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Climate control in the feeding area for Girolando cows: Effects on environmental and production variables[1]

Climatização em área de alimentação de vacas Girolando: Interferências nas variáveis ambientais e produtivas

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HIGHLIGHTS:

The adiabatic evaporative cooling system effectively maintained thermal conditions near the ideal for dairy cows.
The adiabatic evaporative cooling system led to a notable increase in total milk production compared to other environments.
Contents of protein, fat, and lactose in milk remained unaffected by varied climatization systems evaluated.

ABSTRACT: High-production cows require facilities providing comfortable environments to enhance production efficiency and sustain milk quality. This study evaluated the impact of climatizing the feeding area post-morning and afternoon milking on environmental variables, thermal comfort indices, and the yield and quality of milk in lactating Girolando cows. The experiment followed a 4 × 4 Latin square design with four treatments across four experimental periods, using four cows per treatment. The post-milking climate control treatments included: shading; shading + ventilation; shading + ventilation + shower; and an evaporative adiabatic cooling system. The evaporative adiabatic cooling system proved most effective in maintaining thermal conditions near the comfort level for dairy cows, as indicated by lower thermal comfort indices. This system also enhanced morning and overall milk production. However, the climate control systems did not significantly affect the contents of protein, fat, or lactose in the milk.

Key words: temperature, dairy cattle, thermal comfort, productivity

RESUMO: As vacas de alta produção necessitam de instalações que ofereçam ambientes amenos, para que ocorra aumento da sua eficiência produtiva e manutenção da qualidade do leite. Dessa forma, esse trabalho objetivou avaliar a influência da climatização da área de alimentação após o período das ordenhas matutina e vespertina sobre as variáveis ambientais, índices de conforto térmico, produtividade e qualidade do leite de vacas girolando em lactação. Foi utilizado o delineamento em quadrado latino 4 × 4, com quatro tratamentos e quatro períodos experimentais, com quatro animais por tratamento, totalizando 16 repetições. Os tratamentos foram os sistemas de climatização na pós-ordenha: sombreamento; sombreamento + ventilação; sombreamento+ ventilação+ ducha e sistema de resfriamento adiabático evaporativo. O sistema de resfriamento adiabático evaporativo aumenta a produção leiteira na ordenha da manhã e na produção total. Os teores de proteína, gordura e lactose não foram influenciados pelos sistemas de climatização estudados.

Palavras-chave: temperatura, bovinos leiteiros, conforto térmico, produtividade

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Introduction

Dairy cows, due to their inherent genetic characteristics and high production capacity, are particularly sensitive to heat stress. This susceptibility becomes especially pronounced during pregnancy and lactation periods (Bagath et al., 2019). Therefore, these animals must be housed in environments that offer optimal conditions, facilitating effective heat dissipation, and thereby enhancing both productivity and welfare (Nordlund et al., 2019).

Advances in animal genetics not only improve production capacities but also alter animal needs in terms of housing facilities, environmental and thermal comfort, as well as dietary and health management. This is especially true in tropical countries (Moedor et al., 2023). High-production cows need facilities that provide milder microclimates to optimize milk yield (Ahmed et al., 2022). Elevated temperatures correlate directly with thermal discomfort, leading to reduced food intake. This, in turn, diminishes milk production as the energy expenditure for maintaining homeostasis increases (Ji et al., 2019).

Another critical aspect to consider is Brazil's geographical position on the globe. A massive portion of the country lies within the intertropical zone, characterized by high solar radiation values. Averages often exceed 200 watts per square meter over the vast expanses of the territory (Zuluaga et al., 2021). Given this, the deployment of climate-control technologies in facilities dedicated to dairy production is crucial to counteract the detrimental effects of thermal stress on livestock (Becker et al., 2020).

Building on this context, our study sought to assess the impact of climatizing the feeding area post-milking on environmental variables, thermal comfort indices, and the yield and quality of milk in lactating Girolando cows.

