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EFFECT OF HEAT STRESS ON MILK PRODUCTION IN DAIRY COWS

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Abstract: Heat stress in dairy cows is caused by a combination of environmental factors (temperature, relative humidity, solar radiation and air movement). Continual genetic selectin for greater performance results to increased sensitivity to heat stress. It was one of the reasons why lactation curve during summer has decreasing trend compared to spring in which lactation curve maintained within high levels. The trial was conducted in spring (April-May) and summer period (June-July) on total of 40 dairy cows of Holstein-Friesian breed in early lactation period (first 60 days of lactation). Milking capacity in cows and milk chemical ingredients (milk fat and proteins) were statistically significantly higher in the spring period compared to summer, while higher values of lactose were not statistically significant. Total average milk production per cow was significantly higher in spring period (42.74±4.98l) than in summer (39.60±5.09l) at the level of $P<0.05$. A higher rate of milk fat was recorded in spring in relation to summer period the level of significance being $P<0.01$. The content of proteins in milk in spring period was 13% higher than in summer. The established difference was highly statistically significant ($P<0.001$). Obtained values for percentage of lactose varied slightly (4.45±0.54% in spring versus 4.03±0.24% in summer period; $P>0.05$).

Key words: heat stress, milk production, dairy cows

Introduction

A heat stress in dairy cows is provoked by a great number of external factors – temperature, relative air humidity, sunlight radiation, air circulation and precipitations. However, the estimation of how much each of these factors takes part in inducing the thermal stress is limited since the available data are rather unreliable. Most studies on heat stress in dairy cows are focused mostly on temperature and relative air humidity *(Igono et al., 1985; Ravagnolo and Misztal, 2000; Correa-Calderon et al., 2004)*.

Selection in high-yielding dairy breeds of cattle directed towards improving genetic predisposition for higher production of milk and quantity of consumed food especially at the beginning of lactation has resulted in reduced production and reproductive potentials in the periods of increased outdoor temperature, because a due attention has not been payed to a thermoregulative capacity in animals. A consumption of great quantities of food results in the increase of metabolic increments which require efficient thermoregulatory mechanisms in maintaining body temperature and physiological homeostasis. It is rather complicated to determine precisely the moment when the cow enters into the heat stress because the incidence of heat stress is not influenced by energy balance only but also by a quantity of water, and metabolism of sodium, potassium and chlorine *(Kadzere et al., 2002)*. In the conditions of heat stress a reduced milk production is the first perceived consequence. High-yielding dairy cows are the most sensitive to the influence of heat at the beginning of lactation and in cases when a body temperature is higher than 39^{o}C a production of milk significantly falls *(Ravagnolo and Misztal, 2000)*. At the outside temperature of 35^{o}C a quantity of milk is decreased by 33%, and at the temperature of 40^{o}C by 50% *(West, 2003)*.

In the conditions of high external temperature the emission of heat by conduction, convection and radiation is decreased, while an evaporative emission of heat by sweating and panting is increased in a considerable degree *(Berman et al., 1985; West, 2003)*. An inability of organism to adapt to newly created situation leads to health disturbances, reduction in nutritive needs and the production of milk, change in chemical composition of milk and reproductive disorders. During a heat stress dairy cows not only consume less food but also the utilisation of some food ingredients is reduced *(Rhoads et al., 2009)*.

Dairy cows at the beginning of lactation have small chances to fight off a thermal stress, and thus it has the strongest effect on the production of milk in the first 60 days of lactation. A negative balance of energy in dairy cows at the beginning of lactation is even more increased by creating and emitting of higher quantity of thermal energy in the period when animals consume less food. For this reason a high-yielding diary cows are more sensitive to heat stress than cows having a lower genetic potential for milk production *(Collier et al., 2005)*. By emitting the excess heat by way of evaporation there occurs a significant loss of electrolytes especially when the outdoor temperature is above 35^{o}C so the recommendations of the *National Research Council (1989)* are to increase the quantity of sodium from 1.2 to 1.5%, chlorine from 0.4 to 0.6% and magnesium from 0.3 to 0.35% in dry matter. It is also necessary to increase the content of some vitamins in rations, especially the vitamins A (100000 IU/day), C (50000 IU/day) and E (500 IU/day) *(West, 1999)*. The intake of food is the most optimal in the early morning and late in the evening since the digestion of food reaches its peak 3 to 4h after food intake while in this way the hottest part of the day is being evaded.

