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Effect of heat stress on blood parameter, carcass and meat quality of Black Bengal goat

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Abstract

The research was conducted to study the effect of heat stress on blood parameter, carcass characteristics and meat quality of the Black Bengal goat. Nine goats were randomly and equally divided into three groups having almost same age and weight. Three groups were divided as zero hour (T_0), four hours (T_4) and eight hours (T_8) of heat exposure. The T_0 group were not exposed to heat stress, the T_4 and T_8 group were exposed to heat by keeping them at outside for 4 (four) hours and 8 (eight) hours from 9.00 AM to 1.00 PM and from 9.00 AM to 5.00 PM, respectively. Temperature–humidity index (THI) was calculated as 26.88 indicating all the experimental animals were in extreme severe heat stress. The blood parameter such as RBC, PCV%, Hb%, WBC was significantly ($p<0.01$) higher in T_8 group than those of T_4 and T_0 groups. There was also significant ($p<0.05$) effect of heat stress on pH of the meat from different groups of the Black Bengal goats. By-products e.g., blood, pluck, spleen and kidney, and cooking loss were significantly ($p<0.01$) increased with the increase of the heat, but no significant differences were observed for pre-slaughter parameters, carcass weight, drip loss, dressing percentage, and proximate composition of the goat meat for DM, CP and Ash, while the EE significantly ($p<0.05$) differed among the heat treated groups. Heat stress significantly affected the blood parameter, cooking loss, pH, by-product of goats rather than non heat stressed group. It indicates that heat stress limits the qualitative and quantitative production characteristics of goat meat.

Key words: Blood parameter, goat carcass, heat stress, meat by-product

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Introduction

Goats play an important role in the subsistence economy of smallholder and provide 1.31 million MT of meat to the people of Bangladesh (FAO, 2009). Goat is found in almost all the villages, and plays an important role in nutrition, income generation and employment for the rural people of Bangladesh. High environmental temperature challenges the animal's ability to maintain energy, thermal, water, hormonal and mineral balance. Heat stress stimulates excessive production of free radicals (superoxide anion radicals, hydroxyl radical, hydrogen peroxide and singlet oxygen) which are continuously produced in the course of normal aerobic metabolism (Bernabucchi et al. 2001) and these free radicals can in turn damage healthy cells if they are not eliminated. Exposure of animals to heat stress activates the hypothalamo-pituitary-adrenal axis (Abilay et al. 1975) and estimation of concentrations of hormones such as thyroxin, cortisol, and prolactin could be one of the important indicators for assessment of stress in animals.

High ambient temperature and humidity are the major constraint on sheep productivity in tropical and sub-tropical areas (Marai et al. 2007). Increased body temperature and respiration rate are the most important signs for heat stress in goat. These include the aberration of reproductive functions (Roth et al. 2002), oxidative stress and enzymatic dysfunction (David et al. 2001), electrolyte imbalances (West et al. 1991), reduced meat quality (Kadima et al. 2004), and severe economic losses resulting from increased mortalities and decreased overall animal performance (Hahn and Mader 1997). Normal body temperature is essential for physiological adjustment and to prevent hyperthermia (Al-Haidary 2000; Lowe et al. 2001). Animal under heat stress may fail to adjust themselves resulting lower animal productivity and a tremendous economic loss for the goat industry. There is a lack of information related to the effect of heat stress on the blood parameter, carcass characteristics and meat quality of goat in Bangladesh. Therefore, the present study was conducted to investigate the effect of heat stress on blood parameters, carcass characteristics and meat quality of the Black Bengal goat.

