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Replacement of soybean meal by conventional and coated urea in dairy cows: intake, digestibility, production and composition of milk

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ABSTRACT. This study evaluated the effect of dairy cows' diets containing two different sources of urea on dry matter intake, nutrient apparent digestibility, and milk production and composition. Eight crossbred cows (Holandês x Zebu) were confined and randomly assigned to four sequential diets distributed in two 4 x 4 Latin: SM = soybean meal; SRU 0 = conventional urea (CU) 100%/slow release urea (SRU) 0%; SRU 44 = CU 56%/SRU 44%; SRU 88 = CU 12%/SRU 88%. Experimental periods consisted of 21 days, with total duration of 84 days. Dry matter intake, neutral detergent fiber, organic matter, crude protein, and total digestible nutrients were not affected by experimental diets. Dry matter and neutral detergent fiber digestibility coefficient presented average values of 69.43 and 51.07%, respectively. Average digestibility of crude protein was 65.43%. Average milk production was 9.609 kg. The partial replacement of soybean meal by conventional urea and slow release urea, at 2.1% of the diet dry matter, showed that these sources of urea can be offered without production impairment for dairy cows.

Keywords: conventional urea, dry matter intake, slow-release urea.

Substituição do farelo de soja por uréia convencional e protegida em vacas leiteiras: consumo, digestibilidade, produção e composição do leite

RESUMO. Objetivou-se, avaliar o efeito de duas diferentes fontes de ureia em dietas de vacas lactantes sobre consumo, digestibilidade aparente, produção e composição do leite. Utilizaram-se oito vacas mestiças Holandês x Zebu, sendo confinadas e distribuídas aleatoriamente, alocadas a uma sequência de quatro dietas experimentais, em delineamento distribuído em dois quadrados latino 4 x 4. FS - farelo de soja; ULL 0 = ureia convencional (UC) 100% / ureia de liberação lenta (ULL) 0%; ULL 44 = UC 56% / ULL 44%; ULL 88 = UC 12% / ULL 88%. Os períodos experimentais foram de 21 dias, com duração total de 84 dias. Não houve efeito significativo nas dietas experimentais, para os coeficientes de consumo de matéria seca, fibra em detergente neutro, matéria orgânica, proteína bruta e nutrientes digestíveis totais. O coeficiente de digestibilidade da matéria seca apresentou valor 69,43% e o da fibra em detergente neutro de 51,07%. A digestibilidade da proteína bruta obteve média de 65,43%. A média de produção de leite foi de 9,609 kg. A substituição parcial de farelo de soja por ureia em 2,1% da matéria seca da dieta, mostra que as fontes de ureias utilizadas podem ser oferecidas, sem que haja prejuízos produtivos para as vacas lactantes.

Palavras-chave: ureia convencional, consumo de matéria seca, ureia encapsulada.

Introduction

Milk production has continuously increased over the past 40 years due to genetic selection and nutrition of cows (GUMEN et al., 2011). According to FAO (2013), Brazil is the fifth largest producer of cow milk, with 32,091,000 million liters (FAO, 2013).

The Sugarcane contains levels of 2-5% crude protein, so it is recommended supplementing the diet with available sources of nitrogen (HUNTINGTON, 2006).

The additional supply of nitrogen compounds for animals consuming low quality forages may allow an increase in the voluntary consumption of forage and improve the energy balance from fibrous carbohydrate of the forage, since they favor the growth of fibrolytic bacteria (RUSSEL et al., 1992). The use of non-protein nitrogen of slow release in rumen may be a strategy to decrease the use of sources of true protein and livestock urea in ruminant diets, reducing the risk of urea poisoning, and to replace expensive true protein sources and to improve the timing of nutrients in the rumen (SOUZA et al., 2010).

Slow release urea is physically coated by plant waxes in order to reduce the rate of N release in the rumen. It has been already observed increased milk production when it partially replaced soybean meal (INOSTROZA et al., 2010).

This study aimed to evaluate the intake, digestibility, production and composition of milk as a function of diets with partial replacement of soybean meal by conventional urea and coated urea for dairy cows.

Material and methods

The experiment was conducted at Paulistinha Farm, in the municipality of Macarani, Bahia State, and at the State University of Southwest Bahia (UESB), campus of Itapetinga, Bahia State. The study included eight crossbred cows (Holandês x Zebu) of the third or fourth lactation with previous production between 3,000 and 4,000 kg adjusted to 305 days. Animals had a body weight of 445 ± 9 kg, and about 60 days in milk at the beginning of the experimental period.

Cows were confined, being randomly distributed and assigned to a sequence of four experimental diets in a design distributed in two 4x4 Latin squares held simultaneously. SM = soybean meal; SRU 0 = conventional urea (CU) 100%/slow release urea (SRU) 0%; SRU 44 = CU 56%/ SRU 44%; SRU 88 = CU 12%/ SRU 88%. Experimental periods had 21 days, with a total duration of 84 days. Animals were confined in roofed, sand-floored individual pens with three square meters area, provided with feeders and drinkers.

Diets were formulated to meet maintenance requirements, with a view to producing 12 kg milk day^{-1}, 3.5% fat, according to the National Research Council (NRC, 2001).

