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Transition Physiology of Sows: A Study on Hematological and Biochemical Profile

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ABSTRACT

The present study was conducted in pregnant sows to evaluate the hematological and biochemical profile during the transition period. Blood samples were collected from sows on the days -30, -10, -3, 0, +3 and +10 of farrowing and analyzed immediately for hematology and biochemical profile. A significant ($P<0.05$) decrease in red blood cell count and an increase in total white blood cell count, neutrophil, lymphocyte and eosinophil counts were noticed during the transition period. Serum total protein, globulin and albumin levels decreased significantly whereas serum total cholesterol, high density lipoprotein cholesterol, low density lipoprotein cholesterol concentrations increased significantly during the transition period compared to the day -30 of farrowing. Glucose concentration was significantly high on the days -10, -3, 0 and +3 of farrowing. Serum triglycerides significantly increased on the day -10 and day -3 compared to the day -30 and significantly decreased thereafter until day +10 of farrowing. Serum aspartate transaminase activity increased significantly ($P<0.05$) during the transition period compared to the day -30 of farrowing while alanine transaminase activity was highest on the days -3 and 0 of farrowing and gamma glutamyl transaminase activity on the day +3 of farrowing. Blood Urea Nitrogen values increased significantly ($P<0.05$) during transition period, whereas elevation in creatinine levels was seen on the day 0. Calcium and phosphorus levels of serum increased while sodium and chloride levels decreased significantly during transition period compared to day -30. Potassium levels decreased from day 0 until day +10 compared to the day -3 of farrowing.

HIGHLIGHTS

- A significant decrease in RBCs and increase in WBCs during transition period in sows.
- Higher serum glucose and cholesterol during transition period in sows.
- Elevated serum triglycerides before farrowing followed by a drop in its concentration.

Keywords: WBC, Serum triglycerides, Cholesterol, Calcium, Phosphorus, sows

The transition period in sows can be defined as the last 10 d of gestation and the first 10 d of lactation, encompasses substantial changes for the sow (Theil, 2015). It is accompanied by shifts in endocrine profile which in turn lead to metabolic changes that facilitate diversion of nutrients away from maternal stores towards the milk synthesis and nurturing of the newborn (Seifi *et al*., 2007). Characteristic metabolic changes occurring during the transition period may broaden the knowledge about transition physiology of sows and may aid in early diagnosis of metabolic disturbances as well as to improve the piglet survival (Kurpinska *et al*., 2015). Thus, the present study aimed at studying the hematological and

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biochemical parameters of sows during the transition period.

MATERIALS AND METHODS

Ten healthy pregnant sows (75% LWY crossbred pig variety SVVU T17) in second parity with an average litter size of 8-12 piglets were selected for the current investigation. The sows were maintained under standard managemental practices at AICRP on pigs, S.V.V.U, Tirupati, Andhra Pradesh. The care of sows was undertaken as per the guidelines of International animal ethics committee. The committee for the purpose of control and supervision of experiments on animals (CPCSEA), India has approved the protocol of the experiment (No.281/go/REeBi/S/2000/CPCSEA/CVSc/TPTY/010/).

Blood samples were collected from the selected sows on days 30, 10 and 3 before farrowing, on the day of farrowing, 3 and 10 days after farrowing. The bleeding was done by venipuncture of ear vein and blood was collected separately into K_2 EDTA and clot activator vials. Whole blood in EDTA vials was used for studying the hematology. The blood collected in clot activator vials was centrifuged at 2500 rpm for 5 min to separate serum and stored at -80^{o}C for further analysis.

