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Evaluation of the alterations in some blood biochemical parameters and minerals during gestation period in *Damascus* goats

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Abstract:

The health of goats can be accurately predicted by examining their mineral and biochemical profiles. Numerous factors, including the environment, management techniques, gender, age, breed, season, and physiological phases of reproduction, might have an impact on these profiles. Hence, this study investigated the alterations in the metabolic profile of Damascus goats before pregnancy, during gestational, and postpartum period. For this purpose, twelve Damascus goats, bearing single fetuses, aged 3-6 years with an average weight of 40-60 kg, selected from a herd of multiparous goats in which pregnancy was obtained by estrus synchronization, were used in the study. The blood samples of that goats were collected five times from the jugular vein: before synchronization (BS), during pregnancy [55th (early pregnancy; EP), 95th (mid-pregnancy; MP), and 135th (late pregnancy; LP) days], and after parturition (PP). In blood samples, AST(SGOT) U/L, GGT U/L, BUN mg/dL, Glucose mg/dL, Cholesterol mg/dL, Total Protein g/dL, Albumin/dL, Globulin g/dL, Albumin to Globulin ratio, Calcium g/dL, Magnesium g/dL and Phosphorus g/dL concentrations were measured the evaluation of the metabolic profile. AST levels were found to be higher in all other periods (early, mid, and late pregnancy and postpartum) except before synchronization. A notable decrease in serum GGT levels after synchronization and a gradual increase, including during the gestation and postpartum periods, were detected. The different levels of blood urea nitrogen were determined in all pregnancy periods, with the highest level being detected in the MP period. In the MP period, contrary to other gestation periods, both glucose and cholesterol levels were observed to be higher. The concentration of blood proteins was observed to be markedly diminished during the LP period. Serum Ca levels increased in EP compared to BS, while the difference in Ca levels throughout pregnancy did not change statistically significantly. Serum magnesium levels exhibited a regular increase throughout the course of pregnancy. Serum P levels were found to be lower during MP. The study results indicated that cholesterol, phosphorus, albumin, and AST are the most noticeably altered parameters in the mid-pregnancy period, while blood urea nitrogen, glucose, calcium, and magnesium are the parameters more significantly altered in the postpartum period. Accordingly, it was concluded that monitoring the metabolic profile of pregnant Damascus goats from mid-pregnancy to the postpartum period may be useful in preventing possible metabolic problems.

Keywords: *Damascus* Goats; Metabolic Profile; Pregnancy

Şam keçilerinde gebelik süresince bazı kan biyokimyasal parametreleri ve minerallerindeki değişikliklerin değerlendirilmesi

Özet:

Keçilerin sağlığı, mineral ve biyokimyasal profillerinin incelenmesiyle doğru bir şekilde tahmin edilebilir. Çevre, yönetim teknikleri, cinsiyet, yaş, ırk, mevsim ve üreme sürecinin fizyolojik evreleri dahil olmak üzere çok sayıda faktör bu profiller üzerinde etkili olabilir. Bu nedenle, bu çalışmada gebelik öncesi, gebelik ve doğum sonrası dönemlerde Şam keçilerinde metabolik profildeki değişiklikler araştırıldı. Bu amaçla çalışmada, östrus senkronizasyonu ile gebelik elde edilen multipar keçilerden oluşan bir sürüden seçilen, 3-6 yaş arası, ortalama 40-60 kg ağırlığında, tek fötus taşıyan 12 Şam keçisi kullanıldı. Keçilerden juguler ven'den senkronizasyondan önce, gebelik sırasında [55. (erken gebelik), 95. (orta gebelik) ve 135. (geç gebelik) gün] ve doğumdan sonra olmak üzere beş kez kan örnekleri alındı. Kan örneklerinde AST(SGOT) U/L, GGT U/L, BUN mg/dL, Glukoz mg/dL, Kolesterol mg/dL, Toplam Protein g/dL, Albümin/dL, Globulin g/dL, Albümin/Globulin oranı, Kalsiyum g/dL, Magnezyum g/dL ve Fosfor g/dL konsantrasyonları metabolik profilin değerlendirilmesi amacıyla ölçüldü. AST düzeylerinin senkronizasyon öncesi hariç diğer tüm dönemlerde (erken, orta, geç gebelik ve doğum sonrası) daha yüksek olduğu görüldü. Senkronizasyondan sonra serum GGT düzeylerinde belirgin bir azalma, gebelik ve doğum sonrası dönemleri de kapsayan kademeli bir artış tespit edildi. Kan üre azotu düzeyleri tüm gebelik dönemlerinde farklı düzeylerde saptandı, en yüksek düzey orta gebelik döneminde tespit edildi. Bu dönemde diğer gebelik dönemlerinden farklı olarak hem glukoz hem de kolesterol düzeyi daha yüksek izlendi. Geç gebelik döneminde kan proteini konsantrasyonunun belirgin olarak azaldığı izlendi. Serum kalsiyum düzeyleri erken gebelikte senkronizasyon öncesine kıyasla artarken, gebelik boyunca kalsiyum düzeyleri arasındaki fark istatistiksel olarak anlamlı bir şekilde değişmedi. Serum magnezyum düzeyleri gebelik boyunca düzenli bir artış gösterdi. Serum fosfor düzeylerinin orta gebelikte daha düşük olduğu bulundu. Çalışma sonuçları, kolesterol, fosfor, albümin ve AST'nin gebelik ortasında belirgin şekilde değişen parametreler olduğunu, kan üre azotu, glikoz, kalsiyum ve magnezyumun ise doğum sonrası dönemde daha fazla değişen parametreler olduğunu gösterdi. Buna göre, gebe Şam keçilerinin metabolik profilinin gebelik ortasından doğum sonrası döneme kadar izlenmesinin olası metabolik sorunları önlemede yararlı olabileceği kanaatine varıldı.

