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THERMOREGULATORY, HAEMATOLOGICAL, AND METABOLIC RESPONSES OF SOLAR RADIATED FRIESIAN CALVES FED DIETARY PROTECTED FAT

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ABSTRACT

Effects of protected fat supplementation (PF) on thermoregulatory, haematological and metabolic responses of growing Friesian calves exposed to solar radiation (SR) or kept under semi-open shed (SH) were studied through four experimental phases. The 1st phase was to exposing the animals to SR for 6 h daily (SR). The 2nd phase was to keep the calves under shed (SH). The 3rd and the 4th phases were to feeding the exposed and shaded calves on PF (SR+PF and SH+PF, respectively).

Results showed that all calves exposed to very sever heat stress at most of the day times during all experimental phases. In calves exposed to SR, temperatures of hair (HT), skin (ST) and rectum (RT), and respiration (RR) and pulse rate (PR) significantly increased by about 2.3, 4.1, 2.2, 14.5 and 4.4%, respectively. However, red blood cell count (RBC), packed cell volume (PCV%) and concentration of haemoglobin (Hb), total protein (TP), globulin (GL), total lipids (TL), cholesterol (CL) and glucose significantly (P<0.01) decreased by about 10.1, 10.1, 4.5, 3.3 , 6.9 4.0, 4.0 and 6.0%, respectively as compared to the shaded calves.

Feeding calves on PF diet led to increasing (P<0.01) all values of the thermoregulatory responses, improving RBC, PCV% and concentration of Hb, TL and CL and decreasing glucose concentration as compared to those without PF supplementation. Yet, rumen temperature, blood pH value, white blood cell count (WBC) and albumin (AL) was not affected by SR treatment or PF supplementation. On the other hand, values of RBC, Hb, TP, GL and CL during SR + PF did not differ significantly than during SH. While, values of PCV% and glucose concentration were lower (P<0.01) and of TL was higher (P<0.01) in calves during SR + PF than SH. Only, concentration of TL increased (P<0.01) in calves during SH + PF than SH.

The present study suggests the possibility of using PF as a technique for ameliorating heat load on Friesian calves to improve their productivity during summer specially those exposed to solar radiation.

Keywords: Friesian calves, solar radiation, protected fat, thermoregulatory, haematology.

INTRODUCTION

Most of the heat gained in heat stressed animals comes directly or indirectly from solar radiation. Solar radiation is absorbed when animals are exposed to direct sunlight (Abdel-Samee, 1998). The stored heat in animal body causes severe heat stress for the animals exposed to solar radiation involving disturbances in body thermoregulation (Tharwat *et al.*, 1994), blood haematology (Marai *et al.*, 1997) and metabolic functions (Marai and Habeeb, 1997), subsequently affects animal productivity.

Various management practices have been used to eliminate the negative impact of heat stress on farm animals. Fat supplementation with suitable level in ration of sheep can be used to alleviate heat stress to improve animal productivity under subtropics (Abdel-Samee and Diel, 1998). Dietary supplements of fat in the ruminant rations have invariably affected the ruminal metabolism (Marwaha *et al.*, 1972). The fat, however, when was fed in protected form did not show the adverse effect of the normal fat (Macteod *et al.*, 1977).

The information on the effect of dietary supplements of protected fat on the physiologic responses of heat-stressed animals were not available. Therefore, the present study aimed at investigating the thermoregulatory, haematological and metabolic responses of Friesian calves fed dietary protected fat and kept under the direct exposure to solar radiation or under semi-open shed.

MATERIALS AND METHODS

The present study was carried out at the Animal Production Research Station, Sakha, Kafr El-Sheikh Governorate, located in the north Eastern part of the Nile Delta (30 ºN), belonging to the Animal Production Research Institute, during the period from July to August, 1999.

