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TEMPERATURE AND HUMIDITY AS STRESS FACTORS IN MILK PRODUCTION

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Abstrakt

Among the most important paragenetic factors which have a very big influence on the production of cow milk are temperature and air humidity of the surroundings, i.e. temperature index.

Long therm deviation of one or more climate factors from their optimal values causes heat stress to these animals. Heat stress can often lead to decreased milk production, decrease in nutrient consummation, decrease in conception etc.

Data, analyses and conclusions which are shown in this paper are referring to production of milk at "PKB Corporation" farms during the year of 2010. Production and milk quality have been monitored on 7 farms located in the same climate conditions in which air humidity is frequently near its maximum. Average air humidity (by months) has varied in intervals of 75.48% to 93.39%, temperatures have varied between -0.84 and 22.21^{0}C, temperature index has varied between 31.80 and 70.48.

Milk yield, expressed via the milking average, was lowest in months when external air temperatures, as well as THI values were the highest (July and August), amounting to approximately 21.5kg, while in periods with relatively low temperatures and THI, from late autumn until the spring, this value was the highest, remaining in the interval between 22.5 and 24.3kg.

Milk quality follows milk yield, with the lowest values for the content of butterfat, protein, and nonfat dry matter recorded in July and August (3.37 and 3.39% for butterfat, 3.15% for protein and approximately 8.5% for nonfat dry matter), and the highest values recorded in various months in the autumn-winter period, which is in accordance with environmental conditions. The highest contents were 3.84% for butterfat (in January), 3.37% for protein (in October and November), and 8.71% for nonfat dry matter (in November).

Keywords: *milk production, temperature, air humidity, temperature index.*

Introduction

As one of the most important agricultural activities, milk production is exposed to the effects of numerous mutually interacting factors, such as genetic, as well as paragenetic.

Paragenetic effects are especially pronounced in herds with uniform genetic potentials. Among them, climate factors (temperature and humidity, level of precipitation, airflow, etc.) play a prominent role.

In case of a prolonged action of extreme climate factors on cows in lactation, in most cases heat stress will appear. The term heat stress implies the state of a body exposed to long-term adverse effects of one or more climate factors, where the more productive the animal, the more pronounced is the stress (Bohman et al., 2007.).

The most common causes of heat stress are temperature and humidity, based on which values the temperature index, THI, is calculated (Buraoui et al., 2002.). As a measure of the level of heat stress THI, began to develop in the mid 20th century, first in human medicine, and then also in cattle rearing (Berry et al., 1964.). A THI value of 72 is considered as the limit for the onset of heat stress (Ravagnolo et al., 2000.). THI values from 72 to 79 indicate an external temperature stressogenic for the cow’s body. When THI is above 79, the external temperature has a very stressogenic effect on the animal’s health, especially in the case of lactating cows, who are not able to use mechanisms of thermoregulation to maintain their body temperature within physiological limits under such conditions. (West, 2003).

Unfavorable environmental conditions most often lead to a decrease of the quantity and quality of milk, reduced food intake, increased water intake, reproductive disorders, etc.

Materials and methods

The effect of climate factors on milk yield investigated in 2010, on a herd of some 8500 dairy cows of the HF breed, on seven farms of the PKB Corporation.

Farms belonging to the system of the PKB Corporation are located in the vicinity of Beograd in Pancevacki rit, with a temperate continental climate, characterized by a very hot and relatively dry summer, warm temperate autumn, a cold winter, and a short spring. One of the specific features of the climate is the seasonal wind Kosava, a southeastern wind that brings clear and dry weather.

Housing technology, nutrition and care are uniform on all dairy farms. All farms have gerds with a similar genetic structure. The average share of HF genes in the population is over 90%. The housing system for animals are tie-stalls. Barn capacity is 120-130 cows. Buildings are relatively low, not exceeding 5m. Equipment for milking and milk cooling is the same on all farms. The formula used to prepare meals is similar on all farms, as well as nutrients used, with small variations in the composition and quality of forage. Meals are uniform throughout the year.

Data on air temperature and humidity were obtained by measuring, using the iMETOS automated measuring station in Institute “PKB Agroekonomik”, located in the same geographical and climate environment as the farms. The humidity index was calculated using the following formula (Mader et al., 2006):

$$THI = 0.8 x T + ((H/100) x (T-14.3)) + 46.4$$

THI was measured and calculated only for external conditions, but not in buildings. Daily milk yield, milk delivered to the dairy, number of cows milked, and total number of cows were registered daily, while milk quality was tested once weekly, alternately at the morning and the evening milking, for each barn separately, and represents the weighted arithmetic mean for the last four analyses for all parameters, with the exception of somatic cell count, where the geometric mean of the last three analyses is used (AT4 milk control method).

Results and discussion

High external temperatures during summer months are one of the main limiting factors for milk production, especially if they are also accompanied by high humidity. External temperature conditions when the body temperature of animals is within physiological limits, and the quantity of metabolic energy is minimal are called a thermo-neutral environment (Johnson, 1987). The lower limit of a thermo-neutral environment for cows in lactation with a daily milk yield of 30kg, with 4% butterfat, is within the -16 to -37ºC interval (Hamada, 1971), while the upper limit is in the interval between 25 and 26ºC (Berman et al., 1985).

