

Performance of lactating crossbred cows on pasture supplemented with conventional urea or slow release urea

[Desempenho de vacas mestiças lactantes em pasto suplementadas com ureia convencional ou ureia de liberação lenta]

D.C. Abreu^{1,3}, R.P. Lana^{2,6,7}, A.S. Oliveira^{3,6,7}, F.A. Barbosa⁴, F.L. Andrade¹, P.T. Silva¹, M.A. Fonseca², C.P. Ghedini⁵, R.M. Paula¹, F.A. Magalhães⁴

¹Aluno de pós-graduação – Universidade Federal de Viçosa – Viçosa, MG

²Universidade Federal de Viçosa – Viçosa, MG

³Instituto de Ciências Agrária e Ambientais – UFMT – Campus Sinop, MT

⁴Escola de Veterinária – UFMG – Belo Horizonte, MG

⁵University of New Hampshire – UNH – Durham, New Hampshire, United States

⁶Bolsistas de produtividade do CNPq

⁷Pesquisador do INCT-Ciência Animal/CNPq

ABSTRACT

The effect of using conventional urea (CU) or slow release urea (SRU) was evaluated by replacing soybean meal (SBM) in concentrated supplements in levels of 2, 4 or 6% (dry matter basis) on productive performance of crossbred Holstein x Zebu lactating dairy cows (499±61kg body weight and 167 days of lactation) grazing on elephant grass (11.5% CP and 60% NDF) under rotational grazing during the rainy season. A supplement control (no urea) was used containing SBM as a protein source. A total of 21 cows were distributed in an incomplete randomized block design with three periods of 21 days each (14 days of adaptation and seven days of collection). The animals entered the paddocks with a pasture height of 110-120cm and left when the grass reached the height of 40-50cm. The concentrated isonitrogenous supplements (24% crude protein, dry matter basis) were provided in the amount of 3.2kg/cow/day (fed basis). There was no effect ($P>0.05$) on source of crude protein (SBM vs source NPN), source NPN, level of NPN, interaction between source NPN and level of NPN on milk production (10.0kg/day), fat milk production corrected to 3.5% (10.7kg/day), levels of fat (4.01%), protein (3.66%), lactose (4.16%), total solids (12.86%) and non-fat solids (8.60%) in milk. The replacement of CU by SRU does not promote improvement in the productive performance of crossbred dairy cows grazing on elephant grass during the rainy season. Urea (CU or SRU) can be included in up to 6% of the DM concentrated supplements, replacing SBM, without affecting the productive performance of crossbred cows (Holstein x Zebu) in pasture during the rainy season.

Keywords: non-protein nitrogen, milk

RESUMO

Avaliou-se o efeito da utilização de ureia convencional (UC) ou de ureia de liberação lenta (ULL) em suplementos concentrados, nos níveis de 2, 4 ou 6% (base da matéria seca), em substituição ao farelo de soja, sobre o desempenho produtivo de vacas mestiças Holandês x Zebu (499±61kg de peso corporal e 167 dias de lactação) mantidas em pastos de capim-elefante (11,5% de proteína bruta e 60% de FDNcp), sob lotação intermitente, no período das chuvas. Um suplemento controle (sem ureia) foi utilizado contendo farelo de soja como fonte proteica. Foram utilizadas 21 vacas, distribuídas em delineamento em blocos incompletos balanceados, com três períodos de 21 dias cada (14 dias de adaptação e sete dias de coleta). Os animais entraram nos piquetes com altura do pasto de 110-120cm e saíram quando atingiram altura de 40-50cm. Os suplementos concentrados isonitrogenados (24% de proteína bruta,

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E-mail: daniel.abreu@ufv.br

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base da matéria seca) foram fornecidos na quantidade de 3,2kg/vaca/dia (base da matéria natural). Não houve efeito ($P>0,05$) de fonte de proteína bruta (farelo de soja vs. fonte de NNP), de interação entre fonte de NNP (UC vs. ULL) e nível de NNP (2, 4 e 6% na MS do suplemento), de fonte de NNP e de nível de NNP e sobre a produção de leite (10,0kg/dia), produção de leite corrigida para 3,5% de gordura (10,7kg/dia), teores de gordura (4,01%), proteína (3,66%), lactose (4,16%), extrato seco total (12,86%) e extrato seco desengordurado (8,60%) no leite. A substituição da ureia convencional pela ULL não promove melhoria no desempenho produtivo de vacas leiteiras mestiças em pastagem de capim-elefante, no período das chuvas. A ureia (convencional ou de liberação lenta) pode ser incluída em até 6% na MS de suplementos concentrados, em substituição ao farelo de soja, sem afetar o desempenho produtivo de vacas mestiças (Holandês x Zebu) em pastagem, no período das chuvas.

