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Serum electrolyte and glucose profiles of apparently healthy Large White (Yorkshire) sows during gestation and after parturition

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Abstract

This study evaluated the effects of pregnancy and lactation on the serum levels of some macro-minerals and glucose of Large White (LW) sows. Twenty sexually matured LW sows and three LW boars, of mean weight 45.38 ± 1.29 kg, aged between 8 and 10 months were used for the study. The sows were randomly assigned to five groups (A to E) of four sows per group in a completely randomized design, as follows; Group A: Non-pregnant (control), Group B: Early-gestation (38 days), Group C: Mid-gestation (78 days), Group D: Late-gestation (112 days) and Group E: Post-gestation (14 days postpartum). Blood samples were collected from sows in each group and the laboratory determination of the serum levels of minerals and glucose followed standard procedures. Results showed that the mean sodium concentration of early gestation (first trimester) sows was significantly ($p < 0.05$) lower than those of mid-gestation (second trimester) and late gestation (third trimester) groups but showed no significant ($p > 0.05$) difference when compared to non-pregnant control and post-gestation groups. Similarly, the mean serum level of phosphorus in the early gestation group was significantly ($p < 0.05$) lower than those of the mid-gestation and non-pregnant control groups. The mean serum glucose level in the early gestation group was significantly ($p < 0.05$) lower than those of the control and post-gestation groups. The mean serum calcium: phosphorus ratio of the mid-gestation group was significantly ($p < 0.05$) lower than those of the early gestation and post-gestation groups. The mean serum sodium: potassium ratio of the early gestation group was significantly ($p < 0.05$) lower than that of the mid-gestation group. There were however no significant ($p > 0.05$) variations in the mean serum levels of potassium and calcium of all the groups. It was concluded that there are significant variations in the serum levels of some of the assayed minerals and glucose during pregnancy and lactation in the sows.

Keywords: Pigs, Large White (Yorkshire), Pregnancy, Lactation, Serum Minerals, Serum Glucose.

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Introduction

Major adaptations in maternal physiology and metabolism are required for successful pregnancy outcome. Pregnancy and lactation are physiological conditions that modify metabolism in animals and induce stress (Tanritanir *et al.,* 2009). The peri-parturient period is important in terms of its influence on health and the subsequent performance, since sows develop serious metabolic and physiological changes during these periods (Tanaka *et al.,* 2011). The period of transition from early to late pregnancy presents a huge metabolic challenge on sows and the biochemical profile is important in evaluating the health status of sows during this transition (Hagawane *et al.,* 2009). Severe economic losses can result from sub-optimal transition of pregnant animals from late pregnancy to lactation and this could probably impair reproductive performance (Overton and Waldron, 2004).

During pregnancy and lactation, female physiology adapts to meet the added nutritional demands of the foetus. The critical stage in the mineral nutrition of a sow is during late gestation (late pregnancy) and lactation (Mahan, 2006). The single most important demand on the lactating sow for minerals is for the production and secretion of milk to nourish the rapidly growing neonates (Richards and Close, 2001). Metabolism of minerals plays significant roles in the regulation of physiological functions during pregnancy and lactation. Pregnancy and lactation constitute metabolic stress associated with alterations in the mineral profile depending on the reproductive status of dam (Ceylan *et al.,* 2009). Moreover substantial losses of body minerals occur during pregnancy and lactation in the dam.

Concentration of macro-minerals in the serum represents homeostatic mechanisms that are in a close relationship with the hormonal regulation (Krajnicakova *et al.,* 2003). Therefore, blood mineral profiles can be used to predict pre-partum and post-partum problems associated with mineral deficiencies. Serum levels of macro-minerals and glucose within the physiological range are essential for the maintenance of homeostasis and health. Isaac *et al*. (2013) reported that animals with good blood compositions are likely to show good reproductive performance. There are limited data on the serum macro-minerals and glucose profiles of pregnant and peri-parturient Large White (LW) sows in available literature. The present study evaluated the effect of pregnancy and lactation (reproductive stages) on the serum levels of macro-minerals and glucose of LW sows.

