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Relief of The Impact of Heat Stress on Friesian and Cross-Bred Friesian Dairy Cows by Water Showering under Egyptian Hot Humid Summer Conditions in Nile Delta

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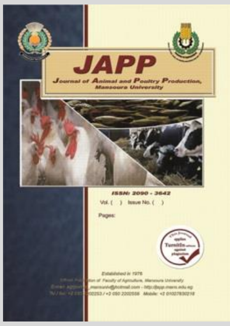

ABSTRACT

The present study aimed to evaluate the response of lactating purebred Friesian cows and crossbred Friesian with Baladi cows during hot-humid Egyptian summer conditions to showering. The experimental work was carried out during June – August. Ten Friesian and ten crossbred Friesian × Baladi dairy cows were used and assigned randomly into four treatment groups: two control groups of cows had access only to shade (Friesian cows and crossbred Friesian cows; S), and two groups were provided showers (Friesian cows and crossbred Friesian cows; S + S). The maximum THI throughout the experimental work was 80.43 to 85.22. Showered cows were taken to a holding pen daily to be cooled. Concentrations of TSH, T_3, T_4, IGF-1, glucose, cholesterol, triglyceride, total protein, albumin, ALP, Na, K, and milk production were significantly ($P<0.01$) increased, while, serum cortisol, prolactin, creatinine, AST, ALT and thermoregulatory traits (rectal temperature; RT, respiration and pulse rate (RR; PR), and skin temperature; ST were significantly decreased ($P<0.01$) in showering than shaded only Friesian and crossbred Friesian cows. Despite crossbred Friesian-Baladi dairy cows displaying more tolerance for heat through attained better parameters for thermoregulatory, endocrinal, and biochemistry and milk production, the amount of improvement of purebred Friesian dairy cows by showering enables cows to express some of their genetic potentials which impeded by the heat stress. Thus, showering can be used to lessen the impact of hot-humid Egyptian summer conditions in the Nile Delta on heat-sensitive exotic purebred dairy cows.

Keywords: Crossbreeding, Heat-stress, Blood, Milk, Cooling

INTRODUCTION

Generally, Egypt is under significant pressure from climate change, particularly in the agricultural sector (Yassin, 2016). The regions surrounding the Nile Delta provide about 60% of Egypt's food production (Agrawala *et al*., 2012). Nile Delta region of Egypt produce about 36.2% from the total milk production in the country. Since, it has approximately 37.8% and 69.5% of dairy cows of exotic pure breeds, primarily Friesian, and crossbred, primarily Baladi × Friesian crossbred, respectively, from the total population of dairy cows in nationwide Egypt (EAS, 2020). The Egyptian hot summer condition was known as hot and humid in the Nile Delta (Zaki & Swelam, 2017), which typically falls outside the cow's "comfort zone" causing heat stress (Hady *et al*., 2018). When the genetic selection were done for growth and milk production it is of important to exacerbate heat stress issues severity as global of warming progresses (Fournel *et al*., 2017).

Heat stress was adversely impact on milk production traits, reproductive performance, and health status in dairy cattle (Sungkhapreecha *et al*., 2021). The temperature-humidity index; THI of dairy cattle affected by temperature and relative humidity and the exceeding of thermoneutral zone led to reduce intake of dry matter, milk yield, and conception rate, which is related to several physiological modulations such as core body temperature (BT), rectal temperature (RT), respiration rate (RR), pulse rate (PR), and sweating rate as noted by Garner *et al*. (2016) and Osei-Amponsah *et al*. (2020). In the dairy industry, heat stress causes devastating economic consequences with yearly losses (between 1.69 and 2.26 billion dollars in the United States) causing a milk drop in India (0.73 million L) in 2020 year (Habimana *et al*., 2023).

Indeed, the thermoneutral zone ranges from 0.5°C to 20°C in *Bos taurus* dairy cattle (Garner *et al*., 2016), that affected by some factors (feeding, climatic conditions, production, and fertility status) (Garner *et al*., 2016; Marumo *et al*., 2022). Dairy cattle experiencing heat load are banned from expressing their genetic potential for milk production (Anderson *et al*., 2013). Shaarawy *et al*. (2023) claimed that even acclimatized Friesian dairy cows have demonstrated a greater susceptibility to the detrimental influences of heat stress than Baladi x Friesian crossbred dairy cows under high-heat environmental conditions in Egypt. Thus, crossbreeding temperate breeds with native breeds highly resilient to heat stress is a quick route to improve animals' thermotolerance. Cross-breeding has raised milk production in hotter zones, attaining pleasant production indices (Daltro

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et al., 2020), and is the base for eliciting the Baladi x Friesian crossbred from decades in Egypt.

With elevation concerns about climatic changes and global warming, cooling means became more beneficial (Cheng *et al*. 2016). When the THI value increases (70 – 72) cooling is recommended to stop the milk yield decline (Broucek *et al*., 2009). The increase in THI value to achieve a range of 72 – 78, led to a decrease in cattle milk production unless applying cooling strategies (Broucek *et al*., 2009). With THI higher than 82, cooling is irreplaceable (Broucek *et al*., 2009). There are different cooling systems can used in heat-stressed cows that could maintain the normal body temperature (Fournel *et al*., 2017), this is to, sustain their physiological processes and, thus their ability to maintain an increased milk yield. Chen *et al*. (2016) reported that milk production could be attenuated reduction as affected by the type and quantity of heat abatement resources provided. It is important to optimize the management practices to improve cow well-being and the profitability of dairy systems. Locally, relative to shade alone, applying water more efficiently decreases the rectal temperature and respiration rate (Abdel-Samee and Ibrahim, 1992; Omar *et al*., 1996) in exotic dairy cow breeds, (Khalifa *et al*., 2011; Imbabi *et al*., 2019) with beneficial impacts on feed intake and milk yield under hot humid summer conditions in Egyptian buffalos.

This study aimed to assess the efficacy of the cooling method (shade or shade with water showering) on the milk production, physiological and blood biochemical responses of mid-lactating Friesian and Friesian × Baladi crossbred dairy cows in free-stall semi-shaded barns in Nile Delta under Egyptian environmental hot humid summer conditions.

MATERIALS AND METHODS

The experimental work investigated the IACUC protocol Number (ARC/APRI/64/23) for the protection of animals used for scientific purposes and feed legislation at Animal Production Research Station Gemmezah, Gharbiya governorate belonging to Animal Production Research Institute (APRI), Agricultural Research Center, Egypt. At latitude 30°48'07.1"N and longitude 31°08'25.4"E with an elevation of 8.30 m from average sea level.

Meteorological variables throughout the experimental study were recorded hourly for the entire experimental period outdoors by the National Aeronautics and Space Administration (NASA) Langley Research Centre (LaRC) Prediction of Worldwide Energy Resource (POWER) Project funded through the NASA Earth Science/Applied Science Program then temperature-humidity index; THI calculated according to Mader *et al*. (2006) as followed:

$$\mathbf{THI = (0.8\ Tdb) + [(RH/100)\ (Tdb - 14.4)] + 46.4}$$

Where's Tdb is the temperature of dry bulb; RH is the relative humidity.

