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Original researches

Seasonal effect on milk productivity and cases of mastitis in Ukrainian Brown Swiss Cows

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Abstract. Seasonality affects milk production, its composition, as well as the spread of mastitis in dairy cows. The aim of the research work was to study the way the seasons affect milk productivity and the manifestation of mastitis among Ukrainian brown Swiss cows at a commercial dairy unit, with the animals kept in naturally ventilated premises. The relationship between the indicators was assessed by Spearman's rank-order correlation coefficient. The influence of a seasonal factor and individual air parameters on cows' milk productivity was evaluated using Factorial ANOVA in Statistica 12 software. The results of the study revealed a high correlation between the content of milk fat and milk protein and the weather conditions (temperature, relative humidity, as well as temperature-humidity index) by seasons. Moreover, the greatest negative relationship between these characteristics was observed in spring (r = 0.4–0.8) and in autumn (r = 0.6), and not in summer during the heat, as we had predicted earlier. The influence rate of the «season» factor was significant both in terms of the daily milk yield and milk components (51–59%) and mastitis prevalence rate in cows (56%) at the dairy unit. In general, the reduction of milk yields in summer and especially in autumn, and the spread of udder pathology in cows during this period should provide for the introduction of managerial and preventive veterinary measures to mitigate the effects of hot summer among Ukrainian Brown Swiss cows at year-round housing of animals in naturally ventilated premises.

Keywords: seasonality; dairy cows; daily milk yield; fat and protein content; influence of factors

Вплив сезону на молочну продуктивність та випадки маститу в українських бурих швіцьких корів

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Анотація. Сезонність впливає на виробництво молока, склад його компонентів, а також поширення маститів у молочних корів. Метою роботи було вивчити як впливає сезон року на молочну продуктивність та прояв маститів серед українських бурих швіцьких корів на одному із комерційних молочних комплексів при їх утриманні в природно-вентильованих приміщеннях. Взаємозв'язок між ознаками оцінювали за коефіцієнтом рангової кореляції Спірмена. Вплив сезонного фактору та окремих параметрів повітряного середовища на молочну продуктивність корів оцінювали використовуючи Factorial ANOVA в програмному забезпеченні Statistica 12. За результатами дослідження виявлено високу кореляцію між вмістом молочного жиру і молочного білка та погодними умовами (температурою, відносною вологістю, а також температурно-вологісним індексом) за сезонами року. Причому, найвищий від'ємний взаємозв'язок між цими ознаками спостерігався навесні (r = 0,4–0,8) та восени (r = 0,6), а не влітку під час спеки, як ми передбачали раніше. Відсоток впливу фактору «сезон» із відповідними погодними умовами виявився значним як на добовий удій і компоненти молока (51–59%), так і поширеність маститів в корів (56%) на молочному комплексі. В цілому зниження надоїв корів у літній і, особливо, в осінній сезон, та поширення в цей період патології молочної залози в корів повинні передбачати впровадження управлінських і превентивних ветеринарних заходів пом'якшення наслідків спекотного літа серед поголів'я українських бурих швіцьких корів за цілорічного утримання тварин в природно-вентильованих приміщеннях.

Ключові слова: сезонність; молочні корови; добовий удій; вміст жиру та білка; вплив факторів

Introduction

Weather conditions are an influential factor in agricultural production systems around the world. It is evident that the thermal environment affects the welfare and productivity of dairy cattle (Bernabucci et al., 2015). Regardless of climate change and future forecasts, hot weather will continue to cause heat stress reactions in cattle not only in warm regions of the world, but also in continental climates such as Ukraine (Mylostyvyi & Sejian, 2019). Therefore, it is extremely important that livestock production systems already consider and implement mitigation strategies (Dahl et al., 2016).

Although cold stress adversely affects the comfort and productivity of cattle (Mader & Griffin, 2015; Belasco et al., 2015), the main focus is on the effects of heat stress (HS) on livestock (Amadori & Spelta, 2021). Research by Nardone et al. (2010) suggest that global warming is likely to have a significant effect on the stability and sustainability of livestock production worldwide, as different models for predicting climate change forecast rise in temperatures from 1.1°C to 6.4°C by the end of this century.