Materials and Methods

Experimental Animals: This experiment was carried out on Large White (LW) sows and LW boars obtained and kept in Captain Commercial Breeding Farm located in Amorji Nike, Enugu East LGA, Enugu State, Nigeria. Twenty sexually matured cycling apparently healthy LW sows and three LW boars (23 pigs in all), of mean weight 45.38 ± 1.29 kg, aged between 8 and 10 months were used for this study. The sows and boars were acclimatized for three weeks during which they were dewormed using ivermectin at a dose of 300 µg/kg, administered subcutaneously first, for 'ecto' and 'endo' parasites and repeated 10 – 14 days for second batch of maturing parasites. The pigs were kept in well ventilated pens at room temperature (25 – 27°C) and 12 hours light/darkness cycle maintained.

Ethical approval for this study was obtained from the Research Ethics Committee of Michael Okpara University of Agriculture Teaching Hospital with Ethical Approval Number, MOUAU/CVM/REC/202114. The standard Guidelines for the Use of Laboratory Animals for Experimental Purposes were strictly adhered to (NRC, 1996).

Experimental Design: The 20 LW sows were randomly assigned to five groups (A to E) of four sows per group in a completely randomized design, as follows; Group A: Non pregnant (control), Group B: Early gestation (38 days), Group C: Mid gestation (78 days), Group D: Late gestation (112 days) and Group E: Post gestation (14 days post-partum).

Oestrus in the sows was synchronized using $PGF_{2\alpha}$ given twice, 11 days apart (Akusu and Egbunike, 1984) at a dose of 10 mg/kg, administered intramuscularly. One boar each was introduced to naturally serve the sows in groups B, C and D (pregnant groups). Following successful mating, pregnancy was confirmed by ultrasonography (B-Ultrasound Scanner, Korea) (Ali and Fahmy, 2008) between days 22 – 23. The pregnant sows were identified with tag letters thus, B_{1-4}, C_{1-4}, D_{1-4}, and kept in separate pens until farrowing and were maintained in these separate pens throughout lactation. The lactating sows were also kept in separate pens and identified thus; E_{1-4} while the control sows (non-pregnant) were identified thus A_{1-4} and kept together in a pen. Sows and boars were fed twice daily while the piglets received udder milk from the lactating sows until the end of lactation (28 days). Sows and piglets were provided with clean fresh water *ad libitum* throughout the period of the study.

Four millilitre of venous blood sample was collected from each sow in a group and dispensed into plain test tubes and allowed to clot in a slanting position and centrifuged at 2,500 revolutions per minute for 10 minutes (Hrubec *et al.,* 2004). The resulting sera were aspirated, stored at - 20°C and used to determine the serum levels of the following minerals and glucose following standard procedures: sodium (Henry *et al.,* 1974), potassium (Tietz, 1976), glucose (Sacks, 1999), phosphorus (Trinder, 1951) and calcium (Thomas, 1998). Calcium/phosphorus (Ca:P) and sodium: potassium (Na:K) ratios were calculated.

Data Analysis: Data obtained during the study were subjected to one way analysis of variance (ANOVA) using Statistical Package for Social Sciences (SPSS) version 20.0 (SPSS, 2012). Variant means were separated using Duncan's New Multiple Range Test (Steel and Torrie, 2006; SAS, 2010). Probability values < 0.05 were considered significant (Bailey, 1995).

Results

The results of the serum levels of macro-minerals and glucose of LW sows are presented in Figures 1 – 5. The mean serum sodium concentration of early gestation sows was significantly ($p < 0.05$) lower than those of mid-gestation and late gestation groups, but showed no significant ($p > 0.05$) difference when compared to pre-gestation control and postpartum groups (Figure 1). There was however no significant ($p > 0.05$) variations in the mean serum levels of potassium (K) among the groups (Figure 2). The mean serum glucose concentration of the early gestation group was significantly ($p < 0.05$) lower than those of the pre-gestation control and the post-gestation groups (Figure 3). The mean serum phosphorus concentration of early gestation, late gestation and post-gestation groups were significantly ($p < 0.05$) lower when compared to the pre-gestation (control) and mid gestation groups (Figure 4). The serum calcium concentration of the groups did not significantly ($p > 0.05$) vary (Figure 5). The serum Calcium: Phosporus ratio of the early gestation and post-gestation groups were significantly ($p < 0.05$) higher than those of the pre-gestation and mid gestation groups (Table 1), but the serum Sodium: Potassium ratio of the mid-gestation group was significantly ($p < 0.05$) higher than those of the pre-gestation, early gestation and post-gestation groups (Table 1).