Anahtar kelimeler: Gebelik; Metabolik Profil; Şam Keçileri

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Introduction

Small ruminant husbandry is a sector that contributes to the environment through the consumption of agricultural residues, mostly practiced in rural areas, and also plays an important role economically by providing income and employment (Mansour et al., 2024). Goats are among the most valuable animals to people all across the world (Bamerny et al., 2022). The ability of goats to adapt to diverse climatic conditions in tropical and subtropical regions is a defining characteristic that enables them to efficiently utilize low-quality forage and thrive in the most challenging environments (Bamerny et al., 2022; Mansour et al., 2024).

Blood biochemical parameters assist in the determination of energy, protein, enzymatic, hormonal, and mineral profiles, as well as the objective evaluation of the nutritional status, milk production, and health status of animals (Waziri et al., 2010; Rawat et al., 2021). In addition, blood biochemical measures such as free fatty acids, total serum protein, triglycerides and urea are useful indicators of an animal's nutritional and health status (Gupta et al., 2007; Bamerny et al., 2022). Cholesterol serves a critical metabolic function as a precursor for steroid hormones, bile acids, and certain vitamins (Abdul-Rahaman et al., 2019). Moreover, cholesterol is also involved in the biosynthetic process of progesterone, a hormone produced by the corpus luteum and placenta that maintains pregnancy (Abdul-Rahaman et al., 2019).

Numerous stressful situations have been shown to affect blood biochemical and hematological parameters. These include nutritional factors, age, gender, breed, housing conditions, starvation, environmental factors, transportation, pregnancy, and lactation (Waziri et al., 2010; Rawat et al., 2021). Previous research on biochemical blood parameters found alterations in the activity and metabolism of liver enzymes during lactation and dry periods in ruminants (Stojević et al., 2005; Karapehlivan et al., 2007; Bamerny et al., 2022). In addition, there are studies showing that there are large variations in biochemical and hematological parameters among different goat breeds (İriadam, 2007; Njidda et al., 2013; Al-Bulushi et al., 2017; Sarıbay et al., 2020; Bamerny et al., 2022).

Pregnancy and lactation are two important physiological states that affect metabolic processes in mammals (İriadam, 2007). Nutritional requirements are known to increase in both, particularly during the late stages of pregnancy and the early postpartum period (Goff and Horst, 1997). In addition, eighty percent of the fetal development is completed in the late stages of pregnancy, resulting in a major increase in nutritional requirements. Although voluntary feed intake is reduced there is a high protein demand for mammary development and colostrum production (Bell, 1995). Minerals play a crucial role in animal nutrition. They have a significant role in regulating the physiological functions associated with the postpartum period. It can be hypothesized that the physiological stage may alter the animal's requirements for these components. As a result, in response to these crucial events, alterations in the metabolic profile of animals may occur, influencing the concentration of biochemical parameters in small ruminants (Ahmed et al., 2000; Sobiech et al., 2008; Allaoua and Mahdi, 2018).

The metabolic profile analysis (MPA) is a quantitative test that is commonly employed to facilitate the early diagnosis of several metabolic disorders and to monitor the health status of animals within a flock (Akkaya et al., 2020). To evaluate MPA, various blood parameters, including liver enzymes (Aspartate aminotransferase (AST), Gamma-glutamyl transferase (GGT)), proteins (Total protein, albumin, globulin, and ratios), glucose, cholesterol, blood urea nitrogen (BUN), and minerals (calcium (Ca), magnesium (Mg), and inorganic phosphorus (P)) can be measured in goats (Akkaya et al., 2020).

