VOL. 5, NO1, JUNE, 2025
ISSN 2756-4444
E-ISSN 2756-4452

# PHYSIOLOGICAL RESPONSE AND SERUM BIOCHEMICAL METABOLITES OF WEST AFRICAN DWARF GOATS GIVEN DIETARY HERBAL SUPPLEMENTS UNDER TROPICAL CLIMATE

**BY**

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**Abstract**

The study was conducted to investigate the physiological responses and serum biochemical metabolites of West African Dwarf (WAD) goats fed *Solanum lycopersicum* (SL) fruit and *Cissus polpunea* (CP) stem powders as dietary herbal supplements. 20 WAD female goats with an average age of 10 ± 1 months and an initial average weight of 7.42kg were used for this experiment. Four experimental diets were formulated and designated as Treatment 1 (T1)- No experimental additive (Control), Treatment 2 (T2)- 10g of CP /300g + basal diet, Treatment 3 (T) -10g of SL /300 g of control diet and Treatment 4 (T4)- 5g of CP and 5g of SL /300 g of diet control). Heat stress significantly elevated the average rectal temperature, while herbal supplementation linearly reduced the heart rate and rectal temperature. ALP and AST were significantly ($p < 0.05$) elevated by heat stress, as revealed before herbal administration. However, TP and CP supplementation decreased both values linearly across all treatments. Combined addition of SL and CP in T4 significantly ($p< 0.05$) elevated the Urea level, while values across other treatments existed within the normal range. Dietary supplementation of SL and CP reduced the evaluated physiological indicators and serum metabolites. Further study should be conducted to test other levels of inclusion.

**Keywords**: Goat, herbs, tomatoes, heat stress, serum, physiological response

## Introduction

Goats have been rated as one of the earliest domesticated animals retaining a close association with humans for several decades (Monteiro *et al*., 2018). This is due to their adaptability to varying environments and climatic conditions, resulting in their re-distribution all over the world (Mahmoud, 2010). Goats are among the most beneficial animals in the world, supplying meat, milk, fiber, organic fertilizer, and draft power (Arafath et al., 2024). The relatively portable size of goats has made their management possible on a small scale. Goats are capable of existing and breeding under various unfavorable conditions, making them an ideal species for resource-poor farmers. Goats' meat is an excellent source of protein; their meat and milk pose little or no religious taboos among the multi-populated humans (Gawat *et al*., 2023). It is low in fat and cholesterol and high in vitamins and minerals. Goat milk is rich, widely relished, and seemingly easier to digest, with profound nutritional qualities. Generally, in developing countries, the contribution of goats cannot be overemphasized and plays an important role in boosting poor households'economy (Khowa *et al*., 2023).

*ISSN 2756-4444*
*E-ISSN 2756-4452*

Unfortunately, goats are often exposed to a range of stressors, including nutritional, physical, mental, chemical, and thermal stress. Thermal stress is one of the most outstanding challenges experienced within the tropical, subtropical, and semi-arid regions, notably due to the changing climate (Govindasamy et al., 2022). The tropical environment has been marked for elevated temperature and humidity, which synergistically align with the high metabolic heat generated in livestock, causing heat stress (Oke *et al.*, 2021). Heat stress is an undeniable discomfort that occurs when an animal is exposed to an extremely hot environment. Stress is a harmful impression initiated by several factors influencing the health and performance of animals. It can also be attributed to the degree of superfluous influences that displace an animal's normal condition (Silanikove *et al.*, 2013). Heat stress resulted in increased serum osmolality and lower white blood cells in animals. It also causes reduced feed intake, weight gain, and high feed conversion ratio, which negatively impacts serum biochemical markers and innate immune balance in livestock (Ahmad et al., 2023). The exponentially increased reactive oxygen species (ROS) emanate in response to thermal stress, making affected animals liable to cellular apoptosis. According to Martemucci *et al*. (2022), herbal feed supplements have recently been regarded as an adequate solution to the problem of inadequate nutrition, health disequilibrium, and a mitigator of stress effects through their innate potential of improving the ROS-scavenging activities of antioxidant enzymes in affected animals. This is possible due to the presence of certain bioactive compounds such as flavonoids, anthraquinone, and carotenoid (lycopene) present in *Cissus polpunea* (CP) and *Solanum lycopersicum* powder (SL), respectively.

