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*Short Communication*

# Effects of Summer Cooling Strategies on Post-Summer Cow Welfare: Evaluating Lameness and Behavior

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**Abstract:** The study aimed to compare the effect of different summer cooling strategies on post-summer lameness prevalence and behavior in Holstein Friesian cows. Twenty-one milking cows were randomly subjected to three different cooling strategies including: 1) a traditional approach (TRD), where cows were continuously cooled using a sprinkler during the daytime; 2) a reduced cooling strategy (2CS), which involved two cooling sessions of one hour each; and 3) increased cooling sessions strategy (4CS), with four cooling sessions daily. Each cooling session lasted for 1 h with a 12 min cycle (3 min water on and 9 min off) with a sprinkler flow rate of 1.25 L/min. The cows' lameness scores, lying behavior, standing behavior, and step counts were assessed during the post-summer period. The results revealed that the 4CS group had lower lameness prevalence compared to the TRD and 2CS groups ($p = 0.015$). Furthermore, the TRD and 2CS groups exhibited higher lying times and lower standing times during post-summer ($p < 0.05$), potentially indicating lameness pain and discomfort. Additionally, the step counts were lowest in the TRD group, followed by the 2CS and 4CS groups ($p < 0.001$). In conclusion, the continuous sprinkling (TRD) as a cooling strategy during summer showed potential negative consequences on post-summer cow welfare. The study highlights the significant influence of cooling strategies on post-summer cow welfare, emphasizing the need for considering long-term effects beyond the summer season.

**Keywords:** dairy cows; summer cooling strategies; post-summer lameness; cow behavior

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## 1. Introduction

Heat stress is one of the significant challenges faced by dairy cows in many parts of the world [1], which has been exacerbated by global warming [2]. Heat stress can lead to physiological and behavioral changes that have detrimental effects on the production and reproduction of dairy animals. Among high-yielding dairy cows, such as Holstein Friesians, the impact of heat stress is particularly severe due to their higher metabolic rate [3]. In Pakistan, these animals are exposed to extreme climatic conditions during the summer, characterized by high temperatures, humidity levels, and temperature-humidity index exceeding 45°C, 85%, and > 72, respectively [4,5]. These conditions have a significant impact on the productivity and welfare of dairy cows.

Various management strategies have been identified as effective in mitigating the negative effects of heat stress, with water sprinklers being commonly used for cooling dairy cows [5–7]. However, excessive sprinkler cooling may result in wet and softened hooves [8], increasing the risk of lameness. Furthermore, extended periods of standing under heat stress can contribute to lameness in cows [9], further compromising their productivity and welfare. Considering the economic losses associated with lameness [10], it is crucial to investigate the association between heat stress management strategies and their impact on lameness prevalence. Differences in the standing and lying time of cows

have been reported with different heat abatement techniques, such as cooling sessions [11] and varying sprinkler flow rates [5–7]. This study hypothesizes that increased standing time during summer, coupled with exposure to high ambient temperatures and humidity, may result in carryover effects of heat stress into the autumn months in the form of lameness.

Therefore, this study aims to assess the effects of different cooling sessions during the summer on post-summer lameness prevalence, production, and behavior in Holstein Friesian cows. By investigating the association between heat stress management strategies and lameness, this research aims to contribute to the development of effective interventions that can mitigate the negative impacts of heat stress on dairy cow welfare and productivity. The findings of this study will provide valuable insights for dairy farmers and industry stakeholders in implementing appropriate heat stress management strategies, ultimately improving the well-being and performance of Holstein Friesian cows in Pakistan and similar climatic regions.

## 2. Materials and Methods

### *2.1. Animals, Housing, and Management*

The study was conducted at the Dairy Animals Training and Research Center, University of Veterinary and Animal Sciences, Ravi Campus, Pattoki, Pakistan (31°03'43.9" N 73°52'36.1" E) from August to December 2019.

Twenty-one lactating Holstein Friesian cows, in late lactation, were selected for the study. The cows were housed in a naturally ventilated freestall shed, with a feed bunk separated from the standing area by a post and rail system. A rubber mat was placed on the concrete standing area in front of the feed bunk. Sprinklers were attached to the polyvinyl water pipe mounted along the feed bunk.

Cows were fed a total mixed ration and had ad libitum access to water as per the farm protocol. Milking was carried out twice a day, at 0600 and 2000 h, in a 6 x 6 herringbone milking parlor (GEA Farm Technologies GmbH-Westfalia surge D-59199 Bönen; Germany). This study was an extension of another trial, in the same experiment station, on evaluating cooling session strategies for dairy cows in summer. Further details on the feeding and management protocols can be found elsewhere [4].

