RESULT AND DISCUSSION

4-RESULTS AND DISCUSSION

4-1 Effect of cooling techniques on Water Consumption: (WC)

Overall mean of water consumption (WC) during the experimental periods was 39.06 ±0.412 L/d. / animal (Table 4).

It could be seen from the table that, The WC decreased significantly ($p<0.05$) by the effect of cooling systems. The lowest WC was obtained in calves exposed to showering cooling system in G_3 which consumed 10.4 L/d or 22.8% less of water/day than control shaded calves in G_1 (35.15 vs. 45.56 L/d, respectively). Also, calves exposed to spraying cooling system in G_2, had a lower WC (36.47 L/d) than control shaded calves in G_1, by about 9.09 L/d or 19.9% per animal. It was observed a significant ($p<0.05$) difference in WC between both cooling systems G_2 and G_3.

Analysis of variance (Table 5) showed significant ($p<0.001$) effect on WC due to both treatment of cooling system and month.

The present results showed a significant ($p<0.05$) difference between means of experimental months, whereas, WC mean was increased gradually through experimental months from Jun. (M_1) to Sept. (M_4) (Table 4 and Figure 1). The lowest WC mean was (34.75 L/d) obtained in M_1, and the highest was (42.82 L/d) in M_4, by difference about 8.1 L/d increase per animal. These differences in WC means through Jun. (M_1) to Sept. (M_4) may be due to the climatic effect of months beside the increase of calves in their water requirements as a result of increase of the weights. In addition

Table (4): Means ± stander error of water consumption (WC L/d) during summer moths, as affected by cooling systems.

Treatments / Months	G_1 (Control group)	G_2 (Spraying group)	G_3 (Showering group)	Means#
M_1 (Jun.)	39.94±0.38	32.69±0.27	31.63±0.21	34.75 ± 0.56^{D}
M_2 (Jul.)	44.11±0.65	35.58±0.38	34.48±0.31	38.06 ± 0.68^{C}
M_3 (Aug.)	47.87±0.13	37.78±0.16	36.18±0.12	40.61 ± 0.76^{B}
M_4 (Sept.)	50.33±0.32	39.83±0.20	38.31±0.32	42.82 ± 0.79^{A}
Means	45.56 ± 0.54^{a}	36.47 ± 0.36^{b}	35.15 ± 0.33^{c}	39.06±0.14

Means within each column and row having different letters are significantly different at $p<0.05$.

Table (5): F-ratio of analysis of variance of factors affecting water consumption (WC L/d) in Friesian calves.

Source of variance	d.f	F-ratio#
		Water consumption
Treatment (T)	2	1247.4***
Month (M)	3	350.6***
T×M	6	8.7*
Remainder d.f	180	
Remainder M.s		1.6491

*=P<0.05 and ***=P<0.001.

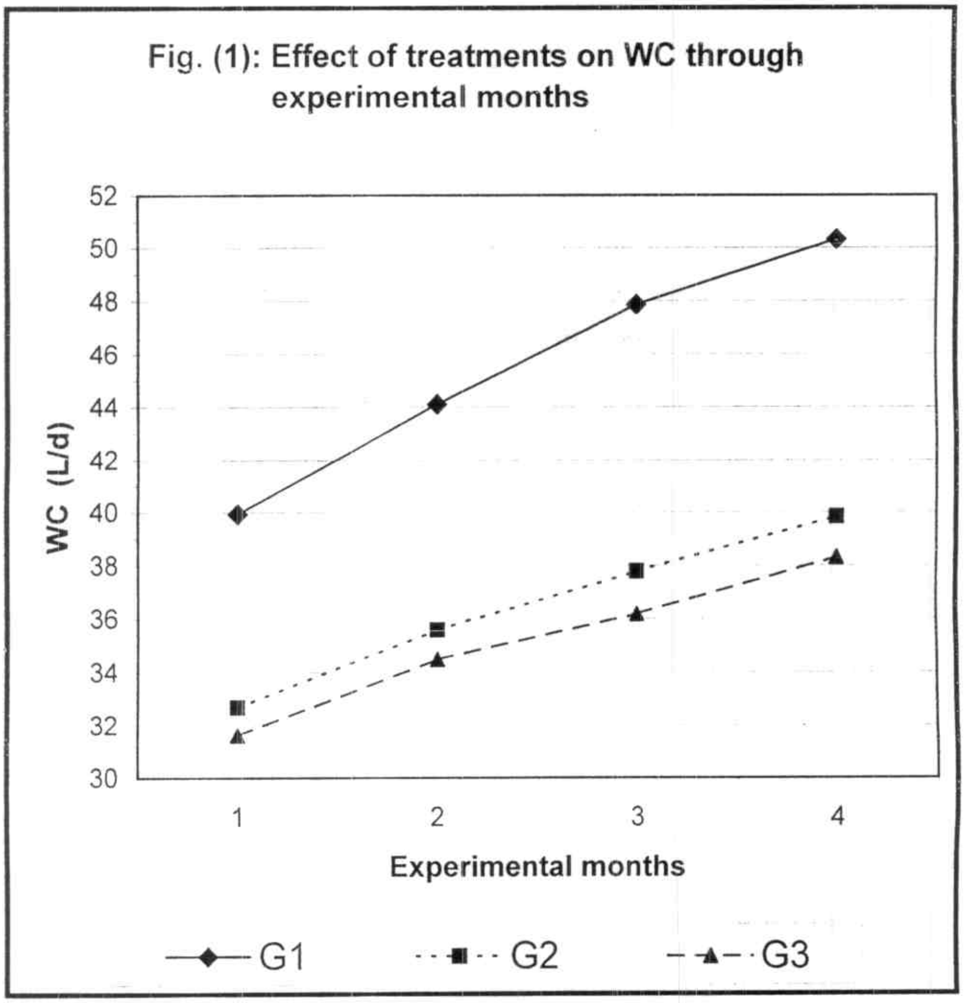


Fig. (1): Effect of treatments on WC through experimental months
WC (L/d)
52
50
48
46
44
42
40
38
36
34
32
30
1
2
3
4
Experimental months
G1
G2
G3

to that, the influence of the change from green fodder to hay in the ration, from end of Jun. (M_1) on WC. Stockdale and king (1983) reported that, the increase in voluntary water intake (VWI) was associated with increased amounts of hay eaten (23.1 to 50.8 L/d) than VWI daily mean of pasture-fed cows (14.6 to 25 L/d).

Also, the WC of the three groups increased gradually through months, but the highest WC was observed in M_4 for G_1, and the lowest WC mean observed in M_1 for G_3, in spite of the narrow of their climatic circumstances.

These results come in complete agreement with those obtained by Flamenbaum *et al.* (1995) who reported that, cooled cows by sprinkling and ventilation consumed 9.1 L or 10% less significance of water per day than uncooled cows (93.6 vs. 102.7 L/d) respectively. Also, Stockdale and King (1983) reported that, rainfall had the greatest single influence on the daily fluctuations in VWI and this was negative ($R=0.38$) significance ($p<0.01$). Increased WC, was cited as major physiological response to high thermal condition by Fuquay (1981); Richards (1985); Beede and collier (1986); McGuire *et al.* (1989); El-Nouty (1996) and Bernabucci *et al.* (1999); these results came in agreement with that obtained in control group, G_1, which exposed to thermal conditions under using shed only.

Otherwise contradictory results, were reported by Trout *et al.* (1998) who found that, WC was decreased significantly under heat stress (38c°) than control (20.8 to25c°) group, it was 46 vs. 73.1 L/d, respectively. Knapp and Grummer (1991) reported that, no differences in WC were observed in Holstein cows for both, heat stressed (31.8c°, 56%RH) or thermo neutral (20.5c°, 38%RH) groups.

4-2 Effect of cooling techniques on Dry Matter Intake: (DMI)

The overall mean of dry matter intake (DMI) for the experimental groups through summer months is presented in table (6).

The present results showed that, cooling systems had no significant effect on DMI comparing with shaded group. It should be mentioned that, each of spraying (G_2) and showering (G_3) groups consumed its ration earlier than control-shaded group (G_1) but at the end of experimental day, all of the three groups were consumed their ration similarly with a little of residuals. So that, in this study we can say that, the sheds and the sheds in addition to spraying or showering had the same effect on DMI.

However, Habeeb *et al.* (1995) found 8% decline in DMI ($p<0.05$) for Friesian calves exposed to high thermal conditions (stressed group) than calves exposed to low thermal conditions (winter group) whereas, using sprinkling cooling system under high thermal summer conditions (cooling group) increased significantly ($p<0.05$) DMI by about 5.9% than stressed group.

Also, results obtained in table (7) showed that, the experimental months had a significant ($p<0.001$) effect on DMI

Table (6): Means ± stander error of Dry matter intake (DMI kg/d/group) during summer months, as affected by cooling systems.

Treatments / Months	$G_{1(5)*}$ (Control group)	$G_{2(5)}$ (Spraying group)	$G_{3(5)}$ (Showering group)	Means#
M_1 (Jun.)	30.23±0.42	30.62±0.46	30.62±0.46	30.49±0.26^{D}
M_2 (Jul.)	37.10±0.43	37.37±0.40	37.50±0.42	37.32±0.24^{C}
M_3 (Aug.)	39.01±0.21	39.18±0.21	39.38±0.03	39.19±0.10^{B}
M_4 (Sept.)	40.33±0.52	40.38±0.53	40.38±0.52	40.36±0.29^{A}
Means	36.67±0.41^{a}	36.89±0.40^{a}	36.97±0.40^{a}	36.84±0.23

Means within each column and row having different letters are significantly different at $p<0.05$.

* Figures in parenthesis indicate the number of animals.

Table (7): F-ratio of analysis of variance of factors affecting dry matter intake (DMI kg/d/group) in Friesian calves.

Source of variance	d.f	F-ratio#
		Dry matter intake
Treatment (T)	2	0.583 Ns
Month (M)	3	347.7***
T×M	6	0.060 Ns
Remainder d.f	348	
Remainder M.s		5.051

Ns=not significant and ***=p<0.001.

Whereas, DMI mean was increased significantly ($p<0.05$) from Jun. (M_1) to sept. (M_4) (Table 6 and Figure 2).

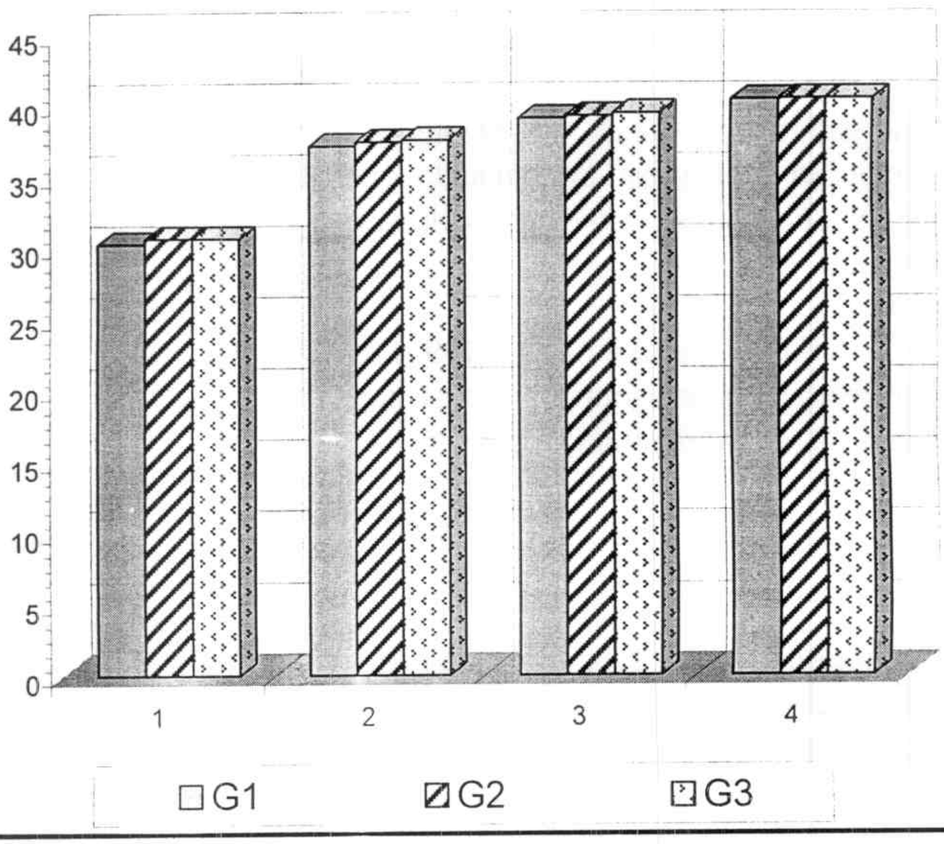
Analysis of variance (Table 7) showed a non-significant effect on DMI due to the interaction between the treatment and experimental months i.e., the increase of DMI through trial months for all groups may be due to the increase of feeding requirement.

The previous results are agree with that obtained by Chen *et al.* (1993) who reported that, evaporative cooling had no-significant effect on DMI for cows kept under shed, exposed to cooling system and received H-Lys diet, and cows kept under shed only and received H-Lys (25.5 vs. 23.9 kg/d) respectively.