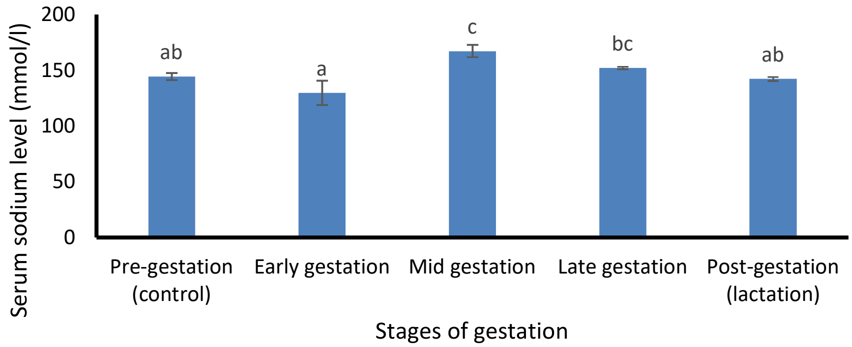

Figure 1: The mean serum sodium concentrations of Large White sows at different stages of gestation. Values are expressed as means ± SEM. Values with different superscripts are statistically ($p < 0.05$) different.

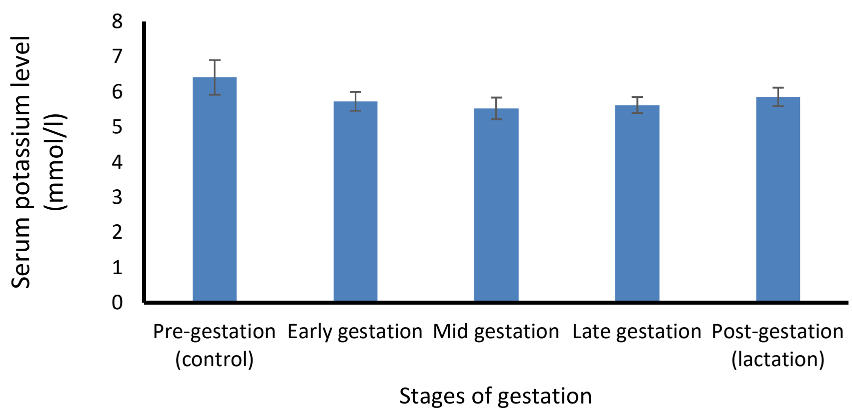

Figure 2: The mean serum potassium concentrations of Large White sows at different stages of gestation. Values are expressed as means ± SEM.

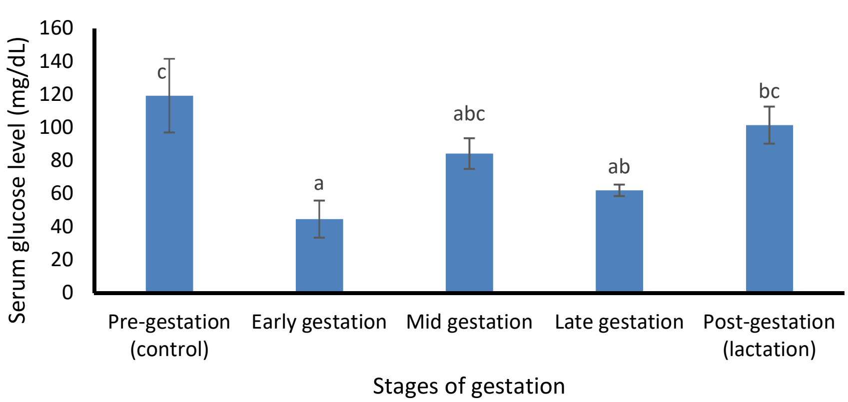

Figure 3: The mean serum glucose levels of Large White sows at different stages of gestation. Values are expressed as means ± SEM. Values with different superscripts are statistically ($p < 0.05$) different.