Material and Methods

The study was conducted at the Piracanjuba Pró-Campo Farm situated at GO-020, km 48, in the rural area of Bela Vista de Goiás-GO. Positioned at a longitude of 16° 58' 22" W and an altitude of 803 m, the farm features an Aw-type climate, described as humid tropical with rainy summers and dry winters, according to the Köppen climate classification (Climate, 2019). The average annual temperature and rainfall are 23.1 °C and 1,355 mm, respectively.

The research spanned from October to December 2018, lasting 56 days. Throughout this period, the average temperature was 23.30 ºC with a humidity level of 79.05%.

All procedures involving the animals were approved by the Committee on Ethics in Animal Use (CEUA-PrP-UEG) under protocol 003/2018.

The study followed a 4x4 Latin square design with four treatments and four experimental periods. Each treatment included four animals, totaling 16 repetitions. The animals underwent each treatment in all evaluation periods. Each period lasted 14 days: the initial seven days for adaptation and the subsequent seven for data collection. The animals were grouped and identified using distinct earrings and necklaces. Their allocation to the different experimental groups was random (Table 1).

The animals were placed in the feeding area post-milking, both in the morning and afternoon, for approximately 30 minutes. The treatments were as follows: S - zinc roof shading (control); S+V - zinc roof shading combined with artificial ventilation; S+V+D - a combination of zinc roof shading, artificial ventilation, and shower; and EACS - an evaporative adiabatic cooling system associated with artificial ventilation and sprinkling.

Table 1 illustrates the rotation of treatments and animal groupings in the 4 × 4 Latin square design for the designated periods.

Each experimental period spanned 14 days, with the initial seven days dedicated to acclimating the animals to the treatments, and the subsequent seven for data collection. Environmental variables were recorded post-milking between 6:00 am to 7:00 am and 4:00 pm to 5:00 pm.

The experiment was set up in a Metalon-made shed, featuring a concrete floor, metallic pillars, and a zinc roof. The ceiling height was 4 m, and each environment under study measured 18 m² (4.5 × 4.0 m), providing 4.5 m² space per animal.

Two fans (Aero™ model) were assigned to each treatment (S+V, S+V+D, and EACS). These fans, powered by a ½ hp three-phase motor, had a 1 m diameter, ran at 1,130 rpm, and could generate an airflow of up to 4 m s^{-1}. They were installed 3 m above the ground, spaced 0.75 m apart, and angled at 40º to the floor.

Located at the milking outlet in the foot bath, the shower system comprised a half-inch PVC pipe with 20 holes of 0.8 mm diameter, ensuring a total flow of 42 L h^{-1}. With a coverage of 1 m and powered by gravity, the shower was activated by motion sensors, functioning only when an animal approached.

The EACS featured two yoke-model sprinkler nozzles with a 60 L h^{-1} flow rate and a range of approximately 2 m, spaced 1 m from each other. These sprinklers were positioned 2 m above the ground, targeting the animals. Additionally, two Aero™ fans, identical to those in other treatments, were incorporated into the system.

Sixteen lactating Girolando cows, each weighing around 500 ± 50 kg, were kept in a compost barn-intensive system. Their diet comprised moist corn grain silage, a concentrate based on soybean meal, and mineral supplementation. Feed quantities were adjusted according to each cow's production level and lactation phase. Animal groupings considered production level and DIL (days in lactation), which averaged 35 ± 10 kg of milk day^{-1} and 80 ± 40 days, respectively.

Table 1. Rotation of treatments and animal groupings in the 4 × 4 Latin square design

Treatment (environment)	Period 1	Period 2	Period 3	Period 4
S	Group 2	Group 1	Group 4	Group 3
S+V	Group 3	Group 2	Group 1	Group 4
S+V+D	Group 4	Group 3	Group 2	Group 1
EACS	Group 1	Group 4	Group 3	Group 2

S - Shading; S+V - Shading + ventilation; S+V+D - Shading + ventilation + shower; EACS - Evaporative adiabatic cooling system. Groups: Four animals per group

A mechanized, herringbone-style milking system was used, featuring a low line with six sets and a central ditch. Post-milking, cows were moved to their respective treatment zones for 30 minutes of acclimatization and subsequently taken to the compost barn facility. The acclimatization was initiated whenever the dry-bulb temperature (Dbt) exceeded 26 °C, a threshold identified as the upper critical temperature for lactating cows (Perissinoto & Moura, 2007).

