasture twice a day that in the morning and in the evening. These animals were not given any mineral supplementation before study.

In the first week of June, blood was duly taken from V. Jugularis from goats of different ages at the end of lactation. After that, all samples were transferred to spesific anticoagulant

tubes. All of the blood samples were centrifuged at 1500×g, 10 minutes in the room temperature (68 to 72°F / 20 to 22°C) at the Laboratuar of Animal Science. After than, serum samples transferred to Eppendorf tubes were stored at -22°C until analysis.

Dilutions of serum (1:10) with deionized water were performed as described for analysis in "standard conditions" (Harrington et al., 2014; Anonymous, 2020c). In this way, the dilution ratio provided the appropriate absorbance range required for analysis. ICP-OES (Device Brand: Thermo Scientific, Device Model: Flash 2000) is an analytical technique in which many elements are analyzed. This technique involves the excitation of the sample by the argon plasma, which is reached to a temperature of 10,000 K by electromagnetic induction, and the determination of the excited elements according to the specific wavelengths they emit. Plasma is obtained by electromagnetically stimulating argon gas with a radio frequency (RF) generator in induction windings. This happens when the hot plasma ionizes the incoming gas and the process continues continuously. Results were measured and presented as ppm.

The results of the minerals obtained from this study were subjected to statistical analysis using SPSS 24.0 version (IBM SPSS Inc, Chicago, USA) (SPSS, 2016). All statistically significant differences ($P<0.05$) were compared and ranked with Duncan's Multiple Range Test. Later, the relationships between minerals were revealed by Pearson Correlation Coefficient ($P\leq0.05$). In addition, in this study, the ranking of macro and micro minerals and the rates of some of these minerals (Ca/Mn, Ca/Mg, Ca/Zn, Cu/Fe, Cu/Zn, Fe/Mn, Fe/Zn, K/Mg, K/Na, K/Mn) were also presented. Minerals ranking of Norduz goats was made according to ppm levels (Patkowska-Sokola et al., 2009).

Results

In this presented study, minimum-maximum (min-max) and mean concentration ± standard error (x±Sx) of serum macro and micro mineral values belonging to Norduz goats that at the end of 1st, 2nd and 3rd lactation were presented in Table 1 and Table 2, respectively. According to these results, the blood mineral levels at the total group (∑) of Norduz goats were detected as K 177.323±6.386 ppm, Mg 14.497±0.815 ppm, Ca 40.306±2.263 ppm, Na 1879.850±57.810 ppm for makro minerals and Co 0.007±0.000 ppm, Cu 0.0674±0.0616 ppm, Fe 1.425±0.079 ppm, Ni 0.009±0.004 ppm, Mn 1.371±0.048 ppm, Se 0.759±0.028 ppm, Zn 0.632±0.033 ppm, Pb 0.016±0.001 ppm for micro minerals. A statistical significance (≤0.05) was determined between the three groups for K, a macro-mineral; a non-significant difference (>0.05) was found for Mg, Ca and Na.

Table 1. Serum macro minerals

Tablo 1. Serum makro mineraller

		At the end of 1st lactation	At the end of 2nd lactation	At the end of 3rd lactation	∑
K	N	10	8	8	26
	Min-Max	163.500-265.900	129.900-220.800	108.800-235.100	108.800-265.900
	X	196.550[a]	162.113[b]	168.500[ab]	177.323
	sX	8.739	9.105	12.548	6.386
	P		*		
Mg	N	10	8	8	26
	Min-Max	9.227-23.690	8.783-22.900	7.294-18.710	7.294-23.690
	X	15.495	15.505	12.243	14.497
	sX	1.247	1.578	1.297	0.815
	P		NS		
Ca	N	10	8	8	26
	Min-Max	25.440-66.170	22.040-53.700	20.830-50.140	20.830-66.170
	X	41.778	41.271	37.501	40.306
	sX	4.348	4.249	3.057	2.263
	P		NS		
Na	N	10	8	8	26
	Min-Max	1664.000-2624.000	1425.000-2320.000	1205.000-2051.000	1205.000-2634.000
	X	2040.600	1768.880	1789.880	1879.850
	sX	85.538	96.591	100.857	57.810
	P		NS		

NS: Non significant; *≤0.05; Letters of a, ab, b represent the Duncan order from uppercase to lowercase.