Cows and the experimental design

Twenty multiparous lactating dairy cows (10 Friesian and 10 Friesian × Baladi crossbred) with an average of 90.9 ±13.2 days in milk, 3.5 ±1.9 parity, age 5.8 ±1.53 years (mean ± standard deviation) were allocated randomly to two equal groups, stratified by days in milk and parity. The control group was kept only under shade(S). A second group of cows was cooled by showering (S+S).

The cows were housed in two analogous semi-shade barns facing each other, with natural ventilation with soil floor. Each barn (19.5 × 17.5 m), which were oriented south/ north, and surrounded by galvanized steel pipes. One-third of the pen was covered by corrugated asbestos sheets, ranging in height from 4.5 to 5 meters at the eave and ridge, respectively (this height was sufficient to ensure a minimal amount of reflected solar radiation from the shads to the cows; (Collier *et al*., 2006). To implement showering treatment, cows from the cooled group walked approximately 20 m from their original barn to the holding area. The cows were come back to their respective barn after the showering session was accomplished.

The experiment was carried out for three months (June, July, and August) with a one-week adaptation period. To get the cows wet for evaporative cooling, we used sprinkler nozzles to generate showering with droplet sizes approximately hassling to that of raindrops. The nozzles were manually turned on and off.

Milking parlor holding area was mounted by nozzles, has dimensions of 12 m wide and 9 m long and includes 24 sprinklers. A water pipe made of polyvinyl with a diameter of 0.75 inches was installed at a height of 2.6 meters along the holding area. From this pipe, four water pipes were extended, spaced 1.4 meters apart. Each water pipe has six sprinkler nozzles for showering, which are spaced 1.3 meters apart on the water pipe. The floor was concrete, thus allowing drainage of sprinkled water. The cows were showered with water for 30 minutes at 1.30-hour intervals from 11.30 to 16.00 h.

All cows were in healthy conditions and clinically free from internal or external parasites, watered freely, and fed according to the (NRC, 2001) recommendation for dairy cattle. Cows were milked twice a day at 5 a.m. and 5 p.m. by a milking machine in the milking parlor.

Physiological Measurements

Milk yield was measured daily throughout the experimental work. Using a clinical thermometer, the rectal temperature (RT) was measured by fully inserting the thermometer for three minutes. To make sure the gadget hit the rectal wall, little pressure was administered. By visually counting costal movements over 30 seconds while using a stopwatch and avoid distracting the animal, the respiration rate (RR) is calculated by multiplying it by 2. The pulse rate (PR) which is measured from coccygeal artery that located at tail base by the pulsation process, was given in beats/minute. To measure skin temperature (ST), a non-contact infrared thermometer was used at the shoulder area. Physiological measurements were collected on resting animals under the shade weekly between 14.30 and 15.00 h, directly in their barn, and so cows were not moved to take those measurements.

Blood collection and sample preparation

Blood samples were collected from the jugular vein of all cows monthly (Pugh, 2002). Serum samples were obtained by centrifuging the blood samples at 5000 g for 10 minutes. The blood serum was transferred into clean dry Eppendorf tubes and stored at -20°C till biochemical analysis.

Serum biochemical parameters examination

Serum thyroid stimulating hormone (TSH), and thyroid hormones (T_3 and T_4) were determined using an ELISA kit (Immunospec Corporation, USA, catalog No.

PekinElmer-10304, PekinElmer-10301, and PekinElmer-10302, respectively with sensitivities of 0.2 µIU/ml,0.25 ng/ml, and 0.5 µg/dl., respectively. Serum cortisol, prolactin, and Insulin-like growth factor (IGF-1) levels were determined using ELISA kits (PekinElmer-10005; DBC, Canada; catalog No. CAN-C-270 and SinoGene-Clon-SG-60105 and SinoGene- Biotech Co.ltd: Catalog No. 60189, respectively with sensitivities of 0.4 µg/dl,0.5ng/ml and 0.3 ng/ml., respectively. For prolactin, the blood samples were taken 5 minutes after milking, and the samples were moved directly to the laboratory for analysis. Special kits (Stain Bio Company) were used for the spectrophotometric determination of total protein, glucose, and Creatinine according to the method of Tietz (1986). Total cholesterol, and triglyceride as described by Anderson and Cockayne (1993). Blood serum Alkaline phosphatase (ALP), Aspartate aminotransferase (AST), and Alanine transaminase (ALT) activities were assayed according to Anderson and Cockayne (1993) methods. Sodium (Na) and potassium (K) in blood samples were determined using special kits according to Tietz (1986).

Statistical analysis

The effects of breed, treatment, and their interaction (breed and treatment) on thermoregulatory, endocrine, and biochemical components, and milk yield were analyzed using the ANOVA model for repeated measures (SAS, 9.0). The differences were determined using Duncan's test (among breeds, treatments, and their interaction) and indicated by *p* values, and superscripts (SAS, 9.0). The significance level was set at $P<0.05$, and a trend at a *P* value between 0.05 and 0.1.

RESULTS AND DISCUSSION

Meteorological Conditions

The maximum, lowest, and average meteorological variables in terms of ambient temperature (Ta, °C), relative humidity (RH, %), temperature-humidity index (THI), wind speed (WS, meter/second), and solar radiation (SR, Watt. Hour/m^2) during the summer season (for 24 h/d, and the trial period from 11.30 to 16.00 h), were illustrated in Table 1. The average monthly THI increased gradually from 76.65 (the minimum value) in June to 81.68 (the maximum value) in August.

Five environmental factors influence effective temperature: ambient temperature, humidity, wind speed, solar radiation, and precipitation (Igono, *et al*., 1992). The best cow discomfort indicator in a natural environment is still the THI since incorporates the impacts of ambient temperature with relative humidity (Polsky and Von Keselink, 2017). Omran *et al*. (2019) indicated that a THI value of 72 or below was considered to be under minimal heat stress, 73 to 77 to mild heat stress, 78 to 89 to moderate heat stress, and beyond 90 to severe heat stress. Based upon the monthly THI means values during 24 hours in this study, these lactating dairy cows were exposed to mild (76.65 in June) to moderate (79.91 – 81.68 in July and August) heat burden. Ambient temperatures and THIs during 24-h, especially the experimental period (11.30-16.00 h) temperatures, were all significantly higher than the thermoneutral zone required for cattle. Since, the thermoneutrality zone is between -5 to 24°C for dairy cattle (Johnson, 1976). Temperature of nighttime ambient inability to drop below 21° C for at least 6 hours (Igono *et al*., 1992), which hinders the cows' ability to release heat, is evidence of the high severity of heat stress.

