

Effects of age and sex on some hematological and biochemical parameters in Hair goats

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Abstract

This study was performed to determine the blood reference values of hematological and biochemical parameters in Hair goats at different ages. For this aim, clinically healthy Hair goats (n = 180, ages of six month and 1-3 years male and female) were used to collect blood samples. In whole blood, white blood cell (WBC), red blood cell (RBC), hemoglobin (HGB), hematocrit (HCT), mean corpuscular volume (MCV), mean corpuscular hemoglobin (MCH), mean corpuscular hemoglobin concentration (MCHC) and red cell distribution width (RDW) were evaluated. The levels of, albumin, total protein, globulin, glucose, total bilirubin, urea, creatinine, phosphorus, magnesium, calcium, aspartate aminotransferase (AST), alkaline phosphatase (ALP), gamma-glutamyl transferase (GGT), creatine kinase (CK), alanine aminotransferase (ALT) and iron levels were investigated in sera. Age and sex had no effect on the cell structures of blood. In the either sex (male or female), age had no effect. However, sex had a significant effect on the blood cell structures except for WBC, HGB, and HCT. Albumin, protein, calcium, AST, ALT, ALP and magnesium values were not different among groups. Both the age and sex of the goats had significant effects on blood levels of glucose, phosphorus, urea, cholesterol, creatinine, GGT, CK and total bilirubin. In conclusion, this was the first study reporting the hematologic and biochemical parameters in blood of the Hair goats. The results indicated that these parameters could show variations under physiological conditions due to age and gender.

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Introduction

The majority of goat population in Türkiye is the Hair goats and they are located all over the country except for the northern territories. They are adapted well to the various climate conditions and land types. These goats could also live in mountainous areas with very low rainfall throughout the year. They are reared in high altitude area villages near forests. They consume bushes, heathers, thorny plants, dry grass, and therefore, are very cost-effective animals.¹ The goat population in Türkiye is about 11 million which is almost 2.00% of the world goat population. The Hair goats in Türkiye are used for milk and meat production and they are mostly found in the mid and south regions of Türkiye throughout Mediterranean

and south Anatolian region along the Toros Mountains.¹ Blood is an easily monitored material to determine the health status of humans and also animals. It helps evaluate the physiological status or pathological cases through hematologic and biochemical parameters.^{2,3} Nutrition, climate, season of the year, age, gender and breed of the animals all have an effect on the physiological parameters of the blood. Furthermore, specific reference ranges of serum biochemical parameters must also be known for thorough evaluations. Reference values of certain parameters change among different age groups.⁴ Minerals are required for normal physiological functions of the body under normal conditions. Mineral levels in the tissues and body fluids demonstrate variations due to breeds, gender, age, season, pregnancy, lactation and health status.⁵

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It is important for the clinicians to diagnose diseases based on the physiological electrophoretic models of animals.⁶

Despite the fact that Hair goats consist the majority of goat population, there is no published information related to blood hematologic and biochemical parameters according to age and gender of these animals. One earlier study has reported the results in female goats in pre- and post-partum stages, but not evaluated age and gender effects.⁷ Therefore, this study was aimed to investigate blood parameters in purebred Hair goats focusing on age and gender differences. As the global warming is a serious issue for the earth, we believe that it is crucial to do research on goats which could easily adapt to various climate conditions and their physiological and genetic characters must be investigated thoroughly.

Materials and Methods

Animals. Female kids (n = 45), male kids (n = 45), non-pregnant does (n = 45) and buck Hair goats (n = 45) were used. The location of the animals used in this study was 38°34 N 34°24 E and 1,210 m above the sea level. The sample collection was done in October 2016. The goats were on pasture and the ambient temperature was 2.00 °C above the normal seasonal average for October. Permission for the study was received from the Dollvet A.Ş. Animal Experiments Local Ethics Committee (2014/79) before the experimental process.

Blood collection and evaluation procedures. In this study, blood samples were collected from animals in private enterprises located in Aksaray, Türkiye. Samplings were selected from healthy flocks under local veterinarian supervision. Clinically healthy female kids (n = 45), male kids (n = 45), non-pregnant does (n = 45) and buck Hair goats (n = 45) were used. Blood was collected from the jugular vein into vacuum tubes without any anticoagulants. Blood was allowed to coagulate and then centrifuged at 3,000 rpm for 10 min. Sera were collected into clean tubes and kept at - 40.00 °C until further analysis. Serum analysis was performed using commercial kits (Assel, Rome, Italy) in a spectrophotometer (Humalyzer 3000; Human GmbH, Wiesbaden, Germany). Hematological evaluations were performed on the freshly collected blood using hemocounter (BC2800 Vet; Mindray, Shenzhen, China) with commercial kits (Mindray).

