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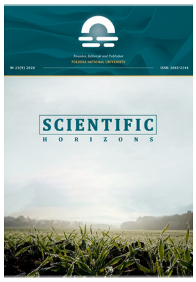

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Ways to reduce the impact of the external environment in summer on the milk productivity of cows

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Abstract. One of the factors of efficient intensive milk production is the creation of comfortable conditions for keeping cows on a farm or complex. Highly productive cows are quite demanding of the indoor microclimate and conditions of keeping. It is believed that the productivity of animals by 10-30% depends on this. The purpose of the study was to examine the possibility of reducing the influence of high ambient temperature on the milk productivity of cows by different approaches to the organisation of their feeding technology. The paper uses analytical, diagnostic, physico-chemical, and statistical research methods. The main climate indicators were monitored during the summer period (June–August). It is established that the decrease in daily milk yield is a consequence of the negative influence of the temperature factor when the daily (from 11^{00} to 17^{00}) air temperature in June-July is at the level of +26-30°C. At an air temperature

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of 26.5°C (about 14^{00}), the body temperature of cows rises from 37.5-37.8°C to 38.20-38.46°C. The proof of this is a decrease in the rate of decline in the level of milk productivity of cows of the experimental groups in August when the average daily air temperature dropped to +24-26°C. It is proved that the introduction of 1.5 kg of protein feed additive with protected TEP-mix protein into the diet of highly productive cows increases the productivity of experimental cows (in terms of basic milk) by 15.7% (4.3 kg). Modernisation of the diet of feeding highly productive cows by increasing the content of non-broken down protein in the rumen to normal during temperature stress contributed to better adaptation of animals in terms of productivity and quality indicators of milk: an increase in the mass fraction of fat by 0.67% and the mass fraction of protein by 0.26%, with the content of somatic cells of 285.06±81.0–409.3±134.3 thousand/cm^3

Keywords: climatic conditions**;** dairy cows; milk productivity; temperature; protected protein

INTRODUCTION

Over the past decades, the trend of global warming has been observed around the world. According to the World Meteorological Organisation (WMO, 2022), the last seven years, from 2015 to 2021, were the warmest on record. Various climate change models predict a further. 1.1-6.4°C increase in temperature by the end of this century. Such climate changes lead to the disruption of thermoneutral conditions, which are a key element of herd health and productivity. Over the past decades, researchers around the world have been modernising the conditions of keep, improving the food feeding strategy, and breeding heat-resistant livestock breeds, but the development of innovative methods to prevent and overcome the negative impact of heat stress on the body of highly productive livestock remains one of the crucial tasks for veterinary medicine.

According to Zotko (2018), a particularly substantial problem of livestock comfort is a substantial increase in ambient temperature in the summer, which leads to heat stress in animals. Researchers (Borshch, 2021; Almuhanna *et al.,* 2021; Schmeling *et al.,* 2022) agreed that high ambient temperatures primarily affect the productivity of dairy cows. Results of monitoring studies by Mylostivy and Kryukova (2020) indicate that when the ambient temperature rises above +21°C, milk yields gradually decrease, and above +29°C – decrease sharply. Therewith, Iqbal *et al.* (2021) determined that in highly productive dairy cows, heat stress can occur already at an air temperature of +20°C, and the decrease in milk yields occurs directly in proportion to the increase in temperature.

Skliarov *et al.* (2022) by experimental studies proved that in ruminants, there is a close relationship between feeding and heat production: the metabolic heat generated during microbial fermentation of feed in the rumen accounts for 3 to 8% of the total heat production of cattle. A group of researchers led by Koshchavka *et al.* (2019) determined that the higher the proportion of coarse feed in the diet, the faster the portions of feed consumed decrease. Ivanov & Bezaltychna (2018) claim that during the increase in the heat load of the environment, adaptive mechanisms are activated and the animal body tries to reduce the metabolic production of heat. That is why, in hot weather, cattle compensate for the temperature effect, reducing portions of feed consumption. According to Becker *et al.* (2020), voluntary feed consumption by cows begins to decrease at an ambient temperature of +25-26°C. The researchers note that dry matter intake is reduced by 9.6-14.6 kg/animal, compared to thermoneutral cows.

