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Original Article

EFFECT OF ORGANIC ZINC SUPPLEMENTATION ON SOME BIOCHEMICAL AND HEMATOLOGICAL PARAMETERS OF LOCAL GOATS DURING PREGNANCY AND LACTATION

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ABSTRACT

The objective of this study was to investigate the effect of organic Zinc (Zn) supplementation on some biochemical parameters of local goats in late pregnancy and lactation stage. The experiment was undertaken at a private goat's field in Akre district/ Dohuk governorate. A total of 24 pregnant local goats at week 6 of pregnancy were allocated by parity into 3 treatments (groups) for Zinc supplement (0.35 and 70 mg Zn) during (4) periods (0, 15, 30 day and after parturition). The results showed that the treatment (35 mg Zn) surpassed significantly ($p<0.05$) the other treatments for glucose, Alanine Aminotransferase (ALT), Lymphocyte Percentage (LYM%), Red Blood Cell Count (RBC) and Packed Cell Volume (PCV) values. However, the period (After-Parturition) significantly affected ($p<0.01$) urea, AST, WBC and RBC surpassing the other physiological stages. Most correlation coefficients between the studied parameters were significant ($p<0.01$). The highest positive coefficient was between RBC and PCV (0.871), while the highest negative coefficient was between RBC and MCV (-0.378). In conclusion, the Zinc treatment revealed that its importance in different periods is to maximize some parameters for improving the physiological status of goats.

Keywords: Goat, Organic Zinc Supplementation, Biochemical Parameters, Pregnancy Lactation.

1. INTRODUCTION

Over the past few decades, dairy goats have become an essential section of livestock farming in many places of the world, especially in arid and semi-arid regions where other livestock species may struggle to thrive (FAO, 2019; Saico & Abul, 2007). Goats are highly adaptable animals, capable of surviving in harsh environments while providing high-quality milk which is rich in essential nutrients (FAO, 2019). The native black goats of the Kurdistan Region are an indigenous breed adapted to the semi-arid and mountainous conditions of the Zagros Mountains. According to Alkass and Mustafa (2023), these goats are primarily raised for meat and milk production, with milk yields ranging from 127 to 189 liters per lactation. They are resilient to harsh environmental conditions, including feed shortages and common diseases, though this adaptability reduces certain economic traits such as growth rate and reproductive performance.

It is well-known deficiency of trace elements affects nearly all physiological processes such as reproduction, growth, immunity, milk production and other processes of animals. Histological sections of organs also showed their ultra-structural changes due to the elemental deficiencies (Haenlein & Anke, 2011). Although administration of Zinc (Zn) supplement in ruminant diets has been increased in recent years, organic Zn is more effective for improving animal performance. Some researchers (Kessler *et al*., 2003; Prasad, 2020) have demonstrated that organic Zn sources exhibit greater bioavailability compared to inorganic forms. Supplementation of animals with organic minerals enhances their growth and reproductive performance, while it decreases mortality of newborn (Formigoni *et al*., 2011). Organic Zn is one of the necessary nutrients required in the body for proper functioning of numerous enzymes involved in energy and protein metabolism apart from being involved in immune system in animals (Hogan *et al*., 1996; Mallaki *et al*., 2015). It has been demonstrated that organic Zn is transported intact from the intestinal lumen into mucosal cells, increasing tissue supply of Zn and thereby improving animal productivity (Garg *et al*., 2008). This study focused on inorganic Zn supplementation, examining its effects on biochemical and haematological changes in the blood and serum, as well as its impact on the health and environmental parameters of Kurdi sheep in the Kurdistan Region. However, there is no evidence of research specifically investigating the use of organic Zn sources in local goats within the region (Al-Kaky & Al-Janabi, 2023; Palani, 2024). The aim of the current study was to determine the physiological effect of organic Zn supplementation on pregnant and lactating goats.