Six male Friesian calves with 11-13 mo old and average body weight of 219.2±5.8 kg were used at four series of experimental phases as following:

Experimental phase	I (SR)	II (SH)	III (SR + PF)	IV (SH + PF)
Climatic treatment	calves exposed to solar radiation (SR) for 6 h from 9:00 a.m. to 15:00 p.m.	Under semi-open shed	SR for 6 h	Under semi-open shed
Dietary treatment	Control diet	Control diet	Control diet supplemented with protected fat (PF)	Control diet supplemented with PF

Each experimental phase lasted 15 d, 10 preliminary days and 5 sampling days. The exposed calves were kept under semi-open shed after the end of the exposure.

The control diet contained 5 kg concentrate feed mixture (CFM) and 2 kg berseem hay (BH), while in PF diets, 250 g of CFM of the control diet were replaced by the same quantity from PF. The protected fat contained 84% palm oil (44% palmitic, 40% oleic, 9.5% linoleic, 5% stearic and 1.5% myrstic acid), 12.5% Ca-carbonate and 3.5% moisture. Chemical composition of CFM and BH are shown in Table (1). Diets were offered to calves once daily at 9.00 h according to the NRC (1981) recommendation, while fresh water was available all day.

Table (1): Dry matter (DM %) and chemical analysis of concentrate feed mixture (CFM) and berseem hay (BH) used in calves feeding.

Feed stuff	DM %	Chemical composition on DM basis (%)				
		CP	EE	CF	NFE	Ash
CFM	90.69	18.23	3.82	10.8	60.16	6.99
BH	87.95	12.16	1.54	31.54	44.57	10.19

Daily maximum and minimum values of ambient temperature (db, ºC) and relative humidity (RH%) during each experimental phase are shown in Table (2). Values of temperature-humidity index (THI) presented in Table 2 was estimated according to Livestock and Poultry Heat Stress Indices, suggested by Agricultural Engineering Technology Guide, Clemson University, Clemson, Sc. 29634, USA, using the following formula:

$$THI = db\ ^oF - (0.55 - 0.55\ RH)(db - 58)$$

Where: db °F = dry bulb temperature in Fahrenheit.
RH = relative humidity (RH / 100).

The obtained values of THI were classified as follows:
Less than 72 = absence of heat stress. 72 to 74 = moderate heat stress.
74 to < 76 = severe heat stress. Over 76 = very severe heat stress.

During the sampling days of each phase, values of temperature (°C) of hair (HT), average of white and black skin (ST), rectum (RT) and rumen (RuT) as well as respiration rate (RR/min.) and pulse rate (PR/min.) were daily recorded for all calves at 9:00 (the beginning of the exposure), 12:00 (3 h after the exposure), 15:00 (the end of the exposure) and 18:00 (3 h after the end of exposure and calves were kept under shed). All body temperatures were estimated by digital thermometer (Fisher, USA) including especial tool for each measurement. While, RuT was recorded by introducing the coil of RT into the end of rubber tube into the rumen.

During the latter three days of each phase, blood samples were daily taken from the jugular vein of all calves. Blood pH values were measured using pH meter immediately after blood collection. Haematological parameters including count of red (RBC) and white blood cells (WBC), packed cell volume percentage (PCV%) and haemoglobin concentration (Hb) were determined in fresh blood. Plasma was separated by centrifugation of the blood at 3000 rpm for 15 min. and then kept frozen at -20°C till analyses.

Concentrations of total protein (TP), albumin (AL), total lipids (TL), cholesterol (CL) and glucose were determined calorimetrically using commercial kits (Pasteur Lab. Egypt-USA). However, concentration of globulin (GL) was computed by subtracting AL from TP.

Data were statistically analyzed as factorial design using the least squares method described by Likelhood SAS Program (1990). The differences among means were tested using Duncan's new multiple range test (Duncan, 1955).

RESULTS AND DISCUSSION

Temperature-humidity index

Data in Table 2 revealed that shaded calves were exposed to severe heat stress at 9:00 h, however, solar radiated and shaded calves exposed to very severe heat stress at the other times, being greater for solar radiated than shaded calves. This indicated that Friesian calves exposed to very heat stress through most times of day during summer season, particularly during July and August months.

