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ANIMAL PRODUCTION

Nitrogen sources associated with different physical forms of corn grain in the diet for steers in feedlot

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ABSTRACT. This study evaluated the substitution of soybean meal with non-protein nitrogen sources, in combination with ground or whole corn for feedlot cattle. Fifty-four Charolais x Nellore steers with 22 ± 0.23 months and 250 ± 15.80 kg were assigned to a 3 x 2 factorial completely randomized experimental design. The treatments consisted of different combinations of concentrate formulation: soybean meal with whole or ground corn, conventional urea with whole or ground corn, and protected urea with whole or ground corn. There was interaction between nitrogen source and collection date for serum albumin, with increasing elevation for soybean meal; while there was elevation from day 0 to day 84, stabilizing until the slaughter, for urea. Higher intakes of dry matter and crude protein, daily weight gain and rumination efficiency were observed for soybean meal. Steers that received protect urea spent more time to feed, in comparison to soybean meal. Longer idle time was verified for soybean meal; while conventional urea was superior to protected urea. Replacing soybean meal by sources of non-protein nitrogen limits the results of blood metabolites, performance and ingestive behavior.

Keywords: albumin; ingestive behavior; non-protein nitrogen; performance.

Fontes nitrogenadas associadas a diferentes formas físicas do grão de milho na dieta de novilhos confinados

RESUMO. Este trabalho foi realizado para avaliar a substituição do farelo de soja por fontes de nitrogênio não proteico, em combinação com milho moído ou inteiro para bovinos confinados. Foram utilizados 54 novilhos, mestiço Charolês x Nelore com 22 ± 0,23 meses e 250 ± 15,80 kg. O delineamento experimental foi o inteiramente casualizado, com arranjo fatorial 3 x 2. Os tratamentos consistiram em diferentes combinações de formulação do concentrado: farelo de soja com milho grão ou moído; ureia convencional com milho grão ou moído, e ureia protegida com milho grão ou moído. Houve interação entre fonte nitrogenada e data de coleta para albumina sérica, com elevação crescente para o farelo de soja, enquanto houve elevação do dia 0 para o dia 84, estabilizando até o abate, para as ureias. Maiores consumos de matéria seca e proteína bruta, ganho de peso diário e eficiência de ruminação foram observadas para farelo de soja. Novilhos que receberam ureia protegida destinaram mais tempo à alimentação, em relação ao farelo de soja. Maior tempo de ócio foi verificado para o farelo de soja, enquanto a ureia convencional foi superior à ureia protegida. Substituir o farelo de soja por fontes de nitrogênio não proteico limita os resultados de metabólitos sanguíneos, desempenho e comportamento ingestivo.

Palavras-chave: albumina; comportamento ingestivo; desempenho; nitrogenio não proteico.

Introduction

Nutrition is an important component to be analyzed in finishing feedlot cattle, as it interferes directly with both the productive and economic response of the system. According to Oliveira and Millen (2014), soybean meal was the main protein ingredient used by cattle nutritionists, but it has lost ground to other sources. This reduction is due to the increase in the acquisition costs of this ingredient, since it is widely used in poultry and pork production, with prices varying in the harvest and off-season periods and with international market demands (Azevedo et al., 2015).

In this scenario, the use of alternative sources, such as non-protein nitrogen, is interesting in the nutrition of ruminants, due to their ability to convert it into microbial protein with high biological value. The main source of non-protein nitrogen used is urea; however, it presents a high rate of hydrolysis at the rumen level, which may lead to losses of nitrogen and metabolic disturbances. Products with controlled release of ammonia, such

as protected urea, may be recommended as an alternative to the disadvantages of high solubility, high renal excretion and ammonia toxicity of conventional urea (Gonçalves et al., 2015). The results of the present study show that rumen hydrolysis is modulated and may favor the synchronization between carbohydrate degradation and nitrogen release for fibrolytic bacteria (Benedeti et al., 2014; Gonçalves et al., 2015).