2. MATERIAL AND METHODS

Experimental Design:

This experiment was carried out at a private goat's farm in Akre district/ Dohuk governorate during September 2024 to March 2025. A total of 24 pregnant local goats at week 6 of pregnancy were allocated according to parity, live-weight and body condition. The animals were randomly divided into three treatments groups (organic Zn supplementation) with 8 goats per group supplemented in three different levels to fresh drinking water. Goats of the control group (A) received no additional Zn (0 mg /day orally); group B was supplemented with organic Zn at the dose of (35 mg /day orally). No matter the effect of the medication, the physiological status of the same

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animals under study should be observed at 0 time (control time), after 15 days, after 30 days, and after parturition. The animals were fed according to the feeding system of the local private farms regime, where the fed composition has roughage and concentrate. The roughage included approximately 11.44% Protein, 2.96% Fat, 4.99% Ash, 32.58% NDF, 17.51% ADF, 11.99% Crude fiber, 0.27% Calcium, 5.71% Moisture, and 0.11% Phosphorus. The forage contained 8.14 mg/kg of Zn. Concentrate fed consisted of 6.19% Protein, 1.51% Fat, 1.00% Ash, 27.11% NDF, 17.87 % ADF, 9.43% Fiber, 4.34% Calcium, 9.81% Moisture, and 0.15% Phosphorus. The concentrated fed had a higher Zn content of 15.62 mg/kg. Blood samples were collected biweekly, using a 10ml wine syringe directly from the jugular vein at 11:00am. The samples were centrifuged at 3000 rpm for 20 minutes to separate the blood serum and later it was stored in 1.0 ml Eppendorf tubes at -20 ºC before further laboratory analysis.

Ethical Statement:

This research has been approved by Animal Ethics Committee of Animal Production Department University of Duhok approval number: AEC-07092025. In terms of experimental design, the goats were maintained under optimal conditions with proper housing, balanced nutrition, and unrestricted access to water throughout the experimental period. Special attention was given to animal welfare, with comprehensive measures implemented to reduce stress and ensure the comfort of all subjects.

Parameters:

The biochemical parameters included: Glucose, Urea, Aspartate Aminotransferase (AST) and ALT. The parameters were determined by Biolis 24i automated clinical chemistry analyzer (Tokyo Boeki Medical System Ltd., Japan). Haematological parameters included WBC, LYM, LYM%, Haemoglobin (Hb), RBC, Mean Corpuscular Volume (MCV), and PCV, that were analyzed using a device of Veterinary haematology analyser on whole-blood samples.

Statistical Analysis:

The collected data was submitted to SPSS software (IBM Corp, 2019, Version 26.0). Descriptive statistics, including means and standard errors, were calculated to summarize the data and provide an initial overview of the measured parameters. Repeated measures (ANOVA) and correlation analysis between the studied variables were applied. Such measures were chosen because the same animals were measured at multiple time points, accounting for the correlation between repeated observations on the same subjects. Bonferroni test was used for post hoc comparisons when significant differences were detected. The level of statistical significance was set at $p<0.05$. For showing correlation analysis between the studied parameters, the Pearson correlation test was used, as the data were parametric and normally distributed.

3. RESULTS

Biochemical parameters:

The analysis of biochemical parameters showed that their overall means were relatively within the normal ranges of local goats (Table 1).

The results also indicated that there were significant differences ($p<0.05$) between glucose and ALT parameters (Table 1), while the other parameters were not affected significantly ($p>0.05$) by the treatments. For glucose, T2 recorded (62.25 mg/dl) and surpassed significantly the T1 with value (49.91 mg/dl), while the third treatment (T3: 70 mg Zn) was intermediate among them (57.38 mg/dl). For ALT parameter, T2 recorded significant superiority ($p<0.05$) (19.28 U/L) on both T1 and T3, which had the means (15.47 U/L and 15.7 U/L, respectively). However, the rest parameter's means of the treatment groups were close to each other. In respect to the physiological status, on the contrary of the effect of treatment, all the studied parameters differed significantly ($p<0.01$); whereas, both glucose and ALT parameters were not affected by the time ($p>0.05$) as shown in (Table l). However, After-Parturition recorded significantly the highest values for Urea (35.33mg/dl) and AST (69.79 U/L) and followed by Time 3 (After 30 days), which had the values of the mentioned parameters as Urea (33.25mg/dl) and AST (48.75 U/L).

