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Characteristics of the ingestive behavior and milk production of F1 Holstein x Zebu cows fed with diets containing increasing levels of urea*

Características do comportamento ingestivo e produção de leite de vacas F1 Holandês x Zebu alimentadas com dietas contendo níveis crescentes de ureia

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Abstract

This work aimed to evaluate the ingestive behavior and milk production of F1 Holstein x Zebu cows subjected to increasing levels of urea in the diets. Diets contained 0, 33, 66 and 100% replacement of soybean bran by urea, which corresponded to 0, 0.92, 1.84 and 2.77% of CP in the form of NPN, formulated to be isoproteic and for an average production of 10 liters of milk per cow day-1. We used two 4 x 4 Latin squares, with 4 animals, 4 diets and 4 experimental periods of 18 days each, with the first 15 days of diet adaptation and the last three days for evaluation of ingestive behavior and milk production. The cows were subjected to visual observation at each period, for two consecutive days. There were differences in feeding and idle times, and total chewing time, with quadratic behavior for these variables. Feeding time decreased with 1.78% NPN and idle time increased with the level of 1.96% of CP in the form of NPN. The total chewing time decreased with 1.95% of CP in the form of NPN. The intake, chewing and ruminating time and the efficiencies of feeding and rumination of the DM and of the NDF did not differ. The replacement of soybean brain by urea in the diet of crossbred cows produced changes in the feeding, idle and total chewing times, however, it did not influence milk production of the cows.

Keywords: intake, non-protein nitrogen, rumination.

Resumo

Objetivou-se por meio deste trabalho avaliar o comportamento ingestivo e a produção de leite de vacas F1 Holandês x Zebu submetidas a níveis crescentes de ureia nas dietas. As dietas foram constituídas de 0, 33, 66 e 100% de substituição do farelo de soja pela ureia, o que correspondeu a 0, 0,92, 1,84 e 2,77% de PB na forma de NNP, formuladas para serem isoproteicas e para uma produção média de 10 litros de leite por vaca/dia^{-1}. Foram utilizados dois quadrados latinos 4 x 4, com 4 animais, 4 dietas e 4 períodos experimentais de 18 dias cada, sendo os primeiros 15 dias de adaptação às dietas e os três últimos dias para avaliações do comportamento ingestivo e produção de leite. As vacas foram submetidas à observação visual a cada período, durante dois dias consecutivos. Houve diferença para os tempos de alimentação, ócio e tempo total de mastigação, com comportamento quadrático para estas variáveis. O tempo de alimentação diminuiu com 1,78% NNP e o tempo em ócio aumentou com o nível de 1,96% de PB na forma de NNP. O tempo total de mastigação diminuiu com 1,95% de PB na forma de NNP. Os tempos de consumo, mastigação e ruminação e as eficiências de alimentação e ruminação da MS e da FDN, não diferiram. A substituição do farelo de soja pela ureia na dieta de vacas mestiças ocasionou mudanças nos tempos de alimentação, ócio e tempo total de mastigação, entretanto, não influenciou a produção de leite das vacas.

Palavras-chave: consumo, nitrogênio não proteico, ruminação.

Introduction

Milk production in Brazil is based mainly on cattle herd of crossbred cows, which allow great flexibility for protein manipulation in their diets (Santos et al., 2012). Lately, urea has been the most widespread and used non-protein nitrogenated compound in the diet of cattle, due to ease of use, its low cost per unit of nitrogen and availability in the market.

On the one hand, among the traditional protein sources, soybean bran is the most used in the feeding of ruminants, however, it presents a high cost. Several studies have evaluated the partial replacement of soybean bran by urea in the diet of lactating cows (Cabrita et al., 2003; Carmo et al., 2005; Pina et al., 2006; Aquino et al., 2007; Guidi et al., 2007; Cavalcanti et al., 2008; Mendes et al., 2010), however, little information is available in the literature on the performance and characteristics of the ingestive behavior

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of F1 Holstein x Zebu cows, when urea completely replaces soybean bran diet of these animals.