Thermoregulatoy responses

Data in Table (3) show that the estimated temperatures of HT, ST and RT increased significantly in exposed than shaded calves. It is of interest to note that the rate of increase in ST of calves due to solar radiation was greater (4.1%) than those for HT (2.2%) and RT (2.2%). However, RuT did not differ significantly as affected by SR. The marked increase in ST of exposed calves was mainly due to the direct effect of sunrise on body surface of calves.

Table (2): Meteorological data and temperature-humidity index (THI) during different experimental periods.

Item	Experimental phase			
	SR	SH	SR + PF	SH + PF
Ambient temperature (ºC):				
Maximum	33.6±0.58	33.7±0.32	34.3±0.43	33.3±0.21
Minimum	23.1±0.43	20.1±0.43	23.4±0.45	21.4±0.39
Relative humidity (RH%):				
Maximum	77.90±5.1	82.6±2.4	82.6±1.5	77.8±1.6
Minimum	56.23±1.6	48.9±3.6	45.9±2.8	45.2±2.0
Temperature-Humidity index (THI):				
09:00 h	78.07±1.08	76.69±1.26	80.54±1.41	76.76±1.30
12:00 h	85.47±1.32	79.75±1.58	82.85±1.62	77.86±1.26
15:00 h	87.79±1.41	80.47±1.34	84.72±1.45	80.62±1.51
18:00 h	84.23±2.01	80.03±1.89	82.12±2.21	78.27±2.00

The significant (P<0.01) increase in RT of exposed calves resulted in higher (P<0.01) rate of increase in RR (14.6%) than in PR (4.4%) (Table 3). This may be a strong reaction of exposed calves to store heat in their bodies (Abdel-Samee, 1998). Generally, exposing calves to SR caused disturbance in animal body thermoregulation, resulting in marked increase (P<0.01) in RT and RR as reported by Abdel-Samee (1995&1997) and Marai *et al.* (1997). Similar results were found by Fawzy and Rabie (1996) and Fawzy *et al.* (1998) in Friesian bulls and calves, respectively.

Table (3): Body physiological responses of calves to climatic and dietary treatment, and time of day.

Item	HT	ST	RT	RuT	RR	PR
Climatic treatment :						
SR	33.20^{A}	36.81^{a}	39.62^{A}	38.44	89.5^{A}	87.3^{A}
SH	32.44^{B}	35.35^{b}	38.75^{B}	38.24	78.1^{B}	83.6^{A}
± SEM	0.10	0.09	0.07	0.11	0.09	0.35
Dietary treatment :						
Without PF	32.64^{B}	35.90^{B}	39.05^{B}	38.36	81.6^{B}	84.7^{b}
With PF	33.01^{A}	36.26^{A}	39.32^{A}	38.32	86.0^{A}	86.2^{a}
± SEM	0.10	0.08	0.06	0.12	0.09	0.40
Experimental phase:						
SR	32.88^{B}	36.62^{B}	39.49^{B}	38.48	87.7^{B}	86.7^{A}
SH	32.40^{C}	35.18^{C}	38.60^{D}	38.24	75.5^{D}	82.6^{C}
SR+PF	33.53^{A}	37.00^{A}	39.74^{A}	38.39	91.2^{A}	87.8^{A}
SH+PF	32.48^{C}	35.51^{C}	38.89^{C}	38.23	80.7^{C}	84.5^{B}
± SEM	0.12	0.12	0.08	0.17	1.08	0.40
Time of day :						
09:00	29.85^{C}	35.24^{C}	38.10^{C}	38.10^{B}	60.3^{D}	77.6^{D}
12:00	35.26^{B}	36.11^{B}	39.79^{A}	38.80^{A}	86.8^{B}	89.8^{B}
15:00	36.24^{A}	37.88^{A}	39.94^{A}	38.33^{B}	100.9^{A}	92.7^{A}
18:00	29.96^{C}	35.09^{C}	38.99^{C}	38.13^{B}	87.3^{C}	81.5^{C}
± SEM	0.11	0.08	0.05	0.13	0.58	0.31

A, B, C and a, b Values within the same column with different superscripts are significantly different at P < 0.01 and P < 0.05, respectively.