Palavras-chave: leite, nitrogênio não proteico

INTRODUCTION

The provision of food concentrates aims to meet the nutritional needs of animals complementing the nutrients present in the forage. Therefore, it is of fundamental importance to know the nutritional characteristics of foods in order to formulate diets that meet the needs of the animals. Among nutrients, protein is considered a high cost in the diet of ruminants, which makes the economic feasibility of animal production highly dependent on the efficiency of utilization of this nutrient.

The conventional protein sources such as oilseed and their respective meals have increasing costs because of competition with grain-based human food systems. Thus, there is growing interest in the use of non-protein nitrogen (NPN) sources in supplementary feeding in ruminant nutrition. The NPN represents an alternative to completing requirements for protein and reduces the cost of this nutrient in animal nutrition (Teixeira and Salvador, 2004). A lot of studies which involve different sources and levels of protein are being published; however, much information about how to increase the use of protein supplements remains unknown. As a result, the protein supplement for dairy cattle is one of the most studied components in ruminant nutrition.

The NPN is used in ruminant nutrition replacing conventional sources of true protein. Among the sources of NPN, urea is the most widespread, mainly because of its low cost. Also, urea is widely used in partial replacement of real protein sources, mainly soybean meal (SBM). However, its high rate of hydrolysis can become a problem for the rapid release of ammonia (NH_3) and consequent accumulation of nitrogen in the rumen as ammonia, which must be absorbed and

carried to the liver for metabolism and conversion into urea. In that form, the urea can be excreted by urine or recycled in rumen membrane or saliva. However, these processes waste energy and reduce the availability of energy in the rumen.

The amount of N required by microorganisms is a function of the amount of energy available in the rumen, because bacteria and protozoa ciliates need sources of nitrogen and energy simultaneously for desirable proliferation to occur (Lucci, 1997). For this reason, urea is best used as a source of nitrogen for protein synthesis, when there is synchronization between the release of energy and nitrogen (Akay *et al.*, 2004). It is possible to control the rate of hydrolysis when it occurs at a speed synchronized with the availability of energy. This enables the conversion of ammonia nitrogen in ruminal microflora, leading to the reduction of output and accumulation of ammonia in the rumen.

With the implementation of new technologies over the last 30 years, products have been developed that seek to control the release of NPN in order to improve the conversion of N into microbial protein and reduce the cost of concentrate in the diets. Recently, a treatment was developed for encapsulating urea with biodegradable polymers capable of slowly releasing the ammonia nitrogen (Optigen[®]). However, studies of slow release urea (SRU) in diets of dairy cows are quite scarce. Most of the published data are related to ruminal parameters and not to animal performance and are geared primarily towards the nutrition of beef cattle (Loest *et al.*, 2001; Akay *et al.*, 2004).

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This study aimed to evaluate the effects of the inclusion (2, 4, or 6% as fed basis) of conventional urea and slow release urea replacing soybean meal, compared to control treatment on intake, digestibility, milk production and milk composition of dairy cows grazing on elephant grass.

MATERIAL AND METHODS

This study was conducted in the experimental unit of the Dairy Research Center at the Animal Science Department, Viçosa, in the state of Minas Gerais, Brazil belonging to the Universidade Federal de Viçosa in the area managed with rotational grazing elephant grass (*Pennisetum purpureum*) in the rainy season, from March to May 2010.