The objective of this study was to evaluate the changes in MPA in Damascus goats during the pre-pregnancy, early, mid and late pregnancy and post-partum periods.

Material and Methods

Animals

The study was performed on twelve Damascus goats aged 3-6 years with an average weight of 40-60 kg, selected from a herd of multiparous goats in which pregnancy was achieved by estrus synchronisation. The animals were grazed on pasture for 12-14 hours, and no supplementary feeding was administered to the animals. Clean and fresh water was provided to the animals daily.

Estrus synchronization and pregnancy diagnosis

Estrus of goats were synchronized during the breeding season (August) with the intravaginal sponge application containing 60 mg medroxyprogesterone acetate (Esponjavet, Hipra, Spain) for nine days and intramuscular injection of 0.075 mg d-cloprostenol (Senkrodin ®, Vetas, Turkey) and 400 IU PMSG (PMSG-Intervet®, Turkey) on the day of sponge removal. Goats in standing heat were mated naturally with fertile male goats. Pregnancy diagnosis performed twice by transrectal ultrasonographic examination on the 35th day and transabdominal ultrasonographic examination on the 55th day post-mating. This was performed using a 6-8 MHz probe ultrasound device (Falco 100, Pie Medical, Netherlands). The hairless region above the mammary gland located ventral to the right fossa paralumbal was chosen for ultrasound imaging (Dinç et al., 1994). Pregnancy results were considered positive when a fluid-filled uterus, placentoma, moving fetus and heartbeat were observed together.

Metabolic profile analysis

Following the pregnancy examinations, a total of 12 goats bearing single fetuses were included in the study. Blood samples were collected by jugular venipuncture into tubes containing no anticoagulant from goats before synchronization (BS), during pregnancy [55th (early pregnancy; EP), 95th (mid pregnancy; MP), and 135th (late pregnancy; LP) days], and after parturition (PP). Blood samples were centrifuged at 3000 rpm for 10 minutes, and sera were separated. The separated sera were transferred to Eppendorf tubes and stored in a deep freezer at -20 ºC until analysis. AST (SGOT) U/L, GGT U/L, BUN mg/dL, Glucose mg/dL, Cholesterol mg/dL, Total Protein g/dL, Albumin/dL, Globulin g/dL, Albumin to Globulin ratio, Calcium g/dL, Magnesium g/dL and Phosphorus g/dL concentrations were measured from serum samples of BS, EP, MP, LP and PP days. All measurements were performed via the automated blood chemistry analyzer (BT 3000 Plus, Biotecnica Instruments, Italy).

Statistical Analysis

For categorical variables, descriptive statistics were presented as frequencies and percentages, and for continuous variables, as arithmetic means and standard errors. The normality assumption was tested using the Shapiro-Wilk test. Repeated measures ANOVA test was used to determine the effect of the gestation period time on selected metabolic profile parameters in goats. In the analysis of variance for repeated measures, the univariate (classical analysis of variance-uncorrected results) or multivariate approach (multivariate approach-corrected results), the distribution characteristics of the data, Mauchly's Test of Sphericity result and epsilon value were taken into consideration (Singh et al., 2013). Analysis of variance with Bonferroni correction was used for within-group statistical analysis. P values of less than 0.05 were considered statistically significant. All statistical analyses were performed in Statistical Package Program for Social Science (SPSS, version 26.0) software program for Windows (IBM Corp, Armonk, NY, USA).

Results

The results of the study showed that cholesterol, phosphorus, albumin and AST were the parameters most significantly altered in the mid-pregnancy period. Blood urea nitrogen, glucose, calcium and magnesium were the parameters more significantly altered in the post-partum period. The alterations in selected blood serum parameters and minerals during gestation period were given in Table 1 and illustrated by Figures 1-5.

Table 1. Seasonal changes in metabolic profile parameters in goats (mean±SEM).