Table 2. Serum micro minerals

Tablo 2. Serum mikro mineraller

		At the end of 1st lactation	At the end of 2nd lactation	At the end of 3rd lactation	∑
Co	N	10	8	8	26
	Min-Max	0.005-0.010	0.004-0.010	0.004-0.010	0.004-0.010
	X	0.007	0.007	0.007	0.007
	sX	0.001	0.001	0.001	0.000
	P		NS		
Cu	N	9	8	8	25
	Min-Max	0.354-1.437	0.094-0.979	0.267-1.179	0.094-1.437
	X	0.639	0.595	0.791	0.674
	sX	0.113	0.105	0.101	0.616
	P		NS		
Fe	N	10	8	8	26
	Min-Max	1.053-2.559	0.546-2.123	0.982-1.728	0.546-2.559
	X	1.514	1.422	1.318	1.425
	sX	0.152	0.1570	0.097	0.079
	P		NS		
Ni	N	4	4	6	14
	Min-Max	0.003-0.054	0.001-0.008	0.002-0.017	0.001-0.054
	X	0.018	0.005	0.006	0.009
	sX	0.024	0.002	0.002	0.004
	P		NS		
Mn	N	10	8	8	26
	Min-Max	1.299-2.297	0.944-1.723	1.120-1.453	0.944-2.297
	X	1.502	1.299	1.280	1.371
	sX	0.091	0.081	0.045	0.048
	P		NS		
Se	N	10	8	8	26
	Min-Max	0.714-1.217	0.473-1.012	0.557-0.839	0.473-1.217
	X	0.835	0.694	0.729	0.759
	sX	0.045	0.057	0.033	0.028
	P		NS		
Zn	N	7	8	7	22
	Min-Max	0.377-0.773	0.452-0.862	0.524-0.924	0.038-0.924
	X	0.552	0.657	0.683	0.632
	sX	0.057	0.054	0.053	0.033
	P		NS		
Pb	N	10	6	8	24
	Min-Max	0.008-0.017	0.005-0.030	0.011-0.032	0.005-0.032
	X	0.013	0.020	0.018	0.016
	sX	0.001	0.003	0.003	0.001
	P		NS		

NS: Non significant

Correlation tables of blood macro and micro minerals of Norduz goats at the end of the 1st, 2nd and 3rd lactations were presented in Table 3, Table 4 and Table 5, respectively. In pearson correlation analysis of mineral levels of goats at the end of the 1st lactation, positive statistical significance (positive correlation) (≤0.05) were calculated between Ca-Cu, Ca-Mg, Ca-Mn, Ca-Se, Cu-Na, Mg-Na, Mg-Se, Na-Ni; positive high correlation was founded. statistical significance (≤0.01) were calculated between Ca-Na, Cu-Mg, Cu-Se, Fe-K, K-Mn, K-Na, K-Se, K-Na, K-Se, Mg-Mn, Mn-Na, Mn-Ni, Na-Se; positive very high statistical significance (≤0.001) were calculated between K-Mn, Mn-Se and negative high statistical significance (≤0.01) were calculated between Na-Zn. In pearson correlation analysis of mineral levels of goats at the end of the 2nd lactation, positive statistical significance (≤0.05) were calculated between Ca-Fe, Ca-Mg, Ca-Mn, Cu-Fe, Cu-K, Cu-Na, Cu-Se, Fe-Zn, Mg-Zn, Mn-Zn; positive high statistical significance (≤0.01) were calculated between Fe-K, Fe-Na, Fe-Se, K-Mn, K-Se, Na-Se; positive very high statistical significance (≤0.001) were calculated between Ca-Zn, Fe-Mn, K-Na, Mn-Se. In pearson correlation analysis of mineral levels of goats at the end of the 3rd lactation, positive statistical significance (≤0.05) were calculated between Ca-Mn, Ca-Na, Ca-Se, Fe-K, Fe-Na, Mg-Na, Na-Se, Pb-Zn; positive high statistical significance (≤0.01) were calculated between K-Na, Mn-Se. The other hand, correlation table of blood macro and micro minerals of all Norduz goats (∑) were presented in Table 6. In pearson corelation coefficient of mineral levels of at the end of the lactation, positive statistical significance (≤0.05) were calculated between Ca-Cu, Ca-K, Co-Mn, Cu-K, Cu-Mg, Cu-Ni, Mg-Ni, Mg-Se, Na-Ni; positive high statistical significance (≤0.01) were calculated between Ca-Fe, Co-Se, Cu-Mn, Cu-Na, Cu-Se, Fe-Mg, Fe-Ni, K-Mg, K-Ni, Mg-Na, Ni-Se, Pb-Zn; positive very high statistical significance (≤0.001) were calculated between Ca-Mg, Ca-Mn, Ca-Na, Ca-Se, Cu-Fe, Fe-K, Fe-Mn, Fe-Na, Fe-Se, K-Mn, K-Na, K-Se, Mg-Mn, Mn-Na, Mn-Ni, Mn-Se, Na-Se.