Also, Bendary *et al.* (1995) reported that, no significant differences were found among shaded and cooled (sprinkling and forced ventilation) group in DMI (for both 100% and 80% requirement groups) whereas, they found, 18.61% more FCM, for cooled group (100% requirement) than uncooled group (100% requirement). Morrison (1983) mentioned that, livestock performance was affected by high thermal conditions, so that, the animals will decrease its heat production by lowering production or growth or probably less production per unit of feed.

The previous reports may be explain that result of this study, although the three groups were consumed DMI as the same, but were given different daily weight gains.

Fig. (2): Effect of treatments on DMI/kg/group through experimental months



4-3 Effect of cooling techniques on Daily weight gain: (DWG)

Overall mean of daily weight gain (DWG) actual means for both treatment groups and experimental summer months are presented in Table (8). Overall mean of the DWG for all experimental calves from Jun. to Sept., was 1.34kg/d. The results in Table (8 and Fig.3) showed that, the cooling systems had a significant effect ($p<0.05$) on DWG, whereas, the highest DWG mean was obtained in G_2, which exposed to spraying cooling system (1.46 kg/d) compared with G_1, control shaded group, (1.23 kg/d) by about 18.3%. Group$_3$ calves, which exposed to showering cooling system, had a higher DWG (1.34 kg/d) than G_1, by about 9.2%. Also, there was a significant ($p<0.05$) difference between G_2 and G_3, whereas, G_2 had a higher DWG, by about 8.3% than that obtained in G_3.

The present results also showed that, the differences between means of experimental months were significant ($p<0.05$) whereas, DWG means of Jun. (M_1) and Sept. (M_4) were higher significantly than Jul. (M_2) and Aug. (M_3) but there were no-significant differences between each of M_1 and M_4, and between M_2 and M_3. The highest DWG was observed through M_4 (1.43 kg/d) and the lowest DWG's were observed through both M_2 (1.28 kg/d) and M_3 (1.26 kg/d) by difference about -10.48% and -11.74%, respectively than M_4.

Analysis of variance (Table 9) showed that, the interaction effect of treatment × month was significant at ($p<0.05$) whereas, the highest DWG mean was observed for G_2 through M_4 (Table 8) this means that, the ambient temperature, relative humidity and air velocity in September

Table (8): Means ± stander error of daily weight gain (DWG kg/d) during summer months, as affected by cooling systems.

Treatments / Months	$G_{1(5)*}$ (Control group)	$G_{2(5)}$ (Spraying group)	$G_{3(5)}$ (Showering group)	Means#
M_1 (Jun.)	1.28±0.013	1.52±0.016	1.41±0.018	$1.40{\pm}0.031^{A}$
M_2 (Jul.)	1.20±0.025	1.36±0.017	1.29±0.007	$1.28{\pm}0.023^{B}$
M_3 (Aug.)	1.18±0.013	1.34±0.009	1.27±0.011	$1.26{\pm}0.021^{B}$
M_4 (Sept.)	1.28±0.021	1.61±0.016	1.41±0.017	$1.43{\pm}0.042^{A}$
Means	$1.23{\pm}0.014^{c}$	$1.46{\pm}0.029^{a}$	$1.34{\pm}0.018^{b}$	1.34±0.018

Means within each column or row having different letters are significantly different at $p<0.05$.

* Figure in parenthesis indicate the number of animals.

Fig. (3): Effect of treatment on DWG through experimental months.

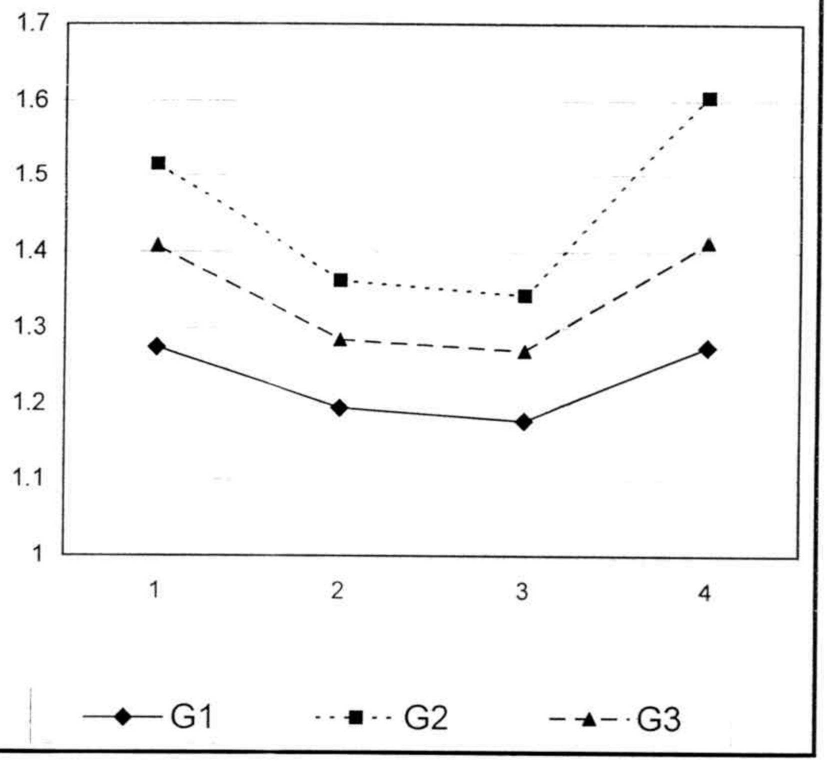


Table (9): F-ratio of analysis of variance of factors affecting daily weight gain (DWG kg/d) in Friesian calves.

Source of variance	d.f	F-ratio #
		Daily weight gain
Treatment (T)	2	204.908***
Month (M)	3	84.849**
T×M	6	6.560*
Remainder d.f	36	
Remainder M.s		0.001

*=p<0.05 **=p<0.01 and ***=p<0.001.

(31.6 ±1.7°c, 54.6±4.1%, or THI 81.17, and 4.66±0.6 m/s, respectively) in addition to using spraying cooling system were moderate conditions for increasing DWG of G_2 calves, i.e., which may be had a good environmental conditions to give a low heat stress physiological responses and a high efficiency of feed utilization.

These results agreed Baccari *et al.* (1983) Hahn (1985) and Marai *et al.* (1995). Similarly, Fawzy *et al.* (1998) reported that, sprinkling of the heat stressed Friesian calves with water improved significantly ($p<0.01$) DWG by +35.8% than heat stressed group (531.1±8.4 vs.391.1±3.5 gm/d). Also, Wiersma *et al.* (1973) found a significant effect on DWG, when using cooling systems (evaporative cooled air, sprinkling shad roof and ground surfaces, and high pressure fogging with conventional shades) compared with using shads. But comparing these cooling systems with each other showed no significant improvement in gain of beef cattle.

Also, direct application of water to beef cattle under sheds has been studied by Morrison *et al.* (1973, 1974 and 1981); they found that, sprinkling at 30 min. intervals, when temperature was above 27°c, resulted in about 0.24 kg/d higher gain for British breeds weighing about 300 to 350 kg, whereas, the performance of the heavier weight of British or British×Brahman cattle was not improved.

On the other hand, results in Table (8) showed that, the lowest DWG was observed for G_1 through M_3, whereas, temperature and relative humidity become little bit higher beside lower air velocity under the shed in Aug. (36±1.6°c, 69±3.2% RH and 3.5±0.25m/s, respectively). The depression in growth rate of G_1 under that high temperate condition of M_3

may be led to unable dissipation of core temperature through animal surface by vaporization, and panting occurrence, which is losed the animal more energy, may be needs for growth, that environmental circumstances may be too decreases concentrations of hormones responsible for anabolism.

That opinion in agrees with obtained by each of Habeeb *et al.* (1995) which contested that depression in growth rate of Friesian calves under high temperated conditions, and attributed that to exposing animals to severe heat, suppresses the production of hormone releasing factors from the hypothalamic center, causing a decrease in pituitary hormonal secretion and consequently lowers the excretion of the thyroid hormones. The shortage of energy, substrates and hormones may be responsible for the depression in gain. Also, the increase in glucocorticoids hormones (Alvarez and Johnson, 1973) or the decrease in insulin (Habeeb, 1987) and/or decrease in plasma glucose (Soni *et al.* 1982) could lead to a disturbance in protein and energy metabolism, which reflect on growth and production.

In addition to that, under thermal conditions, maintenance energy for cattle was shown to be considerable higher (McDowell *et al.* 1969). Morrison (1983) mentioned that, performance is affected by heat stress and humidity because animals having difficulty in losing heat will decrease its heat production by lowering its production.

The previous opinions may be clear why the DWG of the three groups, in this study, decreased through Jul. (M_2) and Aug. (M_3) while it increased at Jun. (M_1) and Sept. (M_4) with superiority for spraying group (G_2) then showering group (G_3) than control group G_1.

4-4 Effect of cooling techniques on Feed utilization (FU):

Feed conversion (FC) and feed efficiency (FE):

The overall mean of feed conversion (FC) and feed efficiency (FE) during the experimental months were 6.94±0.15 kg DMI and 0.148±0.004 kg gain, respectively.

Table (10 and 11) showed that, the spraying cooling system improved significantly ($p<0.05$) FC and FE, whereas, FC and FE rates of G_2 improved by about –14.7% and +17.3%, respectively, compared with G_1. However, there were not significant differences between G_2 and G_3, neither FC nor FE, but as values, G_3 increased by about +8.45% for FC and decreased by about –7.84% for FE, than G_2.

Feed utilization (FU) improvement of G_2, omparing with control group (G_1) may be due to the effect of using water spray to cool the animal's body (Fig.4 a and b) which may be reduced the heat load and improved feed utilization (Habeeb *et al.*1995). Also, the reduction of feed conversion efficiency of G_1 during summer, under that condition is probably due to energy expended in ridding the body of excess heat load by way of increasing RR and others related activities. More dietary energy would have been utilized for the maintenance of homoeothermic, thus reducing feed conversion efficiency to greater extent (Shrikant and Praveen Kumar, 2001).

Data in Table (10 and 11) showed that, the month's averages of FC increased gradually during the first three months reached its maximum at M_3 (5.48±0.112, 7.34±0.126 and 7.8±0.128 kg DMI for M_1, M_2 and M_3, respectively) then decreased then after at last month, M_4 (7.14±0.21 kg DMI). The

Table (10): Means ± stander error of feed conversion (DMI/DWG) during summer months, as affected by cooling systems.

Treatments / Months	G_1 (Control group)	G_2 (Spraying group)	G_3 (Showering group)	Means#
M_1 (Jun.)	5.93±0.062	5.06±0.050	5.44±0.067	$5.48±0.112^C$
M_2 (Jul.)	7.80±0.162	6.88±0.083	7.33±0.037	$7.34±0.126^B$
M_3 (Aug.)	8.31±0.094	7.32±0.047	7.77±0.067	$7.80±0.128^A$
M_4 (Sept.)	7.94±0.131	6.31±0.060	7.17±0.084	$7.14±0.207^B$
Means	$7.49±0.244^a$	$6.39±0.221^b$	$6.93±0.230^{ba}$	6.94±0.147

Means within each column or row having different letters are significantly different at $p<0.05$.

Table (11): Means ± stander error of feed efficiency (DWG/DMI) during summer months, as affected by cooling systems.

Treatments / Months	G_1 (Control group) group)	G_2 (Spraying group)	G_3 (Showering	Means#
M_1 (Jun.)	0.169±0.002	0.198±0.002	0.184±0.002	$0.183±0.004^A$
M_2 (Jul.)	0.128±0.003	0.145±0.002	0.137±0.001	$0.137±.002^{BC}$
M_3 (Aug.)	0.121±0.001	0.136±0.001	0.129±0.001	$0.129±0.002^C$
M_4 (Sept.)	0.127±0.002	0.159±0.002	0.139±0.002	$0.141±0.004^B$
Means	$0.136±.005^b$	$0.160±.006^a$	$0.147±.006^{ba}$	0.148±0.004

Means within each column or row having different letters are significantly different at $p<0.05$.

Fig. (4-a): Effect of treatments on feed conversion during experimental months.