Parameters		BS	EP	MP	LP	PP	P*
AST(SGOT)	U.L^{-1}	57.417±2.472^{e}	70.250±2.829^{c}	83.500±2.707^{ab}	75.333±3.594^{bc}	69.583±3.692^{dc}	0.000
GGT	U.L^{-1}	73.000±2.576^{abc}	61.583±3.406^{e}	63.833±2.573^{de}	65.667±2.447^{cde}	70.083±3.401^{bd}	0.023
BUN	mg.dL^{-1}	6.725±0.496^{de}	9.850±0.732^{c}	15.258±0.645^{b}	4.783±0.367^{e}	18.792±1.057^{a}	0.000
Glucose	mg.dL^{-1}	41.167±2.486^{bc}	36.250±1.523^{cd}	47.417±0.973^{ab}	33.750±2.219^{ce}	53.083±2.083^{a}	0.000
Cholesterol	mg.dL^{-1}	33.917±1.564^{bce}	34.500±1.877^{de}	43.333±2.571^{a}	41.500±1.654^{abd}	38.583±2.999^{acd}	0.013
Total Protein	g.dL^{-1}	7.333±0.166^{ac}	7.750±0.188^{a}	7.442±0.118^{ab}	6.475±0.146^{de}	6.625±0.205^{bcd}	0.000
Albumin	g.dL^{-1}	3.817±0.067^{ce}	4.117±0.099^{abc}	4.083±0.058^{b}	3.517±0.081^{d}	3.408±0.125^{de}	0.000
Globulin	g.dL^{-1}	3.517±0.143^{ab}	3.633±0.125^{a}	3.358±0.087^{ace}	2.958±0.096^{be}	3.217±0.144^{ade}	0.000
Alb/Glob		1.109±0.058	1.143±0.036	1.224±0.032	1.198±0.037	1.080±0.058	0.156
Calcium	mg.dL^{-1}	10.267±0.167^{cd}	10.900±0.278^{a}	10.250±0.228^{ad}	10.825±0.176^{ab}	8.892±0.648^{cde}	0.018
Magnesium	mg.dL^{-1}	2.308±0.042^{d}	2.717±0.085^{c}	3.067±0.058^{b}	3.442±0.097^{a}	2.167±0.113^{de}	0.000
Phosphorus	mg.dL^{-1}	4.525±0.321^{a}	4.358±0.284^{ab}	2.708±0.294d^{e}	3.975±0.243^{ac}	3.533±0.359^{ad}	0.000
Ca/Phos		2.429±0.221b^{ce}	2.605±0.157^{cde}	4.250±0.417^{a}	2.833±0.171^{abd}	2.673±0.185^{ac}	0.000

BS: before synchronization, EP: early pregnancy (55th day), MP: mid pregnancy (95th day), LP: late pregnancy (135th day), PP: After parturition.
a,b,c,d,e: defines the difference between the columns at the P<0.05 level.
*Repeated measurement ANOVA was used.

Discussion

Many analytes are known to undergo significant pre- and postpartum physiological changes. These changes are physiological variations and do not always indicate disease (Tharwat et al., 2015). For example, enzymatic elevations related to the liver may be observed during lipid metabolism, which occurs in the liver to provide energy (Tharwat et al., 2012; Tharwat et al., 2015). Sarıbay et al (2020) reported that AST levels in Damascus goats before synchronization and those carrying single fetus were determined to be 76.9±2.7 and 75.5±3.1 U/L, respectively. In this study, AST levels in other periods (early, mid-, and late pregnancy and postpartum), except during the synchronization period were found to be similar to the results of Sarıbay et al. (2020), and were to be higher in these periods, consistent with the study of Bamerny et al. (2022). Similar to Madan et al., (2020), the highest level of AST was determined in the mid-pregnancy period (Table 1 and Figure 1). The activity of this enzyme (AST) may increase as a result of the essential requirement for amino acids in milk production during the late period of pregnancy or due to changes in liver metabolism during the specified periods (Bamerny et al., 2022). In addition, increased fetal needs during the period may have also influenced this result.

Gamma-glutamyl transferase (GGT) is a membrane-associated enzyme present in cells characterized by elevated secretion or absorption rates. It is evident that elevated activity is observed in the majority of parenchymatous organs, including the liver, spleen, kidneys, pancreas, and intestine (Djuricic et al., 2011). The regulation of amino acid transport into cells via the Gama-glutamine cycle is one of the recognized activities of GGT (Leibova et al., 2016). Although GGT activity can be observed in several tissues, it is primarily utilized as a serum marker for the diagnosis of liver disease in animals. Some authors posit that the enzyme is linked to the metabolism of glutathione, which plays a significant role in the overall antioxidative state of the body (Kramer and Hoffmann, 1997; Milinković-Tur et al., 2005). It is uncertain how serum GGT and cellular GGT relate to one another, however cellular GGT has been shown to be crucial for antioxidant defense mechanisms (Lim et al., 2004). Besides, it is informed that doe colostrum contains a substantial quantity of GGT. The neonatal intestinal wall permits the passage of colostrum GGT and colostral antibodies into the plasma (Kramer and Hoffmann, 1997). Tharwat et al., (2015) report an increase in GGT activity following parturition in pregnant goats. In this study, a notable decrease in blood serum GGT levels after synchronization was observed, followed by a gradual increase throughout the gestation and postpartum periods. However, the elevation observed in GGT levels during gestation was not found to be significant. Conversely, the GGT levels detected in the early pregnancy period were significantly lower than those measured both before synchronization and in the postpartum period (Table 1 and Figure 1). The decrease in GGT levels in early pregnancy may be related to the depletion of body reserves as an antioxidant response to pregnancy at a cellular level, while the high levels in the postpartum period may be related to increased production of colostrum for passive transfer to the kid.