### *2.2. Cooling Strategies in Summer Months*

The enrolled Holstein Friesian cows, with an average days in milk of 225.1 ± 47.5 and daily milk yield of 15.9 ± 4.0 kg (mean ± SD), were assigned to three different cooling strategies included: 1) traditional continuous cooling (TRD), where cows were continuously cooled using showers from 0700 h to 1800 h, representing a common practice in the region; 2) reduced cooling Strategy (2CS), which involved two cooling sessions of one hour each at 0700 and 1500 h; and 3) increased cooling sessions strategy (4CS), with four cooling sessions daily at 0700, 1000, 1500, and 1700 h. The sprinkler flow rate was set at 1.25 L/min, and a 12-minute showering cycle was implemented, consisting of 3 minutes of water on and 9 minutes off. Mechanical ventilation was also provided through fans located at the feed bunk and the freestall area.

The cooling strategies were implemented in the late summer months of August and September 2019. Following the completion of the cooling interventions, the cows were monitored until the end of December. This extended observation period allowed for the evaluation of post-summer variables and the assessment of any potential carryover effects or changes in the cows' behavior and welfare beyond the cooling period.

### *2.3 Post-summer Lameness Measures*

Lameness assessment was conducted on a weekly basis using a 5-point scale, following the method outlined by Sprecher et al. [12]. The scoring system ranged from 1 to 5, where a score of 1 indicated a cow with a normal gait and posture, while a score of 5

indicated a clinically lame animal. A score of 3 represented the threshold between clinically and subclinically lame cows. To evaluate lameness, each cow was given the opportunity to walk along a 50-meter stretch of flat concrete alley located within the shed.

### *2.4 Post-summer Behavioral Measures*

Behavioral recordings, including lying, eating, and standing time, were measured using the Nedap CowControl system (NEDAP, Groenlo, Netherlands). The system utilized neck collars fitted around the cows' necks to capture eating. In addition, leg data loggers were securely attached to the left hind legs of the cows using straps to track standing and lying times, as well as step counts. The behavioral data were collected on alternate days throughout the week.

### *2.5 Statistical Analyses*

All statistical analyses were performed using SAS software (SAS for Academics: SAS Institute Inc., Cary, NC). The behavioral data were aggregated into weekly means for analysis. The normality of the data was assessed using the Shapiro-Wilk test. For normally distributed data, analysis of variance was conducted using the Mixed procedure in SAS, following a completely randomized design. Mean differences were considered statistically significant at a $p$-value of ≤ 0.05.

## 3. Results and Discussion

### *3.1. Lameness Measures*

The results demonstrated a significant influence of cooling strategies on post-summer lameness scores in cows. It was observed that the TRD group had the highest post-summer lameness score, followed by the 2CS and 4CS groups. The mean lameness scores for the TRD, 2CS, and 4CS groups were 2.2, 2.0, and 1.4, respectively, with a standard error (SE) of 0.07 (Table 1). The higher lameness in the TRD group could be attributed to the continuous cooling strategy during summer months, which resulted in prolonged exposure to wet conditions for the cows. This is consistent with previous studies that found a correlation between standing on wet surfaces and lameness susceptibility [8,13]. Wet hooves are known to be softer and can increase the risk of lameness [8]. Furthermore, the cows that received less sprinkling during the summer months (2CS group) experienced prolonged standing time to dissipate body heat [4]. This extended standing had an extra stress on hooves that led to subsequent lameness issues following the summer months.

The summer cooling strategies also had a significant impact on the duration of post-summer lameness. Cows in the 4CS group had 5.6- and 5-week shorter duration of mild lameness (scores 2 and 3) compared to the TRD and 2CS groups, respectively (Table 1). However, the cows exposed to TRD and 2CS cooling strategies had a similar post-summer duration of mild lameness (11.6 vs. 11.0 weeks, respectively; SE = 1.0; $p$ = 0.015; Table 1). The shorter duration of lameness in the 4CS group compared to the 2CS group indicates that cows in the 4CS group experienced significantly less lameness, particularly among those with mild lameness scores. This reduction in lameness may be attributed to lower hoof stress in the 4CS group during the summer months, as they encountered less heat stress. In contrast, cows in the 2CS group had to stand for longer periods during the summer to dissipate heat [4], increasing stress on their hooves and leading to a more severe carryover effect in the form of prolonged post-summer lameness. Similarly, reduced exposure to wet conditions in the 4CS group during summer months, compared to the TRD group, may have had a less negative impact on hoof health, thus shortening the duration of lameness during the post-summer months. These findings indicate that the frequency and duration of cooling sessions during the late summer months affect the occurrence and severity of lameness in cows during the post-summer period.

