Effect of supplementation with sodium bicarbonate on lactating dairy cows during summer

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Background

Heat stress in dairy cattle is a common problem in many areas of the world at least in some months of the year. The main consequences of heat stress are a reduction in dry matter intake, milk production and reproductive performance (Rejeb et al., 2002).

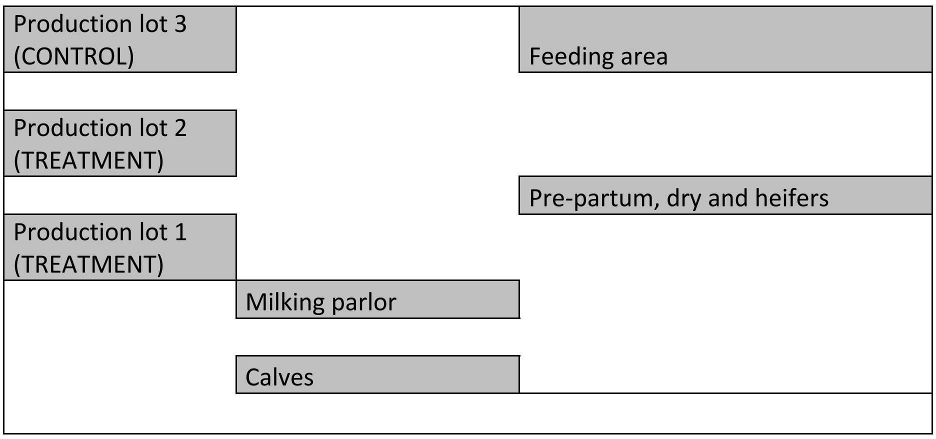
High temperatures may activate the hipothalamic-suprarrenal axis resulting in compensatory mechanisms to help maintain normal body temperature (Rejeb et al., 2002). This often results in the loss of some electrolytes and bicarbonate. It has been suggested that cows under heat stress may find a benefit of being supplemented with additional sodium bicarbonate, resulting in improved productive performance (Beede et al., 1986; Scheneider et al., 1986)

The objective of this study was to evaluate the effectiveness of a product incorporating sodium bicarbonate (BICAR Z® produced by Solvay Química, S.L.) on milk production during heat stress.

Material and Methods

The study was conducted in a farm located in La Garrotxa (Girona, Spain).

Figure 1: Schematics of the distribution of lots within the farm



A total of 197 lactating Holstein cows were used. Animals were distributed in three groups, two for the treatment (treatment group) and one for the control (control group) (see figure 1). Control cows (n=87) cows) were fed a TMR diet once daily (See Table 1) and treatment cows (n=111) received the same diet but with the addition of 250 g per cow per day of sodium bicarbonate (BICAR Z®). The ingredient and chemical composition (average of 4 analyses) of the TMR diet offered as basal diet to all cows is presented in Table 1. The diet was design to meet or exceed dietary and nutritional recommendations for dairy cows in the farm following NRC (2001).

Table 1: Ingredient and chemical composition of basal diet (dry matter base).

Item	(% DM)
Triticale silage	22.9
Corn silage	7.5
Straw	3.1
Corn grain	21.7
Soybean meal	9.9
Brewer's grains	9.0
Barley	9.0
Corn gluten feed	7.7
Linseed meal	3.1
Cottonseed	1.5
Beet molasses	1.0
Calcium soaps	1.1
Soy hulls	0.45
Calcium carbonate	0.79
Bicarbonate (BICAR Z®)	(+ 250 g/cow for treatment group)
Urea	0.50
NaCl	0.20
Vit-Min Mix	0.90
MgO	0.15
Dry matter, %	36.2
UFL, /kg DM	0.99
NE_L Mcal/kg	1,71
Crude protein, %DM	16.9
NDF, %DM	39.6
Fat, %DM	5.19
Ash, %DM	7.86

The study was conducted in two periods: period 1 (1^{st} to 31^{st} July) and period 2 (1^{st} to 31^{st} of August). Temperature, humidity and rainfall were collected daily (Meteorological Service of Catalunya, Vall d'en Bas station; Meteocat) and the Temperature-Humidity-Index (THI) was calculated using the following formula:

$$THI= (1.8xT+32) - ((0.55-0.0055xRH) x (1.8xT-26))$$

T=Temperature; RH=Relative Humidity.

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Daily milk production and dry matter intake by group were determined daily. At the end of each period, respiration rate, rectal temperature and urine samples from a subset of cows (n=14 per treatment group) were collected. Respiratory rate and body temperature were determined between 10:00 and 12:00 h of sampling days, which represent a time of high temperature during the day. Urine samples were analyzed for urinary pH, potassium and bicarbonate concentrations.

Urine samples were collected by spontaneous urination, and pH was determined immediately with a portable pH-meter. The remaining of the sample was frozen at -20ºC for further analysis of bicarbonate and potassium concentrations. Bicarbonate was analyzed by volumetric techniques and potassium by potentiometry at Laboratorios Echevarne (Barcelona, Spain).

Results and discussion

The experiment was conducted in July and August in La Garrotxa (Girona), because these tend to be the two hottest months of the year. Table 2 summarizes weather conditions in the last 15 days of each period to account for long-term effects of temperature over the measurements in sampling days.

Results indicate that the THI index average was just under the threshold of heat stress. However, at the hottest times of the day, the THI was at 86 and 88 for period 1 and 2, respectively. These THI are moderate to severe, and may result in an increase in respiratory rate and body temperature, and result in reduced milk production ranging from 3 to 7 kg of milk daily. These results suggest that cows were at least during part of the day under heat stress conditions, which justifies the use of prevention measures and provide an adequate set-up for the test of feeding bicarbonate in heat-stressed cows.