Table 1: Average values and variability of certain climate condition indicators in the investigated area for 2010

Indicator	N	Average	SD	Min	Max
HUMID	365	84.09	9.37	53	100
Taver	365	10.99	8.72	-10.12	26.9
Tmin	365	4.9	7.25	-16.3	19.8
Tmax	365	16.99	10.7	-7.8	38
PREC	365	2.03	4.93	0	35.2
THIaver	365	52.01	14.62	14.37	77.5
THImin	365	42.19	12.39	3.37	66.48
THImax	365	61.69	17.61	18.28	94.02

HUMID-relative air humidity, %; Taver-average daily temperature, ºC; Tmin – min. daily temperature, ºC; Tmax – max. daily temperature, ºC; PREC – total daily precipitation, mm; THIa – temperature humidity index – average temperature; THImin – temperature humidity index – min. temperature; THImax – temperature humidity index – max. Temperature.

Average values for climate indicators were within the usual limits for Beograd and its surroundings. The average annual temperature was 10.99ºC, humidity 84.09%, precipitation 2.03l/m², and THI 52.01. However, extreme values for these mentioned indicators indicate the possibility of heat stress, since temperatures dropped to -16.3ºC and grew to 38ºC, while THI variations were within the 42.19 to 94.02 interval.

Table 2: Average values for certain climate condition indicators in the investigated area, by months, for 2010

Month	HUMID	Taver	Tmin	Tmax	PREC	THIaver	THImin	THImax
I	92.5	-0.84	-3.7	1.7	1.9	31.8	26.9	36.2
II	90.1	1.66	-2.33	5.5	2.3	36.3	29.5	42.7
III	75.5	6.63	1.7	12.1	1.4	45.5	38.1	53.8
IV	78.8	11.7	4.2	18.4	1	53.6	41.9	64.1
V	81.9	16.1	9.4	22.9	4.7	60.6	49.8	71.4
VI	84.5	19.5	12.4	26.3	3	66.1	54.7	77.2
VII	80.9	22.2	13.8	29.6	1.5	70.5	57.1	82.4
VIII	78.8	21.1	12.4	29.6	0.9	68.7	54.9	82
IX	82.7	15.5	7.8	22.8	2.1	59.8	47.2	71.6
X	85.3	8.5	3	15.5	1.5	48.3	39.2	58.1
XI	85	9	3.2	15.9	2.6	48.9	39.4	60.2
XII	93.4	0.2	-3.57	3.8	1.3	33.2	26.7	39.5
Total	84.1	11	4.9	17	2	52	42.2	61.7

Average temperature values for 2010, by months, were within the interval from -0.84ºC (January) to 22.21ºC (August). Minimum average temperatures were recorded in December and January (below -3ºC), and maximum average temperatures were recorded in July and August (above 29ºC).

By months, humidity was lowest in April and August (78.8), and highest in December (93.4). Average relative humidity was 84.1.

By months, THI was within the interval from 31.8 (January) to 70.5 (July), with an average value of 52.01. Lowest average THI values, below 30, were recorded in the months with the lowest average temperatures (December, January, February) while the highest, above 82, were recorded in July and August.

Table 3: Average production indicators

Month	N	No. of cows milked	Σ cow	Milk delivered to the dairy	Average yield *	BM %	PROT %	NFDM %	CFU	SCC
I	31	7405	8758	173069	23.4	3.84	3.25	8.52	20487	260663
II	28	7522	8788	176687	23.5	3.82	3.26	8.55	20078	274678
III	31	7619	8797	180925	23.8	3.73	3.26	8.53	20251	307524
IV	30	7495	8744	182168	24.3	3.56	3.25	8.6	20209	299595
V	31	7288	8688	175575	24.1	3.42	3.23	8.69	20496	287212
VI	30	7033	8634	159349	22.7	3.44	3.2	8.57	20880	298795
VII	31	6867	8650	146857	21.4	3.39	3.15	8.51	20442	327373
VIII	31	6903	8642	148614	21.5	3.37	3.15	8.46	20780	312872
IX	30	6931	8668	160016	23.1	3.47	3.23	8.55	23060	340483
X	31	6929	8720	158337	22.9	3.54	3.37	8.7	20683	297880
XI	30	7033	8738	158500	22.5	3.55	3.37	8.71	20607	268381
XII	31	7222	8803	164294	22.8	3.46	3.33	8.66	15736	273497
Total	365	7185	8719	165277	23	3.55	3.25	8.58	20301	295853

* milking average – value calculated as the ratio between the quantity of milk delivered to the dairy and the number of cows milked

Temperature stress in cows has an extremely unfavorable effect on milk yield and quality (lower butterfat content, increased somatic cell and bacteria counts), and its physico-chemical characteristics (Milosevic, M., 2002).