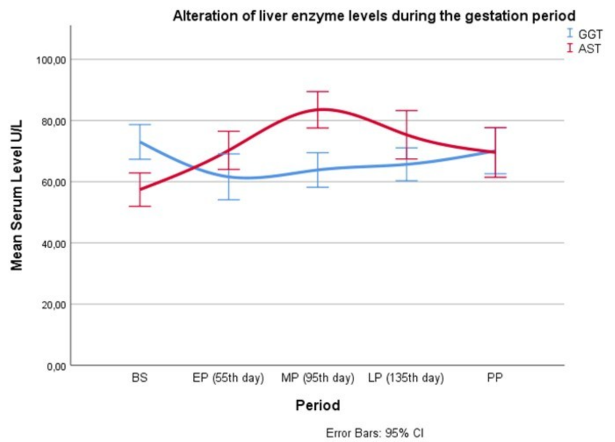

Figure 1. Alteration in liver enzymes level

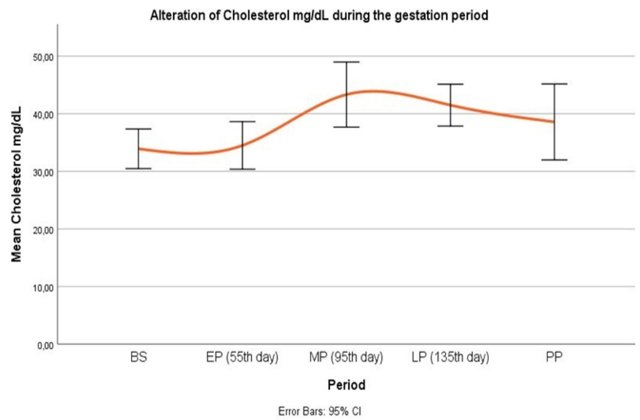

Figure 2. Alteration of cholesterol level

Urea, free fatty acids, triglycerides, and serum total protein are all blood biochemical indicators that reflect an animal's nutritional and health state (Gupta et al., 2007; Bamerny et al., 2022). Alterations observed in urea concentration during pregnancy in goats are associated with protein catabolism and amino acid deamination to meet energy requirements (Madan et al., 2020). The reduction in feed intake resulting from stress and hormonal alterations during the kidding period may lead to a decline in blood urea concentrations in goats around the time of parturition (Madan et al., 2020). In addition, the authors noted a potential reduction in glomerular filtration and urea clearance during the late stages of pregnancy (Rodriguez et al., 1996). Nevertheless, it has been reported that a notable elevation in blood urea nitrogen levels has been documented in various goat breeds during the postpartum period (Sadjadian et al., 2013; Madan et al., 2020). Belkacem et al. (2024) reported that the period when blood urea levels are highest during pregnancy in Damascus goats is the mid-gestation period. Idamokoro et al. (2019) revealed that there may be higher blood urea levels in the postpartum period compared to the late pregnancy period. On the other hand, a study reported that urea levels are lower in pregnant goats than in non-pregnant goats (Abdul-Rahaman et al., 2019). In this study, different levels of blood urea nitrogen were determined in all pregnancy periods, with the highest level being detected in the mid-gestation period (Table 1). Furthermore, the lowest level was determined in late pregnancy, and the highest level was also determined in the postpartum period (Figure 4). Hereby, the study's results appear to be consistent with those of previous studies. The occurrence of periodic differences in urea levels during pregnancy may be associated with protein catabolism and amino acid deamination, which serve to meet the energy requirements at varying levels throughout the gestational period. Furthermore, the lowest level in late pregnancy may be attributed to a reduction in feed intake resulting from stress and hormonal changes that occur close to parturition.

The developing fetus, uterus, and placenta need the energy provided by direct glucose or glucose derived by hepatic glycogenolysis and gluconeogenesis from glucose precursors (Madan et al., 2020). It has been reported that the fetus demands more glucose, and there is an advantageous connection between the fetal abdomen circumference and maternal blood glucose levels (Parretti et al., 2001; Madan et al., 2020). The glucose level in Damascus goats in carrying a single fetus was detected to be 64.1± 2.8 mg.dL-1 by Sarıbay et al., (2020). Madan et al. (2020) report that the glucose level in single-fetus-carrying Beetal goats was detected to be lower in mid-pregnancy (47.03±4.46 mg.dL-1) than postpartum (57.44±2.45 mg.dL-1). Additionally, Bamerny et al., (2022) stated that the level of glucose in pregnant goats was highest during the mid-pregnancy period. In this study, the postpartum glucose level was significantly higher than that of the late pregnancy period. Conversely, in the mid-pregnancy period, contrary to other gestation periods, glucose level was observed to be higher in goats in this study (Figure 3). The cholesterol levels of goats exhibit variability based on several factors, including age, gender, nutritional intake, gestational and lactation periods, and the transition phase between these stages (Lashari et al., 2021; Tekeli et al., 2024). Modifications in lipid metabolism have been identified in the gestation periods to meet maternal metabolic needs, notably energy requirements since glucose is used for fetal growth (Pusukuru et al., 2016; Madan et al., 2020). In a study (Abdul-Rahaman et al., 2019), cholesterol level was found higher in pregnant goats than non-pregnant goats. In another study, the cholesterol