Ruminants are selective while feeding, and the observation of their behavior with regards to different levels of urea in the diet helps to maximize its potential use. However, the characteristics of feed and the feeding conditions can modify the parameters of the ingestive behavior, since the interaction between the nutrients in the diet can increase microbial efficiency and improve the digestibility, reducing the residence time in the rumen.

According to Macedo et al. (2007), for a complete understanding of the daily food consumption, it is necessary to individually study their components, which can be described by the number of meals eaten per day, by the duration of the meals, and by the average feeding time of each meal. Each process is the result of the interaction of the physico-chemical characteristics of diet with the animal's metabolism, stimulating satiety receptors.

Palatability is a characteristic of the food that directly influences feeding time. Urea has low palatability, and may reduce consumption. However, according to Wilson et al. (1975), the intrarumen infusion of urea was as depressant of consumption as was the incorporation of urea to the diet and, according to Visek (1968), the rapid hydrolysis of urea in the rumen could cause toxic acidification of the epithelial cells and alterations in the rumen's motility, demonstrating that changes in consumption as a result of use of urea in the diet of ruminants are related to sensory characteristics and systemic mechanisms.

This work aimed to evaluate the ingestive behavior and milk production of F1 Holstein x Zebu cows undergoing partial and total substitution of soybean bran by urea in the diets.

Material and methods

The experiment was conducted in the Experimental Farm of UNIMONTES - Campus Janaúba/MG. Eight F1 Holstein x Zebu cows, primiparous, with approximately 150 days of lactation were used. The experimental design adopted was two 4 x 4 Latin squares, consisting of four animals, four treatments and four experimental periods each. Four (4) experimental diets were used with increasing levels of substitution of soybean bran by urea, 0; 33; 66 and 100%, which corresponded to 0; 0.36; 0.73 and 1.1 % urea in the MS of the diets and 0; 0.92; 1.84 and 2.77 % of CP in the form of NNP.

The experiment lasted 72 days, divided into four periods of 18 days, with the first 15 days of each period were reserved for adaptation of the animals to the diets and the last three days to collect data, following the methodology described by Santos et al. (2006). The animals were kept in a shed covered with a metal frame which contained the individual boxes of 20 m^2, with cement floor, separated by iron structures, equipped with troughs and drinkers.

Diets were formulated according to the NRC (2001) for cows averaging 450 kg of live weight and milk production of 10 Kg day^{-1}, were formulated to be isoproteic and were provided to the cows twice a day, at 08:00 h and 16:00 h. The sorghum silage forage was used which was weighed daily on a digital scale, placed on their troughs and mixed with the concentrates of each treatment. The leftovers of the troughs were weighed and recorded daily. Diets were adjusted in accordance with the leftovers, keeping the forage:concentrate ratio based on a 80:20 DM, such that the remains represented 10 % of the quantity provided. The proportion of the ingredients and the chemical composition of the diets are shown in Table 1.

In the last three days of each period, samples of the food provided and of the leftovers were collected daily in the morning and stored in a freezer. At the end of the experiment, a sample composed per animal and per period was made, which was pre-dried in a forced ventilation oven at 55 ° C until it reached constant weight. Subsequently, all samples were ground in a knife mill with a mesh sieve of 1 mm in diameter for laboratory analyses.