Milk yield, expressed via the milking average, was lowest in months when external air temperatures, as well as THI values were the highest (July and August), amounting to approximately 21.5kg, while in periods with relatively low temperatures and THI, from late autumn until the spring, this value was the highest, remaining in the interval between 22.5 and 24.3kg. In summer months (June-August), the quantity of milk delivered to the dairy was also considerably lower compared to the remainder of the year.

The number of cows in milking droped in summer months, as a direct consequence of cows being dried off after 7 months of pregnancy, i.e. of good results in reproduction in the November-March period. On the other hand, due to unfavorable climate conditions in July and August (high temperatures and THI), freshly calved cows did not exhibit their full production potential.

Milk quality follows milk yield, with the lowest values for the content of butterfat, protein, and nonfat dry matter recorded in July and August (3.37 and 3.39% for butterfat, 3.15% for protein and approximately 8.5% for nonfat dry matter), and the highest values recorded in various months in the autumn-winter period, which is in accordance with environmental conditions. The highest contents were 3.84% for butterfat (in January), 3.37% for protein (in October and November), and 8.71% for nonfat dry matter (in November).

Highest bacteria and somatic cell counts were registered in September (23060 and 340483), with the lowest bacteria counts registered in December (15736), and the lowest somatic cell counts registered in January (260663). In any case, bacteria and somatic cell counts were within acceptable limits according to technological norms and milk quality standards (100000 CFU and 400000 somatic cells for extra class milk).

Table 4: Correlation between THI, milk quantity and quality

	Milk kg	Butterfat %	Protein %	NFDM %	CFU	SCC
THI	-0.37	-0.69	-0.55	-0.25	0.42	0.59
THImin	-0.36	-0.63	-0.53	-0.25	0.4	0.54
THImax	-0.36	-0.69	-0.5	-0.21	0.42	0.59

Correlations between THI and characteristics of milk production were negative, medium and strong (from -0.36 to -0.69), while between THI and indicators of hygiene (bacteria and somatic cell counts) they were positive, within the interval from 0.4 to 0.59 (medium and strong).

For overcoming issues in production caused by unfortable climate factors, it is necessary to adjust conditions of dairy cattle housing i. e. it is necessary to adapt existing objects or build new ones that would satisfay technological for extreme environmental conditions.

Conclusion

Investigation results indicate that milk production on farms of the PKB Corporation drastically decreases in summer months, resulting to a large extent from unfavorable climate factors, i.e. the exposure of dairy cows to heat stress. The negative effect is evident, both in the quantity of milk produced, and in its quality. In the hottest part of the year, the butterfat and nonfat dry matter content in milk decreases, with a somewhat less pronounced decrease in protein, and an increase in bacterial and somatic cell counts, which all has a negative influence on the quality and nutritional value of milk and dairy products.

The adapting of technological solutions (opening up barns, improving barn ventilation, thermal insulation of roofs, etc.), nutrition (new feeds, a more favorable relation between energy and protein in the diet, better feed digestibility, etc.), of the manner of housing, etc., is required in order to find a way to permanently eliminate or at least mitigate the consequences of temperature stress on lactating cows. In view of the tendency toward climate change, these problems will become more present and more intensive, while economic operating results will depend on the speed and quality of adapting existing technologies to the new situation.

References

Berman, A.J. (2005): Estimates of heat stress relief needs for Holstein dairy cows. J. Anim. Sci. 84:1377–1384.

Berry, I.L., Shanklin, M.D., Johnson, H.D. (1964): Dairy shelter design based on milk production decline as affected by temperature and humidity. Trans. Am. Soc. Ag. Eng. 7: 329-331.

Bohmanova, J., Misztal I., Cole J. B. (2007): Temperature-humidity indices as indicators of milk production losses due to heat stress. J.Dairy Sci. 90:1947–1956.
Bouraoui R., Lahmar M. , Majdoub A., Djemali M., Belyea R. (2002): The relationship of temperature-humidity index with milk production of dairy cows in a Mediterranean climate., Anim. Res. 51: 479–491.
Hamada, T. (1971): Estimation of lower critical temperatures for dry and lactating dairy cows, J. Dairy Sci., 54: 1704-1705.
Johnson, H.D. (1987): Bioclimate effects on growth, reproduction and milk production. In: Johnson H. D. (ed.): Bioclimatology and the adaoptation of livestock. World Animal Science, B5, Chapter3, Elsevier Science Publishers B.V., Amsterdam, The netherlands. 35-57.
Mader, T. L., Davis, M. S., Brown-Brandl, T. (2006): Environmental factors influencing heat stress in feedlot cattle. J. Anim. Sci. 84:712-719.
Milošević, M. (2002): Uticaj temperaturnog stresa na proizvodne i reproduktivne sposobnosti goveda. Mlekarstvo, 1 (7): 2003-2008.
Ravagnolo, O., Misztal I., Hoogenboom, G. (2000): Genetic component of heat stress in dairy cattle, development of heat index function. J Dairy Sci 83: 2120–2125.
West, J. W. (2003): Effects of heat-stress on production in dairy cattle. J. Dairy Sci. 86: 2131–2144.