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Effect of supplementing *Tinospora cordifolia* in the diet of Gaddi goats exposed to heat stress on nutrient intake, utilization and physiological parameters

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Abstract
The research was conducted to study the effect of supplementing *Tinospora cordifolia* (TC) in the diet of Gaddi goats exposed to heat stress. Total Sixteen adult male Gaddi goats were divided into four groups T0H0 (no supplement no heat stress, control), T1H0 (animals fed on diet supplemented with TC stem powder @ 5% of DMI with no heat stress), T0H1 (no treatment with heat stress) and T1H1 (animals fed on diet supplemented with TC stem powder with heat stress). Experiment was arranged in 2×2 factorial in which supplementation (0% versus 5%) and heat stress (normal versus heat exposure) were the main effects to be investigated. Temperature humidity index (THI) value was calculated as 29.42 which designated the experimental animals were in severe heat stress. Rectal temperature had no significant differences among the supplemented and non supplemented groups but individual interaction of heat stress showed significant ($P<0.05$) increased respiration and pulse rate. Interaction of supplementation and heat stress did not affect rectal temperature and pulse rate but respiration rate significantly ($P<0.05$) reduced in T1H1 as compared to T0H1. Daily intake of nutrients were changed by the individual effect of heat stress ($P<0.05$). Dry matter and neutral detergent fibre (NDF) digestibilities in diets were affected by individual effect of heat stress ($P<0.05$), however supplementation of TC did not affect digestibility of any nutrient.

Keywords: *Tinospora cordifolia*, heat stress, Gaddi goats, temperature humidity index (THI)

1. Introduction

Small ruminants i.e. sheep and goat play a considerable role in providing food and economic security to the poor farmers distant from being a foremost portion of the country's farming output. Climate change has in recent times come as one of the serious long term alarming challenges faced by livestock owners and farmers of our country. Temperature and humidity are common environmental stressors. Large-scale environment changes due to anthropogenic activities bring leading drift in animal productivity that depends on composite interaction between climate and intrinsic adaptive nature of the animal itself, even with well-built mechanism of thermo regulation, brutal climatic condition such as severe heat or cold produces stress altering physiological and biochemical 'milieu' of common domesticated animals. Global climate change is primarily caused by greenhouse gas (GHG) emissions that result in warming of the atmosphere [1]. *Tinospora cordifolia* (TC) a member of the family *Menispermaceae* belongs to a group of medicinal plants that grow in the tropical and subtropical regions of India [2]. It is well known for its immunomodulatory, antioxidant, antibacterial and antiviral properties [3]. However the anti-oxidant potential of the plant has been sparsely studied [4] and virtually none in respect of heat stress. About 92% livestock owners in Himachal Pradesh are rural and depend directly on agriculture, horticulture and animal husbandry. "Gaddi" (White Himalayan goat) is the most important goat breed of high altitude, Western temperate Himalayas with its true home tract in the hills of Himachal. In Himachal Pradesh, these goats are reared by traditional "Gaddi" shepherds, a distinct tribe of roaming pastoralists leading to its nomenclature as "Gaddi" breed. Once known for its cool climes, Himachal Pradesh is witnessing the ill effects of global warming as, in the last four decades, the average maximum temperature has increased by 5.2 degrees Celsius in the state. While the average rainfall has remained static, the cycle of rain and snow has changed

marginally. Under the changing climate scenario the objective of this study was to draw out the result of heat stress and supplementation of *Tinspora cordifolia* on nutrient intakes, utilization and physiological parameters of Gaddi ram.

2. Material and methods

2.1 Animals, housing and management

The present study was carried out at ICAR-IVRI Regional Station, Palampur, Himachal Pradesh located at an altitude of 1291m above MSL with latitude and longitude 32.6 ºN and 76 ºE, respectively, India. Sixteen adult male Gaddi goats (Age, 3-4 years and body weight, 30-35 kg) were divided into four groups (T0H0, T1H0, T0H1 and T1H1) in factorial design. Animals were housed in two separate well-ventilated shed under uniform managemental surroundings having services for individual feeding and watering, two groups T0H0, T1H0 are kept in normal temperature and T0H1, T1H1 are heat treated group animals were exposed to 6 hours (10AM to 4PM) at constant temperature 33±2 ºC. Group T0H0 was serve as control group (no treatment no heat stress), where as T1H0 (animals fed on diet supplemented with TC stem powder @ 5% of DMI with no heat stress), T0H1 (no treatment with heat stress) and T1H1 (animals fed on diet supplemented with TC stem powder with heat stress) was treatment group. The microclimatic conditions during the experimental period are presented in Table 1. The minimum and maximum temperature and relative humidity (RH) of the shed were recorded with the help of dry bulb and wet bulb thermometer and expressed in °C; the equation to determine THI for sheep and goats is as follows [5].