To record environmental variables, HOBO ONSET™ H21-002 MicroStation data loggers were positioned in the center of each environment, 2 m off the ground. Each piece of equipment was equipped with three sensors: a dry-bulb temperature (Dbt) sensor (hobo air temperature and humidity model S-THB-M002), a wet bulb temperature (WBT) sensor (model S-TMB-M002, suitable for indoor, outdoor, and underwater use), and a black globe temperature (Bgt) sensor (model S-TMB-M002). These sensors offer an accuracy of ± 0.2 °C for Dbt and ± 2.5% for relative humidity (RH). Wind speed was measured using a Hikari model Hta-400 thermo-anemometer during acclimatization and positioned at the animals' height. These data were recorded every 15 minutes. An external Hobo digital thermohygrometer with an MX1101 data logger was placed 1.6 m high, near the holding pen. Internal holding pen sensors were located at a height of 2.5 m, centered in the setup.

Using the gathered environmental data, we determined the thermal comfort indices based on the subsequent equations:

Eq. 1 - THI - Temperature and Humidity Index (Thom, 1958):

$$\text{THI} = \text{Dbt} + 0.36 \cdot \text{Dpt} + 41.5 \qquad (1)$$

wherein:

Dbt - dry-bulb temperature (°C); and,
Dpt - dew-point temperature (°C).

Eq. 2 - BGTHI - Black Globe Temperature and Humidity Index (Buffington et al., 1981):

$$\text{BGTHI} = \text{Bgt} + 0.36 \cdot \text{Dpt} + 41.5 \qquad (2)$$

wherein:

Bgt - Black Globe Temperature (°C); and,
Dpt - dew-point temperature (°C).

Eq. 3 - TRL - Thermal Radiation Load (Esmay, 1969):

$$\text{TRL} = \tau(\text{MRT})^4$$
$$\text{MRT} = 100\left\{\left[2.51(\text{Ws})^{0.5} \cdot (\text{Bgt} - \text{Dbt}) + \left(\frac{\text{Bgt}}{100}\right)^4\right]\right\} \qquad (3)$$

wherein:

$\tau = 5.67 \times 10^{-8} K^{-4} W^{-1} M^{-2}$ (Stefan-Boltzmann constant).
MRT - Mean Radiant Temperature;
Ws - wind speed ($m\ s^{-1}$);
Bgt - black globe temperature (K); and,
Dbt - dry-bulb temperature (K).

Milk production was measured using six vacuum pressure gauges. These devices had a capacity of up to 37 kg and were connected to the milking system. Readings were taken on five alternate days throughout the experimental period during both morning and afternoon milkings.

Milk composition analyses were conducted on the 1st, 3rd, and 7th days of the data collection phase during the afternoon milking. This resulted in three individual collections for each cow and a total of 12 repetitions per treatment. Samples were directly sourced from the milk meter and stored in plastic containers that contained a Bronopol™ preservative tablet. These samples were then sent to the Milk Quality Laboratory (MQL) of the Federal University of Goiás for analysis of protein, fat, lactose content, and somatic cell count (SCC).

For the statistical analysis, it was employed the SisVar 5.6™ software (Ferreira, 2019). Initially, it was verified the homogeneity of variances and the normality of the residuals using the Shapiro-Wilk test. If needed, data were transformed using the square root method. Finally, mean values were compared using the Tukey test, with a significance threshold set at $p \leq 0.05$.

Results and Discussion

After the morning milking, significant differences in Dbt, Bgt, and Ws ($p \leq 0.05$) were observed as environmental conditions improved. The climatization treatments EACS, S+V, and S+V+D yielded better results than just shading (S) (Table 2). Temperature reductions were 1.7 °C for EACS, 1.4 °C for S+V+D, and 1.4 °C for S+V when compared to treatment S. Treatments S+V, S+V+D, and EACS showed no differences in Dbt and Bgt.

