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A comparative profile of certain biochemical and hematological parameters in Angora and Akkeçi goats during the transition period

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Abstract: This study investigated the comparative changes in hematological and certain biochemical parameters such as glucose, cholesterol, triglyceride calcium, phosphorus and total protein during the transition period in Angora and Akkeçi goats aged 2–4 years. For this purpose, blood samples were regularly taken from the vena jugularis of each goat at 3, 2, and 1 weeks before kidding (–3, –2 and –1), on the day of parturition (0) and 1, 2, and 3 weeks after kidding (+1, +2 and +3). According to the statistical analysis results, the differences between the averages of the groups in terms of MCHC, MCH, Lym, THR, Pct and glucose were not statistically significant. However, there were found statistically significant ($p < 0.05$) differences among the periods for WBC, MPV, PDW, cholesterol and total protein, while there were found statistically significant ($p < 0.05$) differences between the genotypes for Hb, RDW, and cholesterol. Additionally, genotype x period interactions were statistically significant ($p < 0.05$) in terms of RBC, MCV, HCT, Mon, Gra, triglyceride, calcium, and phosphorus. In conclusion, in the transition from pregnancy to lactation, which are different physiological periods, certain similar important metabolic adaptations have occurred in both goat breeds.

Keywords: Parturition, complete blood count, metabolite, prepartum, postpartum

1. Introduction

In goats, as in many mammalian species, the period between the three weeks before parturition and the first three weeks after parturition is called the "transition period" [1,2]. During this period, important changes occur in the metabolism of goats, and the inability that occurs in the transition from the last period of pregnancy to the lactation period, which is a different physiological period, may disrupt the production cycle in animals and thus causes economic losses [3].

In mammals, pregnancy and lactation periods represent two important physiological periods in which a comprehensive set of metabolic adaptations occur to support the development of different tissues such as the development of the fetus during pregnancy and the development of the mammary gland during lactation. In cases where the nutritional needs of the relevant tissues cannot meet during these physiological periods, the animal's production performance is affected and its health is endangered [4].

The postpartum period is a period characterized by marked changes in an animal's endocrine and metabolic status, as well as an increase in nutritional needs for approaching lactogenesis, while a decrease in feed intake. The postpartum period, especially up to 45 days after parturition and covering a part of the transition period is considered as the most physiologically stressful period for animals because of the decrease in feed consumption and endocrine and metabolic changes during parturition and lactation [5]. Additionally, reasons such as metabolic adaptation deficiencies and malnutrition that occur during this period increase the risk of metabolic diseases in animals [1].

There is ample evidence that metabolic adaptations in the body to support pregnancy and lactation in ruminants depend on observed variations in the concentrations of circulating metabolites and hormones. However, it is also difficult to determine whether all chronic changes in blood concentrations represent changes in the production or use of a metabolite or a hormone [4].

Hematological and biochemical parameters are known as indicators that reflect the physiological state of animals and can be used to evaluate the response of animals to various physiologically stressful conditions such as pregnancy, parturition, and lactation [5]. Additionally, blood biochemical parameters are considered as the most

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important indicators used in the determination of energy, protein, enzyme, hormone, and mineral profiles, and therefore in the evaluation of the nutritional status, milk production and health of the animal [2].

It has been observed that the studies carried out to determine the change of hematological and biochemical parameters in the transition period and the factors affecting this change were mostly conducted on cattle and sheep and goat mostly in breeds raised in tropical and subtropical regions. However, it can be said that these studies are seldom conducted on Angora goats. Therefore, this study investigated the comparative changes in hematological and certain biochemical parameters such as glucose (Glu), cholesterol (Chol), triglycerides (Tri), calcium (Ca), phosphorus (P), and total proteins (TP) during the transition period in Angora and Akkeçi goats reared under the same environmental conditions.

2. Materials and method

2.1. Animals and treatment

The ethics committee approval of the study was taken with decision number 2021-5-7 of the Animal Experiments Local Ethics Committee of Ankara University. The study was conducted on four Angora goats (27.3–42.4 kg at the beginning of the experiment) and six Akkeçi goats (45.8–63.6 kg at the beginning of the experiment) aged 2–4 years raised on the farm (39°57'42.5" north latitude, 32°51'56.2" east longitude) at Ankara University, Faculty of Agriculture, Department of Animal Science. The goats were housed in shaded pens, and natural light was allowed to enter through windows and doors. All the goats were clinically healthy. The goats were given concentrated feed and alfalfa hay during the transition period and they were not milking after a postpartum period. Fresh water was made available always for the goats. The management of experimental goats has not intervened in the general operation of the farm and they were housed under the same environmental conditions.

2.2. Blood samples and analysis

Blood samples were taken regularly from the vena jugularis of each goat (before animals morning feeding) weekly throughout 3 weeks before kidding (–3, –2, –1), at parturition (0, within the first 12 h after kidding) and 3 weeks after kidding (+1, +2, +3). Blood samples were collected from each goat in two tubes, 5 mL without anticoagulant (BD Vacutainer® SST II Advance) and 3 mL tubes with anticoagulant (VACUTEST® K3 EDTA 5.4 mg) before the morning feeding. Blood samples taken into tubes without anticoagulant were centrifuged at 4000 g for 5 min and the sera were separated and stored at –20 °C until biochemical analysis. The sera were analyzed using a semiautomatic biochemical analyzer (SABA 18, AMS, Italy) for the determination of serum concentrations of glucose (Glu), cholesterol (Chol), triglycerides (Tri), calcium (Ca), phosphorus (P) and total proteins (TP). Blood samples were taken into tubes containing anticoagulant (whole blood), and analyzed using a hematology analyzer (MS4e, Melet Schloesing Laboratoires, France) for the determination of red blood cells (RBC), mean corpuscular volume (MCV), hematocrit (Hct), hemoglobin (Hb), mean corpuscular hemoglobin concentration (MCHC), mean corpuscular hemoglobin (MCH), red cell distribution width (RDW), white blood cell (WBC), lymphocytes (Lym), granulocyte (Gra), monocyte (Mon), thrombocytes (THR), mean platelet volume (MPV), plateletcrit (Pct) and platelet distribution width (PDW).