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Materials and Methods

The experiment was conducted from April to July, 2011 at the Goat, Sheep and Horse farm of Bangladesh Agricultural University, Mymensingh. Nine Black Bengal female goats were randomly selected for the experiments, and equally divided into three groups almost having similar age and weight. Means of estimating the severity of heat stress was proposed using both ambient temperature and relative humidity, termed as the temperature humidity index (THI) (LPHSI, 1990; Marai et al. (2007). When temperature is measured (^{0}F), the equation to determine THI is as follows (LPHSI, 1990): THI = db ^{0}F – {(0.55 – 0.55 RH) (db ^{0}F – 58)} where db ^{0}F is the dry bulb temperature in ^{0}F and RH is the relative humidity (RH%)/100, for sheep and goats. The obtained values indicate the following: values <82 = absence of heat stress; 82 to <84 = moderate heat stress; 84 to <86 = severe heat stress and over 86 = extreme severe heat stress (LPHSI 1990). When the temperature is expressed in ^{0}C, the equation of Marai *et al.* (2001) changes as follows: THI = db ^{0}C – {(0.31 – 0.31 RH) (db ^{0}C – 14.4)} where db ^{0}C is the dry bulb temperature (^{0}C) and RH is the relative humidity (RH%)/100. The values obtained indicate the following: <22.2 = absence of heat stress; 22.2 to <23.3 = moderate heat stress: 23.3 to <25.6 = severe heat stress and 25.6 and more = extreme severe heat stress (Marai *et al.,* 2001). In the present study during experimental period average temperature was 26.88^{0}C and average relative humidity was 87.83%. Hence, THI value was 28.17 which indicate all the experimental animals were in severe heat stress (Marai et al. 2007).

These were made as 0 hour heat exposure group or control group (without heat exposure in stall feeding), 4 hours heat exposure group (09 am to 01 pm heat exposure in grazing) and 8 hours heat exposure group (9.00 am to 05 pm heat exposure in grazing). That is these groups were as zero hour (T_0), four hours (T_4) and eight hours (T_8) of heat exposure. Goats of these groups were kept in the room separated with fence and were given two months for their psychological and physiological adjustment. The animals in each group was supplied an adequate amount of roughage and concentrate along with *ad libitum* clean drinking water daily. The initial body weight for each animal was recorded and then weighing was carried out by using weigh band for every week at the same time before morning feeding.

The data of Ambient Temperature and Relative Humidity for the experimental days were collected from Meteorological Centre, Bangladesh Agricultural University, Mymensingh. Twenty (20) g of meat sample was taken for the chemical analyses (proximate composition), and 5, 60 and 60 g were also taken for the determination of pH, drip loss and cooking loss, respectively. All these samples were collected from the same region of each slaughtered goat, and then weighed and packed separately. Proximate compositions such as dry matter, crude protein, ether extract and ash were estimated using the method by AOAC, 1995. Dressing percentage and eye muscle area (EMA) were also estimated. The pH was measured using by pH meter (Corning model 250). Drip loss and cooking loss was measured using the principle of Honikel (1998). Blood was collected from jugular vein of the animals by the method described by Schalm et al. (1975).

Data were analyzed statistically using the analysis of variance technique using SAS statistical computer package program (1998) in accordance with the principle of Completely Randomized Design (CRD). Duncan's Multiple Range Test was done to compare variations between treatments.

Results and Discussion

Effect of heat stress on blood parameter

Table 1 shows that the blood parameters the RBC and WBC were 9.38±0.59 and 8.06± 0.26, 9.85±0.45 and 8.59±0.65, and 10.18±0.50 and 9.0±0.30 for T_0, T_4 and T_8, respectively. PCV% and Hb% were 27.65±0.56 and 8.7±0.33, 28.06± 0.85 and 9.08±0.54, and 29.10±1.50 and 10.0±0.45 for T_0, T_4 and T_8, respectively.

The amount of RBC, PCV%, Hb%, WBC was significantly higher ($p<0.01$) in T_8 group than those of T_4 and T_0 group, respectively (Table 1). T_4 group were significantly higher ($p<0.01$) than that of T_0 group. In the present study, both PCV and haemoglobin (Hb) were increased in the T_4 and T_8 which was not in agreement with the findings of Srikandakumar et al. (2003) in sheep and Abdel-Samee (1991) in goats. These increase of hemoglobin and PCV levels might be due to either increased of free radicals on the RBC membrane, which is rich in lipid content, and ultimate lysis of RBC or adequate nutrient availability for hemoglobin synthesis as the animal consumed more feed or decrease voluntary intake under heat stress (Srikandakumar et al. 2003).