The whole blood collected was analysed for hematological profile (RBC count, WBC count and lymphocyte, neutrophil, monocyte and eosinophil counts) using Mindray Vet 2800 Hematology analyzer (Mindray, USA). Biochemical profile of serum was evaluated using A15 biochemical analyzer (Biosystems, Spain) by standard methods i.e., total protein by biuret method (Gornall *et al*., 1949), albumin by bromocresol green method (Doumas *et al*., 1971), glucose by glucose oxidase / peroxidase method (Trinder, 1969), triglycerides by glycerol oxidase / peroxidase method (Fossati and Prencipe, 1982), total cholesterol by cholesterol oxidase / peroxidase method (Allain *et al*., 1974), HDL cholesterol by direct detergent method (Warnick *et al*., 2001), urea by urease method (Gutmann and Bergmeyer, 1974), creatinine by Jaffe & enzymatic method (Peake and Whiting, 2006), alanine transaminase by IFCC method (Schumann *et al*., 2002a), aspartate transaminase by IFCC method (Schumann *et al*., 2002b), gamma glutamyl transferase by IFCC method (Schumann *et al*., 2002c), calcium arsenazo by O-cresolphthalein method (Michaylova and Ilkova, 1971), phosphorus by phosphomolybdate method (Gamst and Try, 1980). LDL cholesterol values were calculated using Friedewald formula (Friedewald *et al*., 1972). The concentration of serum sodium, potassium and chloride levels were analysed using an electrolyte analyser (StarLyte, India). All the data obtained was subjected to One Way ANOVA (Snedecor and Cochran, 1994) followed by Duncan´s multiple range test (SPSS version 22).

RESULTS AND DISCUSSION

Hematology

The current investigation revealed a decrease in RBC count (Table 1) from day -10 to day +3 of farrowing which in accordance with Gaykwad *et al*. (2019) and it was lowest ($P<0.05$) at day -3 to +3. Similar decrease in RBC count at different stages of transition was reported in sows (Okafor *et al*., 2020) which could be due to the mobilization of maternal iron stores into the fetal circulation as well as hemodilution due to the increased plasma volume during the third trimester which would have led to the physiological anemia (Setia *et al*., 1987). Total WBC, neutrophil, lymphocyte, monocyte and eosinophil counts showed a significant ($P<0.05$) alteration with highest count on day +3 (Table 1) which might be due to the pregnancy associated physiological stress (Gaykwad *et al*., 2019; Okafor *et al.,* 2020). Increased glucocortioid secretion during late pregnancy and immediately after parturition could have resulted in high neutrophil and leucocyte count (Nagel *et al.,* 2016; Gregula-Kania *et al*., 2020).

Serum proteins

Serum total protein, albumin and globulin concentration decreased significantly ($P<0.05$) during transition phase with the lowest concentration at day -3 to +3 of farrowing (Table 2). Similar results were reported during peripartum period in sows (Huang *et al.,* 2021; Patra *et al.,* 2021; Ma *et al.*, 2020; Ji *et al.,* 2019; Gaykwad *et al.*, 2019). It might be due to the increased fetal demand for the albumin due to its exponential growth throughout late pregnancy and approaching parturition as well as extracellular fluid expansion. According to Soares *et al*., (2018), draining of globulins into the mammary gland for colostrum synthesis could be responsible for low levels of total

Table 1: Hematological profile of sows during the transition period

	Day '-30'	Day '-10'	Day '-3'	Day '0'	Day '+3'	Day '+10'
RBC ($X10^6/\mu l$)	$5.88^b \pm 0.20$	$5.14^{ab} \pm 0.25$	$4.98^a \pm 0.24$	$4.95^a \pm 0.23$	$4.92^a \pm 0.25$	$5.48^{ab} \pm 0.38$
WBC ($X10^3/\mu l$)	$11.97^a \pm 0.72$	$13.22^{abc} \pm 0.84$	$14.38^{bc} \pm 0.77$	$14.67^{bc} \pm 0.66$	$14.95^c \pm 0.77$	$12.50^{ab} \pm 0.76$
Neutrophil ($X10^3/\mu l$)	$5.92^a \pm 0.29$	$6.71^{abc} \pm 0.47$	$7.42^{bc} \pm 0.42$	$7.49^{bc} \pm 0.44$	$7.74^c \pm 0.25$	$6.54^{ab} \pm 0.29$
Lymphocyte ($X10^3/\mu l$)	$5.85^a \pm 0.25$	$6.33^{ab} \pm 0.26$	$6.54^{ab} \pm 0.46$	$7.08^{bc} \pm 0.23$	$7.83^c \pm 0.25$	$6.87^b \pm 0.24$
Monocyte ($X10^3/\mu l$)	$0.61^a \pm 0.01$	$0.69^{ab} \pm 0.03$	$0.74^b \pm 0.03$	$0.78^{bc} \pm 0.03$	$0.87^c \pm 0.05$	$0.71^b \pm 0.03$
Eosinophil ($X10^3/\mu l$)	$0.16^{ab} \pm 0.02$	$0.14^a \pm 0.01$	$0.14^a \pm 0.01$	$0.28^{bc} \pm 0.07$	$0.36^c \pm 0.06$	$0.26^{abc} \pm 0.03$