Haematological Parameters:

The analysis of haematological parameters showed that their overall means were within the normal ranges for local goats (Table 2). Regarding the impact of the treatments under study, the results showed that the LYM%, RBC, and PCV varied significantly ($p<0.05$) among treatment groups, while other parameters had no effect ($p>0.05$).The second treatment (T2: 35 mg Zn) had the highest LYM% (53.23%) for lymphocytes, which was considerably higher than the control (47.76%). The T3 had an intermediate LYM% (50.53%). T3 showed a notable decline (0.211× RBC10^{12}/L), T1 and T2 exhibited comparable higher values (0.382×10^{12}/L and 0.388×10^{12}/L, respectively). Similar patterns were seen in PCV, with T2 showing the greatest value (1.60%) and T3 the lowest (1.116%). In contrast to the effect of treatment, the influence of time was found to have a significant impact ($p<0.05$) on the majority of indices, including WBC, LYM%, RBC, MCV, and PCV. Time, however, had no discernible impact on Hb or LYM% ($P>0.05$). Notably, Table 2 indicates that WBC increased significantly (12.204 ×109/L) at parturition; whereas, LYM% declined (4.417 ×109/L). Around day 30, RBC and PCV peaked at 0.385 ×10^{12}/L and 1.717%, respectively, indicating an increase in erythropoietin activity. On the other hand, MCV significantly decreased, reaching its lowest value at parturition (38.36 fL).

Table 1: Effect of treatment and Physiological status on Biochemical parameters.

	Glucose (mg/dl)	Urea (mg/dl)	AST(U/L)	ALT(U/L)
Overall Mean				
Mean	56.521	24.792	50.677	16.818
Effect of Treatment				
Treatment	**Glucose (mg/dl)**	**Urea (mg/dl)**	**AST(U/L)**	**ALT(U/L)**
0 mg zinc	49.91 ± 3.89 b	23.594 ± 1.639	52.781 ± 2.307	15.469 ± 1.092 b
35 mg zinc	62.28 ± 3.89 a	26.875 ± 1.639	50.125 ± 2.307	19.281 ± 1.092 a
70 mg zinc	57.38 ± 3.89 ab	23.906 ± 1.639	49.125 ± 2.307	15.704 ± 1.092 b
p value	0.05	0.30 n.s	0.514 n.s	0.026
Physiological status(time)				
Time	**Glucose (mg/dl)**	**Urea (mg/dl)**	**AST(U/L)**	**ALT(U/L)**
Control	54.958 ± 4.492	14.08 ± 1.893 b	42.875 ± 2.664 b	17.167 ± 1.261
After 15 d	52.792 ± 4.492	16.50 ± 1.893 b	41.292 ± 2.664 b	15.333 ± 1.261
After 30 d	63.875 ± 4.492	33.25 ± 1.893 a	48.750 ± 2.664 b	16.125 ± 1.261
After Parturition	54.458 ± 4.492	35.33 ± 1.893 a	69.792 ± 2.664 a	18.647 ± 1.261
± SEM	4.492	1.893	2.664	1.261
p value	0.303 n.s	<0.001	<0.001	0.284 n.s

Table 2: Effect of treatment and physiological status on haematological parameters.

	WBC 10^9/L	LYM 10^9/L	LYM%	HGB (g/dl)	RBC 10^{12}/L	MCV (fL)	PCV%
Overall Mean							
Mean	10.657	5.237	50.506	8.232	0.327	41.376	1.416
Effect of Treatment							
Treatment	**WBC 10^9/L**	**LYM 10^9/L**	**LYM%**	**HGB (g/dl)**	**RBC 10^{12}/L**	**MCV (fL)**	**PCV%**
Control	10.687 ± 0.53	5.056 ± 0.277	47.759 ± 1.794 b	8.284 ± 0.152	0.382 ± 0.036 a	41.263 ± 0.386	1.531 ± 0.142 a
35 mg zinc	10.663 ± 0.53	5.394 ± 0.277	53.234 ± 1.794 a	8.194 ± 0.152	0.388 ± 0.036 a	41.138 ± 0.386	1.600 ± 0.142 a
70 mg zinc	10.622 ± 0.53	5.263 ± 0.277	50.525 ± 1.794 ab	8.219 ± 0.152	0.211 ± 0.036 b	41.728 ± 0.386	1.116 ± 0.142 b
p value	0.996 n.s	0.687 n.s	<0.001 **	0.144 n.s	<0.001 **	0.524 n.s	0.038 *
Physiological status(time)							
Time	**WBC 10^9/L**	**LYM 10^9/L**	**LYM%**	**HGB (g/dl)**	**RBC 10^{12}/L**	**MCV (FL)**	**PCV%**
Control	9.942 ± 0.612 b	5.104 ± 0.320 ab	50.967 ± 2.072	8.579 ± 0.175	0.244 ± 0.042 b	43.388 ± 0.445 a	1.062 ± 0.164 b
After 15 d	10.954 ± 0.612 ab	5.667 ± 0.320 a	52.396 ± 2.072	8.196 ± 0.175	0.293 ± 0.042 ab	42.154 ± 0.445 ab	1.358 ± 0.164 ab
After 30 d	9.529 ± 0.612 b	5.762 ± 0.320 a	61.833 ± 2.072	8.100 ± 0.175	0.385 ± 0.042 a	41.604 ± 0.445 b	1.717 ± 0.164 a
After Parturition	12.204 ± 0.612 a	4.417 ± 0.320 b	36.829 ± 2.072	8.054 ± 0.175	0.387 ± 0.042 a	38.358 ± 0.445 c	1.525 ± 0.164 ab
± SEM	0.612	0.320	2.072	0.175	0.042	0.445	0.164
p value	0.013	0.014	0.104 n.s	0.909 n.s	0.042	0.001	0.43