The results obtained by Miller-Cushon *et al.* (2019) indicate that during the period of heat stress, animals more carefully sort food into fractions and consume, for the most part, small particles. In turn, Meneses *et al.* (2021) note that heat stress reduces dry matter intake by 16%. Osei-Amponsah *et al.* (2020) during the study of the productivity parameters of lactating cows of the Holstein Frisian breed, which were fed robotically, identified that with the increase in ambient temperature milk production decreased by 14%

High ambient temperatures negatively affect not only the volume of milk but also its composition. Specialists (Pragna *et al.,* 2017) identified that changes in the composition of milk occur immediately after an increase in air temperature and even precede a decrease in milk yield. First of all, the number of somatic cells increases, indicating a decrease in the quality of milk produced.

The main goals of managing the feeding of dairy cows during heat stress are to reduce heat gain through digestive processes. Specialists (Koshshavka *et al.,* 2019; Mylostyvyi *et al.,* 2021) propose changing the feeding time (not feeding cows during the hottest hours) and reducing the coarse feed proportion in the diet to reduce metabolic heat loads.

Min *et al.* (2019) note that adding dietary fats, fibre, microbial supplements, minerals, vitamins, metal ion buffers, plant extracts, and anti-stress additives to the main diet of lactating cows that are under the influence of heat stress contributes to the normalisation of digestive processes, reducing rectal temperature and body temperature, increasing milk yield. Fontoura *et al.* (2022) claim that the addition of dietary acids and plant extracts (25% citric acid, 16.7% sorbic acid, 1.7% thymol, 1.0% vanillin, 55.6% triglyceride) to the diet of cows at a dose of 75 mg/kg of body weight twice a day contributed to a decrease in body temperature, increased milk yield and the content of protein and lactose in milk.

Ribeiro *et al*. (2020) and Shan *et al*. (2020) proved that the addition of minerals to the main diet of cows, in particular, chromium, prevents an increase in body temperature under heat stress, but does not substantially affect the quantity and quality of milk. Shah *et al*. (2020) received positive results on the prevention of temperature stress in dairy cows due to the addition of 15 g of betaine per day to the diet. Du *et al*. (2022) obtained similar results for enriching the diet of Holstein cows by adding *Saccharomyces cerevisiae* culture in the quantity of 100 g/d.

Thus, hot weather and heat stress have a substantial negative impact on the well-being and health of dairy cows, the quantity and quality of milk, and cause substantial economic losses. In accordance with the regulations on animal welfare, considering the proven substantial negative impact of high temperatures on the health and productivity of livestock, this factor determines the need to develop and implement special measures for animal protection, one of which is the modernisation of feeding strategies.

The purpose of the study is to examine the possibility of reducing the impact of high ambient temperature on the milk productivity of cows with different approaches to the organisation of their feeding technology.

MATERIALS AND METHODS

The study was conducted as part of the implementation of a scientific research work 29.01.01.02.F (2021-2025) "Physiological Features of Highly Productive Cattle Under Various Feeding Systems Under Climate Change" (state registration number 0121U108647).

The possibility of reducing the negative impact of high temperature in summer on the manifestation of signs of animal productivity by using a protein feed additive with protected protein TEP-mix (Arnika Feed LLC, Ukraine) was investigated. A scientific-economic experiment was conducted in the conditions of the state enterprise "Experimental Farm "Hontarivka" of the Institute of animal science of the National Academy of Agrarian Sciences" Volchansky District of the Kharkiv region on the high-productive cows of the Ukrainian black-and-white dairy breed. Three groups of cows were formed – control and two experimental ones with 8 heads each.

The object of the study was the milk productivity of dairy cows. Experimental groups were formed by the method of matched pairs, considering the breed, milk productivity, lactation phase, and live weight (Vlizlo *et al.,* 2004). Duration of the experiment – 63 days. The conditions of keeping, feeding, and watering, microclimate parameters in all groups of experimental animals were the same and mostly corresponded to the technological standards. Keep on the farm in the summer – on pasture grounds with milking indoors.

Feed samples were taken in the amount of 1 kg, packed in plastic bags. Determination of the factual feed consumption – by conducting control feedings every 10 days according to (Viktorov & Menkin, 1991). Determination of the level of milk productivity of cows – by conducting control milkings with the subsequent sampling of milk to determine its quality.

Milk samples from each cow were taken using a probe, in proportion to milk yield in accordance with the requirements of DSTU ISO 707:2002 Milk and milk products, Guidance on sampling (ISO 707:1997, IDT). Samples were delivered to the laboratory with preserved Broad Spectrum Mikrotabs tablets (USA).