Flavonoids have been observed to improve the nutritional intake and physiological resilience in livestock (Zahra *et al*., 2024). Joseph and Ayo (2024) recorded the modulatory effect of lycopene sourced from SL on Red Sokoto goats exposed to cold-dry induced stress, resulting in an increased rectal temperature value. Aletan *et al*. (2024) observed a non-significant difference in the serum biochemical indices of Wistar albino rats dosed with aqueous stem extract of CP at varying concentrations. In tandem with this finding, Ojekale *et al.* (2006) observed that CP did not negatively disrupt the normal concentration and activities of the serum metabolites (serum AST, ALT, alkaline phosphatase, creatinine, bilirubin, and triglycerides) in normal rabbits after administration in comparison with those of the control group. Aholou *et al*. (2017), contrarily, recorded an increased biochemical index in rabbits when a comparison was made between the effect of *Cissus populnea* and *Synedrella nodiflora* at a 10% dietary inclusion level. According to Mizael *et al.* (2020), the inclusion of tomato powder into the goat's diet modified the metabolic representation of goat meat, seminal plasma, and physiology, with a positive difference in amino acids, nucleotides, and their biochemical outcomes like creatinine, glutathione, and nicotinic acid. To achieve better production performance, there is a need to source additional feed supplements, mainly ethnobotanical, which are cheap, readily available, and contain bioactive elements with highly beneficial effects to improve the overall performance of animals exposed to unfavorable climatic conditions. There is a dearth of information on the combined effect of CP and SL on the physiological response and serum biochemical indices of WAD goats reared under tropical conditions.

**Materials and Methods**

**Experimental area and study duration**

The study was carried out at the small ruminant unit of the Teaching and Research Farm, Kwara State University, Malete, Kwara State, with a Latitude of 8.7oN and a Longitude of 4.46667oE °E, with an average daily relative humidity of 79% and a temperature of 30 °C.

**Preparation of feed Supplements (CP and SL)**

The fresh *Solanum lycopersicum* fruits were purchased from the Mandate market, Ilorin. After which, the fruits were washed under running water to remove the debris and dirt. The fruits were chopped into smaller pieces. *Cissus polpunea* (CP) was likewise obtained from the IIara-Mokin area in Ondo state. The adhering dirt was washed off thoroughly under running water. The two freshly cut herbal materials were dried using different compartments of a parabolic-shaped Solar dryer at Nigerian Stored Products Research Institute (NSPRI) headquarters, situated along Asa Dam, Ilorin metropolis, for 8 days to reduce the moisture content. Their powders were ground into a fine texture, sieved to remove lumps, and to achieve texture uniformity. The fine powders of CL and SL were packed into separate airtight containers for subsequent use.

**Experimental Housing and Biosecurity Measures**

Indoor pens with short walls were partitioned into standard sizes to house each female. Fumigation was done using Morigad, Lysol, and Jik combined with ten liters of water at a ratio of 2:1:2. The pen area was allowed to dry for two weeks before housing the goats.

**Sourcing of Experimental Animals and Management**

20 grower female West African Dwarf (WAD) females with an average age of 6.9 ± 1.1 months were sourced from Share, Kambi, and Ajase Markets within Kwara State with an initial average weight of 7.42kg. The experimental animals were quarantined for 60 days during which they were injected with oxytetracycline (LA 20%), V-Multivor (Multi-vitamin), Lvainor (Ivermectin injection), and dewormed using intramuscularly injected Albendazole. Vaccination was achieved using pestes de petit vaccine intramuscularly after 30 days after the commencement of quarantine. Other medications administered included sulfadimidine and antibiotics. After the 60-day quarantine, experimental diet administration commenced.

