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Effect of different housing systems on haemato-biochemical parameters in crossbred heifer calves

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Abstract

The study evaluated the effect of two housing systems viz., tie barn and loose house, on the haemato-biochemical parameters of 20 crossbred heifer calves aged 5-7 months. The calves were randomly assigned to either housing systems and reared for a period of six months. Both groups were fed Total Mixed Ration (TMR) with 13% crude protein and 60% total digestible nutrients at 3% of body weight (dry matter basis) and were provided with ad libitum access to water. Results indicated slightly higher glucose levels in the tie-barn group (68.99 ± 0.66 mg/dL) compared to the loose house group (65.05 ± 0.81 mg/dL). Cholesterol was marginally higher in the tie-barn group (173.38 ± 1.92 mg/dL vs. 167.18 ± 1.75 mg/dL). ALT levels showed no significant difference (22.23 ± 1.7 U/L vs. 22.46 ± 2.7 U/L), suggesting minimal impact on liver function. Haematological parameters in tie barns, were higher, such as WBC counts (13.56 ± 0.79 thou/ μ L vs. 12.43 ± 0.48 thou/ μ L), haemoglobin (9.90 ± 0.10 g/dL vs. 9.48 ± 0.15 g/dL), RBC ($3.78 \pm 0.25 \times 10^6/\mu$ L vs. $3.47 \pm 0.25 \times 10^6/\mu$ L), haematocrit ($14.99 \pm 1.08\%$ vs. $13.4 \pm 1.01\%$), and platelets ($5139 \pm 486.7 \mu$ L vs. $4605.3 \pm 482.6 \mu$ L).

Keywords: Tie-barn and Loose-house, haematology, biochemical parameters, Crossbred heifer calves

Introduction

Housing systems play a crucial role in livestock management, directly influencing the welfare, productivity, and overall health of farm animals. Proper housing mitigates environmental stressors, enhances feed efficiency, and supports optimal physiological functions (Sinha *et al.*, 2018) [18]. The selection of an appropriate housing system is particularly important for heifer calves, as this developmental phase is characterized by rapid growth and critical physiological changes leading up to puberty. Approximately 75% of skeletal development occurs before puberty, emphasizing the need for optimal environmental conditions to ensure healthy growth and reproductive performance (Boulton *et al.*, 2015) [3]. Heat stress management plays a key role in maintaining haematological parameters such as leukocyte count, haemoglobin concentration, and packed cell volume, which serve as indicators of immune competence and overall health status (Buktare *et al.*, 2020) [4]. Variations in housing systems can influence these parameters, thereby affecting the resilience, productivity, and future reproductive efficiency of heifer calves. This study aims to evaluate the effects of different housing systems on the haematological and biochemical parameters of crossbred heifer calves, optimizing housing conditions to promote better health, welfare, and performance in young dairy replacements.

Materials and Methods

The study was conducted at the Livestock Research Station, Thiruvazhamkunnu Palakkad, Kerala which was located at the longitude of $760\ 22^{\circ}\text{E}$ and the latitude of $110\ 2^{\circ}\text{N}$, on the rear side of Silent Valley hills of Western Ghats, from February to August 2024. Twenty crossbred heifer calves, initially housed individually in hutches until six months of age, were assigned to two treatment groups- The heifer calves in Treatment group 1 were housed in conventional tie barn ($3.3\ \text{m}^2$ per animal), and those in Treatment group 2 were reared under loose housing

system (20 m² per animals). They were reared for a period of six months, with both groups receiving the same Total Mixed Ration (TMR) diet adjusted biweekly according to body weight (3% of body weight). Heifer calves had free access to water, with deworming conducted at the start of the trial and every three months thereafter.