THI is: $db^0C – [(0.31-0.31RH)*(db^0C-14.4)]$

Where, where db^0C = dry-bulb temperature in °C and RH=relative humidity percentage/100. A value for THI below 27.8 was taken to signify an absence of heat stress

Table 1: Micro- climatic condition inside experimental house

Conditions	Temperature (℃)	Relative humidity (%)	Temperature humidity index(THI)
Normal	14.30	72.00	14.29
Heat stress	33.00	38.00	29.42

Table 2: Chemical composition of the feeds offered to experimental animals

Attributes	Concentrate mixture	Hay	TC
Proximate composition			
Dry matter	97.85±1.82	92.56±0.05	73.75±0.88*
Organic matter	93.93±0.61	93.62±0.38	92.97±0.53
Crude protein	17.90±0.24	5.77±0.27	7.24±0.40
Ether extract	3.63±0.15	2.44±0.33	1.18±0.19
Total ash	6.07±0.61	6.38±0.38	7.03±0.53
Fiber fractions			
Nitrogen free extract	61.19±0.18	40.37±2.06	54.35±1.80
Neutral detergent fibre	65.20±3.32	68.63±1.25	33.53±0.85
Acid detergent fibre	10.68 ±0.08	43.94±3.61	22.67±2.77
Cellulose	2.92±0.06	36.00±3.19	6.83±0.42
Hemicellulose	54.52±3.40	24.69±2.37	1.13±0.17
Minerals			
Calcium	0.20±0.04	0.45±0.10	0.99±0.34
Phosphorus	0.51±0.05	0.41±0.05	1.75±0.88

*Moisture percentage on fresh basis
all values are expressed on dry matter basis except moisture

Deworming was done in all the animals with albendazole (10mg/kg body weight) on 0th day. The animals were offered basal diet of local grass hay *ad libitum* along with required amount of concentrate mixture to meet the maintenance requirement in the ratio of (60:40) during 30 days trail period. Animals were offered feed daily at 10 A.M. and were watered two times a day. Daily feed intake was recorded throughout the trial period. The concentrate mixture consisted of 55% ground maize, 23% soybean meal, 17% wheat bran, 2% mineral mixture, and 1% common salt. The chemical composition of the hay, concentrate mixture and TC is presented in Table 2. All experimental measures were permitted and conducted under the recognized standard of the Institutional Animal Ethics Committee (IAEC), constituted as per the article number 13 of the Committee for the Purpose of Control and Supervision of Experiments on Animals (CPCSEA) rules laid down by the Government of India.

2.2 Physiological observations

The physical assessment of the animals was recorded at 14:00 hours each day. The rectal temperature (RT) was measured by a clinical thermometer for 90 seconds inserted deep into the rectum of animals so it was in contact with the mucous membrane; annotations were recorded in degrees Fahrenheit (°F). The respiration rate (RR) was detected by inspecting the movement of the flank for one minute in which every inward and outward movement of the flank was counted as one complete respiration. The pulse rate (PR) of the animals was measured via the femoral artery on the inside of the goats back leg around one third of the way down the thigh expressed as beats per minute.

2.3 Digestion trail

A digestion trial of 6 days interval was conducted towards the end of feeding trial, to find out the digestibility of different proximate fractions. During the digestibility trial weighed quantity of grass hay and concentrate mixture was offered at about 10:00 hour, water was offered *ad libitum* twice daily. Well-mixed representative samples of grass hay and concentrate mixture and their left over residue were taken

daily. The dried samples obtained in trial period were pooled item wise ground and kept in labeled sealed containers for further analyses of proximate principles and fibre fractions. The feces voided in 24 hours by the each animal was collected quantitatively daily, weighed and carried in polythene bags for further sampling in laboratory. A representative sample from all animal was taken individually in a labeled polythene bags. A suitable fecal aliquot (1/10 of fresh feces) was kept for drying at 100±1 °C to a stable weight in a hot air oven for dry matter estimation. The dried samples obtained daily were pooled animal wise, ground and used for proximate analysis. An appropriate fecal aliquot (1/50 of fresh feces) was mixed with 10 ml of 1:4 sulphuric acid and preserved for nitrogen estimation in a sealed bottle. Samples of the feed given, residue surplus and feces excreted were dried at 100 °C in an oven for 24 hours and ground. Grounded samples were analyzed for dry matter, crude protein, ether extract [6]. Neutral detergent fibre (NDF) and acid detergent fibre (ADF) were evaluated as per method described by Van Soest [7].

3. Results and Discussion

3.1 Micro- climatic conditions inside experimental house

Means of estimating the severity of heat stress was proposed using both ambient temperature and relative humidity, termed as the temperature humidity index (THI) [6] and presented in Table 2. The values obtained indicate the following: <27.8 = absence of heat stress and 28.9 and more = severe heat stress. In the present study during experimental period average temperature were 14.3 ºC versus 33 ºC and average relative humidity were 72% versus 38% in normal and heat exposure group respectively. Hence, THI values were 14.29 and 29.40 in normal and heat stress group of animals, which designate all the experimental animals were in severe heat stress.