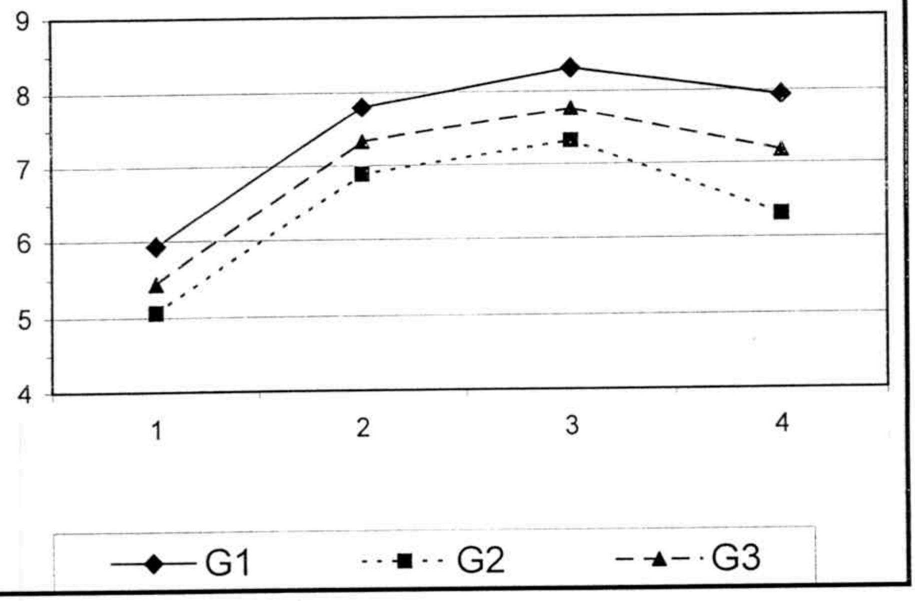
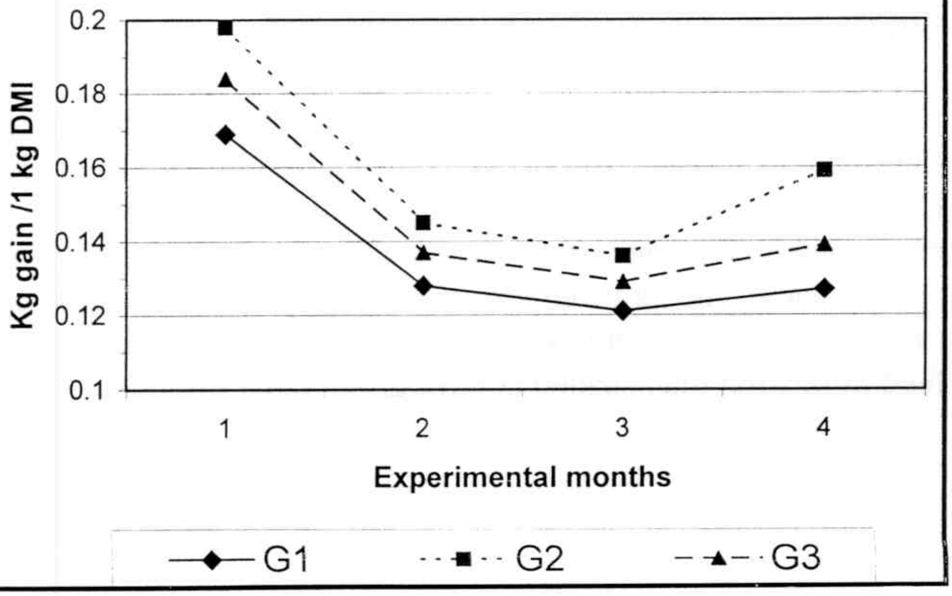


Fig. (4-b): Effect of treatments on feed efficiency during experimental months.



opposite trend was observed for FE, which decreased until M_3 (0.129±0.002 kg gain) then began increased in M_4, reached to 0.141±0.004 kg gains. That is may be due to the effect of month; whereas climatic circumstances in M_2 and M_3 were not fit to improve FU. While in M_4 heat temperature, humidity and air velocity were suitable for FU improvement. Baccari *et al.* (1983) reported, higher feed intake per unit of gain in Friesian calves during thermal conditions, indicating less weight gain per unit of daily feed. Also, Shrikant and Praveen Kumar (2001) decided that, in crossbred Holstein male calves, spring climate in India (in March) did not negatively affected on feed intake and the efficiency of feed utilization. However, feed intake and efficiency of feed utilization, consequently, growth rate were reduced during April-may summer months. Then added, the degree of reduction in intake and feed utilization for growth can be suppressed to some extent by providing mean like optimum covered area.

From table (12) which showed significant interaction (treatment*months) for FC and FE. It was observed from tables (10 and 11) and Figures (4 a and b) that; the highest FC value was obtained for G_1 through M_3 (8.31±0.094 kg DMI) which had the lowest FE (0.121±0.0013 kg gain).

Also, the lowest FC value was obtained for G_2 during M_1 (5.06±0.05 kg DMI) which gained the highest FE value per 1kg DMI (0.198±0.002 kg gain). That is revealed that, the climatic environmental in M_1 (then M_4) beside using spraying cooling system were moderate conditions to improve FU of G_2 calves, i.e. they had good environmental conditions to give the pest feed utilization than shaded control group circumstances.

Table (12): F-ratio of analysis of variance of factors affecting Feed conversion (FC) and feed efficiency, in Friesian calves.

Source of variance	d.f	F-ratio#	
		FC	FE
Treatment (T)	2	164.95**	183.97**
Month (M)	3	415.64***	601.78***
T×M	6	4.306*	6.225*
Remainder d.f	36		
Remainder M.s		0.0296	1.2E-05

*=p<0.05 **=p<0.01 and ***=p<0.001.

From another point, under the highest months thermal conditions (August or M_3) sprayed and showered groups (G_2 and G_3) FC decreased by about –11.9 and –6.5%, respectively than shaded group (G_1). Consequently, FE trends were opposite, whereas, FE of G_2 and G_3 increased by about 12.4 and 6.6%, respectively compared with G_1. The previous observations may be reflecting the effect of the interaction of treatment-months on FU.

These results were in agreed with obtained by, Daader *et al.* (1989) Bendary *et al.* (1995) and Shorem and Adama (2001). Daader *et al.* (1989) reported that, the change of FC and FE due to heat stress, between the summer and winter, were +12.46 and –11.33% for roughage, and +46.8 and –31.65% for concentrate, respectively. And the change due to using drinking cool water and diuretics under summer season conditions for FC and FE of roughage and concentrate were –9.5, +10.15, –19.83 and +23.15%, respectively.

Habeeb *et al.* (1995) reported that, FE (kg LBW/ kg DMI) increased significantly in summer from 0.084 to 0.106 kg due to using sprinkling cooling system, compared with control group. Shrikant and Praveen Kumar (2001) decided that, in Karan-Fries calves, FC (Avg. DMI/ kg gain) were 3.13 and 3.26 in spring (moderate condition) for group A (housed in open and covered area) and B (housed in open area with four feet side walls without sheds) respectively, and there was on significant difference between them during spring. The FC efficiency was decreased during the summer (thermal conditions) and reached to 5.00 and 5.72 for group A and B, respectively.

4-5 Effect of cooling techniques on Thermoregulation responses:

4-5-1 Rectal temperature (RT):

Overall mean of rectal temperature (RT) during the experimental periods was 38.95±0.01°c (Table 13) Which presents the RT's means for experimental groups (G_1, G_2 and G_3) through times of day (at 7am, 2pm and 7pm) and also for summer months (M_1, M_2, M_3 and M_4). It could be seen from the table that, RT decreased significantly ($p<0.05$) by effect of using cooling systems. The present results showed that, the lowest RT's were observed in G_2 and G_3, compared with control group G_1 (38.94±0.01c°and 38.94±0.01c° vs. 39.0±0.01c°, respectively).

This result come in complete agreement with those obtained by (Igono *et al.* 1987; Bendary *et al.* 1995 and Flamenboum *et al.* 1995) Also, Fawzy *et al.* (1998) reported that, exposing Friesian calves to solar radiation resulted in significant ($p<0.01$) increase in RT compared with shaded group by about +4.93%, whereas, treatment the heat stressed calves with water spray decreased RT significantly ($p<0.01$) compared with shaded group by about –1.38%.

Also, the significant months effect was shown (Table 13 and 14) whereas, the highest RT's were obtained through M_2 and M_3 but, the lowest one observed in M_4 (38.97±0.01c°and 38.97±0.01°c vs. 38.94±0.01c°, respectively).

Analysis of variance (Table 14) showed significant ($p<0.05$) effects due to treatment of cooling systems, experimental months and the interaction of treatment*months.

Table (13): Means ± stander error of rectal temperature (RT) c° in different day times during summer months, as affected by cooling systems.

Treatments	(Control group) G_1			(Spraying group) G_2			(Showering group) G_3			Means#
Day time / Months	7 am.	2 pm.	7 pm.	7 am.	2 pm.	7 pm.	7 am.	2 pm.	7 pm.	
M_1 (Jun.)	38.76±.01	39.12±.01	39.03±.01	38.?3±.01	38.73±.01	39.11±.01	38.92±.0'	38.72±.01	39.11±.01	$38.94±.01^B$
M_2 (Jul.)	38.73±.01	39.19±.02	39.11±.02	38.92±.01	38.75±.01	39.17±.01	38.92±.01	38.74±.01	39.16±.01	$38.97±.01^A$
M_3 (Aug.)	38.75±.01	39.17±.01	39.06±.01	38.93±.01	38.76± .01	39.17±.01	38.93±.01	38.76±.01	39.16±.01	$38.97±.01^A$
M_4 (Sept.)	38.73±.01	39.12±.01	39.01±.01	38.93±.01	38.72±.01	39.17±.01	38.93±.01	38.72±.01	39.18±.01	$38.94±.01^B$
Means	$38.74±.01^d$	$39.15±.01^a$	$39.05±.01^b$	$38.93±.004^c$	$38.74±.004^d$	$39.15±.004^a$	$38.93±.01^c$	$38.73±.004^d$	$39.15±.01^a$	
General means	$39.00±.01^a$			$38.94±.01^b$			$38.94±.01^b$			Ov.M. 38.95±. 01

Means within each column or row having different letters are significantly different at $p<0.05$.

Table (14): F-ratio of analysis of variance of factors affecting rectal temperature (RT°c) in Friesian calves.

Source of variance	d.f	F-ratio#
		Rectal temperature
Treatment (T)	8	1511.23**
Month (M)	3	23.79**
T×M	24	5.84**
Remainder d.f	1800	
Remainder M.s		0.0044

**=p<0.01.

In addition to that, the time of day had a significant effect on RT trends of each group (Figures 5 a, b, c and d). Generally, G_1 at 7am., had got the lowest RT (38.74±0.01°c) then the RT of that shaded group increased gradually by day time, reached its maximum value at 2pm. (39.15±0.01°c) then started to be a little bet significantly ($p<0.05$) lower at 7pm. (39.05±0.01°c). The RT of the cooled groups, G_2 and G_3, had the opposite trend, whereas, at 7am, their RT's were the highest RT (38.93±0.004 c° and 38.93±0.01c°, respectively). Then after, they decreased and reached its minimum at 2pm. (38.74±0.004 and 38.73±0.004°c, respectively) then their RT's increased sharply after cessation of the cooling systems, and reached its maximum values at 7pm. (39.15±0.004 and 39.15±0.01°c, respectively). Whereas, Fawzy *et al.* (1998) found that, solar radiation, solar radiation with spray, and shaded group had the highest RT at 14.00h without a significant difference.

From Table (13) it could be seen that, at 7 am, in all groups, through all experimental months, the RT means decreased without significant difference between them. At 2 pm. the RT means of G_1 through M_2 and M_3 were significantly higher than those through M_1 and M_4, at the same time, G_2 and G_3 had the highest RT means during M_3. At night (7 pm.) all experimental calves of the three groups, had RT's above 39°c, but it was been higher significantly ($p<0.05$) in M_2 and M_3 than others.

Generally, these results are in agreement with those reported by Igono *et al.* (1987) who found that, the RT's of shaded cows were higher than in those shaded and sprinkling at afternoon. Bendary *et al.* (1995) reported that, the diurnal

Fig. (5): Effect of cooling treatments, treatment months and day time on RT (°C).

Fig. (5-a): RT of the three groups in the morning during experimental months.

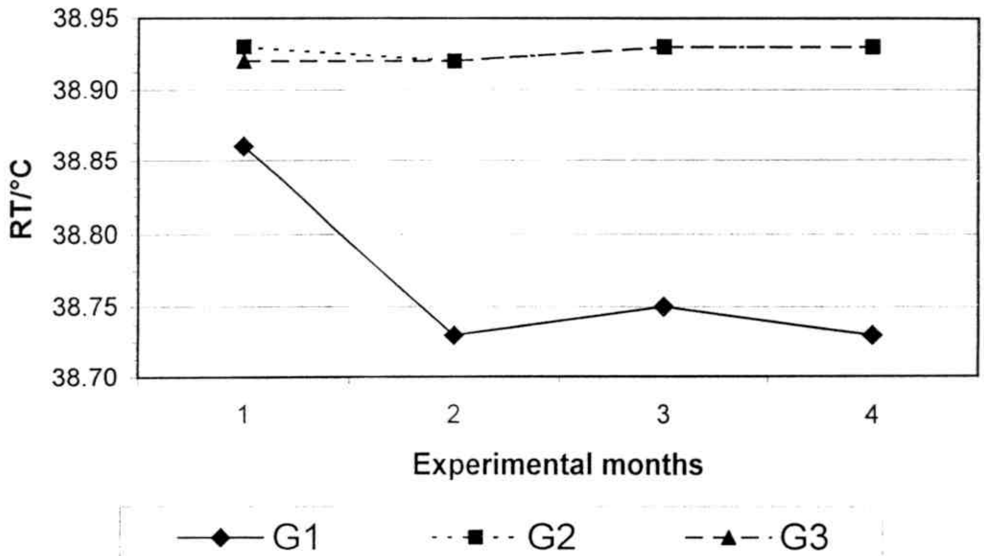


Fig. (5-b): RT of the three groups in the afternoon during experimental months.

