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Effect of dietary betaine supplementati on haematological parameters in male goat kids

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Abstract

Goats play a crucial role in livestock farming in India, particularly in arid and semi-arid regions, due to their ability to withstand high temperatures and limited water availability. With rising global temperatures, improving heat tolerance in goats is essential for sustainable farming. Betaine, a naturally occurring feed additive, has shown potential in enhancing resilience against heat stress, improving nutrient absorption, and supporting physiological functions. This study aimed to assess the effects of betaine supplementation on hematological parameters in male goat kids. Eighteen male goat kids (4–5 months old) were divided into three groups: control (T1), betaine 2 g/day (T2), and betaine 4 g/day (T3). Blood samples were collected at intervals over four months. Results indicated a significant increase ($p<0.05$) in total erythrocyte count, total leukocyte count, hemoglobin levels, and packed cell volume in betaine-supplemented groups, particularly T3. The improved hematological parameters suggest that betaine enhances red blood cell production, immune function, and overall physiological health. These findings highlight betaine's role as a cost-effective nutritional strategy to mitigate heat stress in goats, supporting better growth and productivity. Incorporating betaine in goat diets could improve heat resilience and benefit small-scale farmers in hot climates.

Keywords: Betaine, hematology, goat kids, TEC, TLC, Hb and PCV

Introduction

Goats are a vital part of livestock farming in India, especially in regions experiencing high temperatures and arid or semi-arid climates. They are known for their remarkable adaptability to extreme weather conditions, including heat stress. In India, several indigenous goat breeds have evolved to withstand high temperatures, low humidity, and limited water availability, making them ideal for regions prone to heat stress. With climate change increasing global temperatures, the need for heat-resistant livestock is growing. Indian goat farming is shifting towards improved breed selection, better nutrition management, and shelter modifications to enhance heat tolerance and productivity. Research and sustainable farming practices are also being promoted to support small and marginal farmers who rely on goat farming for their livelihoods. Goat populations have grown by about 50% globally over the past 15 years, whereas sheep numbers have dropped by 4% and cattle numbers have only climbed by 9% (Kumar *et al.* 2019) [6].

Betaine is a valuable feed additive used in goat nutrition, particularly in hot and arid regions, to enhance resilience against heat stress and improve overall productivity. It is a naturally occurring compound derived from sugar beets or available in synthetic form as betaine hydrochloride/ betaine anhydrous. As an osmoprotectant, betaine helps maintain cellular water balance, reducing dehydration risks and minimizing the negative effects of heat stress. Its inclusion in goat diets enhances feed efficiency, nutrient absorption, and fat metabolism, leading to improved growth performance and muscle development, especially in meat goats. In lactating goats, betaine supplementation helps sustain milk yield and quality, even under high-temperature conditions. Additionally, it plays a crucial role in maintaining gut health by supporting intestinal integrity and boosting immunity, making goats less susceptible to diseases. By reducing body temperature and oxidative stress, betaine allows goats to cope better with extreme weather conditions. By interacting with heat shock proteins and restoring denatured proteins, betaine acts as a chaperone (Roth *et al*., 2012) [11]. Overall, betaine serves as a cost-effective solution to enhance heat tolerance, growth performance, hydration, and milk production in goats, making it an essential component of livestock farming in India's hot climates.

Materials and Methods

Eighteen non-descript male goat kids, aged 4-5 months with an initial body weight of 8-9 kg, were selected and randomly assigned to three equal groups: T1, T2, and T3 (n=6) for the study. All animals were in apparent good health and free from physical abnormalities. The experiment was conducted following the guidelines of the Institutional Animal Ethics Committee (IAEC). The T1 group served as the control, while the T2 and T3 groups received betaine supplementation at 2 g/animal/day and 4 g/animal/day, respectively. Feed-grade betaine supplementation commenced on the first day of the experiment and continued for four months. Blood samples (4 mL) were collected from the external jugular vein of each animal on days 0, 30, 60, 90, and 120 of the study. The collected data were analyzed using a completely randomized design (CRD) method.

Results and Discussion

1. Total erythrocyte count (10^6/µL)

The overall mean value of total erythrocyte count (TEC in million/ µL) in (T1) control group (12.78±0.21) was lower than T2 (13.80±0.21) and T3 (14.56±0.25) which differed non-significantly (p>0.05) between groups (Table 01).