Relationship between the studied parameters:

Table 3 presented the correlation analysis of the studied biochemical parameters to assess the relationships among them. The results indicated a significant positive correlation (p<0.05), suggesting that as glucose levels increase, urea levels also tend to increase. Glucose and urea exhibited a significant positive relationship with each other, appearing increments in glucose levels are connected to increments in urea levels. The relationship appears a conceivable interrelation between nitrogen metabolism system and energy metabolism in the studied goats. Urea was correlated positively and significantly (p<0.01) with all studied parameters. Alternately, urea featured a positive and measurably critical relationship (p<0.01) with all the remaining parameters including AST and ALT, as displayed in Table 3.

Table 3: Correlation coefficients between the studied biochemical parameters .

	Glucose (mg/dl)	Urea (mg/dl)	AST (U/l)	ALT (U/l)
Glucose (mg/dl)	1	0.218*	−0.030	0.096
Urea (mg/dl)	0.218*	1	0.401**	0.320**
AST (U/l)	−0.030	0.401**	1	0.194
ALT (U/l)	0.096	0.320**	0.194	1

*. Correlation is significant at the 0.05 level (2-tailed).
**. Correlation is significant at the 0.01 level (2-tailed).

The correlation coefficients between the haematological parameters measured in this study to assess their interrelationships are shown in Table 4.

A significant positive correlation between RBC and PCV was observed (r=0.871, p<0.01). WBC was moderately positively correlated with LYM% (r=0.503, p<0.01), confirming that LYM% constitute a major component of the WBC population. In contrast, WBC exhibited a negative correlation with LYM% (r= -0.365, p<0.01), suggesting that under stress or immune activation, the proportion of LYM% decreases while the overall WBC count increases due to neutrophil proliferation. LYM showed a significant positive correlation with LYM% (r=0.546, p<0.01) and with MCV (r=0.290, p<0.01), indicating that LYM% dynamics are associated with changes in both their proportion and RBC size. LYM% was also positively correlated with MCV (r=0.365, p<0.01), further supporting this relationship.

Hb showed no significant correlations with most indices, reflecting its relative independence from variations in leukocyte and erythrocyte indices.

RBC demonstrated a strong positive correlation with PCV (r=0.871, p<0.01), highlighting that PCV is directly determined by RBC count. Conversely, RBC was negatively correlated with MCV (r= -0.378, p<0.01), suggesting that as the number of RBC increases, their average volume decreases. Finally, PCV showed a significant negative correlation with MCV (r= -0.333, p<0.01), consistent with the inverse relationship observed between RBC and MCV. These correlations collectively emphasize the close interdependence between RBC indices and immune cell dynamics in goats under different physiological stages. Biochemical parameters showed significant positive correlations between AST and urea (r=0.401, p<0.01) and ALT and urea (r=0.320, p<0.01), suggesting that elevated liver enzyme activities are associated with increased nitrogen metabolism. Glucose showed a weaker positive correlation with urea (r=0.218, p<0.05). These associations imply linked hepatic function and protein metabolism, which may be influenced by organic Zn supplementation during late pregnancy and lactation.