Animals fed diets containing 70% forage and 30% concentrate (Table 1). The forage used was sugarcane (*Saccharum*). In order to compose the concentrate e feeds were used: corn, wheat, soybean, urea and mineral mixture. Sources of urea used were conventional urea and slow release urea, and the control diet had soybean meal. The mixture of forage and concentrate was performed at the time of supply of feed.

Sugarcane (*Saccharum officinarum*) variety RB 72-454 was harvested daily and ground with leaves in forage machine at the time of supply. Weekly samples were taken for determination of DM and adjustment of forage: concentrate ratio of the diet. The average concentration of soluble sugars (Brix) of the material analyzed was 18.0°, analyzed by the refractometer.

Table 1. Proportion of ingredients and chemical composition of experimental diets.

Ingredients % DM	Experimental diets			
	SM	SRU 0	SRU 44	SRU 88
Sugarcane	70.0	70.0	70.0	70.0
Ground corn grain	6.8	20.7	20.6	20.6
Soybean meal	22.0	6.0	5.9	5.9
Mineral mix	0.7	0.7	0.7	0.7
Urea	0	2.1	1.38	0.46
Slow release urea	0	0	0.92	1.84
Limestone	0.5	0.5	0.5	0.5
% Nutrient				
OM	99.8	99.8	99.8	99.8
CP	15.8	17.5	16.5	15.6
TDN	72.5	71.5	71.9	71.1
NDF	48.9	52.0	50.2	49.3
EE	2.8	2.7	3.1	2.8
NFC	32.1	25.7	28.9	29.4

Mineral mixture: Calcium – 165.00 g kg^{-1}; Phosphorus – 78.00 g kg^{-1}; Sulfur – 26.00 g kg^{-1}; Magnesium – 20.00 g kg^{-1}; Sodium – 114.00 g kg^{-1}; Cobalt – 90.00 mg kg^{-1}; Copper – 1,238.00 mg kg^{-1}; Chrome – 20.00 mg kg^{-1}; Iron – 2,000.00 mg kg^{-1}; Iodine – 80.00 mg kg^{-1}; Manganese – 2,057.00 mg kg^{-1}; Selenium – 27.50 mg kg^{-1}; Zinc – 4,896.00 mg kg^{-1}; Fluorine – 780.00 mg kg^{-1} .CP: crude protein; TDN: total digestible nitrogen; NDF: neutral detergent fiber; EE: ether extract; NFC: non-fibrous carbohydrates. SM = soybean meal. SRU = slow release urea.

Diets were supplied in the morning at 7:00 am, and in the afternoon at 4:00 pm, in sufficient amount to result in at least 10% of the supplied as daily surplus. The daily intake of natural material was determined by subtracting the total food supplied in two feedings, the weight of the surplus, from 15th to 21st day of each period.

Samples were collected daily from each dietary ingredient and leftovers, per animal and composite samples were formed on the basis of quantities of natural material. These samples were dried in a forced air oven for 72h, at 55°C, and milled in a *Thomas-Wiley* mill with 1mm sieve. A subsample was oven-dried at 105°C, for 24h, to determine the final dry matter. Afterwards, the intake of dry matter was calculated by multiplying the value of the diet dry matter by the daily intake of natural material.

Analyses of dry matter (DM), organic matter (OM), total nitrogen, neutral detergent fiber (NDF), acid detergent fiber (ADF), ether extract (EE), mineral matter (MM) and neutral detergent insoluble nitrogen (NDIN) of food, leftovers and feces were performed according to the procedures described by Silva and Queiroz (2002).

For the analysis of ether extract, were weighed 2.0 g of samples of sugarcane, leftovers, feces and concentrates, which were wrapped in tissue paper napkins (14.0 × 14.0 cm), in the form of cartridges. The ends were clipped and samples were taken to a forced air oven at 55°C for 12 hours, kept in a desiccator until reaching room temperature and then weighed (SILVA; QUEIROZ, 2002).

Each cartridge was placed in the soxhlet extractor fractionated connections and kept under heating for 5h for fat extraction with petroleum ether, adding about 30 mL of ether per cartridge to flat-bottomed round flasks with a capacity of 500 mL. After extraction, flasks were taken again to a forced air oven at 55°C for 12 hours. The fat content was obtained from the difference between the weights of the flasks before and after extraction, and then adjusted to DM (SILVA; QUEIROZ, 2002).

The percentage of total carbohydrates (TC) was obtained by the equation: 100 - (%CP +%EE + %ash) and the percentage of NFC was calculated as 100 - (%NDFcp + %CP + %EE + %ash) (SNIFFEN et al., 1992). For the calculation of TDN, we used the equation proposed by NRC (2001): TDN = DCP + 2.25x DEE + + NDFcpD +DNFC. Where: DCP = digestible crude protein; DEE = digestible ether extract; NDFcpD = neutral detergent fiber (corrected for ash and protein) and DNFC = digestible non-fibrous carbohydrates.

Feces collection was performed for two alternate days, at different times (7:00 am and 5:00 pm), between the 14th and 21st experimental day. Feces of each cow were frozen throughout samplings and formed a composite sampled at the end of each period. The compounds per cow were dried, and NDF, ash and nitrogen were analyzed.

