Caspian Journal of Environmental Sciences
Online ISSN: 1735-3866
Print ISSN: 1735-3033

Impact analysis of cow skin cleaning methods on heat stress

Yurij G. Ivanov, Dmitry A. Ponizovkin*, Arina A. Odintsova

Russian State Agrarian University – Moscow Timiryazev Agricultural Academy, 49 Timiryazevskaya St., Moscow, 127434, Russian Federation

* *Corresponding author's E-mail: dponizovkin@rgau-msha.ru*

ABSTRACT

In this study, three types of skin cleaning: dry, wet, and wet cleaning with special cleaning agents were compared. It was conducted on six Holstein cows using a special climate camera. The methodology consisted of registration of skin temperature and pulse rate of cows under the temperature of 25 °C to 35 °C, relative humidity from 50% to 75%, and airspeed from 0.5 to 2.0 m s^{-1} using different methods of skin cleaning. The study was conducted over four days: before and after skin cleaning with different methods. The skin temperature was recorded in three areas using a pyrometer and thermal camera. It was determined that by temperature increasing from 25 °C to 35 °C and relative humidity from 50 % to 75 %, the skin temperature was increased by 14.3% using dry cleaning, by 11.8% using wet cleaning, while by 11.6 % using wet cleaning with a special cleaning agent. After wet cleaning, the pulse rate in animals decreased to 9.5%, and after wet cleaning with a special cleaning agent, it was 10.7% higher than before skin cleaning. Also, the pulse rate decreased after the wet cleaning by 9.5% and after wet cleaning with a special cleaning agent by 10.7%, which allowed about reducing the influence of heat stress with skin cleaning under higher temperatures and relative humidity. Moreover, an increase of the airspeed directed at the animal from 0.5 m s^{-1} to 2.0 m s^{-1} reduced the increase in skin temperature during dry cleaning to 12.0%, during wet cleaning up to 8.4%, and during wet cleaning with special cleaning agents up to 8.1%. Experiments proved that the researched skin cleaning methods decreased the elevation in body surface temperature, increased heat transfer and sweat evaporation, upraised heat exchange between cows and the environment, and reduced the impact of heat stress. The most effective methods of decreasing heat stress are wet cleaning and wet cleaning with special cleaning methods compared with dry cleaning methods.

Key words: Dairy cattle, Microclimate, Heat stress, Skin cleaning, Holstein cows.
Article type: Research Article.

INTRODUCTION

Many studies confirm that under heat stress, different physiological characteristics appear: increasing breathing rate, pulse rate, body temperature changes insignificant, increasing skin temperature, sweating begins, physical activity decreases, quantity and feed content change and act. It is noted that by reducing temperature and relative humidity and increasing airflow speed, the effect of heat stress can be reduced (Berman 2003, 2005; Ivanov *et al.* 2020). Quantitative values of the pulse rate increase and breathing that characterize the degree of stress on animals under the hot period were established. It was proved that these values are restored under the airflow (Truhachev 2016, 2017; Ivanov *et al.* 2020). Besides this, skin condition also influences the animal reaction (Berman 2004). Evaporating cooling is the main method for heat stress relief in cattle kept indoors. It is most effective in hot and dry climates (Berman 2009). The effectiveness of combining the forced air supply and humidiation of the surface in animals was proved (Berman 2019). The research established the prospects of skin cleaning application with the airflow. However, it was carried out in narrow-minded diapasons: At air temperature 20-30 ℃, and air speed 0.2 m s^{-1}, the skin cleaning was in certain areas 150 × 150 mm (Ivanov *et al.* 2020). The analysis established that

Caspian Journal of Environmental Sciences, Vol. 22 No. 5 pp. 1087-1095 Received: March 06, 2024 Revised: July 23, 2024 Accepted: Aug. 13, 2024
DOI: 10.22124/CJES.2024.8238

Publisher: University of Guilan

the influence of cleaning methods on reducing heat stress for cows was not regarded in the preceding experiments. The aim of the research is to determine the performance evaluation of the efficiency of skin cleaning methods for dairy cattle in decreasing heat stress in hot conditions at air temperatures 25 - 35 ℃, relative humidity 50 - 75%, air speed 0.5 - 2.0 m s^{-1} and complete cleaning of the cow 's body.

MATERIALS AND METHODS

The research determined the effectiveness of different cleaning methods by determining pulse rate and skin temperature. The evaluation method for reducing heat stress is based on the reaction of the cow's thermoregulatory apparatus by releasing excess heat accumulated in the body. An increased heart rate allows excess heat to be removed from animals' internal organs and transferred to the skin's surface through the animal's circulatory system. The use of skin cleansing leads to a decrease in the elevated body surface temperature, an upraise in heat transfer to the environment, and an increase in the intensity of sweat evaporation, which reduces the impact of heat stress. The pulse rate and skin temperature of cows were measured as the air temperature increased from 25 to 35 °C (in increments of 2.5 °C). The studies were carried out at relative air humidity of 50.0, 62.5, and 75.0% and air flow speed directed from the fan to the animals: 0.5, 1.0, and 2.0 m s^{-1}. The studies were carried out in a climate chamber on 12 Holstein cows during the lactation period. It compared the pulse rate in the temperature range from 25 to 35 °C (in increments of 2.5 °C), which was created using the air heat generator. The skin temperature is measured with the same diapason in three areas, which is averaged for each level. The research was conducted under relative humidity of 50.0, 62.5, and 75.0%, and airflow speed directed at the animals: 0.5, 1.0, and 2.0 m s^{-1}. The research was conducted on six Holstein cows during the lactation period. The initial meanings of the pulse rate and skin temperature were recorded under natural pollution with sweat, dust, manure particles, feed, and bedding. The first method involves cleaning with a manual scraper, which removes contamination from the skin. The second method involves skin cleaning with water. A hand brush is moistened with water, and dirt is washed off the skin. The third method involves cleaning with a water solution of the veterinarian-approved detergent. The measurement was carried out an hour after cleaning. To measure skin and body temperature, a pyrometer and a thermal imager were used. For calculations, the average value of the temperature of the lateral surface of the cow's body was used. The error in measuring body temperature does not exceed 0.1 °C. Temperature, relative humidity, and air velocity were recorded using a standardized measuring device. A pyrometer and thermal camera fix the skin temperature remotely. A special standardized measuring instrument fixes the temperature, relative humidity, and air speed. During the research, the animal was in the microclimate camera in the shade; direct sunlight and enclosing structures did not affect it.