Viçosa is located in the Zona da Mata, between the hills of Mantiqueira, Caparaó and Piedade. It lies at an altitude of 649 meters and has the geographical coordinates of the parallel 20°45'14" S latitude and the meridian of 42°52'54" W longitude Gr. The climate is Cwa (mesothermal), according to the Köppen classification, with two well-defined seasons, with hot, humid summers and cold, dry winters. The average rainfall is 1,341.2mm per year. The

maximum and minimum temperatures are 26.1° and 14.0°C, respectively (Universidade..., 1997). The pastures are divided into six paddocks fertilized with waste from pig farms and provided with troughs and salt. The area has a lack of shade and slightly undulating topography. During the experiment the paddocks were managed seeking to maintain high average pre-grazing sward height of 110-120cm and post-grazing residual height of 40-50cm (Oliveira, 2006) in order to ensure adequate residue for regrowth after grazing in the rest period following.

A total of 21 multiparous crossbred Holstein x Zebu cows, with potential milk production of 3,000-4,500kg per lactation and an initial average body weight (BW) of 499±61kg were used. Seven concentrated isonitrogenous supplements were provided (24% crude protein fed basis) in the amount of 3.2kg/cow/day (fed basis): SBM (control); 2, 4 or 6% urea in the concentrate (as fed basis); and 2, 4 or 6% of SRU in the concentrate (Tab. 1). The sulfur source (ammonium sulphate) was added to the urea and SRU in the ratio of 9:1. The concentrated supplements have been formulated to meet the requirements of crude protein (CP) and total digestible nutrients and trace minerals, according to the NRC (National..., 2001).

Table 1. Ingredient composition of the experimental concentrated supplements (dry matter)

Components	Soybean meal	Source of non-protein nitrogen					
		Urea (% of DM)			SRU (% of DM)		
		2	4	6	2	4	6
Corn meal	58.5	69.0	79.5	90.0	69.0	79.5	90.0
Soybean meal	37.5	25.0	12.5	-	25.0	12.5	-
Urea conventional	-	2.0	4.0	6.0	-	-	-
Slow release urea	-	-	-	-	2.0	4.0	6.0
Mineral mix	4.0	4.0	4.0	4.0	4.0	4.0	4.0

The experiment was analyzed in an incomplete randomized block design (Cochran and Cox, 1968), as shown in Tab. 2.

The animals were managed under grazing condition, in the period between milking, and were given supplements twice a day for milking in the morning and afternoon, with free access to a salt trough that contained mineral mixture, and the water trough. The animals were weighed at the beginning and end of each trial period.

Table 2. Delineation on a balanced incomplete block design with seven treatments, using seven cows and three periods

Cow	Period		
	I	II	III
1	7	1	4
2	1	2	5
3	2	3	6
4	3	4	7
5	4	5	1
6	5	6	2
7	6	7	3

Sampling of pasture (with a quadrant-based sampling of 1x1 meters in 10 areas/paddock, with forage clipped close to the ground in the spot that has equivalent height to the average pasture height, and simulated grazing) was made prior to the entry and exit of animals in each paddock and sampling of concentrate. Samples of pasture and feed concentrates were dried in an oven with forced ventilation (60°C for 72 hours) and, together with the feedstuffs, were processed in a grinder with a sieve's porosity at 1 mm for chemical analysis.

The analysis of DM, CP (total nitrogen x 6.25), acid detergent fiber (ADF), lignin (HSO 72% w/w) were performed according to methods described in Silva and Queiroz (2002). For analyzing the concentration of neutral detergent fiber (NDF), the samples were treated with thermostable alpha amylase without the use of sodium sulfite, corrected for ash residue (Mertens, 2002) and residual nitrogen compounds (Licitra *et al.*, 1996). Analyses of NDF and ADF were performed in the Ankon[®] system using TNT bags (non-woven-fabric), with dimensions of 5cm x 5cm, maintaining relationships average of 14mg DM/cm tissue and 100mL of detergent/g of dry sample in air.

The total carbohydrates were calculated according to Sniffen *et al.* (1992), wherein: CT = 100 - (% of CP + % of EE + % of ash). The NFC were calculated as proposed by Hall (200): NFC = 100 - [(% of CP - % CP of urea + % of Urea + % of NDF_{ap} + % of EE + % of ash)].

