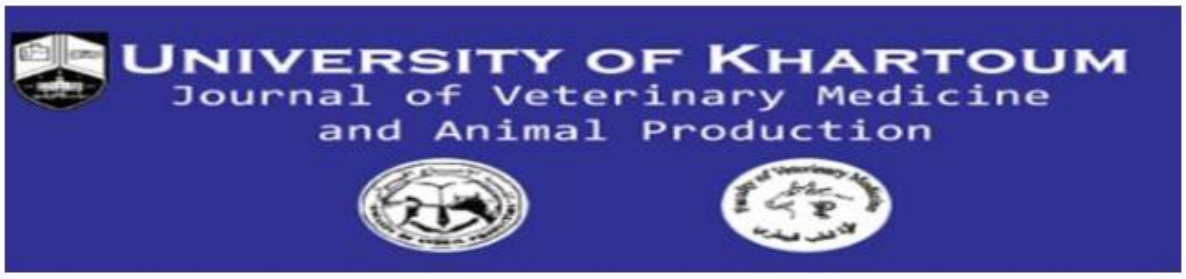
U. of K. J. Vet. Med. Anim. Prod., Vol.9, Issue 1 (2018) page 27- 35
ISSN: 243456



Monitoring of Certain Serum biochemical Parameters DuringTransition Period in Camels (*Camelus dromedarius*)

Nawal M. Elkhair[*1, 2], Mona H. Ahmed[1], Ahmed O. Alameen[1]

[1]*Department of Physiology, Faculty of Veterinary Medicine, University of Khartoum, 13314, Shambat, Sudan*
[2] *Camel Research Centre, Faculty of Veterinary Medicine, University of Khartoum, 13314, Shambat, Sudan*
*****Corresponding author (nawalelkhair@yahoo.com)*

Abstract

The objective of the study was to monitor certain electrolytes, serum proteins and certain acid-base parameters during the transition period in camels. Twenty multiparous females (pregnant and non-pregnant, age: 7-11year, number of parities: 2-3) of Arabi breed were used. Jugular venous blood was collected three times: one month prepartum, at parturition and one month postpartum and once from non-pregnant females to determine blood pH, Na^+, K^+, Cl^-, Pi, total proteins (TP) and albumin. Strong ion difference (SID_3) and the total concentration of non-volatile weak acids (A_{tot}) were calculated using validated equations. Serum- [Na^+], [Cl^-] and [TP] decreased significantly ($P<0.0001$) during the transition period while [Pi] and [albumin] increased ($P\leq0.05$). Serum-[SID_3] and [A_{tot}] tended to increase and decrease on-significantly, respectively. During late pregnancy,[K^+] was correlated negatively and positively ($P<0.05$) to [Cl^-] and [albumin] while [albumin] and [Pi] was correlated positively ($P=0.02$) in non-pregnant camels. During postpartum period, [Na^+] and [Cl^-]; [TP] and [albumin] were correlated positively ($P\leq0.05$). Serum-[SID_3] and [A_{tot}]showed linear relationship ($P<0.0001$, R^2 = 0.55-0.99) to [Cl^-], [Pi] and [albumin] during the transition period and in non-pregnant camels. The transition period has an influence on certain serum electrolyte concentration, serum proteins and certain acid-base parameters. The data could be utilized for the clinical monitoring of metabolic disorders associated with transition period or to formulate dietary ratios to meet the nutritional requirement during these critical periods.

Key words: *Camels, transition period, electrolyte concentrations, total proteins, albumin, acid-base parameters*

المستخلص

الهدف من الدراسة هو رصد تركيز بعض الشوارد وبروتينات المصل وبعض القياسات الحمضية– القاعدية فى مصل الدم خلال الفترة الإنتقالية في الإبل. أستخدمت عشرون من إناث الإبل متعددة الولدات (حوامل وغير حوامل، العمر:7–11 سنة، عدد الولدات: 2–3) من سلالة الإبل العربية. تم جمع عينات دم من الوريد الوداجي ثلاث مرات: شهر واحد قبل الولادة ، عند الولادة وبعد شهر واحد من الولادة ومرة واحدة من الإناث غير الحوامل لتحديد درجة الحموضة في الدم (pH) وبعض الشوارد (Na^+، K^+، Cl^-، Pi) والبروتين الكلي (TP) والألبومين (albumin). تم حساب فرق الأيون القوي (SID_3) والتركيز الكلى للأحماض الضعيفة غير