Supplementation of dietary PF led to significantly higher values of HT, RT, RR ($P<0.01$) and PR ($P<0.05$), however RuT was not affected significantly by dietary treatment (Table 3). Sklan *et al.* (1990) reported marked effect of dietary normal fat on depressing microbial fermentation in rumen, subsequently reducing overall energy availability in ruminants was in protected form. This may reflect in more heat gain, which represents more heat load on calves during SR+PF, resulting in higher responses of these calves than those without dietary PF (Table 3).

In comparing, the differences in thermoregulatory responses during the experimental phases, it is worthy noting that calves during SR+PF showed significantly ($P<0.01$) the highest responses followed by those during SR and SH+PF, while calves showed the lowest ($P<0.01$) responses during SH. However, RuT was not affected significantly at all experimental phases, although there was a tendency of higher values in RuT during SR and SR+PF than SH and SH+PF (Table 3). This is in agreement with the results of Salem (1990) and Murad *et al.*, (1994), who found a tendency of higher RuT in sheep kept at 35°C than 18°C.

Concerning the effect of daytime, values of all measurements (Table3) were parallel to concomitant ambient temperature and values of THI (Table 2). Body temperatures, RR and PR showed significantly ($P<0.01$) the highest values at 15:00 h and the lowest at 9:00 h. While, RuT showed the highest values at 12:00 h (3 h post-feeding) and the lowest at 18:00 h. Yet, values of HT, ST, RT, RR and PR were higher ($P<0.01$) at 18:00 h (3 h from the end of exposure) than those recorded at the beginning of the exposure (9:00 h). The present results indicate that feeding exposed calves on PF diet increased responses of calves to regulate its body temperature.

Haematological response

The present results in Table (4) revealed marked decreases ($P<0.01$) in RBC count, PCV% and Hb concentration by 11.3, 11.2 and 4.7%, respectively in the exposed than shaded calves. The corresponding values also increased ($P<0.01$) by about 3.2, 2.2, and 4.8%, respectively in calves fed with than without PF. However, blood pH value and WBC count was not affected by climatic and dietary treatments.

The results obtained for the experimental phases showed that RBC counts associated with level of Hb concentration, being the lowest ($P<0.01$) during SR as compared to other phases, which did not differ significantly. The significant decrease in RBC count and Hb concentration during SR was reported by several authors (Marai, *et al.*, 1997; Abdel-Samee, 1998 and Fawzy *et al.*, 1998). This may be related to increasing RR rate of calves during SR, which may increase oxygen transportation and this might accompanied by reduction in some trace elements, particularly iron, which are essential metal for Hb synthesis (Kamal *et al*., 1984).

Values of PCV% were the lowest ($P<0.01$) during SR and the highest during SH (Table 4). This trend of differences may be related to change in RBC volume and/or destruction of RBC as a result of climatic treatment (Shebaita and Kamal, 1975). However, the moderate values during SH + PF may be related to the beneficial effect of PF diets on RBC count (Table 4).

Table (4): Haematological parameters of calves as affected by climatic and dietary treatment, and time of day.