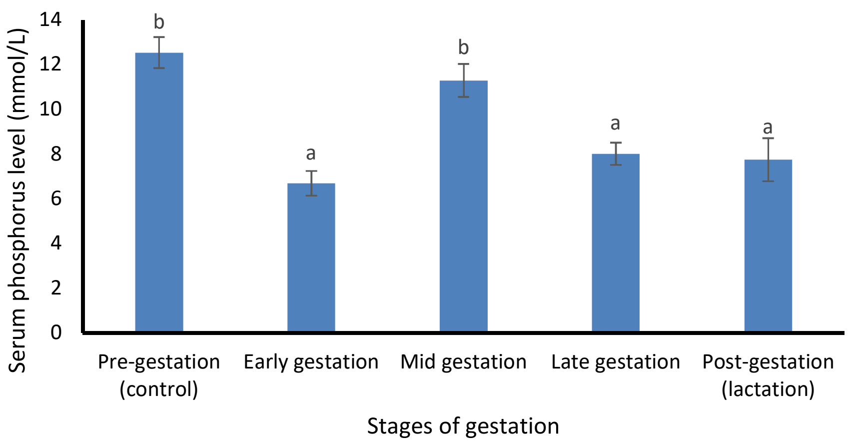

Figure 4. The mean serum phosphorus levels of Large White sows at different stages of gestation. Values are expressed as means ± SEM. Values with different superscripts are statistically ($p < 0.05$) different.

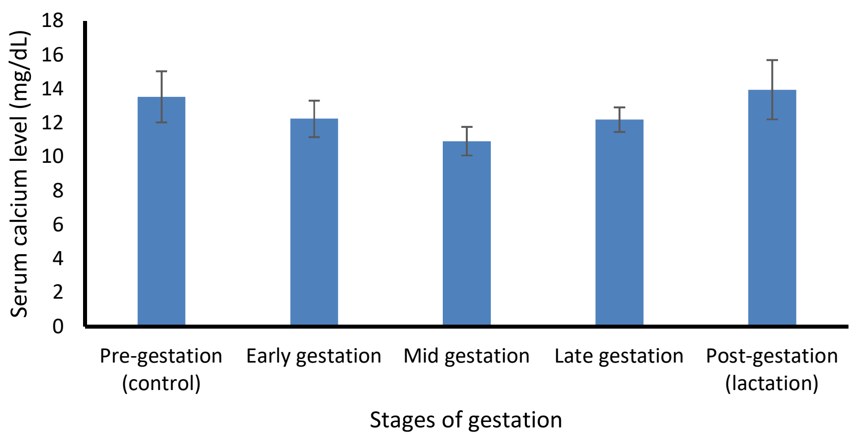

Figure 5: The mean serum calcium concentrations of Large White sows at different stages of gestation. Values are expressed as means ± SEM.

Table 1: The mean calcium: phosphorus (Ca:P) and sodium: potassium (Na:K) ratios of Large White sows at different stages of gestation. [Values are expressed as means ± SEM]

Parameters	Pre-gestation (control)	Early gestation	Mid gestation	Late gestation	Post-gestation (lactation)
Ca:P	0.28 ± 0.03 ^{a}	0.47 ± 0.06 ^{b}	0.25 ± 0.03 ^{a}	0.39 ± 0.04 ^{ab}	0.47 ± 0.07 ^{b}
Na:K	22.97 ± 1.91 ^{a}	22.80 ± 2.24 ^{a}	30.54 ± 1.67 ^{b}	27.19 ± 1.06 ^{ab}	24.49 ± 1.37 ^{a}

$^{a\,b}$ Mean values in the same row with different superscripts are significantly different ($p < 0.05$)

