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Research Article

THE EFFECT OF HEAT STRESS ON DAIRY COW'S PERFORMANCE AND ANIMAL BEHAVIOUR

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ABSTRACT: The aim of this study is to evaluate the effects of heat stress using temperature-humidity index (THI). Two experiments were conducted using lactating Friesian-Holstein cows to measure the effects of heat stress under the Mediterranean climate, on rectal temperature (RT), milk production, respiration rate (RR), heart rate (HR), dry matter intake (DMI) and feed digestibility (FD). The hot environmental temperature had an effect on RT, RR and on HR. They were significantly higher in the heat-stressing treatment, they are respectively 39.39, 79.41 and 78.06 for THI=83.27; whereas they are respectively equal to 38.15, 43.77 and 61.99 for THI=65.62, in average THI values (83.91 ±1.3 vs. 65.62 ± 1.98) in summer and spring period. We can conclude an increase in the daily milk yield In dairy cows, under Tunisian summer conditions. Comparing hot and cold weather, digestibility was higher in summer (68.5% vs. 66.5% in spring), dry matter intake declined more rapidly with increasing temperature (18.28 Kg/d vs. 21.31 Kg/d). The yields of milk fat and protein have not a significant variation, but results show a sign ificant increase in Somatic Cell Counts (SCC).
Keywords: heat stress, dairy cow, temperature-humidity index, milk production, animal behavior.

INTRODUCTION

Heat stress increases the maintenance of energy requirement and reduces milk yielding and reproductive performance, causes serious economic losses. Ambient temperature affects milk production and animal behavior during the hot summer in Tunisia. Physiological stressing conditions acting via the hypothalamic-pituitary-adrenal axis have been associated with a number of responses, to maintain normal body temperatures. Heat stress in particular, can reduce livestock productivity by billions of dollars every year (Rosenkrans Jr et al., 2010).

Under conditions of high temperature and relative humidity, Heat stress causes changes in the homeostasis status of the animals and has been quantified through measurements of rectal temperature (RT), respiratory rate (RR), [14].

The analysis of environmental effects on dairy cow yield under hot temperature revealed that daily yields of milk and milk protein were reduced respectively by 0.38 and 0.01 kg/°C of ambient temperature increase [1] and some observations have suggested that heat stress is associated with changes of milk composition, milk somatic cell counts (SCC) and mastitis frequencies [15].

An increase in body temperature usually accompanies this rise in ambient temperature and may be a primary stimulus for reduction in both feed intake and milk production [6].

The objective was to measure the effects of heat stress on milk production and composition and to examine the relationship between hot temperature and digestibility under significant climate changes.

MATERIAL AND METHODS

Animals, Measurements and Sampling

The study was carried out in 2009 at the OTD Badrouna dairy farm, Bousalem, thirteen dairy cows Holstein heifers 47± 23 months of age and mean weight between 509 ± 15.1 were selected for the study and two experiments were conducted. Measures started at mi day12 pm and finished around 3 pm.

Animals were maintained under dry hot conditions and offered 100% of their dietary estimated net energy requirements.

The first experiment was carried out under spring conditions (mean daily THI value 65.62 ± 1.98, no heat stress; March), and the second during the summer season (mean daily THI value 83.91 ±1.3, stress conditions; August). Prior to the experiments, the cows were housed in a covered free stall barn with the remaining herd. They were fed oat silage for ad libitum and concentrate according to the production level. Farm management and diet composition were typical for the region. Ingredients and chemical compositions of diet fed to animals during the experiment are reported in Table 1.

Table 1: Ingredients of the total mixed ration diet (on dry matter basis)

		Periods	
		Summer (August)	**Spring (March)**
Feeds Ingredients %	Triticale ground green forage	--	17.50
	Bersim green forage	--	14.0
	Corn green forage	24.1	--
	Sorghum green forage	16	--
	Alfalfa forage	14.20	10.0
	Oat hay	8.2	7.1
	Oat silage	38.0	--
	Corn grain grind	11.50	--
	Soybean meal	9.1	7.8
	Corn grain	9.1	--
	Wheat bran	7.4	6.9
	Barley grain	10.0	9.2
	Mineral	2.0	2.0
	Sodium bicarbonate	0.4	--
	Calcium phosphate	0.6	--

Experimental periods are 4 weeks each, preceded by two weeks of adaptation to the experimental conditions. Rectal temperature (RT) was measured using a medical digital thermometer (accuracy to 1°C) in. Heart rate (HR) was counted using a medical stethoscope (breaths/minute). Respiration rate (RR) was measured by counting the flank movements of the individual cows for one minute: period of uninterrupted breathing and reported as the number of inspirations per minute. The following measurements were performed weekly during the experimental periods. Temperature and relative humidity were daily recorded by using a thermo hygrometer. THI values were also determined during the experimental period using the following equation, as described by Kibler [9],

$$THI = 1.8 \times Ta - (1 - RH) \times (Ta - 14.3) + 32 \quad (1)$$

Where *Ta* is the average ambient temperature in °C and RH is the average relative humidity as a fraction of the unit. The cows were milked twice in the day (7:00 and 17:00 h) and milk yield of the individual cows of each milking was recorded on all test days. A weekly composite sample taken from the two milking of each cow was analyzed for protein, fat and somatic cells.