Periods of hot weather have long been associated with deteriorating animal health (Vitali et al., 2020), reproductive function in both males and females (Mylostyvyi & Izhboldina, 2021), and therefore, it is likely that climate change will have even greater impact on the economic efficiency of animal breeding worldwide.

Even with a high level of uncertainty in climate change forecasts and the impact of these changes on dairy cattle in the coming decades, it is already necessary to look for effective livestock management strategies under adverse (extreme) conditions, not just being guided by selection for maximum productivity and adaptation to technological conditions (Gaughan & Cawdell-Smith, 2015).

Thus, a comprehensive understanding of the factors affecting the welfare of dairy cattle, including climatic and economic ones will allow us to develop adequate strategies to improve housing conditions and maintain animal productivity and product quality with increasing weather variability (Maggiolino et al., 2020).

The scientific hypothesis was that weather conditions should significantly affect the milk productivity of cows and the manifestation of udder diseases during year-round housing of animals in naturally ventilated barns (NVB) using farm ground run areas, where weather factors will be directly affecting the body of dairy cows during the year. Therefore, the aim of our work was to determine the rate of seasonal factor influence on milk productivity, as well as the manifestation of mastitis in cows of the brown Swiss breed at one of the commercial dairy units in the continental climate of Ukraine.

Material and Methods

Relationship of the study with scientific programs, plans, topics

The study was performed within the research work at the Department of Technology of Livestock Products Processing of the Dnipro State Agrarian and Economic University of Ukraine titled «Ensuring sustainable development of animal breeding and natural resistance to environmental and technological factors» (state registration number 0120U103848) and the research work titled «Biotechnological substantiation of resource-saving technologies of production and processing of organic livestock and aquaculture products» (state registration No. 0119U001392).

Research Environment

This experiment was conducted in accordance with the animal welfare requirements and approved by the Bioethics Commission of the Institute of Biotechnology and Animal Health. The studies were performed at a commercial dairy unit (48°34'03.1" N, 34°54'47.0" E), where Brown Swiss cows are breed. In simple terms, dairy cows were kept unleashed in NVBs. Rugs were used as bedding in the stalls. Cows had a common mixed diet based on corn silage. The fed rations were balanced for essential nutrients according to the recommendations of the National Research Council (NRC, 2001). The premises had feeding alleys and group drinking bowls with free access. The cows housing conditions were described in more detail in our previously published study (Mylostyvyi et al., 2020).

Air parameters records

The data on air temperature (°C) and relative humidity (%) were obtained from the nearest «Dniprovsky Airport» meteorological station. They were freely available (archival data) on the official website of the Ukrainian Hydrometeorological Centre. The data for the period from January 2019 to December 2020 were statistically processed, the parameters were taken into account every hour and average values for the day, season and year were calculated. The straight-line distance between the livestock premises and the meteorological station did not exceed 21 km. The temperature-humidity index (THI) was calculated according to Kibler (1964):

$$THI = 1.8 \times T - (1 - RH/100) \times (T\text{-}14.3) + 32$$

where THI is the temperature-humidity index, T is the air temperature in °C, and RH is the relative humidity in %.

Records on dairy productivity of animals and the incidence of mastitis

The material for the research was the primary data of milk productivity of cows (daily milk yield per cow in the herd (kg), percentage of milk fat and protein), which was being recorded in the DairyComp 305 herd management system for two years.

Clinical mastitis was diagnosed by general clinical methods of examination (examination and palpation), and its subclinical form - using the California mastitis test.