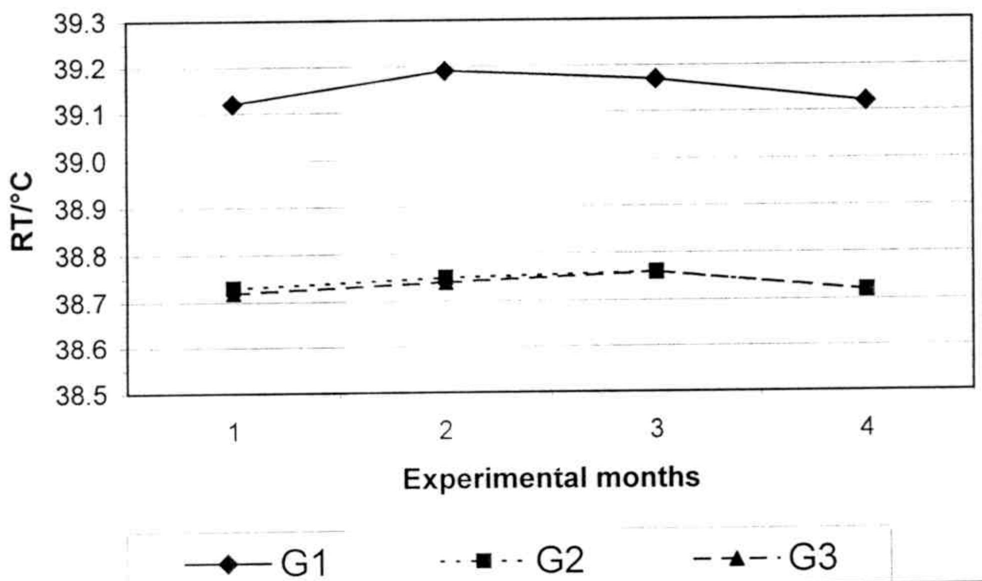


Fig. (5-c): RT of the three groups in the evening during experimental months.

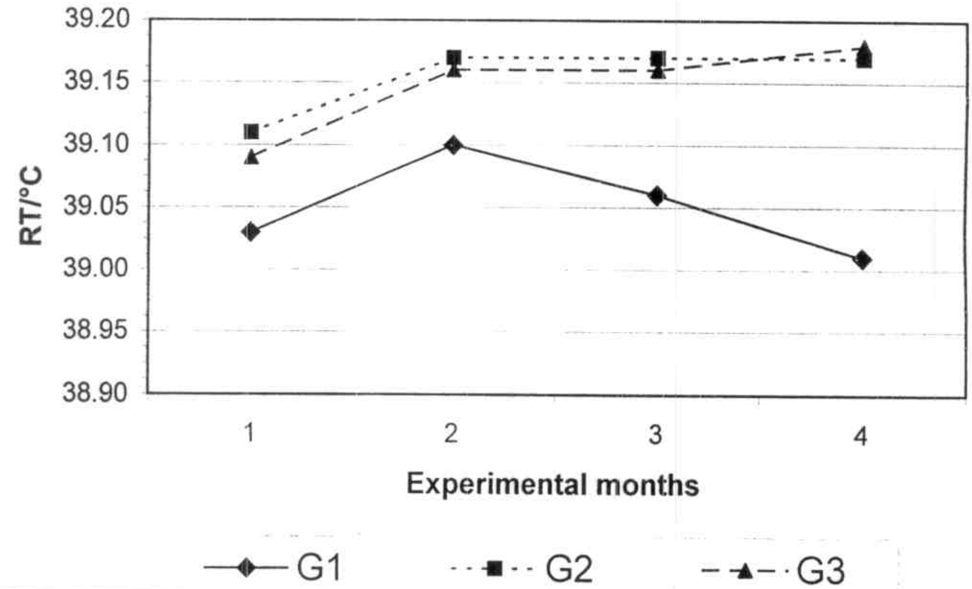
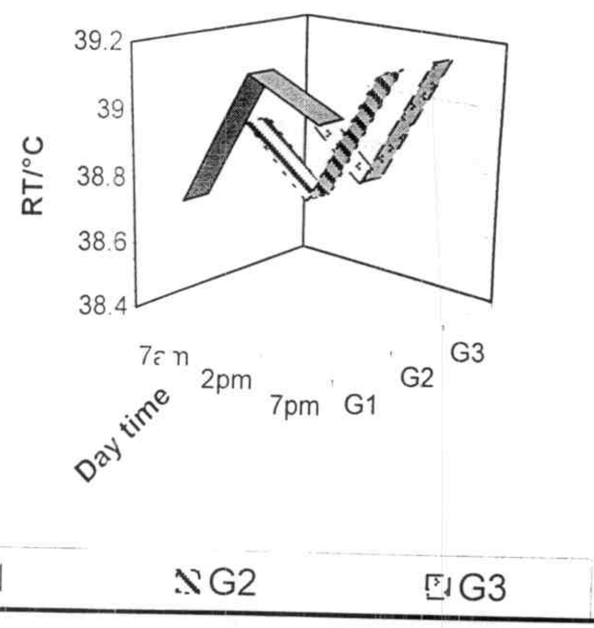


Fig. (5-d): Trend of RT of the three groups through different day time.



pattern of RT for cooled cows was significantly lower ($p<0.01$) than RT's of those kept under shed only, which was above 39°c all over the day except at 9.0 am. . Also, shaded group reached its maximum RT in the afternoon (4pm.) and reached its minimum RT in the morning (9 am.); Whereas, cooled groups decreased its RT at afternoon (4pm.) during the using of cooling system, then reached its maximum RT after cessation of cooling system at night (6pm.) and recorded its minimum RT in the morning. Flamenbaum *et al.* (1995) reported that, cooling provide effective in maintaining body temperature below 38.9°c during the entire experimental period (150d) only as long as the cooling system was active, RT of cooled cows peaked 38.9°c at 1900h, soon after cessation of cooling. But uncooled group was higher ($p<0.01$) than cooled group, and peaked 39.7°c in the evening.

4-5-2 Respiration rate (RR):

The overall mean of respiration rate (RR) during the experimental periods for all the experimental calves was 50.9± 0.18 r.pm. (Table 15).

It could be seen from the table that, the RR decrease significantly ($p<0.05$) by the effect of the cooling systems; The present results showed that, the RR's of G_2 and G_3 were decreased significantly by, about 5.2 and 5.4 % less than G_1 (50.02±0.34 and 49.94±0.34 vs. 52.78±0.19 r.pm, respectively). The decrease in the RR may be due to the reduction in heat load of the treated calves after spraying (or showering) with cold water (Igono *et al.* 1985 and Marai *et al.* 1995).

Table (15): Means ± stander error of respiration rate (RR/rpm) in different day times during summer months, as affected by cooling systems.

Treatments	(Control group) G_1			(Spraying group) G_2			(Showering group) G_3			Means#
Day time / Months	7 am.	2 pm.	7 am.	7 am.	2 pm.	7 pm.	7 am.	2 pm.	7 pm.	
M_1 (Jun.)	47.19±.16	57.12±.14	55.12±.23	47.65±.14	41.10±.11	61.25±.18	47.71±.15	41.10±.13	91.33±.17	51.06±.35[B]
M_2 (Jul.)	47.29±.16	57.87±.26	55.27±.26	47.54±.15	41.44±.15	61.81±.17	47.64±.16	41.15±.22	61.77±.18	51.31±.36[A]
M_3 (Aug.)	46.85±.13	58.02±.27	5.04±.24	47.67±.12	41.64±.14	61.94±.13	47.67±.12	41.17±.11	61.71±.11	51.30±.36[A]
M_4 (Sept.)	45.15±.15	55.58±.17	52.01±.87	46.69±.10	40.69±.11	60.77±.12	47.06±.09	40.40±.11	60.60±.11	49.98±.34[C]
Means	46.62±.10[f]	57.14±.13[b]	54.57±.14[c]	47.39±.07[e]	41.22±.07[g]	61.44±.08[a]	47.52±.07[d]	40.96±.08[h]	61.35±.08[a]	Ov.M. 50.90±.18
General means	52.78±.19[a]			50.02±.34[b]			49.94±.34[b]			

Means within each column or row having different letters are significantly different at $p<0.05$.

Similar results were reported by, Habeeb *et al.* (1995) which found, 41 r.pm less significant ($p<0.01$) due to cooling Friesian calves with sprinkling and drinking cool water, than heat stressed calves (60±2 vs.101±1.5 r.pm, respectively). Fawzy *et al.* (1998) reported that, exposing Friesian calves to solar radiation resulted in a significant ($p<0.01$) increase in RR compared with the shaded group by about 37.69%, whereas, treated heat-stressed calves with water spray decreased RR ($p<0.01$) significantly by about –6.47% compared with shaded group.

Analysis of variance (Table 16) showed that, the month has been a significant ($p<0.05$) effect on RR. Whereas, the RR means of M_2 and M_3 were significantly higher than M_1 and M_4 (51.31±0.36 and 51.30±0.36 vs. 51.06±0.35 and 49.98±0.34, respectively). Also, M_4 RR mean recorded the lowest one ($p<0.05$) compared with the others months.

Also, the daytime had a significant effect on RR trends of both groups, which kept under shed (G_1) or under cooling systems (G_2 and G_3) (Figures 6 a, b, c and d). Whereas, G_1's RR trend recorded its lowest value at 7 am., then reached its maximum at 2pm., then after, decreased gradually until became lower at 7 pm. (46.62±0.1, 57.14±0.13 and 54.57±0.014 r.pm, respectively). Under environmental of cooling system (G_2 and G_3) RR reached its lowest value at 2pm., under using the cooling system, then increased gradually after the stopped of cooling system, until recorded its maximum at 7pm., then after, started to decrease until became lower at 7am.

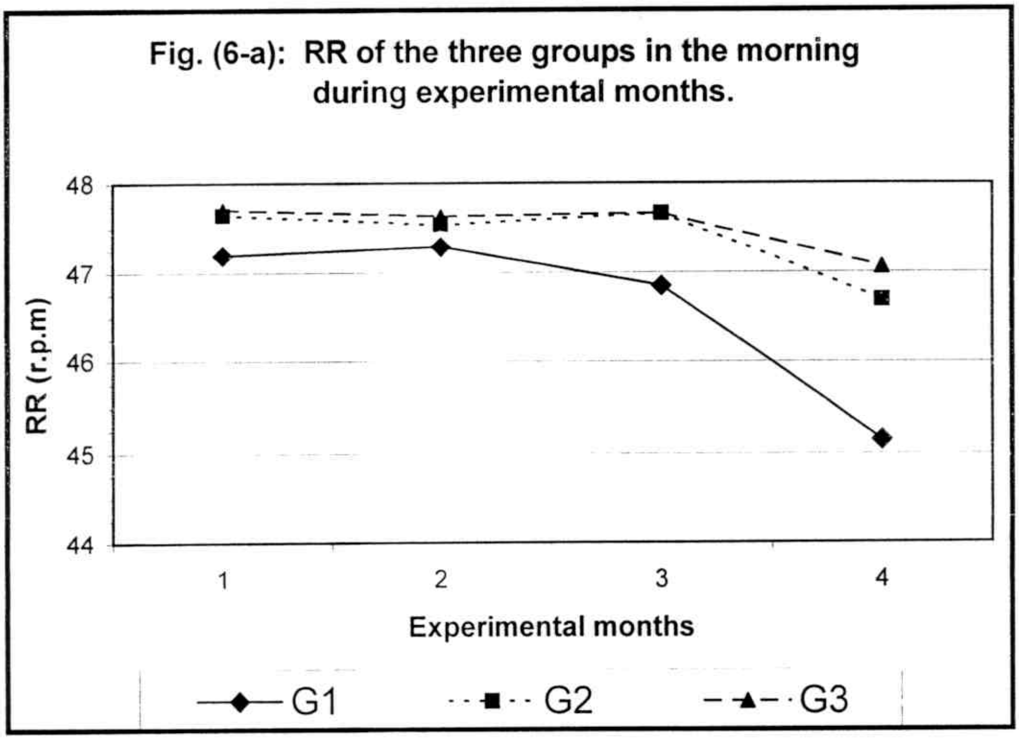
Generally, at 7am. RR mean of the G_3 was the highest ($p<0.05$) significantly (47.52±0.07 r.pm) then, RR mean of the G_2 (47.39±0.07 r.pm) was higher significantly ($p<0.05$) than G_1

Table (16): F-ratio of analysis of variance of factors affecting respiration rate (RR r.pm) in Friesian calves.

Source of variance	d.f	F-ratio#
		Respiration rate
Treatment (T)	3	9410.75**
Month (M)	8	133.697***
T×M	24	5.306***
Remainder d.f	1836	
Remainder M.s		1.402

***= p<0.001.

Fig. (6): Effect of cooling treatments, treatment months and day time on RR (r.p.m).