For a successful use of non-protein nitrogen for ruminants it is necessary that they have excellent synchronization with fermentable carbohydrates that come from other components of the diet. The main source of carbohydrate used in Brazilian feedlot systems is corn (Oliveira & Millen, 2014). However, the way this grain is supplied is still quite discussed. Processing such as grinding is used to increase the surface area of the grains to facilitate digestive processes. Vargas Junior, Sanchez, Wechsler, Bianchini, and Oliveira (2008) provided whole or ground corn for calves without changes in intake and performance. Benedeti et al. (2014) found decreasing dry matter intake when replacing soybean meal by protected urea and attributed it to the high digestibility of the finely ground corn used in the diet, which would not have been accompanied by the assimilation of nitrogen in the rumen, which was released gradually.

This study was carried out to evaluate the replacement of soybean meal with non-protein nitrogen (conventional or protected urea), in combination with ground or whole corn, in the diet for feedlot steers.

Material and methods

The experiment was carried out at the Laboratory of Beef Cattle, belonging to the Animal Science Department, Federal University of Santa Maria [UFSM], municipality of Santa Maria, State of Rio Grande do Sul. A total of 54 steers from advanced generations of rotational crosses between the Charolais and Nellore breeds (65% Charolais 35% Nellore and 65% Nellore 35% Charolais) were used, immunocastrated with Bopriva®, with mean age and body weight of 22 ± 0.23 months and 250 ± 15.80 kg, respectively. After randomization by initial body weight, steers were randomly distributed in the diets tested. These diets consisted of different combinations of nitrogen source and physical form of the corn grain, in the concentrate fraction, being: soybean meal associated with whole or ground corn, conventional urea associated with whole or ground corn and protected urea associated with whole or ground corn. The procedure to obtain the physical form of ground corn was grinding in a hammer mill with a 2 mm sieve, as used in similar work by Vargas Junior et al. (2008).

The roughage:concentrate ratio used was 50:50, with corn silage as a roughage food source. The diets were calculated according to National Research Council (NRC, 2016), seeking to maintain them isonitrogenous and isoenergetic, estimating a weight gain of 1.25 kg day^{-1} and a dry matter intake of 2.53 kg DM 100^{-1} kg body weight. To maintain them isoenergetic, the inert kaolin was used in diets containing soybean meal (Table 1).

Steers were housed in individual covered stalls, with pavement of reinforced concrete, with 3% slope, provided with feeders for the supply of food and drinkers with water at will, regulated with a faucet. The animals were adapted to the diets and facilities for a period of 21 days. In this period, both urea and soybean meal were weighed separately and added to the concentrate, where every two days 15% of the amount recommended by the consumption sheets were added.

The diet was given *ad libitum*, divided into two meals (8 and 14h). Prior to the first supply, the leftovers from the previous day were collected, which were pre-established between 50 and 80 g kg^{-1} of feed offered.

Table 1. Percentage composition and chemical analysis of diets.

Ingredients, % of diet	Diets		
	Soybean meal	Conventional urea	Protected urea
*Corn silage	50.00	50.00	50.00
Corn grain	67.90	94.40	94.30
Soybean meal	27.00	–	–
Calcitic limestone	1.10	1.20	1.00
Sodium chloride	1.00	1.00	1.00
Sulfur	–	0.12	0.12
Kaolin	3.00	–	–
Protected urea	–	–	3.60
Conventional urea	–	3.30	–
	Chemical composition, % DM		
#Dry matter	57.59	57.22	57.17
Crude protein	12.4	12.4	12.4
Ether extract	3.23	3.43	3.42
Neutral detergent fiber	31.52	29.97	30.93
Acid detergent fiber	13.54	12.26	12.91
Total digestible nutrients	65.83	65.44	65.38

*Percentage of dry matter; # Percentage in natural matter.

Once a week, samples of these leftovers from each steer were collected individually. After identified and weighed, they were pre-dried in a forced air oven at 55° C for 72 hours and then milled in a Wiley mill with a 1 mm sieve. In these samples, it were determined the dry matter, crude protein and ether extract contents, according to Association of Official Agricultural Chemists (AOAC, 1995). The neutral and acid detergent fiber

contents were determined by the method of Van Soest, Robertson, and Lewis (1991) and the estimation of the total digestible nutrients was obtained according to Quatrin et al. (2017).