4. DISCUSSION

Zinc plays a crucial role in ruminant health by supporting enzyme function, immune competence, growth, reproduction, and overall metabolic processes (Mir *et al*., 2020). While the study by Spears and Weiss (2008) provides valuable insights into the role of organic Zn in glucose metabolism in cattle, the effects in small ruminants like sheep and goats may differ. Organic zinc's greater bioavailability compared to inorganic Zn makes it increase serum glucose concentration in goats (Kumar *et al*., 2009). However, Zn, even in its organic form, appears to minimal impact on ruminant blood urea nitrogen (NRC, 2007). For ALT parameter, T2 recorded significant (p<0.05) superiority (19.28 U/L) on T1 and T3, which had the similar means (15.47 U/L and 15.7 U/L, respectively). According to Garg *et al*. (2008), organic Zn supplementation boosted liver enzyme activity of ruminants. In our study, and in agreement with Roubies *et al*. (2006), the elevated ALT levels observed in T2 indicated greater liver metabolic activity as organic zinc optimizes cofactors for enzymes' efficiency. The non-linear response observed at higher zinc dosages aligns with the findings of Ulutaş *et al*. (2020) in goats, where urea and AST levels remained unchanged. This stability indicates that these parameters are relatively insensitive to short-term zinc supplementation under adequate dietary conditions.

Table 4: Correlation coefficients between hematological parameters.

Correlation coefficients	WBC 10^9/L	LYM 10^9/L	LYM%	HGB(g/dl)	RBC 10^{12}/L	MCV(FL)	PCV%
WBC 10^9/L	1	0.503**	−0.365**	0.159	0.154	−0.061	0.043
LYM 10^9/L	0.503**	1	0.546**	0.138	0.028	0.290**	0.007
LYM%	−0.365**	0.546**	1	−0.039	−0.118	0.365**	−0.018
Hb(g/dl)	0.159	0.138	−0.039	1	0.019	0.091	−0.124
RBC 10^{12}/L	0.154	0.028	−0.118	0.019	1	−0.378**	0.871**
MCV (fL)	−0.061	0.290**	0.365**	0.091	−0.378**	1	−0.333**
PCV%	0.043	0.007	−0.018	−0.124	0.871**	−0.333**	1

**. Correlation is significant at the 0.01 level (2-tailed).

Physiological stages such as late pregnancy, parturition, and early lactation significantly affect blood biochemical profiles in goats. Urea levels typically increase around parturition due to amplified protein turnover and nitrogen excretion related to colostrum blend and early lactation (Madan *et al*., 2020). According to Roubies *et al*. (2006), blood urea nitrogen fundamentally increases at parturition and remains raised during early lactation, reflecting enhanced catabolic activity. Moreover, Ahmed *et al*. (2016) observed a peak in serum urea within the middle of the fundamental week postpartum in goats, adjusting with the liver recovery. Liver function such as AST and ALT frequently had incremented around parturition, conceivably due to oxidative stress and elevated hepatic activity. Ahmed *et al*. (2016) also found that AST levels were altogether higher after compared to late pregnancy, indicating elevated hepatic transaminase action. El-Sherif and Assad (2001) reported higher AST and ALT levels postpartum, which gradually declined by mid-lactation. Glucose levels ordinarily decrease at mid late pregnancy due to fetal glucose demand but rise strongly after parturition due to hormonal changes (e.g., cortisol and glucagon) and enhanced gluconeogenesis. (Celi *et al*., 2008; López *et al*., 2009 & VanValin *et al*., 2020). In another study, Omar and Barwary (2022) reported that Zn supplementation (36 mg Zn/day) prevented blood glucose levels from dropping or blood glucose concentrations from rising (only in one week) in lambs during a six-week experiment. The results showed that increments in glucose concentrations is quickly after treatments, which stabilized as lactation advanced. These patterns reflect the endocrine system's adaptation to the heightened metabolic demands of lactation. The findings obtained by Dresler (2023) align with previous research indicating that organic Zn supplementation can enhance serum Zn levels without negatively impacting Hb and biochemical parameters in ruminants. This supports the notion that appropriate Zn supplementation can be beneficial during periods of physiological stress, such as early lactation, without compromising overall health. A study by Tantawi *et al*. (2023) observed that organic Zn supplementation improved growth performance, feed intake, and antioxidant capacity in growing Zaraibi male goats.

Administration of 35 mg of organic Zn supplements may improve haematological and immunological function, hence, Zn plays a critical part in vital defense mechanisms including oxidative stress. Ruminants may have an enhanced requirement for it during stressful situations (Mallaki *et al*., 2015), however higher doses may decrease erythropoiesis. Organic Zn is necessary for the development of LYM and the activation of antioxidant enzyme systems, but high concentrations can upset the mineral balance, particularly with regard to copper, which lowers the synthesis of (RBC) (Roubies *et al*., 2006).