2.3. Statistical analysis

Repeated measurement analysis was done using Linear mixed models for the data with IBM SPSS Statistics 20. In this experiment, the parameters studied were evaluated using a model with period (–3, –2, –1, 0, +1, +2, +3), breeds (Angora and Akkeçi) and their interaction [6]. The model used in the experiment is given in Equation.

$$Y_{ijm}=\mu+\alpha_i+\pi_{m(i)}+\beta_j+\alpha\beta_{ij}+\beta\pi_{jm(i)}+\varepsilon_{l(ijm)}$$

μ : Overall mean

α : Fixed effect of i^{th} breed

$\pi_{m(i)}$: Random effect for the m^{th} goat in the i^{th} breed

β_j : Fixed effect of j^{th} period

$\alpha\beta i_j$: Fixed effect for the interaction of the i^{th} breed with j^{th} period

$\beta\pi_{jm(i)}$: Fixed effect for the interaction between the j^{th} period and the m^{th} goat for the i^{th} breed

$\varepsilon_{1(ijm)}$: Random error term

3. Results and discussion

3.1. Hematological parameters

Erythrocyte profile

In this study, descriptive values for the change in erythrocyte profile in the transition period in Angora and Akkeçi goats are shown in Table 1. As a result of the analysis of variance, the differences between the means of the breeds for MCHC and MCH were not found to be statistically significant ($p > 0.05$). However, the differences between the mean levels of the breeds for Hb and RDW were found statistically significant ($p < 0.05$), the breed × period interactions were found statistically different for RBC, MCV, and HCT ($p < 0.05$).

The pattern of changes in RBC, Hb, HCT, and erythrocyte indices (MCV, MCH, MCHC, and RDW) in Angora and Akkeçi goats during the transition period are shown in Figure 1. As Figure 1 shows, there was a slight decrease in RBC counts from the last period of pregnancy to parturition in both goat breeds, and a relatively stable course emerged in the postpartum period, with some fluctuations. Findings similar to the decrease in RBC count

Table 1. Descriptive values of erythrocyte counts (RBC), Hb, HCT, and erythrocyte indices (MCV, MCH, MCHC, and RDW) in Angora and Akkeçi goats during the transition period.

Breeds		**- 3**	**- 2**	**- 1**	**0**	**+ 1**	**+ 2**	**+ 3**
Angora goats (n = 4)	**RBC** (M/mm3)	20.54 ± 0.76 **Aa**	19.60 ± 0.64 **Aa**	19.82 ± 1.35 **Aa**	18.75 ± 0.12 **Aa**	19.17 ± 0.35 **Aa**	18.27 ± 0.05 **Aa**	18.86 ± 1.38 **Aa**
	MCV (fl)	20.43 ± 0.81 **Aa**	20.70 ± 0.65 **Aa**	20.50 ± 0.60 **Aa**	19.83 ± 0.25 **ABa**	20.00 ± 0.60 **ABa**	19.75 ± 0.39 **ABa**	19.23 ± 0.96 **Ba**
	Hct (%)	41.95 ± 2.67 **Aa**	40.43 ± 0.72 **ABa**	40.45 ± 2.41 **ABa**	37.15 ± 0.42 **ABa**	38.30 ± 1.42 **ABa**	36.03 ± 0.65 **Ba**	36.20 ± 3.15 **Ba**
	Hb (g/dL)	13.05 ± 0.22 **a**	12.93 ± 0.39 **a**	13.05 ± 0.93 **a**	12.73 ± 0.40 **a**	12.63 ± 0.19 **a**	11.93 ± 0.41 **a**	11.88 ± 0.99 **a**
	MCHC (g/dL)	31.38 ± 1.64	31.93 ± 0.73	32.15 ± 0.37	33.43 ± 0.66	33.00 ± 1.03	33.07 ± 1.37	32.92 ± 1.49
	MCH (pg)	6.35 ± 0.19	6.55 ± 0.06	6.55 ± 0.17	6.60 ± 0.11	6.55 ± 0.15	6.48 ± 0.21	6.23 ± 0.06
	RDW	16.63 ± 0.71 **a**	15.90 ± 0.57 **a**	16.60 ± 0.83 **a**	17.05 ± 0.48 **a**	16.78 ± 1.14 **a**	16.13 ± 0.49 **a**	15.73 ± 0.53 **a**
Akkeçi goats (n = 6)	**RBC** (M/mm3)	17.23 ± 0.71 **Bb**	15.65 ± 0.41 **Bb**	15.54 ± 0.49 **Bb**	16.67 ± 0.66 **Bb**	16.32 ± 0.41 **Bb**	19.03 ± 0.71 **Aa**	16.41 ± 0.68 **Bb**
	MCV (fl)	19.45 ± 0.42 **Ba**	19.17 ± 0.59 **Ba**	19.07 ± 0.67 **Ba**	19.27 ± 0.38 **Ba**	19.05 ± 0.43 **Ba**	20.42 ± 0.58 **Aa**	19.32 ± 0.47 **Ba**
	Hct (%)	33.55 ± 2.00 **Bb**	30.68 ± 1.08 **Bb**	29.57 ± 1.36 **Bb**	32.12 ± 1.68 **Bb**	31.02 ± 1.03 **Bb**	38.22 ± 1.94 **Aa**	31.75 ± 1.88 **Ba**
	Hb (g/dl)	11.75 ± 0.69 **b**	10.40 ± 0.46 **b**	10.23 ± 0.48 **b**	10.87 ± 0.47 **b**	11.07 ± 0.38 **b**	12.55 ± 0.59 **b**	10.92 ± 0.62 **b**
	MCHC (g/dL)	35.00 ± 0.48	33.42 ± 1.21	34.67 ± 1.21	33.93 ± 0.95	35.63 ± 0.28	32.68 ± 0.22	34.37 ± 0.73
	MCH (pg)	6.75 ± 0.15	6.35 ± 0.31	6.52 ± 0.12	6.48 ± 0.17	6.73 ± 0.14	6.63 ± 0.15	6.58 ± 0.14
	RDW	14.48 ± 0.31 **b**	13.38 ± 0.32 **b**	14.32 ± 0.68 **b**	13.65 ± 0.30 **b**	14.28 ± 0.60 **b**	13.92 ± 0.53 **b**	13.73 ± 0.23 **b**
General (n = 10)	**RBC** (M/mm3)	18.55 ± 0.73	17.23 ± 0.73	17.25 ± 0.90	17.50 ± 0.51	17.46 ± 0.54	18.72 ± 0.43	17.39 ± 0.76
	MCV (fl)	19.84 ± 0.41	19.78 ± 0.48	19.64 ± 0.50	19.49 ± 0.26	19.43 ± 0.37	20.15 ± 0.38	19.28 ± 0.45
	Hct (%)	36.91 ± 2.04	34.58 ± 1.73	33.92 ± 2.13	34.13 ± 1.28	33.93 ± 1.43	37.34 ± 1.20	33.53 ± 1.74
	Hb (g/dL)	12.27 ± 0.46	11.41 ± 0.51	11.36 ± 0.63	11.61 ± 0.43	11.69 ± 0.34	12.30 ± 0.39	11.30 ± 0.53
	MCHC (g/dL)	33.55 ± 0.89	32.82 ± 0.79	33.66 ± 0.82	33.73 ± 0.60	34.58 ± 0.59	32.84 ± 0.52	33.79 ± 0.73
	MCH (pg)	6.59 ± 0.13	6.43 ± 0.18	6.53 ± 0.09	6.53 ± 0.11	6.66 ± 0.10	6.57 ± 0.12	6.44 ± 0.10
	RDW	15.34 ± 0.47	14.39 ± 0.50	15.23 ± 0.62	15.01 ± 0.61	15.28 ± 0.68	14.80 ± 0.51	14.53 ± 0.40

a, b: Mean values within a column with different lower-case symbol differ significantly ($p < 0.05$) in breed comparison.
A, B, C: Mean values within a row with different capital letters differ significantly ($p < 0.05$) in period comparison.