The concentration of indigestible acid detergent fiber (iADF) in food was obtained after

incubation of ruminal foods, leftovers and feces in polyester bags (Ankon[®], filter bag 57) for a period of 264 hours, according Casali *et al.* (2008).

The chemical composition of elephant grass, corn meal and SBM are presented in Tab. 3, while the chemical compositions of concentrated supplements are in Tab. 4. The samples of elephant grass were dried at 65°C, grinder equipped with 1mm diameter sieves and stored along with SBM and corn meal.

Cows were milked mechanically twice daily, at 6:00 and 14:00 hours, making up the daily record of milk production during the last seven days of each experimental period.

Milk was sampled from each animal (first and second milking) during the last two days of each period. The samples were placed in plastic bottles with Bronopol[®] for subsequent determination of milk components, such as protein, fat, lactose and total solids at the Laboratory of Milk Quality in *Centro Nacional de Pesquisa de Gado de Leite*, CNPGL/EMBRAPA, in Juiz de Fora, Minas Gerais state, Brazil, using methods described by IDF (1996). The averages of the milk samples analyzed were considered in order to calculate the corrected milk 3.5% fat (PL_{cor}), which was done using the following formula derived from Tyrrell and Reid (1965), cited by Leiva *et al.* (2000): $PL_{cor} = 12,82 * P_{fat} + 7,13 * P_{ptn} + 0,323 * MP$, in which: MP = Milk production, kg/day; P_{fat} = fat production, kg/day; e P_{ptn} = protein production, kg/day.

Table 3. Chemical composition of elephant grass, corn and soybean meal

Item	Elephant grass	Corn meal	Soybean meal
Dry matter (%)	15.49	88.26	88.81
Crude protein (% of DM)	11.47	8.85	49.28
Ash (% of DM)	12.16	1.72	6.19
Neutral detergent insoluble protein (% of DM)	5.70	3.56	2.04
Acid detergent insoluble protein (% of DM)	2.90	1.24	0.95
Ether extract (% of DM)	1.82	4.13	1.30
Total carbohydrates (% of DM)	74.55	85.30	43.23
Neutral detergent fiber (NDF) (% of DM)	64.29	12.82	11.27
NDF corrected for ash and protein (% of DM)	60.19	11.62	6.81
Non-fibrous carbohydrates (% of DM)	10.26	72.48	31.96
Acid detergent fiber (ADF) (% of DM)	38.95	1.92	8.81
Indigestible acid detergent fiber (iADF) (% of DM)	12.48	0.65	0.02

Table 4. Chemical composition of the experimental concentrate supplements

Item	Soybean meal	Urea (%)			SRU (%)		
		2	4	6	2	4	6
Dry matter (%)	88.88	89.02	89.17	89.31	89.02	89.17	89.31
Ash (% of DM)	7.33	6.73	6.14	5.55	6.73	6.14	5.55
Crude protein (% of DM)	23.66	23.67	23.68	23.69	23.80	23.95	24.09
Neutral detergent fiber (% of DM)	11.73	11.66	11.60	11.54	11.66	11.60	11.54
Acid detergent fiber (% of DM)	4.43	3.53	2.63	1.73	3.53	2.63	1.73
Indigestible acid detergent fiber (% of DM)	0.39	0.45	0.52	0.59	0.45	0.52	0.59
Ether extract (% of DM)	2.90	3.17	3.45	3.72	3.17	3.45	3.72
Acid detergent insoluble protein (% of DM)	1.08	1.09	1.10	1.12	1.09	1.10	1.12
Neutral detergent insoluble protein (% of DM)	2.85	2.97	3.09	3.20	2.97	3.09	3.20
Neutral detergent fiber corrected for ash and protein (% of DM)	9.35	9.72	10.09	10.46	9.72	10.09	10.46
Non-fibrous carbohydrates (% of DM)	54.38	54.77	55.13	55.50	54.64	54.86	55.10

Data were subjected to analysis of variance and regression, using the PROC GLM feature of the SAS statistical package, version 9.0 for Windows, adopting a 5% level of probability for error type I. The variables were analyzed in randomized incomplete block design with treatments arranged so that, in each period, there was a complete block, according to the statistical model:

$$Y_{ijk} = \mu + B_i + T_j + Te_{ijk}$$

Y_{ijk} = i animal, j undergoing treatment in the period k ;

μ = overall effect of the mean;

B_i = end of block (cow) i , where $i = 1, 2, 3, 4, 5, 6, 7$;

T_j = treatment effect j , and $j = 1, 2, 3, 4, 5, 6, 7$;

T_k = effect of length k , where $k = 1, 2, 3$;

e_{ijk} = random error associated with each observation ijk .