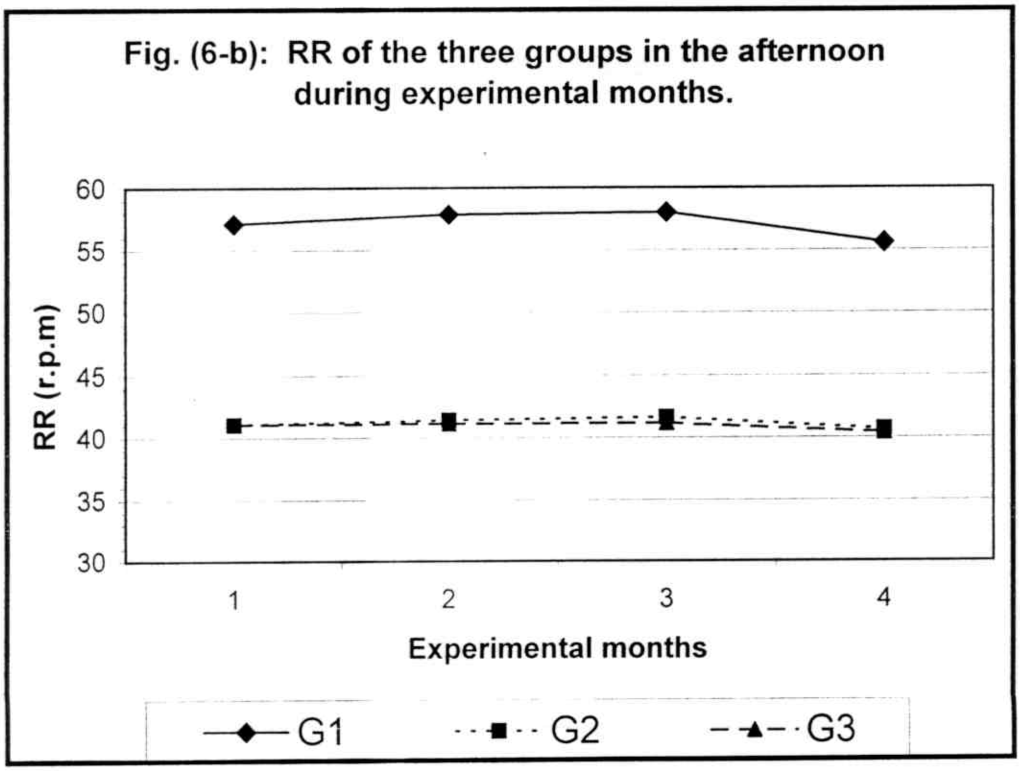


Fig. (6-c): RR of the three groups in the evening during experimental months.

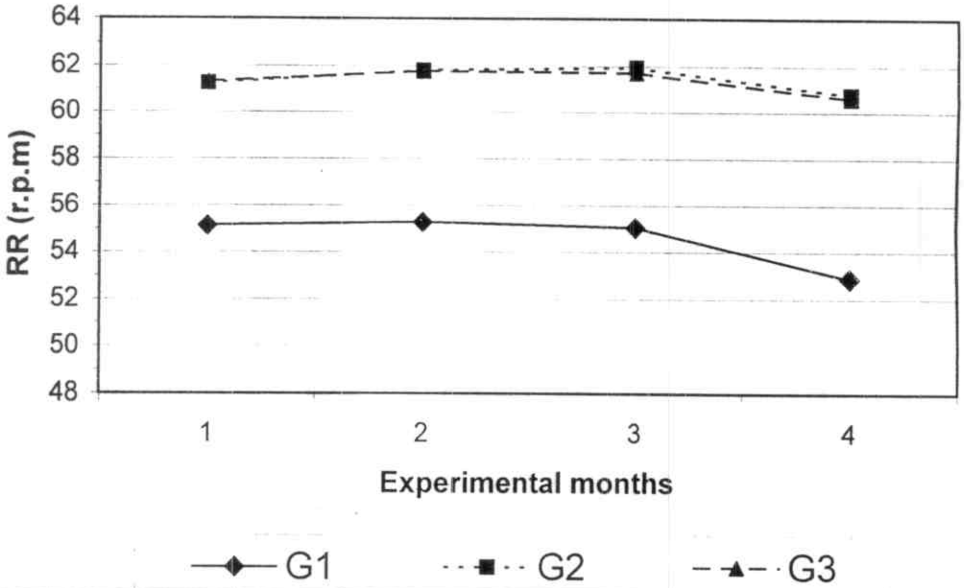
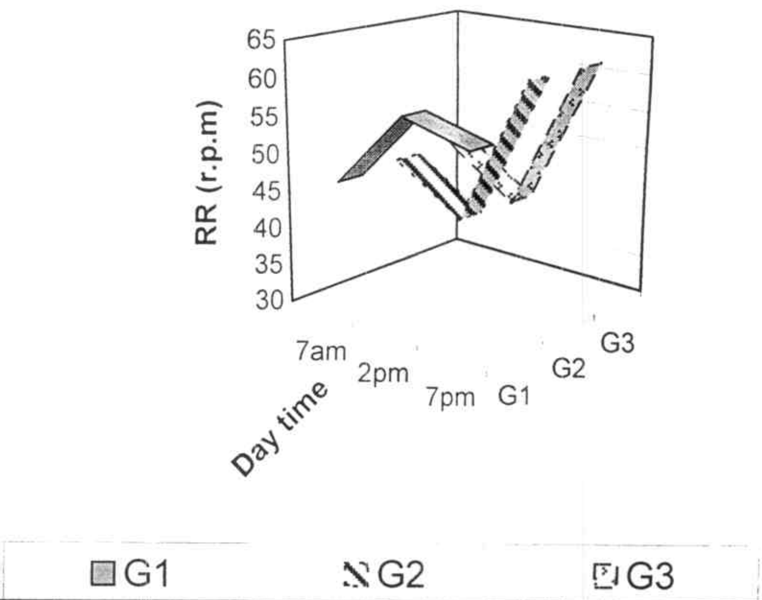


Fig. (6-d): Trend of RR of the three groups through different day time.



(46.62±0.1 r.pm) which recorded the lowest value at that time. At 2 pm., the highest RR mean was recorded by G_1 (57.14±0.13 r.pm) and then G_2, which was significantly ($p<0.05$) higher than G_3, which recorded the lowest one (41.22±0.07 vs. 40.96±0.08 r.pm). At 7pm., G_2 and G_3 RR means were significantly higher than G_1 mean (61.44±0.08 and 61.35±0.08 ver. 54.57±0.14 r.pm).

Looking at table (15) could be observed that, RR means through M_4 (for all groups, at any time of day) were lower than the others months. And the highest significant observations were recorded for G_2 and G_3 (60.77±0.12 and 60.60±0.11 r.pm, respectively) at 7 pm through M_4, themselves, were lower significantly than the others recorded for G_2 and G_3 at 7pm. through M_1, M_2 or M_3.

Also, the lowest observations were recorded for, G_2 and G_3 at 2pm. through M_4 (40.7±0.11 and 40.4±0.11 r.pm, respectively) themselves, were lower significantly than others recorded for the same groups at the same daytime but through M_1, M_2 and M_3. That observations may be indicate that, climatic environmental of Sept. (M_4) generally improved the respiration rates than those experimental months before it, but using cooling systems at that time enhanced the ways of heat loss.

Generally, these results are in agreement with those reported by, Abdel-Ghani *et al.* (1975) which reported that, the average of RR for Friesian cows was 33 in the morning, while it was 48 r.pm in the afternoon.

Bendary *et al.* (1995) found that, cooling significantly ($p<0.01$) decreased RR than shading. Whereas, cooled group exhibited 34.9 r.pm less than shaded group, also RR increased gradually from 9.0 am. To reach its maximum value at 4.0 pm. for both shaded and cooled group. But there was pronounced RR for shaded group than those under cooling by time of day. In cooled group, RR increased thenafter cessation of cooling system at 6.0 pm. Also, Fawzy *et al.* (1998) found in all groups the highest values of RR were recorded at 14:00hr and the lowest were at 9:00hr.

4-6 Effect of cooling techniques on Hematological responses:

4-6-1 Hemoglobin (Hb):

The overall mean of hemoglobin (15.29±0.15%) for the experimental groups through summer months is presented in table (17). It could be seen from Table (17) and (Fig.7) that, cooling systems had a significant ($p<0.05$) effect on Hb%. Results obtained referred that, the lowest Hb% was showed in G_1, which kept under shed only (14.72±0.17%) and severed from heat stress during the summer; and the highest values of Hb% were obtained for G_2 and G_3. These groups were ameliorated their ambient environmental by using applied cooling systems, like winter, and successed in dissipating the high core temperature by water evaporation, i.e., the effect of sprinkling or showering on Hb% were positively, whereas, the high Hb values reflect adaptability and lower Hb and RBC's values are indicative of poor adaptability (Prabha *et al.* 1999).

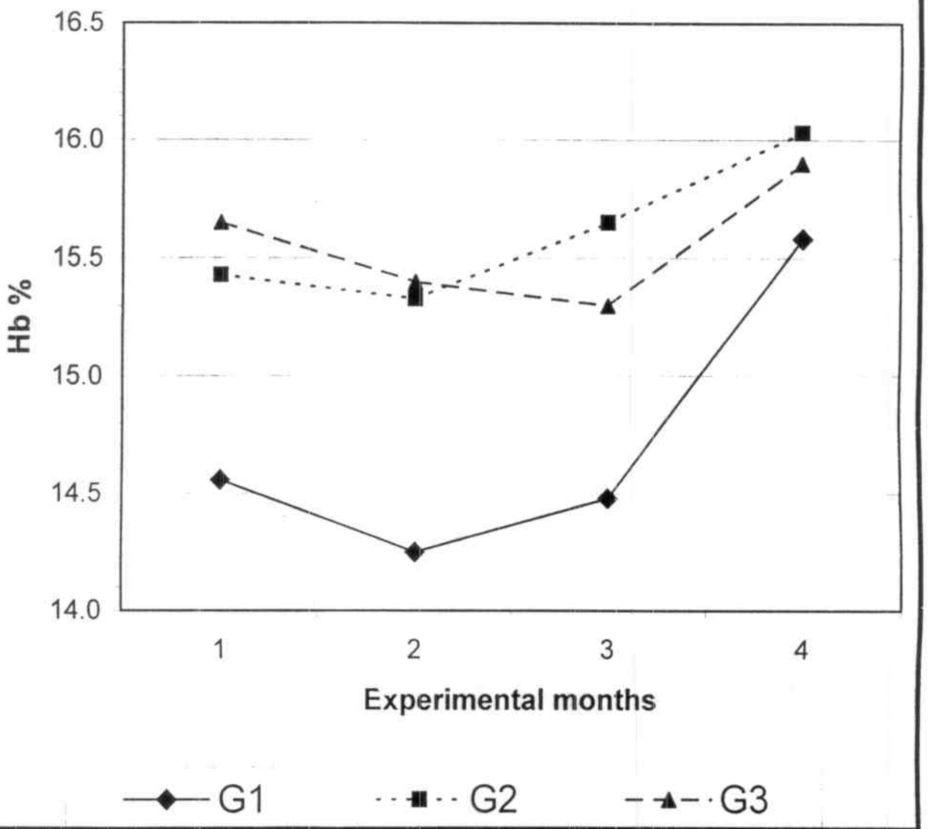
These results were in agreed with those obtained by El-Nouty, et.al. (1990) which found that, Hb ratio was gnificantly elevated during spray period with water than non-spray period

Table (17): Means ± stander error of hemoglobin% (Hb%) during summer months, as affected by cooling systems.

Treatments / Months	G_1 (Control group)	G_2 (Spraying group)	G_3 (Showering group)	Means#
M_1 (Jun.)	14.56±0.26	15.43±0.32	15.65±0.17	15.20±0.17^{B}
M_2 (Jul.)	14.25±0.31	15.33±0.39	15.40±0.27	14.98±0.21^{B}
M_3 (Aug.)	14.48±0.31	15.65±0.16	15.30±0.15	15.14±0.16^{B}
M_4 (Sept.)	15.58±0.30	16.03±0.08	15.90 ±0.19	15.83±0.12^{A}
Means	14.72±.17^{b}	15.61±.14^{a}	15.56±.103^{ba}	15.29±0.10

Means within each column or row having different letters are significantly different at $p<0.05$.

Fig. (7): Effect of treatments on Hb% through experimental months.



(9.8 vs. 9.1g/dl, respectively). Habeeb *et al.* (1995) reported that, Hb decreased significantly from 122 g/l in winter to 102 g/l in summer season, whereas, exposing Friesian calves to water spray 7 times a day, once an hour, increased Hb values significantly by about 8 g/l than summer group. Fawzy *et al.* (1998) found that, significant decrease in Hb about –25.2% for Friesian calves exposed to summer solar radiation, compared with shaded group. Treatment heat stressed calves with water spray increased Hb significantly ($p<0.01$) by about +18.21%.