3.2 Physiological responses

Table 3 shows the RT, RR and PR in normal (T0H0 and T1H0), and high temperatures (T0H1 and T1H1) exposed goats. In the present study the individual interaction of heat stress significantly increased RR and PR (33.31 versus 20.53) and (59.42 versus 41.90) as compare to normal condition. The present results were in similarity with Habeeb *et al.*, [8] who reported that respiration rate can be increased through heat stress in goats. In summer, the respiration rate is increased than in winter for sheep [9]. Elevated RR in animals is most likely adopted to supplement the evaporative cooling. The TC supplementation significantly reduced the RR in T1H1as compared to heat stress group (T0H1). This indicated that the protecting effects of TC supplementation in this study. Goats exposed to heat exposure showed a higher pulse rate compared to the control group. The pulse rate reflects mostly the homeostasis of circulation along with the general metabolic status. The present finding in agreement with Aboulnaga [10] pulse rate increases on exposure to high environmental temperature, similar result was also reported during summer, the pulse rate was significantly higher than during winter, in goat [11]. The same trend was observed in grazing goat [12]. The rectal temperature of animals did not show (P>0.05) any significant effect after exposure of heat which indicate that animals are not in acute stress condition. The supplementation of TC reduced respiration rate significantly (P<0.05) than non supplemented group (30.60±0.27 versus 34.00±0.12). The individual effect of supplementation showed significant difference in supplemented and non supplemented groups. Supplementation of TC stem powder significantly lowered the RR but not to the normal condition thus making the animal little comfortable.

Table 3: Physiological responses in Gaddi goats

Attributes	Rectal temperature (^{0}F)	Respiration rate (breaths/min)	Pulse rate (beats/min)
T0H0	101.8±0.08	20.70±0.14^c	42.06±0.50
T1H0	101.7±0.04	20.36±0.31^c	41.74±0.35
T0H1	101.1±0.83	34.00±0.12^a	59.89±0.18
T1H1	101.9±0.05	30.60±0.27^b	58.95±0.64
SEM	0.20	1.66	2.27
P-value	0.396	0.050	0.504
Main Effect			
Stress			
Normal	101.7±0.04	20.53±0.17^b	41.90±0.29^b
Stress	101.5±0.41	33.31±0.28^a	59.42±0.35^a
P-value	0.55	0.000	0.000
Supplementation			
0	101.4±0.41	27.33±2.51^a	50.98±3.38
5	101.8±0.04	24.51±2.33^b	50.34±3.27
P-value	0.408	0.003	0.183

T0H0 (no treatment no heat stress, control), T1H0 (animals fed on diet supplemented with TC @ 5% of DMI with no heat stress), T0H1 (no treatment with heat stress) and T1H1 (animals fed on diet supplemented with TC with heat stress).

^{a,b,c} Means bearing different superscripts in a column differ significantly for a parameter

3.3 Nutrient intake and digestibility

Effect of supplementing TC in the diet of Gaddi goats exposed to heat stress on nutrient intake and digestibly is presented in Table 4 and Table 5 respectively; shows the means of nutrient intake and digestibility in normal and heat exposed animals during digestion trial. Individual effect of heat stress showed the nutrient intake like DM, OM, EE, NDF, ADF, cellulose and hemicelluloses, NFE significantly (P<0.05) decreased in the animals where heat stress was induced, whereas, there was no change in CP intake. Supplementation of diet with TC could not improve the nutrients intake. There was no interaction between stress and supplementation. The exposure of the animals to heat stress resulted in significant reduction in all the nutrients except CP intake. Supplementation of TC sat the level of 5% DMI was not able to normalize the nutrients intake. Similar findings have been also reported the nutrient uptake decreased up to about 30% of DMI in case of cattle under heat stress conditions [13].

Table 4: Daily intakes of various nutrients during digestion trial in different groups