In this study, average Ta and RH recorded values ranged from 36.63 throughout June to 37.75 in July (°C), and 40.81 in July to 46.85 in June (%) for the summer season during the trial period (11.30 to 16.00 h), respectively (Table 1). Data showed low relative humidity, and high ambient temperature during the daytime which supports better evaporative cooling. Cooling cows with evaporatively cooled air has been effective in areas of low humidity (Armstrong and Wiersma, 1986; Ryan *et al*., 1992). Even in more humid areas, the daytime humidity often is low enough for beneficial cooling (Taylor *et al*., 1986).

Table 1. Monthly maximum, minimum, and mean values of meteorological variables during 24 h and the experimental period (11.30 to 16.00 h) from June to August.

Meteorological variables	Maximum			Minimum			Mean		
Months	**6**	**7**	**8**	**6**	**7**	**8**	**6**	**7**	**8**
Duration	**24-hours**								
Ambient Temperature (°C)	41.00	43.00	41.00	20.00	20.00	22.00	29.08	31.31	31.82
Relative Humidity (%)	82.00	80.00	85.00	34.00	31.00	40.00	56.23	57.29	63.19
Temperature-humidity index	80.43	84.51	85.22	72.44	75.34	78.88	76.65	79.91	81.68
Wind Speed (m/s)	9.32	8.26	7.88	0.54	1.18	0.43	4.28	4.04	3.92
Solar radiation (W. H/m^2)	996.80	1001.29	967.50	0.00	0.00	0.00	332.31	334.34	296.92
Duration	11.30: 16.00-hours								
Ambient Temperature (°C)	41.00	43.00	41.00	30.00	31.00	33.00	36.63	37.75	37.35
Relative Humidity (%)	60.00	56.00	47.00	34.00	31.00	40.00	46.85	40.81	43.08
Temperature-humidity index	92.53	88.88	90.78	82.17	82.87	83.80	86.01	86.05	86.16
Wind Speed (m/s)	9.29	8.26	7.88	2.31	2.27	1.71	6.28	5.80	5.57
Solar radiation (W. H/m^2)	996.80	1001.29	967.50	358.96	406.07	240.77	771.00	791.79	721.70

Average WS recorded values ranged from 3.92 in August to 4.28 in June and 5.57 in August to 6.28 in June m/s in the summer season during 24 h, and trial period (11.30 - 16.00 h), respectively as shown in (Table 1). Data presented in Table 1 imply the availability of a sufficient source of natural ventilation that can be exploited to dry the hide of cows after getting wet by water in favor of improving the effectiveness and efficiency of the cooling process. Alters in wind speed affect the efficiency of the convection cooling process for cows (Davis and Mader, 2003). In the USA during heat stress, an effective wind speed ranges from 1.8 to 2.8 m/s recommended for dairy cows (Bailey *et al*., 2016). It is of interest to note that, during the heat period with elevation of humidity (e.g., via sprayers), efficient cooling cattle using air velocities above 1.0 m/s (Kadzere *et al*., 2002). Stowell (2000) showed that the process of evaporative heat loss reveals that the airflow must be sufficiently direct close to cattle and with a high speed that can remove air moisture-laden from cattle skin and hair coat, also, it is important to replace the air around cows continually with fresher, and drier air. Optimum cooling is achieved with 4-6 mile/hour continuous air speed combined with sprinklers (Brouk *et al*., 2004). Mader *et al*. (2006) reported the THI reduces by 1.99 units for every 1 m/s increase in wind speed.

Thermoregulatory Parameters

The impact of showering on thermoregulatory parameters for both lactating Friesian and crossbred Friesian dairy cows during humid-hot summer heat stress is presented in Table 2.

For the thermoregulatory parameters, there was a positive significant ($P<0.05$) influence due to showering treatment in both genotypes under the hot humid environment (Table 2). As affected by breed rectal temperature (RT), and pulse rate (PR) showed significant differences. However, respiration rate (RR), and skin temperature (ST) were affected insignificantly by the breed (Table 2).

Both showered Frisian (38.78° C) and Friesian × Baladi crossbred (38.75° C) cows showed the lower ($P<0.05$) RT compared to Friesian cows (39.30° C) in the control group. Cow welfare was improved by the showering with lower RT being observed in the cooled groups in both genotypes (Table 2).

Only if an animal can keep a RT below 38.5° C is deemed to have a normal body temperature (Igono *et al*., 1992). While under the heat period (THI 74.1±4.4) the healthy cows revealed a rectal temperature ≥ 39.5°C (Burfeind *et al*., 2012). Dairy cows have RT within normal ranges between 38.20°C and 39.10°C (Asmarasari *et al*., 2023). Current results indicated a 0.52° C and 0.36° C decrease in rectal temperature for both showered groups of Friesian and crossbred Friesian dairy cows, respectively was similar to the results of Chen *et al*. (2016) and Ahmad *et al*. (2018), noted 0.7° C and 0.3° C reductions, respectively, in body temperature of dairy cattle in response to showering.

As reported by Yameogo *et al*. (2021), RT can be used as an indicator to determine the heat stress start in cows which is generated by the microenvironment and nutrition. It is clear to note that, the performance of most livestock species reduced is associated with an increase in the RT by 1°C or less (Manica *et al*., 2022). Buckin and Bary (1998) observed a decrease of 0.4° C in the RT of cows treated to water sprinkling when compared with the control group. Nääs and Arcaro Jr. (2001) obtained decreasing from 0.4 to 0.5 °C in RT after using shading with sprinkling and ventilation. Spray causes drop in BT below the baseline by ~1.0°C, and this advantage can last for ~120 min (Flamenbaum *et al*., 1986). Chen *et al*. (2015) indicated that spray can reduce BT by approximately 0.1°C for 47 min only. In some studies, water cooling reduces BT for several hours after animals are exposed to water (Gaughan *et al*., 2004; Kendall *et al*., 2007). In addition, sprinklers can decrease body temperature for up to 6 h (i.e., after a 90-min treatment; Kendall *et al*., 2007). Similarly, others found remained in BT lower than controls for 1.5 h (Brown-Brandl *et al*., 2010) or even 2 to 4 h after spraying stopped (Araki *et al*., 1985; Kendall *et al*., 2007). Chen *et al*. (2015) applied ≥1.3 L/min, wind extended the duration, similar to when sprinklers are combined with fans (as reviewed by Collier *et al*., 2006). Bah *et al*. (2022) reported that shade alone can decrease the rectal temperature of Holstein Friesian cows throughout summer but is less effective than sprinklers which corroborated the present findings.

A significant decrease in RR ($P<0.05$) was found in both showering groups as compared with their counterparts in shaded groups during the experimental period. Respiration rate values under thermoneutral conditions between 40 to 55 bpm (Yousef, 1985). However, Tresoldi *et al*. (2018b) reported the RR ranged from 65 (typically to 95 breaths per minute at the afternoon). Our results indicated the cooling was efficacious in decreasing the RR of water-showered dairy cattle by approximately 19.71% (16.1 bpm) in the Friesian dairy cows and by approximately 14.29% (10.3 bpm) in the crossbred dairy cows compared with the RR in the dairy cows which in shade only (Table 2). Other studies have reported a decrease in RR caused by cooling, where the cows with a mean baseline RR of 88 bpm prior to cooling observed a decrease of 13 bpm after 48 min of cooling (Chen *et al*., 2015). Additionally, two cooling sessions a day resulted in a decrease of 23 bpm after implementing a cooling application. (Valtorta and Gallardo, 2004).