RESULTS AND DISCUSSION

With natural contamination of the skin of animals, when no cleaning was carried out, at an air temperature (ta) of 25 ° C, relative humidity (ja) of 50%, and an airflow speed of 0.5 m s^{-1}, the pulse rate averaged 60 beats min^{-1}. By an elevation in temperature from 25 °C to 35 °C, a constant relative air humidity of 50%, and an airflow speed of 0.5 m s^{-1}, the pulse rate increased by 21.7% to 73 beats min^{-1} (Fig. 1). At an airflow speed of 1.0 m s^{-1}, the pulse rate increased by 18.3% from 60 to 71 beats min^{-1}; at 2.0 m s^{-1}, it increased by 13.3% from 60 to 68 beats min^{-1}. At the same time, the temperature of the skin changed by 8.0% from 33.2 °C to 35.9 °C at 0.5 m s^{-1}; by 6.4% to 35.4 °C at 1.0 m s^{-1}; and by 5.5 % at 2.0 m s^{-1} from 33.2 to 35.0 °C. When the relative humidity was 62.5% by an airflow speed of 0.5 m s^{-1}, the change in pulse rate was 26.7% from 60 to 76 beats min^{-1}. At 1.0 m s^{-1}, it increased by 23.3% from 60 to 74 beats min^{-1}; at 2.0 m s^{-1}, the increase was 18.3% from 60 to 71 beats min^{-1} (Fig. 2). At a relative air humidity of 75.0% and an airflow speed of 0.5 m s^{-1}, the pulse rate increased by 40.0% from 60 to 84 beats min^{-1}; at 1.0 m s^{-1}, the increase was 36.7% from 60 to 81 beats min^{-1}; by 2.0 m s^{-1}, it was 31.7% from 60 to 79 beats min^{-1} (Fig. 3). After skin cleaning with a hand scraper, at an air temperature (ta) of 25 °C, relative humidity (ja) of 50%, and an airflow speed of 0.5 m s^{-1}, the pulse rate averaged 60 beats min^{-1}. By an elevation in temperature from 25°C to 35 °C, a constant relative air humidity of 50%, and an airflow speed of 0.5 m s^{-1}, the pulse rate increased by 13.3% to 68 beats min^{-1}. At 1.0 m s^{-1}, it increased by 10.0% from 60 to 66 beats min^{-1}; and at 2.0 m s^{-1}, increased by 8.3% from 60 to 65 beats min^{-1}. In addition, the skin temperature changed by 7.3% from 33.1 °C to 35.7 °C at 0.5 m s^{-1}; by 6.7% from 33.0 °C to 35.2 °C at 1.0 m s^{-1} and by 5.5% at 2.0 m s^{-1} from 33.1 °C to 34.9 °C. At a relative humidity (ja) of 62.5% and an airflow speed of 0.5 m s^{-1}, the pulse rate changed by 18.3% from 60 to 71 beats min^{-1}. At 1.0 m s^{-1}, it increased by 16.7% from 60 to 67 beats min^{-1}; and at 2.0 m s^{-1}, increased by 11.7% from 60 to 67 beats min^{-1} (Fig. 4). At a relative humidity (ja) of 75.0% and an airflow speed of 0.5 m s^{-1}, the pulse rate changed by 31.7% from 60 to 79 beats min^{-1}. At 1.0 m s^{-1}, it increased by 26.7% from 60 to 76 beats min^{-1}; and at 2.0 m s^{-1}, increased by 21.7% from 60 to 73 beats min^{-1} (Fig. 5).

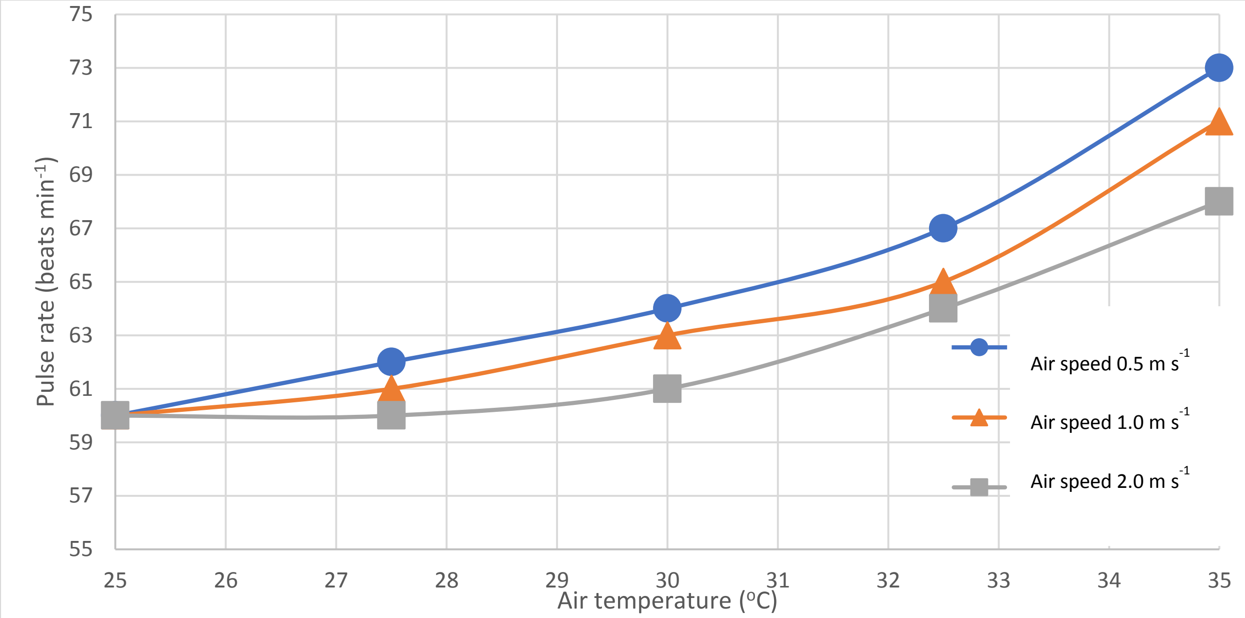

Fig. 1. A trend of pulse rate in natural pollution (φ_a = 50%).