Table 1. Effect of heat stress on blood parameter (Mean±SD)

Parameter	T_0	T_4	T_8
RBC (million/ cubic mm)	9.38^c ±0.59	9.85^b ±0.45	10.18^a ±0.50
WBC (Thousand/ cubic mm)	8.06^c ±0.26	8.59^b ±0. 65	9.0^a ±0.30
PCV%	27.65^c ±0.56	28.06^b ±0.85	29.10^a ±1.50
Hb (g/percent)	8.7^c ±0.33	9.1^b ±0.54	10.0^a ±0.45

Means with different superscript in the same raw differ significantly ($p<0.01$), T_0, zero hour of heat exposure, T_4, four hours of heat exposure; T_8, eight hours heat exposure

Pre-slaughter and carcass parameters of goat

Table 2 represents the pre-slaughter parameter of the Black Bengal goat. Initial and slaughter weight was 12.3±0.60 and 12.5±0.57, 12.33± 0.33 and 12.83±0.33, and 12.66±0.88 and 13.0±0.57 kg for T_0, T_4 and T_8, respectively. Likewise, the body length and heart girth was 47.66±1.20 and 51.00± 0.57, 48.33± 0.88 and 52.33±0.33, and 48.66± 1.85 and 53.33±1.76 cm for T_0, T_4 and T_8, respectively. No significant differences were observed for body weight, length and heart girth among the treatment groups. These findings were consistent with the values described by Hussain (1993). The mean body weight was slightly higher than that of the findings of Singh et al. (1981).

Table 2 shows that the carcass weight were 4.77 ±0.14, 5.50±0.28 and 5.66±0.44 kg with a dressing percentage of 40.28±10.86, 42.81± 1.41 and 40.85±0.63 for T_0, T_4 and T_8, respectively. Rib eye area was 9.25±0.337, 11.77 ±0.81 and 11.33±1.84 cm^2 for T_0, T_4 and T_8, respectively. There were no significant differences among the carcass weight, dressing percentage and rib eye area.

Table 2 demonstrates the pH, drip loss and cooking loss of meat. The pH of meat was 6.16± 0.014, 6.18± 0.016 and 6.30± 0.045 for T_0, T_4 and T_8, respectively. Percentage of drip loss and cooking loss were 12.38± 0.48 and 35.77± 0.79, 11.89± 1.05 and 41.41± 0.55, and 13.61± 0.64 and 42.89± 0.35 for T_0, T_4 and T_8, respectively. The significant ($p<0.05$) difference was observed for heat stress on pH within the different groups of goats. Similarly, the cooking loss demonstrated highly significant ($p<0.01$) effect, but drip loss had no significant variation amongst the experimental groups.

Table 2. Effect of heat stress on pre-slaughter and carcass parameters (Mean±SD) of goat

Parameter	T_0	T_4	T_8	Sig. Level
Initial weight (kg)	12.3 ±0.60	12.33 ±0.33	12.66 ±0.88	NS
Slaughter weight (kg)	12.5 ±0.57	12.83 ±0.33	13.0 ±0.57	NS
Body length (cm)	47.66 ±1.20	48.33 ±0.88	48.66 ±1.85	NS
Heart girth (cm)	51.00 ± 0.57	52.33 ± 0.33	53.33 ±1.76	NS
Carcass weight (Kg)	4.77 ±0.14	5.50 ± 0.28	5.66 ±0.44	NS
Dressing %	40.28 ±10.86	42.8 ± 1.41	40.85 ±0.63	NS
Rib Eye Area (cm^2)	9.25 ±0.337	11.77 ± 0.81	11.33 ±1.84	NS
p^H	6.16^b ±0.014	6.18^b ± 0.016	6.30^a ±0.045	*
Drip Loss (%)	12.38 ±0.48	11.89 ± 1.05	13.61 ±0.64	NS
Cooking loss (%)	35.77^b ±0.79	41.41^a ± 0.55	42.89^a ±0.35	**