Feed intake and Digestibility were recorded during the last 7 days of each period. To determine daily feed intake, the amounts of the feed offered and refused were daily measured during the last 7 days of each period. Refused feed was removed and weighed daily just prior to the morning feeding. Feed components and fecal samples were sampled once each day and dried to constant weight at 105°C in a forced-air oven for 24h. The DM content of feedstuffs was used to adjust ration components for changes in moisture content once per day. All ration refusals and fecal samples of each cow were pooled, dried at 55°C, and stored at -20°C.

For the 30 Holstein cows from each treatment group prior to marker administration were selected for the digestive marker Acid Insoluble Ash (AIA) as a natural marker for determining apparent dry matter (DM) digestibility in ruminants allowed free access to feed. Analyses of AIA were performed according to Van Keulen [18].

Apparent nutrients digestibility was predicted on the basis of offered feed or consumed feed and estimated internal marker. Apparent nutrient digestibility was more accurately predicted using the equation for consumed feed and AIA as the internal marker. The following equations are used for calculated digestibility:

$$Fecal\ dry\ matter\ (kg/day) = \frac{Quantity\ intake\ of\ marker\ (g/day)}{Fecal\ content\ of\ the\ marker(g/kg\ fecal\ dry\ matter)} \quad (2)$$

$$Da = \frac{Quantity\ of\ DMI\ -\ quantity\ of\ fecal\ DM}{Quantity\ DMI} \quad (3)$$

Data were analyzed as repeated measures using the general linear model procedure of SAS (Sevcik,1996) according to the following model:

$$Y_{ijkl} = \mu + S_i + C_{ij} + W_k + e_{ijkl}$$

where:

Y_{ijkl} = the k^{th} day observation on the j^{th} cow in the i^{th} period;

μ = overall mean of the population,

S_i = mean effect of period ($i = 1$ to 2),

C_j = mean effect of cows ($j = 1$ to 30), nested within period i;

W_k = mean effect of the week of sampling ($k = 1$ to 4),

and e_{ijkl} = the unexplained residual element assumed to be independent and normally distributed. Tests of significance were calculated using expected mean squares. A probability of $P < 0.05$ was considered significant.

RESULTS AND DISCUSSION

Environmental conditions during the study are presented in Table 2

Table 2. Environmental conditions during the experimental periods.

		Parameters		
		Average temperature (°C)	**Average RH (%)**	**Average daily THI**
Period	**August**	37.35	31.25	83.27
	σ	2.3289	0.0352	1.8969
	February	20.12	57.70	65.62
	σ	2.0173	0.0736	2.4339

Lactating cows are thought to experience no stress when THI is less than 72 and severe stress when THI exceeds 88 [17].

Figure 1 shows RT, RR and HR variation during spring and summer trial. In this study, heat stress alters ($P < 0.05$) RT, HR and RR

Rectal temperature increased ($P < 0.05$) beyond 39.20°C in the heat-stressing period. The increase in RT observed during the hot temperature reported that sudden exposure of heifers to a hot environment resulted in a rapid increase in rectal temperature. These results coincide with the work carried out by other authors in [14] who did find a significant increase in rectal temperature during the heat stress. The rectal temperature and respiratory rate observed in the present study are higher than those reported by Espinosa et al in [7] for Holstein cows exposed to a THI > 72.

RR and HR were significantly ($P < 0.05$) higher for cows in summer than control month in spring RR was 43.77 versus 79.41 Insp/min, whereas, HR was 61.99 and 78.02 Beat/min respectively, in spring and in summer.

The increase in HR and RR appears to be the result of the adaptation to the hot environment. Even though some large animals use thermo ability as an adaptive strategy to tolerate heat stress [3], the endogenous heat load is thus reduced and the animal brought into thermal balance with its environment [4].

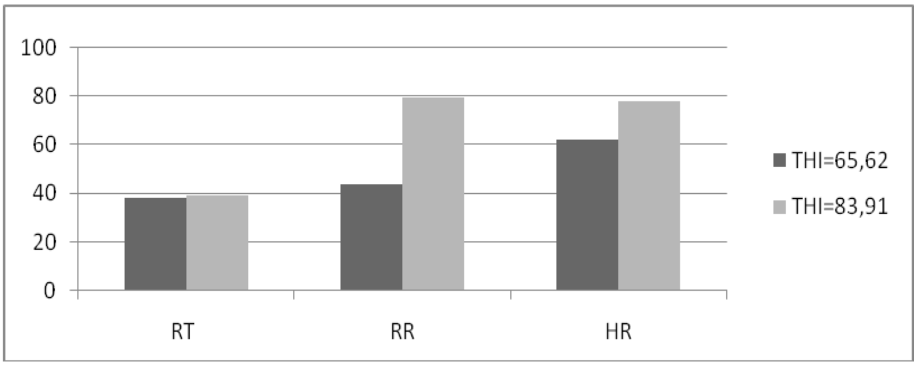

Figure1: Effect of temperature on physiological parameters.