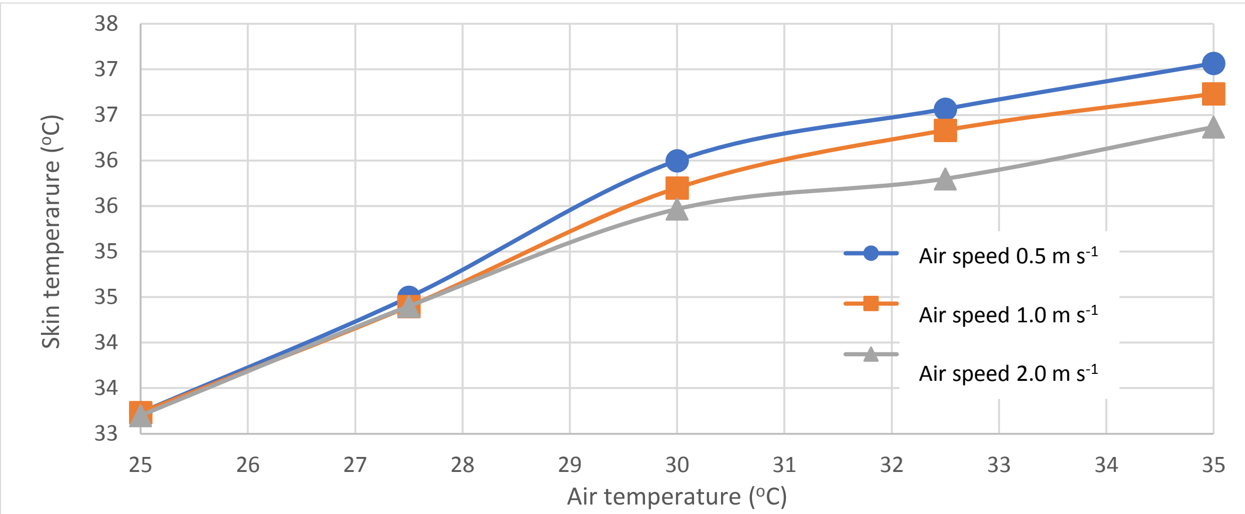

Fig. 2. A trend of skin temperature in natural pollution (φ_a = 62.5%).

After wet skin cleaning with a brush and water at an air temperature (ta) of 25°C, relative humidity (ja) of 50%, and an airflow speed of 0.5 m s^{-1}, the pulse rate averaged 60 beats min^{-1}. By an elevation in temperature from 25 °C to 35 °C, a constant relative air humidity of 50%, and an airflow speed of 0.5 m s^{-1}, the pulse rate increased by 11.7% to 67 beats min^{-1}. At 1.0 m s^{-1}, it increased by 8.3% from 60 to 65 beats min^{-1}; and at 2.0 m s^{-1}, increased by 3.3% from 60 to 62 beats min^{-1}. At the same time, the skin temperature changed by 5.8% from 32.1 °C to 34.0 °C at 0.5 m s^{-1}; by 4.0% from 31.9 °C to 33.1 °C at 1.0 m s^{-1}; and by 3.4% at 2.0 m s^{-1} from 31.6 °C to 32.7 ° C.
At a relative humidity (ja) of 62.5% and an airflow speed of 0.5 m s^{-1}, the pulse rate changed by 16.7% from 60 to 70 beats min^{-1}. At 1.0 m s^{-1}, it increased by 13.3% from 68 to 66 beats min^{-1}; and at 2.0 m s^{-1}, increased by 10.0% from 60 to 66 beats min^{-1}.

A trend of skin temperature is presented in Fig. 6. At a relative humidity (ja) of 75.0% and an airflow speed of 0.5 m s^{-1}, the pulse rate changed by 26.7% from 60 to 76 beats min^{-1}. At 1.0 m s^{-1}, it increased by 20.0% from 60 to 72 beats min^{-1}; and at 2.0 m s^{-1}, by 16.7% from 60 to 70 beats min^{-1}. Fig. 7 presents a trend of skin temperature.
After wet skin cleaning with a brush with water and cleaning agent at an air temperature (ta) of 25°C, relative

humidity (ja) of 50%, and an airflow speed of 0.5 m s^{-1}, the pulse rate averaged 60 beats min^{-1}.

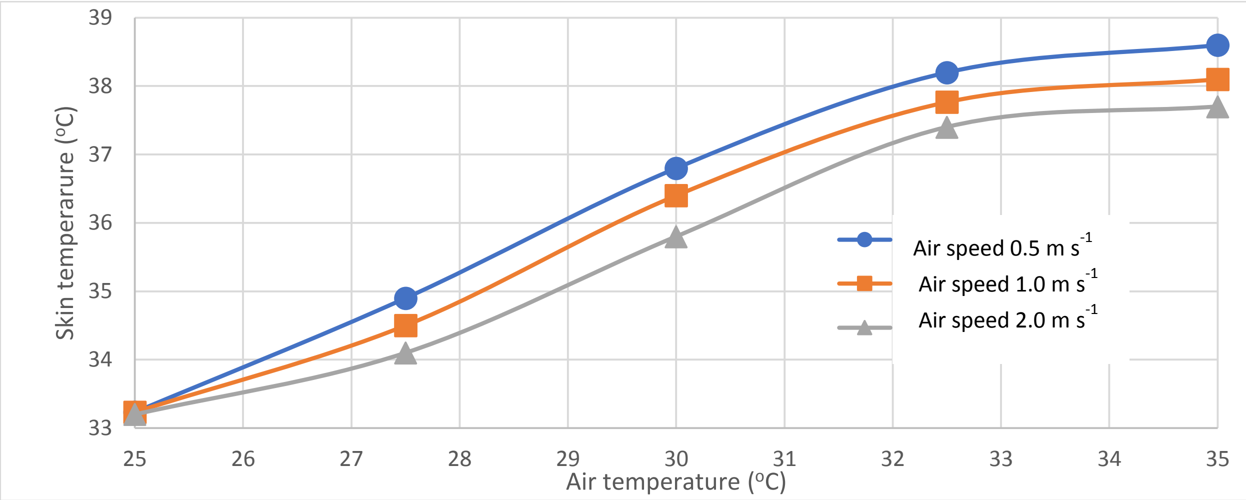

Fig. 3. A trend of skin temperature in natural pollution (φ_a = 75.0%).