Item	pH Value	WBC ($x10^3/mm^3$)	RBC ($x10^6/mm^3$)	PCV (%)	Hb (mg/dl)
Climatic treatment :					
SR	7.25	10.86	5.94^B	32.7^B	12.01^B
SH	7.23	10.90	6.61^A	36.4^A	12.58^A
± SEM	0.005	0.06	0.07	0.09	0.09
Dietary treatment :					
Without PF	7.24	10.87	6.18^b	34.2^B	12.01^B
With PF	7.24	10.89	6.38^a	34.9^A	12.58^A
± SEM	0.005	0.07	0.06	0.09	0.08
Experimental phase :					
SR	7.25	10.79	5.50^B	31.0^D	11.60^B
SH	7.23	10.94	6. 85^A	37.3^A	12.40^A
SR+PF	7.25	10.92	6.38^A	34.4^C	12.42^A
SH+PF	7.22	10.86	6.37^A	35. 4^B	12.76^A
± SEM	0.007	0.10	0.14	0.12	0.13
Time of day :					
09:00	7.25	10.82	6.59^A	35.5^A	12.068^a
12:00	7.23	10.89	6.14^B	34.1^C	12.10^b
15:00	7.23	10.92	6.10^B	33.5^D	11.98^c
18:00	7.25	10.86	6.30^B	35.0^B	12.40^{ab}
± SEM	0.006	0.08	0.08	0.10	0.12

A, B, C and a, b, c Values within the same column with different superscripts are significantly different at P < 0.01 and P < 0.05, respectively.

In general, feeding calves on PF diet during SR led to improving (P<0.01) the haematological responses of exposed calves particularly Hb concentration, which may increase adaptability of these calves more adapted to hot conditions during summer. Pandey and Roy (1969) and Singh (1983) reported that animals showing minimum changes in Hb concentration during stressful temperature are considered more adaptable in hot environment. This may indicate the synergistic affect of PF on increasing level of energy availability (Wainman and Devey, 1987). Also, increasing haematological components were reported in Friesian calves supplemented with dietary fat as compared to the controls (Roy *et al*., 1970).

Concerning the effect of daytime, RBC, PCV% and Hb concentration showed significantly the highest values at 9:00 h and the lowest at 15:00 h. All values were higher at 18:00 than at 9:00 h, but the differences were not significant only for Hb concentration. However, blood pH values and WBC were not affected by daytime in all calves (Table 4).

Metabolic response

Protein metabolism

Solar radiation treatment was accompanied by marked decline (P<0.01) in plasma concentration of TP and GL and wider (P<0.05) AL/ GL ratio. While, AL concentration was not affected significantly (P<0.01). Effect of dietary treatment, however, was not significant on concentration of TP and their fractions (Table 5).

Decreasing metabolism of protein in exposed calves may related to a direct effect on liver function of heat-stressed animals (Abdel-Samee, 1997, Marai and Habeeb, 1997 and Habeeb *et al.*, 1997) or indirectly on the metabolic hormones (Abdel- Samee and Diel, 1998). Similar effect of SR treatment on protein metabolism in exposed animals were reported by Abdel-Samee *et al.*, (1996) and Abdel-Samee (1997) in Friesian cows and Marai *et al.*, (1992) in lambs.

Results of experimental phases revealed that calves showed the lowest concentration of TP (P<0.01) and GL (P<0.01) and the highest (P<0.01) AL/GL ratio during SR and the highest values were recorded during SH. It is of interest to note that calves during SR+PF had significantly higher values of TP and GL concentrations and lower AL/GL ratio than their values during SR and did not differ significantly than those during SH (Table 5). This may indicate ameliorating heat load on exposed calves by dietary PF supplementation. This come in line with results of Abdel-Samee, *et al.*, (1997) Abdel-Samee and Diel (1998), who improved growth performance of heat stressed lambs by dietary fat, which can minimize the heat increment of digestion under heat stress conditions.

Through time of day, calves showed the highest concentration of TP (P<0.01) and Gl (P<0.05) and the lowest (P<0.05) AL/GL ratio at 9:00 h and the lowest values were observed at 15:00 h after 6 h exposure time. At 18:00h (after 3h from the end of the exposure), protein parameters did not reach their initial values before the exposure, but still at lower limits (Table 5).

Table (5): Concentration of total protein, albumin (AL) and globulin (GL) and AL/GL ratio in plasma of calves as affected by climatic and dietary treatment, and time of day.