Table 3. Pearson Corelation Coefficients of mineral levels of goats at the end of the 1st lactation
Tablo 3. 1. Laktasyon sonundaki keçilerin mineral düzeylerinin Pearson Korelasyon Katsayıları

	Ca	Co	Cu	Fe	K	Mg	Mn	Na	Ni	Pb	Se	Zn
Ca	1.000 10	0.122 10	**0.664** 9	0.491 10	0.525 10	**0.732*** 10	**0.691*** 10	**0.814*** 10	0.7864	0.510 10	**0.681*** 10	-0.5657
Co		1.000 10	0.2619	0.080 10	-0.004 10	0.365 10	0.404 10	0.018 10	0.9384	-0.064 10	0.371 10	0.1927
Cu			1.0009	0.7749	0.7609	**0.807**** 9	**0.862**** 9	**0.708*** 9	0.9004	0.333 9	**0.838**** 9	0.2417
Fe				1.000 10	**0.788**** 10	0.508 10	**0.827**** 10	**0.745**** 10	0.9444	-0.091 10	**0.855**** 10	-0.3757
K					1.000 10	0.607 10	**0.859***** 10	**0.824**** 10	**0.973*** 4	0.332 10	**0.833**** 10	-0.3527
Mg						1.000 10	**0.778**** 10	**0.726*** 10	0.8464	0.557 10	**0.709*** 10	-0.0777
Mn							1.000 10	**0.852**** 10	**0.992**** 4	0.273 10	**0.986****** 10	-0.6707
Na								1.000 10	**0.956*** 4	0.304 10	**0.853**** 10	-**0.899**** 7
Ni									10004	0.443 4	0.9814	1.0002
Pb										1000 4	0.178 10	0.3917
Se											1.000 10	-0.7317
Zn												10007

*≤0.05 ** ≤0.01 ***≤0.001

Table 4. Pearson Corelation Coefficients of mineral levels of goats at the end of the 2nd lactation
Tablo 4. 2. Laktasyon sonundaki keçilerin mineral düzeylerinin Pearson Korelasyon Katsayıları

	Ca	Co	Cu	Fe	K	Mg	Mn	Na	Ni	Pb	Se	Zn
Ca	1.0008	0.2578	0.3998	**0.809**8	0.6298	**0.698**8	**0.778***8	0.6158	-0.0794	-0.1926	0.5728	**0.918****8
Co		1.0008	0.0938	0.4518	0.4988	-0.4108	0.6178	0.5748	0.5754	-0.6616	0.6498	0.1318
Cu			1.0008	**0.761**8	**0.737***8	0.3948	0.6568	**0.781***8	-0.2154	0.0976	**0.725***8	0.4458
Fe				1.0008	**0.861****8	0.5098	**0.964****8	**0.895****8	-0.3374	-0.3536	**0.909****8	**0.736***8
K					1.0008	0.3728	**0.882****8	**0.919*****8**	-0.4884	0.0226	**0.905****8	0.6958
Mg						1.0008	0.4088	0.2988	-0.3174	0.4896	0.2568	**0.781***8
Mn							1.0008	0.914008	-0.2054	-0.4526	**0.958*****8	**0.729***8
Na								1.0008	0.0674	-0.1646	**0.933*****8	0.5718
Ni									1.0004	-0.6753	-0.4244	-0.1214
Pb										1.0006	-0.4036	0.0386
Se											1.0008	0.5648
Zn												1.0008