The chemical and bromatological composition of the food provided and of the leftovers were determined at the Laboratory of Food Analysis, Department of Agricultural Sciences of UNIMONTES, Campus - Janaúba. Analyses of dry matter, crude protein, lignin, ether extract, organic matter, mineral matter were performed according to procedures described by the AOAC (1990). The fiber in neutral detergent and the fiber in acid detergent, with the appropriate corrections for the presence of starch, were determined following the recommendations of Van Soest et al. (1991). The content of insoluble nitrogen compounds in neutral detergent (INND) and in acid detergent (INAD) were estimated in the residues obtained after extraction of the samples in the neural and acid detergents, respectively (Van Soest et al., 1991), via the Kjeldahl procedure (AOAC, 1990), and the fiber in neutral detergent in the food was corrected for ashes and protein (NDFap). The total carbohydrates (TCHO) were calculated according to the methodology described by Sniffen et al. (1992). The non-fiber carbohydrates (NFC) of the control treatment diet (without urea) were calculated by the difference between TCHO and NDFap. In the diets with urea, the dietary levels of NFC were calculated by the equation proposed by Hall (2000): NFC = 100 - [(CP - CPu + U) + EE + MM + NDFap]; where: NFC = estimated NFC content (% DM); CP = crude protein content (% DM); EE = ether extract content (% DM); MM = mineral matter content (% DM); NDFap = NDF content corrected for ash and protein (% DM); CPu = crude protein content from urea (% DM), U = urea content (% DM). The TND of the food was estimated according to the NRC (2001).

The composition of the forage and of the ingredientes of the concentrate are listed in Table 2.

Cows were milked with a milking machine, twice daily, at 7:30 and 15:00 h, with suckling calves that suckled residual milk. During the last three days of each experimental period, milk yields per cow were recorded. Milk yield adjusted for 3.5% fat were calculated using the equation proposed by Sklan et al. (1994). After stirring the milk in the tin, milk samples from each animal were collected twice a day, and a pool of the milk samples from the morning and evening milking was made, observing the same proportions of the volume of milk produced daily. Samples were collected at a rate of 2/3 in the morning and 1/3 in the afternoon and then these samples were sent, refrigerated, to the laboratory of Technology of Products Derived from Animals and Plants of the Janaúba Campus and were stored at 5 °C for fat content analysis by the Gerber method (Brazil, 2006) on the same day.

The eight cows were subjected to visual observation for evaluation of ingestive behavior in two consecutive days of each experimental period, after adaptation of the cows to the new diet. On the first day, visual observation of each animal was made every 5 minutes for 24 hours to determine the time

Table 1: Proportion of ingredientes of the experimental diets (%) and chemical composition of the diets, on the basis of dry matter (%)

Composition of the ingredients				
Ingredients	Increasing levels of CP in the form of NPN (%)			
	0	0.92	1.84	2.77
Sorghum silage	80	80	80	80
Soybean bran	6.74	4.5	2.25	-
Ground corn	12.26	14.14	16.02	17.90
Urea: ammonium sulfate (9:1)	-	0.36	0.73	1.1
Mineral Supplement	1	1	1	1
Chemical composition (% DM)				
Dry Matter (%)	46.72	46.71	46.67	46.65
Organic Matter (%)	93.28	93.31	93.40	93.54
Crude Protein (%)	9.84	9.86	9.89	9.92
INND (%)	0.45	0.43	0.50	0.48
INAD (%)	0.025	0.024	0.028	0.027
Ether Extract (%)	1.84	1.85	1.86	1.86
Total Carbohydrates (%)	81.61	81.43	81.25	82.05
Non-fiber carbohydrate (%)	27.41	27.03	27.17	27.14
Fiber in neutral detergent (%)	55.97	55.90	55.83	55.77
NDFap (%)	54.20	54.40	54.08	54.91
Fiber in acid detergent (%)	31.75	31.63	31.5	31.37
Lignine (%)	3.17	3.15	3.12	3.10
Total digestable nutrients (%)2	65.00	65.58	65.18	64.68

INND = insoluble nitrogen in neutral detergent; INAD = insoluble nitrogen in acid detergent; $NDFa_P$ = Neutral detergent fiber corrected for ash and protein.
² TND = CPD + 2.25 x EED + NDFapD + NFCD

Table 2: Chemical composition of the forage and ingredientes of the diet. Contents of crude protein (CP), fiber in neutral detergente (NDF), fiber in acid detergente (ADF), lignine (LIG), ether extract (EE) and total digestible nutrients[1] (TND)

