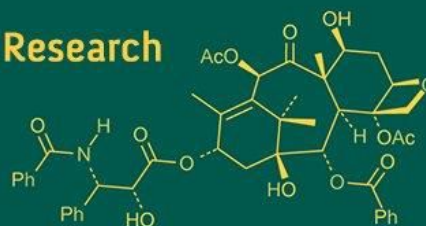


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Role of *Phyllanthus emblica* powder in enhancing antioxidant capacity of Salem Black goats under heat stress

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Abstract

The present study was undertaken to assess the influence of *Phyllanthus emblica* powder supplementation on antioxidant status of Salem Black goats subjected to naturally occurring heat stress. The experimental animals were allotted to five treatment groups: T₁ (control animals maintained under pen area), T₂ (grazing animals without supplementation), T₃ (grazing animals supplemented with *Phyllanthus emblica* @ 15 g/day/goat), T₄ (animals exposed to direct sunlight without supplementation) and T₅ (animals exposed to sunlight with *Phyllanthus emblica* supplementation @ 15 g/day/goat). The study was conducted to evaluate the effectiveness of *Phyllanthus emblica* in alleviating heat stress and enhancing adaptive responses of Salem Black goats under tropical semi-arid environmental conditions. Lipid peroxidase (LPO) levels were markedly increased in the sunlight exposed groups (T₂ and T₄), reflecting enhanced oxidative stress under thermal load. However, goats receiving *Phyllanthus emblica* supplementation in T₃ and T₅ exhibited a highly significant reduction ($p < 0.01$) in LPO activity, suggesting a strengthening of the antioxidant defence mechanism due to supplementation. The average plasma catalase activity varied significantly ($p < 0.05$) among the different treatment groups throughout the experimental period, indicating that both heat stress and amla supplementation influenced the enzymatic antioxidant status of the animals. The body condition score showed a pronounced reduction in T₄, whereas animals in T₃ and T₅ sustained relatively superior scores, clearly indicating the positive influence of amla supplementation on the maintenance of energy reserves and efficient utilization of nutrients in heat stressed goats.

Keywords: Heat stress, lipid peroxidase, catalase, body condition score, *Phyllanthus emblica*

Introduction

Small ruminants, particularly goats, are predominantly reared by resource poor and landless farmers in developing countries and play a vital role in livelihood security due to their adaptability and low input requirements (Singh *et al.*, 2016) ^[17]. Goats are widely distributed across diverse agro-climatic regions and are known for their resilience; however, climate change induced heat stress poses a major challenge to their productivity and health. Elevated ambient temperature combined with high relative humidity disrupts thermoregulation, leading to physiological strain and compromised performance (Banerjee *et al.*, 2014) ^[12]. Heat stress induces oxidative stress by increasing the generation of reactive oxygen species, which adversely affects metabolic functions in goats (Sejian *et al.*, 2017) ^[15]. Supplementation of antioxidants has been shown to reduce oxidative damage and improve stress tolerance during periods of thermal stress. Natural antioxidants such as vitamin C are effective free radical scavengers and enhance antioxidant status under heat stress conditions (Kumar, 2009) ^[8]. *Phyllanthus emblica* (amla), a rich natural source of vitamin C and polyphenolic compounds, has gained attention as an economical antioxidant supplement. Due to its high antioxidant potential and stability in dried form, amla supplementation has been reported to lower oxidative stress and improve physiological adaptation in heat-stressed goats (Kumar, 2009) ^[8].

Materials and Methods

The present study was carried out at the goat unit, Livestock Farm Complex, Veterinary College and Research Institute, Namakkal, Tamil Nadu, during the summer season from

March to May 2025. The study area is located in the north-western agro-climatic zone of Tamil Nadu and is characterized by a semi-arid to sub-humid climate with red loam soil. A total of 30 adult Salem Black female goats aged between 3 and 5 years were selected for the experiment. The animals were allotted into five experimental groups of six goats each based on body weight and body condition scoring. A two-week adaptation period was provided prior to the commencement of the study to acclimatize the animals to experimental conditions. Blood sampling was carried out at fortnightly intervals (0, 15, 30 and 45 days) to evaluate the influence of heat stress on haematological and oxidative stress parameters. Fresh amla (*Phyllanthus emblica*) was purchased, cut, dried, ground and provided to T₃ and T₅ groups at the rate of 15 g/day/goat.