Statistical analysis

The analysis of variance (in our case, factorial one) involves data grouping (coding) before statistical processing. In the case of coding the «Year» and «Season» factors, the data was marked respectively 1 – 2 (1 – 2019; 2 – 2020) and 1–4 (1 – winter; 2 – spring; 3 – summer; 4 – autumn). The «Air temperature» factor was coded based on the values of the thermoneutral zone (+ 4–20 °C) for cattle: 1 – up to 3.9 °C; 2 – from 4.0 to 24 °C; from 24.1 °C and >). The «Relative humidity» factor was distributed depending on the value of standard values as follows: 1 – up to 49.9%; 2 – from 50 to 79.9%; 3 – from 80% and >. The «Temperature-humidity index, THI» factor was coded based on the degree of manifestation of heat stress in dairy cattle according to the previously described principle (Mylostyvyi & Chernenko, 2019): 1 – up to 67.9 units; 2 – from 68 to 71.9 units; 3 – from 72 to 79.9 units; 4 – from 80 and >.

The share (%) of the factors' influence on the milk productivity of cows was measured according to the method of biometric analysis of the variability of traits in farm livestock (Kovalenko et al., 2010) based on the results of factorial data analysis (Factorial ANOVA) using Statistica 12 software (StatSoft, Inc., Tulsa, OK, USA).

Results

Air environment parameters during research

The area where the dairy unit is located according to the Köppen climate classification is referred to the humid continental climate with hot summers (Dfa). Weather conditions during the research were generally within the long-term data typical for the steppe of Ukraine.

It has been established (Table 1) that the main parameters of the air environment by seasons were not significantly different over the years. The difference in air temperature was 0.1–1.6 °C, relative humidity – 1.1–8.0%; temperature-humidity index – 0–2.0 units (with the maximum difference in all parameters during the transition periods of the year).

The difference in the mean annual values (Table 2) was respectively 0.2 °C; 4.3% and 0.5 THI units. Significant differences during the transition periods of the year may be due to the greater variability of weather conditions in the spring and autumn periods.

Since there is no significant difference in the parameters of the air environment by the years, it is possible to combine the data for mathematical analysis in order to increase the sample size.

Table 1. Environmental parameters at the dairy unit location according to the nearest weather station (Mean ± SE)

Season of the year	Indicator[1]		
	Temperature, °C	Relative humidity, %	THI, units
Winter	-0.4 ± 3.79 / -0.3 ± 3.14	86.6 ± 9.79 / 83.0 ± 9.54	33.2 ± 6.12 / 33.9 ± 4.79
Spring	11.2 ± 6.49 /10.0 ± 4.43	64.0 ± 14.44 / 56.0 ± 15.52	52.8 ± 9.28 / 51.5 ± 5.94
Summer	22.3 ± 2.98 / 22.5 ± 3.21	59.3 ± 9.76 / 58.2 ± 10.99	68.1 ± 3.8 / 68.1 ± 4.03
Autumn	10.6 ± 6.84 / 12.2 ± 7.39	71.9 ± 18.69 / 68.3 ± 17.63	51.4 ± 9.76 / 53.4 ± 10.8

Note. [1]In the table, the data for 2019 and 2020 are indicated with a slash. Indicators for these years are calculated using average daily values.

Table 2. Average annual values of air parameters

Indicator[1]	2019				2020			
	Mean	SE	Min	Max	Mean	SE	Min	Max
Temperature, °C	11.0	9.62	-10.0	28.4	11.2	9.41	-11.0	29.3
Relative humidity, %	70.4	17.12	34.0	100	66.1	17.39	27.8	100
THI, units	51.5	14.5	15.4	73.7	52.0	13.9	19.5	76.7

Note. [1]The indicators for these years are calculated using average daily values