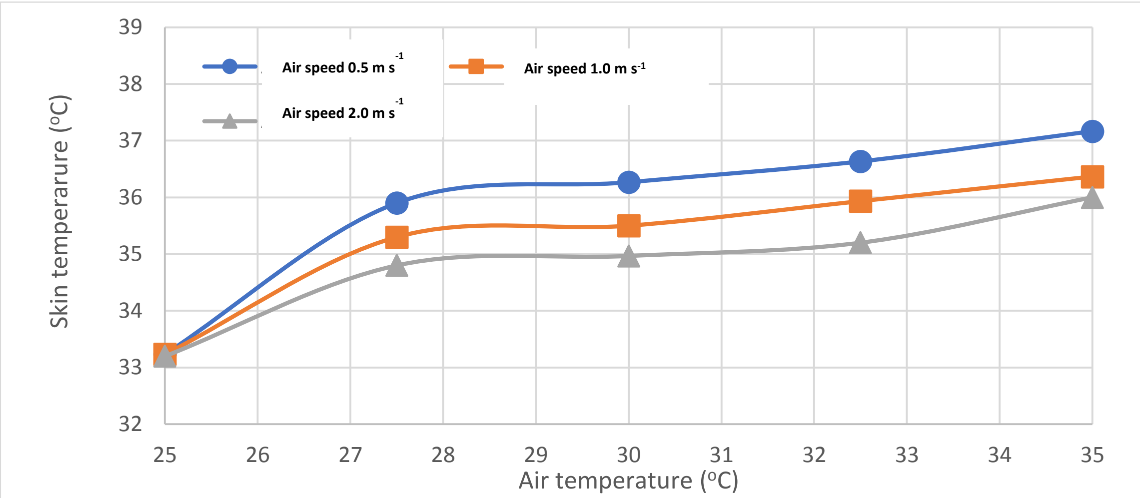

Fig. 4. A trend of skin temperature with the skin cleaning with hand-scrubbing brush (φ_a = 62.5%).

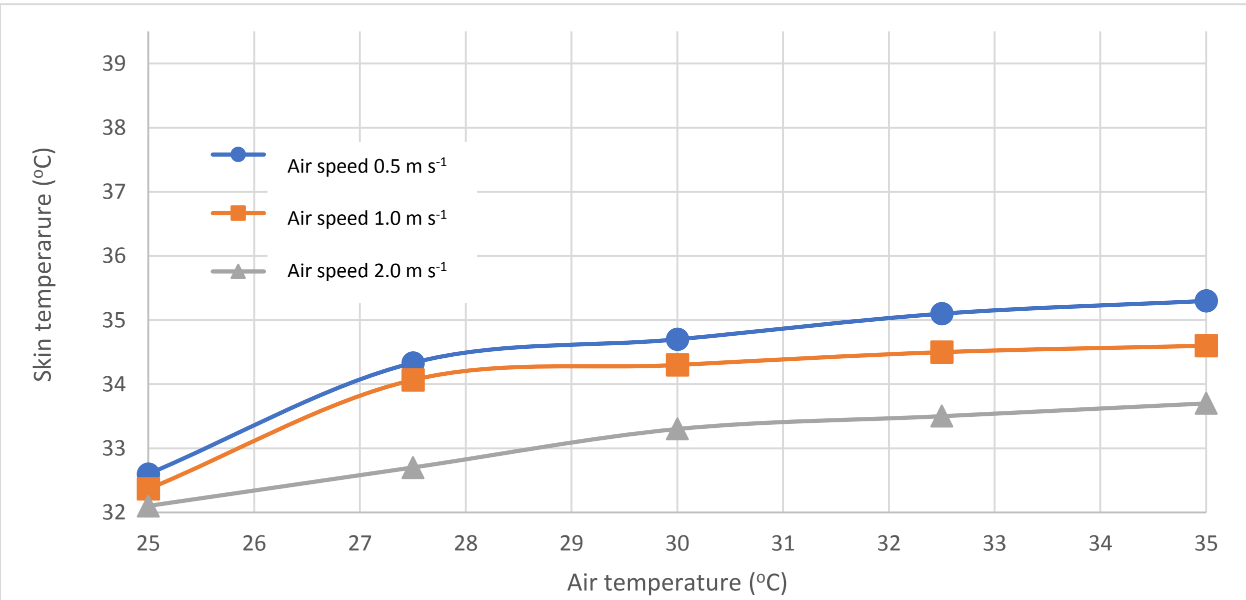

Fig. 5. A trend of skin temperature with the skin cleaning with a hand-scrubbing brush (φ_a = 75.0%).

By an elevation in temperature from 25 °C to 35 °C, a constant relative air humidity of 50%, and an airflow speed of 0.5 m s^{-1}, the pulse rate increased by 11.7% to 67 beats min^{-1}. At 1.0 m s^{-1}, it increased by 6.7% from 60 to 64 beats min^{-1}; and at 2.0 m s^{-1}, increased by 3.3% from 60 to 62 beats min^{-1}. At the same time, the skin temperature changed by 5.6% from 32.1 °C to 33.9 °C at 0.5 m s^{-1}, by 3.8% from 31.8 °C to 33.0 °C at 1.0 m s^{-1}; and by 3.1% at 2.0 m s^{-1} from 31.6 °C to 32.6 °C. At a relative humidity (ja) of 62.5% and an airflow speed of 0.5 m s^{-1}, the pulse rate changed by 16.7% from 60 to 70 beats min^{-1}.