المتطايرة (A_{tot}) بإستخدام معادلات معتمدة. إنخفض [Na^+] و [Cl^-] و [TP] بشكل ملحوظ ($P<0.0001$) خلال الفترة الإنتقالية بينما إرتفع [Pi] و[albumin] معنوياً ($P\leq0.05$). أظهرت [SID_3] و [A_{tot}] ميولاً إلى الزيادة والنقصان بشكل غير معنوي، على التوالي. خلال الفترة الأخيرة للحمل، إرتبط[K^+]إرتباطًا سلبياً وإيجابيا ($P<0.05$) بـ [Cl^-] و [albumin] بينما إرتبط [albumin] و [Pi]إرتباطًا إيجابياً ($P = 0.02$) في الإبل غير الحوامل. خلال فترة ما بعد الولادة، إرتبط [Na^+] و [Cl^-] ؛ [TP] و[albumin] إيجابيا ($P\leq0.05$).أظهرت [SID_3] و [A_{tot}] علاقة خطية ($P<0.0001$, $R^2 = 0.55-0.99$) بـ [Pi] و [Cl^-] و[albumin] أثناء الفترة الانتقالية وفي الإبل غير الحوامل. أثرت الفترة الإنتقالية على تركيزبعض الشوارد وبروتينات المصل وبعض القياسات الحمضية– القاعدية. يمكن إستخدام هذه البيانات للرصد السريري للإضطرابات الأيضية المرتبطة بالفترة الانتقالية أو لصياغة النسب الغذائية لتلبية الإحتياجات الغذائية خلال هذه الفترات الحرجة.

كلمات مفتاحية: *الإبل، الفترة الإنتقالية، تراكيز الشوارد،بروتين المصل الكلى ، الألبومين، القياسات الحمضية– القاعدية*

Introduction

Pregnancy is a physiological status considered to modify metabolism in animals (Iriadam, 2007). Pregnancy is also known as stressful condition associated with many metabolic and physiological changes to satisfy the demands of the fetus, the placenta, and the uterus (Ahmed *et al.,* 2016). High metabolic demands associated with late pregnancy, parturition and initiation of lactation would be expected to increase the production of reactive oxygen species (Sordillo and Aitken, 2009), which may lead to oxidative stress (Castillo *et al.,* 2005; Sharma *et al.,* 2011; AbdEllah 2016; Mohebbi-Fan *et al.*, 2016).

Transition period is defined by many researchers as the period from late pregnancy to early lactation and it is also recognized as the period between 3 weeks before to 3 weeks after parturition (Goff and Horst, 1997; Sharma *et al.*, 2011). The transition period is also considered as one of the most critical periods for health and productivity in camels (Ahmed, 2017), cattle (Drackley, 1999; Esposito *et al.*, 2014; Zebeli *et al.*, 2015; Fiore *et al.*, 2018), sheep (Raoofi *et al.*, 2013; Chnite *et al.*, 2016)and goats (Tharwat *et al.*, 2015; Manat *et al.*, 2016; Cepeda-Palacios *et al.*, 2018). However, limited information has been reported for the transition female camels (Derar *et al.*, 2014; Kelanemer et al.,.,2015; Tharwat *et al.*, 2015; Abd-El-Rahman et al.,2017; El Zahar *et al.*, 2017) compared to other animal species.

The literature concerning the gestation length in the camel varied compared to that reported for other animal species. Yagil, (1985) reported an average gestation length of 390+2 days compared to 375 days reported by Arthur et al.,(1985). Therefore, the gestation length of camels is commonly stated as 13 months (Skidmore, 2011). Concerning the longgestation period; it was assumed that energy requirement of pregnant camels increased rapidly during late pregnancy and thus it may affect the concentrations of some serum biochemical parameters (Saeed *et al.*, 2009; Al Zamely, 2011; Tharwat *et al.*, 2015).