At day 0, there were no significant differences in erythrocyte count between the groups, with values of 11.06±0.15, 11.55±0.18, and 11.61±0.38 for T1, T2, and T3, respectively. By day 30, significant differences emerged, with T3 showing the highest erythrocyte count (13.97±0.21 10^6/µL), followed by T2 (12.86±0.10 10^6/µL) and T1 (11.98±0.14 10^6/µL). Similar trends were observed at days 60 and 90, with T3 consistently having the highest erythrocyte counts. At the end of the study (day 120), T3 had the highest count (16.10±0.24 10^6/µL), followed by T2 (15.43±0.31 10^6/µL), and T1 (14.31±0.29 10^6/µL). Significant differences were observed between groups at days 30, 60, 90, and 120 ($p<0.05$). These results indicate that betaine supplementation positively affected the total erythrocyte count, with the highest values observed in T3. According to Mahmoudnia and Madani (2012) [7], betaine may help with methionine biosynthesis and osmotic pressure regulation, as evidenced by the increased RBC count values in the goat offspring fed with betaine diet as compared to the control group on a conventional diet. It is hypothesized that methionine biosynthesis may be directly or indirectly responsible for the most of the effects observed.

Current research aligns with Kassab *et al.* (2021) [4], who reported increased RBC counts in betaine-supplemented Aberdeen Angus cows in arid regions, and Park and Kim (2017) [10], who found similar results in meat-type ducks under heat stress. However, Abd El-Moniem *et al.* (2016) [1] observed no significant effect in rabbits, Mishra *et al.* (2019b) [9] and Al-Qaisi *et al.* (2022) [3] reported no impact on RBC counts in gestating sows and dairy heifer calves, respectively. Shakkarpude *et al.* (2021) [12] reported that the mean values of TEC, Hb and PCV differed non-significantly between betaine-supplemented and control groups in lactating Murrah buffaloes during hot-humid season.

Table 1: Effect of betaine supplementation on total erythrocyte count (10^6/µL) in male goat kids at different intervals (Mean ± SE)

Treatment Days	T1 (control)	T2	T3
0	11.06±0.15	11.55±0.18	11.61±0.38
30	11.98^a±0.14	12.86^b±0.10	13.97^c±0.21
60	12.95^a±0.20	14.27^b±0.23	15.16^c±0.18
90	13.58^a±0.26	14.89^b±0.22	15.95^c±0.26
120	14.31^a±0.29	15.43^a±0.31	16.10^b±0.24
Overall mean	12.78±0.21	13.80±0.21	14.56±0.25

Mean value with the different superscripts in a row differ significantly ($p<0.05$).

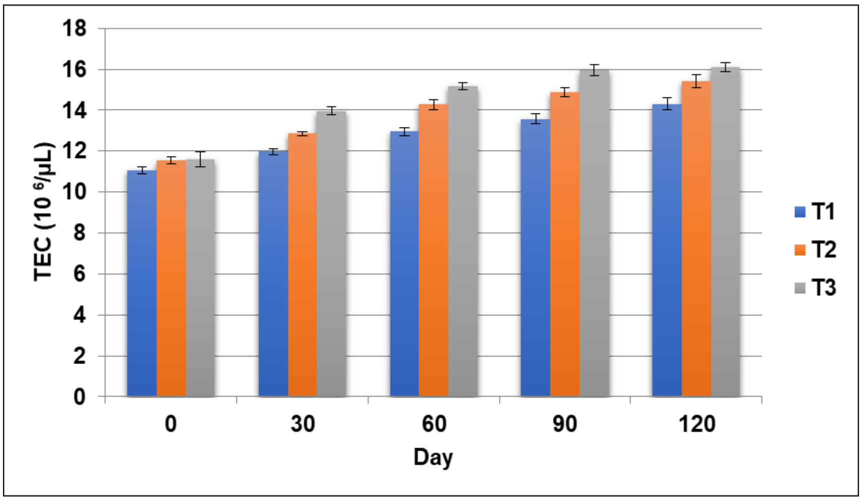

Fig 1: Effect of betaine supplementation on total erythrocyte count in male goat kids at different intervals

2. Total leukocyte count (10^3/µL)

The overall mean value of total leukocyte count (TLC - 10^3/µL) in (T1) control group (12.07±0.17) was lower than T2 (12.38±0.29) and T3 (12.85±0.24) which differed non-significantly (p>0.05) between groups (Table 02).

The mean values of total leukocyte count of male goat kids differ non significantly between all the groups T1, T2 and T3 on day 0 (11.15±0.20, 11.18±0.33 and 11.25±0.29) and 30 (11.46±0.24, 11.74±0.27 and 12.12±0.29) of the experiment. On day60, 90 and 120 of experiment the mean values of TLC (13.26±0.15, 13.79±0.29 and 13.85±0.18) of T3 were higher than T2 (12.44±0.29, 13.13±0.32and 13.39±0.22) and T1 (12.18±0.15, 12.66±0.18 and 12.92±0.09) groups and differed significantly ($p<0.05$) between groups.