**Table 1: Locally sourced ingredients used in experimental feed composition**

| Ingredients | Quantity |
|---|---|
| Cassava peel | 40kg |
| Wheat offal | 20kg |
| Rice bran | 10kg |
| PKC | 18.5kg |
| GNC | 5kg |
| Bone meal | 3kg |
| Oyster shell | 2kg |
| Salt | 1kg |
| Premix | 0.1kg |
| Total | 100kg |

VOL. 5, NO1, JUNE, 2025
ISSN 2756-4444
E-ISSN 2756-4452

**Experimental Design**

Twenty female West African Dwarf Goats were randomly allocated into four treatment groups, with five replicates each:

Treatment 1- Feed containing experimental additive (Control)
Treatment 2- Feed containing 10g of CP / 300 g of control diet
Treatment 3 -Feed containing 10g of SL / 300 g of control diet
Treatment 4- Feed containing 5g of CP and 5g of SL / 300 g of diet control

**Data Collection**

Initial body weight (g): This was first observed on the first day of purchase by placing the goats on an electronic digital scale with the brand name Camry Ek4150 (China).

**Meteorological Data**

**Environmental Temperature**

Ambient temperature ($^0$C) was recorded daily inside the brooding pen using an HTC-1 digital electronic alarm clock hygrometer, which was manufactured by Jianda and was made in China. (El-Desoky *et al*., 2021).

**Relative Humidity**

The daily relative humidity (RH% %) was recorded daily using an HTC-1 digital electronic alarm clock hygrometer, which was manufactured by Jianda and was made in China (El-Desoky *et al*., 2021).

**Temperature Humidity Index**

The Temperature-Humidity Index (THI) is a measure of the combined effect of temperature and humidity on animal comfort calculated using the following formula:

THI = 0.8 x (Temperature) x (Humidity / 100) x (Temperature - 14.4) + 46.4

Where:
- Temperature is degrees Celsius($^0$C)
- Humidity is in percentage (%)

The values for temperature and humidity were plugged into this formula to calculate the THI. The resulting THI value can help assess the comfort level or stress caused by the temperature and humidity conditions.

**Physiological Data**

**Rectal Temperature**

VOL. 5, NO1, JUNE, 2025
ISSN 2756-4444
E-ISSN 2756-4452

Rectal temperature of each animal was individually measured daily in the morning using a D-Notec digital thermometer that was manufactured by Haiden Technology (India). It was gently introduced into the rectum, and a peeping sound signaled attainment of the highest rectal temperature for the animal under evaluation, which was then recorded appropriately.

**Heart Rate**

The heart rate was measured by counting the number of beats per minute using a dual-head stethoscope (Greater Goods, Japan), placed on the left side of the heart.

**Respiration Rate**

The respiration rate was measured by counting the number of flank movements during the complete inhalation–exhalation cycle (breath) per minute (Dißmann et al., 2022).

**Blood collection**

Blood collection was done twice within the period of the experiment; the initial collection was done after quarantine and before commencement of herbal supplementation, while the second blood collection was done at the termination of the experiment. At each collection, 5 mls blood samples were withdrawn from the jugular vein of each animal into plain sample bottles in the early hours of the morning before sunrise and taken to reputable research laboratories for biochemical analyses biochemical analysis. The serum metabolites evaluated include total protein, albumin, globulin, high-density lipoprotein (HDL), low-density lipoprotein (LDL), triglycerides (TRIG), total cholesterol, creatinine, alkaline phosphatase (ALP), alanine aminotransferase (AST), alkaline transaminase (ALT), glucose, and urea.

**Data Analysis**

Data collected were subjected to statistical analysis using a statistical software program (SPSS) for Windows, version 16.0, SPSS Inc., Chicago, IL. Duncan's *post hoc* test determined the level of significance between the groups. A linearity test was done, and means were separated using the Duncan Multiple Range Test (DMRT). The data were presented as the mean ± standard error of mean (SEM) with level of significance tested at $P<0.05$.