Voluntary intake was recorded daily, obtained by the difference between the food offered and the leftovers of the following day. The steers were weighed, every 28 days, with solid and liquid fasting for 14 hours. Concomitant to weighing, the body condition score was evaluated, with scores of 1 to 5 being attributed by visual observation, in which 1 = very thin and 5 = very fat. The daily weight gain was obtained by the weight difference between weighings, divided by the interval of days between weighings. Feed conversion was calculated by the quotient between the dry matter intake and the daily weight gain.

Blood samples were taken from five steers of each diet on days 0 and 84 of the experimental phase and on boarding to the slaughterhouse to determine the serum concentration of albumin and total circulating proteins in the blood. After immobilized in a containment facility, approximately 3 mL blood was collected from the jugular vein, using vacuum tubes containing anticoagulant solution of sodium fluoride (glycolysis inhibitor). Subsequently, samples were centrifuged at 2,500 rpm for 10 minutes to obtain the serum, identified, packed in Eppendorf tubes and frozen at -20º C. The tests were performed with specific Labtest® kits. The globulin concentration was obtained by the difference between total proteins and albumin.

Evaluations of ingestive behavior were performed every 28 days for 24 continuous hours, starting and ending at 8 h, according to Bürger et al. (2000). During the night period, the environment was maintained with artificial lighting. Activities of feeding, idle and rumination of each animal were recorded every 10 minutes. The results were interpreted according to the following equations:

$$RE_{DM} = \frac{DMI}{RT} \text{ e}$$

$$RE_{NDF} = \frac{INDF}{RT},$$

where:
RE_{DM}: dry matter rumination efficiency; DMI: dry matter intake; RT: rumination time; RE_{NDF}: rumination efficiency of neutral detergent fiber and INDF: intake of neutral detergent fiber. The daily chewing time was obtained by summing feeding and rumination times.

After reaching an average weight of 420 kg (slaughter criterion), the steers were sent to a commercial slaughterhouse, with state inspection, following the standard procedures of the establishment.

The experiment was a 3 x 2 factorial completely randomized design, with nine replications per treatment. The collected data were tested for normality of residues by the Kolmogorov-Smirnov test. Subsequently, they were subjected to analysis of variance by the F-test, by PROC GLM for the intake and performance variables and by the PROC MIXED for variables of metabolic profile and ingestive behavior. The mean values were compared by Tukey's test, at a 5% probability level. Statistical analyses were run using the statistical package of Statistical Analysis System (SAS, 2016), *SAS® Studio* version 3.5. The mathematical model used for the performance variables was:

$$Y_{ijk} = \mu + NS_i + PF_j + (NS * PF)_{ij} + \varepsilon_{ijk},$$

where:
Y_{ijk} = dependent variables; μ = mean of all observations in the k-th repetition; NS_i = effect of the i-th source of N; PF_j = effect of the j-th physical form of corn grain; NS_i*PF_j = effect of the interaction between the i-th source of N and the j-th physical form of corn grain; ε_{ijk} = residual random error.

For the ingestive behavior evaluations, the effects of the evaluation date were added to the above model as a repeated measure and of the animal within the diet (error a).

For the blood metabolites, the following model was used:

$$Y_{ijkl} = \mu + NS_i + PF_j + D_k + (NS * PF)_{ij} + (NS * D)_{ik} + (PF * D)_{jk} + (NS * PF * D)_{ijk} + \varepsilon_{ijkl},$$

where:
Y_{ijkl} = dependent variables; μ = mean of all observations, in the 1-th repetition; NS_i ; PF_i e NS_i*PF_i = as described in the above model; D_k = effect of the k-th collection date; NS_i*D_k = interaction between the i-th source of N and the k-th collection date; PF_i*D_k = interaction between the j-th physical form of corn grain and the k-th collection date; $NS_i*PF_i*D_k$ = interaction between the i-th source of N, the j-th physical form of corn grain and the k-th collection date; ε_{ijkl}: residual random error.