**Table 1.** Effect of different summer cooling sessions on post-summer lameness and behavioral responses of Holstein Friesian cows

| Variables | Cooling Sessions[1] | | | SEM | *p*-Value |
|---|---|---|---|---|---|
| | TRD | 2CS | 4CS | | |
| Lameness measures | | | | | |
| Lameness prevalence (score) | 2.22[b] | 1.99[ab] | 1.44[a] | 0.007 | 0.005 |
| Mild lameness duration, weeks | 11.6[a] | 11.0[a] | 5.7[b] | 0.5 | 0.015 |
| Lying behavior | | | | | |
| Total lying time (h/day) | 11.4 | 11.4 | 10.7 | 0.12 | 0.012 |
| Lying bouts (no/24 h) | 10.04 | 9.63 | 9.84 | 0.48 | 0.447 |
| Average lying bout length (min/bout) | 74.44[ab] | 80.19[b] | 72.51[a] | 3.70 | 0.0253 |
| Feeding behavior | | | | | |
| Total feeding time (min/24h) | 379 | 385 | 406 | 16 | 0.007 |
| Feeding bouts (no/24 h) | 27 | 30 | 28 | 0.5 | 0.010 |
| Average feeding bout length (min/bout) | 14.9 | 14.8 | 13.5 | 0.5 | 0.103 |
| Standing behavior | | | | | |
| Total standing time (h/day) | 12.6 | 12.6 | 13.3 | 0.4 | 0.012 |
| Standing bouts (no/24 h) | 10.3 | 10.0 | 10.4 | 0.4 | 0.415 |
| Average standing bout length (min/bout) | 78 | 75 | 77 | 4 | 0.746 |
| Step counts (no/24 h) | 3575[a] | 4093[b] | 4434[c] | 61 | < 0.001 |

[a–c] Values with different superscripts in a row are significantly different ($p \leq 0.05$).
[1] Cooling sessions: 1) a traditional approach (TRD), where cows were continuously cooled using a sprinkler during the daytime; 2) reduced cooling strategy (2CS), which involved two cooling sessions of one hour each; and 3) increased cooling sessions strategy (4CS), with four cooling sessions daily. Each cooling session lasted for 1 h with a 12 min cycle (3 min water on and 9 min off) with a sprinkler flow rate of 1.25 L/min.

### *3.2. Behavioral Measures*

Summer cooling strategies significantly influenced post-summer behavioral measures (Table 1). During the post-summer months, cows in the TRD and 2CS groups spent approximately 0.7 hours (42 minutes) more per day lying down compared to those in the 4CS group (11.4 and 11.4 vs. 10.7 hours per day, respectively; SE = 7; Table 1). Conversely, the TRD and 2CS groups spent about 0.7 hours less time standing per day than the 4CS group (12.6 and 12.6 vs. 13.3 hours per day; SE = 7; Table 1). The increased lameness observed in the TRD and 2CS groups may explain their higher lying time and reduced standing time during the post-summer period [14], as these cows likely experienced pain during standing and lying, leading them to avoid these behaviors. These findings could be explained by the summer cooling strategies. As described earlier, the 4CS group exhibited less lameness in the post-summer months compared to both the 2CS and TRD groups. The TRD group, having continuous showering, experienced continuous exposure to wet conditions during the summer, which likely contributed to increased tissue softness and, consequently, higher lameness levels in the post-summer period. On the other hand, the 2CS group had less sprinkler cooling during the summer and thus faced greater heat stress compared to the 4CS group. To manage this heat stress, cows in the 2CS group had to extend their standing times to enhance heat dissipation through increased exposure of the body surface [4]. This strategy led to prolonged standing periods, which placed additional stress on their hooves. The increased standing time during the

summer had a carryover effect, resulting in higher instances of lameness in the post-summer period in 2CS compared to the 4CS.

Cows in the 4CS group spent on average 21 minutes more per day feeding compared to those in the TRD and 2CS groups (406 vs. 379 and 385 minutes per day, respectively; SE = 4; Table 1). This suggests that summer cooling strategies may also influence post-summer feeding time, which is a critical factor for total feed intake and, consequently, milk production. Step counts varied significantly across the cooling strategies, with the lowest counts observed in the TRD group, followed by the 2CS and 4CS groups (Table 1). The reduced step count in the TRD group may also be a strategy to avoid pain, as discussed earlier.

## 5. Conclusions

In conclusion, the findings of this study highlight the significant impact of summer cooling sessions on post-summer lameness prevalence and the lying and standing behavior of cows. Interestingly, continuous showering as a cooling method during summer showed potential negative consequences on post-summer cow welfare. These findings emphasize the importance of considering the long-term effects of cooling strategies on cow well-being beyond the summer season. Further research and alternative cooling approaches are warranted to optimize cow welfare and productivity throughout the year.

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