Discussion

Electrolytes are essential for controlling membrane potential, muscle contraction, nerve conduction and enzymatic reactions, and they play a major role in most physiological processes (Kohnke, 2009). The significantly lower serum levels of sodium in the early gestation group when compared to the mid and late gestation groups is thought to be related to the changes in renal regulation of water and electrolyte balance. Pregnancy alters sodium excretion through changes in renal perfusion, glomerular filtration rate (GFR) and proximal tubular morphology (Arthur and Green, 1986). The lower serum sodium level during early pregnancy in this present study could possibly be due to increase in sodium (Na) loss in urine due to the effect of progressive increase in progesterone level during early pregnancy. Also, the lower serum Na level during early pregnancy may partly be related to the increase in foetal demands leading to an increase in accumulation of Na in the foetal tissues during early pregnancy (McDonald *et al.,* 1979). The significantly lower serum sodium levels recorded in the present study during early gestation agrees with the earlier reports of Mohamed and Abdalla (2010) which showed lower serum Na levels at early pregnancy compared to other stages of gestation. It is thought that the lack of significant variations in serum potassium levels may possibly be as a result of the fact that potassium is principally an intracellular cation.

In agreement with the findings of Hamadeh *et al*. (1996) and Castillo *et al*. (1999) it was observed in this study that the serum glucose levels of non-pregnant sows (pre-gestation control) was higher than those of the pregnant sows. Atakisi *et al*. (2009) reported that, in sheep, serum glucose levels were lower in the last 3 months of gestation compared to levels before pregnancy and this equally agrees with our findings. These researchers attributed the reduction observed in blood glucose levels in late gestation to the increased use of glucose by the foetus, uterus, foetal tissues and placenta. The present result is also consistent with the findings of Antunovic *et al*. (2011) who reported a decrease in serum glucose levels at late gestation. This lower blood glucose concentration during pregnancy has been associated with foetal development and mobilization of maternal glucose to foetal blood circulation (Jacob and Vadodaria, 2001). Results of serum glucose levels in the present study however disagrees with the report of Zvorc *et al*. (2006) which showed lower post-partum glucose concentrations compared to pregnant sows. Changes in glucose concentration that occur during transition from gravidity to lactation are the result of physiological changes in metabolic processes which take place at the beginning of lactation. Glucose delivery and uptake by the mammary gland are a rate limiting step of milk synthesis. It is thought that insulin independent glucose uptake decreases in tissues, except for the mammary gland, and insulin resistance in the whole body increases following the onset of lactation (Komatsu *et al.,* 2005).

Phosphorus (P) is a mineral required in large quantities for skeleton mineralization. Results of the present study showed that the serum phosphorus level was significantly lower during early gestation, late gestation and post-gestation. This agrees with the result of earlier work of Mohamed and Abdalla (2010) who reported reductions in serum phosphorus levels at early pregnancy compared to other stages of gestation. The findings in the present study with regards to serum phosphorus levels partly concurs with previous reports by Braithwaite (1983a & b), which showed lower serum phosphorus levels during late pregnancy and attributed it to an increase in the rate of mobilization of phosphorus out of maternal blood circulation into the foetus, which was not balanced by an increase in the rate of phosphorus absorption from the gut or in the rate of resorption of phosphorus from the bones of the dam. The results of the present study however contrasts with a previous report by Ozkan *et al*. (2015) which showed no significant changes in serum phosphorus levels during gestation in Angora Cats.

The present study revealed that the serum concentration of calcium did not show any significant variations among the groups. This finding was in agreement with what was previously reported in camels (Omidi *et al.,* 2014; Tharwat *et al.,* 2015), but is in contrast with the reports on buffaloes by Hagawane *et al.* (2009) who showed lower calcium levels at the end of pregnancy. The authors attributed such findings to the impairment of absorption of this metabolite from the alimentary tract and to the excessive losses through urine and colostrum.

The significantly higher calcium: phosphorus ratio recorded in this present study during early gestation and post-gestation was above the normal range of Ca: phosphorus ratio of 0.40 needed for optimum reproductive performance and large enough to avoid the predisposition of the sows to urinary calculi and osteoporosis during gestation and lactation. The significantly higher sodium: potassium ratio recorded in this present study during mid-gestation could possibly be optimally needed for preserving cardiovascular health during mid-gestation.