Abd El-Moniem *et al.* (2016) [1] reported significantly higher WBC and lymphocyte counts in betaine and vitamin C-supplemented rabbits. Similarly, Mendoza (2017) [8] found that betaine supplementation helped restore WBC counts in heat-stressed swine. However, Mishra *et al.* (2019) [9] and Kondiba *et al.* (2023) [5] observed no significant effects on WBC counts in gestating sows and Deoni cows, respectively. The significant increase in TLC values in T2 and T3 groups highlights the beneficial effects of betaine, attributed to its antioxidant properties, promoting immune function and overall physiological health.

Table 2: Effect of betaine supplementation on total leukocyte count ($10^3/\mu L$) in male goat kids at different intervals (Mean ± SE)

Treatment Days	T1 (control)	T2	T3
0	11.15±0.20	11.18±0.33	11.25±0.29
30	11.46±0.24	11.74±0.27	12.12±0.29
60	12.18ᵃ±0.15	12.44ᵃ±0.29	13.26ᵇ±0.15
90	12.66ᵃ±0.18	13.13ᵃᵇ±0.32	13.79ᵇ±0.29
120	12.92ᵃ±0.09	13.39ᵃᵇ±0.22	13.85ᵇ±0.18
Overall mean	12.07±0.17	12.38±0.29	12.85±0.24

Mean value with the different superscripts in a row differ significantly (*p*<0.05)

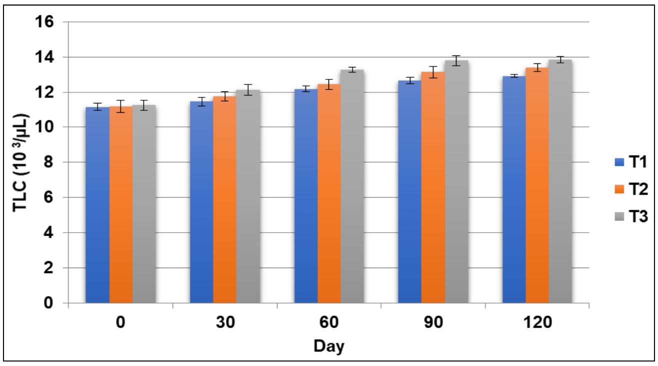

Fig 2: Effect of betaine supplementation on total leukocyte count in male goat kids at different intervals

3. Haemoglobin (g/dL)

The overall mean value of haemoglobin (g/dL) in control group (T1) (10.12±0.27) was lower than T2 (10.55±0.31) and T3 (10.90±0.28) which differed non-significantly (p>0.05) between groups (Table 03).

The mean values of haemoglobin concentration of male goat kids differed non significantly between all the groups T1, T2 and T3 on day 0 (9.48±0.32, 9.33±0.40 and 9.28±0.43 g/dL) and 30 (9.65±0.57, 9.72±0.27 and 9.95±0.19 g/dL) of experiment. On day 60, 90 and 120 of experiment the mean value of Hb (11.08±0.18, 11.78±0.39 and 12.43±0.22 g/dL) of T3 was higher than T2 (10.53±0.24, 11.23±0.30 and 11.95±0.32 g/dL) and T1 (9.82±0.08, 10.43±0.27 and 11.22±0.13 g/dL) group and differ significantly (*p*<0.05) between groups.

Kassab *et al.* (2021) [4] found that dietary betaine significantly increased hemoglobin concentration and RBC count in cows and bulls. Abdelsattar (2019) [2] also reported increased hemoglobin levels and RBC count in growing lambs with betaine supplementation. However, Abd El-Moniem *et al.* (2016) [1] observed no significant difference in hemoglobin levels in heat-stressed rabbits. Similarly, Mishra *et al.* (2019) [9] and Kondiba *et al.* (2023) [5] found no significant effects on hemoglobin concentration in gestating sows and Deoni cows, respectively. The notable increase in haemoglobin levels in the T2 and T3 groups highlights the beneficial effects of betaine supplementation. Its role in improving oxygen transport and supporting overall health and well-being is evident.

Table 3: Effect of betaine supplementation on haemoglobin (g/dL) in male goat kids at different intervals (Mean ± SE)

Treatment Days	T1 (control)	T2	T3
0	9.48±0.32	9.33±0.40	9.28±0.43
30	9.65±0.57	9.72±0.27	9.95±0.19
60	9.82ᵃ±0.08	10.53ᵇ±0.24	11.08ᶜ±0.18
90	10.43ᵃ±0.27	11.23ᵃᵇ±0.30	11.78ᵇ±0.39
120	11.22ᵃ±0.13	11.95ᵃ±0.32	12.43ᵇ±0.22
Overall mean	10.12±0.27	10.55±0.31	10.90±0.28

Mean value with the different superscripts in a row differ significantly (*p*<0.05).