Table 3. Dairy productivity in a herd of brown Swiss breed

Indicator[1]	2019		2020	
	Mean ± SE	min–max	Mean ± SE	min–max
Winter				
Average daily milk yield, kg	29.2 ± 0.64	26.7–30.4	28.8 ± 0.74	27.3–30.2
Milk fat, %	4.03 ± 0.09	3.81–4.17	3.97 ± 0.15	3.78–4.34
Milk protein, %	3.56 ± 0.049	3.47–3.62	3.56 ± 0.043	3.47–3.62
Spring				
Average daily milk yield, kg	29.4 ± 0.42	28.2–30.5	30.5 ± 0.59	29.1–31.7
Milk fat, %	3.73 ± 0.14	3.52–4.01	3.76 ± 0.07	3.61–3.92
Milk protein, %	3.43 ± 0.03	3.37–3.57	3.54 ± 0.04	3.42–3.62
Summer				
Average daily milk yield, kg	28.3 ± 0.54	26.8–29.3	29.4 ± 0.63	27.5–31.6
Milk fat, %	3.61 ± 0.06	3.32–3.77	3.67 ± 0.05	3.51–3.78
Milk protein, %	3.38 ± 0.049	3.28–3.42	3.42 ± 0.037	3.33–3.52
Autumn				
Average daily milk yield, kg	27.6 ± 0.54	26.4–28.7	28.2 ± 0.57	27.3–30.1
Milk fat, %	3.83 ± 0.11	3.59–4.13	4.00 ± 0.14	3.68–4.26
Milk protein, %	3.52 ± 0.049	3.42–3.57	3.51 ± 0.03	3.42–3.57
Mean by years				
Average daily milk yield, kg	28.62 ± 0.89	26.4–30.5	29.28 ± 1.068	27.2–31.7
Milk fat, %	3.80 ± 0.18	3.32–4.17	3.85 ± 0.18	3.51–4.34
Milk protein, %	3.47 ± 0.083	3.28–3.62	3.51 ± 0.065	3.33–3.62

Note. [1]The calculation was made on average daily values for a herd of cows

Dairy productivity of cows

The analysis of these indicators of daily milk productivity by herd for two years showed (Table 3) that the average milk productivity of Swiss cows was about 28 – 29 kg/day, with a milk fat and protein content of 3.8 and 3.5%, respectively. There was no significant difference between these indicators by years. The highest productivity by seasons was in winter and spring – 28 – 30 kg/day, the lowest was in summer and autumn – 27 – 29 kg/day. The content of milk fat and protein in these periods ranged from 3.7 to 4.0% and 3.4 to 3.5% (winter – spring) and from 3.6 to 4.0% and from 3.4 to 3.5% (summer – autumn) respectively.

Since there was no significant difference between the indicators of milk productivity by year, generalized (average) data on milk productivity in the farm for 2019 and 2020 were used for a correlative and variance analysis.

The data (Table 4) indicate seasonal differences in milk productivity between the seasons of the year, which were probably related to the state of the air environment.

Correlations between air parameters and milk productivity indicators

There is a reliable relationship between air parameters and milk productivity (Table 5), conditioned by the seasonal factor.

It has been established that there is a weak relationship between the milk yield and temperature and humidity – from positive in winter (+0.16), to negative average (-0.44) – in autumn ($P < 0.05$). The multiple correlation between these parameters and milk components is indicative. Its value, from medium in winter (-0.4) to low in summer (-0.3), was defined relative to the content of milk fat. In these seasons, the multiple correlation between milk protein content and air temperature was also low – from +0.4 (in winter) to -0.3 (in summer). The relationship between THI and milk yield in these seasons was, unexpectedly for us, quite poor (0.1) in different areas. However, the relationship was stronger (0.3 – 0.4) and reliable ($P < 0.05$) between the milk components and the temperature-humidity index.

It is significant that the multiple correlation between the temperature-humidity status and the animal productivity was much higher in the transitional periods of the year, rather than in the extreme ones (winter - summer), as we predicted. In spring, the negative correlation between the milk components (milk protein and fat content) and the state of the air environment (temperature, relative humidity and THI) increased to 0.4–0.8 ($P < 0.05$), and in the fall – up to 0.6 ($P < 0.05$).

The rate of influence (%) of weather factors on the cows' milk productivity

It has been established (Table 6) that the rate of the seasonal factor influence on the productivity of cows was more than 50% ($P < 0.05$). Moreover, the share of the seasonal factor's contribution in the milk yield was 50–55%, of the annual factor – 13%, and their interaction accounted for about 9% ($P < 0.05$).