Values are Mean ± SE (n=10); a,b,c different superscripts row wise differ significantly (P<0.05).

Table 2: Serum proteins in sows during the transition period

	Day '-30'	Day '-10'	Day '-3'	Day '0'	Day '+3'	Day '+10'
Total protein (g/dl)	$8.03^d \pm 0.13$	$6.57^{bc} \pm 0.06$	$6.17^b \pm 0.15$	$5.90^a \pm 0.32$	$6.18^b \pm 0.28$	$6.72^c \pm 0.18$
Albumin (g/dl)	$4.07^b \pm 0.06$	$3.80^{ab} \pm 0.04$	$3.73^a \pm 0.06$	$3.65^a \pm 0.17$	$3.70^a \pm 0.16$	$3.80^{ab} \pm 0.08$
Globulins (g/dl)	$3.97^c \pm 0.10$	$3.12^b \pm 0.12$	$2.37^a \pm 0.12$	$2.25^a \pm 0.25$	$2.23^a \pm 0.29$	$2.92^b \pm 0.15$
A/G ratio	$1.03^a \pm 0.03$	$1.12^a \pm 0.10$	$1.62^{bc} \pm 0.07$	$1.74^{bc} \pm 0.24$	$1.80^c \pm 0.25$	$1.32^{ab} \pm 0.07$

Values are Mean ± SE (n=10); a,b,c different superscripts row wise differ significantly (P<0.05).

proteins and globulins during late pregnancy and early lactation. However, serum total protein and globulin levels increased (P<0.05) post farrowing (on day +10 compared to day 0) with a similar finding reported in goats (Madan *et al*., 2020).

Serum glucose and lipid profile

A significant (P<0.05) increase in glucose levels from day -10 to -3 of transition period in the present study (Table 3), is in accordance with earlier reports (Patra *et al.*, 2021; Ma *et al.*, 2020). Higher insulin resistance and the decreased insulin-independent uptake of glucose in tissues (except the mammary gland) during the transition from gravidity to lactation in sows, would have led to the increase in serum glucose concentration (Zvorc *et al.,* 2006; Huang *et al*., 2023). This could also be contributed by increased cortisol during transition period, which promotes hepatic glycogenolysis and gluconeogenesis, leading to a rise in serum glucose concentration (Soares *et al.,* 2018).

Serum triglycerides (TG) concentration increased on the days -10 and -3 compared to the day -30 and then decreased until day +10 of farrowing (Table 3) which is in accordance with previous studies in sows (Huang *et al.,* 2021; Ma *et al.*, 2020). As the sow approaches farrowing, increased insulin resistance could have resulted in elevated serum TG concentration through enhanced lipid mobilization from adipose tissue (Mosnier *et al.,* 2010). Further, lower TG levels after parturition might be due to a drain of TG into mammary gland for milk fat synthesis (Duque *et al.,* 2013).

An increase in total cholesterol, HDL-C and LDL-C concentrations during the transition period compared to day -30 of farrowing observed in the present study (Table 3), is in accordance with Duque *et al.* (2013), where increased cholesterol concentration was reported during different stages of transition period. Glucagon-induced lipid mobilization and an increase in plasmatic lipoprotein production during lactation could have resulted in hypercholesterolemia (Cavestany *et al*., 2005). Moreover, the effect of estrogens around the time of parturition could have resulted in higher insulin resistance leading to an increase in cholesterol synthesis (Duque *et al*., 2013).