In order to estimate the fecal output it was used indigestible neutral detergent fiber (iNDF) as internal marker. Samples of supplied food (sugarcane and concentrate), leftovers and feces were incubated for 240 hours (CASALI et al., 2008), in duplicate (20 mg DM cm^{-2}), in in non-woven fabric bags (100 g m^{-2}) in the rumen of a Hostein x Zebu crossbred calf. After this period, the remaining material was subjected to extraction with neutral detergent (MERTENS, 2002) for quantification of iNDF. Values of fecal output were obtained through the relationship between intake and fecal concentration of iNDF.

Cows were milked twice daily at 6:00 and at 16:00h. In each sample, we determined the levels of fat, protein and urea in milk. Of this composite sample, an aliquot of 10 mL was mixed with 5 mL 25% trichloroacetic acid, filtered through filter paper, and the supernatant stored at -20°C for later analysis of urea and allantoin in the deproteinized milk (VALADARES et al., 1999).

Results were interpreted statistically and subjected to contrast analysis at 5% probability to determine the behavior of responses achieved, whether linear or quadratic. All statistical procedures were run with the software SAS (2002).

Results and discussion

No significant difference was detected for intake values calculated in metabolic weight of dry matter, neutral detergent fiber, organic matter, crude protein, ether extract and total digestible nutrients. Mean values found in the intake were 0.14 kg PM-1; 0.066 kg PM-1 0.14 kg PM-1; 21.89 g PM-1; 0.004 g PM-1; 0.10 kg PM-1, respectively. The intake of non-fibrous carbohydrate (CNF) was different between treatments, higher in diets with use of soybean (FS) as the sole nitrogen source. The lower intake of CNF was recorded when it was used the conventional urea uniquely replacing the FS. This might be explained by the presence of non-fibrous carbohydrates in soybean, increasing the supply. The inclusion of 2.1% urea in the concentrate replacing soybean meal promoted a satisfactory combination of fermentable carbohydrates and nitrogen compounds, promoting rumen synchrony and balance of different nitrogen compounds without interfering with dry matter intake. Aquino et al. (2007) worked with partial replacement of soybean meal by urea, and observed no effect of diets on the dry matter intake in dairy cows, indicating the lack of influence on the feed intake of animals.

Some results in the literature evidenced that the use of urea in the diet may reduce the consumption of dry matter by cows. Lana et al. (1997) have shown that diets containing conventional urea caused a much lower consumption than diets without urea. Oliveira et al. (2001) and Silva et al. (2001) registered significant differences in the DM intake when increased the levels of urea from 0 to 2.1% in the diet. Silva et al. (1999) supplied feeds in which soybean meal was gradually replaced by urea (0, 50 and 100%) in the concentrate, and verified a reduced intake, as the urea replaced the soybean. However, the inclusion of 1.9% total urea replacing soybean meal has reduced the feed efficiency (BRITO; BRODERICK, 2007), suggesting that including NNP above classical recommendations, around 1% of diet (REID, 1953), may not be advantageous.

In relation to experimental diets with coated urea, the dry matter intake did not differ from other diets, even participating in the total diet at the ratio of 2.1%. The encapsulation of NNP in the Optigen®II could be an unfavorable factor for the discussion that sensory factors would be involved in consumer responses. Highstreet et al. (2010) observed no significant difference for the dry matter intake between conventional and slow release urea, in supplemented diets to lactating cows, with high levels of soluble protein. Silveira et al. (2012) when used slow release urea for dairy cows, also registered no significant difference for the dry matter intake. The Mean intake of nutrients in relation to metabolic weight (kg $kg^{-0.75}$), significance of contrasts according to experimental diets, in dairy cows fed diets with different sources of nitrogen (Table 2).

Table 2. Mean intake of nutrients in relation to metabolic weight (kg $kg^{-0.75}$), significance of contrasts according to experimental diets, in dairy cows fed diets with different sources of nitrogen.

Experimental diets	DM (kg $kg^{-0.75}$)	NDF (kg $kg^{-0.75}$)	OM (kg $kg^{-0.75}$)	NFC (kg $kg^{-0.75}$)	CP (kg $kg^{-0.75}$)	EE (kg $kg^{-0.75}$)	TDN (kg $kg^{-0.75}$)
SM	0.14	0.068	0.14	0.09	21.75	0.004	0.10
SRU 0	0.13	0.063	0.13	0.06	22.72	0.003	0.10
SRU 44	0.14	0.065	0.14	0.08	20.36	0.004	0.11
SRU 88	0.14	0.067	0.14	0.08	22.71	0.004	0.10
Mean	0.14	0.066	0.14	0.08	21.89	0.004	0.10
SEM	0.0042	0.0022	0.0042	0.0040	0.9511	0.0002	0.0024
L*	0.2569	0.3029	0.2569	0.0817	0.9970	0.1616	0.5188
Q*	0.9167	0.9584	0.9167	0.3334	0.2361	0.7353	0.2804
Contrasts							
vs. (2 + 3 + 4)	0.3049	0.2422	0.3480	0.0327*	0.9169	0.5900	0.7566
2 vs. (3 + 4)	0.2178	0.3010	0.2197	0.0191*	0.5108	0.2366	0.8476
1 vs. 2	0.1271	0.1265	0.1456	0.0034*	0.6416	0.2633	0.7225
1 vs. 3	0.8475	0.7419	0.9059	0.2841	0.6471	0.6367	0.6135
1 vs. 4	0.4386	0.3187	0.4811	0.2507	0.5049	0.5117	0.3742
2 vs. 3	0.1772	0.2210	0.1782	0.0356*	0.9939	0.1194	0.4069
2 vs. 4	0.4299	0.5713	0.4333	0.0420*	0.2620	0.6333	0.6186
3 vs. 4	0.5579	0.4983	0.5562	0.9351	0.2651	0.2652	0.1719