Few Studies have been conducted to describe serum biochemical profile of female camels during postpartum and transition period (Agarwal *et al.*, 1992; Tharwat *et al.*, 2015; El Zahar *et al.*, 2017). Therefore, the present study aimed to provide additional information on the concentration of certain serum biochemical parameters in dromedary female camels during the transition period in comparison to non-pregnant females.

Materials and Methods

Ethical approval: The study was approved by The Sudan Veterinary Council (EA/0030/2018).

Animals and management: Twenty clinically healthy female camels (10 non

pregnant and 10 time-mated pregnant camels (aged 7-11year, weight: 600-700kg, body condition score: 2.5-3, number of parities: 2-3) were used. The animals were selected from the herd of the Camel research Centre of the University of Khartoum, Sudan. Non-pregnant non-lactating female camels were selected under the same conditions to provide the normal values for investigated parameters. Time-mated pregnant camels were selected according to the records of mating time for each female included in the experiment, which indicated the expected time for parturition. The pregnant camels were monitored from one month prepartum up to one month postpartum. During the experimental period, the female camels were housed in an outdoor environment in a shaded corral. Animals were maintained on grazing and browsing trees and shrubs in the vicinity of the Camel Centre and occasionally received fresh grass and concentrate supplements, which was offered daily with free access to fresh water.

Sample Collection and Laboratory Analysis: Jugular venous blood samples were collected by venipuncture using plastic syringes (7.5 ml, Pirmvetta®, Laboratory Technique, GmbH, Germany) three times: one month prepartum, at parturition and one month postpartum and once from non-pregnant females. The blood samples were centrifuged and the serum was collected in sterile containers and frozen at -20º C for further analysis. Serum samples were used for the determination of sodium (Na^+) and potassium (K^+) (Flame photometer technique, PFP7 Jeway, EU), chloride (Cl^-) and inorganic phosphate (Pi) (Standard spectrophotometric methods using commercial kits, Spinreact, Spain), plasma total proteins and albumin (Biuret and Bromcresol green standard spectrophotometric methods using commercial kits, Spinreact, Spain). The values of electrolytes, plasma total proteins and albumin were used for the calculation of $SID_3$and A^- (Stewart 1983; Elkhair and Hartmann 2010).

Serum- $[SID_3]$ mmol/l = $[Na^+]$ + $[K^+]$ - $[Cl^-]$ mmol/l

(1) Serum- $[A^-]$ mmol/l = [albumin] g/l ×(0.123×pH-0.631) + [Pi] mmol/l × 0.309×pH-0.469) (2)

Statistical analysis: Statistical analysis was performed using SPSS for Windows version 20. General Linear Model (GLM), ANOVA (Levine's Test and Post Hoc Test) was used to assess the significant differences among the groups. A correlation and linear regression were performed to assess the effect of transition period on the parameters investigated. The difference was considered significant at $P \leq 0.05$.

Results

The responses of certain serum electrolytes, plasma total proteins, albumin acid-base parameters to different physiological states are shown in Table 1. Serum-$[Na^+]$, $[Cl^-]$ and [TP]decreased significantly ($P<0.0001$) during the transition period (late pregnancy, at parturition and postpartum period) compared to non-pregnant females, whereas[Pi] and [albumin]increased significantly ($P\leq0.05$).Serum-$[K^+]$ and $[SID_3]$ tended to increase during the transition period compared to non-pregnant females while $[A_{tot}]$ decreased; however, this pattern of response was not statistically significant.

The correlation between certain serum biochemical parameters of female camels during the transition period is shown in Table 2.In non-pregnant camels, serum-[albumin]was correlated positively ($P=0.02$) to [Pi]. During late pregnancy, serum-$[K^+]$was correlated negatively and positively ($P<0.05$) to $[Cl^-]$ and [albumin], respectively. A positive correlation ($P\leq0.05$) was observed between $[Na^+]$ and $[Cl^-]$, and [TP] and [albumin]one month postpartum period.