Beede and Collier (1986) have recommended 3 menagement strategies which minimize the effects of heat stress: 1. change of surrounding, providing of shade and cooling the animals; 2. creating the breeds tolerant to heat stress and 3. improved nutrition habits. By the combination of these measures it is possible to improve the production of dairy cows in the conditions of high temperature and humidity.

The aim of this study was to examine the influence of heat stress on the production and chemical composition of milk (milk fat, proteins and lactose) in Holstein-Friesian cows in early lactation period.

Materials and Methods

The trial was conducted in spring (April-May) and summer period (June-July), on a cattle farm in Serbia, on total of 40 dairy cows of Holstein-Friesian breed in early lactation period (first 60 days of lactation). For both periods of trial 20 cows in their second lactation have been chosen per each period.

Milking capacity was recorded every day in the course of trial period in both seasons, by direct reading on a milking device of the type Alfa Laval, Sweden. Cows were fed 2 times a day with mixed rations (Table 1) and manual distribution of 2 kg alfalfa hay.

Table 1. Daily feedstufs consumption per cow

Feeds	Quantity (kg)
Grass hay	3,50
Corn silage, 35-40% DM	19,00
Alfaalfa haylage	4,00
Wet brewers grains	5,00
Corn grain	2,00
Barley grain	2,00
Soybean meal	1,50
Soybean flour	1,20
Wheat flour	1,40
Minerals and vitamines	0,80
TOTAL	40,40

Nutritional value of meals are shown in Table 2.

Table 2. Nutritional value of meals

Chemical composition	
Dry matter, kg	22,10
NEL, MJ	158,00
Crude protein, % DM	16,00
Crude fiber, % DM	17,50
Crude fat, % DM	4,55
Ca, % SM	0,90
P, % SM	0,55

The milk samples for chemical analysis were taken in sterile plastic cups from each quarter of udders on the 15th, 30th and 60th day of lactation immediately before morning milking. A chemical composition of milk was determined on the apparatus Lactoscope-Delta Instruments-C-4 2.0 Holland.

Testing of the significances of determined differences between studied parameteres was performed by Student t-test.

Results and Discussion

Milking capacity in cows and the results of milk chemical analysis (percentage of milk fat, proteins and lactose) in dairy cows of Holstein-Friesian breed in the first 60 days of lactation during spring and summer periods are shown in Table 3.

Table 3. Milking capacity in cows and the results of milk chemical analysis in the first 60 days of lactation during spring and summer periods

Period	Quantity of milk (l)		Milk fat (%)		Proteins (%)		Lactose (%)	
	$\overline{x}$	SD	$\overline{x}$	SD	$\overline{x}$	SD	$\overline{x}$	SD
Spring period (April-May)	42,74	4,98	3,25	1,26	3,15	0,21	4,45	0,54
Summer period (June-July)	39,60	5,09	2,62	0,49	2,75	0,23	4,03	0,24

A quantity of milk in a spring period was 42.74±4.98l, and in summer 39.60±5.09l wherein a confirmed statistical significance of difference was at the level of $P<0.05$. A higher rate of milk fat was recorded in spring (3.25±1.26%) in relation to summer period (2.62±0.49%) the level of significance being $P<0.01$. The content of proteins in milk in spring period was 3.15±0.21%, and in summer 2.75±0.23%. The established difference was highly statistically significant ($P<0.001$). Obtained values for percentage of lactose varied slightly and ranged from 4.45±0.54% in spring to 4.03±0.24% in summer period. Between these values the statistically significant differences were not confirmed.