Item	Total protein (g/dl)	Albumin (g/dl)	Globulin (g/dl)	AL/GL Ratio
Climatic treatment :				
SR	6.76^{B}	3.93	2.84^{B}	1.39^{a}
SH	6.99^{A}	3.94	3.05^{A}	1.29^{b}
± SEM	0.03	0.03	0.03	0.03
Dietary treatment :				
Without PF	6.82	3.93	2.89	1.36
With PF	6.93	3.94	2.99	1.32
± SEM	0.03	0.03	0.03	0.03
Experimental phase :				
SR	6.51^{B}	3.86	2.65^{c}	1.55^{A}
SH	7.12^{A}	3.99	3.13^{a}	1.21^{B}
SR+PF	7.01^{A}	3.99	3.02^{a}	1.25^{B}
SH+PF	6.85^{A}	3.88	2.97^{b}	1.38^{B}
± SEM	0.04	0.05	0.04	0.04
Time of day :				
09:00	7.03^{A}	3.87	3.16^{a}	0.99^{c}
12:00	6.85^{BC}	3.92	2.93^{b}	1.34^{b}
15:00	6.74^{C}	3.95	2.79^{d}	1.42^{a}
18:00	6.87^{B}	3.98	2.89^{c}	1.38^{ab}
± SEM	0.03	0.03	0.02	0.02

A, B, C and a, b, c Values within the same column with different superscripts are significantly different at P < 0.01 and P < 0.05, respectively.

Metabolism of fat and glucose

As response of calves to SR treatment, concentration of TL, CL and glucose decreased (P<0.01) by about 4.0, 4.0 and 6.1 % (Table 6). Similar results were reported by Marai *et al.*, (1992) and Abdel-Samee (1997) on decreasing concentration of TL and CL in animals exposed to heat stress. However, highly significant (P<0.01) effect of temperature were observed on plasma concentration of CL and glucose, being lowest in hot temperature season (Shaffer *et al.*, 1981)

On the other hand, calves supplemented with PF showed marked increase (P<0.01) in concentration of TL and CL by 8.6 and 6.2 % and decrease by about 2.3 % in concentration of glucose (Table 6). It is worthy noting that feeding calves on PF during SR resulted in improving concentration of TL (P0.01) and CL (P0.05) to be similar to that in calves during SH +PF and more than those during SH, but the differences were significant only for TL. This may indicate alleviation of the heat-stressed calves by PF supplementation. However, glucose concentration still significantly (P<0.01) higher during SH than the other phases. The trend of change in glucose concentration seemed to be affected by RR (Table 3). Roussel *et al.* (1971) reported that increasing RR causes a rapid utilization of glucose by respiratory muscles and then decreasing its level.

Table (6): Concentration of total lipids, cholesterol and glucose in plasma of calves as affected by climatic and dietary treatment, and time of day.

Item	Total lipids (mg/dl)	Cholesterol (mg/dl)	Glucose (mg/dl)
Climatic treatment :			
SR	577.1^{B}	207.5^{B}	59.62^{B}
SH	601.3^{A}	216.1^{A}	63.45^{A}
± SEM	5.6	2.1	0.39
Dietary treatment :			
Without PF	565.0^{B}	205.4^{B}	62.28^{a}
With PF	613.4^{A}	218.2^{A}	60.83^{b}
± SEM	5.1	2.0	0.40
Experimental phase :			
SR	545.0^{C}	198.3^{b}	59.53^{B}
SH	585.0^{B}	212.4^{a}	65.03^{A}
SR+PF	609.2^{A}	216.6^{a}	59.71^{B}
SH+PF	617.5^{A}	219.7^{a}	61.95^{B}
± SEM	6.3	2.8	0.42
Time of day :			
09:00	578.0^{B}	207.9	61.01
12:00	602.1^{A}	209.7	62.23
15:00	579.6^{B}	213.9	62.20
18:00	597.1^{AB}	215.6	60.78
± SEM	5.3	2.5	0.41

A, B, C and a, b Values within the same column with different superscripts are significantly different at P < 0.01 and P < 0.05, respectively.