The analysis of milk was conducted by chemical composition, nutritional and energy value. Determination of physical and technological properties: mass fraction of true (tru) protein, fat (Fat), lactose (Lac), dry matter (Solids), solids-not-fat (SNF), total (total) protein was conducted according to DSTU 8396:2015 (2016) Cows milk. Determination of the mass fraction of fat, protein, lactose, dry matter – by infrared spectrometry (express method), freezing point (FPD) according to DSTU 7671:2014 (2015) Cows milk. Determination of the freezing point by the conductometric method (express method) – on the Bentley Combi 150 device (Bentley, USA). Nutritional and energy value is calculated based on the content of nutrients and their caloric coefficients. The content of somatic cells in milk – instrumentally according to DSTU 7672:2014 (2015) Cows milk. Determination of the number of somatic cells – by flow cytometry (express method) on the Bentley Somacaunt 150 device (Bentley, USA).

Methods of organising feeding of experimental animals. The diets of all experimental animals for all limited organic and mineral nutrients were balanced according to the current detailed feeding standards (Bogdanov *et al.,* 2012), considering the factual chemical composition and nutritional value of the feed.

Difference between the diets of the control and experimental groups – in the composition and structure of mixed feed – in the experimental groups, some of the concentrated feed was replaced with protected energy and protein supplement TEP-mix, which was distributed to cows individually. As part of the diet of the first experimental group, 1.5 kg of TEP-mix additive was used, and in the second experimental group – 1.0 kg of the same additive instead of part of the mixed feed. Moreover, despite the fact that different amounts of TEP-mix were introduced into the diets of the experimental groups, the ratio of protein broken down in the rumen (BP) to protein not broken down in the rumen (NBP) was always maintained at 40:60%.

In the diet of the control and experimental groups, the content of metabolic energy, energetic feed units, dry matter, and crude fibre was almost the same – the difference did not exceed 2.5%. For crude protein, the advantage of the first experimental group over the control group was 79 g or 2.46%, and the second experimental group – 32 g (1%). The diet of the first experimental group included 297 g or 41.4% more non-cleaved protein than the control and the diet of the second experimental group – 189 g (26.3%). In terms of crude fat content, the control group was inferior to the first experimental group by 157 g or 24.6%, and to the second experimental group – 104 g or 16.3%. Therewith, in terms of starch content, the control group had higher indicators over the first experimental group by 559 g (13.8%) and the second experimental group – 375 g (9.2%).

Methods for determining climate indicators. The following parameters were examined: air temperature, °C; humidity, %; air velocity, m/s; they were measured at pasture sites with an interval of 3 hours: at 8, 11, 14, 17, 20.

Methods for determining cow body temperature indicators. Body surface temperature was measured twice a day – at 14 and 20, using a BOSH non-contact thermometer. The measurement points are shown in Figure 1.

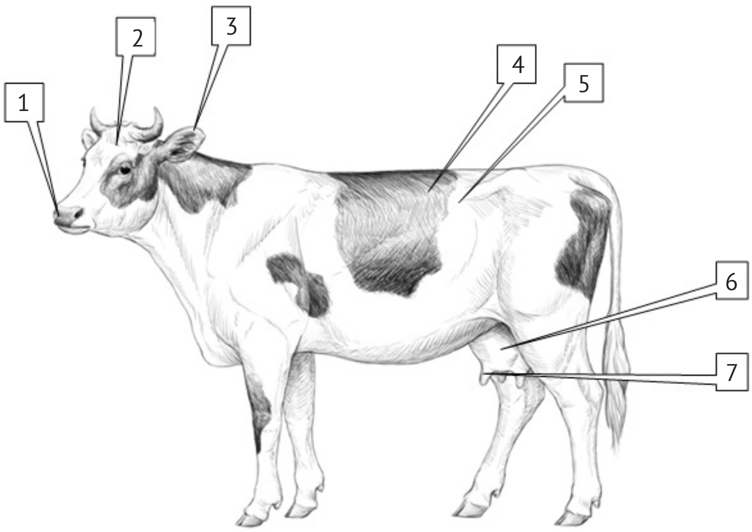

Figure 1. *Temperature measurement points: 1 – nasal mirror; 2 – forehead; 3 – ear; 4 – black parts of the body; 5 – light parts of the body; 6 – udder; 7 – udder teats.*

Source: *compiled by the authors*

Statistical analysis. The analysis of experimental studies was conducted using the Microsoft Excel 2010 programme. The results obtained in this study were statistically calculated using the Fisher-Student method, considering statistical errors, and the probability of the indicators compared. Indicators with a level above 95%.