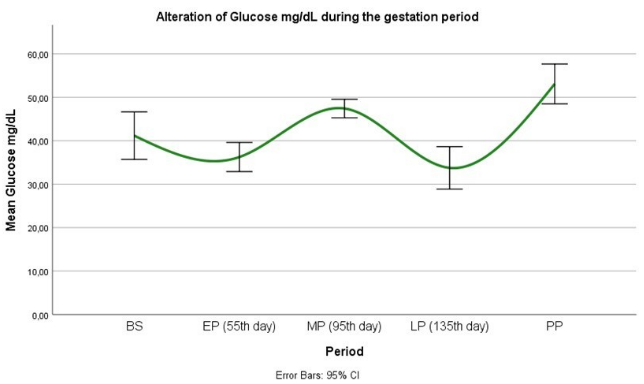

Figure 3. Alteration of glucose level

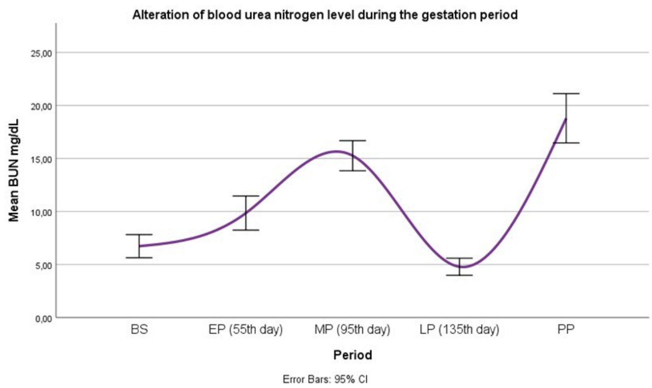

Figure 4. Alteration of blood urea nitrogen (BUN) level

level in single-fetus-carrying Beetal goats was determined to be 50.07±3.15 mg.dL-1 in mid-pregnancy period, and to be 39.82±1.88 mg.dL-1 in postpartum (Madan et al., 2020). Bamerny et al. (2022) reported that cholesterol levels in pregnant goats were the highest during the mid-pregnancy period, paralleling glucose. In contrast, Shittu et al., (2023) noted that the highest cholesterol levels in goats during the gestation period were observed in the mid-pregnancy period, but this was not the case for glucose levels. In this study, the highest cholesterol level in Damascus goats was observed during the mid-pregnancy period, and no notable alterations in cholesterol levels were observed between mid-pregnancy and postpartum (Table 1). These parallel changes observed in both glucose and cholesterol levels, especially in mid-gestation, may be related to meeting the mother's needs as well as providing the energy metabolism required for the development of the fetus. Furthermore, the notable decline in glucose levels documented in the latter stages of pregnancy in this study can be attributed to the fact that eighty percent of fetal development occurs during this period (Bell, 1995).

The accelerated growth of the fetus results in the synthesis of proteins from amino acids obtained from the mother, thereby reducing the concentration of total protein in the dam's bloodstream. This phenomenon contributes to the decline in total protein concentrations observed during late pregnancy in small ruminants (Jainudee and Hafez, 1994; Balıkcı et al., 2007; Idamokoro et al., 2019). Additionally, it is reported that the decrease in albumin in humans may be observed during pregnancy due to either decreased production or increased elimination in urine in pregnancy (Ogbodo et al., 2012; Akkaya et al., 2020). In their 2015 study, Tharwat and colleagues observed an increase in total protein and globulin levels in goats following parturition, but no change in albumin levels. Similar findings for serum proteins in goats during the transition period are also reported by Soares et al., (2018). The findings of our study indicate that, in the postpartum period, contrary to the late pregnancy period, there was a numerical increase in total protein and globulin levels, but not in albumin levels. However, these changes in the blood proteins did not reach statistical significance. On the other hand, it has been observed that the concentration of blood proteins in pregnancy decreases significantly during the last period of pregnancy (Table 1 and Figure 5). The observed increase in total protein levels in the postpartum period may be attributed to the elevated production of globulins resulting from the increased colostrum production during the final trimester of pregnancy. Conversely, the observed decline in protein levels during the late pregnancy period may be associated with the accelerated fetal development and the increased energy demands of the mother.