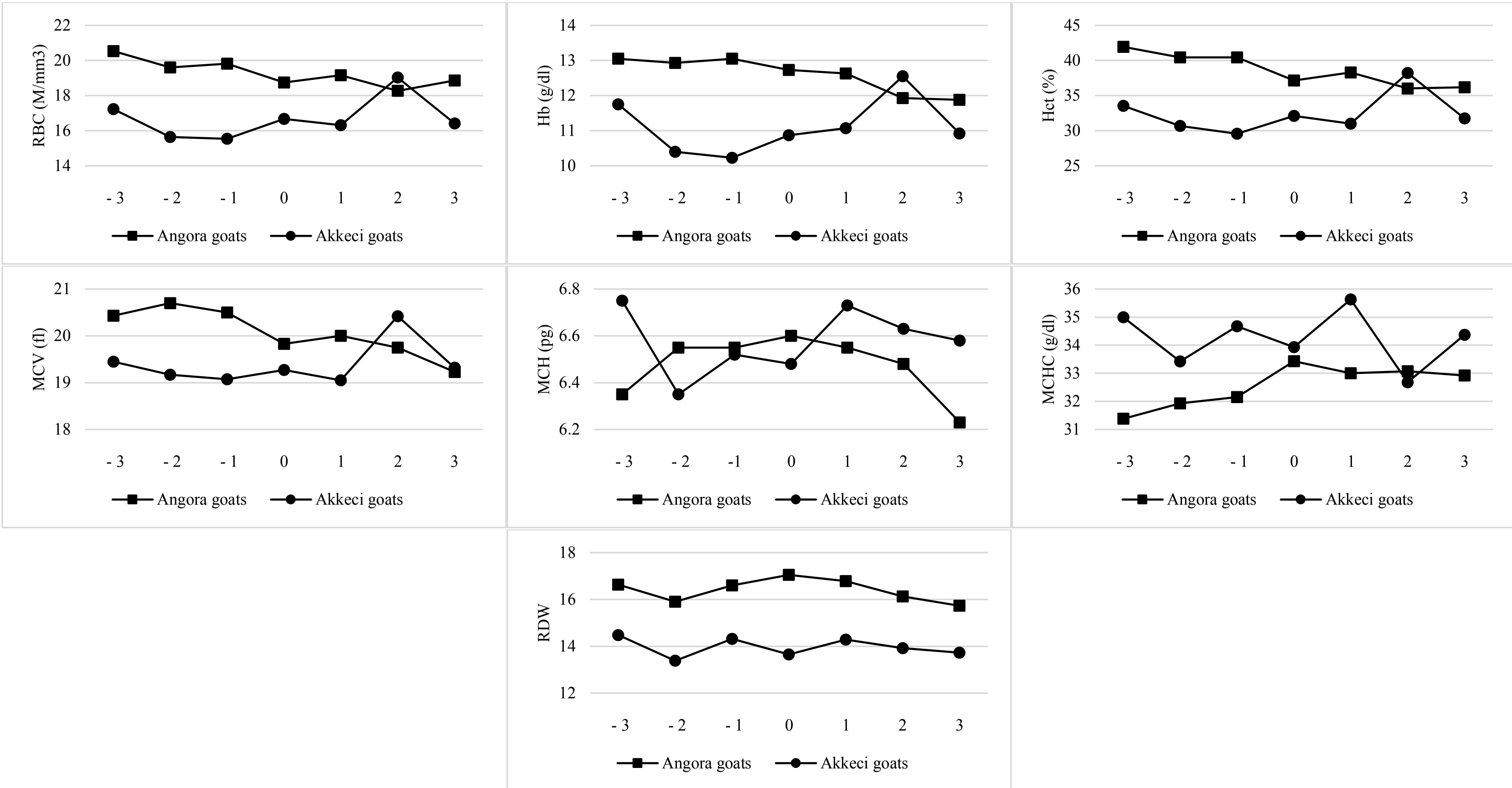

Figure 1. The patterns of changes in erythrocyte counts (RBC), Hb, HCT, and erythrocyte indices (MCV, MCH, MCHC, and RDW) in Angora and Akkeçi goats during the transition period.

in the last period of pregnancy in this study were also reported in other studies conducted on Baladi goats [7], Kilis goats [8], and native goats [3]. In this study, it can be argued that the decrease in the last period of pregnancy in Angora and Akkeçi goats is due to the expansion of plasma volume due to the hemodilution effect that occurred in the same period. As a matter of fact, the decrease in HCT and Hb values in both breeds during the same period supports this finding. The decrease in erythrocyte indices due to the hemodilution effect in the last period of pregnancy may have physiological importance as it reduces blood viscosity and thus greatly increases blood flow in small blood vessels. It has been reported that this is an important regulation mechanism in terms of increasing the transfer of O_2 and nutrients to the fetus in the last period of pregnancy [7,8].

Leukocyte profile

In this research, descriptive values for the change in leukocyte profile in Angora and Akkeçi goats during the transition period are shown in Table 2. As a result of the statistical analysis, the differences between the averages of the breeds for lymphocyte (%) were not found to be statistically different ($p > 0.05$). While breed x period interactions were statistically different ($p < 0.05$) for Monocyte (%) and Granulocyte (%), significant differences ($p < 0.05$) were found among the periods for WBC counts.

The pattern of changes in total leukocyte counts (WBC) and differential leukocyte (granulocyte, lymphocyte and, monocyte) distributions in Angora and Akkeçi goats during the transition period are shown in Figure 2. As Figure 2 shows, in both goat breeds, an increase in WBC

Table 2. Descriptive values of total leukocyte counts (WBC) and differential leukocyte (Granulocyte, Lymphocyte, and Monocyte) distributions in Angora and Akkeçi goats during the transition period.