Results and discussion

Among the factors studied, there was an interaction, only between collection date and nitrogen source, on the concentration of protein metabolites (Figure 1).

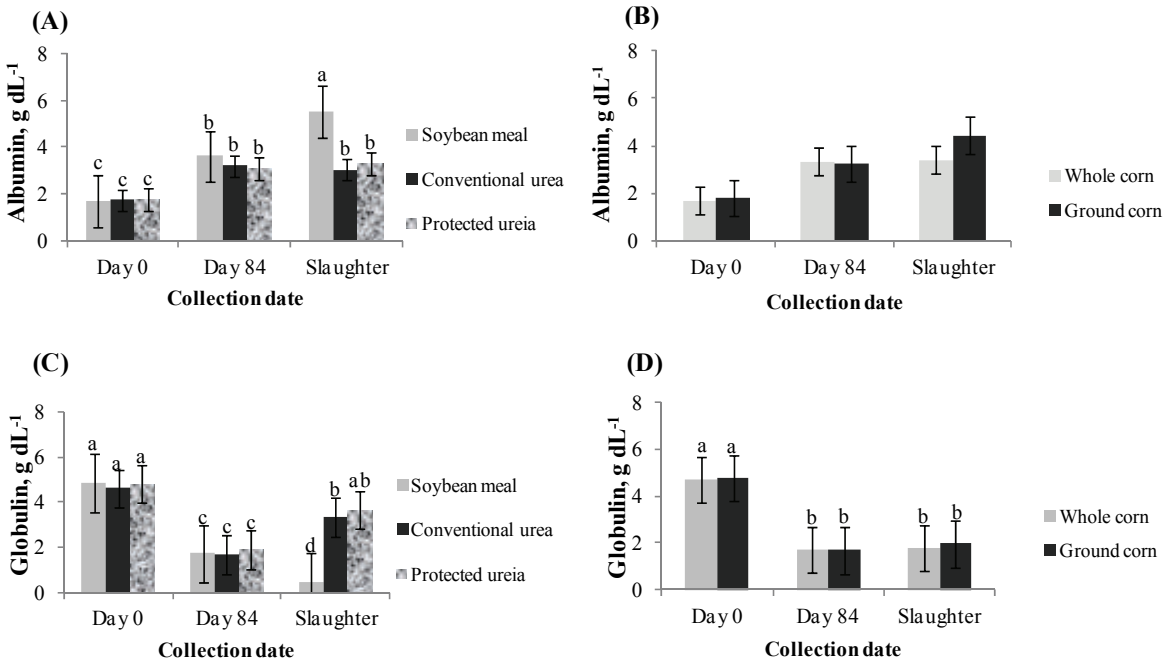

Figure 1. Serum albumin and globulin levels in feedlot steers fed with different nitrogen sources and corn grain physical form, on three collection dates.

In the first collection, the steers of all diets had serum albumin levels below 2.0 g dL^{-1}, without differences from each other. These values indicate that steers came from inadequate protein nutrition prior to the start of the study, as Kaneko, Harvey, and Bruss (2008) state that the reference values would be from 2.6 to 3.7 g dL^{-1} for cattle with adequate nutrition. However, it can be seen that the nutritional intake from the diets caused all animals to present adequate levels of serum albumin after 84 days in feedlot, not differing between the nitrogen sources.

Steers consuming soybean meal showed increasing values of serum albumin until the end of the study (Figure 1.A). In contrast, those fed urea had a stabilization in levels of circulating albumin, from day 84 to slaughter, but without compromising protein nutrition. It can be observed from these results that cattle fed soybean meal reach higher albumin levels in relation to steers fed with non-protein nitrogen. This result is because soybean meal is a source of degradable protein in the rumen and of non-degradable protein in the rumen that reaches the intestine, increasing the supply of metabolizable protein (Fernandes et al., 2009), while urea is exclusively the source of degradable protein in the rumen.