For heat-stressed cows shaded-only, RR was significantly ($P<0.05$) decreased with crossbred Frisian cows compared to Friesian cows (Table 2). A similar difference between Friesian and crossbred Friesian dairy cows during the summer on RR in favor of crossbred Friesian dairy cows (Shaarawy *et al*., 2023), substantiates the findings of the present study.

During the hot-humid summer, the raising of RT and RR values of cows in both shade-only groups illustrate that these cows endured heat stress since the elevation of RT and RR are normal mechanisms by which cows remove heat to conserve thermoregulation in heat ambient conditions (Yousef, 1985). In the present study, water showering provided greater cooling benefits in constant with other studies which found that the combination of cooling resources reduces rectal temperature and respiration rate than shade alone (Avendaño-Reyes *et al*., 2006; Chen *et al*., 2013).

The pulse rate (PR) was significantly ($P<0.05$) lower during hot-humid summer for Friesian and crossbred Friesian cows by showering treatment as compared to their counterparts kept under shade only. There were decreases insignificantly ($P>0.05$) between crossbred Friesian and Friesian cows entire the same treatment (Table 2).

In the hot-humid condition, PR was significantly ameliorated by both misting and splashing (Yadav et al., 2021b) in lactating cows and by wallowing (Yadav et al., 2016) in lactating buffaloes, which was in agreement with the current study. In normal dairy cows, PR ranged from 54 to 84 beats per min. (Chen et al., 2022). Livestock heart rate rises due to the heat stress induced by extreme ambient conditions. This is due to the increased in RR, which increases the activity of respiratory muscles to accelerate blood pumping to the surface of skin then release body heat. The increase in blood temperature directly effect on the heart and increases

PR. Peripheral vasodilation had effect on lowering the pressure of blood (Yameogo et al., 2021).

The performance of animals is a paramount challenge in tropical and subtropical zones because of high ambient temperatures, especially in summer months when ambient temperature elevates by more than 4°C as compared to the typical environmental temperature (Upadhyay *et al*., 2007). A significant correlation between THI (Table 1) and thermoregulatory parameters such as RT, RR, as well as PR was also noted by (Bouraoui *et al*., 2002) substantiating the findings of the present trial. On the same line, various authors (Ankush *et al*., 2014 and Sinha *et al*., 2017) reported significantly decreased RR and PR in dairy cattle kept under the cooling system with force ventilation and animals were more comfortable.

The skin temperature (ST) significantly ameliorated (P<0.05) in showering groups compared to shaded-only groups without significant differences between genotypes under the same treatment (Table 2). Similar trends were also observed by Tresoldi *et al*. (2018a) in lactating Holstein cows, corroborating the findings of the current study. Skin temperature is a potential input into the thermoregulatory system that represents an integration of several physical and physiological factors (e.g., hair coat properties, ambient temperature, cutaneous vasomotion, and sweat rate) (Spiers *et al*., 2018). Under heat stress conditions, the cows' skin temperature was closely related to their RR (Collier *et al*., 2017; Peretti *et al*., 2022).

Thermoregulatory parameters are critical indicators of animal welfare (Polsky and Von Keselink, 2017). The showering practice had a better animal welfare result because it had lower RT, RR, PR, as well as ST of the cows. Under hot-humid summer conditions, a higher rate of cutaneous evaporation (Fat-Halla, 1975) may be an important factor that impacts the better adaptation of Baladi × Friesian crossbred than pure Friesian dairy cows in hot-humid summer. However, skin cooling with sprinklers in combination with sufficient ventilation is a preferable solution for skin evaporative heat loss when the sweating rate is lesser than the potential evaporation rate, especially in dry climates (Chen *et al*., 2020). Thus, showering cows was more effective in reducing skin temperature than shade-alone cows during the experimental period.

In the current study, we applied to shower the cows for 30 min in one session taking into account that 13 minutes of water application was the minimum duration needed for the skin to reach a temperature similar to the water sprayed (Triesoldi *et al*., 2018a). As reported by Brouk *et al*. (2003), we enhanced the cooling benefits by exploiting sufficient WS (Table 1) directly to cows while their coat were drying. Designing of holding area open, permitting the wind to flow, and allowing for WS implications. Since WS during drying affects the magnitude of amelioration of some thermoregulatory parameters (Triesoldi *et al*., 2018a). Finally, despite the values of RT, RR, PR, and ST in crossbred Friesian cows being the lowest reflecting more heat tolerance, the amount of response of Friesian cows to showering was more effective for these parameters since using showering modulates the impact of harsh summer with body temperature for heat sensitive dairy cows.

Table 2. Influence of shade and shade with showers on thermoregulatory parameters for Friesian and Cross-bred Friesian dairy cows during summer conditions.

Items	RT	RR	PR	ST
Breed				
F	39.04^{b}±0.025	73.65±0.707	78.70^{a}±0.200	37.91±0.042
CF	39.93^{a}±0.025	66.95±0.707	71.55^{b}±0.200	36.59±0.042
P-value	0.0029	0.0511	0.0286	0.0544
Cool				
S	39.21^{a}±0.025	76.90^{a}±0.707	83.15^{a}±0.200	38.01^{a}±0.042
S + S	38.77^{b}±0.025	63.70^{b}±0.707	67.10^{b}±0.200	35.61^{b}±0.042
P-value	0.0009	0.0003	<0.0001	<0.0001
Breed × Cool				
F S	39.30^{a} ±0.036	81.70^{a} ±1.001	87.40^{a} ±0.283	38.28^{a} ±0.060
F S + S	38.78^{b} ±0.036	65.60^{bc} ±1.001	70.00^{bc} ±0.283	35.75^{b} ±0.060
CF S	39.11^{ab} ±0.036	72.10^{b} ±1.001	78.90^{ab} ±0.283	37.73^{a} ±0.060
CF S + S	38.75^{b} ±0.036	61.80^{c} ±1.001	64.20^{c} ±0.283	35.46^{b} ±0.060
P-value	0.0298	0.0040	<0.0001	0.0328

The values are the mean ± S.E.

The values with the different superscripts in the same column (a, b, and c) differed significantly (P<0.05); F, Friesian; CF, Crossbred Friesian; S, shade; S + S, shade with shower; RT, rectal temperature; RR, respiration rate; PR, pulse rate; ST, skin temperature.

Endocrine Parameters

The impact of showering on TSH, T_3, T_4, prolactin, cortisol, and IGF-1 during summer load in Friesian and crossbred Friesian dairy cows is illustrated in Table 3.