Nutrients	MS	PB	FDN	FDA	EE	LIG	NDT
Food	% Dry matter						
Sorghum silage	36.36	7.03	66.51	37.99	1.67	3.56	64.34
Corn meal	87.42	8.56	14.29	5.5	2.95	1.39	82.10
Soybean bran	89.43	47.01	15.00	10.2	2.15	2.30	79.89

[1]Estimate by the equations of the NRC (2001)

spent on feeding (FT), rumination (RT) and idle (IT) and the number of feeding periods (NFP), rumination (NRP) and idle (NIP), according to methodology described by Johnson & Combs (1991). The following day, counts were made of the number of chews/ruminal bolus and the time spent ruminating each ruminal bolus was determined, for each animal, using a digital chronometer. The values of the time spent and the number of chews per ruminal bolus were obtained from observations made during rumination of three ruminal bolus, in three different periods of the day (10 to 12h; 13 to 15h and 18 to 20h) according to the methodology described by Burger et al. (2000). During the night observation of the cows, the environment was maintained with artificial lighting, set three days before the evaluation of ingestive behavior such that the animals could adapt to this condition. The duration of the feeding period (DFP) was calculated by dividing the feeding time (FT) by the number of meals per day; duration of the rumination period (DRP) from the division of the ruminating time (RT) by the ruminating number per day and duration of the idle period (DIP) from the division of idle time (IT) by the number of idle periods per day, in minutes/period. The dry matter intake (DMI) was calculated by dividing the feeding time by the dry matter intake and the consumption of fiber in neutral detergent (NDFI) was calculated by dividing the time of feeding by the consumption of NDF, given in min/Kg. The rumination of dry matter (RDM) was calculated by dividing the rumination time by the consumption of DM; the rumination of fiber in neutral detergent (RNDF) by dividing rumination time by the consumption of NDF; the chewing of dry matter (CDM) by dividing the total time of chewing by the consumption of DM and the chewing of fiber in neutral detergent (CNDF) by dividing the total chewing time by the consumption of NDF, in minutes/Kg. The feed efficiency (FE), rumination efficiency (RE), the number of ruminal bolus per day (NRB), the chewing time per day (CT) and the number of chews per day (NC/day) were obtained according to the technique described by Burger et al. (2000).

Data were subjected to analysis of variance and regression, considering the probability of 5 %, using the program Ferreira (2011).

Results and discussion

The feeding (FT) and idle (IT) times were influenced ($P < 0.05$) by the levels of urea in the diets (Table 3), with a quadratic behavior for the two variables, with the minimum level of non-protein nitrogen (NPN) in the diet in which the feeding time decreased was 1.77% and the maximum level in which the idle time increased was from 1.96 % PB in the form of NPN.

The longer feeding time for the diet with the highest level of urea may be related to sensory characteristics of urea, resulting in low palatability, but also the increase in osmolarity in the rumen, which may have caused a stomach indisposition, changing the behavior of the animal. According to Kozloski (2011), the dietary conditions that result in high concentrations of ammonia in the rumen fluid without a drop in pH, the passive transport of the non-ionized fraction can be significant. According to Visek (1968), the rapid hydrolysis of urea in the rumen could cause toxic acidification of epithelial cells and a change ruminal motility, thus demonstrating that changes in consumption as a result of the use of urea in the diet of ruminants are related to sensory characteristics and systemic mechanisms. Santos et al. (2011) reported a reduction in the consumption of dairy cows with the addition of urea in the diet, however, they do not believe that low palatability was the prevalent mechanism for this reduction, given the use of a feeding system in complete diet and the low contente of NPN.