At an airflow speed of 1.0 m s^{-1}, the pulse rate increased by 13.3% from 68 to 65 beats min^{-1}; and at 2.0 m s^{-1}, it increased by 8.7% from 60 to 65 beats min^{-1}. A trend of skin temperature is presented in Fig. 8. At a relative humidity (ja) of 75.0% and an airflow speed of 0.5 m s^{-1}, the pulse rate changed by 26.7% from 60 to 76 beats min^{-1}. At 1.0 m s^{-1}, it increased by 20.0% from 60 to 72 beats min^{-1}; and at 2.0 m s^{-1}, increased by 16.7% from 60 to 70 beats min^{-1}. A trend of skin temperature is presented in Fig. 9. As a result of the research, it was found that by a relative air humidity of 50%, an airflow speed of 0.5 m s^{-1}, and a change in air temperature from 25 to 35 °C in the case where skin cleaning was not used, the increase in the cow's pulse was 21.7% from 60 to 73 beats min^{-1} and the skin temperature increased by 8.0% from 33.2 to 35.9 °C. When using wet cleaning, the pulse rate increased by 11.7% from 60 to 67 beats min^{-1}, and the skin temperature increased by 5.8% from 32.1 to 34.0 °C. When cleaning with detergent, the pulse increased by 10.0% from 60 to 66 beats min^{-1}, and the skin temperature increased by 5.6% from 32.1 to 33.9 °C. When using the dry cleaning method, the pulse rate changed by 13.3% from 60 to 68 beats min^{-1}, and the skin temperature increased by 7.3% from 33.1 to 35.5 °C. The pulse rate results from the air speed with different cleaning methods are established in Figs. 10-12.

The wet cleaning (2) is done with a special cleaning agent. When the air temperature rises, increasing the airflow allows the skin temperature and pulse rate to decrease, especially by wet cleaning. Due to evaporation from the skin, wet cleaning allows the decrease of heat stress, and elevating the air flow speed allows the upraise of evaporation speed. Noteworthy, the overall effectiveness of wet cleaning appears at low relative humidity (50% or less). When relative humidity is between 62.5 and 75.0 %, the effectiveness of wet cleaning drops and becomes equal to dry skin cleaning. As a result of research, it was found that by an elevation in temperature from 25 °C to 35 °C and relative humidity from 50% to 75%, the skin temperature upraises by 14.3% using dry cleaning, while by 11.8% using wet cleaning and by 11.6% using wet cleaning with detergent. The pulse rate in animals is also lower when using wet cleaning by 9.5% and cleaning with special cleaning agent by 10.7%.

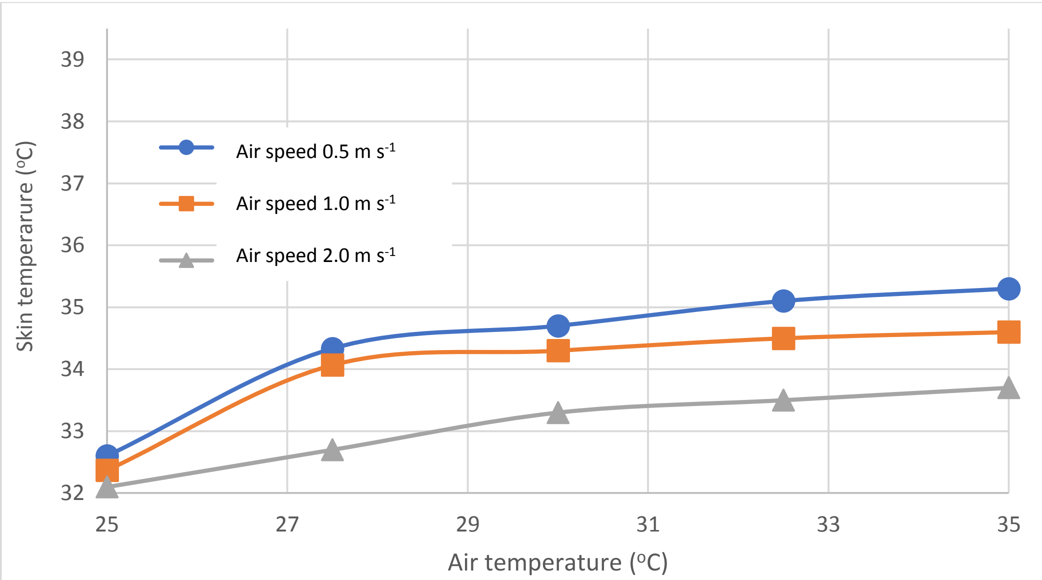

Fig. 6. A trend of skin temperature with water cleaning (φ_a = 62.5%).

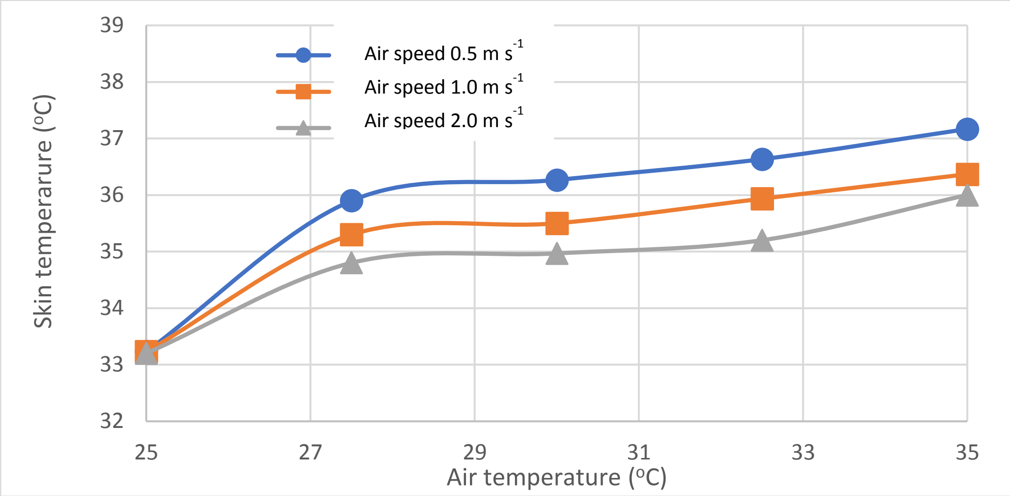

Fig. 7. A trend of skin temperature with water cleaning ($\varphi_a = 75.0\%$).