Breeds		- 3	- 2	- 1	0	+ 1	+ 2	+ 3
Angora goats (n = 4)	WBC (m/mm3)	10.72 ± 1.18	11.67 ± 1.08	12.28 ± 1.41	9.95 ± 0.33	15.34 ± 3.42	12.70 ± 2.52	12.18 ± 0.72
	Gra (%)	64.50 ± 5.23 **ABa**	61.80 ± 5.13 **ABa**	65.03 ± 6.83 **ABa**	58.38 ± 4.06 **Ba**	64.60 ± 7.66 **ABa**	64.85 ± 2.76 **ABa**	68.22 ± 8.40 **Aa**
	Lym (%)	30.15 ± 5.00	32.70 ± 4.80	29.70 ± 6.41	35.52 ± 4.20	30.77 ± 7.48	29.82 ± 2.64	27.45 ± 8.01
	Mon (%)	5.35 ± 0.39 **ABb**	5.50 ± 0.50 **ABb**	5.28 ± 0.63 **ABb**	6.10 ± 0.30 **Aa**	4.63 ± 0.46 **ABb**	5.33 ± 0.47 **ABa**	4.33 ± 0.54 **Ba**
Akkeçi goats (n = 6)	WBC (M/mm3)	12.51 ± 2.37	14.10 ± 1.81	15.24 ± 1.73	14.84 ± 2.07	16.89 ± 1.64	16.52 ± 1.16	17.56 ± 1.80
	Gra (%)	49.20 ± 2.99 **Bb**	50.08 ± 4.22 **Ba**	46.75 ± 3.30 **Bb**	57.17 ± 3.47 **Aa**	57.78 ± 4.59 **Aa**	61.23 ± 3.47 **Aa**	60.05 ± 4.43 **Aa**
	Lym (%)	40.70 ± 3.42	41.30 ± 4.35	45.45 ± 3.51	35.48 ± 3.31	35.33 ± 4.24	33.12 ± 3.41	34.10 ± 4.51
	Mon (%)	10.10 ± 1.09 **Aa**	8.62 ± 0.20 **Ba**	7.80 ± 0.32 **BCa**	7.35 ± 0.51 **BCa**	6.88 ± 0.60 **CDa**	5.65 ± 0.33 **Da**	5.85 ± 0.28 **Da**
General (n = 10)	WBC (M/mm3)	11.80 ± 1.46 **C**	13.13 ± 1.19 **ABC**	14.06 ± 1.22 **ABC**	12.88 ± 1.44 **BC**	16.27 ± 1.59 **A**	14.99 ± 1.30 **AB**	15.40 ± 1.38 **AB**
	Gra (%)	55.32 ± 3.59	54.77 ± 3.62	54.06 ± 4.33	57.65 ± 2.50	60.51 ± 4.01	62.68 ± 2.32	63.32 ± 4.21
	Lym (%)	36.48 ± 3.19	37.86 ± 3.37	39.15 ± 4.02	35.50 ± 2.45	33.51 ± 3.74	31.80 ± 2.26	31.44 ± 4.06
	Mon (%)	8.20 ± 1.01	7.37 ± 0.55	6.79 ± 0.51	6.85 ± 0.37	5.98 ± 0.54	5.52 ± 0.26	5.24 ± 0.36

a, b: Mean values within a column with different lower-case symbols differ significantly ($p < 0.05$) in breed comparison.
A, B, C, D: Mean values within a row with different capital letters differ significantly ($p < 0.05$) in period comparison.

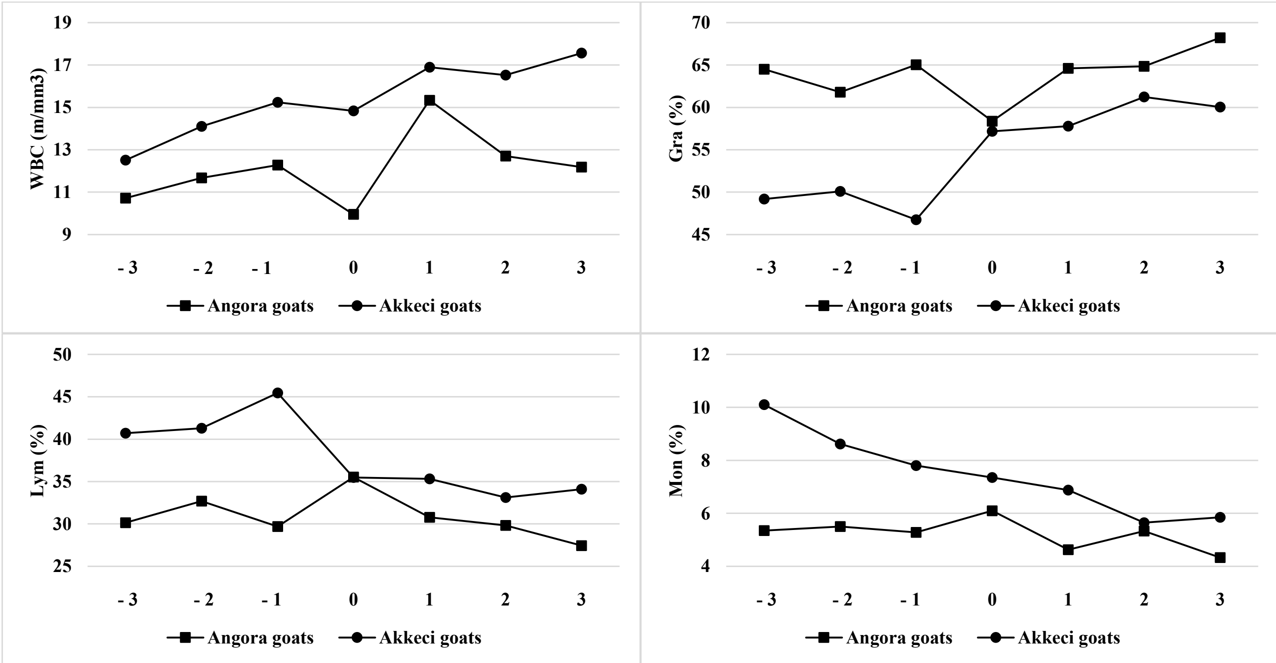

Figure 2. The patterns of changes in total leukocyte counts (WBC) and differential leukocyte (granulocyte, lymphocyte, and monocyte) distributions in Angora and Akkeçi goats during the transition period.

counts from the 3rd week to the 1st week before parturition, a decrease in the week of parturition, a significant increase in the postpartum period and then fluctuating trend were observed. It can be argued that the decrease in both breeds during parturition week is due to the increased glucocorticoid concentrations in the circulation due to the stress occurring in this period. In fact, it has been reported that increasing glucocorticoid levels weaken the immune response and increase the formation of neutrophils by decreasing the amount of lymphatic tissue and the number of lymphocytes and eosinophils at the cellular level [9]. It can also be argued that the significant increase at the beginning of the postpartum period is due to the increase in granulocytes. Indeed, in this study, while granulocyte levels increased in both breeds during the same period, lymphocyte and monocyte levels decreased (Figure 2). Similar findings have been reported in other studies conducted on different goat breeds [3,7,8].

