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The effects of L-carnitine administration on energy metabolism in pregnant Halep (Damascus) goats

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Abstract: The aim of this study was to determine the effects of parenteral administration of L-carnitine on some biochemical parameters in Halep (Damascus) goats during the last month of pregnancy. L-carnitine was administrated to goats in group I (n = 13) by subcutaneous injections once a week during the last month of the pregnancy. Physiologic salt solution was administered to goats in group II (n = 12) by the same route during the same period. Differences of glucose concentration between groups were not significant ($P > 0.05$). Serum β-hydroxybutyric acid (BHB) concentrations in both groups increased until parturition. However, differences between groups were not significant ($P > 0.05$). Concentration of serum NEFA (Non Esterified Fatty Acid) in group I was lower compared to group II 2 weeks before parturition ($P < 0.05$). Differences of serum triglyceride and cholesterol concentration between groups were not significant ($P > 0.05$). Level of glucose concentration in L-carnitine administered goats with twin kids was higher than the controls with twin kids in the 2nd ($P < 0.01$) and 3rd weeks ($P < 0.05$) before parturition. It was concluded that parenteral administration of L-carnitine might be a protective measure against pregnancy toxemia (ketosis) via increasing serum glucose concentration in goats with twin pregnancy.

Key words: Halep (Damascus) goat, L-carnitine, energy metabolism, prepartum, postpartum

Gebe Halep (Damascus) keçilerinde L-carnitine uygulamalarının enerji metabolizmasına etkileri

Özet: Bu çalışmada, gebeliğin son bir ayı içerisinde bulunan Halep (Damascus) keçilerinde L-carnitine uygulamalarının bazı biyokimyasal parametrelere etkisi araştırıldı. Gebeliğin son bir ayı içerisinde bulunan Grup I'deki keçilere (n = 13) bir hafta aralıklarla L-carnitine subkutan yolla uygulandı. Grup II'deki (n = 12) keçilere ise aynı dönemde subkutan yolla % 0,9'luk serum fizyolojik uygulandı. Grup I ve Grup II'deki keçilerde serum glukoz konsantrasyonları yönünden

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istatistiksel bir fark tespit edilmedi (P > 0,05). Serum β-hidroksibutirik asit (BHB) konsantrasyonunun her iki grupta doğuma kadar arttığı ve gruplar arasında istatistiksel bir fark olmadığı tespit edildi (P > 0,05). Serum NEFA (Non-Esterified Fatty Acid) konsantrasyonunun doğumdan iki hafta önce grup I'de daha düşük olduğu görüldü (P < 0,05). Gruplarda serum trigliserid ve serum kolestrol konsantrasyonları arasında istatistiksel bir fark tespit edilmedi (P > 0,05). L-carnitine uygulanan ve ikiz doğuran keçilerde serum glukoz konsantrasyonlarının doğumdan iki hafta (P < 0,01) ve doğumdan üç hafta (P < 0,05) önce kontrol grubunda ikiz doğuran keçilerden daha yüksek olduğu saptandı. Paranteral L-carnitine uygulamalarının ikiz doğum yapan keçilerde serum glukoz konsantrasyonunu arttırarak gebelik toksemisi gibi hastalıklara karşı koruyucu bir güç olabileceği sonucuna varıldı.

Anahtar sözcükler: Halep (Damascus) keçisi, L-carnitine, enerji metabolizması, prepartum, postpartum

Introduction

The Halep (Damascus) is a goat breed raised in Syria, Lebanon, Turkey, and North Cyprus primarily for milk production. Moreover, the Damascus goat has high reproductive performance (1). The high productivity of the Damascus goat, coupled with under-nutrition and unbalanced feeding during pre- and postpartum period, leads to the mobilization of body fat and protein, which would obviously be of considerable importance in determining animal productivity and, in many instances, survival. In small ruminants with high productivity, the mobilization of body fat and protein during pre- and postpartum period causes a fatty liver and clinical ketosis called pregnancy toxemia. Pregnancy toxemia can be fatal for mothers, kids and kittens and is one of the most important metabolic diseases causing big economical losses (2).

