Rev. Agr. Acad., v.3, n.4, Jul/Ago (2020)

Revista Agrária Acadêmica

Agrarian Academic Journal

Volume 3 – Número 4 – Jul/Ago (2020)

OPEN ACCESS

doi: 10.32406/v3n42020/78-86/agrariacad

Protected niacin and chromium-enriched yeast effect in dairy cows under heat stress: behavioral parameters. Efeito da niacina protegida e da levedura enriquecida em cromo em vacas leiteiras sob estresse térmico: parâmetros comportamentais.

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Abstract

The objective of this work was to supplement niacin and chromium in dairy cows under thermal stress. 46 lactating cows were used, distributed in the groups: niacin, chromium, niacin and chromium, and control. The dry and wet bulb temperatures were measured to calculate the temperature and humidity index, as well as the surface temperature of the fur. Milk production was computed during the experimental period. The frequencies of rumination, food and water intake, and leisure were also monitored. We conclude that niacin associated or not with chromium increased 1,26 L in milk production and improved the comfort of cows under moderate to severe heat stress.
Keywords: Minerals. Vitamins. High temperature. High humidity. Cattle.

Resumo

O objetivo deste trabalho foi suplementar niacina e cromo em vacas leiteiras sob estresse térmico. Foram utilizadas 46 vacas em lactação, distribuídas nos grupos: niacina, cromo, niacina e cromo, e controle. As temperaturas de bulbo seco e úmido foram mensuradas, para o cálculo do índice de temperatura e umidade, assim como a temperatura de superfície de pelame. A produção de leite foi computada durante o período experimental. As frequências de ruminação, ingestão de alimento e água, e ócio também foram monitoradas. Concluímos que a niacina associada ou não ao cromo incrementou 1, 26 L na produção de leite e melhorou o conforto de vacas em estresse térmico moderado a severo.
Palavras-chave: Minerais. Vitaminas. Elevada temperatura. Elevada umidade. Bovinos.

Introduction

The productivity and well-being of dairy cows can be affected by high temperatures combined with high air humidity, one of the main effects of stress caused by climatic conditions is the reduction of milk production (ROENFELDT, 1998; TAO et al., 2020). It is estimated that in the United States this reduction can reach up to 35% (ST-PIERRE et al., 2003), and even in milder heat stress situations the losses are considerable, reaching 8,3% (OMINSKI et al., 2002).

In this sense, niacin supplementation is an option in cases of heat stress, since it leads to superficial vasodilation, consequently increasing peripheral heat loss (DI COSTANZO et al., 1997), through production of prostaglandin D by epidermal Langherhans cells (BENYO et al., 2006) and endothelial receptors for prostaglandin D2 (CHENG et al., 2006). It is also worth mentioning its already known functions, as it is known that it is a water-soluble vitamin that acts directly on the metabolism of carbohydrates, lipids and amino acids (NRC, 2001), reducing non-esterified fatty acids (AGNE) (KARKOODI e TAMIZRAD, 2009), the risk of ketosis (DUFVA et al., 1983), and increasing milk production at the beginning of lactation (GAO et al., 2008).

Regarding Chromium (Cr), it is an essential micromineral in the absorption of sugar (SCAWARZ e MERTZ, 1959), it is believed to be an active part of the glucose tolerance factor (GTF) (ANDERSON e MERTZ, 1977) and act by enhancing the action of insulin, facilitating its binding to cellular receptors and amplifying its signal. In addition, protein, lipid and carbohydrate metabolism are sensitive to supplementation (ANDERSON, 1987; MERTZ, 1992).

Niacin and chromium, when used separately, have satisfactory effects on the performance of dairy cows under heat stress. However, there is no research addressing the association of these components in cows in this condition. Our objective was to supplement dairy cows under heat stress, with protected niacin and chromium-enriched yeast, and evaluate their effects on productive and behavioral parameters.

Material and methods

Animal Use Ethics Committee

The experimental protocol was approved by the Animal Use Ethics Committee of the Federal University of Santa Maria (CEUA/UFSM).

Place and period of execution

The experiment was carried out on a dairy farm located in the northwest region of the state of Rio Grande do Sul, Brazil, during the months of February and March.

Animals

46 Holstein bovine females were used, with an average lactation of 207 days and an average production of 23,4 liters of milk/day. The animals remained in a shed with a free stall system, and received 41 kg of dry matter/cow/day of a total mixing system diet, consisting of corn silage, tifton hay, soybean meal, corn meal, barley grain, oat grain and mineral mixture (Table 1).