Statistical analysis. Data were analyzed using SPSS Software (version 15.0; SPSS, Inc., Chicago, USA). Differences among the groups were analyzed by the student's *t*-test. Data were presented as mean ± SEM and $p < 0.05$ was considered as significant. Descriptive statistics were used for mean, SEM, minimum and maximum. For continuous variables, one-way ANOVA was used and group means were compared by Duncan multiple comparison tests.

Results

The white blood cells (WBC) counts were numerically higher in bucks compared to male kids but were not statistically significant. The red blood cells (RBC) counts were the highest in the male kids and the female kids had statistically higher RBC compared to the does ($p < 0.05$). Although hemoglobin values were higher in the kids, hematocrit was greater in the matured goats, however, it was not significant. The mean corpuscular volume (MCV) and mean corpuscular hemoglobin (MCH) were higher in females compared to males ($p < 0.05$). The hemoglobin concentrations (MCHC) and red blood cell distribution width (RDW) were greater in the males ($p < 0.05$). The evaluated hematologic parameters are summarized in Table 1.

Blood albumin levels were found to be higher numerically in females. Total protein levels were the greatest in the bucks, and the females tended to have more blood protein than the kids. Globulin levels were insignificantly higher in the males compared to the females. In general, blood glucose levels were higher in the males, however, the does had the lowest glucose levels ($p < 0.05$). Both the matured and male young kids had greater phosphor levels and the bucks had more phosphorus than the does ($p < 0.05$). Calcium and magnesium levels were similar in all age and gender groups. The aspartate aminotransferase (AST) levels tended to be higher in the kids compared to matured goats. The alkaline phosphatase (ALP) levels did not differ. Measured alanine aminotransferase (ALT) levels did not show any significant differences although there were some numerical differences among the groups (Table 2). The gamma-glutamyl transferase (GGT) levels were found to be higher in the males. The male kids had the highest GGT levels whereas the female kids had the lowest amount ($p < 0.05$). The only difference in the blood urea levels was between female kids and the bucks ($p < 0.05$).

The matured goats displayed very similar urea levels regardless of the gender. Blood creatinine levels were greater in the males and the males had significantly high urea levels than the female kids ($p < 0.05$). The creatinine levels tended to be higher in the male goat, however, the difference was not significant. Creatinine kinase levels were higher in the female kids significantly compared to the other groups ($p < 0.05$). Also, its level was significantly higher in the does than the bucks and male kids ($p < 0.05$). Total bilirubin levels were higher in the female goats, specifically in the does ($p < 0.05$). The female kids and the bucks had greater iron levels compared to the male kids ($p < 0.05$), however, the difference from the does was not significant. The results of biochemical analyses are summarized in Table 2.

Table 1. Hematologic parameters in Hair goats.

Parameters	Female young kids	Male kids	Non-pregnant does	Bucks
Red blood cell ($\times 10^6 \mu\text{L}^{-1}$)	17.43 \pm 0.75 ^{bc}	18.24 \pm 0.61 ^{bd}	15.76 \pm 0.61 ^{ac}	17.54 \pm 0.50 ^{ad}
Hemoglobin (g dL ⁻¹)	8.74 \pm 0.37 ^a	8.90 \pm 0.31 ^a	8.06 \pm 0.32 ^a	8.84 \pm 0.33 ^a
Hematocrit (%)	22.67 \pm 0.83 ^a	21.65 \pm 0.65 ^a	21.29 \pm 0.75 ^a	22.80 \pm 0.85 ^a
Mean corpuscular volume (fL)	13.57 \pm 0.31 ^{ab}	12.55 \pm 0.29 ^{ac}	13.92 \pm 0.35 ^{ab}	12.88 \pm 0.85 ^{ac}
Mean corpuscular hemoglobin (pg)	5.17 \pm 0.09 ^{ab}	4.85 \pm 0.75 ^{ac}	5.15 \pm 0.08 ^{ab}	5.01 \pm 0.86 ^{ac}
Mean corpuscular hemoglobin concentration (g dL ⁻¹)	38.58 \pm 0.41 ^{ab}	39.39 \pm 0.58 ^{ac}	38.26 \pm 0.43 ^{ab}	39.74 \pm 0.52 ^{ac}
Red cell distribution width (%)	23.30 \pm 0.49 ^{ab}	24.41 \pm 0.51 ^{ac}	22.68 \pm 0.42 ^{ab}	23.70 \pm 0.52 ^{ac}
White blood cell ($\times 10^3 \mu\text{L}^{-1}$)	19.22 \pm 0.63 ^a	17.40 \pm 0.82 ^a	18.60 \pm 0.97 ^a	19.75 \pm 0.98 ^a

^{abcd} Differences between groups are shown with different superscripts in the same column that are statistically significant ($p < 0.05$).