All experimental studies were conducted in accordance with modern methodological approaches and in compliance with the relevant requirements and standards, in particular, they meet the requirements of DSTU ISO/IEC 17025:2005 (2006). The keep of animals and all manipulations were conducted in accordance with the Order by the HCM of Ukraine No. 416/20729 on the "Approval of the Procedure of Animal Tests in Research Institutes's (Law of Ukraine No. 249, 2012), the European Convention for the Protection of Vertebrate Animals used for Experimental and Other Scientific Purposes (European convention…, 1986).

RESULTS AND DISCUSSION

In connection with the integration of Ukraine into the European Union and the Joint Trade Organisation, there is a need to produce competitive and environmentally safe for the life and health of the population of dairy and meat products, which in turn puts forward new conditions for improving production technologies towards reducing the impact of negative factors on the level of productivity of animals, their stress resistance to technological and natural factors and resistance to diseases (Betlii *et al.*, 2014; Rodionova *et al.*, 2020a; Rodionova *et al.*, 2020b).

Many researchers (Voitenko & Sydorenko, 2020; Gauly & Ammer, 2020) predicted that over the century, changes in the Earth's climate will continue, in particular, an increase in air temperature and a decrease in its humidity. During the summer period (June-August), the main climate indicators were monitored (Figure 2-4).