Platelet profile

In this research, descriptive values of the change in platelet counts (THR) and platelet indices (MPV, Pct, and PDW) in Angora and Akkeçi goats during the transition period are given in Table 3. As a result of the analysis of variance, the differences between the means of the breeds for THR and Pct were not found to be statistically significant ($p > 0.05$), while the differences between the mean levels of the periods for MPV and PDW were found statistically significant ($p < 0.05$).

In Figure 3, the graph of change in platelet counts (THR) and platelet indices (MPV, Pct, and PDW) in Angora and Akkeçi goats during the transition period are given. As Figure 3 shows, THR counts and platelet indices (MPV, Pct, and PDW) followed a fluctuating trend in both breeds during the transition period. The platelet profile findings obtained from this study were consistent with the reference values reported by Frandson et al. [10] for mammalian species.

3.2. Biochemical parameters

In this study, descriptive values of the change in biochemical parameters in Angora and Akkeçi goats during the transition period are given in Table 4. As a result of the statistical analysis, the differences between the mean levels of the breeds for Glu were not found to be statistically different ($p > 0.05$). However, the differences between the mean levels of the periods for TP were found statistically significant ($p < 0.05$), while the differences between the mean level of both periods and breeds for Chol were found to be statistically significant ($p < 0.05$). Breed × period interactions were statistically different ($p < 0.05$) for Ca, P and Tri.

In Figure 4, the graph of change in glucose (Glu), cholesterol (Chol), triglycerides (Tri), Ca, P and total proteins (TP) in Angora and Akkeçi goats during the transition period are given. As Figure 4 shows, although the glucose concentrations were not statistically significant in both breeds, they increased in the last period of

Table 3. Descriptive values of platelet counts (THR) and platelet indices (MPV, Pct, and PDW) in Angora and Akkeçi goats during the transition period.

Breeds		- 3	- 2	- 1	0	+ 1	+ 2	+ 3
Angora goats (n = 4)	**THR** (m/mm3)	247.0 ± 29.3	177.0 ± 21.2	197.0 ± 33.5	187.5 ± 16.8	194.5 ± 17.4	198.3 ± 20.4	249.8 ± 51.2
	MPV (fl)	5.00 ± 0.08	5.25 ± 0.06	5.18 ± 0.11	5.20 ± 0.01	5.18 ± 0.03	5.20 ± 0.07	5.03 ± 0.10
	Pct (%)	0.12 ± 0.01	0.09 ± 0.01	0.10 ± 0.02	0.10 ± 0.01	0.10 ± 0.01	0.10 ± 0.01	0.12 ± 0.02
	PDW	4.83 ± 0.47	4.08 ± 0.38	4.35 ± 0.44	4.20 ± 0.26	4.20 ± 0.20	4.23 ± 0.28	5.25 ± 0.56
Akkeçi goats (n = 6)	**THR** (m/mm3)	177.3 ± 15.3	180.2 ± 32.1	151.0 ± 24.8	197.3 ± 57.1	173.0 ± 21.9	195.5 ± 28.2	202.7 ± 17.6
	MPV (fl)	5.23 ± 0.06	5.20 ± 0.70	5.30 ± 0.05	5.22 ± 0.14	5.23 ± 0.07	5.12 ± 0.06	5.05 ± 0.04
	Pct (%)	0.09 ± 0.01	0.08 ± 0.02	0.08 ± 0.01	0.10 ± 0.02	0.09 ± 0.01	0.10 ± 0.01	0.10 ± 0.01
	PDW	5.07 ± 0.62	5.68 ± 0.30	4.87 ± 0.53	4.87 ± 0.51	5.02 ± 0.51	5.60 ± 0.36	6.28 ± 0.34
General (n = 10)	**THR** (m/mm3)	205.2 ± 17.9	178.9 ± 20.1	169.4 ± 20.3	193.4 ± 33.6	181.6 ± 14.6	196.6 ± 17.9	221.5 ± 22.6
	MPV (fl)	5.14 ± 0.06 **AB**	5.22 ± 0.05 **A**	5.25 ± 0.05 **A**	5.21 ± 0.08 **A**	5.21 ± 0.04 **A**	5.15 ± 0.05 **AB**	5.04 ± 0.05 **B**
	Pct (%)	0.10 ± 0.01	0.09 ± 0.01	0.09 ± 0.01	0.10 ± 0.01	0.09 ± 0.01	0.10 ± 0.01	0.11 ± 0.01
	PDW	4.97 ± 0.40 **B**	5.04 ± 0.35 **B**	4.66 ± 0.36 **B**	4.60 ± 0.33 **B**	4.69 ± 0.33 **B**	5.05 ± 0.32 **B**	5.87 ± 0.33 **A**

A, B: Mean values within a row with different capital letters differ significantly ($p < 0.05$) in period comparison.

pregnancy, decreased from this week to the first week after parturition, and then followed a fluctuating trend. In this study, it can be argued that the decrease in glucose concentrations at the week of parturition may be due to the energy need of the goats at that time and the increase in energy transfer to the fetus during this process. In fact, this was also reported in the study by Khan and Ludri [11]. However, in the studies conducted by Soares et al. [2] in crossbred goats and by Zamuner et al. [12] in dairy goats, contrary to the findings obtained from this study, it was stated that there was an increase in glucose concentrations at the time of birth and this increase was due to the gluconeogenesis and lipolysis processes due to the stress that occurred during parturition. Additionally, in this study, glucose concentrations decreased in the first week after parturition in both breeds, and the decrease was more dramatic in Akkeçi goats. It can be argued that this situation is due to the negative energy balance that occurs after parturition and lactose synthesis in the mammary gland with the onset of lactation. Thus, in the studies conducted by Sadjadian et al. [13], Radin et al. [14], and Soares et al. [2], it has been reported that this decrease in the first weeks of lactation is due to the increased demand for blood glucose for high levels of lactose production, especially in goats with a high milk yield.