During the data collection period, spanning from October to December, the average dry bulb temperature was observed to be 23.3 °C, which is lower than the maximum value recommended for dairy cows (Dbt < 26 °C) as per Perissinoto & Moura (2007). Notably, even though the average Dbt remained below the critical threshold of 26 °C, the relative humidity surpassed the recommended 60%, averaging 79% throughout the study. This underscores the significance of using mechanisms to enhance environmental conditions and

Table 2. Mean values for environmental variables: dry bulb temperature (Dbt), black globe temperature (Bgt), relative air humidity (RH), and wind speed (Ws) following morning and afternoon milking, alongside their respective coefficients of variation and statistical probabilities

Environmental variable	Treatments				C.V. (%)
	S	S+V	S+V+D	EACS	
Morning					
Dbt (°C)	22.7 a	21.3 b	21.3 b	21.0 b	4.5
Bgt (°C)	23.2 a	21.6 b	21.7 b	21.3 b	4.8
RH (%)	96.6 a	98.1 a	98.4 a	92.4 b	5.2
Ws ($m\ s^{-1}$)	0.1 b	1.3 a	1.2 a	1.9 a	28.9
Afternoon					
Dbt (°C)	29.3 a	27.4 ab	27.1 b	24.7 c	10.0
Bgt (°C)	31.5 a	29.2 ab	28.5 b	27.1 b	12.7
Ws ($m\ s^{-1}$)	1.19 b	2.2 a	2.2a	2.2a	11.6

S - Shading; S+V - Shading + ventilation; S+V+D - Shading + ventilation + shower; EACS - Evaporative adiabatic cooling system. C.V (%)- coefficient of variation. Means followed by different letters in the rows differ from each other by Tukey's test ($p \leq 0.05$)

ensure animal welfare. In this study, one factor contributing to the favorable conditions was the local altitude, approximately 803 meters above sea level, which played a role in maintaining milder temperatures during the research period.

According to Perissinoto & Moura (2007), temperatures below 22 °C provide thermal comfort to animals, irrespective of the relative humidity levels. Only the control treatment (S) exhibited a Dbt value higher than recommended, while treatments S+V, S+V+D, and EACS effectively improved the environmental conditions for dairy cows. The enhanced efficiency of combined strategies in improving the thermal environment was also noted by Passini et al. (2013). These authors observed lower values of Dbt and Bgt in treatments that combined ventilation with reflective roof painting compared to using these strategies independently.

Ji et al. (2019) emphasized that Dbt values serve as a straightforward measure to assess the ongoing thermal conditions in which dairy cows are housed, furnishing crucial data that can inform decision-making. The most pronounced reduction in Dbt in this study was noted when comparing the EACS and S treatments. The cooling mechanism led to a drop of 1.7 °C, a figure statistically comparable to the reductions seen in the S+V and S+V+D treatments (where Dbt decreased by 1.4 °C). While this reduction in Dbt might seem marginal, recent scientific studies draw attention to climate change, which contributes to global temperature escalation. This directly affects dairy cow production (Key et al., 2014). Hence, any Dbt reduction should be considered significant, as it fosters a more favorable environment for dairy cows, promoting both animal welfare and enhanced productivity.

In this study, for the Bgt variable, the treatment S statistically differed from the other environments during the morning. Utilizing the Bgt variable is vital when aiming to regulate the thermal environment to guarantee animals remain within their thermal comfort zone (Zanetoni et al., 2019). The comfort range for dairy cattle lies between 7 and 26 °C (Mota, 2001), indicating that the environments in this research were within this comfort spectrum.

The EACS treatment yielded Bgt values that were 4.3 °C lower than those of the S treatment, aligning with findings by Silva & Passini (2017). In their study, these authors assessed Girolando cows during lactation within a climate-controlled setting equipped with sprinklers and ventilation in the holding area. This resulted in a Bgt decrease of 6.2 °C compared to the shaded environment. Similarly, Arcaro Júnior et al. (2003) noted a Tgn decrease when using sprinklers and ventilation in the waiting area - a reduction of 5.1°C in contrast to the non-climatized setting. These findings underscore the temperature-lowering impact of employing sprinklers and ventilation on the Tgn variable.