For the serum endocrinal parameters, there was an ameliorate significant (P<0.05, <0.0001) effect in both Friesian and crossbred Friesian dairy cows by cooling under the hot humid summer conditions (Table 3). During the experimental period, crossbred Friesian dairy cows had blood serum T_3, and IGF-1 concentrations were significantly higher (P<0.05), while, cortisol, T_4, as well as prolactin levels were significantly lower (P<0.05, <0.0001) as compared with Friesian dairy cows. However, TSH levels were not changed between groups (Table 3).

The serum prolactin concentration decreased significantly (P<0.05) in both showered groups as compared to the control groups, however, the prolactin level increased significantly (P<0.05) in Friesian shaded-only cows compared with crossbred Friesian shaded-only cows (Table 3). The cortisol decreased significantly (P<0.05) in showering groups than shaded-only groups without significant differences between genotypes under the same treatment (Table 3). Showering was able to increase significantly (P<0.05) triiodothyronine (T_3) level for both genotypes compared with shaded-only cows, whereas, the T_3 level was significantly (P<0.05) higher in crossbred Friesian control cows than in Friesian control cows. The thyroxin levels increased significantly (P<0.05) in showering groups than shaded-only groups without significant differences between genotypes under the same treatment (Table 3).

Endocrine alterations are of paramount prominence for heat stress acclimation (Lakhani *et al*., 2020; Yadav *et al*., 2021a). Thyroid hormones, prolactin and glucocorticoids are the main hormones implicated in the acclamatory response to heat stress (Kumar *et al*. 2018; Lakhani *et al*., 2020; Yadav *et al*., 2021a). Blood serum T_3 and T_4 have lower levels under heat stress during summer than their levels under normal conditions (Aleena *et al*., 2016). Since cows endure heat stress reduces their heat metabolic activities, and thus their heat production (Gaughan, 2012). Therefore, using means to mitigate the thermal load as showering is expected to improve thyroid activity (Aggarwal and Singh, 2009). The present results agree with the report of Al-Hassan (2018) reported cows kept under water spray plus shade had higher serum concentrations of T_3 and T_4 than cows under shade alone.

In the current study, heat stress-induced elevation in prolactin and cortisol (Kumar *et al*., 2018; Shaarawy *et al*., 2023; Yadav *et al*., 2015) has previously been demonstrated in cows under heat stress. Showering was found to be largely effective in inhibiting the elevation of prolactin and cortisol levels. Under heat stress conditions, the splashing reduces both prolactin and cortisol concentrations in lactating cows (Yadav *et al*., 2021b) which substantiates the results of the present study. The RT, RR, PR, cortisol, prolactin, as well as thyroxine levels were demonstrated to be functionally related to THI (Djelailia *et al*., 2021), corroborating present results.

Both showering groups of cows; Friesian (132.10 ng/ml) and crossbred Friesian (133.00 ng/ml) were significantly (P<0.05) higher IGF-1 levels than shaded-only groups; Friesian cows (118.20 ng/ml) and Crossbred Friesian cows (126.60 ng/ml) during hot-humid summer conditions (Table 3). A similar effect of providing more comfortable climatic condition was reported (Abd El-Hafeez *et al*., 2020) in Baladi calves. Heat stress in dairy cows can lead to a decrease in dry matter intake (DMI) (Fuquay, 1981), which can prolong the period of negative energy balance. This, in turn, can cause a reduction in the plasma level of IGF-I in lactating dairy cattle (Brown, 2010). Aggarwal and Upadhyay (2013) showed the level of IGF-1 decreases during heat stress in cows. As IGF-1 levels decrease in response to stress (McCusker, 1998; Carroll *et al*., 1999), was observed elevation in glucocorticoids can inhibit IGF-1 concentrations (MohanKumar *et al*., 2012). The current harmony in our results between cortisol concentrations and IGF-1 concentrations observed is consistent with previous studies.

Our results indicated that despite all dairy cows were endured some degree of heat discomfort, showering contributed to a somewhat enhancement for crossbred Friesian dairy cows than Friesian dairy cows in terms of welfare pointed out by endocrine parameters. However, Friesian cows responded to showering better than crossbred Friesian cows as compared with their counterparts which kept under shade only.

Blood biochemistry analysis

Serum biochemical metabolites, enzyme activity, and electrolytic concentrations, including glucose, cholesterol, triglyceride, total protein, albumin, ALP, ALT, AST, creatinine, Na, and K, there was a favorable significant (P<0.01) impact due to showering treatment in both Friesian and crossbred Friesian dairy cows under the hot humid environment (Tables 4 and 5). The insulin growth factor-1 (IGF-1), glucose, cholesterol, triglyceride, total protein, albumin, and ALP levels were significantly increased (P<0.05); while, ALT, AST, Na, as well as K levels, were significantly decreased (P<0.05). However, creatinine concentrations tended to decrease (P<0.1) in crossbred Friesian cows than in Friesian cows during the experimental period (Tables 4 and 5).

In the current study, the glucose, cholesterol, triglycerides, TP, creatinine, AST, Na, and K concentrations were altered by showering in both Friesian and crossbred Friesian cows significantly. Results revealed that these modulations perhaps a common metabolic enhancement for dairy cattle (regardless of breed) by showering during hot-humid summer conditions.

Table 3. Influences of shade (S) and shade with showers (S + S) on endocrine parameters for Friesian and Cross-bred Friesian dairy cows during summer conditions.

Items		TSH (µIU/ml)	T_3 (ng/ml)	T_4 (µg/dl)	Cortisol (µg/dl)	Prolactin (ng/ml)	IGF-1 (ng/ml)
				Breed			
F		0.720 ±0.013	1.81^{b} ±0.003	6.51^{a} ±0.016	18.76^{a} ±0.036	111.00^{a} ±0.438	125.15^{b} ±0.338
CF		0.750 ±0.013	1.85^{a} ±0.003	6.06^{b} ±0.016	17.85^{b} ±0.036	105.50^{b} ±0.438	129.80^{a} ±0.338
P-value		0.1122	0.0357	0.0491	<0.0001	0.0112	<0.0001
				Cool			
S		0.685^{b} ±0.013	1.70^{b} ±0.003	5.86^{b} ±0.016	20.76^{a} ±0.036	121.00^{a} ±0.438	122.40^{b} ±0.338
S + S		0.785^{a} ±0.013	1.95^{a} ±0.003	6.58^{a} ±0.016	15.85^{b} ±0.036	95.50^{b} ±0.438	132.55^{a} ±0.338
P-value		<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	0.0073
				Breed × Cool			
F	S	0.660 ±0.018	1.67^{c} ±0.004	5.52^{b} ±0.022	21.42^{a} ±0.051	125.00^{a} ±0.620	118.20^{c} ±0.479
F	S + S	0.780 ±0.018	1.94^{a} ±0.004	6.69^{a} ±0.022	16.10^{b} ±0.051	97.00^{c} ±0.620	132.10^{a} ±0.479
CF	S	0.710 ±0.018	1.73^{b} ±0.004	5.65^{b} ±0.022	20.10^{a} ±0.051	117.00^{b} ±0.620	126.60^{b} ±0.479
CF	S + S	0.790 ±0.018	1.96^{a} ±0.004	6.47^{a} ±0.022	15.60^{b} ±0.051	94.00^{c} ±0.620	133.00^{a} ±0.479
P-value		0.2849	<0.0001	<0.0001	0.0025	0.0049	<0.0001

The values are the mean ± S.E.