*≤0.05 ** ≤0.01 ***≤0.001

Table 5. Pearson Corelation Coefficients of mineral levels of goats at the end of the 3rd lactation
Tablo 5. 3. Laktasyon sonundaki keçilerin mineral düzeylerinin pearson korelasyon katsayıları

	Ca	Co	Cu	Fe	K	Mg	Mn	Na	Ni	Pb	Se	Zn
Ca	1.000 8	0.308 8	0.530 8	0.282 8	0.3778	0.551 8	**0.770*** 8	**0.718*** 8	-0.0486	0.1868	**0.789*** 8	0.1147
Co		1.000 8	-0.317 8	-0.675 8	-0.5208	-0.312 8	0.3508	-0.1618	0.7286	0.4828	0.4818	0.4917
Cu			1.000 8	0.668 8	0.3088	0.667 8	0.6428	0.5938	-0.1596	-0.2238	0.4218	-0.3367
Fe				1.000 8	**0.800*** 8	0.691 8	0.2638	**0.739*** 8	-0.3786	-0.1508	0.2278	-0.4827
K					1.0008	0.665 8	0.1608	**0.825*** 8	-0.1776	0.1738	0.2628	-0.347
Mg						1.000 8	0.6688	**0.776*** 8	0.0976	0.0688	0.4848	0.2317
Mn							1.0008	0.6608	0.2376	0.3818	**0.904*** 8	0.3477
Na								1.0008	0.0266	0.3978	**0.735*** 8	0.1527
Ni									1.0006	0.5586	0.2266	0.7255
Pb										1.008	0.6278	**0.762*** 7
Se											1.0008	0.4607
Zn												1.0007

*≤0.05 ** ≤0.01 ***≤0.001

Table 6. Pearson Corelation Coefficients of mineral levels of all goats (∑) at the end of the lactation

Tablo 6. Laktasyon sonundaki tüm keçilerin (∑) mineral düzeylerinin Pearson Korelasyon Katsayıları

	Age	Ca	Co	Cu	Fe	K	Mg	Mn	Na	Ni	Pb	Se	Zn
Age	1.000 26	-0.152 26	-0.043 26	0.202 25	-0.203 26	**-0.382*** 26	-0.319 26	**-0.392*** 26	-0.373 26	-0.353 14	0.337 24	-0.328 26	0.350 22
Ca		1.000 26	0.196 26	**0.460*** 25	**0.576**** 26	**0.461*** 26	**0.679***** 26	**0.691***** 26	**0.674***** 26	0.516 14	0.168 24	**0.610***** 26	0.308 22
Co			1.000 26	0.059 25	0.064 26	0.027 26	-0.124 26	**0.440*** 26	0.019 26	0.508 14	-0.128 24	**0.505**** 26	0.228 22
Cu				1.000 25	**0.6445***** 25	**0.463*** 25	**0.466*** 25	**0.593**** 25	**0.561**** 25	**0.601*** 14	0.042 23	**0.596**** 25	0.243 22
Fe					1.000 26	**0.731***** 26	**0.552**** 26	**0.791***** 26	**0.752***** 26	**0.669**** 14	-0.158 24	**0.756***** 26	0.095 22
K						1.000 26	**0.511**** 26	**0.717***** 26	**0.875***** 26	**0.699**** 14	-0.068 24	**0.734***** 26	0.030 22
Mg							1.000 26	**0.604***** 26	**0.572**** 26	**0.467*** 14	0.232 24	**0.452*** 26	0.356 22
Mn								1.000 26	**0.831***** 26	**0.846***** 14	-0.126 24	**0.950***** 26	0.186 22
Na									1.000 26	**0.596*** 14	-0.035 24	**0.864***** 26	-0.064 22
Ni										1.000 14	-0.022 13	**0.744**** 14	0.390 11
Pb											1.000 24	-0.117 24	**0.549**** 20
Se												1.000 26	0.157 22
Zn													1000 22

*≤0.05 ** ≤0.01 ***≤0.001

The macro and micro minerals whose levels were determined for ranked from largest to smallest in Table 7. The order of the first 6 minerals (Na, K, Ca, Mg, Fe, Mn) was the same in all groups. For the other 6 minerals (Se, Zn, Cu, Pb, Ni, Co) there were differences in the ordering of the groups.