SM = soybean meal; SRU 0 = conventional urea (UC) 100% / slow release urea (SRU) 0%; SRU 44 = UC 56% / SRU 44%; SRU 88 = UC 12% / SRU 88%; L* =linear Q*= quadratic; SEM: standard error of the mean; Contrasts: 1 - SM; 2 - SRU 0; 3 - SRU 44; 4 - SRU 88. * = Significant at 5% probability.

Regarding the partial replacement of experimental diets, from the inclusion to the mixture of urea, the NDF intake did not differ significantly. The percentage of urea of 1% of total diet in partial replacement of soybean has not impaired the intake. Conventional urea can be considered the controller of the supplement intake, which was used by Baroni et al. (2010). For Alvarez Almora et al. (2012), urea is rapidly hydrolyzed when reaches the rumen, resulting in an increased concentration of ammonia in the first hour after feeding. According to Highstreet et al. (2010), the balanced intake of dry matter and neutral detergent fiber at 2.1% concentrate of the diet was attributed to the balance in ruminal ammonia concentration of nitrogen compounds and fermentable carbohydrates.

The lowest consumption of non-fibrous carbohydrate was achieved by using 100% conventional urea, equivalent to 0.06 kg PM^{-1}, with significant difference compared with other treatments. The partial replacement of soybean by types of urea affected the intake of non-fibrous carbohydrate, indicating a positive effect when adding coated urea to the feed. The greater intake of non-fibrous carbohydrate was observed in the control, which can be due to the increased percentage of non-degradable protein in the rumen. For Franco et al. (2004), the main factors affecting the protein degradability are pH, rumen N-NH_3, passage rate and degradation of forage organic matter. Sudden changes in ruminal pH may cease microbial activity as well as low levels of rumen NH_3-N may limit fermentation. Thus it is assumed that the use of nitrogenous compounds can influence the degradation of carbohydrates. In this way, stabilization of rumen pH is also due to the rapid assimilation of soluble carbohydrates by these microorganisms, contributing thus to ensure the functional integrity of the rumen. As the non-fibrous carbohydrate fraction is a substrate almost completely degraded in the rumen, reducing its consumption may have negative impacts on ruminal microbial protein synthesis, the main source of digestible amino acids in the small intestine in ruminants. Mendonça et al. (2004) who evaluated the consumption of sugarcane and urea by dairy cows, verified a higher intake of non-fibrous carbohydrates for the diet with sugarcane and a 50:50 forage: concentrate ratio, compared with treatments with F:C of 60:40, which can be justified by the greater participation of concentrate in the diet.

The partial replacement of soybean by types of urea has not affected the intake of crude protein. Therefore, what influences the amount of crude protein ingested are not the sources, but rather the protein composition of the diet. Silveira et al. (2012) used coated urea to dairy cows and detected no significant difference for the intake of crude protein. The inclusion of coated urea replacing soybean did not affect the intake of TDN, similarly to Martins et al. (2011), whose studies found no differences in the TDN intake in lactating cows, using concentrate, urea and sugarcane.

The apparent digestibility of dry matter was not different between experimental diets (Table 3), with a mean value of 69.43%. This result was higher than reported by Teixeira et al. (2010) who found 54.5% digestibility of DM in diets based on sugarcane and concentrate for dairy cows. Galo et al. (2003) reported an increase in the total digestibility of DM and CP in Holstein dairy cows, when used polymer coated urea as a source of NPP, at 0.77% dry matter. Similar results were obtained by Xin et al. (2010)

who fed lactating cows with 1.7% coated urea, and registered that the intake of DM improves the digestibility of nutrients in diets with coated urea, compared with those with conventional urea.

The digestibility of neutral detergent fiber was not affected by experimental diets, averaging 51.07% NDF in DM. Our results were higher than found by Oliveira et al. (2011) who used sugarcane for dairy cows and observed NDF digestibility of 42.60%. Sinclair et al. (2012) by replacing soybean meal by conventional urea and coated urea in lactating cows, found digestibility values close to 54 and 53% using conventional urea and coated urea, respectively.

Some authors attribute the reduction in NDF digestibility mainly to the lower rate of digestion of the fibrous fraction, potentially digestible, which increases the retention time of the food in the reticulo-rumen and reduces the rate of passage through the gastrointestinal tract (MAGALHÃES et al., 2006; PEREIRA et al., 2000). According to Rocha Júnior et al. (2003), lignin has been recognized as the main chemical component of the sugarcane, which affects the digestibility of the cell wall, whose direct effect has been explained by different assumptions, such as: i) toxic effect to fibrolytic microorganisms; ii) limited activity of fibrolytic enzymes, resulting from deposition of lignin polymers with plant maturity; and iii) physical restriction caused by the polysaccharide lignin linkage, which would limit the access of enzymes.