The values with the different superscripts in the same column (a, b, and c) differed significantly (P<0.05); F, Friesian; CF, Crossbred Friesian; S, shade; S + S, shade with shower; TSH, thyroid stimulating hormone; T_3, triiodothyronine; T_4, thyroxine; IGF-1, insulin growth factor-1.

The glucose concentration was increased significantly (P<0.05) in both showering groups compared to shaded-only groups while no significant differences were found between breeds (Friesian and crossbred Friesian cows) under the same treatment (Table 4). The mean serum values of glucose in Friesian dairy cows were found to be 61.20 and 68.40 mg/dl and in crossbred Friesian dairy cows were found to be 63.90 and 69.40 mg/dl for control and showering treatments, respectively during hot-humid conditions. A similar effect of cooling was found by Marai *et al*. (1995) in growing Friesian calves and Vijayakumar *et al*. (2011) in buffalo heifers. The elevation of glucose levels in the showered groups than in the control groups could reveal that showers reduced the heat burden due to enhanced heat dissipation in cows via evaporative cooling. Therefore, showering can also, decrease the cost of thermoregulation and downregulation of gluconeogenesis, as an endocrine acclimation as a result of reducing heat stress implications.

Table (4) showed a significant elevation (P<0.05) in blood serum cholesterol in both showering groups compared to the counterparts in control groups without any significant differences regard to breeds (Friesian and crossbred Friesian dairy cows) under the same treatment. Similar reports were also observed (Imbabi *et al*., 2019) in Egyptian buffaloes which corroborated the present finding. The previous studies showed that liver activity reduces during summer causing low cholesterol levels (Ronchi *et al*., 1999). Also, during heat stress it could be accounted for by changes in ruminal fermentation, in this respect, Verma *et al*. (2000) observed a reduction in acetate concentration, which is the primary precursor for the synthesis of cholesterol in heat-stressed lactating Murrah buffaloes. In contrast, Abdel-Samee and Ibrahim (1992) reported cholesterol levels increased insignificantly by spray cooling of heat-stressed lactating Holstein and Friesian cows under Egyptian conditions.

Triglyceride concentrations were significantly (P<0.05) elevated in both showered Friesian (25.46 mg/dl) and crossbred Friesian (26.84 mg/dl) cows as compared to in both shaded-only Friesian (20.90 mg/dl) and crossbred Friesian (23.58 mg/dl) cows during hot-humid summer. Also, shaded crossbred Friesian cows had a significant (P<0.05) increase in triglyceride concentrations as compared to shaded Friesian cows throughout the experimental period (Table 4). On the same line, (Teama, 2016) reported crossbred cows (Brown-Swiss × Baladi) in the thermal-neutral condition had considerably higher concentrations of triglycerides than those in the hot condition.

The total protein (TP) concentrations of Friesian and Friesian-Baladi crossbred dairy cows treated with water showering during hot humid summer conditions were positively impacted (P<0.05) compared to the lowest total protein concentrations of cows shaded only (Table 4). Similar reports were also observed (Abdel-Samee and Ibrahim, 1992) with dairy Holstein and Friesian cows and (Imbabi *et al*., 2019) with dairy Egyptian buffaloes which corroborated the present findings. In general, both genotypes of shaded-only cows have lower TP concentrations; this is perhaps attributed to the hemodilution impact, which occurs when more water is consumed for an evaporative cooling mechanism (Ali, 2001). Gao *et al*. (2006) attributed the enhancement of protein synthesis to the elevation levels of IGF-1 since it plays a vital role in various physiological processes. These findings are in agreement with the current results in Table 3.

Serum creatinine concentration showed an increase in both shaded-only cows compared to their counterparts in showering groups (Table 4). The heat load induce protein degradations and it used as a substrate for gluconeogenesis in energy production process to maintain euthymia which led to increase serum creatinine levels in the control groups (Yadav *et al*., 2016), thus the decrease in both showering groups could be justified.

Levels of sodium (Na) and potassium (k) were lower in shaded cows during the experimental period as compared to showered cows of both genotypes. In corroborates with the present results Yadav *et al*. (2016) indicated that wallowing use during hot humid conditions was significantly effective in maintaining normal potassium and sodium levels. Moreover, showering was observed to be more efficient in preventing a reduction because of the loss of Na and K concentration in crossbred-Friesian dairy cows (7.91 and 17.81%, respectively) than in Friesian dairy cows (5.86 and 9.88%, respectively). The decreased in electrolyte concentrations was attributed with their loss during sweating in cooling the body during heat stress, meanwhile, the cooled groups electrolyte levels did not changed because the heat loss from the body as a dampened skin surface by sprinkling was able to minimize animal heat load. Sprinkling helped in maintain sodium and potassium balance during summer stress in lactating Sahiwal cows (Yadav *et al*., 2021b).

Albumin, ALP, and ALT levels fluctuated by showering in Friesian dairy cows but not in crossbred Friesian cows, significantly or in a tendency.

Table 4. Influences of shade (S) and shade with showers (S + S) on serum biochemical metabolites, concentrations for Friesian and Cross-bred Friesian dairy cows during summer conditions.

	Glucose (mg/dl)	Cholesterol (mg/dl)	Triglycerides (mg/dl)	Total protein (g/dl)	Albumin (g/dl)	Creatinine (mg/dl)
			Breed			
F	64.80^{b} ±0.100	187.20^{b} ±0.222	23.18^{b} ±0.160	7.59^{b} ±0.013	3.74^{b} ±0.012	1.25 ±0.002
CF	66.65^{a} ±0.100	190.80^{a} ±0.222	25.21^{a} ±0.160	7.71^{a} ±0.013	3.80^{a} ±0.012	0.89 ±0.002
P-value	<0.0001	<0.0001	0.0143	0.0432	0.0014	0.0539
			Cool			
S	62.55^{b} ±0.100	172.50^{b} ±0.222	22.24^{b} ±0.160	7.36^{b} ±0.013	3.65^{b} ±0.012	1.12^{a} ±0.002
S + S	68.90^{a} ±0.100	205.50^{a} ±0.222	26.15^{a} ±0.160	7.94^{a} ±0.013	3.91^{a} ±0.012	0.93^{b} ±0.002
P-value	<0.0001	<0.0001	<0.0001	<0.0001	0.0032	<0.0001
			Breed × Cool			
F S	61.20^{b} ±0.142	169.60^{b} ±0.314	20.90^{c} ±0.226	7.28^{b} ±0.019	3.60^{b} ±0.017	1.16^{a} ±0.003
F S +S	68.40^{a} ±0.142	204.80^{a} ±0.314	25.46^{ab} ±0.226	7.90^{a} ±0.019	3.89^{a} ±0.017	0.94^{c} ±0.003
CF S	63.90^{b} ±0.142	175.40^{b} ±0.314	23.58^{b} ±0.226	7.44^{b} ±0.019	3.69^{ab} ±0.017	1.08^{b} ±0.003
CF S +S	69.40^{a} ±0.142	206.20^{a} ±0.314	26.84^{a} ±0.226	7.98^{a} ±0.019	3.92^{a} ±0.017	0.92^{c} ±0.003
P-value	<0.0001	<0.0001	0.0043	0.0429	0.0526	0.0349

The values are the mean ± S.E.
The values with the different superscripts in the same column (a, b, and c) differed significantly (P<0.05); F, Friesian; CF, Crossbred Friesian; S, shade; S + S, shade with shower.