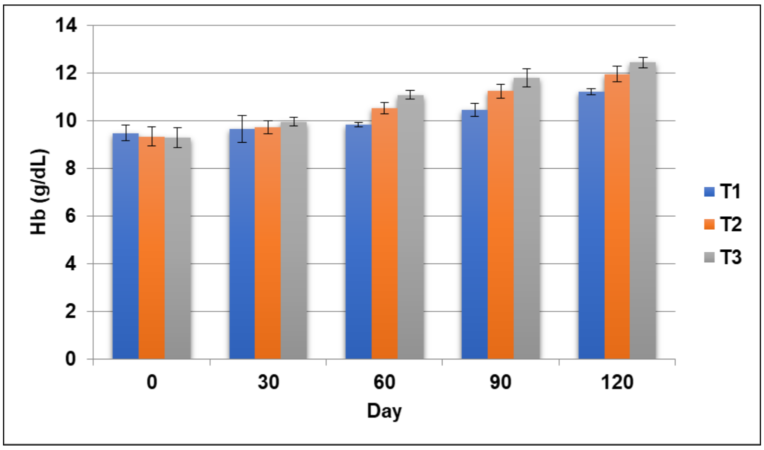

Fig 3: Effect of betaine supplementation on haemoglobin in male goat kids at different intervals

4. Packed Cell Volume (%)

The overall mean value of packed cell volume (PCV) in (T1) control group (27.80±0.60) was lower than T2 (28.40±0.57) and T3 (29.51±0.57) which differed non-significantly (p>0.05) between groups (Table 04).

The mean values of PCV of male goat kids differ non-significantly (p>0.05) between groups, T1, T2 and T3 on day 0 (25.63±0.60, 25.23±0.95 and 25.45±1.09%) and 30 (27.35±1.47, 27.62±1.19 and 27.95±0.54%) of experiment. On day 60, 90 and 120 of experiment the mean value of PCV (30.78±0.55, 31.35±0.07 and 32.03±0.60%) of T3 was higher than T2 (28.75±0.29, 29.85±0.16 and 30.57±0.25%) and T1 (27.62±0.36, 28.83±0.15 and 29.55±0.40%) group and differed (*p*<0.05) significantly between groups.

The observed increase in packed cell volume (PCV in per cent) in T2 and T3 groups suggests that betaine supplementation may have a positive effect on red blood cell production and overall blood health. This could be attributed to the potential of betaine to enhance cell function and support physiological processes. Park and Kim (2017)

[10] reported a 36% increase in PCV values in betaine-supplemented meat-type ducks under heat stress. In contrast, Mishra *et al*. (2019b) [9] found no significant changes in PCV in gestating sows. Similarly, Kondiba *et al*. (2023) [5] observed no significant effect on PCV in betaine-supplemented cows compared to the control group.

Table 4: Effect of betaine supplementation on packed cell volume (%) in male goat kids at different intervals (Mean ± SE)

Treatment Days	T1 (control)	T2	T3
0	25.63±0.60	25.23±0.95	25.45±1.09
30	27.35±1.47	27.62±1.19	27.95±0.54
60	$27.62^{a}\pm0.36$	$28.75^{b}\pm0.29$	$30.78^{b}\pm0.55$
90	$28.83^{a}\pm0.15$	$29.85^{ab}\pm0.16$	$31.35^{b}\pm0.07$
120	$29.55^{a}\pm0.40$	$30.57^{b}\pm0.25$	$32.03^{b}\pm0.60$
Overall mean	27.80±0.60	28.40±0.57	29.51±0.57

Mean value with the different superscripts in a row differ significantly ($p<0.05$).

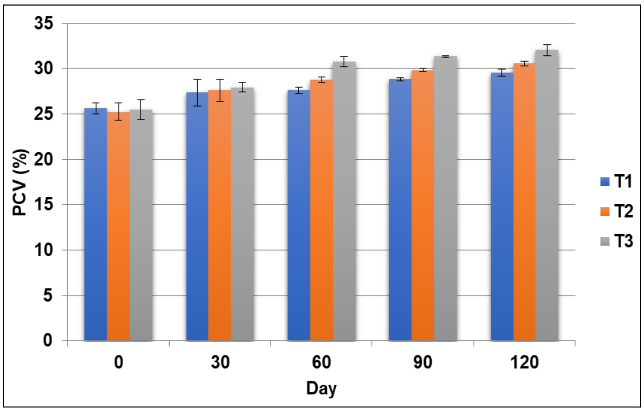

Fig 4: Effect of betaine supplementation on packed cell volume in male goat kids at different intervals

Conclusion

Betaine supplementation had a positive impact on the haematological parameters of male goat kids. The findings suggest that higher doses of betaine (4 g/animal/day) significantly enhance total erythrocyte count, leukocyte count, haemoglobin levels, and packed cell volume, indicating improved blood health, immune function, and physiological resilience to heat stress. Given its affordability and effectiveness, betaine can be considered a valuable feed additive for improving goat health and productivity in hot climatic conditions.

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