Albumin is considered the most sensitive indicator to evaluate the nutritional status of cattle, demonstrating long-term protein nutritional status, in which persistently low values suggest inadequate protein intake (González, Conceição, Siqueira, & La Rosa, 2000). These same authors cite albumin values of 50 to 65% of the total protein (albumin + globulin) as indicative of good nutritional status, being this the main protein synthesized by the liver.

From the interaction between collection date and nitrogen source, we can observe that when they entered the feedlot, the steers had a higher concentration of globulin and similar between nitrogen sources (Figure 1. C), reducing after 84 days, with similar values between the diets. However, at slaughter, the steers fed soybean meal continued to show a reduction in globulin levels; while those fed with non-protein nitrogen had elevation in these levels in relation to the collection made in the intermediate period.

Regarding the physical form of corn grains, only the collection date influenced the globulin levels, which were higher at the beginning of the study. The globulin values are inversely proportional to albumin, the former being related to the health status of cattle. According to Delfino et al. (2014), one of the factors that increase globulin levels are periods after vaccinations. Therefore, the main causes for the higher levels of serum globulin at the beginning of the study are the low concentration of albumin due to nutritional deficiency, possible stress from the new facilities and the worming done at the

beginning of the feedlot. Therefore, the combined analysis of the two metabolites allows us to conclude that steers under nutrient restriction, when fed with balanced diets for weight gain, reestablish adequate levels of protein metabolites, with a greater emphasis on steers fed with a true protein source.

There was no interaction ($p > 0.05$) between dietary nitrogen source and corn grain physical form on consumption and performance variables (Table 2).

Table 2. Intake and performance of confined steers, fed with different nitrogen sources and physical form of corn grain.

Variables	Nitrogen source			Physical form		CV	P-value		
	SM	CU	PU	WC	GC		NS	PF	NS*PF
IW, kg	253.44	247.28	242.94	247.19	248.74	19.11	0.8066	0.8978	0.8605
FW, kg	421.5	413.72	412.41	410.19	421.48	14.57	0.8891	0.5024	0.9434
DMI, kg day^{-1}	9.24a	7.63b	7.47b	7.97	8.27	18.33	0.0024	0.4982	0.3508
DMIBW, % PV	2.76a	2.27b	2.33b	2.44	2.47	15.31	0.0003	0.6410	0.3604
CPI, kg day^{-1}	1.31a	0.94b	1.00b	1.03	1.14	23.05	0.0004	0.1635	0.1632
TDNI, kg day^{-1}	5.79	5.03	5.03	5.02	5.55	21.73	0.0782	0.0944	0.3875
NDFI, kg day^{-1}	3.38	2.92	2.98	3.07	3.11	21.82	0.1039	0.8429	0.7547
ADG, kg day^{-1}	1.60a	1.24b	1.22b	1.34	1.37	17.78	<0.0001	0.5856	0.7655
FC, DMI:ADG	5.93	6.17	6.17	6.12	6.05	17.93	0.5079	0.6469	0.7742
IBCS, points	2.35	2.40	2.33	2.32	2.41	8.99	0.5930	0.1209	0.6279
FBCS, points	4.00	3.85	4.02	3.94	3.97	11.58	0.5248	0.5564	0.3230

Means followed by different lowercase letters, for the same characteristic, differ ($p < .05$) by Tukey's test, using PROC GLM; SM: Soybean meal; CU: conventional urea; PU: Protected urea; WC: Whole corn; GC: Ground corn; NS: Nitrogen source; PF: Physical form; CV: Coefficient of variation (%); IW: Initial weight; FW: Final weight; DMI: Dry matter intake; DMIBW: Dry matter intake in relation to body weight; CPI: Crude protein intake; TDNI: Total digestible nutrient intake; NDFI: Neutral detergent fiber intake; ADG: Average daily gain; FC: Feed conversion; IBCS: Initial body condition score; FBCS: Final body condition score.