Plasma lipid peroxidation was estimated by measuring thiobarbituric acid reactive substances (TBARS) using the method of Esterbauer and Cheeseman (1990) [6]. Plasma samples were incubated at 37 °C for one hour, followed by the addition of trichloroacetic acid and thiobarbituric acid. The mixture was heated in a boiling water bath for 30 minutes, cooled and centrifuged at 3000 rpm for 15 minutes. The absorbance of the supernatant was read at 535 nm, and TBARS concentration was calculated using malondialdehyde as the standard. Catalase activity was assessed according to the method of Bonaventura *et al.* (1972) [3]. A small volume of plasma homogenate was added to hydrogen peroxide solution and the reaction was monitored spectrophotometrically at 240 nm at 25 °C. The decline in absorbance was recorded at one-minute intervals for three minutes, reflecting the rate of hydrogen peroxide degradation. Catalase activity was expressed as units corresponding to the amount of enzyme required to decompose 1 µmol of hydrogen peroxide per minute.

Body condition score (BCS) was evaluated following the guidelines described by Villaquiran *et al.* (2004) [19] and Ghosh *et al.* (2019) [7]. Under this scoring method, goats were assigned scores ranging from 1, indicating extremely poor body condition, to 5, representing excessive fatness.

Statistical analysis

The data obtained from this study were statistically analysed following the procedure described by Snedecor and Cochran (1996) [18].

Results

The mean (± SE) lipid peroxidase activity in Salem Black goats subjected to different treatment regimens is depicted in Table 1. During the initial phase of the experiment (0th and 15th days), no statistically significant differences were observed among the treatment groups. However, marked differences emerged on the 30th ($p < 0.05$) and 45th ($p < 0.01$) days of the experimental period. On the 30th day, goats in T₄ (4.38 ± 0.42) and T₂ (3.90 ± 0.32) exhibited significantly higher ($p < 0.05$) lipid peroxidase levels compared to T₁, T₃ and T₅, indicating increased oxidative stress associated with heat exposure. By 45th day, lipid peroxidase activity further increased in T₄ (4.83 ± 0.30) and T₂ (4.35 ± 0.25), with values being highly significant ($p < 0.01$) when compared with the remaining treatment groups.

The mean (± SE) catalase activity across the different experimental treatment groups is presented in Table 2. Statistically significant differences were not detected among the groups on 0th and 15th days of the study. However, on

30th day, goats in T₄ (135.35 ± 8.95) and T₂ (129.55 ± 6.94) showed significantly higher ($p < 0.05$) catalase activity compared to T₁ (125.56 ± 8.11), T₃ (121.08 ± 8.20) and T₅ (124.21 ± 8.10). A comparable pattern was evident on the 45th day, wherein catalase activity was markedly elevated in T₄ (139.58 ± 7.15) and T₂ (133.61 ± 4.50), with values being highly significant ($p < 0.01$) relative to the remaining treatment groups.

Body condition score did not differ significantly among the groups at day 0 and day 15. However, a significant decline ($p < 0.01$) was observed in the sunlight-exposed unsupplemented group (T₄) from 30 day onwards, indicating adverse effects of heat stress. In contrast, the pen-housed control group (T₁) showed a significant improvement in BCS during the same period, recording the highest values at days 30 and 45. The amla-supplemented group (T₃) exhibited significantly higher BCS than T₂ but remained lower than T₁ ($p < 0.01$), demonstrating that *Phyllanthus emblica* supplementation partially mitigated heat stress induced loss of body condition.