In this study, fluctuating trends were observed in cholesterol levels in both breeds until the parturition, and significant increases occurred after parturition (Figure 4). With the onset of lactation, especially in animals with high milk yield, due to the decrease in feed consumption, in cases where the energy needed by the organism cannot be met, a negative energy balance occurs, and the energy

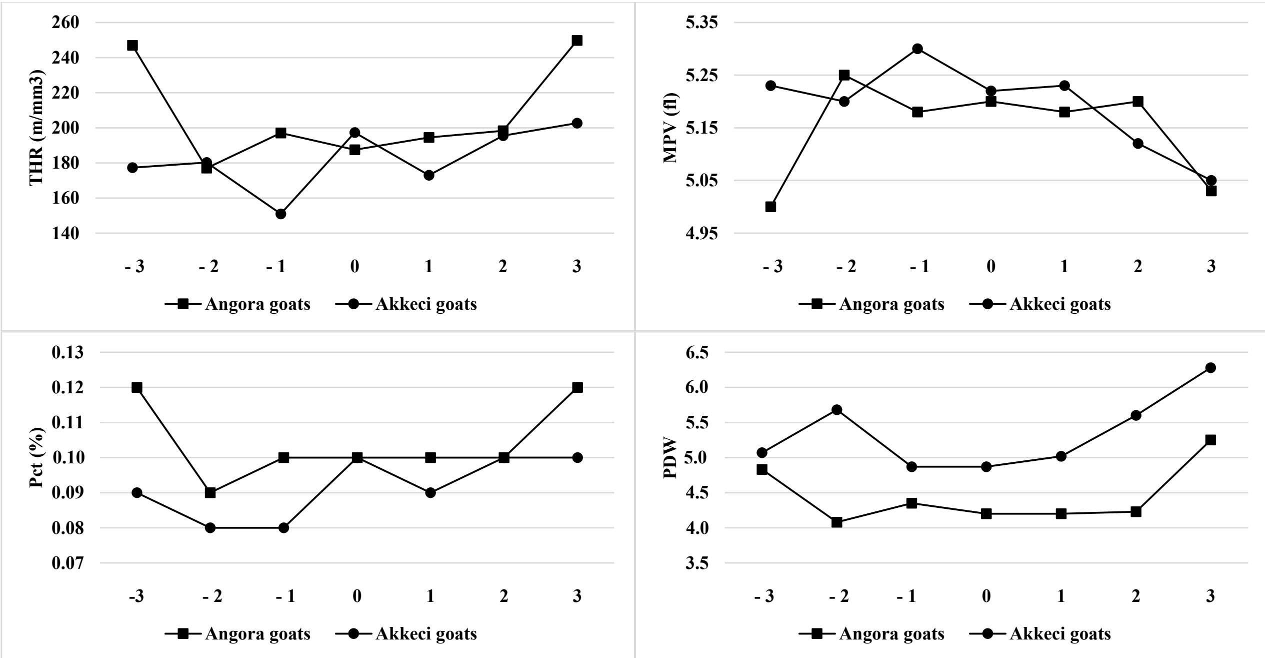

Figure 3. The patterns of changes in platelet counts (THR) and platelet indices (MPV, Pct, and PDW) in Angora and Akkeçi goats during the transition period.

needed by the body is tried to be met by passing the storage fats into the blood through lipolysis [15]. Indeed, in this study, the increase in cholesterol levels was found to be higher, especially in Akkeçi goat breeds with higher milk yield levels. Similar findings have been reported by Sadjadian et al. [13], Akkaya [1] and Salar et al. [16] in Saanen goats, by Tanrıtanır et al. [17] in hair goats, by Anwar et al. [18] in Anglo-Nubian, Angora, Baladi, and Damascus goats, by Soares et al. [2] in dairy goats and by Madan et al. [19] in Beetal goats.

As Figure 4 shows, serum triglyceride levels of goats peaked two weeks before parturition in both breeds and it decreased from this week until the first week of lactation. It has been reported that similar decreases occurred during the same period in studies conducted in different goat breeds [1,2,3,13,14,19–21]. In these studies, it has been suggested that the significant decrease in triglyceride levels is due to the uptake of triglycerides from the blood for milk fat synthesis by the mammary gland with the onset of lactation. As a matter of fact, in this study, with the onset of lactation, significant decreases were observed in blood triglyceride levels in both goat breeds (Figure 4).

In this study, an increase in Ca levels up to 1 week before parturition and a significant decrease from this week until the first week of lactation were observed in both breeds (Figure 4). It can be said that the decrease in Ca concentrations in the postpartum period is due to the transfer of Ca from blood to milk with the onset of lactation. As a matter of fact, it has been reported in studies [2,3,16,21,22] conducted in different goat breeds that the decreased blood Ca concentration in the postpartum period is due to colostrum and milk production.

As Figure 4 shows, while fluctuating trends were observed before parturition in P levels, a significant increase occurred after birth in both breeds. It can be said that this increase in the postpartum period may be due to feeding, as well as due to the decrease in blood Ca levels in the same period. As a matter of fact, it has been reported that serum phosphorous levels increase in women during lactation/breastfeeding due to phosphate resorption from the maternal skeleton, renal reabsorption, and increased intestinal absorption [23]. Findings obtained from this study regarding blood P levels in the postpartum period were found to be consistent with the findings obtained from other studies performed in goats [1,3,8,16,24].

In this study, while the total protein concentration followed fluctuating trends, there was a significant decrease, especially in the first week after parturition in both breeds (Figure 4). It can be suggested that this decrease in both genotypes is due to the onset of lactation and protein transfer from the blood tissue to the colostrum secretion, which has a high protein content, due to colostrogenesis. Indeed, Soares et al. [2] reported a similar finding in a study on crossbred dairy goats, and it was reported that this may be related to the transfer of blood globulins directly from the blood to the mammary gland for colostrogenesis. Thus, Soares et al. [2], a similar finding was reported in a study on crossbred dairy goats,

Table 4. Descriptive values of glucose (Glu), cholesterol (Chol), triglycerides (Tri), Ca, P and total proteins (TP) in Angora and Akkeçi goats during the transition period.