Glucose is the main energy source for goats at the fetal term (3). However, fat is not an important source of energy at this term (4). Fetal development is dependent on glucose concentration that passes to fetus from the maternal blood. The fetus's glucogenesis need is provided from maternal blood because its glucogenesis capacities do not develop at this term (2). Glucose is also used by the fetus to form fructose, glycogen, and fat (5,6).

BHB (β-hidroxybutiric acid), synthesized from fatty acids in energy deficiency, composes the main part of ketone bodies (2).

In sheep and goats with pregnancy ketosis or multiple pregnancy, blood serum concentrations of free fatty acids, triglyceride, cholesterol, urea, and creatinine were determined to be higher compared to sheep and goats without pregnancy ketosis and multiple pregnancy (7,8).

Bickhardt et al. (8) ascertained that the level of serum Ca decreases significantly in sheep and goats with hypocalcemia and also pregnancy ketosis.

L-carnitine is the form of amino acid Lysine and Methionin (9). L-carnitine is Gamma-Trimetylamino-β-Hidroxy fatty acid synthesized in brain. L-carnitine plays an important role in transforming of free fatty acids into energy. It forms free fatty acid esters and causes oxidation of free fatty-acids in mitochondria. L-carnitine has a number of functions, such as transforming fatty acids into energy, preventing ketosis, carrying ATP from mitochondria to cytosole, increasing milk rate, supporting immune system, and by this way protecting body against infections (9,10).

If L-carnitine is inadequate, β-oxidation of long chained fatty acids impaired. β-oxidation of fatty acid to support the energy need is important during the late pregnancy period (11,12). Therefore, L-carnitine added to feed has been used to protect ruminants from clinical ketosis by means of supporting the energy need appearing in late pregnancy period. However, effects of subcutaneous administration of L-carnitine during late pregnancy on pregnancy toxemia are not known.

The aim of this study was to investigate the effects of L-carnitine, administered by subcutaneous route, on energy metabolism in pregnant Damascus goats.

Materials and methods

Animals and herd management

The experiment was carried out on a farm located in Şanlıurfa (altitude 540 m) in the southeastern region of Turkey, from November to April (breeding season, 2006).

Study material consisted of 3-5 years old 25 Halep (Damascus) goats. Goats were allowed to graze on natural pasture from 07:30 to 17:30 and kept in pens from 17:30 to 07:30 during the trial. During the study, they were fed with 75% tender whole crop barley and 25% mustard straw (23% dry matter, 9.2% organic matter, 14% crude protein, 0.5% crude lipid, 24% crude cellulose, 7.2% crude ash, and 54.3% nitrogen free extract). Fresh water was available ad libitum. The management of the goat did not change during the experimental period. One Damascus male goat with proven fertility was used for insemination in the trial. The estrous signs detected were restlessness, vocalization, frequent urination, tail wagging, hyperemia and edema of the vulva, vaginal discharge, and immobility on teaser buck, which were characteristics considered as the onset of estrous. Animals were bred at the detection of estrus.

Pregnancy was determined on day 30 after breeding by transrectal ultrasonography with a 6-8 MHz linear probe using ESAOTE LC 100 (Pie Medical, Netherlands). Pregnant goats were then randomly divided into 2 groups. L-carnitine (20 mg/kg) was administrated to goats in group I by subcutaneous (sc) injection once a week during the last month of the pregnancy. Placebo (0.9% NaCl in bidistilled water) was administered by the same way in group II (control) during the last month of pregnancy.

Blood parameters

Blood samples were taken from jugular vein to vacutainer tubes with EDTA and without EDTA before every administration during the last month of pregnancy and 1 week prepartum (totally 5 blood samples were collected). To obtain the serum, the collected blood samples were centrifuged at 3000x rpm for 10 min. Sera were decanted and stored frozen at -20 °C until biochemical analyses. BHB, NEFA, glucose, triglyceride, cholesterol, urea, creatinine, and calcium in serum were determined. BHB (β-hydroxybutyric acid) and NEFA (Non-Esterified Fatty Acid) analyses were performed using commercial kits (Randox, United Kingdom). Glucose, triglyceride, cholesterol, urea, creatinine, and calcium analyses were carried out using commercial kits (Bia Mrives-France).