Tabela 3: Average of the feeding (FT), rumination (RT) and idle (IT) times, in hours/day; number of feeding (NFP), rumination (NRP) and idling (NIP) periods, in number/day; duration of the feeding (DFP), rumination (DRP) and idling (DIP) periods, in minutes/period, of F1 Holstein x Zebu cows, fed with increasing levels of urea, variation coefficients (VC), and respective regression equations (RE)

Items	Increasing levels of CP in the form of NPN (%)				VC(%)	RE
	0	0.92	1.84	2.77		
FT (h./day)	7.11	7.26	7.15	8.00	7.96	1
RT (h./ day)	8.71	8.35	8.73	8.65	7.39	Ŷ=8.61
IT (h./ day)	8.16	8.38	8.13	7.35	8.48	2
NFP (nº/ day)	18.00	21.00	19.00	21.00	17.76	Ŷ=19.56
NRP (nº/ day)	20.00	19.00	21.00	20.00	11.15	Ŷ=19.96
NIP (nº/ day)	27.00	29.00	27.00	27.00	11.13	Ŷ=27.53
DFP (min./perd.)	27.00	22.00	24.00	23.00	22.76	Ŷ=24.00
DRP (min./perd.)	27.00	27.00	26.00	27.00	12.56	Ŷ=26.93
DIP (min./perd.)	19.00	18.00	18.00	16.00	9.45	Ŷ=17.78

1 $\hat{Y} = 7.61-0.619x+0.175x^2$; $R^2=0.85$
2 $\hat{Y} = 7.42+0.982x-0.25x^2$; $R^2=0.99$

Barros et al. (2011) also found a quadratic response for feeding time, when they included increasing levels of ammoniated sugar cane bagasse with urea in the diet of cattle, with a reduction of this time starting from the level of 36.75% bagasse. Miranda et al. (1999) worked with Holstein x Zebu crossbred heifers fed diets based on sugar cane, using different levels of NPN and probiotics and found no difference in feeding time.

Bispo et al. (2010) worked with lactating cows in which they added palm and urea in the diets and observed no change in feeding and idle time, probably due to the fact that consumption of DM and NDF was not influenced by the inclusion of these foods and the concentration of NDF in the diets are similar. Despite the changes in feeding and idle times, the DM and NDF intakes (Table 5) were similar (P > 0.05) between the different levels of substitution of soybean brain by urea, suggesting an adaptation of the ingestive behavior of the cows.

For the rumination time (RT) no difference was observed (P > 0.05) for the levels of urea in replacement of soybean bran. According to Welch & Hooper (1988), the time spent ruminating is highly correlated with the consumption of NDF by cattle. In this study, the consumption of NDF was equal in all diets, in addition to considering that the forage:concentrate ratio (80:20) was the same. However, the addition of urea to the diet provides a greater amount of nitrogen to the rumen microorganisms, allowing for an increase of the microbial efficiency resulting in higher microbial degradability of DM and NDF, which would reflect in higher digestibility, which would probably decrease the rumination time.

The number of periods of feeding, ruminating and idling (nº/ day) and the duration of the feeding, ruminating and idling periods (min./per.) of the animals did not show differences (P > 0.05) for the partial and total replacement of soybean bran by urea in the diets (Table 3). Because there was no variation in rumination time and in the number of rumination periods per day, there was a similarity in the results of duration of the period of rumination. And even with the variation that has taken place in the feeding and idle times, no diferences were observed in the feeding and idling periods. Thus, the inclusion of urea up to the level of 2.77% of CP in the form of NPN of the diet does not affect the temporal successions in F1 Holstein x Zebu cows in the dietary conditions that they were subjected to. Similar results were found by Alves et al. (2010), when they used the mesquite pod bran associated with levels of urea in the diet of sheep.

The time of chews per bolus (TCB/bolus) and the number of chews (NCB) per bolus were not affected (P > 0.05) by the inclusion levels of urea in the diets (Table 4). Similar results were found by Miranda et al. (1999), when they supplemented crossbred Holstein x Zebu heifers with urea and poultry litter. However, these authors pointed out that the urea-fed animals showed a trend towards a greater number of chews per day, minute and bolus. According to Albright (1993), the time spent on feeding is a limiting factor for the consumption of food, because of the number of chewing movements. Thus, with this trend towards a greater number of chews observed by these authors, a lower nutrient intake is understood. Fischer et al. (1997) also emphasize that animals that consume more food have a lower number of ruminal bolus and less chewing time per bolus. The reported fact was not observed in this study, because the consumption of DM and NDF were equal among the inclusion levels of urea.