Breeds		**- 3**	**- 2**	**- 1**	**0**	**+ 1**	**+ 2**	**+ 3**
Angora goats (n = 4)	**Glu** (mg/dL)	52.25 ± 4.91	62.00 ± 4.53	64.75 ± 4.66	62.50 ± 2.53	61.25 ± 7.41	67.00 ± 4.30	53.50 ± 2.50
	Chol (mg/dL)	59.00 ± 4.71	58.00 ± 2.74	62.50 ± 7.08	59.50 ± 3.86	62.50 ± 8.09	67.75 ± 4.71	75.75 ± 4.19
	Tri (mg/dL)	28.00 ± 1.35 **ABb**	35.00 ± 3.81 **Ab**	33.25 ± 2.10 **ABb**	19.00 ± 2.16 **Bb**	21.25 ± 2.50 **ABa**	21.50 ± 4.37 **ABa**	21.50 ± 1.94 **ABb**
	Ca (mg/dL)	6.08 ± 0.06 **Ca**	8.58 ± 0.08 **Aa**	8.38 ± 0.16 **ABa**	7.45 ± 0.31 **Ba**	4.75 ± 0.25 **Da**	4.10 ± 0.08 **Da**	2.43 ± 0.28 **Eb**
	P (mg/dL)	5.70 ± 0.41 **Aa**	4.38 ± 0.15 **ABb**	4.80 ± 0.38 **ABa**	3.93 ± 0.31 **Bb**	4.25 ± 0.77 **ABb**	5.45 ± 0.34 **ABb**	5.63 ± 0.79 **Ab**
	TP (g/dL)	6.18 ± 0.06	6.15 ± 0.10	6.23 ± 0.05	6.28 ± 0.10	5.98 ± 0.08	5.98 ± 0.11	5.90 ± 0.07
Akkeçi goats (n = 6)	**Glu** (mg/dL)	61.83 ± 3.20	64.83 ± 4.11	66.33 ± 3.69	58.33 ± 5.27	54.50 ± 7.00	63.00 ± 3.42	55.50 ± 11.50
	Chol (mg/dL)	77.00 ± 5.05	72.83 ± 4.97	76.83 ± 2.33	69.83 ± 3.71	77.33 ± 3.92	84.00 ± 4.68	77.50 ± 4.97
	Tri (mg/dL)	60.00 ± 4.77 **ABa**	61.83 ± 5.77 **Aa**	49.83 ± 5.24 **Ba**	53.50 ± 6.39 **Aba**	26.17 ± 1.25 **Ca**	29.33 ± 1.87 **Ca**	34.50 ± 6.31 **Ca**
	Ca (mg/dL)	6.02 ± 0.15 **Ba**	8.18 ± 0.46 **Aa**	8.28 ± 0.13 **Aa**	7.73 ± 0.07 **Aa**	4.03 ± 0.31 **Ca**	4.62 ± 0.20 **Ca**	4.78 ± 0.54 **Ca**
	P (mg/dL)	5.72 ± 0.46 **Ba**	5.85 ± 0.38 **Ba**	5.43 ± 0.43 **Ba**	5.97 ± 0.31 **Ba**	6.63 ± 0.65 **Ba**	8.07 ± 0.44 **Aa**	8.17 ± 0.27 **Aa**
	TP (g/dL)	5.92 ± 0.06	6.13 ± 0.10	5.93 ± 0.07	6.08 ± 0.07	5.82 ± 0.10	5.93 ± 0.06	6.03 ± 0.04
General (n = 10)	**Glu** (mg/dL)	58.00 ± 3.01	63.70 ± 2.93	65.70 ± 2.74	60.00 ± 3.25	57.20 ± 5.42	64.60 ± 2.60	54.70 ± 6.69
	Chol (mg/dL)	69.80 ± 4.48 **AB**	66.90 ± 3.89 **B**	71.10 ± 3.74 **AB**	65.70 ± 3.07 **B**	71.40 ± 4.44 **AB**	77.50 ± 4.16 **A**	76.80 ± 3.27 **A**
	Tri (mg/dL)	47.20 ± 5.93	51.10 ± 5.68	43.20 ± 4.13	39.70 ± 6.78	24.20 ± 1.41	26.20 ± 2.31	29.30 ± 4.27
	Ca (mg/dL)	6.04 ± 0.09	8.34 ± 0.28	8.32 ± 0.09	7.62 ± 0.13	4.32 ± 0.23	4.41 ± 0.15	3.84 ± 0.51
	P (mg/dL)	5.71 ± 0.30	5.26 ± 0.33	5.18 ± 0.30	5.15 ± 0.40	5.68 ± 0.61	7.02 ± 0.51	7.15 ± 0.53
	TP (g/dL)	6.02 ± 0.06 **ABCD**	6.14 ± 0.07 **AB**	6.05 ± 0.06 **ABC**	6.16 ± 0.06 **A**	5.88 ± 0.07 **D**	5.95 ± 0.05 **CD**	5.98 ± 0.04 **BCD**

a, b: Mean values within a column with different lower-case symbols differ significantly ($p < 0.05$) in breed comparison.
A, B, C, D: Mean values within a row with different capital letters differ significantly ($p < 0.05$) in period comparison.

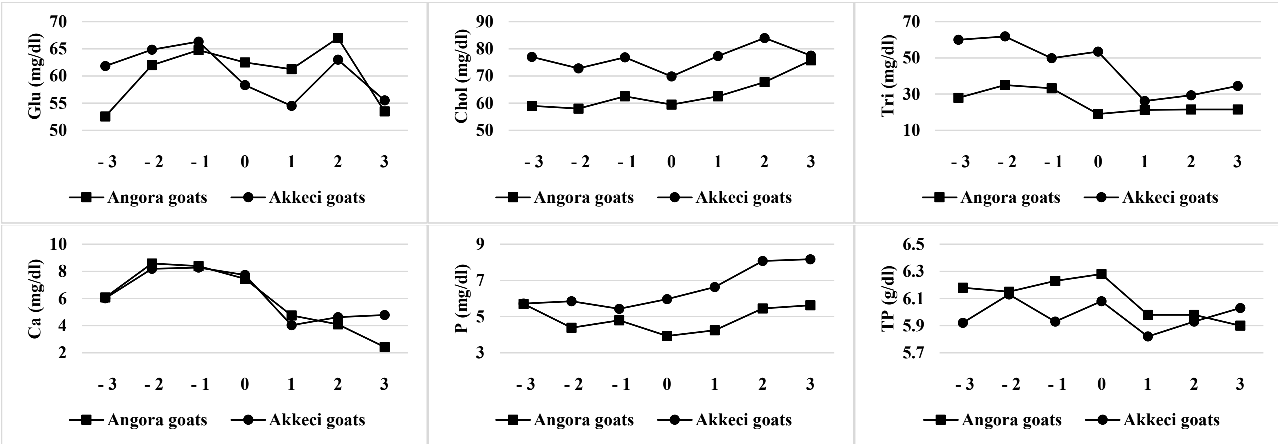

Figure 4. The patterns of changes of glucose (Glu), cholesterol (Chol), triglycerides (Tri), Ca, P and total proteins (TP) in Angora and Akkeçi goats during transition period.

and it was reported that this situation may be related to the direct transfer of blood globulins from the blood to the mammary gland for colostrum synthesis. Additionally, in some studies conducted in goats, it has been suggested that the decreases in total protein concentration in the last stages of pregnancy are due to the use of amino acids taken from the goats for fetal development [1,13,17].