Also, experimental months had significant ($p<0.05$) effect on Hb%; (Tables17 and 18). Whereas, M_4 (Sept.) had the highest value of Hb% (15.83±0.12%) while, M_1, M_2 and M_3 had no significant difference (15.2±0.17,14.98±0.21 and 15.14±0.16, respectively) the values were significantly lower than that of M_4.

That is may be due to increasing calves in age. This is in agree with Prabha *et al.* (1999) who reported that, a significant decrease in Hb values in calves at birth and at one month of age than the Hb concentration of calves at 4-5 and 10-11 months.

From another point of view, the decrease of Hb values through M_2 and M_3 may be due to partial effect of month, as high temperature and humidity and low air velocity, which increase rate of respiration, consequently may be caused a considerable loss of body water, due to that more water intake was obtained and hemodilution case was occurred.

Daader *et al.* (1989) reported that, under thermal stress, Hb values decreased significantly than winter Friesian group

Table (18): F-ratio of analysis of variance of factors affecting Hemoglobin (Hb%) in Friesian calves.

Source of variance	d.f	F-ratio#
		Hemoglobin (Hb%)
Treatment (T)	2	15.09**
Month (M)	3	6.288**
T×M	6	0.752 Ns
Remainder d.f	84	
Remainder M.s		0.531

Ns=not significant **=p<0.01.

by about 15.57%, and by about 8% when heat stress elevated, by drinking cool water and diuretics administration, and added, that decline in Hb attributed to the water retention, which observed in Friesian calves under thermal conditions. Tharwat *et al.* (1991) indicated that, some hem concentration within two hours after drinking or hemodilution. Shafie *et al.* (1994) reported that, the reduction in Hb under thermal conditions might be due to the dilution of blood through more water intake in order to furnish evaporative cooling of the body.

The interaction effect between treatments and experimental months was detected for Hb% (Table 17 and 18) whereas, it was higher significantly ($p<0.05$) through M_1, M_2 and M_3 for the water treatment groups (G_2 and G_3) than G_1. But, through M_4, there were no significant differences between Hb% means for the three groups. That is reveals that, the effect of sprinkling or showering on Hb% was higher than shading effect, under climatic conditions of M_1, M_2 and M_3. But through M_4, the temperature and humidity were decreased and the air velocity increased, so that the effect of shading on Hb% had got the same effect of the water treatments.

Fawzy *et al.* (1998) found that, Hb% increased significantly from 8.4±0.37, in solar radiation group, to 11.23±0.54 for shaded group.

4-6-2 Total count of white blood cells(WBC):

Total count of white blood cells (WBC) overall mean for all experimental calves during experimental months was 11190±274 WBC/cm^3 (Table 19).

It could be seen from tables (19 and 20) and figure (8) that, cooling systems had a significant effect ($p<0.05$) on WBC

Table (19): Means ± stander error of white blood cells (WBC/m^3) during summe months, as affected by cooling systems.

Treatments / Months	G_1 (Control group)	G_2 (Spraying group)	G_3 (Showering group)	Means#
M_1 (Jun.)	8875.0±120.6	11225.0±442.7	10087.5±44.1	10062.5±248^D
M_2 (Jul.)	9500.0±172.2	11787.5±312.5	10337.5±123.8	10541.7±231^C
M_3 (Aug.)	9962.5±193.6	13787.5±358.3	11137.5±126.7	11629.2±360^B
M_4 (Sept.)	10375.0±52.6	15575±204.2	11625 ±254.1	12524.9±473.9^A
Means	9678.1±121.6^c	13093.8±348.8^a	10796.9±133.2^b	11189.6±273.8

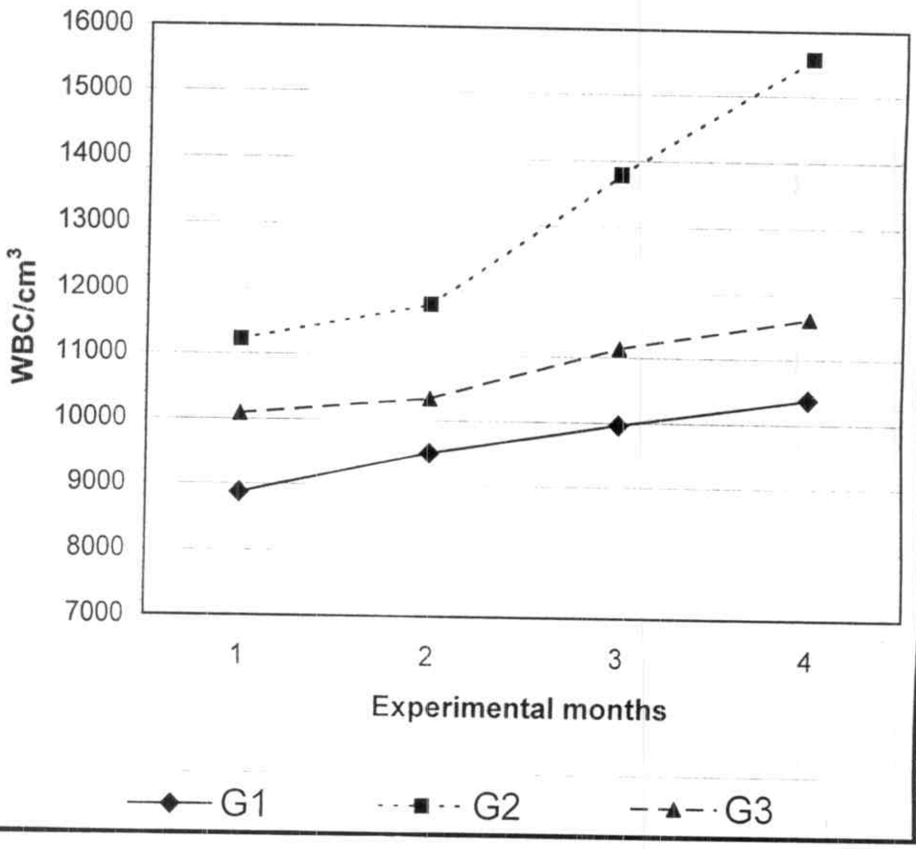
Means within each column or row having different letters are significantly different at $p<0.05$.

Table (20): F-ratio of analysis of variance of factors affecting white blood cells (WBC) in Friesian calves.

Source of variance	d.f	F-ratio#
		White blood cells
Treatment (T)	2	225.3**
Month (M)	3	68.109**
T×M	6	11.132**
Remainder d.f	84	
Remainder M.s		430685

**= p<0.01.

Fig. (8): Effect of treatments on WBC through experimental months.



total count, whereas, application water treats (G_2 and G_3) had higher significant effect on WBC than shaded control group G_1 (13093.8±349 and 10796.9±133 ver. 9678.1±122 WBC/cm^3) respectively. Also, G_2 WBC mean was significantly higher than that of G_3, by about 12.3%.

Results obtained in Table (20) showed that, experimental months had a significant ($p<0.05$) effect on WBC total count, from table 19 and Fig. 8; it was observed that, WBC increased gradually through experimental months from Jun (M_1) to Sept. (M_4). Whereas, the highest mean of WBC was observed in M_4 (12524.9±473.9WBC/cm^3) and the lowest one was observed in M_1 (10062.5±248 WBC/cm^3).

Also, the highest WBC total count was observed through M_4 for G_2 (15575±204) and the lowest one was recorded in M_1 for G_1 (8875±121 WBC/cm^3) because of, the near of climatic conditions of M_1 and M_4 through experimental period, we can say that, the difference in WBC between these groups may be due to the effect of treatments more than the effect of months climatic conditions.

The nearest results from that obtained previous was reported, by El-Nouty *et al.* (1990) which found that, sprinkling the cows increased the value of total count of WBC than non-sprinkling group (5.3±0.47 and 5.0±0.47 WBC×10^3/ mm^3, respectively) but with out significant difference between groups. On the other side, Fawzy *et al.* (1998) reported that, water spray for heat stressed calves decreased WBC_s significantly by about –0.52% than shaded group.

4-6-3 Total proteins (TP):

Treatment Friesian calves, under hot humid summer conditions, with water spray (G_2) or shower (G_3) affected positively on TP concentration comparing with using shad only (G_1) which was the lowest one ($p<0.05$) (Table 21).

It could be observed from that table that, there was no significant difference between TP means under conditions of using water spray or showering.

Table (22) showed a significant ($p<0.05$) effect of experimental months. Also, Table (21) and Figure (9) showed that, TP means of M_1 and M_4 were significantly higher than those of M_2 and M_3. That is may be reflecting the effect of climatic conditions through Jun. and Sept. (M_1 and M_4) which were suitable for protein anabolism.

Generally, TP decrease of G_1 blood calves (if we regarded it stressed group) may be due to hemodilution effect, where more water is transported in the circulatory system and higher water intake for evaporative cooling mechanism (Ali, 2001). Collier *et al.* 1982 and Yousef *et al.* 1997, reported that, shaded animals had higher plasma protein than non shaded animals, may be as a result of expanded plasma volume, as they would have had higher water requirements for evaporative water loss.

Increase of plasma TP of cooled groups, G_2 and G_3, was in agreed with Habeeb *et al.* (1995) which reported that, cooling calves by water spray in the summer increased TP in blood serum than heat stressed calves by 15g/l (89±4 vs. 74±5 g/l).

Table (21): Means ± stander error of plasma total proteins (TP gm/dl) during summer months, as affected by cooling systems.

Treatments / Months	G_1 (Control group)	G_2 (Spraying group)	G_3 (Showering group)	Means#
M_1 (Jun.)	4.22±0.226	4.78±0.334	4.55±0.129	$4.52±0.143^{A}$
M_2 (Jul.)	3.86±0.324	4.11±0.176	4.30±0.198	$4.09±0.138^{B}$
M_3 (Aug.)	3.91±0.239	4.35±0.277	3.99±0.159	$4.08±0.133^{B}$
M_4 (Sept.)	4.29±0.297	4.88±0.156	4.56±0.338	$4.58±0.160^{A}$
Means	$4.07±0.135^{b}$	$4.53±0.130^{a}$	$4.35±0.113^{a}$	4.32±0.136

Means within each column or row having different letters are significantly different at $p<0.05$.

Table (22): F-ratio of analysis of variance of factors affecting plasma total proteins (TP) in Friesian calves.

Source of variance	d.f	F-ratio#
		Total proteins
Treatment (T)	2	3.545*
Month (M)	3	3.484*
T×M	6	0.300 Ns.
Remainder d.f	84	
Remainder M.s		0.493

Ns= not significant and *= p<0.5.

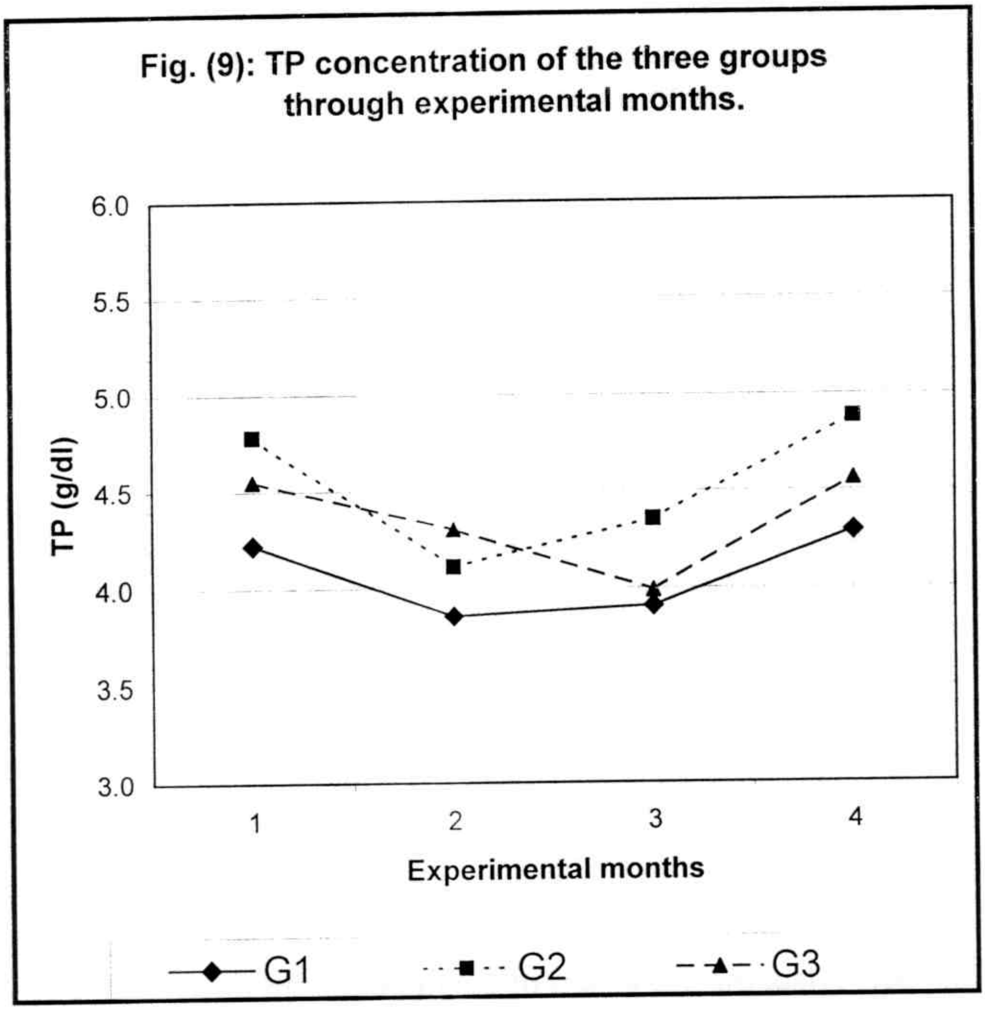


Fig. (9): TP concentration of the three groups through experimental months.
6.0
5.5
5.0
4.5
4.0
3.5
3.0
TP (g/dl)
1
2
3
4
Experimental months
G1
G2
G3

4-6-4 Total lipids(TL):

Plasma total lipids (TL) overall mean, for all experimental calves through experimental months, was (2.79±0.16 g/l) and it presented in table (23).