Table 1 - Composition and percentages of inclusion of ingredients and dietary minerals*

Item	%
Ingredients	
Corn silage	61
Corn bran	16
Soybean meal	8
Barley grain	6
Tifton hay	4
Oat grain	4
Mineral mixture	1
Chemical composition of total diet	
Dry Matter	48,6
Crude protein (% dry matter)	15,5
NDF†	34,9
ADF‡	15,65
EE§	3,42
Calcium	0,81
Phosphorus	0,35

*Based on a diet of total mixture composed of 41 Kg of dry matter.
† NDF: Neutral detergent fiber; ‡ ADF: Acid detergent fiber; § EE: Ether extract.

The animals were divided into four groups by sampling in random blocks, according to the days of lactation, in the different treatments. The niacin group (NG, n = 12) received 12 g of protected niacin (BALCHEM, New Hampton, Nova York), while for the chromium group (CrG, n = 11) 20g of chromium-enriched yeast (*Saccharomyces cerevisiae* enriquecida enriched in chromium 0.5 mg of chromium/Kg MS) were provided (ALLTECH, Brasil). To the niacin and chromium group (NCrG, n = 12), a combined supply of 12 g of protected niacin and 20 g of chromium-enriched yeast was established. The control group (CG, n = 11) did not receive supplementation. The different treatments were provided individually, once a day, for a period of 35 days, mixed with 100 g of soybean meal, right after the morning milking. At the time of supply, the control group received only soybean meal.

Analysis

The collected environmental data were dry bulb temperature (DBT) and wet bulb temperature (WBT), obtained by a black globe thermometer (model TGD-200, INSTRUTHERM). Measurements were performed daily at 7 am, 10 am, 1 pm, 4 pm and 7 pm, throughout all the experimental period. The temperature and humidity index (TUI) was calculated using a formula according to THOM (1959) TUI = DBT + 0,36 WBT + 41,2. The fur surface temperature (FST) was measured at three-day intervals at 1 pm, using an infrared thermometer (TI-890, INSTRUTHERM). This evaluation was carried out in the scapular region in areas of black and white fur.

Milking was performed three times a day (4 am, 10 am and 5 pm) and production computed using an automatic weighing system. The frequency of rumination, food and water ingestion, and leisure were monitored during 24 h, weekly, at 30 min intervals, with the exception of water ingestion, which was measured continuously throughout all the observation period. The animals were properly identified according to the respective groups and the notes were made in spreadsheets containing distinction of time intervals, to identify the intervals of greater and lower intensity of activities. The intervals used were 1 pm – 6 pm, 7 pm – 12 am, 01 am – 06 am, 07 am - 12 pm.

Statistical analysis

The data were tested for normality using the Kolmogorov-Smirnov test. The effect of different treatments on the surface temperature of the fur and behavior (rumination, food and water ingestion and leisure were submitted to analysis of variance (one-way), followed by comparison between averages by the Tukey test. The level of significance used was 5% ($p < 0,05$). The data were analyzed by the statistical program SPSS Statistic 19.

Results and discussion

Heat stress remains one of the most important factors that limit the production and welfare of dairy cattle (TAO et al., 2020). These animals experience situations of heat stress when any of these combinations of environmental conditions (temperature, relative humidity, solar radiation, wind and precipitation) make the effective temperature of the environment to exceed the thermoneutrality zone (ARMSTRONG, 1994; TAO et al., 2020). That way, high production dairy cows under heat stress have their homeostasis challenged, and changes in their performance are commonly observed due to the direct and indirect effects involved in thermal regulation, energy balance and endocrine changes (MARTELLO, 2004). In 66,7% of the measurements made over the experimental period, the TUI remained above 72, a determining value for the occurrence of heat stress in dairy cows of European origin (JOHNSON, 1980). The hottest times were at 1 pm and 4 pm, and the heat stress in the period was considered moderate to severe, according to the TUI classification.

As for black and white FST, there was no difference between groups ($p > 0,05$) (Table 2). Similar results were obtained by Zimbelman et al. (2010), when administering encapsulated niacin to multiparous Holstein cows subjected to moderate heat stress. While Rungruang et al. (2014), when testing supplementation with protected niacin in two different environments (thermoneutrality and heat stress) showed an increase in FST during the thermoneutrality zone, but without changes in body temperature. According to Alfonzo et al. (2016) Holstein cows are less tolerant of heat stress, moreover, they have difficulty in dissipating heat due to their larger body size, as well as the fact that they have thicker and longer hair. Di Costanzo et al. (1997) observed a reduction in body surface temperature using unprotected niacin, and according to these authors, the reduction may be related to the better efficiency in the heat transfer process between the animal and the environment caused by niacin.