Fig 1: Loose house system



Fig 2: Tie barn system

Blood collection

Blood samples were collected from experimental animals at the beginning of the study and at monthly intervals via jugular venipuncture using an 18 G needle. To ensure proper restraint and minimize stress during blood collection, heifer calves were restrained using a head rope while being gently secured by an assistant to prevent sudden movements. Whole blood was transferred to EDTA vacutainers for haematological analysis, while 5 ml was collected in serum vacutainers for biochemical analysis. After clotting for 30 minutes at room temperature, serum was separated by centrifugation and stored at -20°C for later analysis.

Estimation of haematological parameters

Haematological parameters like WBC, haemoglobin, RBC, HCT and platelet, were estimated in whole blood using automatic Vet haematology analyser (Mindray BC-30 Vet).

Biochemical parameters

Serum biochemical parameters, including glucose, alanine transaminase (ALT), cholesterol, and total protein, were analysed. Glucose concentration was estimated photometrically using the GOD-POD method (Trinder, 1969) [19] with Euro glucose kits. Serum ALT was measured by the IFCC-recommended method using Euro ALT kits. Cholesterol levels were determined via an enzymatic colorimetric method with diagnostic kits (PZ Cormay S.A., Poland), and total protein was quantified using the biuret

method (Doumas *et al.*, 1971) [6] with the same brand of diagnostic kits.

Statistical analysis

The collected data were analysed by t test using SPSS (Statistical Package for Social Science) version 24

Result and Discussion

The serum concentration of biochemical parameters and haematological parameters observed in the study are presented in table 1

Table 1: Mean Blood values in tie barn and loose house (Mean $\pm$ SE)

Blood parameter	Tie barn	Loose house	t- value	P value
Glucose (mg/dL)	68.99 $\pm$ 0.66	65.05 $\pm$ 0.81	4.0	0.9
Cholesterol (mg/dL)	173.38 $\pm$ 1.92	167.18 $\pm$ 1.75	2.2	0.7
ALT (U/L)	22.23 $\pm$ 1.7	22.46 $\pm$ 2.7	0.1	0.5
Total Protein (g/dL)	6.15 $\pm$ 0.06	5.92 $\pm$ 0.08	2.7	0.5
WBC (thou/ μ L)	13.56 $\pm$ 0.79	12.43 $\pm$ 0.48	1.1	0.1
HGB (g/dL)	9.90 $\pm$ 0.10	9.48 $\pm$ 0.15	3.5	0.3
RBC ($\times 10^6$ / μ L)	3.78 $\pm$ 0.25	3.47 $\pm$ 0.25	0.8	0.9
HCT (%)	14.99 $\pm$ 1.08	13.4 $\pm$ 1.01	1.0	0.8
Platelet (platelets/ μ L)	5139 $\pm$ 486.7	4605.3 $\pm$ 482.6	0.5	0.9

Glucose

Table 1 shows the average glucose levels in heifer calves housed in tie barns and loose housing systems throughout the experimental period. The results reveal a non-significantly higher average glucose level in tie-barn housing (68.99 $\pm$ 0.66 mg/dL) compared to loose housing (65.05 $\pm$ 0.81 mg/dL) with P value 0.9. Despite these variations, the glucose levels for both groups remained within the normal physiological range (42.1–74.5 mg/dL) as reported by the Merck Veterinary Manual (Aielle *et al.*, 1998). This slight difference might be associated with differences in stress levels, feeding patterns, and environmental comfort. Tie-barn housing may induce slightly higher stress levels or modify feeding behaviour, potentially resulting in increased glucose concentrations. The observed results are consistent with findings by Waghmode (2021) [20], who reported higher average monthly glucose concentrations in calves housed in conventional shelter systems (96.38 $\pm$ 6.57 mg/dL) compared to loose housing (91.33 $\pm$ 5.61 mg/dL), although the differences were not statistically significant. However, contrasting observations were noted in a study by Gautam (2012) [9], where blood glucose levels were significantly higher in calves raised in loose housing systems (48.75 $\pm$ 2.17 g%) compared to those in conventional tie barns (47.37 $\pm$ 0.64 g%).