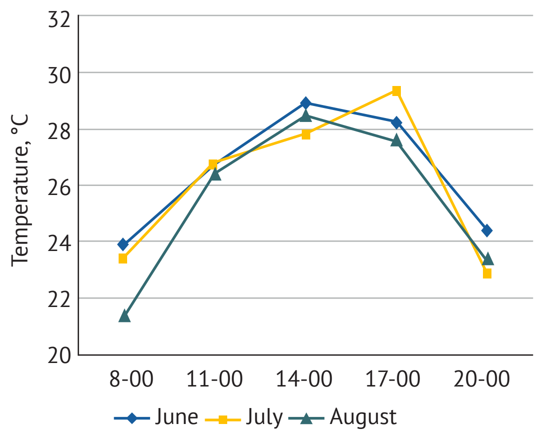

Figure 2. *Dynamics of daytime temperature*

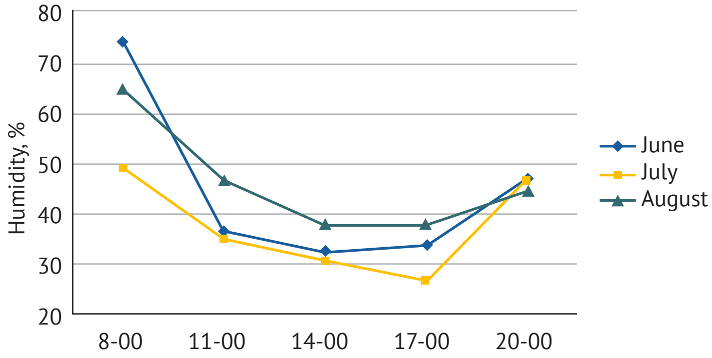

Figure 3. *Dynamics of air humidity during the day*

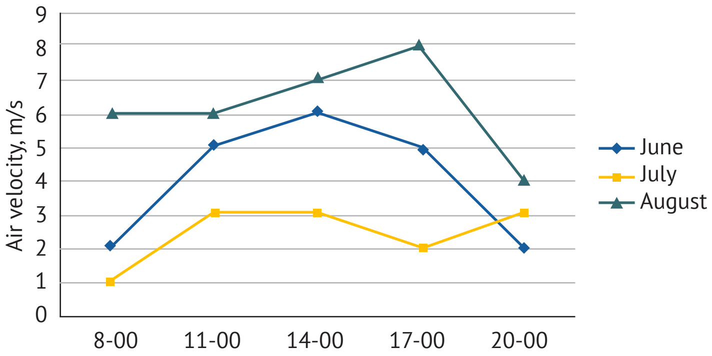

Figure 4. *Dynamics of air velocity during the day*

Source*: compiled by the authors*

As for the reaction of dairy cows to high temperature and low humidity, it was identified that the body temperature of cows and the temperature of their skin in hot times of the day substantially differed than under comfortable conditions of keep. The study was conducted on 5 animals from each group. Thus, at an air temperature of 26.5°C at 14 o'clock, the body temperature of cows ranged from 38.20°C to 38.46°C, and the temperature of individual parts of the body and skin had slightly lower indicators (°C): forehead – 35.6-36.2; nasal mirror – 33.9-34.3; ears – 36.7-36.9; black parts of the body – 35.8-36.2, light – 35.1-35.5; udder – 36.4-36.6; udder teats – 35.4-35.6 (Table 1).

Table 1. *Indicators of the temperature of individual parts of the body of experimental cows in the summer at 14^{00}, on average by group, °C, (M±m), n= 5*

Group	Body temperature	Forehead	Nasal mirror	Ear	White spot	Black spot	Udder	Teat
				June				
control	38.40±0.08	35.64±0.05	34.02±0.08	36.66±0.05	35.12±0.05	35.84±0.04	36.50±0.05	35.52±0.04
First experimental	38.30±0.12	35.76±0.05	34.04±0.04	36.72±0.04	35.22±0.04	35.88±0.06	36.54±0.04	35.54±0.05
Second experimental	38.38±0.11	35.66±0.04	33.92±0.06	36.88±0.07	35.26±0.05	35.84±0.07	36.54±0.05	35.52±0.04
				July				
control	38.40±0.16	36.18±0.11	34.28±0.07	36.86±0.04	35.52±0.04	36.28±0.07	36.54±0.07	35.5±0.05
First experimental	38.20±0.11	35.90±0.04	34.18±0.07	36.82±0.06	35.44±0.07	36.22±0.07	36.60±0.07	35.54±0.02
Second experimental	38.44±0.09	36.02±0.07	34.06±0.05	36.94±0.05	35.42±0.10	36.28±0.05	36.60±0.04	35.58±0.04
				August				
control	38.36±0.12	35.88±0.04	33.94±0.05	36.7±0.05	35.08±0.06	35.86±0.05	36.50±0.05	35.38±0.04

Table 1, Continued

Group	Body temperature	Forehead	Nasal mirror	Ear	White spot	Black spot	Udder	Teat
First experimental	38.26±0.10	35.86±0.07	34.14±0.06	36.76±0.07	35.32±0.06	35.94±0.05	36.50±0.04	35.50±0.04
Second experimental	38.46±0.06	35.76±0.02	34.12±0.06	36.86±0.06	35.30±0.03	36.04±0.05	36.40±0.05	35.36±0.04

***Source**: compiled by the authors*

Therewith, in the evening, when the air temperature dropped to comfortable conditions, the temperature of the skin and individual parts of the body changed accordingly (Table 2).

***Table 2.** Indicators of the temperature of individual parts of the body of experimental cows in the summer period at 20^{00}, on average by group, °C, (M±m), n=5*

Group	Body temperature	Forehead	Nasal mirror	Ear	White spot	Black spot	Udder	Teat
				June				
control	38.10±0.07	35.32±0.06	33.48±0.09	36.34±0.04	34.42±0.06	35.32±0.04	36.32±0.04	35.12±0.04
First experimental	38.12±0.06	35.32±0.04	33.92±0.06	36.28±0.04	35.06±0.05	35.44±0.07	36.32±0.04	32.56±0.04
Second experimental	38.08±0.11	35.28±0.04	33.54±0.04	36.50±0.08	34.98±0.08	35.36±0.07	36.20±0.05	35.20±0.05
				July				
control	38.26±0.10	35.42±0.09	33.60±0.07	36.42±0.06	34.66±0.06	35.54±0.06	36.44±0.05	35.14±0.04
First experimental	38.10±0.08	35.34±0.05	34.00±0.04	36.38±0.05	35.20±0.07	35.8±0.06	36.30±0.05	35.26±0.02
Second experimental	38.44±0.09	36.02±0.07	34.06±0.05	36.94±0.05	35.42±0.10	36.28±0.05	36.60±0.04	35.58±0.04
				August				
control	38.14±0.09	35.88±0.04	33.94±0.05	36.66±0.05	35.12±0.05	35.86±0.05	36.50±0.05	35.52±0.04
First experimental	38.12±0.07	35.30±0.04	34.00±0.04	36.38±0.06	35.14±0.05	35.50±0.09	36.20±0.03	35.22±0.05
Second experimental	38.06±0.12	35.28±0.04	33.80±0.04	36.56±0.09	34.96±0.09	35.66±0.05	36.16±0.07	35.08±0.04