In addition to releasing hormones like insulin and acting as a cofactor for enzymes like those in the coagulation cascade, calcium also acts as an intracellular messenger for nerve impulse transmission, muscle contraction, blood vessel constriction and relaxation, among other functions. There is a greater need for calcium during pregnancy and lactation. Following delivery, the need for calcium increases quickly, which is linked to the excretion of significant amounts of this element through milk (Hisira et al., 2013). Processes that require energy expenditure, such as muscle contraction, blood clotting, and heart control, directly involve Ca, in addition to P and Mg, which play an important role in ATP production

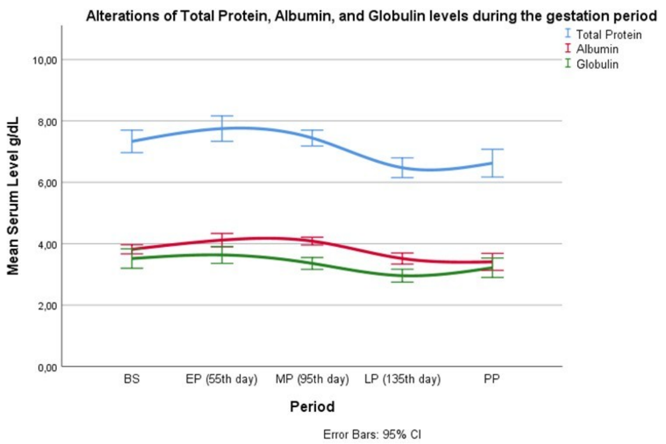

Figure 5. Alteration in serum proteins level

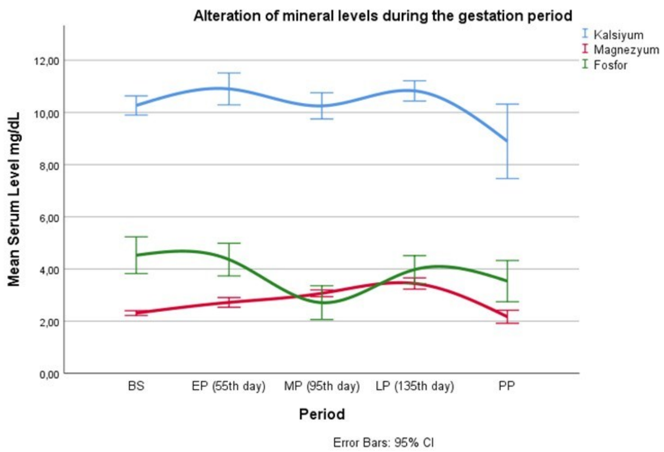

Figure 6. Alteration in minerals level

(Suttle, 2010). The physiological changes that occur throughout pregnancy are addressed by the sufficient calcium and magnesium reserves in the bodies of goats until the 80th day of pregnancy. These reserves are sufficient to meet the future development requirements unique to pregnancy (Härter et al., 2015). In order to accommodate the growing fetus and placenta, the uterus undergoes a rapid expansion during the early stages of pregnancy, driven by the proliferation of blood cells, including hemoglobin and platelets (Scheaffer et al., 2001). To meet the increased demand for these minerals, the absorption of Ca and Mg taken from food increases. Additionally, bone mobilization increases and provides additional resources. Härter et al., (2015) reported a slight increase in serum Ca levels until the 80th day of pregnancy. In their 2020 study, Sarıbay and colleagues also demonstrated that the seasons (breeding or non-breeding) and fecundity influence calcium levels in Damascus goats. In this study, serum Ca levels increased in early pregnancy compared to levels measured before synchronization, while the difference in Ca levels throughout pregnancy did not change statistically significantly. This result is compatible with the stable serum Ca levels expected in women throughout pregnancy (Kovacs, 2001). There are many studies reporting that blood Ca levels decrease in late pregnancy (Elias & Shainkin-Kestenbaum, 1990; Azab & Abdel-Maksoud, 1999; Jacob et al., 2002). However, Lincoln and Lane (1990) indicated that serum Ca concentration remains stable during pregnancy and decreases a few days after parturition. Similarly, Soares et al. (2018) reported that the calcium levels during parturition were lower than those observed in the late pregnancy period. In this study, serum Ca levels, which remained stable throughout pregnancy, including late pregnancy, were observed to decrease rapidly in the postpartum period.