Cholesterol

The mean cholesterol levels (mg/dL) in heifer calves housed in tie barns and loose houses are presented in Table 1. The results revealed non significantly higher cholesterol levels in calves housed in the tie-barn system compared to those in the loose housing system. The average cholesterol level recorded was 173.38 $\pm$ 1.92 mg/dL for tie-barn housing, whereas it was 167.18 $\pm$ 1.75 mg/dL for loose housing with P value 0.7. The elevated cholesterol levels in tie-barn housed animals may be attributed to the restricted movement and limited physical activity associated with this housing system, which could lead to a slower metabolic rate (Meissner *et al.*, 2010) [14]. Conversely, animals in the loose housing system had greater freedom of movement, resulting in increased energy expenditure and comparatively lower cholesterol levels.

These findings are in line with the observations of Abd-Allah *et al.* (2015) ^[1], who reported that animals raised in groups exhibited non-significantly lower cholesterol levels (211.45 ± 7.925 mg/dL) compared to those raised individually (223.53 ± 7.925 mg/dL). The similarity between these studies highlights the role of housing systems and physical activity in influencing cholesterol metabolism in cattle. In addition, the lower cholesterol levels observed in the loose housing system could indicate improved welfare and metabolic health due to reduced stress levels and enhanced opportunities for natural behaviours such as walking, lying, and social interaction. These results emphasize the importance of selecting appropriate housing systems to support the overall health and well-being of livestock.

Alanine transaminase (ALT)

The mean alanine transaminase (ALT) levels (U/L) for heifer calves housed in tie barns and loose housing systems over a period of six months are presented in Table 1. The average ALT levels in tie barns and loose housing were 22.23 ± 1.7 U/L and 22.46 ± 2.7 U/L, respectively with P value 0.5. Statistical analysis revealed no significant difference ($P > 0.05$) between the two treatment groups, indicating that the housing systems did not have a profound impact on liver function. The observed ALT levels in both housing systems remained well within the typical reference range of 11–40 U/L as reported by Ingvarsten (2006) ^[10]. ALT is a key liver enzyme used to evaluate liver function, and elevated levels can indicate liver damage or metabolic stress. These findings are in contrast with Abd-Allah *et al.* (2015) ^[1], who reported significantly higher ALT levels in individually housed calves compared to group-housed calves. This difference may be attributed to the role of group housing in minimizing stress and improving overall welfare. In the present study, both tie-barn and loose housing systems allowed the calves to maintain acceptable liver function, as reflected by ALT levels within the normal physiological range. This suggests that the management practices and housing environments adopted in the study were better to the health and well-being of the calves. This finding aligns with the understanding that proper management and environmental conditions play a critical role in maintaining animal health, regardless of housing type.

Total protein (g/dL)

The mean total protein levels (g/dL) presented in Table 1. The total protein levels were non significantly higher in the tie-barn system compared to the loose-house system, with average values of 6.15 ± 0.06 g/dL and 5.92 ± 0.08 g/dL, respectively with P value 0.5. The higher total protein levels observed in the tie-barn system may be attributed to improved microclimatic conditions and reduced physical activity, which likely contributed to better protein retention and overall metabolic status. In contrast, animals in the loose-house system, having more freedom of movement, may have experienced increased energy expenditure, potentially leading to slightly lower protein levels. The results are consistent with the findings of Abd-Allah *et al.* (2015) ^[1], who reported that individually housed calves exhibited higher total protein levels compared to those housed in loose systems. Additionally, Gaafar *et al.* (2021) ^[7] observed elevated total protein levels in animals exposed to cooler environmental conditions, which aligns with the controlled environment often maintained in tie-barn housing systems. The higher total protein levels in tie-barn systems could also reflect improved feed efficiency and reduced heat stress due to better

environmental management, as tie-barn housing typically provides better protection against adverse weather conditions (Gao *et al.*, 2017) ^[8]. In contrast, animals in loose housing are often exposed to greater temperature variations, which can negatively impact protein synthesis and metabolism. Overall, the study demonstrates that housing systems play a pivotal role in influencing the physiological parameters of heifer calves, with tie-barn systems showing advantages in maintaining higher total protein levels.