The relationship between the individual values of SID_3 and A_{tot} and their corresponding values of serum electrolytes and albumin was determined using linear regression (Figs. 1, 2aand 2b). Based on the equation 1: Serum- $[SID_3] = [Na^+] + [K^+] - [Cl^-]$, the changes in SID_3 depended on the changes in one or more of the three strong ions.The results shown in Fig.1 indicate that the decrease in SID_3 depended mainly on the changes in $[Cl^-]$ at parturition (R^2=0.89, P<0.0001) and one month postpartum (R^2=0.94, P<0.0001). According to the equation 2: Serum- $[A^-]$ = [albumin] g/l × (0.123×pH-0.631) + [Pi] mmol/l × 0.309×pH-0.469), serum- $[A_{tot}]$ showed linear regression relationship to [Pi] during the transition period(R^2=0.99, P<0.0001) and only to [albumin] one month postpartum (R^2=0.55, P<0.05) and in non-pregnant camels (R^2=0.78, P<0.01).All individual values of R^2layclose to the regression line (Fig. 2a). $R^2$was generally higher during the transition period compared to non-pregnant camels.

Table 1: Certain electrolytes concentration, serum total proteins and albumin concentration and acid-base parameters during the transition period in female camels (*Camelus dromedarius*) (n=20)

parameter	Non pregnant	Transition period			Level of significance	Reference range
		Late pregnancy	Parturition	One month Postpartum		
Serum -[Na^+] (mmol/l)	149.8 [a] ±6.6	140.8 [b] ±2.3	140 [b] ±2.4	142 [b] ±1.3	P<0.0001	142-160 * 140-178 **
Serum -[K^+] (mmol/l)	4.1 [a] ±0.3	4.5 [a] ±0.8	4.6 [a] ±0.8	4.7 [a] ±1.3	NS	3.7-4.8 * 3.5- 6.3**
Serum -[Cl^-] (mmol/l)	110.4 [a] ±6.2	95.6 [b] ±6.4	96.5 [b] ±6.5	96.9 [b] ±8.5	P<0.0001	101-122 * 106-123 **
Serum -[Pi] (mmol/l)	1.86 [a] ±0.3	4.98 [b] ±3.3	4.76 [b] ±2.1	4.69 [b] ±2.4	P≤0.05	1.3-2.6 * 4.8-8.4**
Serum -[TP] (g/l)	64 [a] ±6.6	56 [b] ±1.3	56 [b] ±0.8	56 [b] ±0.7	P<0.0001	51-74 * 63-83 **
Serum -[albumin] (g/l)	31.9 [a] ±0.6	38.8 [b] ±0.6	38.2 [b] ±0.6	37.9 [b] ±0.4	P≤0.05	25-45 **
Serum -[SID_3] (mmol/l)	43.4 [a] ±2.3	47.5 [a] ±6.3	48.2 [a] ±7.7	49.8 [a] ±9.2	NS	39-48 ***
Serum -[A_{tot}] (mmol/l)	12.4 [a] ±1.4	11.0 [a] ±4.3	10.6 [a] ±2.3	11.8 [a] ±3.9	NS	10-15 ***

Brackets ([ ]) donate concentration, m ± s: Mean± SD (Standard deviation)
TP: Total proteins, SID_3: strong ion difference, A_{tot}: total concentration of non-volatile weak acids of the blood
[a and b] Means within the same row bearing different superscripts are significantly different at p≤0.05
NS: Non-significant
Reference range: * Elkhair, (2016), ** Faye and Bengoumi, (2018), ***Elkhair *et al.,* (2010)

Table 2: Correlation between certain serum biochemical parameters during transition period in female camels (*Camelus dromedarius*) reared under semi-intensive system (n=20)

Physiological status	Parameters	Pearson Correlation	Level of significance
Non-pregnant	[Albumin] - [Pi]	0.72*	0.02
Late pregnancy	$[K^+]$ - $[Cl^-]$ $[K^+]$ - [Albumin]	-0.64* 0.64*	0.05 0.05
At parturition	No significant correlation found		
One month postpartum	$[Na^+]$ - $[Cl^-]$ [TP] - [Albumin]	0.94** 0.72*	0.0001 0.03

Correlation is significant at * the 0.05 level and ** at the 0.01 level (2-tailed).
Brackets ([ ]) donate concentration, TP: Total protein