***Source**: compiled by the authors*

The prevalence of heat stress in animals is expected to increase in frequency, duration, and severity. This will have a big negative impact on the health, reproductive capacity, and productivity of farm animals, that is, it will lead to a decrease in the volume of milk and meat production because due to heat stress, livestock consumes less feed. (Vaculíková *et al.,* 2017; Shan *et al.,* 2018; Kim *et al.,* 2018).

Since the creation of comfortable environmental conditions is very relevant for a highly productive herd, fluctuations in temperature and humidity can lead to a decrease in the dairy productivity of cows and product quality. During the summer period, the temperature of atmospheric air had a substantial negative impact on high-productive cows of the second half of lactation kept on pasture grounds (Table 3).

***Table 3.** Indicators of milk productivity of cows of the second half of lactation and milk quality in the summer period (M±m), n=8*

Parameter	Duration of the study		
	June	July	August
Daily milk yield, kg:			
Control group	21.6±1.19	22.7±1.52	18.8±1.04
First experimental	30.9±0.87	22.5±0.57	20.7±0.99
Second experimental	28.1±1.93	26.4±1.81	20.3±1.57

Table 3, Continued

Parameter	Duration of the study		
	June	**July**	**August**
Mass fraction of fat in milk, %:			
Control group	3.96±0.09	3.94±0.04	3.79±0.06
First experimental	3.67±0.04	4.75±0.06	4.34±0.07
Second experimental	4.05±0.10	4.05±0.06	4.07±0.10
Daily milk yield of basic fat content, kg:			
Control group	25.2±1.72	26.4±1.81	21.0±1.46
First experimental	40.0±1.42	29.0±0.78	26.4±1.21
Second experimental	33.4±2.35	31.4±2.27	24.3±1.96
Mass fraction of protein in milk, %:			
Control group	2.90±0.03	2.87±0.03	2.70±0.06
First experimental	3.03±0.06	3.13±0.07	3.30±0.09
Second experimental	2.98±0.08	2.97±0.08	3.22±0.11
Somatic cell content, thousand/cm^3:			
Control group	460.0±148.6	815.0±326.8	616.8±160.4
First experimental	285.06±81.0	488.0±196.3	409.3±134.3
Second experimental	278.0±69.7	309.6±85.9	444.4±84.4

Source*: compiled by the authors*

It was identified that in the period from June to August, the dairy productivity of animals of the control group decreased by 13.1%. Therewith, in cows of the experimental groups, the average daily milk yield decreased by 33.1% in the first and by 27.5% in the second. However, due to the increase in the content of bypass protein to the norm, the productivity of cows in the experimental groups remained still higher compared to the control by 1.9 kg and 1.5 kg, and in terms of basic milk – by 5.4 kg (25.7%) and 4.3 kg (15.7%), respectively.

This decrease in daily milk yields is a consequence of the negative influence of the temperature factor when the daily (from 11^{00} up to 17^{00} hours) air temperature in June-July was at the level of +26-30°C. The proof of this is a decrease in the rate of decline in the level of milk productivity of cows of the experimental groups in August, when the average daily air temperature dropped to +24-26°C.

Therewith, it was identified that during the summer period in experimental cows had an increase in the mass fraction of fat in milk compared to the previous level – in the first experimental group – by 0.67%, and in the second – by 0.02%; protein – by 0.26% and 0.24%, respectively. The fact that the content of somatic cells in the milk of cows of the first and second experimental groups was lower than in the control group and met the requirements of the grades extra, top, or first for this indicator according to DSTU 3662:2018 Raw cow milk. Technical specifications.

It is known that in hot weather, the consumption of feed by cows during the daytime decreases. The authors observed that most of the diet was eaten by experimental animals in the evening, after evening milking, and in the morning – before morning milking. In addition, cows tried to stay in the shade under canopies and drink water more often. That is, if the air temperature was not hot in June and July, then the curve of decreasing milk production would have a different shape, and milk production in this period in general would be larger. Consequently, the use of the proposed intake during temperature stress contributed to better adaptation of animals in relation to the quality indicators of milk.