*Means with different superscript in the same raw differ significantly; **, $p<0.01$; *, $p<0.05$; NS, non significant, T_0, zero hour of heat exposure, T_4, four hours of heat exposure; T_8, eight hours heat exposure*

Table 3. Effect of heat stress on by-products parameter (Mean±SD) of goat meat

Variables (g)	T_0	T_4	T_8	Sig. Level
Blood	173.33^b ± 6.66	240.00^b ± 17.32	436.66^a ±29.62	**
Head	606.66 ± 6.66	793.33 ± 17.63	816.66 ± 55.55	NS
Feet	198.33 ± 27.43	206.66 ± 20.27	220.00 ± 32.11	NS
Pluck	370.00^b ± 25.16	423.33^b ± 23.33	573.33^a ± 14.55	**
Heart	32.33^b ±1.45	36.66^{ab} ±3.33	50.00^a ±5.77	*
Spleen	20.00^b ±2.88	36.66^{ab} ±3.33	43.33^a ±3.33	**
Liver	165.00 ±8.66	186.66 ±17.63	263.33 ±47.03	NS
Kidney	20.00^b ±2.88	36.66^a ±3.33	43.33^a ±3.33	**
Lung plus Trachea	101.66 ±14.81	103.33 ±8.81	136.66 ±18.55	NS

*Means with different superscript in the same raw differ significantly; **, $p<0.01$; *, $p<0.05$; NS, non significant, T_0, zero hour of heat exposure, T_4, four hours of heat exposure; T_8, eight hours heat exposure*

By-products parameter of goat meat

The results of by-products as blood, head, feet, pluck, heart, spleen, liver, kidney and lung plus trachea for T_0, T_4 and T_8 groups are showed in Table 3. The blood, pluck, spleen and kidney had highly significant ($p<0.01$) difference among different groups. Blood, pluck, spleen and kidney were markedly increased in T_8 group than those of T_0 and T_4 groups. Moniruzzaman et al. (2000) showed a little bit higher weight of blood than that of our findings.

Proximate component of goat meat

The proximate components e.g. dry matter (DM), crude protein (CP), ash and ether extract (EE) of the Black Bengal goat meat for T_0, T_4 and T_8 groups were summarized in Table 4.

Table 4. Effect of heat stress on proximate composition (Mean±SD) of goat meat

Variable (%)	T_0	T_4	T_8
DM	23.82±0.67	22.95±0.76	22.77±0.39
CP	17.00±1.28	15.60±1.92	15.85±0.72
Ash	2.37±0.19	2.83±0.22	2.54±0.02
EE	2.60^{a}±0.17	2.05^{ab}±0.33	1.26^{b}±0.44

Means with different superscript in the same raw differ significantly ($p<0.01$), T_0, zero hour of heat exposure, T_4, four hours of heat exposure; T_8, eight hours heat exposure

The DM, CP and Ash had no significant difference while heat stress had significantly ($p<0.05$) effect on EE among the groups. Moniruzzaman et al. (2000) explained that there was an effect of different feeding system on the composition of Black Bengal goat meat and they observed that DM percentage of meat varied significantly ($p>0.05$) for different feeding systems. Similarly, the EE also significantly ($p<0.01$) differed due to different feeding systems of goat.

Conclusion

Heat stress significantly affects blood parameters, cooking loss, pH and by-products of the Black Bengal goat. Further, in depth study is needed to explore more information to minimize the effect of heat on blood and meat characteristics for both qualitative and quantitative production approaches of goat meat.

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