In our study, the wind speed for treatment S showed statistical differences from the other treatments when assessed after the morning milking. However, the ventilation system was not activated daily during the morning hours, given that the Dbt was below 26 °C. As a result, in the S+V, S+V+D, and EACS treatments, the air circulation rate was insufficient to reduce the RH, which remained notably high, averaging 96.4%.

Differences in the thermal comfort indexes, THI and BGTHI ($p \leq 0.05$), were statistically significant during the morning period, as shown in Table 3.

Statistical differences were evident between the S treatment and the other treatments - S+V, S+V+D, and EACS - for both THI and BGTHI indexes following the morning milking. The S, S+V, and S+V+D environments fell within the alert range for THI, suggesting that climatic conditions were at the edge of optimum for animal production.

According to Pires et al. (2010), a THI value of 70 or below is deemed ideal for optimal productive performance. This contrasts with Ji et al. (2019), who argued that THI values should be below 64, emphasizing that higher values adversely affect milk production. In this study, the environments S, S+V, and S+V+D exhibited THI values exceeding those suggested in the literature, indicating the need for additional measures to improve environmental conditions. Although the EACS environment showed a numerically lower THI than the other treatments (S+V and S+V+D), it might still pose stress to cows. Depending on the reference used for comparison, the THI values for EACS approach the upper limit of the comfort zone, potentially placing them outside the ideal range.

A statistical difference was observed between treatment S and the other treatments (S+V, S+V+D, and EACS) in terms of the BGTHI. The values for the environments were as follows: S (72.1), S+V (70.4), S+V+D (70.5), and EACS (69.9). The EACS displayed values 2.23 points lower on the index than the S system. This reduction in both indexes (THI and BGTHI) through ventilation is attributed to the wind's ability to refresh the barn's internal air, displacing the warm air and some of the humidity. Passini et al. (2013) investigated thermal indexes in poultry barns with varied climatization methods and found that ventilation reduced the BGTHI to 77.5, as opposed to 78 in barns without ventilation.

According to Ji et al. (2019), the average BGTHI should be below 78 for the environment to be deemed comfortable for cows without adversely affecting milk production. Based on the data presented earlier, all the treatments examined in this study managed to maintain the BGTHI below this critical threshold for dairy cows. However, the S treatment was the least efficient compared to the others. Dairy cows are overly sensitive to heat stress, which is intensified during pregnancy or lactation periods (Bagath et al., 2019). Therefore, any reduction in thermal comfort indexes achieved by the treatments studied is crucial for providing a more favorable environment for the cows.

Table 3. Average values of thermal comfort indexes: Temperature and Humidity Index (THI) and Black Globe Temperature and Humidity Index (BGTHI) for the morning, along with their respective coefficients of variation and statistical probabilities

Thermal index	Treatment				C.V. (%)
	S	S+V	S+V+D	EACS	
THI	71.6 a	70.1 b	70.1 b	69.6 b	1.6
BGTHI	72.1 a	70.4 b	70.5 b	69.9 b	1.7

S - Shading; S+V - Shading + ventilation; S+V+D - Shading + ventilation + shower; EACS - Evaporative adiabatic cooling system. C.V (%)- coefficient of variation. Means followed by different letters in the rows differ from each other by Tukey's test ($p \leq 0.05$)

As seen in Table 4, there were statistical differences between treatments for the environmental variables Dbt, Bgt, and Ws in the afternoon following milking ($p \leq 0.05$). The EACS treatment recorded the lowest Dbt value at 24.7 °C, setting it apart from the other treatments. The highest Dbt value was observed for the S treatment at 29.3 °C, while the treatments S+V and S+V+D posted intermediate values of 27.4 and 27.1 °C, respectively, and did not show significant differences between them. According to Perissinoto & Moura (2007), the thermoneutral range for dairy cows is between 4 and 26 °C. Only the EACS treatment achieved a Dbt value within this range, marking a reduction of 4.6 °C compared to the S treatment.