Conclusion: Based on the result of the study it was concluded that in Large White sows, serum levels of sodium, phosphorus, glucose, Ca:P ratio and Na:K ratio are significantly affected by pregnancy and gestation.

Conflict of Interest

The authors declare that there is no conflict of interest.

References

Akusu MO and Egbunike GN (1984). Fertility of the West African Dwarf goat in its native environment following prostaglandin F2-alpha induced estrus. *The Veterinary Quarterly Journal,* 6(3)**:** 173 – 176.

Ali A and Fahmy S (2008). Ultrasonographic fetometry and determination of foetal sex in buffaloes (*Bubalus bubalis*). *Animal Reproduction Science*, 106: 90 – 99.

Antunovic Z, Novoselec J, Sauerwein H, Speranda M, Vegara M and Pavic V (2011). Blood metabolic profile and some of hormones concentration in ewes during different physiological status. *Bulgarian Journal of Agricultural Science*, 17: 687 – 695.

Arthur SK and Green R (1986). Fluid reabsorption by the proximal convoluted tubules of the kidney in lactating rats. *Journal of Physiology London*, 371: 267 – 275.

Atakişi E, Atakişi O, Merhan O, Ogun M, Ozcan A and Maraşlı S (2009). Koyunlarda gebelik oncesi, gebelik ve doğum sonrası β-hidroksibutirik asit, glukoz ve trigliserid duzeylerinin araştırılması. *Journal of Faculty of Veterinary Medicine University of Erciyes*, 6: 37 – 41.

Bailey NT (1995). Statistical Methods in Biology. Cambridge University Press.

Braithwaite GD (1983a). Calcium and Phosphorus requirements of the ewe during pregnancy and lactation. I. Calcium. *British Journal of Nutrition*, 50: 711 – 722.

Braithwaite GD (1983b). Calcium and Phosphorus requirements of the ewe during pregnancy and lactation. II. Phosphorus. *British Journal of Nutrition*, 50: 723 – 736.

Castillo C, Hernandez J, Lopez AM, Miranda M and Benedito JL (1999). Effect of physiological stage and nutritional management on some serum metabolite concentrations in Assaf ovine breed. *Arch. Tierz. Dummerstorf*, 42(4): 377 – 386.

Ceylan E, Tanritanir P and Dede D (2009). Changes in some macro-minerals and biochemical parameters in female healthy siirt hair goats before and after parturition. *Journal of Animal and Veterinary Advances*, 8(3): 530 – 533.

Hagawane SD, Shinde SB and Rajguru DN (2009). Haematological and blood biochemical profile in lactating buffaloes in and around Parbhani city. *Veterinary World*, 2: 467 – 469.

Hamadeh ME, Bostedt H and Failing K (1996). Concentration of metabolic parameters in the blood of heavily pregnant and non-pregnant ewes. *Berl Munch Tierarztl Wochenschr*, 109(3): 81 – 86.

Henry RF (1974). Clinical Chemistry Principles and Technics. 2nd Ed. Harper and Row, Hargersein, M.D.

Hrubec TC, Whichard JM, Larsen CT and Pierson FW (2004). Plasma versus serum: Specific differences in biochemical analytic values. *Journal of Avian Medicine and Surgery*, 16(2): 101 – 105.

Isaac LJ, Abah G, Akpan B and Ekaette IU (2013). Haematological properties of different breeds and sexes of rabbits. *Proceedings of the 18th Annual Conference of Animal Science Association of Nigeria*, pp. 24 – 27.

Jacob N and Vadodaria VP (2001). Levels of glucose and cortisol in blood of Patanwadi ewes around parturition. *Indian Veterinary Journal*, 78: 890 – 892.

Kohnke J (2009). Blood Counts: A Practical Guide to Common Problems. A John Kohnke article www.kohnkesown.com.

Komatsu T, Itoh F, Kushibiki S and Hodate K (2005). Changes in gene expression of glucose transports in lactating and non lactating cows. *Journal of Animal Science*, 83: 557 – 564.