Five contrasts were applied: SBM vs NPN, effect of NPN source (urea vs. SRU); effect of level of NPN (linear and quadratic), and interaction effect between source of NPN and level of NPN. The means were presented as means of least squares.

RESULTS AND DISCUSSION

There was no effect ($P > 0.05$) in the replacement of SBM with NPN on BW, milk yield and milk

composition (Tab. 5). Other authors have observed no effect in the substitution of an organic protein source by urea on milk yield and milk composition. Rangel *et al.* (2005), working with dairy cows fed isonitrogenous diets based on sugar cane and soybean meal containing 0.4, 0.8 or 1.2% mixture of urea and ammonium sulphate (9:1) in sugar cane, there was also no difference observed in milk yield (average 20 kg/day) and milk composition.

Imaizumi *et al.* (2003), using cows producing around 12kg milk/day, fed corn silage instead, found that the partial replacement of soybean meal by urea (1.3% DM) did not affect the milk production.

Santos *et al.* (1998) summarized 23 comparisons in which conventional urea replaced partially or totally by true protein sources for housed cows with yields ranging from 29 to 42kg milk/day. Milk production was not affected in 20 out of 23 comparisons and decreased in only three, with the inclusion of urea in the rations.

Souza *et al.* (2010) evaluating the effects of the partial replacement of SBM by SRU in lactating Holstein cows producing 42kg of milk/day in a free-stall barn, found that the partial replacement did not decrease the milk yield or milk composition.

Table 5. Production and composition of milk as a function of concentrates in the diet of crossbred Holstein x Zebu cows

Item	SBM	Source of Nonprotein nitrogen (NPN)						CV (%)	Contrasts (Valor-P)			
		Urea (%)			SRU (%)				SBM vs. NPN	U vs SRU	Level of NPN	
		2	4	6	2	4	6				L	Q
BW (kg)	513.10	521.15	516.57	518.97	517.51	522.63	524.05	11.56	0.79	0.90	0.93	0.98
Milk yield (kg/day)	10.37	10.12	9.30	9.40	10.28	10.18	10.32	31.70	0.77	0.54	0.81	0.79
Corrected milk (kg/day)	10.61	10.70	9.80	10.12	11.42	11.00	11.20	30.48	0.95	0.37	0.78	0.68
Fat (%)	3.69	3.88	3.90	4.09	4.24	4.07	4.20	20.64	0.32	0.44	0.81	0.66
Protein (%)	3.64	3.60	3.64	3.65	3.62	3.80	3.66	14.07	0.91	0.71	0.85	0.61
Lactose (%)	4.34	4.08	4.05	4.12	4.31	4.14	4.05	13.30	0.40	0.67	0.65	0.82
Dry extract (%)	12.71	12.26	13.17	13.07	12.80	13.30	12.74	10.05	0.76	0.79	0.51	0.24
Non fatty dry extract (%)	8.80	8.45	8.47	8.56	8.75	8.73	8.47	6.80	0.41	0.40	0.73	0.83

CV = coefficient of variation; SBM vs. NPN = soybean meal *versus* nonprotein nitrogen; U vs SRU = urea *versus* slow release urea; L = linear effect of level of NPN; Q = quadratic effect of NPN; BW = body weight.

The efficiency of utilization of true protein and NPN sources may be interfered by a high concentration of ammonia in the rumen, observed usually three to five hours after the feeding of bran protein, one to two hours after administration of urea and 16 hours after providing SRU (Guimarães Júnior *et al.*, 2007). Optimizing the use of ammonia depends on balancing the diet, mainly by the addition of concentrated energy that creates appropriate conditions for the use of NPN (maximizing production of microbial protein). Apparently, the energy availability of pasture and supplement favored the use of ammonia coming from the source of dietary NPN, even at the highest levels of NPN in the supplement.