Table 2. Biochemical parameters in Hair goats.

Parameters	Female kids	Male kids	Non-pregnant does	Bucks
Total protein (g dL ⁻¹)	14.14 \pm 1.59	14.44 \pm 2.95	14.65 \pm 2.26	14.92 \pm 2.55
Albumin (g dL ⁻¹)	6.27 \pm 1.34	5.53 \pm 1.33	6.38 \pm 1.17	5.59 \pm 1.45
Globulin (g dL ⁻¹)	7.00 \pm 3.25	7.65 \pm 1.35	7.00 \pm 3.20	7.83 \pm 1.85
Glucose (mg dL ⁻¹)	82.17 \pm 10.68 ^a	89.60 \pm 15.17 ^a	64.42 \pm 18.17 ^b	85.52 \pm 27.05 ^a
Phosphorus (mg dL ⁻¹)	8.13 \pm 2.03 ^a	8.71 \pm 2.02 ^a	6.47 \pm 1.65 ^b	9.35 \pm 2.62 ^a
Calcium (mg dL ⁻¹)	13.86 \pm 4.04	14.83 \pm 3.01	14.47 \pm 3.05	15.60 \pm 5.43
Magnesium (mg dL ⁻¹)	2.15 \pm 0.21	2.11 \pm 0.26	2.09 \pm 0.41	2.20 \pm 0.30
Aspartate aminotransferase (IU L ⁻¹)	81.06 \pm 25.03	80.03 \pm 33.13	75.75 \pm 12.56	69.22 \pm 17.86
Alkaline phosphatase (U L ⁻¹)	293.73 \pm 193.75	293.26 \pm 181.77	208.31 \pm 51.81	310.87 \pm 181.45
Alanine aminotransferase (IU L ⁻¹)	13.92 \pm 3.26	16.10 \pm 9.28	15.39 \pm 4.11	13.98 \pm 2.83
Gamma-glutamyl transferase (IU L ⁻¹)	73.07 \pm 27.14 ^{ab}	106.29 \pm 46.61 ^a	81.10 \pm 49.15 ^b	100.03 \pm 40.00 ^{ab}
Urea (mg dL ⁻¹)	32.77 \pm 13.71 ^a	27.16 \pm 8.38 ^{ab}	27.88 \pm 10.37 ^{ab}	23.73 \pm 7.03 ^b
Creatinine (mg dL ⁻¹)	0.74 \pm 0.36 ^b	1.09 \pm 0.41 ^a	0.84 \pm 0.34 ^{ab}	1.12 \pm 0.55 ^a
Creatine kinase (IU L ⁻¹)	182.00 \pm 40.16 ^c	141.60 \pm 32.13 ^b	151.00 \pm 27.46 ^a	103.40 \pm 27.55 ^b
Total bilirubin (mg dL ⁻¹)	0.18 \pm 0.06 ^{ab}	0.17 \pm 0.04 ^{ab}	0.22 \pm 0.05 ^a	0.13 \pm 0.03 ^b
Iron ($\mu\text{g dL}^{-1}$)	166.17 \pm 64.70 ^b	118.39 \pm 43.69 ^a	138.40 \pm 59.40 ^{ab}	161.53 \pm 70.84 ^b

^{abc} Differences between groups are shown with different superscripts in the same column that are statistically significant ($p < 0.05$).