White Blood Cell (WBC)

The mean White Blood Cell (WBC) counts (thousand cells per microlitre $\times 10^3/\mu\text{L}$) for two housing systems is presented in Table 1. The results indicate that the WBC count in cattle housed in the tie barn system was non significantly higher than those in the loose house system ($13.56 \pm 0.79 \times 10^3/\mu\text{L}$ vs. 12.43 ± 0.48) with P value 0.1. A further notable observation was the increase in WBC counts during the rainy season, where values in tie barns peaked at $14.49 \pm 1.213 \times 10^3/\mu\text{L}$, compared to $12.95 \pm 1.213 \times 10^3/\mu\text{L}$ in loose housing. These elevated counts, while within or slightly above the reported normal range of $4.0 - 12.0 \times 10^3/\mu\text{L}$ (Aielle *et al.*, 1998), suggest an increased immune response in cattle subjected to the tie barn environment during rainy season. The higher WBC counts in tie barns may be attributed to greater exposure to environmental stressors, such as increased humidity, and restricted movement. This observation aligns with findings by Mazzullo *et al.* (2014) ^[13], who linked elevated WBC counts to environmental stress, and Gaafar *et al.* (2021) ^[7], who reported seasonal variations in immune function among cattle. Elevated WBC levels are indicative of immune activation, which can occur in response to environmental stress or mild inflammatory conditions. In the current study, tie barn systems likely imposed a higher degree of thermal and physical stress. Loose housing, by providing more space and better ventilation, may mitigate such stressors and thereby reduce the immune burden on the animals. These findings highlight the significant impact of housing systems on cattle health and stress.

Haemoglobin (g/dL)

The mean haemoglobin (Hb) levels (g/dL) of animals housed in two different systems: tie barn and loose house, over a six-month period are presented in Table 1. The Hb level was non significantly higher for heifer calves housed in tie barns (9.90 ± 0.10 g/dL) compared to those in loose housing systems (9.48 ± 0.15 g/dL) with P value 0.3. These values fall within the normal reference range of 8–15 g/dL as reported in the Merck Veterinary Manual (Aielle *et al.*, 1998). The results align with findings reported by Buktare *et al.* (2020) ^[4], who observed that stall-fed cows exhibited a significantly higher haemoglobin concentration (11.34 ± 0.11 g/dL) compared to cows housed in loose systems (10.81 ± 0.11 g/dL). In contrast, Patil *et al.* (2016) ^[16] found no significant difference in haemoglobin levels between conventional and loose housing systems in Pandharpuri buffalo calves. In the current study, a slight elevation in haemoglobin levels was noted during the rainy season. This seasonal variation could be attributed to environmental factors, such as direct solar as mentioned by Sejian *et al.* (2013) ^[17], who reported that heat stress reduces haemoglobin concentration in cattle. The higher haemoglobin levels in tie-barn systems might be associated with reduced physical activity and lower energy expenditure compared to loose housing systems. Animals housed in tie barns may experience less fluctuations in environmental

temperature, which could support more stable haematological parameters. In contrast, cattle housed in loose systems are exposed to fluctuating environmental conditions, which may influence haemoglobin dynamics. Overall, the results highlight the influence of housing systems and environmental conditions on haemoglobin levels in dairy cattle.

Red Blood Cell (RBC)