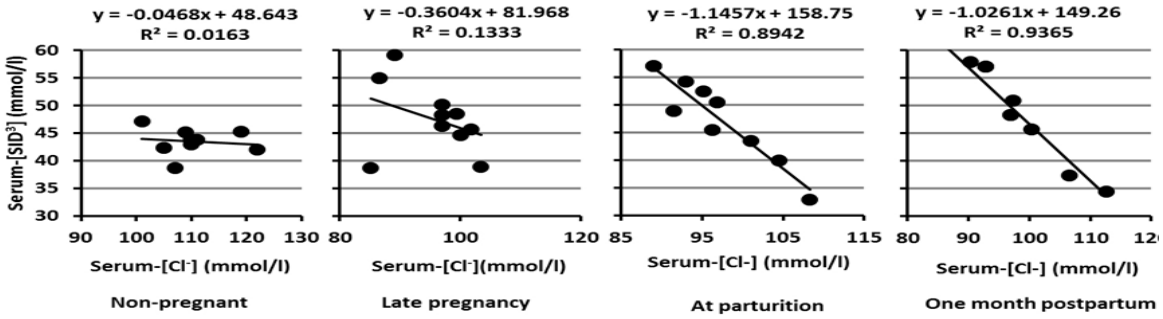


Fig. 1 The relationship between serum- [SID_3] (mmol/l) and serum- [Cl^-] (mmol/l) during transition period in female camels (*Camelus dromedarius*) (n= 20). (Linear regression equation: y=ax + b; R^2: Coefficient of determination)

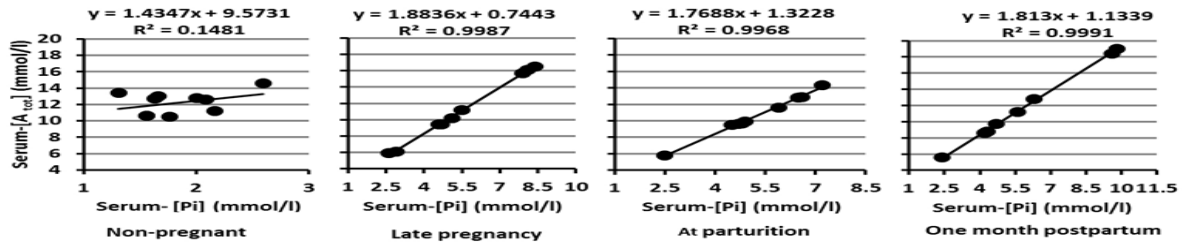


Fig. 2a The relationship between serum- [A_{tot}] (mmol/l) and serum- [Pi] (mmol/l) during transition period in female camels (*Camelus dromedarius*) (n= 20). (Linear regression equation: y=ax + b; R^2: Coefficient of determination)

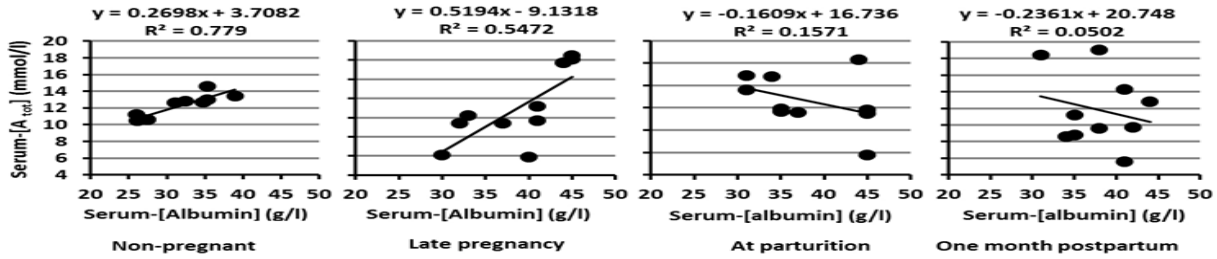


Fig. 2b The relationship between serum- [A_{tot}] (mmol/l) and serum- [ablumin] (g/l) during transition period in female camels (*Camelus dromedarius*) (n= 20). (Linear regression equation: y=ax + b; R^2: Coefficient of determination)

Discussion

The data obtained in the present study demonstrate that certain serum electrolytes concentration, serum total proteins and albumin were influenced by the transition period in dromedary camels as adaptive physiological mechanisms associated with rapid fetal growth and lactogenesis. The findings are supported by the significant decrease in serum- [Na^+], [Cl^-] and [TP]accompanied by a significant increase in [Pi] and [albumin]observed during the transition period compared to non-pregnant females (Table.1).