Discussion

Hematologic and biochemical parameters in the blood could be influenced by age, gender, breed as well as nutrition, stress, diseases.² Analysis of these blood parameters presents clues for the health status of animals. However, veterinarians should know the reference ranges of these parameters for each species and breed to exert through evaluation.⁴ In the present study, we evaluated some parameters in the Hair goat blood that were affected by age, gender or both. The RBC count in the Hair goat in this study was determined to be higher compared to some other goat breeds.⁸⁻¹⁵ Erythrocyte values in the does Hair goats were similar,^{9,10} lower,¹⁶ or higher^{13,17} compared to other breeds. However, this study showed that erythrocyte counts were higher in the young goats compared to those found in earlier studies.^{8,12} Piccione *et al.* indicated that there was no correlation between the RBC count and age.⁹ However, Daramola *et al.* in a study with 10 mature and 10 kids found that the does had a statistically higher number of erythrocytes than kids.⁸ In a study with Saanen goats (72 goats at different ages), Elitok pointed that number of erythrocytes in the blood was increased with aging.¹⁸ In this study, however, young goats regardless of the gender had significantly more erythrocytes than that of the matured goats. Although the Hair goats in this study

had greater number of erythrocytes compared to the results of earlier studies, hemoglobin values were lower.^{8,11,12,14} In general, Hair goats in this study presented lower hemoglobin values than other studies where the RBC counts were similar or lower than our results.^{9,16} The greater RBC count with lower hemoglobin values determined in this study in the Hair goats could be considered as a distinctive character of this breed. Obtained values for hemoglobin, MCV, MCH and RDW appeared to be smaller regardless of the age and gender compared to the other studies on different breeds.^{8,10-15} Hematocrit value was lower,^{10,15,16} or higher compared to the previous studies.^{13,17} The WBC counts were found to be greater than that of the earlier studies. Similar to the RBC, this could also be a physiologically distinctive character of the Hair goats. These goats are known to be disease resistant breed.¹ Thus, physiologically high number of WBC may be the reason for this resistance. The MCHC values were either lower,^{9,10,15,16} or greater,^{8,11,12,18} compared to the results of earlier studies. The Hair goats studied here had higher albumin, globulin and protein levels in the serum compared to the reported levels by others.^{7-10,13,15} The females had higher albumin levels than the males. Also, blood glucose levels were also higher in this study except for the matured females which had either lower or higher levels compared to the other studies.^{7,8,11,13,18,19} The does presented lower

glucose values than those of the younger kids and the bucks. The values obtained from the does were within the reference range reported by Kaneko *et al.* while the other groups were outside of the high end of the reference range. Blood glucose level is regulated by nutrition and hormones whereas age, gender, breed and environmental factors are also considered.^{13,20} The higher glucose levels seen in the kids could be due to their different metabolic status.²¹ In the present study, calcium levels detected were found to be greater than the reference values reported in previous studies.^{8,11,22-26,29} The reason for higher calcium levels from the other breeds of goats could be that the Hair goats live in mountainous areas which may require more stable and powerful bones. To confirm this, bone density and stability tests could be performed for the goats which live in various land types and environmental conditions. The serum phosphorus levels were in accordance with the reference range of Kaneko *et al.* but were greater than the reported results.^{8,11,22-29} Similarly, magnesium levels obtained were either higher^{22,24,25} or lower^{27,29} compared to the values obtained by other studies. In conclusion, serum calcium levels were above the range and phosphorus and magnesium levels were slightly below the range reported by Kaneko *et al.*²⁹ Calcium levels were not significantly higher in the males while the phosphorus levels were higher significantly. The liver enzymes had intracellular functions, thus, their presence in the blood indicated tissue damage in the liver.²⁵ The activity of such enzymes as ALT, AST, and GGT were used as indicators of physical stress.⁹ Normal blood level for AST was defined to be 167 - 513 UL⁻¹ in goats,²⁹ however, the values presented in this study were lower. Similarly, the values were also found to be lower compared to an earlier study in female goats at prepartum and postpartum stages in Siirt Hair goats.⁷ However AST levels in our study were higher than values reported by other groups Piccione *et al.*,¹⁰ Waziri *et al.*¹¹ The AST values in Nguni goats were similar with ours.²⁵ This discrepancy might be due to autumn condition when we collected the blood sample as the goats were mostly allowed to raise in the pasture, therefore, the type of nutrition may have affected the AST levels. The ALP levels here were consistent with the reference values of Kaneko *et al.*,²⁹ but not with Tschuor *et al.*,²² Elitok¹⁸ and Al-Bulushi *et al.*¹⁵ The does had also lower ALP levels than that of reported by Tanritanır *et al.*²³ In Saanen goats, it was shown that age and gender had a significant effect on ALP levels, however, the present study did not show such an effect in the Hair goats. As for ALT levels, they were within the range reported by Kaneko *et al.*,²⁹ but lower than those reported by the others.^{9,11,14,15,18,22} It is reported that the ALT levels in goat and sheep may be affected by the breeding season.³⁰ The low AST levels that we detected could then be due to the fact that the blood samples were collected out of the breeding season. The primary role of GGT enzymes is to provide amino acids, specifically