In conclusion, we observed that similar important metabolic adaptations occurred in both goat breeds reared under the same conditions during the transition from pregnancy, which is a different physiological period, to lactation, which is another physiological period. These results can be used to adjust the feeding programs of animals so that economic losses during and after the transition period are kept to a minimum. Thus, it can contribute to increasing the economic profitability of livestock enterprises.

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References

1. Akkaya F. Saanen keçilerinde geçiş dönemi boyunca metabolik profillerin değerlendirilmesi. PhD, Uludağ University, Bursa, Turkey, 2017 (in Turkish).
2. Soares GSL, Souto RJC, Cajueiro JFP, Afonso JAB, Rego RO et al. Adaptive changes in blood biochemical profile of dairy goats during the period of transition. Revue de Médecine Vétérinaire 2018; 169 (1-3): 65-75.
3. Tharwat M, Ali A, Al-Sobayil F. Hematological and biochemical profiles in goats during the transition period. Comparative Clinical Pathology 2015; 24: 1-7. https://doi.org/10.1007/s00580-013-1842-1
4. Chávez J, Bernal G, Rodríguez A, Mark K, Díaz E et al. Influence of pregnancy and lactation on glucose metabolism of Nubian goats. Tropical and Subtropical Agroecosystems 2009; 11: 225-232.
5. Manat TD, Chaudhary SS, Singh VK, Sanjay Patel B, Puri G. Hematobiochemical profile in Surti goats during post-partum period. Veterinary World 2016; 9: 19-24. https://doi.org/10.14202/vetworld.2016.19-24
6. Winer BJ, Brown DR., Michels KM. Statistical Principles in Experimental Design. 3rd ed. New York, NY, USA: McGraw-Hill Companies; 1991.
7. Azab ME, Abdel-Maksoud HA. Changes in some hematological and biochemical parameters during prepartum and postpartum periods in female Baladi goats. Small Ruminant Research 1999; 34: 77-85. https://doi.org/10.1016/S0921-4488(99)00049-8
8. Iriadam M. Variation in certain hematological and biochemical parameters during the peri-partum period in Kilis does. Small Ruminant Research 2007: 73 (1-3): 54-57. https://doi.org/10.1016/j.smallrumres.2006.11.001
9. Squires EJ. Applied animal endocrinology. Cabi Publushing, ISBN: 0-85199-594-2, USA. pp. 234. 2003.
10. Frandson RD, Wilke WL, Fails AD. Anatomy and Physiology of Farm Animals. Seventh editions, pp. 512, John Wiley & Sons - New York, NY. 2009.
11. Khan JR, Ludri RS. Hormone profile of crossbred goats during the periparturient period. Tropical Animal Health and Production 2002; 34: 151-162. https://doi.org/10.1023/A:1014270207145

12. Zamuner F, DiGiacomo K, Cameron AWN, Leury BJ. Endocrine and metabolic status of commercial dairy goats during the transition period. Journal of Dairy Science 2020; 103 (6): 5616-5628. https://doi.org/10.3168/jds.2019-18040

13. Sadjadian R, Seifi HA, Mohri M, Naserian AA, Farzaneh N. Variations of energy biochemical metabolites in periparturient dairy Saanen goats. Comparative Clinical Pathology 2013; 22: 449-456. https://doi.org/10.1007/s00580-012-1431-8

14. Radin L, Šimpraga M, Vince S, Kostelić A, Milinković-Tur S. Metabolic and oxidative status of Saanen goats of different parity during the peripartum period. Journal of Dairy Research 2015; 82 (4): 426-433. https://doi.org/10.1017/s0022029915000552

15. Serbester U, Çinar M, Hayırlı A. Negative Energy Balance in Dairy Cattle and Its Metabolic Indicators. Kafkas Universitesi Veteriner Fakültesi Dergisi 2012; 18 (4): 705-711. https://doi.org/10.9775/kvfd.2012.6559 (in Turkish with an abstract in English).

16. Salar S, Baştan İ, Baştan A, Pekcan M, Sel T. Investigation of changes in metabolic parameters and paraoxonase-1 during the transition period in Turkish Saanen goats. Kafkas Universitesi Veteriner Fakültesi Dergisi 2018; 24 (1): 117-122. https://doi.org/10.9775/kvfd.2017.18479

17. Tanrıtanır P, Ceylan E, Dede S. Sağlıklı Siirt kıl keçilerinde doğum öncesi ve doğum sonrasında bazı kan parametrelerinin araştırılması. YYU Veteriner Fakültesi Dergisi 2010; 21 (2): 103-105 (in Turkish with an abstract in English).

18. Anwar MM, Ramadan TA, Taha TA. Serum metabolites, milk yield, and physiological responses during the first week after kidding in Anglo-Nubian, Angora, Baladi, and Damascus goats under subtropical conditions. Journal of Animal Science 2012; 90: 4795-4806. https://doi.org/10.2527/jas.2012-5236

19. Madan J, Sindhu S, Rose MK. Changes in plasma biochemical parameters and hormones during transition period in Beetal goats carrying single and twin fetus. Veterinary World 2020; 13 (6): 1025-1029. https://doi.org/10.14202%2Fvetworld.2020.1025-1029

20. Skotnicka E, Muszczyński Z, Suska M. Effect of The periparturient period on serum lipid and cholesterol lipoprotein concentrations in goats (Capra hircus). Acta Veterinaria Hungarica 2011; 59 (4): 445-454. https://doi.org/10.1556/avet.2011.032

21. Eşki F, Taşal İ, Karslı MA, Şendağ S, Uslu BA et al. Concentrations of NEFA, β-HBA, triglycerides, and certain blood metabolites in healthy colored Angora goats during the peripartum period. Turkish Journal of Veterinary & Animal Sciences 2015; 39: 401-405. https://doi.org/10.3906/vet-1412-25

22. Cajueiro JFDP, Souto RJC, Melo EHD, Carvalho CCD, Silva, RJD et al. Influence of calcium concentrations on the metabolic profile of dairy goats during the transitional period. Research, Society and Development 2021; l0 (11): 1-22. http://dx.doi.org/10.33448/rsd-v10i11.19462

23. Topaloğlu Ö, Şahin B, Şahin İ. Gebelikte ve laktasyonda mineral metabolizması ve hipoparatiroidizm. Kocaeli Medical Journal 2021; 10 (2): 194-204. https://dx.doi.org/10.5505/ktd.2021.26932

24. Cappai MG, Liesegang A, Dimauro C, Mossad F, Pinna W. Circulating electrolytes in the bloodstream of transition Sarda goats make the difference in body fluid distribution between single vs. twin gestation. Research in Veterinary Science 2019; 123: 84–90. https://doi.org/10.1016/j.rvsc.2018.12.016