Discussion

The lipid peroxidase (LPO) activity in Salem Black goats varied from 3.05 to 4.83 nmol MDA/ml and differed significantly ($p < 0.01$) among the treatment groups (Table 1). Substantially elevated LPO levels recorded in T₂ and T₄ suggested enhanced oxidative stress associated with grazing and direct exposure to solar radiation, whereas relatively reduced values observed in T₁ and T₃ indicated improved antioxidant status and minimized oxidative injury, which may be attributed to restricted sunlight exposure under pen conditions (T₁) and *Phyllanthus emblica* supplementation (T₃).

The present findings are in agreement with the observations of Randhawa *et al.* (2013), who reported a pronounced reduction in LPO levels (166.05 nmol MDA/g Hb) following amla supplementation in heat-stressed goats, thereby supporting the lower oxidative stress markers noted in the supplemented groups (T₃ and T₅) of the current study. Similar trends were reported by Chaudhary *et al.* (2015) and Rathwa *et al.* (2017) [13], who documented increased LPO concentrations (4.5 and 4.8 nmol MDA/ml) during hot seasons compared to cooler periods (3.1 and 3.5 nmol MDA/ml). Likewise, Megahed *et al.* (2008) [10] observed significantly higher lipid peroxidation during summer (4.97 µmol/l) than winter (4.03 µmol/l), further substantiating the role of heat stress in inducing oxidative imbalance.

The mean plasma catalase activity in Salem Black goats ranged from 120.05 to 139.58 µmol/min/mg and exhibited significant differences ($p < 0.05$) among the experimental treatment groups (Table 2). Elevated catalase activity recorded in T₂ and T₄ suggests a compensatory enhancement of antioxidant defense mechanisms in response to sustained heat stress, while the relatively lower enzyme activity observed in the remaining groups indicates a reduced oxidative burden in goats maintained under pen conditions (T₁) and those receiving *Phyllanthus emblica* supplementation (T₃ and T₅).

The present results are in agreement with the findings of Chandra (2009) [4] and Lallawmkimi *et al.* (2009) [9], who documented higher catalase activity during the summer season (159.9 µmol/min/mg) compared to winter (153.8 µmol/min/mg) in cattle and buffaloes, thereby confirming the activation of antioxidant enzymes under thermal stress

conditions. Likewise, Shi *et al.* (2020) [16] reported a significant elevation in catalase activity (2.16 to 2.55 U/ml) in heat-stressed lambs relative to control animals (1.79±0.30 U/ml), further supporting the observations of the present study.

The body condition score of Salem Black goats differed significantly among treatments ($p < 0.01$), with the control group maintaining the highest BCS, while the heat stressed group exhibited the lowest values, reflecting the adverse effect of prolonged solar exposure on body reserves. Goats supplemented with *Phyllanthus emblica* showed

intermediate BCS, indicating partial protection against heat-induced loss of body condition. These findings concur with Sejian *et al.* (2014) [14], who reported reduced BCS under heat stress and improvement with antioxidant supplementation. Similar seasonal declines in BCS were noted by Muthuramalingam *et al.* (2020) [11], while Akinmoladun *et al.* (2020) [1] demonstrated improved body condition in vitamin C supplemented goats, supporting the beneficial role of *P. emblica* in mitigating heat-related metabolic stress.

Table 1: Mean (± SE) lipid peroxidase enzyme profile of Salem Black goats exposed to heat stress and supplemented with *Phyllanthus emblica* powder

Parameters	Period (in days)	T ₁ (Control-pen)	T ₂ (Grazing)	T ₃ (Grazing + amla)	T ₄ (Run)	T ₅ (Run + amla)	P-Value
Lipid peroxidase (nanomole of MDA per ml)	0	3.12±0.26	3.82±0.40	3.49±0.41	3.90±0.56	3.78±0.46	0.702
	15	3.07±0.24	3.83±0.33	3.39±0.41	4.15±0.46	3.72±0.34	0.275
	30	3.05 ^a ±0.24	3.90 ^{abc} ±0.32	3.22 ^{ab} ±0.40	4.38 ^c ±0.42	3.31 ^{ab} ±0.37	0.050
	45	3.02 ^a ±0.26	4.35 ^b ±0.25	3.09 ^a ±0.40	4.83 ^b ±0.30	3.19 ^a ±0.45	<0.001