In the conditions of heat stress the animals consume less quantites of feeds in relation to their real needs. The quantity of food intaken is decreased by even up to 20% in summer period in relation to spring period, and when outdoor temperature reaches 40^{o}C the consumption of food can decrease by even 50% *(NRC, 1989)*, what disturbs the energy balance of animal *(Rhoads et al., 2009)* and therefore, the activity of mammary gland. *Sacido et al. (2001)* and *Seignalini et al. (2011)* state that in dairy cows in the conditions of heat stress the production of milk is being decreased by between 10 and 30%, with significant reduction in fat and proteins. At the temperature higher than 30^{o}C the quantity of milk is being decreased by up to 30% while the content of fat is reduced from 3.6% to 3.2%, and the content of proteins from 3.34% to 3%. *Zheng et al. (2009)* suggests that heat stress significantly reduces the production of milk, percentage of milk fat and percentage of proteins, but that it has no effect on the content of lactose in milk, what is in accord with our investigation. Also, *Kadzere et al. (2002)* point to the fact that at the temperature of 35^{o}C the quantity of milk is reduced by 33%, and at 40^{o}C by 50%. The same authors state that the percentage of milk fat is reduced by 39.7%, and proteins by 16.9%.

Correspondingly to our investigations *Ostojić (2007)* observes that the content of lactose is being slightly increased in the course of lactation period in spring as well as in summer. *Vuković (2008)* also reports that the content of lactose is being reduced from 4.5% in spring to 4.43% in summer but that these differences are not statistically significant.

Conclusion

The cooling systems for the farm buildings and dairy cows have lately been increasingly in use in summer months in order to make better conditions and to reduce losses in the milk production. However, even besides measures undertaken the heat stress is still one of the major factors which affects unfavourably the health, reproductive capability and production of milk. Only an intensive management can reduce the influence of heat stress on the quantity of milk and profitability. Before hot weather comes certain measures must be taken because dairy cows are very sensitive to heat stress: to protect cows from direct sun rays; to provide cooling by use of fans and sprinkle systems; to provide high quality food (adequate proteins, fats, minerals and vitamins); to feed cows several times a day by smaller rations during the colder periods of day; to clean the feeders in order to prevent the spoiling of ration and to provide unlimited quantities of clear, cold water.

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Uticaj toplotnog stresa na proizvodnju mleka kod mlečnih krava

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Rezime

Toplotni stres kod mlečnih krava uzrokovan je većim brojem spoljašnjih faktora - temperaturom, relativnom vlažnošću vazduha, sunčevom radijacijom i kretanjem vazduha. Genetska selekcija za veće proizvodne rezultate povećava osetljivost na toplotni stres. To je jedan od razloga što laktaciona kriva za vreme letnjeg perioda ima trend pada u poređenju sa prolećem kada laktaciona kriva dostiže visoke nivoe. Ogled je izveden u prolećnom (april-maj) i letnjem periodu (jun-jul) na ukupno 40 mlečnih krava holštajn-frizijske rase u ranom laktacionom periodu (prvih 60 dana laktacije). Mlečnost krava i hemijski sastojci mleka (mlečna mast i proteini) su bili statistički značajno veći u prolećnom periodu u odnosu na letnji, dok veće vrednosti laktoze nisu bile i statistički značajne. Ukupna prosečna proizvodnja mleka po kravi je bila značajno veća u prolećnom periodu (42,74±4,98l) nego u letnjem (39,60±5, 09l) na nivou od P<0,05. Veći procenat mlečne masti zabeležen je u prolećnom nego u letnjem periodu na nivou značajnosti P<0,01. Sadržaj proteina u mleku u prolećnom periodu bio je 13% veći nego u letnjem. Ustanovljena razlika bila je visoko statistički značajna (P<0,001). Dobijene vrednosti za procenat laktoze malo su varirale (4,45±0,54% u prolećnom prema 4,03±0,24% u letnjem periodu; P>0,05).

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