Table 4. Mean values of milk productivity for a herd of Swiss breed by seasons (Mean ± SE)

Season of the year	Indicators of milk productivity^2		
	milk yield, kg	fat, %	protein, %
Winter	29.01 ± 0.72	4.0 ± 0.12	3.56 ± 0.046
Spring	29.96 ± 0.77	3.75 ± 0.11	3.49 ± 0.063
Summer	28.85 ± 0.83	3.64 ± 0.07	3.40 ± 0.048
Autumn	27.94 ± 0.63*	3.92 ± 0.15	3.51 ± 0.04

Note. ^{2}The indicated values are the mean indicators for two years. * Significance of the difference ($P < 0.05$) between milk yield in spring and autumn.

Table 5. Correlation between air parameters and milk productivity of cows

Indicator	Correlation value (r)		
	milk yield, kg	fat, %	protein, %
Winter			
Temperature × Humidity	+0.156	-0.387*	+0.383*
THI	+0.131	-0.358*	+0.217*
Spring			
Temperature × Humidity	-0.115	-0.788*	-0.533*
THI	-0.024	-0.783*	-0.351*
Summer			
Temperature × Humidity	-0.1341	-0.285*	-0.337*
THI	-0.138	-0.246*	-0.359*
Autumn			
Temperature × Humidity	-0.444*	-0.642*	-0.609*
THI	+0.241*	-0.631*	-0.538*

Note. *Significance of relationship $P < 0.05$.

In view of the fact that there is no significant difference between the air parameters by years, we can assume that a significant share of the impact (12.53%) of the «year» factor (F = 41.44; P = 0.0000) is still associated with the action of technological factors, taking into account that the share of influence of separate parameters of air environment (temperature, relative humidity, and THI) on the milk yield was only 1% (Table 7).

Thus, the rate of the impact of seasonal and annual fluctuations on milk yield can exceed 70%, while the rate of the impact of individual air parameters was, unexpectedly, very low (up to 1 %). However, the exception was the «air temperature» factor, the share of influence of which on the milk fat content was 13 %. The significant rate of the «year» influence on the milk yield is probably related to the influence of technological factors, as the average parameters of the air environment (temperature, relative humidity and THI) did not show a significant difference over the years.

The incidence of mastitis in cows and the influence of seasonal factors on its manifestation

In general, the incidence of mastitis in cows at the dairy unit was low for two years (Table 8).

It was established that the incidence of mastitis in a herd of cows over the years was about 3%. Although it is difficult to state that there are seasonal differences in the manifestation of breast pathology based on the above data, the analysis of variance indicates a significant influence of seasonal factors (Table 9).

Thus, the seasonal factor has a significant impact on both the milk productivity of cows and the manifestation of udder pathology in cows.

Table 6. Rate of seasonal impact on milk production of cows

Criteria	Parameters Factorial ANOVA		
	η_x^2,%	F	p-value
Average daily milk yield, kg	50.5	17.48	0.0000
Milk fat, %	58.9	406.75	0.0000
Milk protein, %	56.1	422.69	0.0000

Note. η_x^2,% – the rate of influence of the studied factor; F – Fisher criterion; p-value – the degree of probability of the result.

Table 7. The rate of influence of air parameters on milk productivity of cows

Criteria	Parameters Factorial ANOVA		
	η_x^2,%	F	p-value
Air temperature, °C			
Average daily milk yield, kg	0.9	0.93	0.3972
Milk fat, %	12.8	18.44	0.0000
Milk protein, %	2.0	3.10	0.1148
Relative humidity, %			
Average daily milk yield, kg	0.7	0.66	0.5193
Milk fat, %	0.3	0.28	0.7588
Milk protein, %	0.7	0.84	0.4359
THI, units			
Average daily milk yield, kg	0.7	0.84	0.4358
Milk fat, %	1.9	2.11	0.1269
Milk protein, %	1.9	2.07	0.1319

Note. η_x^2,% – the rate of influence of the studied factor; F – Fisher criterion; p-value – the degree of probability of the result.