Means with at least one common superscript within same row do not differ significantly ($p > 0.05$)

Number of observations (n) = 6

Table 2: Mean (± SE) catalase enzyme profile of Salem Black goats exposed to heat stress and supplemented with *Phyllanthus emblica* powder

Parameters	Period (in days)	T ₁ (Control-pen)	T ₂ (Grazing)	T ₃ (Grazing + amla)	T ₄ (Run)	T ₅ (Run + amla)	P-Value
Catalase (μmol/min/mg)	0	126.28±7.84	125.96±10.00	126.66±10.15	125.95±9.39	125.00±7.96	0.585
	15	125.85±8.03	127.21±8.42	124.60±9.50	129.50±9.13	124.40±8.66	0.717
	30	125.56 ^a ±8.11	129.55 ^b ±6.94	121.08 ^a ±8.20	135.35 ^c ±8.95	124.21 ^a ±8.15	0.013
	45	123.90 ^a ±7.64	133.61 ^b ±4.56	120.05 ^a ±7.71	139.58 ^c ±7.15	123.58 ^a ±7.63	<0.001

Means with at least one common superscript within same row do not differ significantly ($p > 0.05$)

Number of observations (n) = 6

Table 3: Mean (± SE) body condition scoring of Salem Black goats exposed to heat stress and supplemented with *Phyllanthus emblica* powder

Period (in days)	T ₁ (Control-pen)	T ₂ (Grazing)	T ₃ (Grazing + amla)	T ₄ (Run)	T ₅ (Run + amla)	P-Value
0	2.83±0.10	2.83±0.10	2.66±0.25	2.91±0.08	2.75±0.11	0.504
15	2.91±0.15	2.66±0.10	2.88±0.08	2.58±0.08	2.66±0.10	0.213
30	3.25 ^c ±0.11	2.33 ^a ±0.10	2.91 ^b ±0.08	2.16 ^a ±0.10	2.52 ^b ±0.10	<0.001
45	3.33 ^c ±0.10	2.25 ^b ±0.11	3.16 ^c ±0.16	2.00 ^a ±0.00	2.39 ^b ±0.10	<0.001

Means with at least one common superscript within same row do not differ significantly ($p > 0.05$)

Number of observations (n) = 6

Conclusion

The present study demonstrated that natural heat stress significantly increased oxidative stress in Salem Black goats, as evidenced by elevated lipid peroxidase and catalase activities, along with a decline in body condition score in heat-exposed groups. Supplementation with *Phyllanthus emblica* effectively reduced lipid peroxidation and modulated antioxidant enzyme activity, indicating improved antioxidant status under thermal stress. Goats receiving amla supplementation also maintained better body condition, reflecting enhanced energy balance and metabolic efficiency. These findings suggest that *Phyllanthus emblica* is a promising, economical antioxidant supplement for mitigating heat stress induced oxidative damage in goats. Overall, amla supplementation at the rate of 15 g/day/goat can be recommended as a practical nutritional strategy to improve stress resilience and productivity of Salem Black goats under tropical semi-arid conditions.

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References

1. Akinmoladun OF, Fon FN, Mpendulo CT, Okoh O. Performance, heat tolerance response and blood metabolites of water-restricted Xhosa goats supplemented with vitamin C. *Transl Anim Sci.* 2020 Apr;4(2):1113-1127.
2. Banerjee D, Upadhyay RC, Chaudhary UB, Kumar R, Singh S, Ashutosh GJM, *et al.* Seasonal variation in expression pattern of genes under HSP70 family in heat- and cold-adapted goats. *Cell Stress Chaperones.* 2014 Oct;19(4):401-408.
3. Bonaventura J, Schroeder WA, Fang S. Human erythrocyte catalase: an improved method of isolation and a reevaluation of reported properties. *Arch Biochem Biophys.* 1972 Jun;150(2):606-617.