Statistical analysis

Results were statistically evaluated by SPSS for Windows version 14.0. Plasma metabolites were analyzed as a 2-factor t-test with group (L-carnitine and control) and period. Data are presented as mean ± standard errors and P values less than 0.05 were considered significant.

Results

It was determined by ultrasonography that 7 goats had 1 kid and 6 goats had twins in the experimental group, and 6 goats had twins, 6 goats had 1 kid in the control group.

No significant differences were observed between 2 groups in terms of serum glucose concentration ($P > 0.05$). Although no significant difference between goats with a single kid was observed, there was a significant difference in serum glucose concentrations between goat with twin kids during the 3rd ($P < 0.05$) and 2nd ($P < 0.01$) weeks prepartum (Table 1).

Regarding serum BHB concentration, no significant differences were found between group I and control group ($P > 0.05$). Serum BHB concentration decreased in group I after parturition while it increased in the control group. This increase, however, was not statistically significant ($P > 0.05$). No significant difference was detected between goats with single or twin kids in L-carnitine administered goats or the controls in terms of serum BHB concentration ($P > 0.05$, Table 2).

Two weeks before parturition, serum NEFA concentration in group I was lower compared to group II ($P < 0.05$). The concentration of NEFA increased from the beginning until parturition in both groups, but there was no significant difference between goats with single or twin kids in L-carnitine or control groups in terms of serum NEFA concentration ($P > 0.05$, Table 3).

There was no statistical significant difference between groups in triglyceride concentrations ($P > 0.05$, Table 4).

Serum cholesterol concentration decreased from 122.5 ± 14.2 mg/dL to 75.6 ± 12.9 mg/dL until the end of trial in group I. In the control group, it decreased from 119.2 ± 13.1 mg/dL to 77.6 ± 5.1 mg/dL. With regard to cholesterol concentration, no significant

Table 1. Serum glucose (mg/dL) concentrations of Damascus does.

Time	Groups					
	L-carnitine			Control		
	Mean	Single	Twin	Mean	Single	Twin
4 weeks prepartum	65.5 ± 2.1	63.5 ± 1.1	66.8 ± 1.4	64.7 ± 2.3	64.5 ± 1.5	64.4 ± 2.5
3 weeks prepartum	67.6 ± 1.4	65.3 ± 2.0	[a]67.8 ± 1.9	64.8 ± 2.7	66.0 ± 1.6	[b]64.6 ± 2.7
2 weeks prepartum	66.5 ± 1.4	65.1 ± 2.1	[c]66.9 ± 1.5	64.3 ± 1.5	64.8 ± 2.2	[d]64.3 ± 1.0
1 week prepartum	64.7 ± 2.7	64.0 ± 3.5	65.7 ± 2.2	63.7 ± 2.0	63.5 ± 2.1	63.8 ± 2.0
Parturition	58.8 ± 1.9	57.7 ± 1.4	59.5 ± 2.1	58.6 ± 1.8	58.3 ± 2.2	59.9 ± 1.8
1 week postpartum	60.4 ± 2.1	59.9 ± 2.9	60.7 ± 1.6	59.5 ± 1.9	60.8 ± 0.8	58.1 ± 2.0

a:b = $P < 0.05$ (between L-carnitine and control groups with twin pregnancy, 3 weeks prepartum)
c:d = $P < 0.01$ (between L-carnitine and control groups with twin pregnancy, 2 weeks prepartum)

Table 2. Serum BHB (mmol/L) concentrations of Damascus does.

Time	Groups					
	L-carnitine			Control		
	Mean	Single	Twin	Mean	Single	Twin
4 weeks Prepartum	0.58 ± 0.6	0.59 ± 0.06	0.57 ± 0.06	0.58 ± 0.7	0.57 ± 0.1	0.60 ± 0.02
3 weeks prepartum	0.58 ± 0.3	0.59 ± 0.06	0.60 ± 0.02	0.60 ± 0.4	0.61 ± 0.04	0.59 ± 0.04
2 weeks prepartum	0.64 ± 0.1	0.59 ± 0.04	0.63 ± 0.06	0.61 ± 0.4	0.58 ± 0.04	0.63 ± 0.02
1 week prepartum	0.70 ± 0.1	0.68 ± 0.04	0.70 ± 0.06	0.69 ± 0.1	0.67 ± 0.07	0.72 ± 0.02
Parturition	0.81 ± 0.8	0.79 ± 0.05	0.84 ± 0.07	0.80 ± 0.9	0.73 ± 0.07	0.86 ± 0.02
1 week postpartum	0.79 ± 0.1	0.77 ± 0.1	0.81 ± 0.09	0.84 ± 0.08	0.77 ± 0.06	0.91 ± 0.02

Table 3. Serum NEFA (ηm/L) concentrations of Damascus does.