Serum albumin levels were increased in both showering groups compared to their counterparts in shaded-only cows (Table 4). A similar effect for sprinkling was notified by Imbabi *et al*. (2019) for buffalos and Holstein lactating cows (Peretti *et al*., 2022). In normal conditions, liver produces albumin and increasing its synthesis can use as an indicator for liver health, this may be an indirect response for cooling in the present study which permits the liver to be more efficient due to the general physiological conditions of the animal (Koch *et al*., 2016).

Serum AST and ALP activities were measured to assess the influence of different heat stress-alleviating interventions either in growing calves (Marai *et al*., 1995) and in cows (Yadav *et al*., 2021b). Exposure to heat stress results in elevated levels of AST and reduced levels of ALP activity in dairy cows (Shaarawy *et al*., 2023). Results from the study indicate that shower treatment effectively maintained normal levels of serum AST and ALP (Table 5). Generally, current results indicate that showering has a degree of positive impact on biochemistry analysis in both purebred Friesian cows and crossbred Friesian cows which have experienced moderate heat stress. However, crossbred Friesian cows seem to respond better to showering than purebred Friesian cows.

Table 5. Influences of shade (S) and shade with showers (S + S) on serum enzyme activity, and electrolytic contents concentrations for Friesian and Cross-bred Friesian dairy cows during summer conditions.

Items		ALP (U/l)	ALT (U/l)	AST (U/l)	Na (mEq/l)	K (mg/dl)
				Breed		
F		61.16^{b} ±0.175	28.94^{a} ±0.051	66.70^{a} ±0.062	136.90^{a} ±0.142	4.25^{a} ±0.012
CF		63.04^{a} ±0.175	26.95^{b} ±0.051	63.30^{b} ±0.062	134.10^{b} ±0.142	3.97^{b} ±0.012
P-value		<.0001	0.0134	0.0008	<.0001	0.0375
				Cool		
S		58.12^{b} ±0.175	29.14^{a} ±0.051	67.55^{a} ±0.062	131.00^{b} ±0.142	3.85^{b} ±0.012
S + S		66.08^{a} ±0.175	26.75^{b} ±0.051	62.45^{b} ±0.062	140.00^{a} ±0.142	4.37^{a} ±0.012
P-value		0.0043	0.0035	<0.0001	<0.0001	0.0002
				Breed × Cool		
F	S	56.94^{b} ±0.248	30.28^{a} ±0.072	69.42^{a} ±0.088	133.00^{b} ±0.200	4.05^{b} ±0.017
F	S + S	65.38^{a} ±0.248	27.60^{b} ±0.072	63.98^{b} ±0.088	140.80^{a} ±0.200	4.45^{a} ±0.017
CF	S	59.30^{ab} ±0.248	28.00^{b} ±0.072	65.68^{b} ±0.088	129.00^{b} ±0.200	3.65^{c} ±0.017
CF	S + S	66.78^{a} ±0.248	25.90^{b} ±0.072	60.92^{c} ±0.088	139.20^{a} ±0.200	4.30^{ab} ±0.017
P-value		0.0531	<.0001	0.0001	<.0001	<.0001

The values are the mean ± S.E.
The values with the different superscripts in the same row (a, b, and c) differed significantly (P<0.05); F, Friesian; CF, Crossbred Friesian; S, shade; S + S, shade with shower; ALP, Alkaline phosphatase; ALT, Alanine aminotransferase; AST, Aspartate aminotransferase; Na, sodium; K, potassium.

Milk Production

Impact of showering on daily milk yield (DMY) is presented in Table 6. At the start of the experiment, each group of cows had a similar daily milk yield. Data showed significant decreased (P<0.05) in DMY among the experimental period in all groups. The results indicated that the decrease in DMY may be due to heat stress side by side with the advancing of lactation. A thermal environment is a crucial factor that can adversely influence milk production in cows. Heat stress can reduce nutrient intake (Joo *et al*., 2021). Studies have shown that reduced dry matter intake (DMI) accounts for 35 to 50% of heat-related milk production losses (Rhoads *et al*., 2009; Wheelock *et al*., 2010), and other thermoregulatory mechanisms (Baumgard and Rhoads, 2012) contribute. Also, as a direct effect of heat stress and nutrient reduction, cows do not display the normal metabolic profile (Wheelock *et al*., 2010). The thermoregulatory metabolic profile compounds as shown in our results of biochemistry analysis in Tables 4 and 5 was confirmed by Chen *et al*. (2013) who reported that sprinklers ability to moderate heat-related reduction in feeding time may be a mechanism for water cooling.

Mechanisms respond to showering; this could explain the treatment differences we found for DMY in response to nutrient intake. This is also ascribed to showering on the positive influence of minimize production losses in the summer. Avendaño-Reyes *et al*. (2010) confirmed the effectiveness of showering since they reported that after the cooling episode, the cows went directly to the feed bunk, suggesting a higher feed intake that may have increased their milk yield compared to non-cooled cows.

Average daily milk yield values decreased significantly (P<0.05) in all groups during the experimental period. However, the showering treatment prevented the precipitous decline that occurred in mean daily milk yield values in shaded-only groups (Table 6). Despite the negative impacts of heat stress and advancing lactation, it was observed that showering was highly effective in maintaining DMY in Friesen dairy cows as compared with crossbred Friesian dairy cows. Current results indicated that improving the DMY of water-showered dairy cows by approximately 9.42% (1.43 kg/d) in the Friesian dairy cows and by approximately 4.07% (0.65 kg/d) in the crossbred dairy cows compared with the DMY in their counterparts' cows kept in shade only (Table 6). The amelioration influences on cow milk production by water-cooling were suggested by Chaiyabutr *et al*. (2011) in crossbred Holstein Friesian cows, and in Holstein dairy cows (Domingos *et al*., 2013), as well as, in buffaloes (Imbabi *et al*., 2019; Yadav *et al*., 2016). Anderson *et al*. (2013) reported that dairy cattle produced 2 kg/day more milk under shade plus cooled using fans and spray as compared with dairy cattle shaded only. Showering showed more effective in heat loss because of conductive and convective heat dissipation prevailed, since the readily exchange of heat from the skin to water, which favor helps for additional heat loss from cows (Yadav *et al*., 2016). Regular daily showering with shade illustrated immediate and positive impacts on milk production.