Highstreet et al. (2010) found similar apparent NDF digestibility with the supply of slow-release urea or urea to 2 groups of lactating cows. Santos et al. (2011), working with 0.61% Optigen-II, also got no difference in the neutral detergent fiber digestibility, when using coated urea compared with conventional urea for dairy cows. With the use of coated urea, it was expected a more constant supply of nitrogen in the rumen, resulting in improved digestibility of the fibrous portion of the diet, which was not observed.

The average apparent digestibility of non-fibrous carbohydrates was 90.68%. Despite differences in the consumption of NFC, there were differences for digestibility of experimental diets. The control treatment promoted a higher digestibility of NFC fractions, 95.11%. The inclusion of coated urea to experimental diets led to a lower NFC digestibility compared with the control group. NFC fractions recognizably present true digestibility coefficient between 95 and 98%, even in tropical conditions (DETMANN et al., 2006; VAN SOEST, 1994).

The average apparent digestibility of crude protein was 65.83%. The inclusion of nitrogen compounds provided no significant change in crude protein digestibility. Silva et al. (2009) used coated urea to evaluate the apparent digestibility of nutrients of dairy cows, and observed that the digestibility of CP increased according to the level of CP in the diet, which is related to the higher content of urea in the diet, which was not verified in this study.

The average apparent digestibility of ether extract (EE) was 90.74%, with no differences between experimental diets. These results showed that the use of nitrogen compounds at a ratio of 1% of total dry matter had not affected the EE digestibility. Oliveira et al. (2001), working with dairy cows, registered a variation in the EE digestibility in dairy cows for diets with increasing levels of conventional urea (0; 0.7; 1.4 and 2.1% total DM of the diet). At higher values of nitrogen compounds in the diet occurs variation in the digestibility of ether extract.

The mean production and composition of milks, significance of contrasts according to experimental diets, observed in dairy cows fed diets with different sources of nitrogen has been in Table 4.

Table 3. Mean digestibility of dry matter and nutrients, significance of contrasts according to experimental diets, observed in dairy cows fed diets with different sources of nitrogen.

Experimental diets	DM (%)	NDF (%)	OM (%)	NFC (%)	CP (%)	EE(%)
SM	67.49	48.96	68.1160	95.11	68.11	91.88
SRU 0	69.47	50.66	70.0196	90.38	62.69	84.24
SRU 44	68.62	50.17	72.3680	89.77	69.75	94.39
SRU 88	72.12	54.5	69.1161	87.47	62.78	92.47
Mean	69.43	51.07	69.90	90.68	65.83	90.74
SEM	1.33	1.93	1.30	1.26	2.89	3.02
L*	0.1656	0.201	0.2214	0.8199	0.3420	0.3017
Q*	0.1888	0.3487	0.2145	0.2676	0.5906	0.7031
Contrasts						
1 vs. (2 + 3 + 4)	0.2374	0.399	0.2586	0.0077*	0.6246	0.8228
2 vs. (3 + 4)	0.6955	0.6348	0.7439	0.4104	0.5871	0.2095
1 vs. 2	0.4543	0.6758	0.4582	0.0652	0.4773	0.3612
1 vs. 3	0.6674	0.7657	0.1051	0.0398*	0.8286	0.7614
1 vs. 4	0.0891	0.1808	0.6955	0.0053*	0.4848	0.9432
2 vs. 3	0.7477	0.9039	0.3615	0.8031	0.3570	0.2290
2 vs. 4	0.3218	0.349	0.7236	0.2432	0.9903	0.3263
3 vs. 4	0.1937	0.2921	0.2100	0.3529	0.3632	0.8161

SM = soybean meal; SRU 0 = conventional urea (UC) 100% / slow release urea (SRU) 0%; SRU 44 = UC 56% / SRU 44%; SRU 88 = UC 12% / SRU 88%; L* =linear Q*= quadratic; SEM: standard error of the mean; Contrasts: 1 - SM; 2 - SRU 0; 3 - SRU 44; 4 - SRU 88; * = Significant at 5% probability.

Table 4. Mean production and composition of milks, significance of contrasts according to experimental diets, observed in dairy cows fed diets with different sources of nitrogen.