It could be noticed from tables (23 and 24) and Fig. (10) that, cooling systems in G_2 and G_3 had no significant effect on TL comparing with shaded group G_1 (2.84±0.13 and 2.80±0.12 vs. 2.68±0.11 g/l, respectively).

Also, table 23 appeared that, the summer experimental months had no significant effect on TL, 2.93±0.13, 2.59±0.18, 2.74±0.11 and 2.82±0.15 g/l for M_1, M_2, M_3 and M_4, respectively.

Comparing between the three means for heat stress elevation, shed, spraying and showering, the previous results revealed that, shading had ameliorative effect as spraying or showering on plasma TL. That is in agree with Yousef *et al.* (1997) on different types of sheds and Habeeb *et al.* (1995) on cooling systems.

Habeeb *et al.* (1995) reported that, treatment of the heat stressed Friesian calves with drinking cool water and sprinkling led to a significant increase in TL by about 13.5% than heat stressed summer group (4.2±0.2 vs. 3.7±0.2 g/l). From Fig. (10) we can notice that, TL as values, were higher for G_2 than those of G_1. Also, the TL values of the three groups decreased in M_2 and M_3, especially G_3 at M_2, whereas, high humidity through these months (68.8±5.3 and 69.0±3.2% RH, respectively).

Table (23): Means ± stander error of plasma total lipids (TLg/l) during summer months, as affected by cooling systems.

Treatments	G_1	G_2	G_3	Means#
Months	(Control group)	(Spraying group)	(Showering group)	
M_1 (Jun.)	2.74±0.13	2.97±0.27	2.99±0.28	$2.93{\pm}0.13^{A}$
M_2 (Jul.)	2.58±0.35	2.68±0.37	2.51±0.23	$2.59{\pm}0.18^{A}$
M_3 (Aug.)	2.65±0.24	2.82±0.16	2.74±0.17	$2.74{\pm}0.11^{A}$
M_4 (Sept.)	2.74±0.16	2.90±0.28	2.97±0.30	$2.87{\pm}0.14^{A}$
Means	$2.68{\pm}0.11^{a}$	$2.84{\pm}0.13^{a}$	$2.80{\pm}0.12^{a}$	2.79±0.16

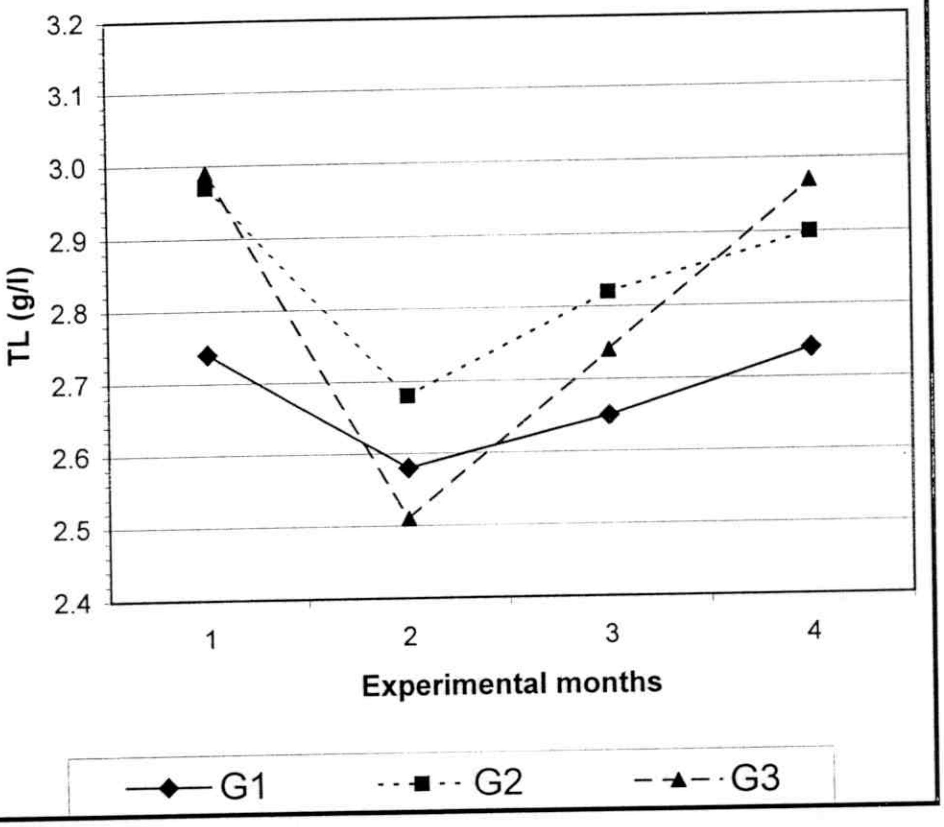
Means within each column or row having different letters are significantly different at $p<0.05$.

Table (24): F-ratio of analysis of variance of factors affecting Plasma total lipids (TL) in Friesian calves.

Source of variance	d.f	F-ratio#
		Total lipids
Treatment (T)	2	0.568 Ns.
Month (M)	3	1.078 Ns.
T×M	6	0.108 Ns.
Remainder d.f	84	
Remainder M.s		0.517

Ns=not significant.

Fig. (10): TL concentration of the three groups through experimental months.



The cause may be explained by Karihaloo *et al.* (1970) which reported that, blood fatty acids were negatively correlated with RH% and cooling, when they increased free fatty acids decreased. Also, Soni *et al.* (1982) found that, plasma free fatty acids decreased during hot humid periods for control, shower and wallowing groups of lactating buffaloes.

4-7 **Effect of cooling techniques on Thyroid function: -**

4-7-1 **Thyroxin (T_4):**

Thyroxin (T_4) overall mean (7.19±0.21 μg/dl) for all experimental calves through all experimental months is presented in table (25) which showed that, using water spray or showering in G_2 and G_3 affected positively on T_4 plasma concentration than control group (Fig.11). Whereas, using spraying in G_2 or showering in G_3 had no-significant difference between them (6.58±0.19, 7.50±0.17 and 7.33±0.21 μg/dl for G_1 vs. G_2 and G_3, respectively).

Also, the significance effect of month on T_4 concentration and its interaction with treatment is presented in table (26). T_4 concentration affected significantly ($p<0.05$) by experimental months whereas, its concentrations were higher significantly in M_1 and M_4 (7.62±0.21 and 7.54±0.20 μ g/dl, respectively) than M_2 and M_3 (6.48±0.24 and 6.90±0.20 μg/dl, respectively). That is may be because of higher temperatures and humidity of M_2 and M_3 than those of M_1 and M_4, that is reflect the effect of environmental months conditions on T_4 blood concentration, which was higher than that effect of treatments (p-value = 0.001 vs. 0.01).

Table (25): Means ± stander error of plasma thyroxin (T_4 µg/dl) during summer months, as affected by cooling systems.

Treatments / Months	G_1 (Control group)	G_2 (Spraying group)	G_3 (Showering group)	Means#
M_1 (Jun.)	7.25±0.43	8.01±0.28	7.61±0.36	7.62 ± 0.21^{A}
M_2 (Jul.)	5.89±0.42	7.02±0.35	6.54±0.40	6.48 ± 0.23^{B}
M_3 (Aug.)	5.99±0.12	7.24±0.26	7.47±0.37	6.90 ± 0.20^{B}
M_4 (Sept.)	7.18±0.17	7.73±0.37	7.70±0.45	7.54 ± 0.20^{A}
Means	6.58 ± 0.19^{b}	7.50 ± 0.17^{a}	7.33 ± 0.21^{a}	7.19±0.21

Means within each column or row having different letters are significantly different at $p<0.05$.

Fig. (11): T_4 concentration of the three groups through experimental months.

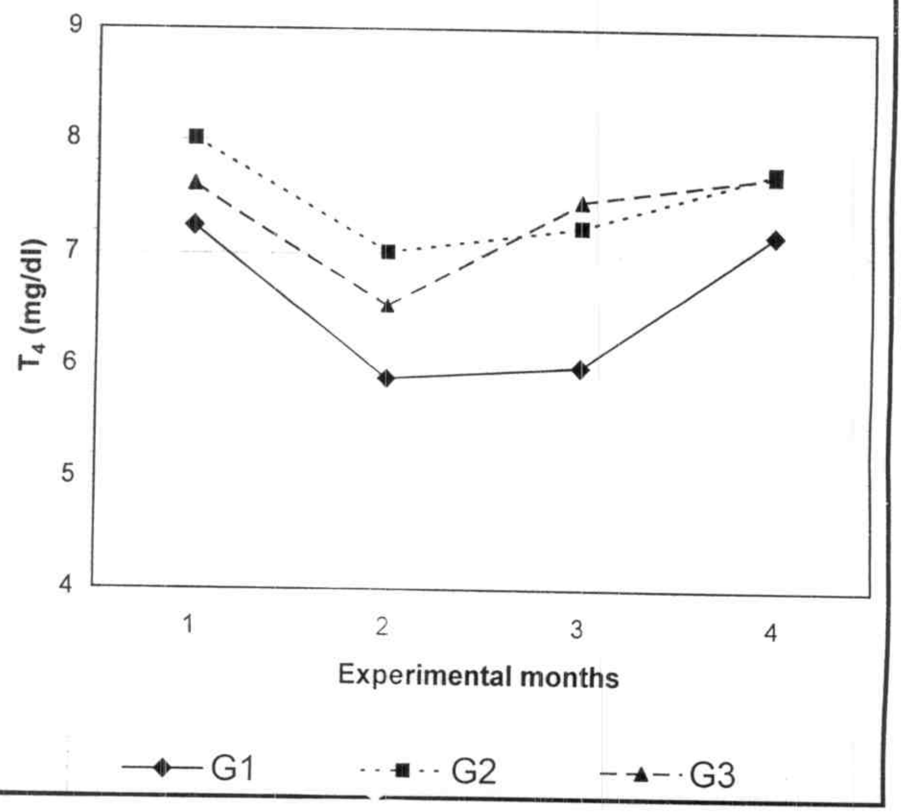


Table (26): F-ratio of analysis of variance of factors affecting Plasma thyroxin (T_4) in Friesian calves.

Source of variance	d.f	F-ratio#
		Thyroxin
Treatment (T)	2	4.739 *
Month (M)	3	5.932 **
T×M	6	0.266 Ns.
Remainder d.f	84	
Remainder M.s		1.097

Ns=not significant *=p<0.05 and **=p<0.01.

In control group (G_1) T_4 concentration decreased significantly through M_2 and M_3 (5.89±0.42 and 5.99±0.12 µg/dl, respectively) than M_1 and M_4 whereas, temperature and humidity were a little bet lower, beside the air velocity was a little bet higher through M_1 and M_4 (7.25±0.43 and 7.18±0.17 µg/dl, respectively).

In G_2 and G_3, using water applications for evaporative cooling increased T_4 concentration through hot-humid months (M_2 and M_3) whereas, T_4 concentrations had no-significant difference between the experimental four months (Table 25).

The previous results of using cooling systems or shed under hot summer conditions were in agree with Collier *et al.* 1982; El-Nouty *et al.*1990; Habeeb *et al.*1995 and Fawzy *et al.*1998. El-Nouty *et al.* (1990) reported that, using water spray cooling system elevated T_4 level from 48.5 to 60.3 ng/ml for non-spray and spray periods, respectively.

Hbeeb *et al.* (1995) found that, sprinkling Friesian calves with water spray caused a significant increase in T_4 concentration by about 82% than summer control group. Also, Fawzy *et al.* (1998) found that, keeping Friesian calves under shed increased T_4 by about 24.7% than heat stressed group, whereas, treatment these stressed group with water spray increased T_4 concentration significantly by about 26.7%.

4-7-2 Triiodothyronine (T_3):

The overall mean of triiodothyronine (T_3) was 121.95±7.94 ng/dl during the experimental periods (Table 27). The present results showed that, using water applications to cool heat-stressed shaded animals by spraying or showering (G_2

Table (27): Means ± stander error of plasma triiodothyronine (T_3 ng/dl) during summer months, as affected by cooling systems.