The number of ruminated boluses (NRB/day) also did not differ (P > 0.05) as a function of the levels of urea in the diet, and presented a mean value of 599.76 boluses/day (Table 4). The number of ruminated boluses comes from the rumination time and from the time of chewing per ruminated bolus, and the fact that no change occurred in these times explains the similarity

Table 4: Chewing time per bolus (CT/bolus), number of mastications per bolus (NC/bolus), number of mastications per minute (NC/min), number of mastications per day (NC/day), number of ruminated bolus per day (NRB/day), total chewing time (TCT) in hours, of F1 Holstein x Zebu cows fed with increasing levels of urea, and variation coefficients (VC) and respective regression equations (RE)

Items	Increasing levels of CP in the form of NPN (%)				VC (%)	RE
	0	0.92	1.84	2.77		
CT/bolus	51.91	52.02	53.21	52.58	6.81	Ŷ= 52.43
NC/bolus	53.97	55.11	55.25	55.77	7.15	Ŷ= 55.02
NC/min.	22.60	22.10	22.70	22.90	8.23	Ŷ= 22.55
NC/day	32533.25	31790.25	32617	32967.37	8.23	Ŷ=32476.97
NRB/day	608.47	589.62	603.12	597.82	10.33	Ŷ= 599.76
TCT.hours	15.85	15.63	15.88	16.66	4.27	1

1 $Y=16.57-0.9656x+0.2469x^2$; $R^2=0.99$

in the number of ruminated boluses between treatments. With the increase of urea, a source of degradable nitrogen in the rumen, it could have been expected that the degradability of the dietary fiber fractions would increase due to an increased microbial activity and thus there would be a lower number of ruminated boluses due to a possible reduction in the rumination and chewing per bolus times, but this effect was not observed.

Mendonça et al. (2004), when working with lactating cows fed with sugar cane with two levels of urea and sorghum silage, also found no significant difference in the number of ruminated boluses per day, 548 and 555, respectively. The same was shown by Alves et al. (2010), who found an average value of 609.81, a value close to that found in this work.

As for the total chewing time (TCT), in hours/day, an effect (P < 0.05) of the levels of inclusion of urea in the diets was observed, presenting quadratic behavior (Table 4), where the minimum level of NPN in which the total chewing time was reduced was 1.95 % in the diet. This probably occurred due to changes in feeding time, since this is measured by the sum of the feeding and rumination times, although there were no differences in the consumption of DM and NDF.

The time spent in consumption, rumination and chewing of DM and NDF, respectively, in min/kg (Table 5) did not differ with the levels of urea in the diets (P > 0.05). The variation observed in feeding time (Table 3) was not capable of changing the consumption of DM and NDF in min/Kg, and the consumption of DM and NDF in kg/day better defined these results, since they had no differences between the treatments. As there was no difference in the rumination time (Table 4) and in the consumption of DM and NDF in Kg/day, no differences were found for rumination of the DM and NDF in min/Kg. According to Deswysen et al. (1993), the highest average daily consumption of DM is associated, primarily, with less time spent ingesting and ruminating daily.

Even with the change in total chewing time, there was no change in chewing of DM and NDF in min./Kg, given that the consumption of DM and NDF in kg/day was not affected by the inclusion levels of urea.

Miranda et al. (1999) observed that the results obtained for the mean time ruminating in min/kg of DM and NDF, in relation to the sources of NPN, were higher for the animals fed with urea. While the results for the mean consumption and chewing times, in min/kg, of DM and NDF did not differ between sources of NPN, similar to the results of this study.

The efficiencies of feeding and rumination of DM and of the NDF in g/hour (Table 6) did not differ between diets (P>0.05).