Milk production is a parameter that can be directly related to the animals' sensitivity to thermal stress, since the processes involved in lactation are responsible for great heat generation

(KADZERE, 2002; TAO et al., 2020). This way, the biggest challenge for high production cows, kept in hot climates, is to dissipate the heat produced by metabolic processes (MARTELLO, 2004). In our study, NCrG showed a significant increase (20%) in milk production, when compared to NG and CrG (p < 0,05) (Table 2). When compared to the CG, the NCrG produced 1,26 L more milk, although this effect was not significant (p > 0,05) (Table 2). In addition, NCrG milk production remained above the average of the other groups throughout all the experimental period (Table 2).

The concomitant use of protected niacin and organic chromium as supplements for dairy cows subjected to heat stress is not described in the current literature by any study. Through the data published by Xinjian et al. (2006) we know that Cr nicotinate provided an increase of 12,02% in the production of dairy cows during the summer. Soltan (2010) after supplementing Holstein cows in heat stress in the pre and postpartum period with Cr, also observed an increase in milk production. Findings similar to those of Al-Saiady et al. (2004), who reported increased production when administering chromium-enriched yeast after peak lactation in cows under heat stress. However, using protected niacin during the same season (summer) Yuan et al. (2011) and Zimbelman et al. (2010), did not observe significant differences in the productive indexes of the supplemented animals.

The increase in milk production observed in our work in animals supplemented with niacin and chromium combined, may be associated with the activity of GTF in the potentiation of insulin and consequently in a greater supply of glucose to the mammary gland. Since it is believed that niacin, in addition to having an anti-lipolytic effect, has gluconeogenic properties (DI COSTANZO et al., 1997), and because nicotinic acid also makes up the GTF molecule, as well as chromium, glutamic acid, glycine and cysteine (TOEPFER et al., 1977).

Table 2 - Effect of treatments: niacin (NG), chromium (CrG), niacin and chromium (NCrG) and control (CG) in dairy cows subjected to heat stress, in the productive and behavioral parameters.

Parameters	**Treatments**			
	NG	**CrG**	**NCrG**	**CG**
Milk production (L)	22, 95 ± 1,83^{bc}	22,08 ± 1,42^{c}	24,83 ± 1,22^{a}	23,57 ± 1,60^{ab}
Black FST[1] (°C)	38,33 ± 2,78^{a}	38,35 ± 2,11^{a}	37,99 ± 2,96^{a}	38,7 ± 2,89^{a}
White FST[1] (°C)	37,78 ± 3,16^{a}	37,48 ± 3,49^{a}	39,14 ± 3,17^{a}	37,7 ± 3,08^{a}