These findings are consistent with previous research that demonstrated Zn had a dose-dependent effect on ruminant haematological markers (Angeles *et al*., 2020). According to Sahoo *et al*. (2021), goats receiving 500 ppm, 750 ppm, and 1000 ppm Zn had significantly higher RBC counts and Hb on day 30 ($p<0.05$) than the control group .According to Hayman and Al Janabi (2023), the goats fed with Zn Sulfate and spiraling had significantly higher WBC counts ($p<0.05$) than the control group, indicating the immune system is stimulated. However, there were no appreciable differences ($p>0.05$) in Hb concentration, PCV, or RBC count between the therapy groups.

Our results were consistent with Garg *et al*. (2008), Elamin *et al*., (2013) and El-Katcha *et al*., (2016), who found that goats' leukocyte and erythrocyte parameters are considerably improved by dietary organic Zn supplementation. In agreement with the results of Mellado *et al*. (2005) and Piccione *et al*. (2009), the WBC counts increased significantly ($p<0.05$) during parturition compared to prepartum levels. This similarity indicates that leucocytosis around parturition is a consistent physiological response in goats.

As reported in a previous study by Omar and Barwary (2022), the effects of Zn supplementation on the haematological parameters of lambs subjected to heat stress throughout the hot climatic season. The main findings highlighted variations in HB, PCV, and LYM, with notable impacts of time and therapy noted during the trial. The stability of Hb levels, despite significant alterations in other haematological parameters, is consistent with the findings of Kumar *et al*. (2009), who reported that Zn supplementation typically does not induce significant changes in Hb concentration. This suggests that organic Zn is essential for maintaining haematological homeostasis in goats during the physiologically demanding per parturient phase.

According to our results, there was a coefficient correlation between glucose and urea. Elevated glucose levels may lead to increased amino acid catabolism, thereby raising urea levels (Guyton & Hall, 2011). Furthermore, the positive affiliation with such parameters might be a sign of liver association in gluconeogenesis and the urea synthesis (Holeček, 2024). Hailemariam *et al*. (2021) suggested that the liver's digestive system may account for this relationship. A study by El-Sayed *et al*. (2024) on Barki ewes found significant increases in serum non-esterified fatty acids and thyroid hormones during early lactation, indicating heightened metabolic activity. These findings indicate the association between physiological interaction physiological interaction of hepatic function, nitrogen metabolism and protein metabolism. The liver produces albumin, which is the leading constituent of ads up to serum protein and is emphatically related with the entire protein. Moreover, more noteworthy levels of urea, AST, and ALT a protein digestion system and liver enzymatic movement factors "are consistent with expanded protein turnover or liver trouble (McDowell *et al*., 2007; Murray *et al*., 2018).

Roubies *et al*. (2006) found a high positive association between RBC and PCV in goats and ewes across physiological stages, which was consistent with other studies on goats under physiological stress.

A compensation process during physiological stress, such parturition, where smaller, more numerous red cells are created to meet oxygen needs, may be indicated by this inverse association. There have been reports of inverse RBC-MCV interactions and high RBC-PCV correlations (Elamin *et al*., 2013; Roubies *et al*., 2006).

According to Kumar *et al*. (2009), goats given Zn supplements displayed a negative correlation between PCV and MCV values, suggesting that during enhanced erythropoiesis, smaller RBC are produced, which in turn results in higher PCV values. According to Joo *et al*. (2021), the complicated relationships among white cell subpopulations (WBC, LYM, and LYM%) represent normal immune system adjustments throughout the postpartum phase. Adding credence to Ryan *et al*. (2002), RBC count, PCV, Hb concentration were among the haematological parameters that significantly improved with Zn supplementation. The results indicated that Zn supplementation positively influenced RBC and HB levels, supporting the findings of Sahoo *et al*. (2021).

5. CONCLUSION

It is concluded from the results that the organic Zn treatments have a significant effect on glucose and ALT, which were not affected by the time; while urea was affected by time. That means, by time, the last parameters may be changed without needing any treatment of Zn. The combined effects of Zn treatment and time indicate its importance in supporting physiological status. Overall, moderate organic Zn contributes to improved immune function and general health during late pregnancy and early lactation.

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Ethical Statment:

This research has been approved by Animal Ethics Committee of Animal Production Department University of Duhok approval number: AEC-07092025.

Conflict of Interests:

The authors declare no competing interests.

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Author Contributions:

D.B.F. & M.S.Q.: Conceptualization, study design, data collection, manuscript drafting, Data analysis and reporting. All authors have reviewed the final version of the manuscript and agreed to be accountable for all aspects of the work.

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