The serum biochemical profile obtained in the present study showed that the mean values of serum- [Na^+], [K^+], [Cl^-], [Pi], [TP] and [albumin] were within the reference range for female dromedary camels in Sudan and other countries (Elkhair, 2016; Faye and Bengoumi, 2018). Studies on humans indicated that maternal homeostatic responses mainly $Na^+$to pregnancy can be considered as a result of activation of rennin angiotensin aldosterone system (Scaife and Mohaupt, 2017). Therefore, the marked significant changes in serum electrolytes concentration that occurred could be associated with increased metabolic demands during the critical transition period in order to maintain the homoeostatic situation within physiological levels. Similar characteristic changes in electrolytes profile have been observed during the transition in cattle(Skrzypczak *et al.,*2014), sheep(Chnite *et al.,* 2016) and goats (Iriadam, 2007).Earlier study conducted by Safwate *et al.,* (1981) reported a decrease in electrolytes concentration, in particular Na^+ during postpartum period as a consequence of decreased plasma rennin activity. Asif *et al.,* (1996) explained that decrease in serum-[Na^+] may be also influenced by the higher concentration of prostaglandins, which is known to increase urinary [Na^+] excretion.

The results obtained in the present study showed that the mean values of serum-[TP] decreased significantly during the transition period, which reflected the maternal requirement of proteins for fetal growth or to cope with colostrum and milk synthesis and production and providing immunoglobulins (Kaneko *et al.,* 2008; Faye and Bengoumi, 2018). It is well established that protein requirement increases during late pregnancy as indicated by decreased maternal serum protein concentrations with advancing pregnancy in camels(Saeed et al.,2009). Furthermore, an increase in fetal growth accompanied by higher utilization of amino acids from the maternal circulation for protein synthesis has been observed in farm animals (Jainudeen and Hafez, 1994).Similar significant decrease in serum- [TP] during the transition period has been reported previously in camels(Tharwat*et al.,*2015; El Zahar *et al.,* 2017),cattle(Skrzypczak *et al.,* 2014), sheep (Chnite *et al.,* 2016) and goats (Iriadam, 2007).

In the present study, serum SID_3 and A_{tot} (A^-) for non-pregnant camels were within the reference range for dromedary camels (Elkhair and Hartmann, 2010). However, female camels during the transition period showed higher mean values of SID_3 accompanied by relatively lower mean values for A_{tot} compared to non-pregnant camels. This pattern of response could be attributed to the significant changes on serum- [Cl^-], [Pi] and [albumin] observed (Figs. 1, 2a and 2b). According to Stewart's terminology, the decrease in SID_3 indicated metabolic acidosis whereas the increase is considered as metabolic alkalosis. Also Stewart,(1983) defined the decrease and the increase in A_{tot} as acidotic and basic responses, respectively. Since the increase in SID_3 of 5.1 mmol/l calculated during the transition period compared to non-pregnant females and A_{tot} values decreased by 1.3 mmol/l was

not statistically significant; therefore, the net results for the transition female camels was a moderate metabolic alkalosis (hypochloremia and hypoproteinemia, Table 1). Therefore, the present results indicate that the transition female camels shifted towards a basic response, which should be considered in the nutritional program by formulating a diet with low cations and high anion contents. This diagnostic finding supported by strong significant correlations between strong cations and anions and between albumin and total proteins observed during late pregnancy and postpartum period (Table 2).

Conclusion

The present study indicates the transition period has an influence on the concentration of certain electrolyte concentration, serum total proteins and acid-base parameters in camels. The data could be utilized for clinical monitoring of metabolic disorders that may occur during late pregnancy and/or during postpartum period. The present data can be useful to formulate dietary ratios in order to meet the nutritional requirement for female camels during these critical periods.

Acknowledgments

The authors thank the authorities at the Camel Research Centre and the Department of Physiology, Faculty of Veterinary Medicine, University of Khartoum for their help during the experimental work and laboratory assistance. This work was sponsored by the Ministry of Higher Education and Scientific Research, Sudan.

References

AbdEllah, M. R. (2016).Oxidant and antioxidants during the transition period in dairy cows.J. Adv. Vet. Res., 6 (4): 130–133.