4. Chandra G. Antioxidative status of high body condition periparturient crossbred cows with and without supplementation of alpha tocopherol acetate during summer and winter seasons [MVSc thesis]. Karnal (India): NDRI, Deemed University; 2009. p. 1-120.
5. Chaudhary SS, Singh VK, Upadhyay RC, Puri G, Odedara B, Patel PA. Evaluation of physiological and biochemical responses in different seasons in Surti buffaloes. *Vet World*. 2015 Jun;8(6):727-731.
6. Esterbauer H, Cheeseman KH. Determination of aldehydic lipid peroxidation products: malondialdehyde and 4-hydroxynonenal. *Methods Enzymol*. 1990;186:407-421.
7. Ghosh CP, Datta S, Mandal D, Das AK, Roy DC, Roy A, *et al*. Body condition scoring in goat: impact and significance. *J Entomol Zool Stud*. 2019 Feb;5(2):554-560.
8. Kumar M. Reproductive performance and blood biochemical profile of summer stressed goats following antioxidant supplementation [MVSc thesis]. Ludhiana (India): Guru Angad Dev Veterinary and Animal Sciences University; 2009. p. 1-110.
9. Lallawmkimi CM. Impact of thermal stress and vitamin E supplementation on heat shock protein 72 and antioxidant enzymes in Murrah buffaloes [PhD thesis]. Karnal (India): NDRI, Deemed University; 2009. p. 1-145.
10. Megahed GA, Anwar MM, Wasfy SI, Hammadeh ME. Influence of heat stress on the cortisol and oxidant-antioxidants balance during oestrous phase in buffalo-cows (*Bubalus bubalis*): thermo-protective role of antioxidant treatment. *Reprod Domest Anim*. 2008 Nov;43(6):672-677.
11. Muthuramalingam T, Meenakshi Sundaram S, Tensingh Gnanaraj P, Sivakumar T, Vairamuthu S, Rangasamy S, *et al*. Seasonal variation in body condition and haemato-biochemical parameters of Tellicherry does in semi-arid summer climate. *J Entomol Zool Stud*. 2020 Aug;8(5):1586-1590.
12. Randhawa HK. Effect of amla powder supplementation on physiological and blood biochemical responses in heat stressed goats [MVSc thesis]. Ludhiana (India): Guru Angad Dev Veterinary and Animal Sciences University; 2013. p. 1-105.
13. Rathwa SD, Vasava AA, Pathan MM, Madhira SP, Patel YG, Pande AM. Effect of season on physiological, biochemical, hormonal and oxidative stress parameters of indigenous sheep. *Vet World*. 2017 Jun;10(6):650-655.
14. Sejian V, Singh AK, Sahoo A, Naqvi SMK. Effect of mineral mixture and antioxidant supplementation on growth, reproductive performance and adaptive capability of Malpura ewes subjected to heat stress. *J Anim Physiol Anim Nutr*. 2014 Jan;98(1):72-83.
15. Sejian V, Kumar D, Gaughan JB, Naqvi SMK. Effect of multiple environmental stressors on the adaptive capability of Malpura rams based on physiological responses in a semi-arid tropical environment. *J Vet Behav*. 2017 Jan;17:1-30.
16. Shi L, Xu Y, Mao C, Wang Z, Guo S, Jin X, *et al*. Effects of heat stress on antioxidant status and immune function and expression of related genes in lambs. *Int J Biometeorol*. 2020 Aug;64(12):2093-2104.
17. Singh KM, Sanjeev S, Ganguly I, Ganguly A, Nachiappan RK. Evaluation of Indian sheep breeds of arid zone under heat stress condition. *Small Rumin Res*. 2016 Aug;141:113-117.
18. Snedecor GW, Cochran WG. Statistical methods. 8th ed. Ames (IA): Iowa State Press; 1989. p. 1-503.
19. Villaquiran M, Gipson TA, Merkel RC, Sahl T. Body condition scores in goats. Langston (OK): Langston University; 2004. p. 1-8.