Time	Groups					
	L-carnitine			Control		
	Mean	Single	Twin	Mean	Single	Twin
4 weeks prepartum	268.7 ± 3.7	268.1 ± 5.7	269.2 ± 2.2	270.7 ± 3.7	271.1 ± 3.2	272.7 ± 3.5
3 weeks prepartum	272.7 ± 3.8	269.8 ± 6.9	273.0 ± 2.9	272.6 ± 4.7	271.6 ± 2.4	273.6 ± 6.4
2 weeks prepartum	*271.5 ± 5.0	271.3 ± 2.7	272.0 ± 0.3	*275.5 ± 3.4	274.2 ± 4.9	276.6 ± 5.6
1 week prepartum	280.2 ± 3.6	277.4 ± 3.2	282.1 ± 2.6	281.0 ± 5.1	281.9 ± 5.8	280.1 ± 4.9
Parturition	297.6 ± 10.6	293.8 ± 8.1	303.1 ± 6.5	298.4 ± 6.8	295.3 ± 5.7	299.7 ± 8.1
1 week postpartum	283.4 ± 9.4	276.9 ± 9.7	287.7 ± 7.0	285.8 ± 8.9	280.8 ± 4.5	290.7 ± 9.9

*$P < 0.05$ (between L-carnitine and control groups, 2 weeks prepartum)

difference was observed between groups (P > 0.05). In goats of both groups with single or twin kids, no significant difference within each group and between groups was determined at parturition (P > 0.05, Table 5).

Serum creatinine concentration of the control group was higher than that of the experimental group 2 weeks before parturition (P < 0.05). Serum creatinine concentration in group I was 1.55 ± 0.2 mg/dL at the beginning, and 1.15 ± 0.9 mg/dL at the end of the trial. These values were 1.51 ± 0.1 mg/dL and 1.14 ± 0.3 mg/dL in the controls, respectively. There was no significant difference between groups in terms of serum creatinine concentrations measured prepartum (P > 0.05, Table 6).

For goats in L-carnitine and control groups, a statistically significant difference in serum urea concentrations at parturition and 2 weeks before parturition was observed (P < 0.05). In other periods there were no statistically significant differences (P > 0.05). A statistically significant difference was determined for goats with a single kid in both L-carnitine and control groups (P < 0.01, Table 7).

In the first period of the trial, calcium concentration (9.6 ± 0.3 mg/dL) in group I was lower than that in the control group (10.4±0.7 mg/dL) and there was a significant difference between 2 groups (P < 0.01). This difference continued until parturition. After parturition, no significant difference was found between 2 groups. Goats with single or twin kids in L-carnitine and control groups did not have important difference for serum calcium concentration during all periods (P > 0.05, Table 8).

Table 4. Serum triglyceride (mg/dL) concentrations of Damascus does.

Time	Groups					
	L-carnitine			Control		
	Mean	Single	Twin	Mean	Single	Twin
4 weeks prepartum	29.4 ± 3.5	31.8 ± 7.2	28.6 ± 2.4	27.4 ± 2.8	27.6 ± 3.8	27.4 ± 1.3
3 weeks prepartum	28.9 ± 4.4	29.9 ± 7.3	28.4 ± 2.4	28.9 ± 5.3	31.3 ± 6.9	27.0 ± 1.6
2 weeks prepartum	29.8 ± 2.4	30.2 ± 4.8	29.5 ± 3.2	29.5 ± 3.2	30.5 ± 4.8	28.8 ± 2.1
1 week prepartum	26.9 ± 2.6	27.9 ± 3.3	26.2 ± 1.9	27.1 ± 4.0	27.3 ± 4.9	25.3 ± 2.4
Parturition	22.6 ± 1.3	21.9 ± 0.7	23.0 ± 1.4	22.6 ± 2.5	22.2 ± 4.6	21.6 ± 0.8
1 week postpartum	18.7 ± 0.9	18.6 ± 0.7	18.7 ± 1.2	21.1 ± 4.8	23.0 ± 6.4	18.9 ± 1.1

Table 5. Serum cholesterol (mg/dL) concentrations of Damascus does.