cysteine, for the synthesis of intracellular GSH, therefore, it has antioxidant activity.³¹ The GGT levels in this study were much higher than that of the previous studies.^{15,18,29} The GGT levels were significantly higher in the males compared to the females. The blood urea levels were similar to the values reported by Kaneko *et al.*,²⁹ but lower^{7,9} or higher^{11,21} than those of earlier studies. The levels observed in the matured goats and the male kids were lower than values of Saanen goats, however, the female kids have similar levels.¹⁸ In this study, the blood creatinine levels were similar in the male but lower in the female compared to the results by Kaneko *et al.*,²⁹ however, were higher than the range reported by Tschuor *et al.*²² The blood creatinine levels in the male were similar to what was found in Sahel goats but lower in the females.²² Regardless of the gender, the creatinine levels were much lower than the values reported by Mohammed *et al.*¹³ The creatinine kinase (CK) is used to define myocyte damage in the body.¹³ In this study, we found that CK levels were in accordance with the reference range given by Tschuor *et al.*²² only for the female kids. The levels were higher significantly in the does. Within the females, the kids had higher CK levels. Total bilirubin values detected here were within the reference range of Kaneko *et al.*²⁹ However, the levels were higher than those of earlier studies.^{14,15,18,22} The females had higher total bilirubin than the males. The blood iron is a dependable parameter to identify the physiological and pathological status of the body.³² We found out that the blood iron levels were much higher compared to the results of previous studies.^{7,32} The male kids in this study presented significantly lower iron levels than the female kids and the bucks. In conclusion, blood hematological and biochemical values of goats may be different depending on age and sex.

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Conflict of interest

The authors declare no conflict of interest.

References

1. Koncagül S, Demirlap C, Aksümer N, et al. Domestic animal genetic resources in Turkey. 1st ed. Ankara, Turkey: General directorate of agricultural research 2011; 10-100.
2. Coles EH. *Veterinary clinical pathology*. 4th ed. Philadelphia, USA: WB Saunders 1986; 1-19.
3. Bush BM. *Interpretation of laboratory results for small animal clinicians*. London UK: Wiley 1991; 221-310.