Table 7. Ranking of macro and micro minerals
Tablo 7. Makro ve mikro minerallerin sıralaması

	1	2	3	4	5	6	7	8	9	10	11	12
At the end of 1st lactation	Na	K	Ca	Mg	Fe	Mn	Se	Cu	Zn	Ni	Pb	Co
At the end of 2nd lactation	Na	K	Ca	Mg	Fe	Mn	Se	Zn	Cu	Pb	Co	Ni
At the end of 3rd lactation	Na	K	Ca	Mg	Fe	Mn	Cu	Zn	Se	Pb	Co	Ni
∑	Na	K	Ca	Mg	Fe	Mn	Se	Zn	Cu	Pb	Ni	Co

The proportional values of macro and micro minerals that had a proportional relationship with each other according to the literature (Jacobson et all., 1971) were presented in Table 8. The rates of macro and micro minerals were determined for Na/K, K/Mg, K/Mn, Ca/Mg, Ca/Mn, Ca/Zn, Fe/Mn, Fe/Zn, Fe/Cu, Cu/Zn.

Table 8. Rates of some macro and micro minerals
Tablo 8. Bazı makro ve mikro minerallerin oranları

	Na/K	K/Mg	K/Mn	Ca/Mg	Ca/Mn	Ca/Zn	Fe/Mn	Fe/Zn	Fe/Cu	Cu/Zn
At the end of 1st lactation	10.382	12.685	130.859	2.696	27.815	75.685	1.008	2.743	2.369	1.158
At the end of 2nd lactation	10.911	10.456	124.798	2.662	31.771	62.817	1.095	2.164	2.390	0.906
At the end of 3rd lactation	10.622	13.770	131.641	3.063	29.298	54.906	1.030	1.930	1.666	1.158
∑	10.601	12.232	129.338	2.780	29.399	63.775	1.039	2.255	2.114	1.066

Discussion and Conclusion

Goats are a species rich in racial diversity. Studies are being carried out on the blood biochemistry and mineral values of these breeds. However, there is still not enough literature available on the basis of race. For this reason, in many studies, the discussion section is made by taking into consideration the literature of different races.

According to the results of a study conducted by Altuğ et al (2013); Na and K levels in goats with chronic fluorosis were determined as 142.1±11.5 mEq/L and 5.30±0.55 mEq/L, respectively. In this study, measured Na and K levels (1879.850±57.810 ppm and 177.323±6.386 ppm) lower than the values reported by Altuğ et al., (2013).

In a study investigated mineral levels in Honamlı goats, Demir et al. (2020) determined serum Ca and Mg levels as 6.786±0.206 mg/dL and 2.161±0.05 mg/dL, respectively. An another study conducted by Altuğ et al., (2013) Ca and Mg levels of goats were determined as 8.85±0.58 mg/dL and 2.62±0.10 mg/dL, respectively. In a study in which they investigated the hematobiochemical values and mineral status of Chegu Pashmina goats, Katoch et al. (2020) reported that Ca and Mg levels were as 10.14±0.412 mg/dl and 3.50±0.14 mg/dl, respectively, In this study, measured Ca and Mg levels (40.306±2.263 ppm and 14.497±0.815 ppm) lower than the values reorted by Demir et al. (2020), Altuğ et al., (2013) and Katoch et al. (2020). On the other hand, Sovende et al. (2008) reported the blood mineral Ca level of Wad goats grazing in natural pastures as 5.39±0.21 mmol/L. However, the value reported by Sovende et al. (2008) was much lower than the Ca level of this study.