The dry matter intake, expressed as kg day^{-1} and percentage of body weight, and protein intake (kg day^{-1}) were higher for steers consuming soybean meal, not differing between conventional and protected urea. The urea levels used in the diets were 1.65 kg 100 kg^{-1} DM and 1.80 kg 100 kg^{-1} DM, respectively, for conventional and protected urea. This fact negatively influenced the intake by the low palatability of urea, corroborating the information of Gonçalves et al. (2015) mentioning high levels of urea as limiting dry matter intake due to its low palatability.

The results obtained in this study corroborate Benedeti et al. (2014) who evaluated the substitution of soybean meal with slow release urea (0, 33, 66 and 100%) in finishing diets for cattle, and reported a linear decline effect on dry matter intake and Bourg, Tedeschi, Wickersham, and Tricarico (2012) that obtained similarity in this parameter between conventional and protected urea.

Considering the physical form of the corn grain included in the concentrate fraction, there was no difference ($p > 0.05$) in the intake values. A similar result was reported by Vargas Junior et al. (2008) evaluating whole or ground grain in the feeding of feedlot calves. It was expected that there would be interaction between the factors studied by the presence of non-protein nitrogen, combined with ground corn, due to the possible greater synchronism in the degradation of carbohydrates and nitrogen compounds, but this hypothesis was not confirmed.

Higher crude protein intake was observed in diets with soybean meal in relation to non - protein nitrogen sources. This result is due to the higher intake of dry matter since the diets were isonitrogenous.

Total replacement of soybean meal with conventional or protected urea in the diet caused a reduction in daily weight gain ($p < 0.05$). The superiority in the weight gain of steers receiving soybean is in agreement with the concentrations of the protein metabolites (Figure 1) and with the intake of dry matter and protein (Table 2). The increase in dry matter intake is one of the main factors that affects animal performance, since it determines the level of nutrient intake (Maggioni et al., 2009). The protein profile of the diets was also a determining factor for differences in weight gain, since in a similar study Fernandes et al. (2009) completely replaced soybean meal with conventional urea and found a reduction in daily weight gain. According to the authors, there was excess degradable protein in the rumen in the diet with urea, whereas in the diet with soybean meal, this requirement was exactly met, concomitantly the presence of non-degradable protein in the rumen, which aided in the metabolizable protein balance.

As for the similarity in weight gain between conventional and protected urea, the results are consistent with Pazdiora et al. (2013) that provided the same sources of urea for feedlot Nellore young bulls and did not obtain differences in weight gain, with a mean value of 1.31 kg day^{-1} for both diets, thus values close to those obtained in the present study for diets with two sources of non-protein nitrogen.

The initial weight of the steers (250 kg) may also have been responsible for the lower daily weight gain of urea-fed steers due to their greater growth spurt in relation to heavier animals. According to Guimarães (2015), when high proportions of rumen degradable protein are used for animals below 350 kg, their performance is limited by the lack of an adequate metabolizable protein profile.

As the final weight was preset as a criterion for slaughter, it did not differ among diets ($p > 0.05$). However, steers fed soybean meal, with both physical forms of corn grain, reached this target weight before the others due to differences in daily weight gain. When assessing the operational cost of a feedlot, the fact that animals are able to slaughter

earlier is advantageous, as it provides faster capital turnover, reduced labor costs per lot in feed-lot, in addition to free up physical space for other animals.

Corn grain processing did not result in any changes in animal performance ($p > 0.05$). Although grinding is used to increase starch digestion at the rumen level, in the present work this fact did not interfere with the animal response. This result corroborates Vargas Junior et al. (2008), who did not observe effect of corn milling on intake and performance of calves.

From the point of view of practicality and operational processes, the result obtained for the physical form of the grain is extremely relevant, since it demonstrates that it is not necessary to grind the grain before supplying it to the finishing cattle. In their studies (Vargas Junior et al. (2008)) observed an electricity consumption of 6.3 kWh per ton of ground corn compared to an energy consumption of zero when supplying whole grains, a relevance aspect in this type of study.