Experimental Diets	Production/milk (kg)	CP/milk (%)	Fat/milk (%)	Fat/Protein ratio
SM	10.26	2.89	3.21	1.14
SRU 0	9.21	2.70	4.03	1.39
SRU 44	9.35	2.92	3.38	1.21
SRU 88	9.6	3.03	3.29	1.12
Mean	9.6	2.88	3.57	1.22
SEM	0.18	0.10	0.25	0.08
L*	0.3664	0.5244	0.0429*	0.3851
Q*	0.889	0.4635	0.1481	0.3605
1 vs. (2 + 3 + 4)	0.0287*	0.9588	0.5456	0.5401
2 vs. (3 + 4)	0.5137	0.3104	0.3171	0.2350
1 vs. 2	0.0315*	0.5279	0.2732	0.2283
1 vs. 3	0.0598	0.9381	0.8235	0.7229
1 vs. 4	0.1619	0.6684	0.9187	0.9093
2 vs. 3	0.761	0.4790	0.3919	0.3743
2 vs. 4	0.4089	0.2928	0.3601	0.2345
3 vs. 4	0.599	0.7255	0.9062	0.6514

SM = soybean meal; SRU 0 = conventional urea (UC) 100% / slow release urea (SRU) 0%; SRU 44 = UC 56% / SRU 44%; SRU 88 = UC 12% / SRU 88%; L* =linear Q*= quadratic; SEM: standard error of the mean; Contrasts: 1 - FS; 2 - SRU 0; 3 - SRU 44; 4 - SRU 88. * = Significant at 5% probability.

Milk production was lower ($p < 0.05$) when used 100% conventional urea and with significant difference, compared with the control treatment. This result was influenced by lower intake of non-fibrous carbohydrates, impacting the proportions of volatile fatty acids produced in the rumen, and influencing thus the production of milk.

In the experimental diets with urea, there was significant difference in milk production compared with the control group. Therefore, the results showed that the use of urea to partially replace soybean meal, can reduce the productive performance of dairy cows fed diets based on sugar cane. The partial replacement of soybean meal by coated urea has not reduced the productive performance of lactating cows.

Souza et al. (2010) examined the effects of coated urea on production and composition of milk in dairy cows, using a diet with 11.4% soybean and another with 0.4% coated urea + 9.0% soybean meal, and detected no differences in daily production of milk.

There were no significant differences in milk production for treatments using (0, 44, 88%) coated urea. In agreement with Azevedo et al. (2010), the use of coated and conventional urea to dairy cows caused no significant difference, and for this is considered determinant the low efficiency of its coat, verified by means of ammonia release in the rumen, which was similar over time.

The partial replacement of conventional and soybean by coated urea showed no influence on the percentage of crude protein in milk between diets, similarly to Galo et al. (2003) when evaluating the effect of coated urea for lactating cows.

Santos et al. (2011) reported no difference in milk composition of cows fed diets with different levels of urea, soybean meal. In contrast, Susmel et al. (1995) found an increase in milk protein due to the addition of urea to diet given to the cows. Under the conditions of the present study, the partial replacement of soybean meal by urea has not affect milk protein, which can be because the sugarcane promotes a balanced fermentation of organic matter, allowing microorganisms to capture and transform nitrogen into microbial protein, regardless of the protein source.

The average value of fat content of milk was observed for the experimental diet with 100% conventional urea, with 4.03%. The highest synthesis of milk fat in cows fed conventional urea can be assigned to the impact in the proportion of volatile fatty acids produced in the rumen, especially the acetic acid (a precursor for milk fat synthesis). The possible mechanisms that resulted in the lowest content of fat of milk from cows fed diets with coated urea are to be elucidated, since the base diet supplied to animals was similar between treatments, and met the requirements of physically effective fiber. Souza et al. (2010) observed in lactating cows that the supplementation of coated urea has diminished the percentage of fat, however with values below 2.99% with soybean meal, and 2.71% with slow release urea.

The average value of the relationship between fat and protein in milk was 1.22, without significant difference between treatments.

Conclusion

The partial replacement of soybean meal by conventional urea and slow release urea, at 2.1% dry matter of the diet, showed that these sources of urea are products that can be supplied without production impairment for dairy cows.

References

ALVAREZ ALMORA, E. G.; HUNTINGTON, G. B.; BURNS, J. C. Effects of supplemental urea sources and feeding frequency on ruminal fermentation, fiber digestion, and nitrogen balance in beef steers. **Animal Feed Science and Technology**, v. 171, n. 2, p. 136-145, 2012.

AQUINO, A. A.; BOTARO. B. G.; IKEDA, F. S. Efeito de níveis crescentes de uréia na dieta de vacas em lactação sobre a produção e a composição físico-química do leite **Revista Brasileira de Zootecnia**, v. 36, n. 4, p. 881-887, 2007.

AZEVEDO, E. B.; OSPINA-PATINO, H.; SILVEIRA, A. L. F. Suplementação nitrogenada com ureia comum ou encapsulada sobre parâmetros ruminais de novilhos alimentados com feno de baixa qualidade. **Ciência Rural**, v. 40, n. 3, p. 622-627, 2010.

BARONI, C. E. S.; LANA, R. P.; MANCIO, A. B. Níveis de suplemento à base de fubá de milho para novilhos Nelore terminados a pasto na seca: desempenho, características de carcaça e avaliação do pasto. **Revista Brasileira de Zootecnia**, v. 39, n. 1, p. 175-182, 2010.

BRITO, A. F.; BRODERICK, G. A. Effects of different protein supplements on milk production and nutrient utilization in lactating dairy cows. **Journal of Dairy Science**, v. 90, n. 4, p. 1816-1827, 2007.