**Results and Discussion**

Table 2 shows the physiological response of female WAD goats before and after administration of dietary herbal supplements. The average heart rate, respiratory rate, and rectal temperature were assessed after a 60-day acclimatization period to the experimental area and continuously till the end of herbal administration (70-day herbal administration). It was discerned that the average heart rate and respiratory rate were increased before the administration began. However, an insignificant decline in the values was observed at the end of the herbal administration of SL fruit and CP stem powders. In contrast to the above, the rectal temperature was noted to be significantly ($p<0.05$) affected by the tropical thermal assault as reflected by elevated values in the goats across

VOL. 5, NO1, JUNE, 2025
ISSN 2756-4444
E-ISSN 2756-4452

treatments 1-3 designated with values 39.11± 0.14, 39.21± 0.14, and 39.22± 0.10, respectively. A significant decrease was observed in T4 goats (38.42±0.99).

**Table 2: Physiological response of female WAD goats before and after administration of dietary herbal supplements**

| Parameters | T1 | T2 | T3 | T4 | P value |
|---|---|---|---|---|---|
| Av heart rate (Before herbal Administration) | 57.31±1.50 | 56.82±1.64 | 59.44±2.27 | 58.13 ±1.69 | 0.75 |
| Av heart rate (After herbal Administration) | 45.33 ±6.57 | 54.00 ±3.06 | 57.33 ±0.67 | 57.50 ±0.3 | 0.14 |
| Av resp rate (Before herbal Administration) | 21.49±0.60 | 21.04±0.46 | 21.04±0.53 | 21.22±0.25 | 0.90 |
| Av. resp rate (After herbal Administration) | 19.67 ±0.88 | 19.33 ±0.67 | 16.33 ±1.67 | 17.50 ±0.96 | 0.19 |
| Av rect temp (Before herbal Administration) | 39.11±0.14[a] | 39.21±0.14 [a] | 39.22±0.10 [a] | 38.42±0.99[b] | 0.00 |
| Av rect temp (Before herbal Administration) | 37.17 ± 2.2 | 39.10 ±0.53 | 39.50 ±0.30 | 39.40 ± 0.32 | 0.43 |

Table 3 expresses the serum biochemical indices of experimental goats before administration of herbal supplements. The parameters evaluated include total protein, albumin, high-density, low-density lipoprotein, triglycerides, total cholesterol, creatinine, alanine aminotransferase (ALT), alkaline phosphatase (ALP), alkaline amino transferase (AST), glucose, and Urea. It was discerned that the liver enzymes were significantly ($p<0.05$) affected by the tropical climatic conditions of the experimental animals. The ALP values were significantly increased. in T4 goats (57.95 ± 0.59) with an opposing significantly ($p<0.05$) depressed values under T1, T2 and T3 (49.69 ± 0.76, 52.83±1.19 and 56.65± 0.39) respectively. The values of AST showed a significant elevation under T1 (28.64 ± 2.7) and T2 (32.32 ± 3.05), while a significant decrease was noted in T3 (15.96 ±2.73) and T4 (19.45 ± 6.39), respectively.

*ISSN 2756-4444*
*E-ISSN 2756-4452*

**Table 3: Serum Biochemical indices of experimental goats prior to administration of dietary supplementations**

| Parameters | T1 | T2 | T3 | T4 | P value |
|---|---|---|---|---|---|
| Total Protein (g/dl) | 5.63±0.63 | 5.43±0.48 | 5.36±0.56 | 4.42±0.27 | 0.13 |
| Albumin (mmol/l) | 3.48±0.24 | 3.88±0.47 | 3.82±0.28 | 3.78±0.4 | 0.48 |
| Globulin (mmol/l) | 2.15±0.21 | 1.55±0.11 | 1.54±0.1 | 0.64±0.03 | 0.34 |
| HDL (mmol/l) | 1.03±0.75 | 1.13±0.07 | 1.24±0.05 | 1.02±0.38 | 0.07 |
| LDL (mmol/l) | 1.36±0.19 | 1.54±0.28 | 1.88±0.29 | 1.11±0.19 | 0.05 |
| TRIG (mmol/l) | 1.19±0.32 | 1.48±0.28 | 1.40±0.16 | 1.19±0.16 | 0.4 |
| Total Cholesterol (mmol/l) | 2.63±0.29 | 2.96±0.36 | 3.40±0.28 | 2.37±0.24 | 0.12 |
| Creatinine (Umol/l | 35.50±4.13 | 53.58±8.48 | 48.80±1.31 | 32.99±10.79 | 0.19 |
| ALP(U/L) | 49.69±0.76[c] | 52.83±1.19[b] | 56.65±0.39[ab] | 57.95±0.59[a] | 0.00 |
| AST(U/L) | 28.64±2.7[ab] | 32.21±3.05[a] | 15.96±2.73[c] | 19.45±6.39[bc] | 0.03 |
| ALT(U/L) | 26.39±6.69 | 33.48±3.59 | 31.61±6.36 | 40.94±7.82 | 0.15 |
| Glucose (mmol/l)) | 1.23±0.06 | 1.22±0.37 | 1.37±1.31 | 1.23±0.05 | 0.24 |
| Urea(mg/dl) | 24.15±4.8 | 28.46±3.96 | 28.46±4.14 | 24.92±5.26 | 0.55 |