Table 8. Incidence of mastitis in dairy cows over two years

Month	Cows/percentage per herd		Month	Cows/percentage per herd	
	2019	2020		2019	2020
January	47/3.7	63/4.9	July	47/3.8	40/3.0
February	44/3.6	46/3.5	August	39/3.1	28/2.1
March	31/2.5	32/2.5	September	33/2.6	42/3.1
April	35/2.8	19/1.4	October	55/4.4	47/3.5
May	41/3.3	30/2.3	November	37/2.9	54/3.9
June	39/3.2	43/3.2	December	48/3.8	38/2.8

Table 9. The rate of influence of seasonal factors on the manifestation of mastitis in a herd of dairy cows

ANOVA parameters				
SS	MS	F	p-value	η_x^2,%
10.4583	3.4861	9.2963	0.0009	56.2

Note. SS – the sum of squares; MS – mean square; η_x^2,% – the rate of influence of the studied factor; F – Fisher criterion; p-value – the degree of probability of the result.

Discussion

The amplitude of seasonality of milk production is determined by both biological and economic factors, which are usually closely related. In the EU, production peaks in spring/summer, followed by a drop in prices, while declining supply in autumn/winter cause seasonal increases in milk purchase prices. Moreover, in autumn/winter, milk usually contains more fat and protein, which has a positive effect on its price (Olipra, 2019).

An important factor influencing the amount of milk produced is also the seasonality of calving, which is associated with the peak of lactation in cows during the first hundred days after birth. For example, cows that gave birth in winter and spring (Baul et al., 2014) had sharper lactation curves, involving an increase in the daily amount of milk in the first month of lactation, and declining by the end of lactation. In cows that calved in summer, the lactation curve was steadily decreasing by the end of lactation.

High and low ambient temperatures can affect the well-being, productivity and reproduction of dairy cows. The composition of milk is also subject to changes, including the total number of bacteria and somatic cells in it, which may indicate the subclinical mastitis in cows (Colakoglu et al. 2017).

It is known that periods of summer heat are accompanied by the HS in cows (Maggiolino et al., 2020). Under conditions of metabolic stress associated with the postpartum period (Sordillo & Raphael, 2013), dairy cattle also suffer from oxidative stress accompanied by tissue and cell damage (Sordillo & Aitken, 2009), including that of the udder (Tao et al., 2018). Therefore, in order to restore adequate antioxidant status and activate the immune system, the animal must expend energy that could be used for the milk production (Amadori & Spelta, 2021).

It is believed (Staples & Thatcher, 2011) that heat stress has a greater impact on highly productive animals. It is clearly enough, given the positive correlation between the increased milk yield, feed consumption and metabolic heat production (Kadzere et al., 2002). For example (Purwanto et al., 1990), cows with milk yields of 18.5 kg/day and 31.6 kg/day had 27.3% and 48.5% more metabolic heat production, respectively, compared to dry cows.

Decreased milk yield in summer, paradoxically, may be associated with photoperiodism (Amadori & Spelta, 2021). Although the length of daylight hours causes a significant secretion of prolactin, it, however, inhibits the expression of hormone receptors in udder tissue, which makes udder secretory cells less susceptible to prolactin and slows their development.

As THI increases, the milk yield, fat and protein content reduce in dairy cows (Bernabucci et al., 2015; Amamou et al., 2019). Maggiolino et al. (2020) report that an increase in THI per unit above the threshold value for Swiss cows was accompanied by a decrease in milk yield within the range from 0.38 to 1.00 kg/day per cow. The established THI threshold values for milk yield, milk fat and protein content indicate that Swiss cows have higher heat resistance compared to the literature values for Holstein cows (Heinicke et al., 2018). For example, for them the loss was 0.41 kg/day at THI values slightly higher than 69 units (Bouraoui et al., 2002); from 0.43 to 1.27 kg/day at THI values exceeding 70 units (Bernabucci et al., 2014), and even at THI values slightly higher than 55 units – by 0.13 kg/day (Amamou et al., 2019). It is revealing that as THI grows, Swiss cows tend to produce the same amount of milk, but with a deterioration in the quality of the components (Maggiolino et al., 2020).