Abd-El-Rahman, H. M. A., Ibrahim, M. A.andElmetwaly, H. A.(2017). Hormonal profile, antioxidant status and some biochemical parameters during pregnancy and periparturientperiod in dromedary she camel.Egypt. J. Vet. Sci.,48(2): 81–94.

Agarwal, S. P., Rai, A. K and Khanna, N. D. (1992).Hormonal studies in postpartum female camels and their neonates. Theriogenology,38:735–47.

Ahmed, Y. F., Mahmoud, K. GhM., Kandiel, M. M. M., Nawito, M. F. and AbdelRazik, A. M. A.(2016). Histomorphometry aspect of thyroid gland and biochemical profile in pregnant and non-pregnant dromedary camels. Afr. J. Biotechnol.,15: 370–375.

Al Zamely, H. A.(2011). Oxidant–antioxidant status and some biochemical parameters in pregnant and non-pregnant Iraqi she camels.The Iraqi J. Vet. Med.,35(2): 46–51.

Arthur, G. H., A/Rahim, A. T. and Al Hindi, A. S. (1985).Reproduction and genital diseases of the camel. Brit. Vet. J., 141 (6): 650–659.

Asif, M. M., Rahman, Z. U., Haq, I. U. and Javed, I.(1996).Trace element and electrolyte concentrations in different physiological states of sahiwal cattle. J. Islam. Acad. Sci.,9 (4):125–128.

Castillo, C., Hernandez, J., Bravo, A., Lopez-Alonso, M., Pereira, V. and Benedito, J. L. (2005).Oxidative status during late pregnancy and early lactation in dairy cows. Vet. J., 169(2):286–292.

Cepeda-Palacios, R., Fuente-Gómez, M. G., Ramirez-Orduna, J. M., Garcia-Alvarez, A., LIinas-Cervantes, X. and Angulo, C.(2018). Effects of pregnancy and post-kidding stages on hemato-chemical parameters in cross-bred goats.J. Appl. Anim. Res., 46(1):269–273.

Chnite, M., Salhi, I.,Harrabi, H., Khorchani, T., Laine, A. L., Nowak, K. and Hammadi, M. (2016). Physiological changes in the peri-partum period and colostralIgG transfer in prolific D'man sheep: effects of parity and litter size.Trop. Anim. Health. Prod.,48(2): 387–394.

Derar, R., Ali, A. and Al-Sobayil, F. A. (2014).The postpartum period in dromedary camels: Uterine involution, ovarian activity, hormonal changes, and response to GnRH treatment. Anim.Reprod. Sci., 151:186–93.

Drackley, J. (1999). Biology of dairy cows during the transition period: the final frontier? J. Dairy Sci., 82(11): 2259–2273.

El Zahar, H., Zaher, H.,Alkablawy, A., Al Sharifi, S and Swelum, A.(2017). Monitoring the changes in certain hematological and biochemical parameters in camels (*Camelu sdromedarius*) during postpartum period.J.Fert. Biomarkers,1(1): 47–54.

Elkhair, N. M. and Hartmann, H. (2010).Studies on acid-base status (Stewart's model) of young camels (*Camelus dromedarius*) after acid-load with NH_4Cl. Berl.Münch.Tierarztl. Wochenschr.,123(3&4):153–159.

Elkhair, N. M.(2016). Influence of age and sex on certain serum biochemical parameters of dromedary camels (*Camelus dromedarius*). Nova J. Med. Bio. Sci.,5(3):1–8.

Esposito, G., Irons, P. C., Webb, E. C.andChapwanya, A. (2014). Interactions between negative energy balance, metabolic diseases, uterine health and immune response in transition dairy cows. Anim.Reprod. Sci., 144(3-4):60–71.

Faye, B. and Bengoumi, M. (2018).Camel Clinical Biochemistry and Hematology.Springer International Publishing AG, Springer Nature.

Fiore, E., Piccione, G., Rizzo, M., Morgante, M., Barberio,A., Giudice, E. and Gianesella, M.(2018). Adaptation of some energetic parameters during transition period in dairy cows.J. Appl. Anim. Res.,46(1):402–405.

Goff, J. P. and Horst R. L.(1997). Physiological changes at parturition and their relationship to metabolic disorders. J. Dairy Sci., 80(7):1260 –1268.