Table 4 shows the serum biochemical indices of WAD goats after herbal administration of experimental supplements, with exactly similar parameters evaluated in Table 3. Among all evaluated parameters, only HDL and Urea were significantly ($p<0.05$) affected by the herbal supplement. The HDL values were significantly ($p<0.05$) elevated in the control and treatment 1, while being depressed under T3 and T4, respectively. The urea values were significantly ($p<0.05$) hiked under treatment 4 and significantly ($p<0.05$) reduced across other treatment groups.

**Table 4: Serum Biochemical indices of experimental goats after administration of dietary supplements**

| Parameters | T1 | T2 | T3 | T4 | Pvalue |
|---|---|---|---|---|---|
| Total Protein (g/dl) | 6.78±0.75 | 5.32±1.07 | 7.14±0.47 | 7.45±0.55 | 0.22 |
| Albumin (g/dl) | 2.17±0.19 | 2.59±0.44 | 3.09±0.14 | 2.51 ± 0.40 | 0.35 |
| Globulin (g/dl) | 4.61±0.45 | 2.64±0.41 | 4.05±0.24 | 4.94± 0.19 | 0.25 |
| HDL (mmol/l) | 0.83±0.01[a] | 0.83±0.01[a] | 0.78±0.01[b] | 0.81±0.03[ab] | 0.01 |
| LDL (mmol/l) | 1.64±0.16 | 1.36±0.15 | 1.13±0.11 | 1.73±0.18 | 0.10 |
| TRIG (mmol/l) | 0.81±0.03 | 0.83±0.06 | 0.89±0.06 | 0.92±0.04 | 0.57 |

| | | | | | |
|---|---|---|---|---|---|
| Total Cholesterol (mmol/l) | 2.51±0.08 | 3.02±0.38 | 2.80±1.29 | 2.94±0.19 | 0.43 |
| Creatinine (Umol/l) | 88.50±13.54 | 234.01±117.8 | 62.91±22.47 | 132.07±18.09 | 0.23 |
| ALP (U/L) | 28.54±5.05 | 23.56±4.42 | 30.29±14.99 | 27.99±12.37 | 0.98 |
| AST(U/L) | 14.86±1.99 | 14.33±2.56 | 9.65±1.09 | 8.72±2.15 | 0.12 |
| ALT(U/L) | 16.91±3.20 | 21.76±3.76 | 17.81±3.27 | 17.36±3.35 | 0.75 |
| Glucose(mmol/l)) | 2.85±0.04 | 2.86±0.19 | 3.32±0.28 | 3.22±0.22 | 0.30 |
| Urea(mg/dl) | 13.46±3.59$^{ab}$ | 16.83±1.21$^{b}$ | 15.38±3.24$^{b}$ | 40.77±4.36$^{a}$ | 0.00 |

**Discussion**

Physiological indices evoke a quick expression of thermal stress and the magnitude of the animal's internal calmness or unrest, which the animal is exposed to. As reiterated by Danso *et al*. (2024), the key factors of thermal stress in goats include increased body temperature, heart rate, and respiration rate. The sudden elevation of these homeostasis indicators could disrupt the oxidative stability, electrolyte-endocrine balance, and overall performance of the goats. The linear decrease in the average heart rate after dietary herbal supplementation could have been due to the presence of strong antioxidant and bioactive components in the CP and SL, comprising lycopene, polyphenols, flavonoids, and carotenoids. This array of bioactive compounds could have been responsible for mitigating the negative impacts of heat stress in the goats. This result corroborates the report of Sahin *et al*. (2008), who fed quails with 2.5 or 5% of tomato powder in their study.