4. Meyer DJ, Harvey JW. *Veterinary laboratory medicine: interpretation and diagnosis*. 3rd ed. St. Louis, USA: Saunders 2004; 157-199.
5. Khan ZI, Ashraf M, Ahmad K, et al. Mineral status of forage and its relationship with that of plasma of farm animals in southern Punjab Pakistan. *Pak J Bot* 2009; 41(1): 67-72.
6. Nagy O, Tóthová C, Nagyová V, et al. Changes in the serum protein electrophoretic pattern in lambs during the first month of life. *Acta Vet Brno* 2014; 83: 187-193.
7. Tanritanır P, Ceylan E, Dede S. The determination of some blood parameters in healthy Siirt Hair goats before and after parturition [Turkish]. *YYU Vet Fak Derg* 2010; 21(2): 103-105.
8. Daramola JO, Adeloye AA, Fatoba TA, et al. Hematological and biochemical parameters of West African Dwarf goats. *Livest Res Rural Dev* 2005; 17(8): #95. Retrieved December 11, 2021, from <http://www.lrrd.org/lrrd17/8/dara17095.htm>.
9. Piccione G, Casella S, Lutri L, et al. Reference values for some hematological, hematochemical and electrophoretic parameters in the Girgentana goat. *Turk J Vet Anim Sci* 2010; 34(2): 197-204.
10. Piccione G, Monteverde V, Rizzo M, et al. Reference intervals of some electrophoretic and hematological parameters in Italian goats: comparison between Girgentana and Aspromontana breeds. *J Appl Anim Res* 2014; 42(4): 434-439.
11. Waziri MA, Ribadu AY, Sivachelvan N. Changes in the serum proteins, hematological and some serum biochemical profiles in the gestation period in the Sahel goats. *Vet Arh* 2010; 80(2): 215-224.
12. Njidda AA, Hassan IT, Olatunji EA. Hematological and biochemical parameters of goats of semi-arid environment fed on natural grazing rangeland of northern Nigeria. *IOSR J Agric Vet Sci* 2013; 3(2): 1-8.
13. Mohammed SA, Razzaque MA, Omar A, et al. Biochemical and hematological profile of different breeds of goat maintained under intensive production system. *Afr J Biotechnol* 2016; 15(24): 1253-1257.
14. Sunder J, Sujatha T, Kundu A, et al. Haemato-biochemical profile of the Teressa Goat: An indigenous goat of A&N Islands, India. *J Immunol Immunopathol* 2016; 18(1): 47-50.
15. Al-Bulushi S, Shawaf T, Al-Hasani A. Some hematological and biochemical parameters of different goat breeds in Sultanate of Oman "A preliminary study". *Vet World* 2017; 10(4): 461-466.
16. Arfuso F, Fazio F, Rizzo M, et al. Factors affecting the hematological parameters in different goat breeds from Italy. *Ann Anim Sci* 2016; 16(3): 743-757.
17. Zamfirescu S, Topoleanu I, Nadolu D. Observations concerning haematological profile in goat. *Uni Agric Sci Vet Med Iasi, Anim Husb Ser* 2009; 52: 86-91.
18. Elitok B. Reference values for hematological and biochemical parameters in Saanen goats breeding in Afyon-karahisar province. *Kocatepe Vet J* 2012; 5(1): 7-11.
19. Ocak S, Darcan N, Çankaya S, et al. Physiological and biochemical responses in German Fawn kids subjected to cooling treatments under Mediterranean climate conditions. *Turk J Vet Anim Sci* 2009; 33(6): 455-461.
20. Sakha M, Shamesdini M, Mohamad-zadeh F. Serum biochemistry values in Raini goat of Iran. *Internet J Vet Med* 2009; 6(1): 1-7.
21. Abdolvahabi S, Zaeemi M, Mohri M, et al. Age related changes in serum biochemical profile of Saanen goat kids during the first three months of life. *Rev Med Vet* 2016; 167(3): 106-112.
22. Tschuor AC, Riond B, Braun, U et al. Hematological and clinicochemical reference values for adult goats and sheep [German]. *Schweiz Arch Tierheilkd* 2008; 150(6): 287-295.
23. Tanritanır P, Dede S, Ceylan E. Changes in some macro minerals and biochemical parameters in female healthy Siirt Hair goats before and after parturition. *J Anim Vet Adv* 2009; 8(3): 530-533.
24. Samardžija M, Dobranić T, Lipar M, et al. Comparison of blood serum macromineral concentrations in meat and dairy goats during puerperium. *Vet Arh* 2011; 81(1): 1-11.
25. Gwaze FR, Chimonyo M, Dzama K. Effect of season and age on blood minerals, liver enzyme levels, and faecal egg counts in Nguni goats of South Africa. *Czech J Anim Sci* 2012; 57(10): 443-453.
26. Eşki F, Taşal İ, Karşlı MA, et al. Concentrations of NEFA, β -HBA, triglycerides, and certain blood metabolites in healthy colored Angora goats during the peripartum period. *Turk J Vet Anim Sci* 2015; 39: 401-405.
27. Olmedo-Juárez A, Rojo R, Salem AZM. Concentration of some elements in blood serum of nonlactating goats in a subtropical region of southwest of México state. *Trop Subtrop Agroecosystems* 2012; 15(1): 71-75.
28. Yattoo MI, Saxena A, Kumar P, et al. Evaluation of serum mineral status and hormone profile in goats and some of their inter-relations. *Vet World* 2013; 6(6): 318-320.
29. Kaneko JJ, Harvey JW, Bruss ML. *Clinical biochemistry of domestic animals*. 6th ed. London, UK: Elsevier Academic Press 2009; 184-235.
30. Yokus B, Cakir DU, Kanay Z, et al. Effects of seasonal and physiological variations on the serum chemistry, vitamins and thyroid hormone concentrations in sheep. *J Vet Med A Physiol Pathol Clin Med* 2006; 53(6): 271-276.
31. Şener A, Çevik Ö. Association of gamma-glutamyl transferase with oxidative stress and cardiovascular diseases [Turkish]. *Cumhuriyet Tıp Derg* 2013; 35: 291-301.
32. Gürgöze SY, Zonturlu AK, Özyurtlu N, et al. Investigation of some biochemical parameters and mineral substance during pregnancy and postpartum period in Awassi ewes. *Kafkas Univ Vet Fak Derg* 2009; 15(6): 957-963.