Time	Groups					
	L-carnitine			Control		
	Mean	Single	Twin	Mean	Single	Twin
4 weeks prepartum	122.5 ± 14.2	113.2 ± 17.9	128.8 ± 7.4	119.2 ± 13.1	109.9 ± 11.6	122.9 ± 15.0
3 weeks prepartum	113.9 ± 17.9	113.1 ± 16.6	119.3 ± 12.5	114.2 ± 13.6	109.1 ± 12.9	118.3 ± 13.0
2 weeks prepartum	110.3 ± 13.9	100.8 ± 18.4	116.3 ± 10.4	115.7 ± 11.9	114.5 ± 13.9	120.8 ± 6.0
1 week prepartum	99.9 ± 15.2	95.6 ± 20.5	106.5 ± 10.0	101.0 ± 10.3	96.7 ± 4.9	107.8 ± 8.6
Parturition	83.8 ± 17.4	*67.2 ± 8.2	95.8 ± 16.3	86.1 ± 7.4	*79.6 ± 8.2	91.3 ± 5.8
1 week postpartum	75.7 ± 16.5	67.5 ± 17.7	81.1 ± 14.7	76.1 ± 10.6	71.3 ± 8.6	80.9 ± 10.9

*P < 0.05 (between L-carnitine and control groups with single pregnancy at the parturition)

Table 6. Serum creatinine (mg/dL) concentrations of Damascus does.

Time	Groups					
	L-carnitine			Control		
	Mean	Single	Twin	Mean	Single	Twin
4 weeks prepartum	1.55 ± 0.2	1.56 ± 0.1	1.55 ± 0.2	1.51 ± 0.1	1.48 ± 0.05	1.55 ± 0.08
3 weeks prepartum	1.54 ± 0.2	1.52 ± 0.04	1.56 ± 0.1	1.54 ± 0.1	1.53 ± 0.1	1.52 ± 0.07
2 weeks prepartum	[a]1.44 ± 0.1	1.63 ± 0.1	1.47 ± 0.1	[b]1.56 ± 0.1	1.53 ± 0.07	1.59 ± 0.1
1 week prepartum	1.53 ± 0.1	1.56 ± 0.08	1.52 ± 0.06	1.49 ± 0.1	1.47 ± 0.2	1.52 ± 0.1
Parturition	1.25 ± 0.9	[*]1.27 ± 0.04	1.25 ± 0.1	1.19 ± 0.6	[*]1.16 ± 0.04	1.21 ± 0.07
1 week postpartum	1.15 ± 0.08	1.13 ± 0.03	1.16 ± 0.09	1.14 ± 0.07	1.11 ± 0.08	1.17 ± 0.03

a:b = P < 0.05 (between L-carnitine and control groups, 2 weeks prepartum)
[*]P < 0.01 (between L-carnitine and control groups with single pregnancy at the parturition)

Table 7. Serum urea (mg/dL) concentrations of Damascus does.

Time	Groups					
	L-carnitine			Control		
	Mean	Single	Twin	Mean	Single	Twin
4 weeks prepartum	24.5 ± 2.1	25.5 ± 2.6	23.8 ± 1.5	25.4 ± 1.9	25.9 ± 2.3	24.3 ± 1.3
3 weeks prepartum	26.3 ± 3.5	26.8 ± 3.4	25.6 ± 2.9	25.1 ± 1.6	25.6 ± 1.9	24.3 ± 1.3
2 weeks prepartum	[a]26.9 ± 2.2	28.3 ± 2.9	25.2 ± 1.9	[b]25.1 ± 1.4	25.4 ± 1.2	24.9 ± 1.7
1 week prepartum	27.5 ± 2.9	28.3 ± 24.5	26.9 ± 1.4	25.3 ± 1.9	24.8 ± 1.7	25.8 ± 2.2
Parturition	[*]34.2 ± 3.1	[c]35.9 ± 2.8	32.9 ± 2.6	[*]31.2 ± 2.2	[d]29.3 ± 0.7	32.7 ± 1.9
1 week postpartum	33.1 ± 2.2	32.6 ± 2.6	33.4 ± 2.1	32.3 ± 2.7	30.4 ± 2.0	34.1 ± 1.8