The positive influences of showering on DMY of dairy cows can be induced by the decreased cost of thermoregulation mechanisms appearing in reduced RT, RR, and ST (Table 2) since there are significant relationships between them with raising milk production (Kou *et al*., 2017). In addition, reducing body temperature provides more nutrient utilization for milk synthesis and blood-borne by elevation in the circulating IGF-1 as shown in Table 3, by which the liver and mammary tissues contribute (Sammad *et al*., 2020; Bernabucci *et al*., 2010). Also, the increased availability of blood glucose (Table 4) originating from propionate favors greater milk production instead of being used to regulate body temperature, through insulin (Wheelock *et al*., 2010), which is partially inhibited by reduced prolactin (Table 3) (Dunshea *et al*., 2013), resulting in more glucose directed to the mammary gland for the synthesis of lactose (Wattiaux and Howard, 2022) then increase the produced milk (Herbut *et al*., 2019).

Table 6. Influences of shade and shade with showers on daily milk yield for Friesian and Cross-bred Friesian dairy cows during summer season months of June, July, and August.

Items	Levels	DMY (kg/d)	*P*-value
Breed	F	$15.90^{B}\pm0.057$	0.0002
	CF	$16.21^{A}\pm0.057$	
Cool	S	$15.48^{B}\pm0.057$	<0.0001
	S + S	$16.62^{A}\pm0.057$	
Month	June	$17.28^{A}\pm0.070$	<0.0001
	July	$15.90^{B}\pm0.070$	
	August	$14.98^{C}\pm0.070$	
Breed × Cool			
F	S	$15.18^{C}\pm0.081$	0.0003
F	S + S	$16.61^{A}\pm0.081$	
CF	S	$15.78^{B}\pm0.081$	
CF	S + S	$16.63^{A}\pm0.081$	
Breed × Month			
F	June	$16.97^{B}\pm0.100$	0.0213
F	July	$15.82^{C}\pm0.100$	
F	August	$14.91^{D}\pm0.100$	
CF	June	$17.59^{A}\pm0.100$	
CF	July	$15.98^{C}\pm0.100$	
CF	August	$15.04^{D}\pm0.100$	
Cool × Month			
S	June	$16.50^{B}\pm0.100$	0.0009
S	July	$15.41^{C}\pm0.100$	
S	August	$14.54^{D}\pm0.100$	
S + S	June	$18.06^{A}\pm0.100$	
S + S	July	$16.39^{B}\pm0.100$	
S + S	August	$15.41^{C}\pm0.100$	
Breed × Cool × Month			
June	F × S	$15.74^{F}\pm0.141$	<0.0001
	F × S+S	$18.19^{A}\pm0.141$	
	CF × S	$17.25^{C}\pm0.141$	
	CF × S+S	$17.93^{B}\pm0.141$	
July	F × S	$15.33^{J}\pm0.141$	
	F × S+S	$16.30^{E}\pm0.141$	
	CF × S	$15.50^{G}\pm0.141$	
	CF × S+S	$16.47^{D}\pm0.141$	
August	F × S	$14.48^{L}\pm0.141$	
	F × S+S	$15.35^{I}\pm0.141$	
	CF × S	$14.61^{K}\pm0.141$	
	CF × S+S	$15.47^{H}\pm0.141$	

The values are the mean ± S.E.
The values with the different superscripts in the same column (a, b, …, and l) differed significantly (P<0.05); F, Friesian; CF, Crossbred Friesian; S, shade; S + S, shade with shower; DMY, daily milk yield.

CONCLUSION

The quantum of improvement of purebred Friesian dairy cows by showering was more pronounced in the thermoregulatory, endocrinal, and biochemistry parameters, and milk production as expressing some of their genetic potentials were impeded by heat stress. Thus, showering reverts the negative impact of hot-humid Egyptian summer conditions in the Nile Delta on heat-sensitive exotic purebred dairy cows.

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تخفيف تأثير الإجهاد الحراري على أبقار الفريزيان والخليط فريزيان الحلابة عن طريق الاستحمام بالمياه في ظل ظروف الصيف المصري الحار الرطب في دلتا النيل

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الملخص

هدفت الدراسة الحالية إلى تقييم استجابة أبقار الفريزيان الأصيلة والأبقار الخليط فريزيان مع البلدي الحلابة خلال ظروف الصيف المصري الحار والرطب للاستحمام. تم إجراء التجربة العملية في الفترة من شهر يونيو حتى شهر أغسطس. تم تقسيم عشرة أبقار فريزيان وعشرة أبقار خليط فريزيان × بلدي حلابة متكافئة في أيام الحليب، وإنتاجية الحليب، وعدد المواسم عشوائيًا لأربعة مجموعات: مجموعتان ضابطتان من الأبقار حصلتا على الظل فقط (أبقار الفريزيان وأبقار خليط فريزيان)، وتم توفير الاستحمام لمجموعتين (أبقار الفريزيان وأبقار خليط فريزيان). تراوح دليل درجة الحرارة العظمى والرطوبة النسبية طوال التجربة العملية من ٨٠,٤٣ إلى ٨٥,٢٢. يجرى الاستحمام بمنطقة التحكم بالمحلب لمجاميع الابقار المعاملة يومياً. ارتفعت تركيزات الهرمون المحفز للغدة الدرقية، التراي-أيودو-ثريونين، الثيروكسين، عامل نمو الانسولين-١، الجلوكوز، الكولسترول، الدهون الثلاثية، البروتين الكلي، الألبومين، الفوسفاتيز القلوية، أيونات الصوديوم والبوتاسيوم، وإنتاج الحليب معنوياً (P <0.01)، بينما انخفضت كل من درجة حرارة المستقيم، ومعدل التنفس، ومعدل النبض، ودرجة حرارة الجلد، والكورتيزول، والبرولاكتين، والكرياتينين، ونشاط أنزيمات ألانين أمينو ترانسفيريز وأسبارتات أمينو ترانسفيريز في مصل الدم معنوياً (P <0.01) في الأبقار الفريزيان والخليط المعاملة بالاستحمام مقارنة بنظائرها في المجاميع الضابطة. في الختام، على الرغم من أن أبقار الألبان الخليط فريزيان مع البلدي تظهر قدرًا أكبر على تحمل الحرارة حيث حققت معايير أفضل للتنظيم الحراري والهرمونات والمركبات الكيميائية الحيوية بالدم وإنتاج الحليب، إلا أن مقدار التحسن في أبقار الألبان الفريزيان الأصيلة بالاستحمام يمكّن الأبقار من التعبير عن بعض إمكاناتها الوراثية التي يعوقها الإجهاد الحراري. وبالتالي، يمكن استخدام الاستحمام لتقليل تأثير ظروف الصيف المصرية الحارة والرطبة في دلتا النيل على أبقار الألبان الأصيلة الحساسة للحرارة.