Mg is required for bone development, numerous biological activities, and the regulation of enzyme function. The body requires magnesium, which is known to increase during pregnancy and lactation (Hisira et al., 2013). Thus, during the period of intensive lactation, lactating females are at risk of developing hypomagnesaemia as a result of the significant quantity of magnesium that is absorbed from dietary sources and excreted in the urine (Hisira et al., 2013). According to Yokus and Cakır (2006), cows' magnesium levels decline during pregnancy and gradually increase throughout lactation. In contrast, several studies have found that Mg levels in cows peaked at 8 months of pregnancy and then declined throughout lactation (Jacob et al., 2002; Yildiz et al, 2006). There are also studies that show that periods do not impact Mg levels in cows (Kulcu and Yur, 2003) or sheep (Dakka and Abd El-Al, 1992). As reported by Vihan and Rai (1987), prepartum periods had the lowest Mg level, followed by parturition in sheep; however, there was no significant difference between prepartum, parturition and postpartum periods in goats. Conversely, Azab and Abdel-Maksoud (1999) discovered that in Baladi goats, plasma Mg levels considerably increased at 4 and 3 weeks before parturition and declined at 2 and 1 weeks prior. The findings of our study indicate that serum magnesium levels exhibit a regular increase throughout the course of pregnancy, followed by a decline to levels observed before synchronization in the postpartum period (Table 1 and Figure 6). The goats utilized in the study were lactating at the time of synchronization and dried off in the final trimester of pregnancy. The highest serum magnesium levels observed during the LP may be explained by the body's retention of magnesium, which is required for milk production. Furthermore, this gradual increase observed during pregnancy may be associated with the regulatory role of magnesium in enzymatic activities, which is consistent with the increases in enzymatic activities observed in this study.

Animals given P-deficient diets rich in Ca may have lower P absorption due to a decrease in rumen P solubility as well as a decrease in the availability of dietary P farther down the small intestine. Milk's P content remains generally stable regardless of dietary P consumption, making it a primary source of endogenous P loss (Qureshi and Deeba, 2019). If dietary P levels are appropriate, the level of dietary calcium (Ca) has no influence on P absorption. The ideal Ca to P ratio has traditionally been established as being between 1:1 and 2:1 due to the Ca to P ratio of bones (Qureshi and Deeba, 2019). In small ruminants, a decline in bone mineralization occurs during the early stages of lactation, followed by an increase in mineral content after mid-lactation (Kovacs, 2014; Qureshi and Deeba, 2019). During pregnancy in mammals, plasma calcitriol levels rise regardless of dietary Ca shortage or PTH levels. Calcitonin levels rise owing to its synthesis in the mammary gland, placenta, and thyroid gland. The developing mammary gland and placenta create PTHrP, which stimulates bone mineralization in the fetus (Kovacs, 2014; Qureshi and Deeba, 2019). Prolactin and placental lactogen directly contribute to increased intestinal calcium absorption when calcitriol is not present. All of these elements promote bone resorption and stimulate bone metabolism, particularly in the third trimester when the growing fetus has the highest mineral deposition (Qureshi and Deeba, 2019). According to several studies, P levels in goats at various periods of growth, reproduction, pregnancy, and lactation did not significantly differ from one another (Kaushik and Bugalia, 1999; Krajnicakova et al., 2003). However, some studies have also indicated that the levels of phosphorus (P) in goats exhibit a marked increase during the latter stages of pregnancy and the postpartum period (Ahmed et al., 2000; Tanritanir et al., 2009). Pregnant sheep have been shown to have a significant decrease in plasma P levels (Sansom et al., 1982). Gürgöze et al., (2009) reported that serum P levels in sheep were found to be low enough to be below the reference range on day 120 of pregnancy. In the present study, in accordance with Gürgöze et al., (2009), serum P levels were found to be considerably low on day 95 of pregnancy (MP). This significant decrease in serum P levels may be a result of lactation and dry-off as seen in Mg levels. Furthermore, the observed alterations in calcium and phosphorus levels may also be linked to the compensatory mechanism of metabolism that serves to maintain the Ca/P ratio (Table 1) in bone mineral balance during pregnancy. However, since the midterm period of pregnancy also represents the transition from autumn pasture to winter pasture, it may also be possible that all minerals are affected by the feed consumed.

The study results indicated that cholesterol, phosphorus, albumin, and AST were the parameters most significantly altered during the mid-pregnancy period, while blood urea nitrogen, glucose, calcium, and magnesium exhibited the greatest alterations during the postpartum period. In light of the results of the study, it was concluded that performing metabolic profile analysis in pregnant Damascus goats from the mid-pregnancy period to the postpartum period may be beneficial in preventing potential metabolic complications. Furthermore, it should be considered that the amounts of the metabolites indicated may exhibit dramatic fluctuations that could be fatal, particularly in multiple pregnancies. So, to control the serum levels of metabolites that may change according to the pregnancy period in herds, veterinary practitioners can also apply different strategies thanks to metabolic profile analyses, ranging from nutritional changes to feed additives.

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