Changes in the eating behaviour of animals lead to a disruption of the energy balance and, as a result, a decrease in productivity. However, the data on the exact relationship between air temperature and milk yield varies. Petrusha and Dibirov (2014) report that when the air temperature rises to +28°C, the milk yield decreases by 2.16%, +32°C – 10.7%, +34°C – 20.14%, +36°C – 22.3%, +40°C – 29.5%, respectively. Lees *et al.* (2019) note that an increase in the ambient temperature to +29°C reduces milk yield by 23%. Therewith, another group of researchers (Molina Benavides *et al.*, 2018; Chung *et al.*, 2020; Polishchuk *et al.*, 2021) calculated that during hot days, milk productivity losses can reach 20%.

These data correlate with the results of this study, which once again confirm that the increase in ambient temperature associated with climate change is the main factor that negatively affects the productivity of highly productive dairy cows and milk quality. It was identified that in the summer period (June-August), the dairy productivity of experimental animals decreases by 24.56%.

Now the processing industry puts forward increased requirements for the quality of milk. The main indicators that determine its quality are protein and fat content, acidity, the number of somatic cells, etc. (Bogatko *et al.,* 2018; 2019). The studies of recent years (Hall *et al.,* 2018; Sejian *et al.,* 2018; Hou *et al.,* 2021) indicate that due to heat stress, the content of milk fat, protein, solids-not-fat, total nitrogen, and lactose decreases, while the content of non-protein nitrogen, palmitic and stearic acids, on the contrary, increases. A substantial increase in the content of somatic cells in milk was also recorded**.**

This hypothesis is also confirmed by the conducted scientific experiments. Due to heat stress, high-productive cows in the control group showed a decrease in the mass fraction of fat from 3.96±0.09% in June to 3.79±0.06% in August and the mass fraction of protein from 2.90±0.03% to 2.70±0.06%, respectively. Therewith, the number of somatic cells increased by 34.09%, reaching the highest levels in August – 616.8±160.4 thousand/cm^3.

Feeding is a factor that determines the vital activity of animals. The level of productivity, reproductive qualities, health, and, ultimately, the economic and breeding value of livestock directly depend on the level and usefulness of feeding (Riznychuk *et al.,* 2021). Farms need to create comfortable conditions for keeping animals (Kravchenko *et al.,* 2019; Mylostyvyi *et al.,* 2021; Lutnicki *et al.,* 2021), organise synchronous feeding, develop and use optimised diets for feeding using a variety of innovative feed additives that can increase the absorption of nutrients to reduce the impact of heat stress (Min *et al.,* 2017; Bondarenko & Dvorska, 2015).

Researchers (Dunshea *et al.,* 2019; Hmelovskyi, 2020; Suprun & Kurylenko, 2022) investigate and substantiate the feasibility of using various energy feed additives (betaine, glycerin, propylene glycol, ENERGY-TOP, etc.), buffering additives (sodium bicarbonate), probiotic yeast additives and antioxidants (beta-carotene, vitamin E, selenium) in diets to normalise the pH of the rumen and compensate for possible mineral and vitamin deficiencies.

Lees *et al.* (2019) note that there is substantial variability in the success of feeding correction methods during heat load, and further research is needed to verify the appropriateness of dietary supplements as a means of reducing heat load. A number of researchers Gonzalez-Rivas *et al.,* 2018 Polsky & Von Keyserlingk, 2017) prove that for the same purpose, it is advisable to use high-energy diets with reduced protein and fibre content and increased fat content in feeding highly productive cows. However, the conducted study confirms the opposite.

Testing of protein feed additive with protected protein TEP-mix (LLC Arnika feed, Ukraine) in the conditions of an experimental farm against the background of heat stress in animals in the summer season has a positive effect on the productivity of high-performance dairy cows and milk quality. It was experimentally proved that due to the modernisation of the animal diet, the preservation of milk productivity at the level of 20.5±0.08 kg was achieved, which is almost 2 kg higher than the control. Besides, the use of the proposed measure during temperature stress contributed to better adaptation of animals in relation to the quality indicators of milk.