Although the values recorded were all below the normal range of 70-90 beats per minute in goats. Heat stress was observed to increase the average respiratory rate as reflected in the high values recorded before administration; however, administration of SL and CP might have still enhanced its alignment within the normal range of 12-30 breaths per minute as documented by Bello (2016) while still linearly reducing the values. The increased average rectal temperature in the experimental goats revealed that they were stressed by the environmental factors. The high values obtained for the metabolic rate indicators reflected an incidence of stress in the experimental goat due to the adverse environmental condition coupled with confinement stress, as supported by Bello *et al* (2016). This corroborates the findings of Joseph and Ayo (2024), who recorded an increased rectal temperature value in red Sokoto goats after their exposure to cold-dry stress. The duo of scientists further unveiled the reversal effect of lycopene obtained from SL on the goats with reduced rectal temperature value. The recorded rectal temperature in this study did not follow a particular pattern before or after herbal supplementation, although a slightly lower value was noticed in the control group at the post-herbal administration stage, while all other values existed within the normal rectal temperature range of 38.50 - 39.70 as documented by Robertshaw (2004).

Heat stress remarkably affects goat health and productivity, affecting various enzymatic activities, specifically alkaline phosphatase (ALP). Studies have shown that heat stress increases ALP levels in goats. specifying a definite correlation between heat stress and serum ALP levels. The values recorded for ALP and Aspartate Aminotransferase (AST) fall within the normal range reported by Daramola *et al* (2005) and Danso *et al* (2024) for healthy goats. The improved serum level of HDL was noticeable in goats under the control and CP treatments, which could have been possible through the enhancing influence of CP on the HDL; all values recorded exist within the normal range of

0.75 to 1.65 mmol/L. This is in conjunction with the claims of Geidam *et al*. (2015), who observed an elevated HDL and triglyceride level in normal and alloxan-induced diabetic albino rats, following an intragastric administration of 100 mg/kg body weight of aqueous stem bark extract of *Cissus populnea*.

On the contrary, Matawalli (2015) reported a reduction in the HDL, triglycerides, and LDL values in Wistar rats, after which CP intubation caused a decreased serum level of total cholesterol. This also connects with the research conclusions of a closely related species of CP known as *Cissus sicyoides*, probably due to phyto-constituents such as tannins, flavonoids, anthraquinones, and arginine present in CP. The reduced HDL observable in SL-supplemented diet could also be due to the hypoglycemic, antilipemic reaction and anti-inflammation nature of Lycopene, which could have been responsible for this outcome. This is in line with the findings of Khalil *et al*. (2022), who recorded a depression in the HDL values of diabetic rats given tomato juice. This might be due to the presence of steroidal glycoalkaloid tomatine, which binds strongly with the insoluble complexes of cholesterol *in vitro*, which might have resulted in the depreciation. Urea is noted as a major nitrogen-containing by-product resulting from the breakdown of protein. The synergistic combination of SL and CP could have prompted the elevated serum urea level as observed in T4, potentially through an elevated protein ingestion or modified rumen fermentation, as supported by Wójtowski *et al*. (2025). The formation of urea following the conversion of ammonia from protein metabolism perhaps result in a higher urea concentration beyond the normal range of 1.8-20 mg/dl, known as hyperuremia. SL and CP supplementation did not pose any ill health conditions in the experimental goats; an improved homeostatic balance was achieved in line with the lowered physiological indicators. Most of the serum metabolites exist within the normal range. Dietary supplementation of SL and CP either singly or in synergy is therefore recommended. Further research using graded levels is therefore recommended.

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