The data regarding Dbt and Bgt provide valuable insights into the thermal comfort conditions during the afternoon milking. It is evident that all implemented resources, to varying degrees, improved the thermal environment. Among them, the EACS treatment achieved the most significant reductions in Dbt and Bgt compared to the S treatment, with decreases of 4.6 and 4.4 °C, respectively. According to Mota (2001), the optimal environmental temperature should be maintained between 7 and 26 °C. Temperatures exceeding this range can induce thermal stress in animals.

Mondaca (2019), in a study involving Holstein cows, noted that when temperatures remained below 35 °C, an increase in wind speed led to less stressed animals. This was evidenced by a decrease in respiratory rates, especially at speeds exceeding 2.2 m s^{-1}. In the afternoon evaluations, significant statistical differences were observed for both the THI and BGTHI indexes among the different environments ($p < 0.05$). The S treatment exhibited the highest values for these variables (Table 4).

The S environment showed the highest THI values, while the EACS had the most favorable values. The other treatments displayed intermediate values. Compared to the S environment, the EACS treatment resulted in a reduction of 5.5 points in the THI, illustrating its effectiveness in enhancing the thermal comfort of cows. Yan et al. (2020) suggested that both THI and BGTHI are crucial indices for evaluating the environmental conditions under which dairy cows are raised, and hence being directly linked to welfare and productivity.

All treatments exhibited THI values exceeding the range deemed ideal for animals (THI < 70). Even the EACS treatment showed values within the alert range (73 to 78), surpassing the critical index which can impact milk production. This was similar to the S+V and S+V+D treatments. The S environment fell into the danger range (79 to 82), posing threats to the physiological functions of animals (Pires et al., 2010). Ji et al. (2019) noted that dairy cows' susceptibility to heat stress increases with their productivity, finding a THI threshold of < 69 for cows yielding 31 kg/cow/day. This underscores the importance of technologies that ensure a conducive environment for the animals.

Table 4. Average values of thermal comfort indexes: Temperature and Humidity Index (THI) and Black Globe Temperature and Humidity Index (BGTHI) for the afternoon

Thermal index	Treatment				C.V. (%)
	S	S+V	S+V+D	EACS	
THI	79.5 a	77.0 b	76.4 b	73.9 c	4.0
BGTHI	81.6 a	78.7 b	77.8 b	76.4 b	5.1

S - Shading; S+V - Shading + ventilation; S+V+D - Shading + ventilation + shower; EACS - Evaporative adiabatic cooling system. C.V (%)- coefficient of variation. Means followed by different letters in the rows differ from each other by Tukey's test ($p \leq 0.05$)

For the BGTHI in the afternoon, the S treatment had the highest averages, statistically distinct from the other treatments (S+V, S+V+D, and EACS). Ji et al. (2019) defined thermal comfort with BGTHI values up to 78, values from 78 to 98 as an alert situation and values above 98 as an emergency. Consequently, only EACS registered a value below the ideal range, while the average of S+V+D reached the upper limit of acceptability. Both S and S+V were beyond the comfort zone, falling into the alert category.

The findings of this study indicate that the employed methods (shading, ventilation, shower, and adiabatic cooling) can enhance environmental conditions to varying extents. However, additional strategies should be explored to achieve optimal conditions for the animals, ensuring that they express their full genetic production potential.

Regarding milk production, significant differences emerged during the morning milking for the EACS treatment. Total production revealed higher yields for the EACS and S+V+D treatments ($p < 0.05$). However, no significant differences in milk production were found during the afternoon milking (Table 5).

Cows in the EACS environment outperformed those in other environments in milk production, with a morning milking increase of 1.2 kg compared to the S environment. When comparing with the S environment, the increase in milk production was 0.5, 0.5, and 1.8 kg per day for S+V, S+V+D, and EACS treatments, respectively.

For total milk production, the environments S+V+D and EACS showed no statistical differences, recording values of 30.8 and 32.1 kg per day, respectively. However, the EACS environment differed from the S environment, registering an increase of 1.8 kg per day in total production.