Table 2: Average temperature, humidity, rainfall and Temperature-Humidity Index in the wheather station of La Garrotxa in July (Period 1) and August (Period 2).

	Period 1	Period 2
Temperature, ºC		
Average	20.6	20.5
Maximum	33.3	34.7
Minimum	13.9	12.7
Relative Humidity, %	73	75
Rainfall, mm	142.4	129.2
Temperature-Humidity-Index		
Average	67	67
Maximum	86	88

Respiration rate was high in both control and treatment cows, compared with normal breathing rates that range from 30 to 50 breaths per minute, but the addition of Bicarb-Z did not affect this frequency. Rectal temperature was below normal ranges (generally suggested between 38.0 and 39.3 for lactating dairy cows), which may be associated with methodological processes. However, rectal temperature was reduced by 0.52 ºC on average in cows fed BICAR Z®. This reduction is relevant for dairy cows and has been associated with a reduction of milk production (Zimbelman et al., 2009). Urinary pH was within normal range for lactating dairy cows, but tended to decrease in the BICAR Z® treatment. Bicarbonate concentration in the urine was also reduced with the BICAR Z® treatment, but potassium concentration was not affected. Overall, data suggest that animals had some degree of heat stress, and that the addition of BICAR Z® appear to reduce some of the.

Table 3: Respiratory frequency (breaths per minute), rectal temperature and urine profile of cows fed a TMR with and without Bicarbonate (BICAR Z®).

	Control	BICAR Z®	SEM	P<
Respiratory rate, (min)	62.6	59.6	3.00	0.49
Rectal Temperature ºC	37.76	37.24	0.082	<0.001
Urinary				
pH	7.97	7.80	0.056	0.10
Bicarbonate	262.1	229.5	12.6	0.05
Potassium	186.8	178.8	7.76	0.47

Table 4: Milk production, dry matter intake and days in milk of cows fed a control diet with and without BICAR Z®

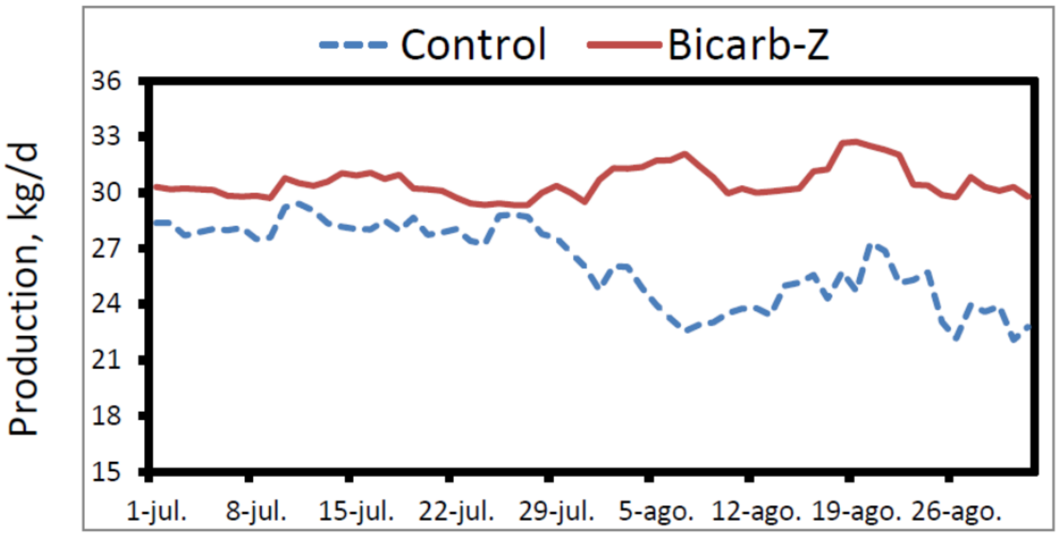
Variable	Treatment		SEM	P <
	CTR	TRT		TRAT
Milk production (MP), Kg/d	26.2	30.5	0.199	<.0001
Dry Matter Intake (DMI), Kg/d	18.6	20.2	0.173	<.0001
Days in milk (DIM), d	204	205	0.341	0.640
Ratio MP/DMI L/kg MS	1.41	1.51		

While the physiological reaction of cows indicate that they were under heat stress, at least part of the day, and that cows reacted towards a better condition when fed BICAR Z®, production performance followed the same direction, likely with a above-average response (Table 4). Milk production increased 4.3 kg of milk, likely due to higher dry matter intake for the treatment group compared with control group (reduction of 2.2 kg of dry matter daily). This difference of milk production could not be attributed to differences in days in milk (very similar between groups). It should be noted, however, that the control and treatment groups were about 2 kg of milk difference before the trial started, and that the major differences were observed in August. However, even if the initial difference is subtracted from the overall difference, the effect in milk production is highly relevant. The reason for the sharp change at the beginning of August and the persistent different along that month has no obvious explanation. The above average response is difficult to explain because heat stress only occurred during the day, and it is well documented (West, 2003) that when night temperatures are belo heat stress levels, this relieves part of the heat stress suffered during the day.

Conclusions

The experiment was conducted under heat stress conditions justified by weather measurement and animal measurements. The addition of BICAR Z® reduced some of the indicators of heat stress (rectal temperature, urinary bicarbonate and pH), and improved dry matter intake and milk production compared with control animals not fed bicarbonate.

Figure 2: Effect of BICAR Z® on milk production under heat stress conditions



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http://www.dairynz.co.nz/page/pageid/2145857378/Temperature_Humidity_Index_THI_Calculator