The obtained data correlates with the results obtained by other researchers. Thus, Kaufman *et al.* (2017) identified that an increase in the BP:NBP ratio in diets contributed to a decrease in daily milk yield and milk fat, protein, and lactose content under prolonged temperature stress. This suggests that milk fat and protein precursors were reduced and limited cow productivity. Gonzalez-Rivas *et al.* (2018), managed to reduce the effect of temperature stress on the milk productivity of cows by reducing heat increase during digestion by using processed end feeds.

According to Garner *et al.* (2022), cows receiving concentrated feed with a reduced starch fermentation rate as part of the diet recovered milk productivity faster after exposure to temperature stress, while having higher protein, fat, and lactose yields.

An increase in ambient temperature in summer causes heat stress in highly productive dairy cows and, as a result, negatively affects their productivity and milk quality. Testing of the food strategy for introducing a protein feed additive with protected TEP-mix protein into the diet of experimental animals during temperature stress contributed to the normalisation of productivity and improvement of milk quality indicators.

CONCLUSIONS

According to the results of monitoring studies of climate indicators, it was established that in the summer period (June-August), the daytime ambient temperature was +26-30°C. The hottest month is July when daytime air temperature (from 14^{00} to 17^{00}) reached +29-30°C.

It was proved that such climatic conditions (high temperature and low humidity) negatively affect the milk productivity of cows: in the period from June to August, the milk productivity of animals of the control group decreased by 13.1%. Due to heat stress in cows, the mass fraction of fat in milk and the mass fraction of protein decreased by 0.2%, while the somatic cell content increased by 55.6%. Due to the use of a protein feed additive with protected protein TEP-mix, the productivity of experimental cows is higher compared to the control by 1.9 kg (first group) and 1.5 kg (second group), and in terms of basic milk – by 5.4 kg (25.7%) and 4.3 kg (15.7%), respectively.

The introduction of 1.5 kg of TEP-mix supplement into the diet during temperature stress is optimal, which contributes to better adaptation of animals to the quality indicators of milk: an increase in the mass fraction of fat by 0.67% and the mass fraction of protein by 0.26%, with the content of somatic cells of 285.06±81.0-409.3±134.3 thousand/cm^3.

The prospect of further research is to develop a strategy to reduce the long-term impact of temperature stress in the cultivation of rearing animals and heifers through the use of feed additives with protein and starch protected from being broken down in the rumen.

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CONFLICT OF INTEREST

The authors declare no conflict of interest.

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Шляхи зниження впливу зовнішнього середовища в літній період на молочну продуктивність корів

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Анотація. Одним з чинників ефективного виробництва молока за інтенсивного ведення галузі є створення комфортних умов утримання корів на фермі або комплексі. Високопродуктивні корови доволі вибагливі до мікроклімату в приміщенні та умов утримання. Вважається, що продуктивність тварин на 10-30 % залежить від цього. Метою дослідження є вивчення можливості зниження впливу високої температури зовнішнього середовища на молочну продуктивність корів за різних підходів до організації технології їх годівлі. В роботі використано аналітичні, діагностичні, фізико-хімічні та статистичні методи дослідженя. Було проведено моніторинг основних кліматичних показників впродовж літнього періоду (червень-серпень). Встановлено, що зниження добового надою є наслідком негативного впливу температурного фактору, коли денна (з 11^{00} до 17^{00} години) температура повітря у червні–липні місяці була на рівні +26...30 °С. За температури повітря 26,5 °С (о 14^{00} годині) температура тіла корів підвищується з 37,5…37,8°С до 38,20…38,46 °С. Доказом цього є зниження швидкості падіння рівня молочної продуктивності корів дослідних груп у серпні місяці, коли середня денна температура повітря знизилася до +24...26 °С. Доведено, що введення у склад раціону високопродуктивних корів 1,5 кг білкової кормової добавки з захищеним протеїном ТЕП-мікс сприяє підвищенню продуктивність дослідних корів (у перерахунку на базисне молоко) на 15,7 % (4,3 кг). Модернізація раціону годівлі високоудійних корів за рахунок підвищення вмісту нерозщеплюваного протеїну у рубці до норми під час температурного стресу сприяло кращій адаптації тварин щодо продуктивності та якісних показників молока: більшення масової частки жиру на 0,67 % та масової частки білка на 0,26 %, при вмісті соматичних клітин 285,06±81,0...409,3±134,3 тис/см^3

Ключові слова: кліматичні умови**;** дійні корови; молочна продуктивність; температура; захищений протеїн