The mean Red Blood Cell (RBC) counts for animals housed in tie barns and loose housing systems over a six-month period are summarized in Table 1. The study observed no statistically significant difference in RBC counts between heifer calves housed in tie barns ($3.78 \pm 0.25 \times 10^6/\mu\text{L}$) and those in loose housing systems ($3.47 \pm 0.25 \times 10^6/\mu\text{L}$) with P value 0.46. RBC counts ranged from 3.207 to $4.478 \times 10^6/\mu\text{L}$, which were below the normal reference range of $5\text{--}10 \times 10^6/\mu\text{L}$ as reported in the Merck Veterinary Manual (Aiello *et al.*, 1998). These findings are consistent with previous studies by Waghmode *et al.* (2021) [20] and Patil *et al.* (2016) [16], which also reported no significant differences in RBC counts between housing systems. The lack of variation may be attributed to similar environmental conditions influencing erythropoiesis in both systems. High ambient temperature and humidity, as suggested by Koubkova *et al.* (2002) [11], are known to suppress erythropoiesis, which could explain the overall lower RBC counts observed in this study. The slight increase in RBC values during the rainy season might be associated with improved comfort due to lower environmental temperatures and reduced heat stress, leading to better physiological adaptation. However, further investigation is required to evaluate the role of seasonality and housing in influencing RBC production and overall hematological health in dairy cattle.

Haematocrit (HCT)

Table 1 presents the monthly mean hematocrit (HCT) levels for animals housed in two different systems: tie barn and loose housing, over a six-month study period. The results indicate that, mean HCT values for heifer calves housed in tie barns ($14.99 \pm 1.08\%$) were non significantly higher than those for heifer calves in loose housing ($13.4 \pm 1.01\%$), although the difference was statistically non-significant (P: 0.8). The HCT values recorded in both housing systems remained within the normal physiological range for cattle (24–46%; Aiello *et al.*, 1998). However, seasonal variations appeared to influence the haematocrit levels, with a notable decline during the summer months. This decrease can be attributed to heat stress-induced haemodilution, a phenomenon also reported by Lee *et al.* (1976) [12], where excessive heat results in haemodilution and reduced erythrocyte concentration. The current findings align with previous research, which suggests that housing systems and seasonal variations have a significant impact on the physiological and hematological parameters of dairy cattle. While the differences observed were statistically non-significant, the trends underscore the need for further studies with larger sample sizes and longer durations to determine the precise influence of housing systems on hematological parameters such as HCT. Overall, these results provide valuable insights into the impact of housing systems on cattle welfare and performance, emphasizing the importance of considering housing design and environmental management strategies to optimize animal health during critical seasonal periods.

Platelet (platelets/ μL)

The mean platelet levels between heifer calves housed in a tie-barn and loose housing system is presented in Table 1. Throughout the study period, platelet levels in calves housed in the tie-barn system were non-significantly (P value 0.9) higher than those observed in the loose housing system. The average platelet count in the tie-barn system was recorded as 5139 ± 486.7 platelets/ μL , whereas in the loose housing system, it was 4605.3 ± 482.6 platelets/ μL . These values fall within the normal reference range for cattle platelet counts ($100\text{--}800 \times 10^3/\mu\text{L}$) as established by the Merck Veterinary Manual (Aiello *et al.*, 1998) [2]. The findings indicate that neither housing system exerted adverse effects on platelet levels. The slight elevation in platelet levels observed in the tie-barn system may be attributed to improved thermal stress management. This was similar to the observation by Mirzadeh *et al.* (2010) [15], who reported that heat stress can reduce platelet counts in cattle. The more controlled microclimate of the tie-barn system may have contributed to reduced thermal stress, resulting in slightly higher platelet levels. These results emphasize the importance of optimized housing systems in maintaining cattle health and welfare.

Conclusion

The study delved the impact of housing systems on various physiological parameters in heifer calves. Results indicated that calves housed in tie barns had higher glucose, cholesterol, total protein, and white blood cell counts compared to those in loose housing systems, likely due to reduced physical activity and environmental stress in tie barns. Alanine transaminase (ALT) levels remained similar between the two systems, suggesting that liver function was not significantly affected by housing type. The loose housing system promotes better animal welfare by allowing greater freedom of movement, natural behaviours, and improved overall health. However, due to increased physical activity levels like walking and playing, animals in this system require additional feed to meet their energy demands and maintain optimal haematological and biochemical values, ensuring their well-being and productivity.

Conflict of Interest

Not available

Financial Support

Not available

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