Krajnicakova M, Kovac G, Kostecky M, Valocky I, Maracek I, Sutiakova I and Lenhardt L (2003). Selected clinico- biochemical parameters in the puerperal period of goats. *Bulletin of Veterinary Research Institute Pulawy*, 47: 177 – 182.

Mahan DC (2006). The changing mineral status of high producing sows. *In Proceedings of Swine Nutrition Conference, Indianapolis*, 7th Sept., 17 – 27.

McDonald I, Robinson JJ, Fraser C and Smart RI (1979). Studies on reproduction in prolific ewes. 5. The accretion of nutrients in the foetal and adnexa. *Journal of Agricultural Science (Cambridge)*, 92: 591 – 603.

Mohamed EE and Abdalla MA (2010). The minerals profile in desert ewes (*Ovis aries*): Effects of pregnancy, lactation and dietary supplementation. *American-Eurasian Journal of Agriculture and Environmental Sciences*, 7(1): 18 – 30.

NRC (National Research Council) (1996). Guide for the Care and Use of Laboratory Animals, 7th ed. Washington, DC: National Academy Press.

Omidi A, Sajedi ZH, MontazerTorbati MB and Mostafai M (2014). Metabolic profile of pregnant, non pregnant and male two humped camels (*Camelus bactrianus*) of Iran. *Iranian Journal of Veterinary Medicine*, 8: 235 – 242.

Overton TR and Waldron MR (2004). Nutritional management of transition dairy cows: Strategies to optimize metabolic health. *Journal of Dairy Science*, 87: 105 – 119.

Ozkan S, Sevket A and Miyase C (2015). Reference values for selected haematological and biochemical blood parameters from pre-pregnancy to advanced gestation in Angora cats. *Turkish Journal of Veterinary and Animal Sciences*, 39: 29 – 33.

Richards MP and Close WH (2001). Mineral nutrition of the sow. In Lyons, T.P., Cole, D.J. A. (Eds.)**:** Concepts in Pig Science. Nottingham University Press, Nottingham, UK, pp. 131 – 145.

Sacks DB (1999). Carbohydrates. In: Burtis CA, Ashwood ER (Editors), Tietz Textbook of Clinical Chemistry, 3rd ed., W.B Saunders Company, Philadelphia, pp. 750 – 808.

SAS (Statistical Analysis System) (2010). SAS User's Guide, SAS Institute, Cary, New York.

SPSS (Statistical Package for Social Sciences) (2012). International Businesses machines of Statistical Package for Social Sciences Statistics for Windows, Version 21.0. IBM Corp., Armonk, NY.

Steel RDG and Torrie JH (2006). Principles and Procedures of Statistics, 3rd edition, McGraw-Hill Book Co. Inc., New York.

Tanaka M, Kamiya Y, Suzuki T and Nakai Y (2011). Changes in oxidative status in periparturient dairy cows in hot conditions. *Animal Science Journal*, 82: 320 – 324.

Tanritanir P, Dede S and Ceylan E (2009). Changes in some macro mineral and biochemical parameters in female healthy Siirt Hair goats before and after parturition. *Journal of Animal and Veterinary Advances*, 8: 530 – 533.

Tharwat M, Ali A, Al-Sobayil F, Selim L and Abbas H (2015). Haemato-biochemical profile in female camels (Camelusdromedarius) during the periparturient period. *Journal of Camel Practice and Research*, 22(1): 101 – 106.

Thomas L (1998). Clinical Laboratory Diagnostics. 1st ed. Frankfurt: TH-Books Verlagsgesellschaft, P. 295 – 298.

Tietz NW (1976). Fundamental of Clinical Chemistry, 2nd Edition, W.B. Saunders Co., Philadelphia, pp. 874.

Trinder P (1951). A rapid method for the determination of sodium in serum. *Analyst*, 76(907): 596 – 599.

Zvorc Z, Mrljak V, Susic V and Gotal JP (2006). Haematological and biochemical parameters during pregnancy and lactation in sows. *Veterinary Archives*, 76: 245 **–** 253**.**