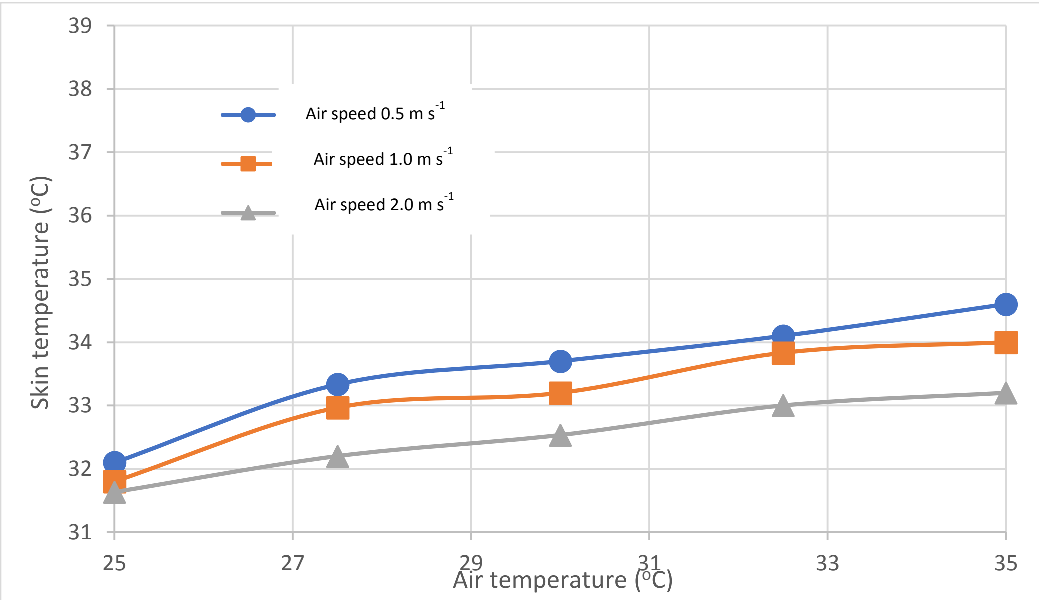

Fig. 8. A trend of skin temperature with wet cleaning with the special cleaning agent ($\varphi_a = 62.5\%$).

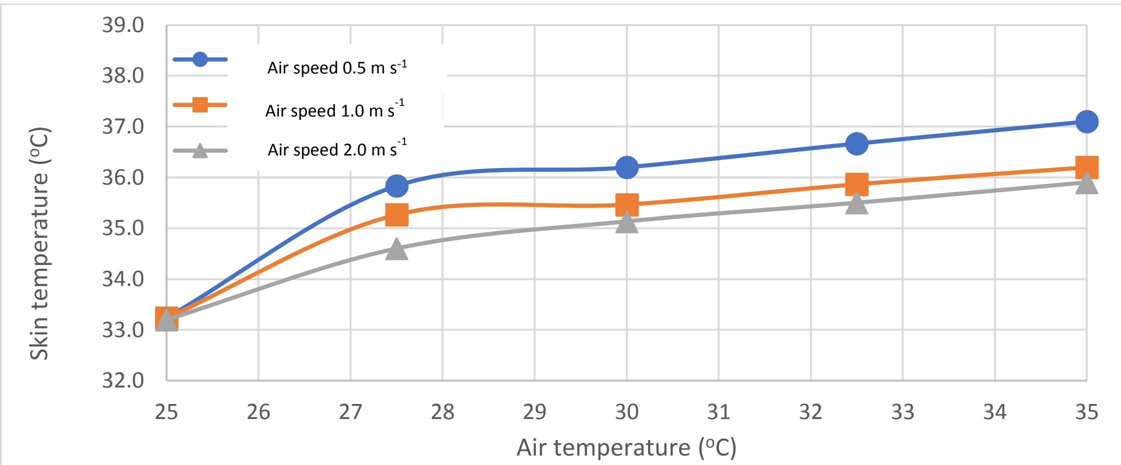

Fig. 9. A trend of skin temperature with wet cleaning with the special cleaning agent ($\varphi_a = 75.0\%$).

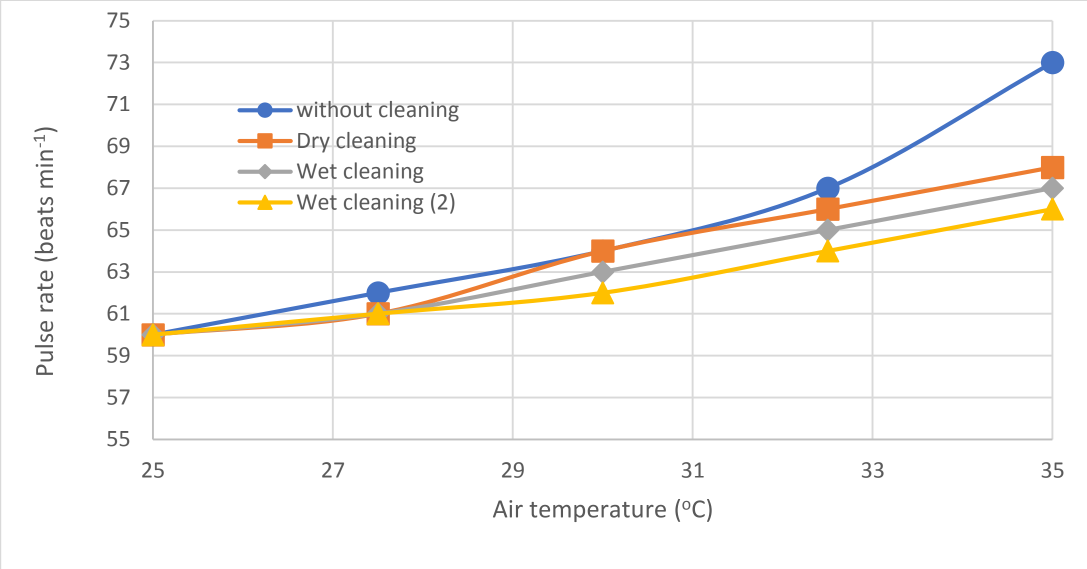

Fig. 10. A trend of pulse rate with different cleaning methods (φ_a = 50%, V_a = 0.5 m s^{-1}).