Table 3. Milk production, milk components, dry matter intake and digestibility evolution in term of THI

		Parameters					
		Milk protein (%)	Milk fat (%)	Somatic Cell counts × 10^5	Milk Production (Kg/Day)	DMI (kg/day)	Digestibility (%)
Period	Summer	3,24	3,65	8,8	24,26	18,28	68,5
	σ	0,0396	0,0543	0,3535	0,1935	0,1881	0,2456
	Spring	3,30	3,79	5,3	30,42	21,31	66,5
	σ	0,0147	0,0339	0,0707	0,2382	0,1324	0,2123

The decline of milk production shown in Figure 2, summarizes that the exposure to heat stress has a very detrimental effect on milk production. All cows showed lower ($P < 0.01$) milk yields in the hottest summer month (August) than control month spring (February), Milk yield average value in spring was 30,42 Kg/day greater than milk production in summer 24,26 Kg/day. Decreased milk yield would be due to the cumulative effects of heat stress on feed intake, metabolism and the physiology of dairy cattle [12].

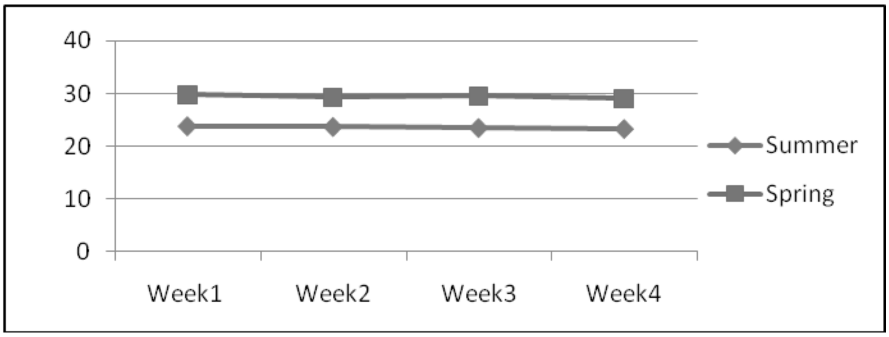

Figure2: Effect of heat stress on milk production

Results summarized in table 3 show a significant effect of heat stress on milk components, the heat stress affected milk protein which was declined ($P<0.01$) by 0.06% in August. The reduction in milk protein observed during the summer month can be attributed to lower dietary energy and protein intake, which is a consequence of decreased feed intake.

Heat stress significantly reduced (P<0.01) milk fat content from 3.79% during the spring (THI = 65.62) to 3.65% during the summer (THI 83.91), other author in [10] found no significant decrease in fat percentage for cows under heat stress. The depressed fat percentage could be attributed to the decrease in forage intake (17%) which may have resulted in an inadequate fiber level in the diet to maintain normal rumen function [15]. Holstein cows produced much more (P < 0.05) SCC (8.8 10^5 counts /ml) in summer month comparing to the spring month 5.3 10^5 counts/ml. Some observations have suggested a positive relationship between the stress at high summer environmental temperatures and high somatic cell count in milk [13]. Dairy cows exposed to high environmental temperature, DMI normally decreases, and consequently, milk yield is also reduced [1]

The DMI decreased (P < 0.05) by 21.31 kg/d in spring 18.28 kg/d in summer. Add to that, increasingly physiological responses of dairy cattle to heat stress. Such as decreased DMI, increased maintenance requirements, and decreased milk production start to occur at a THI of 72. Further research suggests that a maximum daily THI of 72 will decrease DMI in dairy cattle, and a minimum THI of 56 is more closely correlated with the initiation of decreases in DMI [11]. Decreases in DMI usually occur in animals exposed to hot environment [2], [16]. Under hot conditions, diet digestibility rate was affected by a reduction in DMI: digestibility rates were respectively (P < 0.05) 68.5% in summer, whereas they were 66.5% in spring.

The reduction of DMI is generally associated with an increase in diet digestibility and a decrease in rumen passage [2], Christopherson and Kennedy in [5] described positive effects of high ambient temperature on diet digestibility and suggested that the reduction in passage rate of digesta caused by the reduction of gastrointestinal motility that usually occurs under hot environments [8] was the responsible.

Heat stress is a serious problem in dairy and beef production; it affects the animal behaviour, feed intake, digestibility and feed efficiency [12].

CONCLUSION

In this study cows were stressed, as indicated by rectal temperature (RT), respiration rate (RR), heart rate (HR), when the THI values increased from 65 to 83. The hot environmental temperature reduced DMI and rumen passage rate in dairy heifers. Diet digestibility was affected by hot weather, DMI decreased by 3.61 kg and milk production by 6,19 Kg/day. The responses of the studied physiological variables show that the dairy cow responded to climatic factors associated with heat stress to maintain homeostasis.

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