Attributes	DMI (g/d)	DMI (%BW)	DMI (g/kg $W^{0.75}$)	OM intake (g/d)	OM (g/kg$W^{0.75}$)	CP intake (g/d)	NDF intake (g/d)	ADF Intake (g/d)	Hemi cellulose intake (g/d)	Cellulose intake (g/d)
T0H0	822.6	2.53	60.34	772.9	67.70	92.32	552.4	244.0	308.2	194.4
T1H0	864.2	2.65	63.24	811.9	66.82	96.40	580.4	257.9	322.3	205.9
T0H1	747.6	2.43	57.13	702.4	71.97	89.17	500.5	207.2	293.1	160.9
T1H1	751.0	2.46	57.71	710.9	71.71	89.23	506.8	212.5	294.1	165.8
SEM	17.20	0.04	0.93	15.66	0.67	1.45	11.34	6.58	5.13	5.78
P-value	0.474	0.565	0.463	0.525	0.655	0.481	0.528	0.606	0.489	0.64
Main effect										
Stress										
Normal	843.4[a]	2.59	61.79[a]	792.4[a]	67.26[b]	94.36	566.4[a]	250.9[a]	315.2[a]	200.2[a]
Stress	749.3[b]	2.44	57.42[b]	706.6[b]	71.84[a]	89.20	503.7[b]	209.8[b]	293.6[b]	163.3[b]
P-value	0.003	0.075	0.014	0.003	0.000	0.087	0.003	0.000	0.036	0.000
Supplementation										
0	785.2	2.48	58.74	737.6	69.84	90.74	526.5	225.6	300.6	177.6
5	807.6	2.55	60.47	761.4	69.26	92.82	543.6	235.2	308.2	185.9
P-value	0.402	0.322	0.278	0.329	0.402	0.468	0.325	0.262	0.424	0.251

T0H0 (no treatment no heat stress, control), T1H0 (animals fed on diet supplemented with TC @ 5% of DMI with no heat stress), T0H1 (no treatment with heat stress) and T1H1 (animals fed on diet supplemented with TC with heat stress). [a,b] Means bearing different superscripts in a column differ significantly for a parameter SEM, standard error of the mean; DMI, dry matter intake; NDF, neutral detergent fibre; ADF, acid detergent fibre; CP, crude protein; OM, organic matter.

Table 5: Digestibility (%) of different nutrients and fibre fractions during digestion trial

Attributes	DM	CP	NDF	ADF	Hemi cellulose	Cellulose	EE	NFE	OM
T0H0	61.60	70.20	61.20	39.56	69.12	51.29	70.11	72.00	72.29
T1H0	61.90	71.30	61.63	40.29	70.65	51.28	69.51	72.10	73.16
T0H1	64.20	73.31	63.14	42.59	70.77	51.88	70.55	73.17	72.46
T1H1	64.50	74.08	63.47	42.16	71.10	52.00	71.31	73.80	74.24
SEM	0.61	0.80	0.50	0.65	0.68	0.52	0.33	0.56	10.06
P-value	0.986	0.916	0.952	0.651	0.693	0.954	0.31	0.825	0.682
Main effect									
Stress									
Normal	61.75[b]	70.70	61.40[b]	39.93	69.88	51.30	69.81	72.05	72.72
Stress	64.34[a]	73.70	63.30[a]	42.37	70.94	51.90	70.93	73.50	73.35
P-value	0.043	0.076	0.030	0.076	0.486	0.577	0.105	0.249	0.571
Supplementation									
0	62.81	71.75	62.20	41.08	69.94	51.60	70.33	72.60	72.37
5	63.06	72.68	62.50	41.22	70.88	51.64	70.41	72.95	73.70
P-value	0.778	0.553	0.628	0.909	0.537	0.964	0.909	0.776	0.242

T0H0 (no treatment no heat stress, control), T1H0 (animals fed on diet supplemented with TC @ 5% of DMI with no heat stress), T0H1 (no treatment with heat stress) and T1H1 (animals fed on diet supplemented with TC with heat stress). [a,b] Means bearing different superscripts in a column differ significantly for a parameter SEM, standard error of the mean; DM, dry matter; CP, crude protein; NDF, neutral detergent fibre; ADF, acid detergent fibre; EE, ether extract; NFE, nitrogen free extract; OM, organic matter.

In the present study, under heat stress, the digestibility of DM (64.34 versus 61.75) and NDF (63.30 versus 61.40) increased significantly. CP digestibility also increased marginally. The digestibility did not show stress and supplementation interaction. There was also no individual effect of TC supplementation on digestibility of any nutrient. The present finding of increased DM and NDF digestibility in agreement with the dry matter and neutral detergent fibre digestibility were higher ($P<0.05$) at 35 °C compared to 25 °C and 30 °C exposure [14]. In present study, the increase in digestibility at exposure of heat stress might be attributed to increase in retention time of the digesta; however retention time was not estimated in this study. In agreement with this study, it was acknowledged that high ambient temperature and humidity decreased feed intake of Awassi wethers [15].

4. Conclusion

It can be concluded from the present study that 33±2 ºC heat exposure began to induce heat stress in Gaddi goats as exhibited by changes in physiological parameters (RR and PR), reduced the feed intake and increased nutrient digestibility (DM and NDF). Supplementation of TC stem powder significantly lowered the RR thus making the animal little comfortable. The result of the present study suggests that TC stem powder can be used as a source of stress ameliorating agent in the animals under the heat stress condition.

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