Treatments	G_1	G_2	G_3	
Months	(Control group)	(Spraying group)	(Showering group)	Means#
M_1 (Jun.)	098.05±02.84	160.10±11.77	117.48±09.99	125.21±07.36^{B}
M_2 (Jul.)	098.09±14.70	152.81±15.75	117.17±14.68	122.69±09.56^{BA}
M_3 (Aug.)	081.78±02.78	114.69±15.10	84.05±11.03	093.51±06.81^{C}
M_4 (Sept.)	105.36±11.01	203.16±15.10	130.62±14.22	146.38±11.43^{A}
Means	095.82±04.73^{c}	157.69±8.92^{a}	112.33±6.76^{b}	121.95±07.94

Means within each column or row having different letters are significantly different at $p<0.05$.

and G_3) had a significant ($p<0.05$) effect on T_3 concentration than using shed only in G_1 (Table 25 and Fig 12). Whereas, using water spray in G_2 had higher positive effect on T_3 than using showering system (95.82±4.73, 157.69±8.92 and 112.33±6.76 ng/dl for G_1, G_2 and G_3, respectively).

Analysis of variance (Table 28) showed a significant ($p<0.001$) effect on T_3 concentration due to of cooling system treatment and effect of months. Johnson *et al.* (1987) reported that, in hot humid environmental, water spray and wind increased T_3 and feed intake significantly. Also, using internal cooling technique by using diuretics and drinking cool water under summer hot conditions improved T_3 up-take% significantly ($p<0.01$) by about 17.39% over those Friesian calves of control summer group (Daader *et al.* 1989).

On the other hand, El-Nouty *et al.* (1990) reported that, using water spray had non-significant effect on T_3 concentration of sprayed and non-sprayed periods in Holstein cows during hot summer (42 c°, 43% RH). Habeeb *et al.* (1995) reported that, treatment Friesian calves with cool water spray in hot summer decreased T_3 uptake significantly ($p<0.05$) from 29±0.3 to 26±1.0% for control and cooled group, respectively.

The present results showed a significant ($p<0.05$) difference between means of treatment months, whereas, the highest T_3 concentration was obtained in M_4 (146.38±1.43 ng/dl) then in M_1 (125.21±7.36 ng/dl) and the lowest T_3 concentration was observed in M_3 (93.51±6.81 ng/dl).

As shown in table (28) the interaction effect of months× treatment was not significant. In any way, the highest value of T_3 was observed through M_4 for G_2 (203.16±15 ng/dl) and the

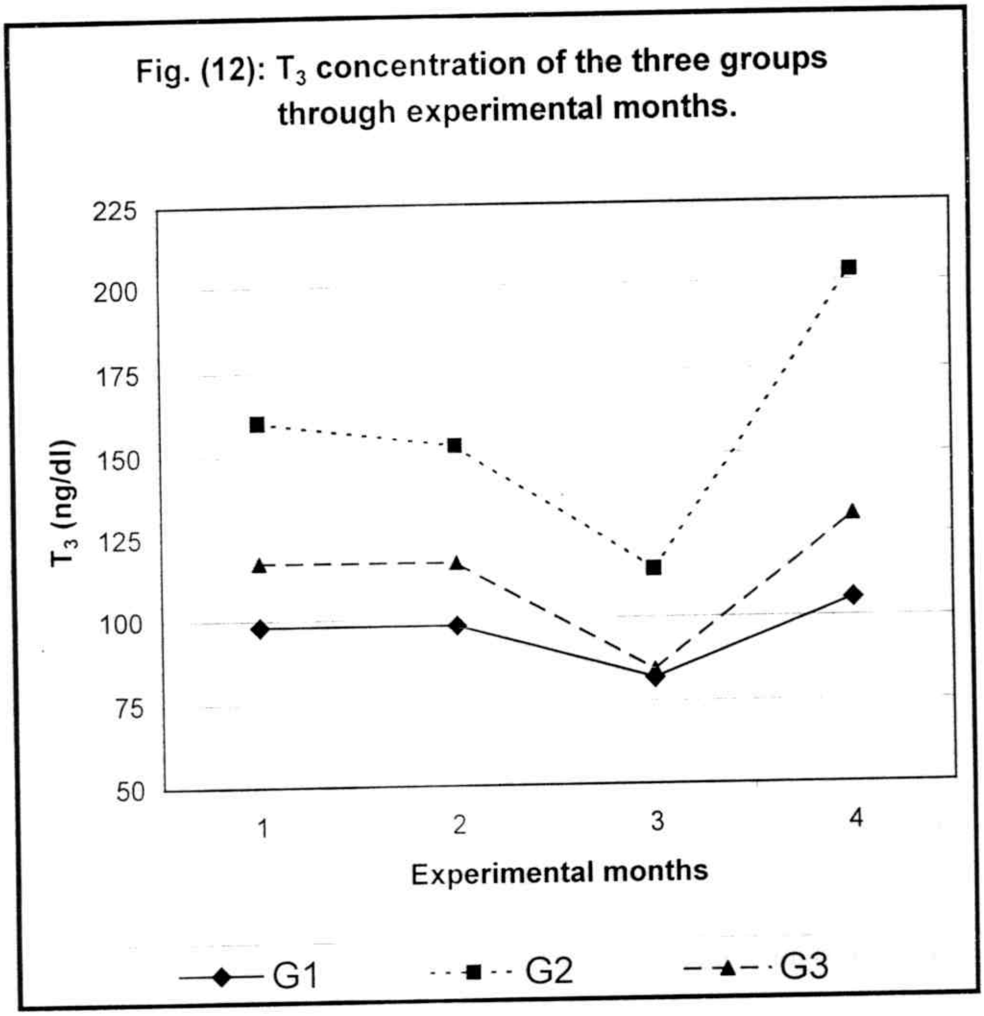


Fig. (12): T_3 concentration of the three groups through experimental months.
225
200
175
150
125
100
75
50
T_3 (ng/dl)
1
2
3
4
Experimental months
G1
G2
G3

Table (28): F-ratio of analysis of variance of factors affecting Plasma triiodothyronine (T_3) in Friesian calves.

Source of variance	d.f	F-ratio#
		Triiodothyronine
Treatment (T)	2	26.807 ***
Month (M)	3	9.253 ***
T×M	6	1.281 Ns.
Remainder d.f	84	
Remainder M.s		1225.181

Ns=not significant and ***=p<0.001.

lowest one was observed for G1 through M_3 (81.8±2.8 ng/dl). If we joined between these values and RT's averages of the same groups in the same months (38.94±0.02 and 39±0.02 c°) may be explain why T3 increased significantly in G2 and G3 than G1, whereas Guerrini and Bertchinger (1983) studied the relationship between T3 and RT in sheep, they found that, T3 concentration was correlated to the increase in RT than environmental temperature.

4-8 Testosterone: -

Overall mean of plasma testosterone, for all experimental calves through experimental months, was 4.55±0.44(ng/ml).

Keeping Friesian calves under shed only (control group G_1) showed the lowest value of testosterone concentration, whereas, using water spray under shed (G_2) increased testosterone significantly from 3.99±0.43 for G_1 to 5.31±0.42 ng/ml. Also, using showering cooling system (G_3) recorded (4.34±042 ng/ml) testosterone value more than G_1, and less than G_2 but, without significance (Table 29 and Fig. 13). El-Baz (1991) reported that, exposing Friesian bulls to solar radiation recorded the lowest values of testosterone in comparison to those in either shade or sprinkling and forced ventilation groups, (2.20±0.25, 2.95± 0.30 and 2.43±0.23 ng/ml, respectively). However, the differences among treatments were not significant.

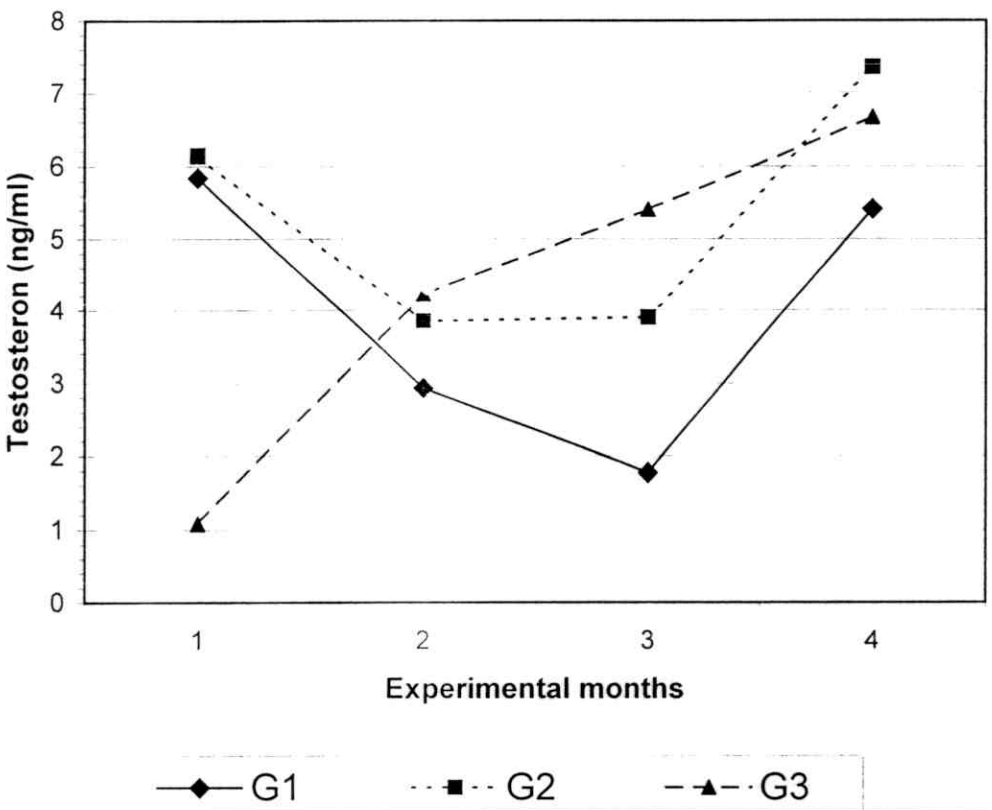
In this study, using water spray or showering improved testosterone values more over the using of shed. That is reflects the more active effect of sprinkling on dissipating more over come core temperature leading to more testosterone secretion from testes leydig cells than using showering, which may be

Table (29): Means ± stander error of Testosterone (ng/ml) during plasma summer months, as affected by cooling systems.

Treatments / Months	G_1 (Control group)	G_2 (Spraying group)	G_3 (Showering group)	Means#
M_1 (Jun.)	5.84±0.38	6.14±0.76	1.08±0.47	$4.35±0.57^{B}$
M_2 (Jul.)	2.93±1.03	3.84±0.51	4.22±0.40	$3.67±0.40^{B}$
M_3 (Aug.)	1.77±0.67	3.89±0.42	5.41±0.33	$3.69±0.41^{B}$
M_4 (Sept.)	5.42±0.22	7.35±0.93	6.66±0.46	$6.48±0.38^{A}$
Means	$3.99±0.43^{b}$	$5.31±0.42^{a}$	$4.34±0.42^{ab}$	4.55±0.44

Means within each column or row having different letters are significantly different at $p<0.05$.

Fig. (13): Effect of treatments on plasma testosteron during experimental months.



increased humidity resulted in low efficiency in dissipating high core temperature.

The effect of month and the interaction between treatment and month are shown in tables 29 and 30. It was observed that, the averages plasma testosterone concentration decreased between M_2 and M_3 and reached its maximum in M_4 (6.48±0.38 ng/ml). El-Baz (1991) were observed the same trend that, plasma testosterone was gradually decreased between week 4 to 10 of the experimental periods and increased at week 11-12.

As shown in table 29, the monthly testosterone averages in G_1 and G_2 had the same trend, which increased in M_1 and M_4 and decreased in M_2 and M_3. Whereas, in G_3 testosterone concentration increased gradually through experimental months, reached its maximum in M_4 (Fig. 13).

Generally, Hafez (1967) pointed out that, high temperature can caused hypofunction of the anterior pituitary and decrease in LH secretion, leading to an atrophy of the interstitial cells. Rhynes and Ewing (1973) reported that, plasma testosterone was reduced in Herford bulls during the first 2 weeks of heat stress.

Whereas, Minton *et al.* (1981) fond that, the averages serum testosterone were similar in both heat stressed and control shaded bulls.

Lee and Thaddeus (1983) found that, monthly variation in testosterone means followed the typical seasonal pattern for rams with levels being relatively high in hot summer and fall and relatively low in winter and spring.

Table (30): F-ratio of analysis of variance of factors affecting plasma testosterone (ng/ml) in Friesian calves.

Source of variance	d.f	F-ratio#
		Testosterone
Treatment (T)	2	5.217 **
Month (M)	3	14.808 ***
T×M	6	10.238 ***
Remainder d.f	84	
Remainder M.s		2.847

**= p<0.01 and ***= p<0.001.