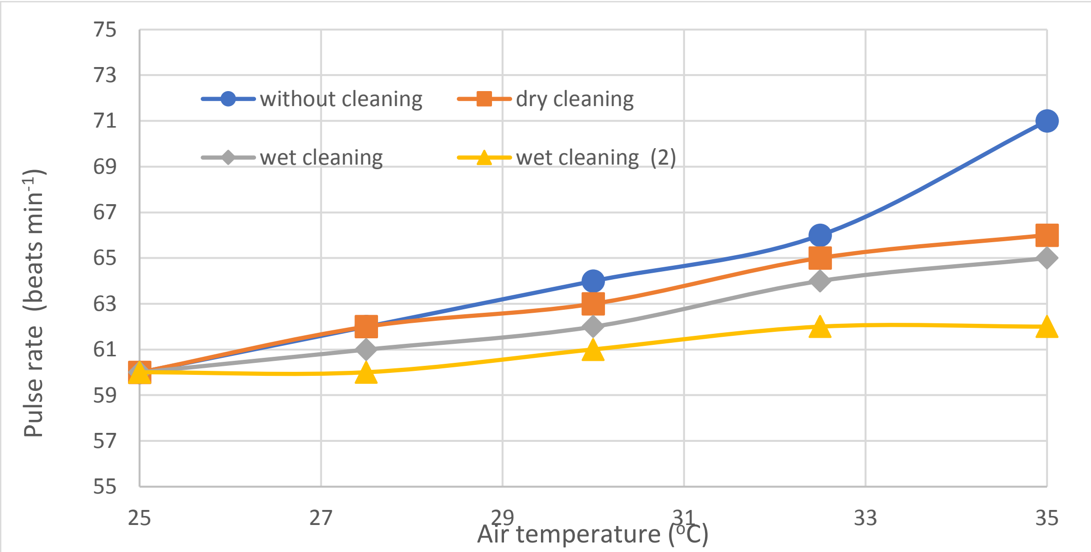

Fig. 11. A trend of pulse rate with different cleaning methods (φ_a = 50%, V_a = 1.0 m s^{-1}).

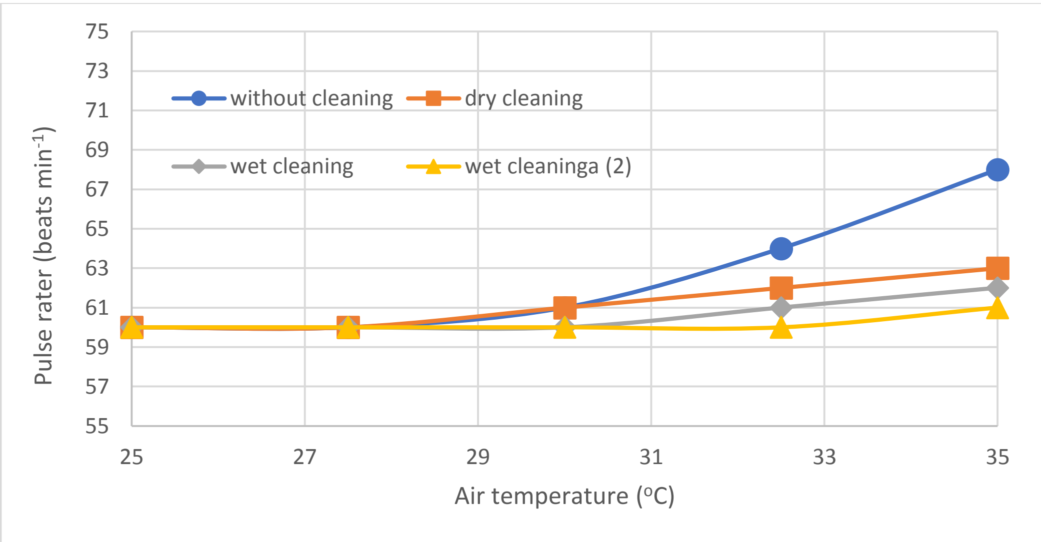

Fig. 12. A trend of pulse rate with different cleaning methods (φ_a = 50%, V_a = 2.0 m s^{-1}).

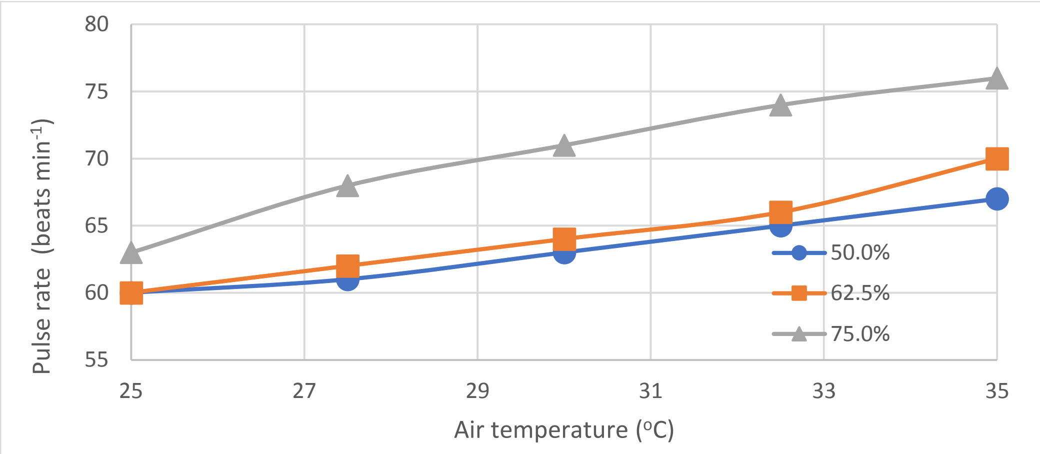

Fig. 13. A trend of pulse rate after wet cleaning with different meanings of relative humidity (V_a = 0.5 m s^{-1}).