The present study indicates that SR treatment during hot summer season in Egypt adversely affected the thermoregulatory, haematological and metabolic responses, which may subsequently affect growth rate of calves. Supplementation of dietary PF succeeded in removing the impaired effects of SR on the haematological and biochemical parameters of blood. Diets with protected fat may use as a technique for ameliorating heat load on Friesian calves exposed directly to solar radiation or the heat-stressed calves kept under sheds to improve their productivity.

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استجابات التنظيم الحراري والاستجابات الهيماتولوجية والتمثيلية لعجول الفريزيان المعرضة لأشعة الشمس

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استخدم في هذه الدراسة 6 عجول فريزيان لدراسة تأثير إضافة عليقه محتوية أو غير محتوية على الدهون المحمية إلى عجول معرضة لأشعة الشمس المباشرة لمدة 6 ساعات من الساعة التاسعة صباحاً حتى الساعة الثالثة ظهراً ، أو تلك الموجودة تحت مظلات نصف مفتوحة خلال نفس الفترة وذلك خلال أربع مراحل تجريبية:

1- شمس بدون عليقه دهن محمى.
2- ظل بدون عليقه دهن محمى.
3- شمس مع عليقه دهن محمى.
4- ظل مع عليقه دهن محمى.

وخلال المراحل التجريبية تم قياس درجات الحرارة الجوية والرطوبة النسبية تحت ظروف معيشة الحيوانات وكذلك قياس حرارة الشعر والجلد والمستقيم والكرش ومعدل التنفس ومعدل النبض ، كما تم أيضاً أخذ بعض القياسات الهيماتولوجية والكيماوية للدم.

وكانت النتائج كما يلي:

1- أظهرت النتائج أن الحيوانات كانت تعانى من الإجهاد الحراري طوال أوقات التعريض سواء تلك المعرضة لأشعة الشمس المباشرة أو تحت المظلات.
2- أدى التعريض لأشعة الشمس المباشرة إلى زيادة معنوية في جميع درجات حرارة الجسم ، بينما درجة حرارة الكرش مالت إلى الزيادة غير المعنوية. وكانت أعلى نسبة من الزيادة في معدل التنفس (14.5%) يليها كل من درجة حرارة الجسم (4,4%) ومعدل النبض (4,4%) ، وأقل زيادة في حرارة الشعر والمستقيم (2,2%) .
3- -انخفاض معنوي في عدد وحجم الخلايا الدموية الحمراء وتركيز كل من الهيموجلوبين والبروتين الكلى والجلوبيولين والدهون الكلية والكولسترول والجلوكوز بمعدل (10.1 ، 10.1 ، 4,4 ، 3,3 ، 6.9 ، 4.0 ، 4.0 ، 6.0% على الترتيب) في العجول المعرضة للشمس مقارنة بالعجول تحت المظلات.
4- أدت تغذية العجول على عليقه الدهون المحمية إلى زيادة معنوية في جميع درجات حرارة الجسم ، معدل التنفس ، النبض ، ولم تتأثر درجة حرارة الكرش ، بينما تحسن عدد وحجم الخلايا الدموية الحمراء وتركيز الهيموجلوبين والدهون الكلية والكولسترول تحسناً معنوياً ، وانخفض تركيز الجلوكوز معنوياً في العجول المغذاة على عليقه دهن محمى مقارنة بتلك المغذاة على عليقه غير محتوية على دهون محمية.
5- أدى إضافة الدهن المحمى إلى عليقه العجول المعرضة لأشعة الشمس إلى زيادة معنوية في درجات حرارة الجسم ومعدل النبض والتنفس ، وتحسن معنوي في الخصائص الهيماتولوجية والبيوكيماوية للدم عن تلك المعرضة لأشعة الشمس بدون عليقه محتوية على دهن محمى.

وتقترح الدراسة إمكانية استخدام الدهون المحمية في علائق العجول لتحسين إنتاجيتها تحت ظروف الإجهاد الحراري وخصوصاً تلك المعرضة لأشعة الشمس المباشرة.