The effect of SRU with calcium chloride (0.61% of DM) in partial replacement for soybean meal in diets of dairy cows was studied by Golombesk *et al.* (2006). They observed that the use of SRU improved feed efficiency due to reduction of the dry matter intake, without affecting milk production.

The same effect of the SRU polymer used in this study was evaluated by Gallo *et al.* (2003). The authors partially replaced true protein sources by conventional urea in rations of high producing dairy cows (35kg of milk/day) in three diets. Two diets with 18% of CP (with or without the addition of 0.77% of SRU in DM) and another

one with 16% of CP and 0.77% of urea in DM basis containing SRU. Milk production was highest for the treatment containing 18% of CP without SRM (35.6kg of milk/day), intermediate for the treatment containing 18% of CP with SRU (34.8kg of milk/day) and lowest in diets containing 16% of CP and 0.77% of SRU (33.8kg of milk/day).

There was no effect ($P>0.05$) on the different sources of NPN (urea *vs.* SRU), level of NPN, and interaction between source of NPN and level of NPN on BW, milk yield, fat corrected milk, protein, and non fatty dry extract. Thus, due to the higher price, which is usually three times the price of urea, it is questionable to use SRU to replace conventional urea in diets for low production cows under pasture regimen.

It would be expected that the increase in milk yield with the replacement of urea with SRU for synchronizing release of ammonia with energy metabolism in the rumen would lead to better utilization of ruminal ammonia by microorganisms, optimization of the synthesis of bacterial protein and consequent reduction of the uptake by rumen papillae towards the liver (metabolism in the urea cycle). However, recycling of urea in the rumen (Hall *et al.*, 2007; Reynolds *et al.*, 2008) may have been a factor compensating the higher release rate of urea,

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which may explain the lack of effect on animal performance.

When the levels of conventional urea were increased, there was an increase in the balance of the feed, but the increase in the levels of SRU

increased spending in the use of concentrate, thus reducing the balance of the feed. These results demonstrate the infeasibility of using SRU in the diet of crossbred cows to replace conventional urea (Tab. 6).

Table 6. Balance of food obtained on the basis of conventional urea and slow release to replace soybean meal

Item	FS	Urea (%)			SRU (%)		
		2	4	6	2	4	6
Milk yield ¹ (kg/day)	10.00	10.00	10.00	10.00	10.00	10.00	10.00
Milk sold per cow ² (R\$/day)	6.80	6.80	6.80	6.80	6.80	6.80	6.80
Cost of concentrate ³ (R\$/day)	2.09	2.04	1.99	1.94	2.18	2.26	2.35
Cost of pasture ⁴ (R\$/day)	0.47	0.47	0.47	0.47	0.47	0.47	0.47
Cost of feed (R\$/day)	2.56	2.51	2.46	2.41	2.65	2.73	2.82
Cost of feed (base 100)	100	98.05	96.09	94.14	104	107	110
Balance of feed (R\$/day)	4.24	4.29	4.34	4.39	4.15	4.07	3.98
Balance (base 100)	100	101	102	104	97.88	95.99	93.87
Balance of feed (R\$/kg of milk)	0.42	0.43	0.43	0.44	0.42	0.41	0.40
Relationship food expense/value of production (%)	37.65	36.91	36.18	35.44	38.97	40.15	41.47

¹Since there was no treatment effect ($P>0.05$), we used the average value for all treatments.

²Milk price (R\$/kg): 0.68 - Practiced by Nestlé in Curvelo, state of Minas Gerais, Brazil, on 05/06/2010.

³Cost of concentrates (R\$/kg of DM): 0.65, 0.64, 0.62, 0.61, 0.68, 0.71 and 0.73, calculated from the prices charged by Itambé (Belo Horizonte, Minas Gerais state, Brazil).

⁴Cost of renting the pasture (R\$/animal/day).

CONCLUSIONS

The replacement of conventional urea by slow release urea did not promote improvement in the productive performance of crossbred dairy cows in tropical pastures during the rainy season. Urea (fast or slow release) can be included in up to 6% of DM in concentrated supplements, replacing soybean meal, without affecting the productive performance of crossbred dairy cows.

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