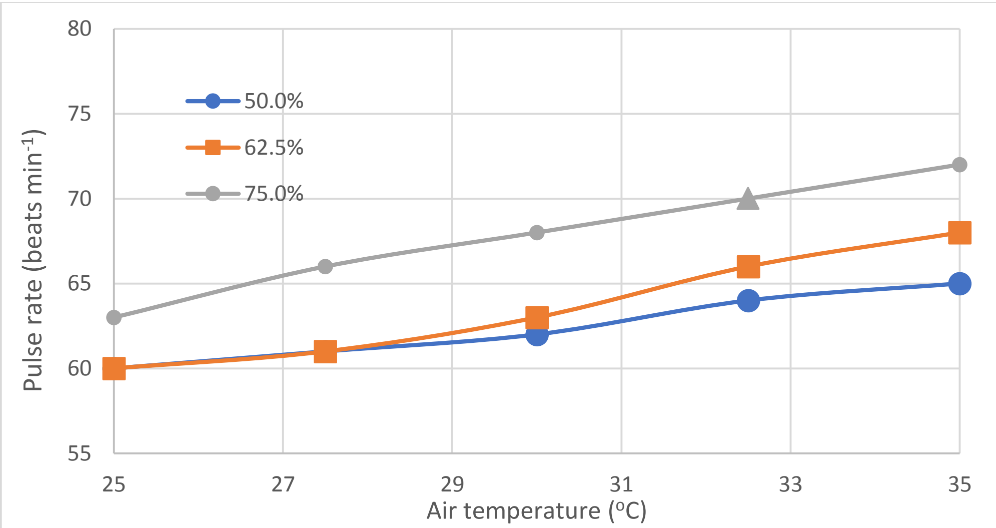

Fig. 14. A trend of pulse rate after wet cleaning with different meanings of relative humidity (V_a = 1.0 m s^{-1}).

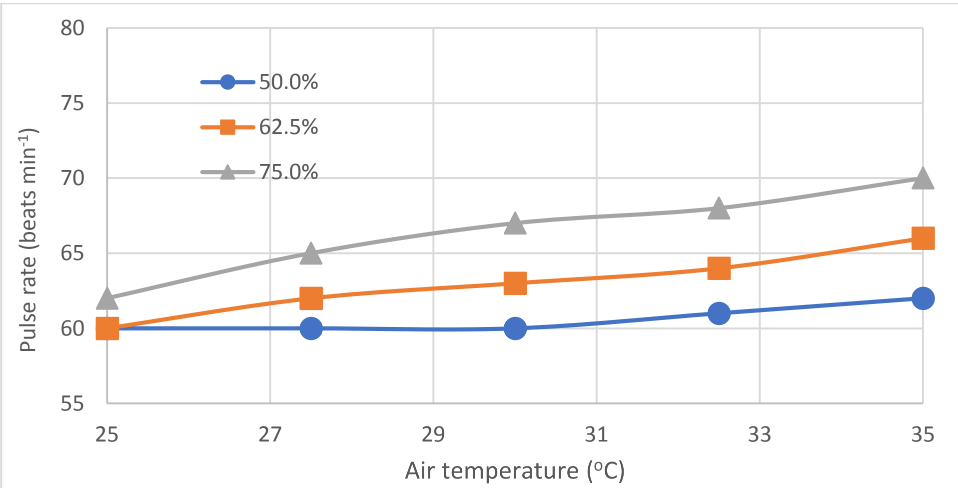

Fig. 15. A trend of pulse rate after wet cleaning with different meanings of relative humidity (V_a = 2.0 m s^{-1}).

CONCLUSION

In this research, the influence of cleaning methods on the reduction of heat stress for cows in a hot period with a temperature of 25 - 35 °C, relative humidity of 50 - 75%, air speed of 0.5 - 2.0 m s^{-1}, and complete cleaning of the cow´s body was carried out. Experiments proved that the researched skin cleaning methods decreased the elevation in body surface temperature, upraised heat transfer and sweat evaporation, increased heat exchange between cows and the environment, and reduced the impact of heat stress. The most effective methods are wet and wet cleaning compared to dry cleaning with special cleaning agents. Applying the dry cleaning method in hot and dry weather, when the relative air humidity increases to 75%, and elevates the effectiveness of wet cleaning compared to dry cleaning. Using skin cleaning, the heat load on the cow was decreased, and the transfer of endogenous heat to the environment was improved. This confirmed the physiological reaction of the body by reducing the pulse rate and skin temperature in the animal. Follow-up experiments would be advisable to create the automatic insertion of skin cleaning and the algorithm of cleaning under different environmental conditions.

ACKNOWLEDGEMENTS
This study was carried out with the support of the Priority 2030 program.

REFERENCES

Berman, A 2003, Effects of body surface area estimates on predicted energy requirements and heat stress. *Journal of Dairy Science*, 86: 3605-3610, https://doi.org/10.3168/jds.S0022-0302(03)73966-6.

Berman, A 2004, Tissue and external insulation estimates and their effects on prediction of energy requirements and of heat stress. *Journal of Dairy Science*, 87: 1400-1412, https://doi.org/10.3168/jds.S0022-0302(04)73289-0 .

Berman, A 2005, Estimates of heat stress relief needs for Holstein dairy cows. *Journal of Animal Science*, 83: 1377-1384 https://doi.org/10.2527/2005.8361377x.

Berman, A 2009, Predicted limits for evaporative cooling in heat stress relief of cattle in warm conditions, *Journal of Animal Science* , 87: 3413-3417, https://doi.org/10.2527/jas.2008-1104.

Berman, A 2019, An overview of heat stress relief with global warming in perspective, *International Journal of Biometeorology*, 63:493-498, https://doi.org/10.1007/s00484-019-01680-7.

Ivanov, Yu, Baimukanov, D, Borulko, G, Ponizovkin, D & Dzhanabekova, G 2020, Influence of cow skin cleaning on physiological parameters under heat stresses in warm season, *Bulletin of National academy of Sciences of the Republic of Kazakhstan*, 4: 100-108 (In Russian) https://doi.org/10.32014/2020.2518-1467.109.

Trukhachev, V, Zlydnev N & Sycheva, O 2016, Formation of quality of dairy products on the example of a family business Kaasboerderij Weenink Netherlands, *Research Journal of Pharmaceutical, Biological and Chemical Sciences*. 7(1): 1125-1129.

Truhachev, V, Kostyukova, E & Bobryshev, A 2017, Development of management accounting in Russia, *Espacios*. 38(27): 7.

ibliographic information of this paper for citing:
Ivanov, YG, Ponizovkin, DA, Odintsova, AA 2024, Impact analysis of cow skin cleaning methods on heat stress, Caspian Journal of Environmental Sciences, 22: 1087-1095.