Although it has long been known about the reduction of milk yields in dairy farms in autumn (Ray et al., 1992), only recently has this phenomenon been characterized as «autumn low milk yield syndrome» (Syndrome della bassa produzione di latte in autunno, SBPLA) in Italy (Amadori & Spelta, 2021). This syndrome is characterized by the inability of dairy cows to realise all their productive potential in autumn, resulting in a decrease in milk yield compared to spring at thermoneutral temperatures, at the same physiological state, stage of lactation and feeding quality.

Once cows return to a comfortable environment, the effects of HS may persist for a long period, adversely affecting subsequent lactation (Tao & Dahl, 2013) and even the productivity and health of their daughters (Dahl et al., 2016).

It is telling that low milk productivity in autumn coincides with an increase in the manifestations of clinical mastitis. In particular (Vitali et al., 2020), after the peak of clinical cases of mastitis in July due to increasing heat load, the manifestations of udder pathology increased again in October, and there was a second, clear peak in the prevalence of mastitis in cows from November to January.

Increased amount of manifestations of certain infections among cattle at extremely high temperatures in summer can cause a deep transition from cellular to humoral immune response (Lacetera et al., 2005), and therefore a higher incidence of mastitis and other so-called «industrial diseases» (metritis, placental retention, abomasum displacement, etc.) in cows associated with high milk yields may depend on seasonal factors.

According to the concept of Amadori & Spelta (2021), both SBPLA and the spread of clinical mastitis after the HS decline are based on the mechanisms of manifestation of past stressors «memory» against the background of metabolic stress of previous lactation.

The amplitude of seasonality of milk production is negatively correlated with the size of dairy farms and their specialization. In particular (Olipra, 2019), due to better opportunities on larger farms (high-yielding dairy breeds, better veterinary care, high-quality feed), the seasonal amplitude of milk production is smoother. However, the effect of seasonality in any case will be notable.

The measures to prevent milk loss in the fall are well known. They are associated with reduced exposure of cows to summer HS. This includes provision of free access to water for the animals, the use of shade and fans (Amadori & Spelta, 2021), as well as nutrition strategies (DiGiacomo et al., 2016) aimed at restoring body energy balance at HS. Given the negative effects of the impact of HS on dry cows and their further productivity, it is possible to plan cows insemination in spring, prior to the manifestation of summer anestrus with the basic share of calving in winter, then cows postpartum and transitional period will not coincide with the summer heat.

Numerous researches have recently been conducted to study the potential of genomic selection to increase heat tolerance in dairy cattle. It is known (Nguyen et al., 2017) that the coefficient of heredity in terms of reducing milk yield during HS is 0.19; and as the sensitivity of animals to HS varies depending on genetic factors, this allows the application of genetic methods to solve HS problems in animal breeding (Binsiya et al., 2016). Although this approach is a long-term one, it can improve the adaptation of animals to excessive heat load as one of the strategies to prevent HS. However, the commercial feasibility of genomic selection for heat resistance still needs economic evaluation (Nguyen et al., 2017), because regardless of it highly productive cows may be more susceptible to hot weather, which implies the need for additional heat transfer (Lees et al., 2018).

Conclusions

Multiple correlations between temperature and humidity status and animal productivity were significantly greater during the transition periods of the year. In the spring, the negative correlation between the milk components (protein and fat content) and the air environment (temperature, relative humidity and THI) was 0.4–0.8, an in the autumn it was 0.6. The rate of influence of seasonal fluctuations of weather conditions on milking can make up to 60%. Given the significant impact of the seasonal factor on milk yield and milk components, more effective measures should be envisaged to reduce milk losses in the summer and autumn period. Similarly, the mastitis seasonality in cows should serve as a guide for veterinarians to enhance the preventive measures.

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