BUN and serum creatinine

Significant increase in BUN values was observed during the transition period of sows (Table 4) which might be due to the skeletal muscle catabolism to provide amino acids for energy during lactation (Rempel *et al*., 2018; Shang *et*

Table 3: Serum glucose and lipid profile in sows during the transition period

	Day '-30'	Day '-10'	Day '-3'	Day '0'	Day '+3'	Day '+10'
Glucose (mg/dl)	$52.00^{a} \pm 2.56$	$68.33^{b} \pm 5.40$	$70.17^{b} \pm 6.61$	$69.00^{b} \pm 2.21$	$67.33^{b} \pm 2.30$	$52.33^{a} \pm 2.94$
Triglycerides (mg/dl)	$162.50^{b} \pm 1.56$	$232.83^{c} \pm 17.04$	$218.00^{c} \pm 25.40$	$118.33^{a} \pm 15.49$	$111.67^{a} \pm 7.09$	$123.33^{ab} \pm 5.65$
Total cholesterol (mg/dl)	$73.67^{a} \pm 1.65$	$166.50^{bc} \pm 9.60$	$155.00^{bc} \pm 4.66$	$146.50^{b} \pm 7.70$	$176.67^{cd} \pm 14.41$	$172.00^{c} \pm 3.15$
HDL-C (mg/dl)	$15.05^{a} \pm 2.17$	$27.40^{bc} \pm 0.36$	$26.20^{b} \pm 0.48$	$23.90^{b} \pm 3.18$	$29.23^{bc} \pm 2.72$	$33.02^{c} \pm 1.85$
LDL-C (mg/dl)	$58.62^{a} \pm 2.72$	$142.30^{c} \pm 9.19$	$119.68^{bc} \pm 6.71$	$112.43^{b} \pm 12.21$	$147.43^{c} \pm 13.40$	$135.48^{bc} \pm 3.73$

Values are Mean ± SE (n=10); a,b,c different superscripts row wise differ significantly (P<0.05).

Table 4: Serum Enzyme activities in sows during the transition period

	Day '-10'	Day '-3'	Day '0'	Day '+3'	Day '+10'	Day '-10'
BUN (mg/dl)	$13.00^{a} \pm 1.80$	$27.88^{b} \pm 1.94$	$27.54^{b} \pm 1.65$	$29.95^{b} \pm 2.70$	$25.40^{b} \pm 1.27$	$28.79^{b} \pm 1.41$
Creatinine (mg/dl)	$1.78^{a} \pm 0.16$	$1.64^{a} \pm 0.02$	$1.72^{a} \pm 0.11$	$2.16^{b} \pm 0.01$	$1.85^{a} \pm 0.13$	$1.66^{a} \pm 0.08$
AST (U/L)	$35.33^{a} \pm 2.90$	$54.32^{b} \pm 4.77$	$45.10^{ab} \pm 5.00$	$56.78^{b} \pm 3.46$	$56.15^{b} \pm 5.72$	$71.45^{c} \pm 2.37$
ALT (U/L)	$62.48^{a} \pm 8.01$	$73.08^{ab} \pm 6.52$	$93.15^{b} \pm 5.40$	$87.50^{b} \pm 6.17$	$81.72^{ab} \pm 5.88$	$81.75^{ab} \pm 7.24$
GGT (U/L)	$48.67^{ab} \pm 1.12$	$49.33^{ab} \pm 2.58$	$42.00^{a} \pm 6.97$	$50.33^{ab} \pm 1.14$	$57.50^{b} \pm 5.66$	$46.17^{ab} \pm 3.17$

Values are Mean ± SE (n=10); a,b,c different superscripts row wise differ significantly (P<0.05).