Iriadam, M. (2007).Variation in certain hematological and biochemical parameters during the peri-partum period in Kilis does. Small Rumin. Res., 73: 54–57.

Jainudeen, M. R. and Hafez, E. S. E. (1994).Gestation, prenatal physiology and parturition. In: Hafez ESE, eds. Reproduction in Farm Animals,pp: 247–283. Lippincott, Williams and Wilkins.

Kaneko, J. J., Harvey, J. W.andBruss, M. L. (2008).Clinical Biochemistry of Domestic Animals. 6thed. San Diego, CA: Academic Press.

Kelanemer, R., Antoine-Moussiaux, N., Moula, N., Abu-Median, A. A. K.,Hanzen,Ch. and Kaidi, R. (2015). Effect of nutrition on reproductive performance during the peri-partum period of female camel (*Camelus dromedarius*) in Algeria.J. Anim. Vet. Adv.,14:192–196.

Manat, T. D., Chaudhary, S. S., Singh, V. K., Patel, S. B. and Puri, G.(2016). Hemato-biochemical profile in Surti goats during post-partum period. Vet. World,9(1): 19–24.

Mohebbi-Fani, M., Ansari-Lari, M., Nazifi, S., Abbasi, F.andShabbooei, Z. (2016).Oxidative status and acute phase response in post-transition early- and mid-lactation Holstein cows and their correlations with some performance records. 2016. J. Fac. Vet. Med. Istanbul Univ.,42 (1): 65–73.

Raoofi, A., Jafarian, M., Safi, Sh.andVatankhah, M.(2013). Fluctuations in energy-related metabolites during the peri-parturition period in Lori-Bakhtiariewes. Small Rumin. Res., 109(1): 64–68.

Saeed, A., Khan, I. A. and Hussein, M. M. (2009). Change in biochemical profile of pregnant camels (*Camelusdromedarius*) at term. Comp.Clin. Pathol.,18:139–43.

Safwate, A., Davicco, M. J., Barlet, P.andDelost, P. (1981).Sodium and potassium in blood and milk and plasma

aldosterone levels in high-yield dairy cows. Reprod. Nutr. Dev., 21(4):601–610.

Scaife, P. J.andMohaupt,M. G. (2017). Salt, aldosterone and extra-renal Na^+-sensitive responses in pregnancy. Placenta, 56: 53–58.

Sharma, N., Singh, N. K., Singh, O. P., Pandey, V. and Verma, P. K.(2011). Oxidative stress and antioxidant status during transition period in dairy cows.Asian-Aust. J. Anim., Sci. 24(4): 479–484.

Skidmore, J. A. (2011). Reproductive physiology in female old world camelids.Anim.Reprod. Sci., 124(3–3):148–154.

Skrzypczak, W., Kurpinska, A., Stanski, L. and Jarosz, A. (2014).Sodium, potassium and chloride homeostasis in cows during pregnancy and first months of lactation.ActaBiol.Cracoviensia Zool.,55/56: 58– 64.

Sordillo, L. M. and Aitken, S. L. (2009).Impact of oxidative stress on the health and immune function of dairy cattle. Vet. Immunol. Immunopathol., 128: 104–109.

Stewart, P. A. (1983). Modern quantitative acid-base chemistry.Can. J. Physiol. Pharmacol.,61(9):1444–1461.

Tharwat, M., Ali, A., Al-Sobayil, F., Selim, L. and Abbas, H. (2015).Hemato-biochemical profile in female camels (*Camelus dromedarius*) during the periparturientperiod.J.Camel Pract. Res.,22(1): 101–106.

Tharwat, M., Ali, A. and Al-Sobayil, F. (2015).Haematological and biochemical profiles in goats during the transition period. Comp.Clin.Pathol., 24: 1–7.

Yagil, R. (1985). The desert camel: Comparative physiological adaptation. Comparative Animal Nutrition, Basel, Switzerland, Karger.

Zebeli, Q., Ghareeb, K., Humer, E., Metzler-Zebeli, B. U. and Bensenfelder, U. (2015).Nutrition, rumen health and inflammation in the transition period and their role on overall health and fertility in dairy cows. Res. Vet. Sci.,103: 126–136.