Barbosa et al. (2004) reported lower milk production in crossbred Girolando cows that were sprayed with water before and after milking - enough to moisten their body surface. These cows showed milk production values of 11.7 kg per day, compared to 10.9 kg per day for cows that were not sprayed.

In a study on lactating cows in a waiting corral, Silva & Passini (2018) observed that the use of EACS, in comparison to a solely shaded environment, led to an average increase in total milk production of 1.38 kg per day. Such studies, targeting different areas of the milking parlors underscore the potential for enhancing the thermal comfort of animals waiting in handling areas.

Table 5. Averages of milk production (kg per day) in each treatment

Milk production	Treatment				C.V. (%)
	S	S+V	S+V+D	EACS	
Morning	17.9 a	17.3 b	17.7 b	19.1 a	16.5
Afternoon	12.4 a	12.5 a	13.1 a	13.0 a	16.4
Sum	30.3 b	29.8 b	30.8 ab	32.1 a	17.1

S - Shading; S+V - Shading + ventilation; S+V+D - Shading + ventilation + shower; EACS - Evaporative adiabatic cooling system. CV (%) - Coefficient of variation. Means followed by different letters in the rows differ from each other by Tukey's test ($p \leq 0.05$)

Table 6. Averages of milk composition contents: protein (%), fat (%), lactose (%), and somatic cell count (SCC, × 1000 mL^2) in each treatment

Compound	Treatment				C.V.
	S	S+V	S+V+D	EACS	(%)
Protein	3.3 a	2.5 a	2.5 a	3.3 a	4.8
Lactose	4.6 a	3.4 a	3.4 a	4.6 a	7.1
Fat	4.0 a	2.7 a	2.9 a	3.9 a	25.1
SCC	244.1 a	163.0 b	126.2 b	241.4 b	15.9

S - Shading; S+V - Shading + ventilation; S+V+D - Shading + ventilation + shower; EACS - Evaporative adiabatic cooling system. C.V (%)- coefficient of variation. Means followed by different letters in the rows differ from each other by Tukey's test ($p \leq 0.05$)

Regarding milk composition - specifically protein, lactose, and fat - no significant differences were discerned among the studied environments ($p < 0.05$). However, the SCC reached the highest value in the shading treatment, with a value of 244.1 (SCC, × 1000 mL^2) ($p < 0.05$) (Table 6).

The S treatment exhibited elevated SCC values; a phenomenon attributed to the thermal stress experienced by the animals in that setting. Such stress can compromise the animal's immune response, leading to a heightened risk of mastitis, which consequently raises the somatic cell count (SCC). Elevated temperatures combined with high humidity levels provide an ideal environment for the rapid proliferation of microorganisms, thereby enhancing vulnerability to infections (Ludovico et al., 2015).

Nascimento et al. (2013) defined milk quality through several factors, including proper handling parameters, physicochemical composition, and hygiene. Essential components like protein, lactose, fat, and mineral salts are indicative of milk's quality. These macromolecules are influenced by numerous factors, such as animal management techniques, breed differences, dietary changes, lactation period, body score, or exposure to stressful conditions. Nonetheless, factors such as climate control and the duration of exposure did not notably alter the milk's chemical composition.

In their research, Almeida et al. (2013) reported that varying cooling durations for dairy cows in waiting corrals - 10, 20, or 30 minutes - did not significantly influence the chemical composition or overall quality of the milk when compared with a non-acclimatized control. Parallel findings concerning protein, fat, and lactose in environments that were acclimatized with both ventilation and sprinklers were presented by Arcaro Júnior et al. (2003), with respective values being 3.15, 3.73, and 4.64%.

Conclusions

1. The evaporative adiabatic cooling system effectively maintained temperatures closer to the comfort range for dairy cows, as observed through the reduced values of the dry bulb and black globe temperatures, leading to lower thermal comfort indicesduring both morning and afternoon milkings.

2. The evaporative adiabatic cooling system increased total milk production when compared to other environments.

3. The contents of protein, fat, and lactose showed no significant variation across the different climatization systems assessed.

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