CASALI, A. O.; DETMANN, E.; VALADARES FILHO, S. C. Influência do tempo de incubação e do tamanho de partículas sobre os teores de compostos indigestíveis em alimentos e fezes bovinas obtidos por procedimentos *in situ*. **Revista Brasileira de Zootecnia**, v. 37, n. 2, p. 335-342, 2008.

DETMANN, E.; VALADARES FILHO, S. C.; HENRIQUES, L. T. Estimação da digestibilidade dos carboidratos não-fibrosos em bovinos utilizando-se o conceito de entidade nutricional em condições brasileiras. **Revista Brasileira de Zootecnia**, v. 35, n. 4, p. 1479-1486, 2006.

DUFFIELD, T. F.; KELTON, D. F.; LESLIE, K. E. Use of test day milk fat and milk protein to predict subclinical ketosis in Ontario dairy cattle. **Canadian Veterinary Journal**, v. 38, n. 11, p. 713-718, 1997.

FAO-Food and Agriculture Organization. Organizações das Nações Unidas para a Alimentação e a Agricultura. **Rebanho bovino leiteiro no Brasil**. Available from: <http://www.fasotat.fao.org/2012>. Access on: Mar. 3, 2013.

FRANCO, A. V. M.; FRANCO, G. L.; ANDRADE, P. Parâmetros ruminais e desaparecimento da MS, PB e FDN da forragem em bovinos suplementados em pastagem na estação seca. **Revista Brasileira de Zootecnia**, v. 33, n. 5, p. 1316-1324, 2004.

GALO, E.; EMANUELE, S. M.; SNIFFEN, C. J. Effects of a polymer-coated urea product on nitrogen metabolism in lactating Holstein dairy cattle. **Journal of Dairy Science**, v. 86, n. 6, p. 2154-2162, 2003.

GUMEN, A.; KESKIN, A.; YILMAZBAS-MECITOGLU, G. Dry period management and optimization of post-partum reproductive management in dairy cattle. **Reproduction in Domestic Animals**, v. 46, Suppl. 3, p. 11-17, 2011.

HIGHSTREET, A.; ROBINSON, P. H.; ROBISON, J. Response of Holstein cows to replacing urea with a slowly rumen released urea in a diet high in soluble crude protein. **Livestock Production Science**, v. 129, n. 1-3, p. 179-185, 2010.

HUNTINGTON, G. B. Effects of a slow-release urea source on absorption of mmonia and endogenous production of urea by cattle. **Animal Feed Science and Technology**, v. 130, n. 3, p. 225-241, 2006.

INOSTROZA, J. F.; SHAVER, R. D.; CABRERA, V. E. Effect of diets containing a controlled-release urea product on milk yield, milk composition, and milk component yields in commercial Wisconsin dairy herds and economic implications. **The Professional Animal Scientist**, v. 26, n. 2, p. 175-180, 2010.

LANA, R. P.; FOX, D. G.; RUSSELL, J. B. Influence of monensin on Holstein steers fed high-concentrate diets containing soybean meal or urea. **Journal of Animal Science**, n. 75, p. 2571-2579, 1997.

MAGALHÃES, A. L. R.; CAMPOS, J. M. S; CABRAL, L. S. Cana-de-açúcar em substituição à silagem de milho em dietas para vacas em lactação: parâmetros digestivos e ruminais. **Revista Brasileira de Zootecnia**, v. 35, n. 10, p. 591-599, 2006.

MARTINS, S. C. S. G.; ROCHA JÚNIOR, V. R.; CALDEIRA, L. A. Consumo, digestibilidade, produção de leite e análise econômica de dietas com diferentes volumosos **Revista Brasileira de Saúde e Produção Animal**, v. 12, n. 3, p. 691-708, 2011.

MENDONÇA, S. S.; CAMPOS, J. M. S.; VALADARES FILHO, S. C. Consumo, digestibilidade aparente, produção e composição do leite e variáveis ruminais em vacas leiteiras alimentadas com dietas à base de cana-de-açúcar. **Revista Brasileira de Zootecnia**, v. 33, n. 2, p. 481-492, 2004.

MERTENS, D. R. Gravimetric determination of amylase-treated neutral detergent fiber in feeds with refluxing in beakers or crucibles: collaborative study. **Journal of AOAC International**, v. 85, n. 3, p. 1217-1240, 2002.

NRC-National Research Council. **Nutrient requirements of dairy cattle**. 7th ed. Washington, D.C.: National Academic Press, 2001.

OLIVEIRA, A. S.; VALADARES, R. F. D.; VALADARES FILHO, S. C. Consumo, digestibilidade aparente, produção e composição do leite em vacas alimentadas com quatro níveis de compostos nitrogenados não-proteicos. **Revista Brasileira de Zootecnia**, v. 30, n. 4, p. 1358-1366, 2001.

OLIVEIRA, A. S.; DETMANN, E.; CAMPOS, J. M. S. Meta-análise do impacto da fibra em detergente neutro sobre o consumo, a digestibilidade eo desempenho de vacas leiteiras em lactação. **Revista Brasileira de Zootecnia**, v. 40, n. 7, p. 1587-1595. 2011.

PEREIRA, E. S.; QUEIROZ, A. C.; PAULINO, M. F. Determinação das frações protéicas e de carboidratos e taxas de degradação *in vitro* da cana-de-açúcar, da cama de frango e do farelo de algodão. **Revista Brasileira de Zootecnia**, v. 29, n. 3, p. 1887-1893, 2000.