Yatoo et al. (2013) reported that blood Cu, Zn and Fe levels of goats were 0.548±0.094 mg/L, 0.864±0.211 mg/L and 1.548±0.173 mg/L, respectively. In addition, Fathy Nawito et al. (2015) reported Cu, Zn and Fe levels of non-pregnant goats raised in South Sinai, Egypt as 0.49±0.05 ppm, 4.65±0.24 ppm and 4.91±0.09 ppm, respectively. In a study conducted by Altuğ et al., (2013), blood Cu, Zn and Fe levels of animals in the control group was determined as 0.550±0.05 mg/L, 0.574±0.08 mg/L and 1.245±0.03 mg/L, respectively. In another study conducted by Demir et al., (2020) investigating serum mineral levels in Honamlı goats, mineral Fe level was determined as 110.706±2.510 µg/dL. The Fe level measured in this study (1.425±0.079 ppm) was close to the reported value by Yatoo et al. (2013), Altuğ et al., (2013) and Demir et al., (2020) but less than reported by Fathy Nawito et al. (2015).

At a study conducted by Altuğ et al., (2013) Mn and Ni were determined as 0.0186±0.02 mg/L and 0.166±0.01 mg/L, respectively. The Mn level measured in this study (1.371±0.048 ppm) was very higher than Altuğ et al., (2013)'s result. But, Ni level measured in this study (0.009±0.004 ppm) was very lower than Altuğ et al., (2013)'s result. The other hand, in a study from Katoch et al. (2020) Co level was determined as 0.18±0.01 ppm. The Co level measured in this study (0.007±0.000 ppm) was very lower than Katoch et al. (2020)'s result.

Pechová et al. (2015) reported the blood Se levels of newly weaned kids and 4-week-old kids as 141.0 ± 35.7 µg/L and 124.0 ± 29.1 µg/L, respectively. The other, as a result of a study conducted by Pavlata et al. (2011) the mean Se concentrations in the blood of the goats in the control group at the beginning of the study were reported as 109.6 ± 34.3 µg/L. The Se level measured in this study (0.759±0.028 ppm) was very higher than Pechová et al. (2015) and Pavlata et al. (2011)'s result.

Blood Pb levels were investigated in goats raised in areas close to primary pollution areas caused by Pb-Zn, an ecological pollutant (Swarup et al., 2006). As a result of the same research, the blood Pb average of the goats in the control group was 0.015±0.015 µg/ml; in goats raised in the vicinity of drinking water, which is thought to be contaminated due to contact with metal wastes, the mean Pb was reported as 0.373±0.093 µg/ml. In another study investigating high doses of Pb in the blood, the blood Pb levels of Red Sokoto goats freely grazing on open pastures in Zaria ranged from 0.26 mg/L to1.56 mg/L, while the mean Pb level

was reported as 0.89±0.43 mg/L. According to the results of the same study, it was reported that as Red Sokota goats were freely grazed in Zaria, the blood Pb level exceeds the permissible limit for health and therefore was not safe for human consumption (Ugumanim et al., 2015). In a study conducted by Altuğ et al., (2013) in goats with chronic fluorosis, blood Pb serum value of animals in the control group was determined as 0.109±0.03 mg/L. The Pb level measured in this study (0.016±0.001 ppm) was determined by Swarup et al. (2006) was close to the reported value. And Ugumanim et al. (2015) reported that it was below the permissible toxic limit for health. Therefore, blood Pb levels of Norduz goats in this study were within the limits specified in the relevant literature. But, the Pb results of this study were significantly lower than the value reported by Altuğ et al. (2013).

In the literature review, it was seen that the biochemical and hematological studies conducted in Norduz Goats were insufficient. However, the macro and micro mineral values of these animals are closely related to nutrition, reproduction and diseases. Especially during the lactation period, it is expected that the decreasing mineral stores will be renewed and the body will be ready for a new pregnancy in a healthy way after collecting itself. This is only possible if the reference values of healthy goats at the end of lactation are known. In this respect, it is thought that this study is very important in terms of being a reference for future studies. This study is thought to be important in terms of being a reference in determining the blood mineral levels of Norduz goats at the end of lactation. Moreover, as a result of this study, since the results of Mn, Ni and Co were highly different from the literature reports, it is thought that these minerals should be investigated more comprehensively in Norduz goats.

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