[*]P < 0.05 (between L-carnitine and control groups at the parturition)
a:b = P < 0.05 (between L-carnitine and control groups, 2 weeks prepartum)
c:d = P < 0.01 (between L-carnitine and control groups with single pregnancy at the parturition)

Table 8. Serum Ca (mg/dL) concentrations of Damascus does.

Time	Groups					
	L-carnitine			Control		
	Mean	Single	Twin	Mean	Single	Twin
4 weeks prepartum	[*]9.6 ± 0.3	9.8 ± 0.5	9.6 ± 0.4	[*]10.4 ± 0.7	10.7 ± 0.7	10.2 ± 0.7
3 weeks prepartum	9.8 ± 0.3	9.6 ± 0.2	9.7 ± 0.2	10.2 ± 0.6	10.1 ± 0.5	10.2 ± 0.7
2 weeks prepartum	9.7 ± 0.2	9.8 ± 0.5	9.7 ± 0.2	10.2 ± 0.6	10.3 ± 0.8	10.1 ± 0.5
1 week prepartum	9.5 ± 0.2	9.6 ± 0.3	9.4 ± 0.1	9.9 ± 0.6	9.9 ± 0.4	9.9 ± 0.7
Parturition	9.1 ± 0.2	9.0 ± 0.3	9.1 ± 0.2	9.2 ± 0.2	9.1 ± 0.2	9.3 ± 0.06
1 week postpartum	9.0 ± 0.2	8.9 ± 0.3	9.1 ± 0.3	9.01 ± 0.3	9.0 ± 0.3	9.1 ± 0.2

[*]P < 0.01 (between L-carnitine and control groups, 4 weeks prepartum)

Discussion

There are not sufficient numbers of studies in the literature investigating the effects of L-carnitine on energy metabolism of pregnant goats. Some studies have been conducted on the prevention of ketosis (11,13,14). The effects of L-carnitine on metabolism in various animals, such as ruminants (15,16), pigs (17), and dogs (18) have been investigated.

LaCount et al. (16) and Chapa et al. (15) reported that a 2-week adaptation period is needed when L-carnitine was orally administered in ruminants. In the present study, we determined that adaptation period was not needed if L-carnitine was parenterally administered; the result of which may be that microorganisms of rumen needed time to adapt L-carnitine when it was orally given to ruminants.

In the current study, there was a continuous increase in the serum glucose concentration; especially in the 3rd ($P < 0.05$) and 2nd ($P < 0.001$) weeks before parturition in goats with multiple pregnancy. In this period, glucose concentration was higher in L-carnitine administered goats than in controls. Chapa et al. (15) and Drackley and LaCount (19) found similar results in lambs and cows. With the advanced pregnancy, glucose concentration in blood increases to balance the needs of the metabolism (2). According to Hodgson et al. (3), 40% of glucose in the body is consumed by the uterus in a pregnant sheep. Increasing glucose consumption during pregnancy causes a decrease in the blood glucose level (20). In goats kept in a sufficient feeding system during the entire pregnancy period, the glucose and ketone concentration in blood is at a standard level. There is a strong correlation between glucose and the free fatty acid concentration in blood. Insufficient feeding or starvation decreases blood glucose level, but it increases the free fatty acid concentration (21). In goats with multiple fetuses, their serum glucose concentration decreases due to a decrease in feeding intake. Because a uterus with multiple fetuses occupies more space, it applies more force on the rumen (2). In the current study, it was observed that L-carnitine administrations to goats with multiple kids during gestation led to an increase in serum glucose concentrations compared to the control group. This result was in agreement with other studies carried out by Chapa et al. (15) and Drackley and LaCount (19).