ROCHA JÚNIOR, V. R.; VALADARES FILHO, S. C.; BORGES, Á. M. Estimativa do valor energético dos alimentos e validação das equações propostas pelo NRC (2001) **Revista Brasileira de Zootecnia**, v. 32, n. 2, p. 480-490, 2003.

REID, J. T. Urea as a protein replacement for ruminants: a review. **Journal of Dairy Science**, v. 36, n. 9, p. 955-996, 1953.

RUSSELL, J. B.; O'CONNOR, J. D.; FOX D. G. A net carbohydrate and protein system for evaluating cattle diets: I. Ruminal fermentation. **Journal of Animal Science**, v. 70, n. 11, p. 3551-3561, 1992.

SANTOS, J. F.; DIAS JUNIOR, G. S.; BITENCOURT, L. L. Resposta de vacas leiteiras a substituição o parcial de farelo de soja por ureia encapsulada. **Arquivo Brasileiro de Medicina Veterinária e Zootecnia**, v. 63, n. 2, p. 423-432, 2011.

SAS-Statistical Analysis System. **User's guide**. Cary: SAS Institute, 2002.

SILVA, R. M. N.; VALADARES, R. F. D.; VALADARES FILHO, S. C. Ureia para vacas em lactação. 1. Consumo, digestibilidade, produção e composição do leite. **Revista Brasileira de Zootecnia**, v. 30, n. 5, p. 1639-1649, 2001.

SILVA, C. V.; LANA, R. P.; CAMPOS, J. M. S. Consumo, digestibilidade aparente dos nutrientes e desempenho de vacas leiteiras em pastejo com dietas com diversos níveis de concentrado e proteína bruta **Revista Brasileira de Zootecnia**, v. 38, n. 7, p. 1372-1380, 2009.

SILVA, D. J.; QUEIROZ, A. C. **Análise de alimentos** (métodos químicos e biológicos). Viçosa: UFV, 2002.

SILVA, L. M.; FEIJÓ, G. L. D.; THIAGO, L. R. L. Desempenho e avaliação do potencial produtivo de forragens para ensilagem, por intermédio de diferentes fontes de suplementação nitrogenada. **Revista Brasileira de Zootecnia**, v. 28, n. 3, p. 642-653, 1999.

SILVEIRA, V. A.; LOPES, N. M.; OLIVEIRA, R. C. Substituição parcial de farelo de soja por ureia de liberação lenta em rebanhos leiteiros comerciais. **Revista Brasileira de Saúde Produção Animal**, v. 13, n. 2, p. 383-395, 2012.

SINCLAIR, L. A.; BLAKE, C. W.; GRIFFIN, P.; JONES, G. H. The partial replacement of soyabean meal and rapeseed meal with feed grade urea or a slowrelease urea and its effect on the performance, metabolism and digestibility in dairy cows. **Animal**, v. 6, n. 6, p. 920-927, 2012.

SNIFFEN, C. J.; O'CONNOR, J. D.; VAN SOEST, P. J. A net carbohydrate and protein system for evaluating cattle diets: II. Carbohydrate and protein availability. **Journal of Animal Science**, v. 70, n. 11, p. 3562-3577, 1992.

SOUZA, V. L. S.; ALMEIDA, R.; SILVA, D. F. F. S.; PIEKARKI, P. R. B.; JESUS, C. P. Substituição parcial de farelo de soja por ureia protegida na produção e composição de leite. **Arquivo Brasileiro de Medicina Veterinária e Zootecnia**, v. 62, n. 6, p. 1415-1422, 2010.

SUSMEL, P.; SPANGHERO, M.; STEFANON, B. Nitrogen balance and partitioning of some nitrogen catabolites in milk and urine of lactating cows. **Livestock Production Science**, v. 44, n. 2, p. 207-209, 1995.

VALADARES, R. F. D.; BRODERICK, G. A.; VALADARES FILHO, S. C. Effect of replacing alfafa silage with high moisture corn on ruminal protein synthesis estimated from excretion of total purine derivatives. **Journal of Dairy Science**, v. 82, n. 12, p. 2686-2696, 1999.

VAN SOEST, P. J. **Nutritional ecology of the ruminants**. 2nd ed. Ithaca: Cornell University Press, 1994.

TEIXEIRA, R. M. A.; LANA, R. P.; FERNANDES, L. O.; OLIVEIRA, A. S.; QUEIROZ, A. C.; PIMENTEL, J. J. O. Desempenho produtivo de vacas da raça Gir leiteira em confinamento alimentadas com níveis de concentrado e proteína bruta nas dietas. **Revista Brasileira de Zootecnia**, v. 39, n. 11, p. 2527-2534, 2010.

XIN, H. S.; SCHAEFER, D. M.; LIU, Q. P. Effects of polyurethane coated urea supplement on *in vitro* ruminal fermentation, ammonia release dynamics and lactating performance of Holstein dairy cows fed a steam-flaked corn-based diet. **Asian - Australasian Journal of Animal Science**, v. 23, n. 4, p. 491-500, 2010.

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