Tabela 5: Dry matter intake (DMI), fiber in neutral detergent intake (NDFI), dry matter rumination (DMR), fiber in neutral detergent rumination (NDFR), dry matter chewing (DMC), fiber in neutral detergent chewing (NDFC), of F1 Holstein x Zebu cows fed with increasing levels of urea, variation coefficient (VC), and respective regression equations (RE)

Items	Increasing levels of CP in the form of NPN (%)				VC (%)	RE
	0	0.92	1.84	2.77		
Intake						
DM (Kg/day)	13.27	13.10	13.28	13.83	8.28	Ŷ= 13.37
DM (min./Kg)	32.28	33.76	32.60	35.08	8.56	Ŷ=33.42
NDF (Kg/day)	8.12	7.49	7.96	8.41	8.35	Ŷ= 7.99
NDF (min./Kg)	52.86	59.23	54.48	57.54	8.78	Ŷ=56.02
Rumination						
DM (min./Kg)	39.50	38.63	40.13	37.75	13.01	Ŷ=39.00
NDF (min./Kg)	64.75	67.75	66.75	62.13	13.51	Ŷ=65.34
Mastication						
DM (min./Kg)	71.88	72.38	72.63	72.88	9.25	Ŷ=72,43
NDF (min./Kg)	117.75	126.75	121.13	119.88	9.78	Ŷ=121,37

The lack of effect on the efficiencies of feeding and rumination of DM and NDF can be explained by the similarity observed in the consumption of DM and NDF and in the rumination time, despite the variation in feeding time as a function of the levels of urea in the diet. Carvalho et al. (2004) observed in experiments with lactating goats less rumination efficiency when these animals consumed smaller amounts of DM and NDF. Grant (1997) noted that the rumination per unit of consumed NDF forage increased when the NDF content of the diet decreased, suggesting that cows have an adaptive mechanism to increase the efficiency of rumination when the consumption of physically effective NDF was limited. However, in this study, the diets exhibited the same forage:concentrate ratio (80:20), therefore, with a high proportion of fiber, and the only source of variation was the level of inclusion of urea in replacement of soybean bran, which did not affect consumption and consequently the milk production of the cows, as seen in Table 6. The results found for milk production indicate that the nutritional requirements for

Table 6: Feeding efficiency of dry matter (FEDM), feeding efficiency of fiber in neutral detergen (FENDF), rumination efficiency of MS (REDM), rumination efficiency of FDN (RENDF) in grams per hour, production of milk and production of milk corrected for 3.5% fat (PMC), of F1 Holstein x Zebu cows fed with increasing levels of urea, variation coefficient (VC), and respective regression equations (RE)

Items	Increasing levels of CP in the form of NPN (%)				VC (%)	RE
	0	0.92	1.84	2.77		
FEDM (g/h)	1905.84	1814.95	1868.50	1757.73	8.88	Ŷ=1836.75
FENDF (g/h)	1166.75	1038.13	1119.13	1068.05	9.13	Ŷ=1098.01
REDM (g/h)	1548.09	1578.24	1533.34	1622.79	12.71	Ŷ=1570.61
RENDF (g/h)	944.96	900.54	919.26	990.55	12.87	Ŷ=938.82
Milk production	8.07	8.51	8.13	8.06	4.29	Ŷ=8.19
PMC	9.97	10.36	9.93	9.92	4.99	Ŷ=10.05

the animal category studied were sufficiently addressed with the total replacement of soybean bran by urea. It can be inferred that the ruminal microorganisms were able to make good use of these compounds, given that milk production was similar in all treatments, and therefore demonstrating that, for the average level of milk production of 10 Kg day^{-1}, the exclusive use of urea as a protein source in the diet may represent a viable option for the production system.

Conclusions

The inclusion level of urea in the diet of lactating F1 Holstein x Zebu cows, affects their ingestive behavior, especially in relation to the feeding, idle and chewing times, however, it does not influence the dry matter intake and milk production of the cows. Therefore, urea can substitute soybean bran in the diet of crossbred cows with average milk production of 10 kg day^{-1}.

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