In healthy goats and sheep, serum BHB concentration is 0.1–1.4 mmol/L. In goats and sheep with ketosis, serum BHB concentration is between 1.6 and 8.0 mmol/L (9). BHB concentration behavior is just the opposite of the glucose concentration (22), which is supported by the present study. We found that when the glucose concentration was low, BHB was high, and vice versa. In this study, BHB concentrations continuously increased at pre- and post-parturition, which was attributed to the increasing glucose need for compensation of energy deficiency during the late trimester of pregnancy. It is also possible to say that energy requirement is met by the body fat metabolism.

Vernon et al. (23) pointed out that body fat reserves increase in the early period of pregnancy and fat tissue mobilizes to be used at the advanced stage of pregnancy and in the early postpartum period. Present study shows that administration of L-carnitine does not affect serum β-hydroxibutyrate (BHB) in large amounts. Serum BHB concentration changes were between 0.58 ± 0.6 mmol/L and 0.81 ± 0.8 mmol/L in goats administered L-carnitine. Changes for the same parameter were between 0.58 ± 0.7 mmol/L and 0.84 ± 0.08 mmol/L in the control group. In both groups of does, BHB level was within a normal range as reported by other researchers (9,24). In the present study, it was observed that serum BHB concentrations of goats with a single kid were lower than those with twin kids. Goats with twin kids had high BHB values before parturition as described by König (22).

Hallford and Galyean (24) searched plasma glyceride levels in pre- and postpartum periods. These researchers identified glyceride levels of 0.44 ± 0.04 mmol/L 6 weeks before parturition; 0.47 ± 0.05 mmol/L at parturition, and 0.45 ± 0.05 mmol/L 8 weeks after parturition. Hallford and Galyean (24) reported plasma cholesterol levels of 1.81 ± 0.12 mmol/L for the last 6 weeks of pregnancy; 1.82 ± 0.12 mmol/L at parturition; 1.93 ± 0.11 mmol/L for the lactation period.

In present study, the serum NEFA level in experimental goats was higher compared to controls 2 weeks before parturition ($P < 0.05$). Goats carrying twin kids, when administered L-carnitine, showed lower NEFA values in the third and forth weeks before

parturition. In each period after L-carnitine administration, serum cholesterol level in the experimental group was lower than those in the control group, except the early stages of the experiment. This can be explained with a biological mechanism where L-carnitine stimulates the lipid metabolism that is responsible for carrying acyl groups from mitochondrial membranes (17). In a study carried out by LaCount et al. (16), it was determined that the blood NEFA level decreased when 6 g L-carnitine for each cow was given by feeding. A research, conducted in the sheep, emphasized that the lack of energy caused urea and creatinine concentration to rise in the serum (25).

In the present study, it was recorded that creatinine and urea concentration in the serum changed during pregnancy. In goats administered L-carnitine, the serum creatinine concentration decreased until 1 week before parturition, although the same parameter increased in the control group until 2 weeks before parturition. Regarding with the serum creatinine concentrations, there was a significant difference between groups ($P < 0.05$). At this point, it is thought that L-carnitine can prevent the increase of serum creatinine concentration caused by the lack of energy. Moreover, in creatine concentration there was significant difference between groups I and II 2 weeks before parturition ($P < 0.05$). Serum urea concentrations increased in both of the groups. However, this increase was higher in L-carnitine administered goats compared to controls. In the present study, the finding that urea and creatine concentrations were higher in goats injected L-carnitine with a single kid did not agree with Kellog and Miller (26).

In goats with pregnancy ketosis, absorption of mobilized calcium ions stemming from the intestine decreases. It was reported that deficiency of Ca absorption causes hypocalcaemia in 1 of 5 pregnant goats (9). In the current study, Ca levels decreased in goats during pregnancy but they were in normal ranges in both groups. Higher serum Ca concentration in the control group may have originated from differences of the initial serum Ca concentrations between groups I and II. In this study, there was a difference between groups I and II in the level of serum Ca on the fourth week; however, this difference was within reference values.

In the conclusion, L-carnitine administrations increased glucose (the main source of energy) concentration in advanced pregnant Damascus goats with multiple pregnancies. For this reason, parenteral administration of L-carnitine can be used to prevent pregnancy ketosis, the most important metabolic disease that develops due to the lack of energy. Also subcutaneous administration of L-carnitine may be considered as an alternative to oral use of L-carnitine in goats.

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