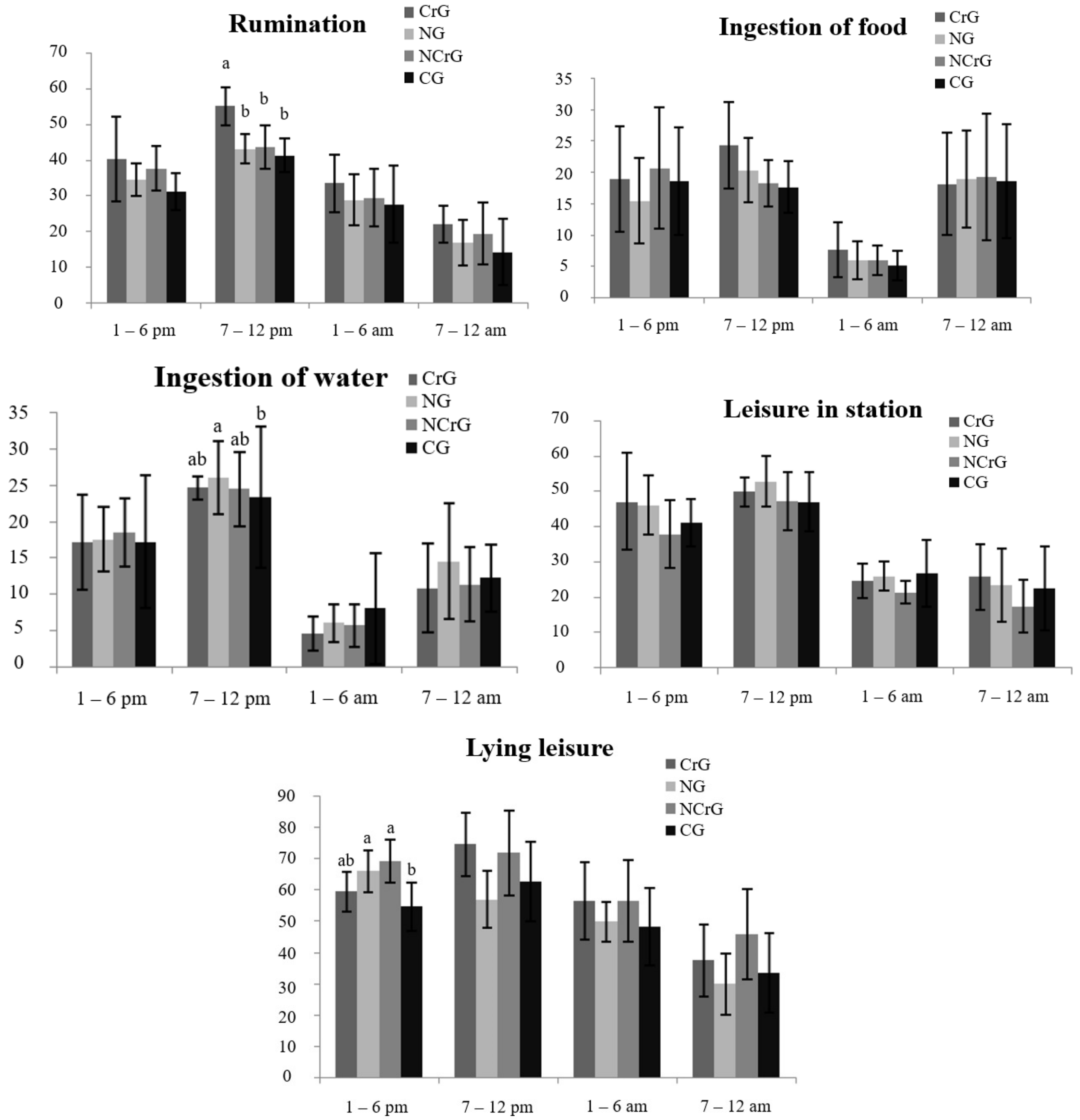
The results are expressed as average ± standard error, different letters refer to differences (p < 0,05) between groups. 1 FST: fur surface temperature.

In the interval 7 pm - 12 am, the CrG showed greater rumination activity compared to the others (p = 0,0005) (Figure 1a). Despite the close relationship between the increase in environmental and body temperature, with a consequent decrease in dry matter ingestion are well established (WEST, 2003), we did not observe significant differences between groups in food ingestion (p > 0,05) (Figure 1b). However, NG had a higher water ingestion compared to CG (p = 0,049), in the same interval (Figure 1c), a result that was also not found by Yang et al. (2010), however, it is justified, since one of the confrontation strategies in the face of thermal stress consists of altering eating behavior, with increased water consumption and reduced dry matter ingestion, prioritizing its consumption in colder periods of the day (DE RENSIS e SCARAMUZZI, 2003).

The animals of the NG and NCrG remained lying longer in leisure in the interval between 1 pm - 6 pm (p = 0,007) compared to the animals of the CG (Figure 1e). During the experiment, this interval corresponded to the hottest period of the day, suggesting that niacin allowed greater comfort for the animals. Consequently, leisure in station (Figure 1d) did not show significant differences between groups (p > 0,05).

Despite the promising results found by our group, Yang et al. (2010) did not report significant differences in resting behavior in cows that received niacin in unprotected form and were kept under high temperatures. As demonstrated by Allen et al. (2015), in situations of thermal stress, animals remain standing longer, as it facilitates the process of dissipating body heat, not just being a behavioral response to heat.

Figure 1 - Frequency (%) of **a)** rumination, **b)** ingestion of food, **c)** ingestion of water, **d)** leisure in station, **e)** lying leisure, of dairy cows subjected to heat stress and treated with chromium, niacin, chromium + niacin and control at different times of the day.



Conclusion

The use of niacin associated or not with chromium in dairy cows promoted an increase of 1,26 L in milk production and provided greater comfort in situations of moderate to severe thermal stress.

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Recebido em 4 de maio de 2020
Retornado para ajustes em 25 de junho de 2020
Recebido com ajustes em 29 de junho de 2020
Aceito em 8 de julho de 2020