Table 5: Serum calcium and phosphorus in sows during the transition period

	Day '-30'	Day '-10'	Day '-3'	Day '0'	Day '+3'	Day '+10'
Calcium (mg/dl)	$6.42^{a} \pm 0.01$	$7.41^{b} \pm 0.28$	$7.25^{b} \pm 0.15$	$7.00^{b} \pm 0.32$	$7.05^{b} \pm 0.11$	$7.08^{b} \pm 0.08$
Phophorus (mg/dl)	$6.02^{a} \pm 0.31$	$7.21^{bc} \pm 0.16$	$7.25^{bc} \pm 0.14$	$7.38^{d} \pm 0.20$	$6.89^{bc} \pm 0.31$	$6.64^{ab} \pm 0.11$
Sodium (mEq/L)	$147.32^{c} \pm 3.72$	$134.14^{ab} \pm 1.66$	$130.90^{a} \pm 1.41$	$134.68^{ab} \pm 1.27$	$136.17^{ab} \pm 1.69$	$138.38^{b} \pm 2.21$
Potassium (mEq/L)	$4.80^{b} \pm 0.02$	$4.96^{b} \pm 0.17$	$5.62^{c} \pm 0.14$	$4.44^{a} \pm 0.09$	$4.40^{a} \pm 0.06$	$4.82^{b} \pm 0.18$
Chloride (mEq/L)	$109.93^{c} \pm 3.09$	$96.80^{ab} \pm 1.52$	$98.60^{ab} \pm 1.09$	$97.08^{ab} \pm 1.86$	$94.75^{a} \pm 0.59$	$101.12^{b} \pm 1.10$

Values are Mean ± SE (n=10); a,b,c different superscripts row wise differ significantly (P<0.05).

al., 2021; Ma *et al*., 2020; Huang *et al*., 2021). Increased catabolism of amino acids could also be related to either to high cortisol level or the greater protein intake during late gestation (Mosnier *et al*., 2010). Maximum concentration of creatinine was also reported on day 0 of farrowing which may be due to greater muscle breakdown due to intense muscular activity on the day of farrowing (Rempel *et al*., 2018).

Serum enzyme activities

Increased AST activity in transition phase of current investigation (Table 4) could be attributed to muscle cell breakdown caused by the intense muscular activity during parturition and mobilization of body reserves (Iriadam, 2007). Increased AST activity from late gestation until early-mid lactation was reported by Seifi *et al.* (2007) and Cavestany *et al*. (2005) in cows, and Soares *et al.* (2018) in goats. Significant peak observed in AST activity on the day +10 compared to the day +3 of farrowing which could be due to increased metabolic rate after parturition with possible energy loss leading to cellular hypoxia, increased cell membrane permeability and leaking of the enzymes out of the cell (Zvorc *et al.,* 2006). Enhanced ALT activity was observed during the transition period compared to the day -30 of farrowing (Table 4) which might be attributed to the stress induced gluconeogenesis (Verheyen *et al.,* 2007). Similar to the earlier reports, GGT activity was observed to be higher on the day +3 compared to day -3 of farrowing (Verheyen *et al*., 2007).

Serum electrolytes

Serum calcium and phosphorus levels were elevated during the transition period (Table 5) which might be due to increased serum estrogen levels during late gestation and postpartum to support mammary gland development. Estrogen in turn regulates parathyroid hormone (PTH) release leading to elevated serum calcium and phosphorus thus helps to meet the demands of foetal bone formation and milk production during late gestation and early lactation respectively (Lee *et al*., 2020). Similar increase in calcium levels was reported by Upadhaya *et al.* (2021), Patra *et al.* (2021), Ji *et al.* (2019) and Tan *et al.* (2016) during transition phase in sows. However, serum calcium and phosphorus levels decreased after farrowing which might be due to initiation of lactation and drainage of blood minerals into milk (Seifi *et al.,* 2007). Sodium and chloride concentrations decreased during the transition period of sows compared to day -30 of farrowing, whereas potassium levels decreased from the day of farrowing (Table 5). Similar findings were reported in goats and mares which might be related to electrolyte loss in the fluid during delivery or through colostrum (Madan *et al.*, 2020; Bazzano *et al*., 2016).

CONCLUSION

The present study brings knowledge more particularly on energy metabolism resulting from insulin resistance during the transition period of sows. Different dietary measures to improve insulin sensitivity during this phase would be beneficial for improving the reproductive efficiency of the sows. Moreover, the altered serum electrolyte levels in the present study emphasizes the need for respective supplementation during the transition period in sows.

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