The feed conversion did not differ between the nitrogen sources ($p > 0.05$). As the proportion between weight gain and dry matter intake was maintained, and both increased for steers fed with soybean meal, there was no significant difference in feed conversion. This result is in agreement with Fernandes et al. (2009) and Azevedo et al. (2015), who evaluated, respectively, the substitution of soybean meal with common and protected urea, without differences in feed conversion. The physical forms of corn also presented similarity for feed conversion ($p > 0.05$), as observed by Vargas Junior et al. (2008).

Differences in daily weight gain between nitrogen sources did not influence the final body score, considering the total feedlot period (Table 2). However, it is important to note that the steers were subjected to different feedlot periods, a fact that possibly influenced the similarity in the body condition score. It should be noted, however, that at the end of the study, the steers presented a mean body score of 3.95 points, being considered fat by the scale used.

There was no interaction between the nitrogen sources and the physical forms of the corn grain for any of the variables related to the ingestive behavior ($p > 0.05$) that are listed in table 3. Times spent in feeding, idle and rumination were influenced by nitrogen sources in the diet. Protected urea-fed steers spent more time in feeding than steers fed diets with soybean meal ($p < 0.05$); while the diet with conventional urea did not differ from the others.

Feeding is an activity that is strictly related to dietary characteristics, in which animals stop consuming when they meet their physiological needs, unless there is physical limitation, with distension of the ruminal wall (Maggioni et al., 2009). It is observed that steers that received soybean meal, despite having a higher intake of dry matter (Table 2), remained less time in feeding. This result suggests that animals may have satiated more quickly than animals that consumed urea, both protected and conventional. Another aspect discussed refers to the palatability of diets with high content of urea (Gonçalves et al., 2015). Thus, steers receiving diets with urea remained longer in feeding because they did not eat large amounts at each meal.

Table 3. Ingestive behavior of confined steers, fed with different nitrogen sources and physical form of corn grain.

Variables	Nitrogen source			Physical form		CV	P-value		
	SM	CU	PU	WC	GC		NS	PF	NS*PF
FT, hours day^{-1}	3.89b	4.09 ab	4.42a	4.14	4.06	13.92	0.0196	0.6088	0.1607
IT, hours day^{-1}	12.98a	11.95b	11.24c	11.92	12.13	7.33	<0.0001	0.3923	0.0507
RT, hours day^{-1}	7.13b	7.96a	8.34a	7.81	7.76	10.02	<0.0001	0.8367	0.5210
RE_{DM}, kg hour^{-1}	1.20a	0.83b	0.85b	0.960	0. 97	22.53	<0.0001	0.9659	0.9561
RE_{NDF}, kg hour^{-1}	0.45a	0.34b	0.32b	0.38	0.36	22.22	<0.0001	0.3372	0.7641
NDC, hours day^{-1}	10.99c	11.93b	12.75a	11.97	11.81	6.99	<0.0001	0.5161	0.0501

Means followed by different lowercase letters, for the same characteristic, differ ($p < 0.05$) by t-test, using PROC MIXED. SM: Soybean meal; CU: Conventional urea; PU: Protected urea; WC: Whole corn; GC: Ground corn; CV: Coefficient of variation (%); FT: Feeding time; IT: Idle time; RT: Rumination time; RE_{DM}: Rumination efficiency of dry matter; RE_{NDF}: Rumination efficiency of neutral detergent fiber; NDC: number of daily chews.

Feeding and idle times of cattle are inversely proportional, which can be observed in this study because the longer time in idling was observed for soybean meal, followed by conventional urea, with a lower idle time for steers fed with protected urea ($p < 0.05$). In this study, a negative correlation was observed between idle and feeding times ($r = -0.51$, $p < 0.0001$), confirming the previous statement.

Steers fed urea, either conventional or protected, presented superior rumination time to steers fed with soybean meal. This result was not expected, since the roughage: concentrate ratio was the same in all diets and also because the diets with urea contained more corn (source of rapidly fermentable starch) that theoretically could reduce rumination time. Contrasting results were obtained by Lima et al. (2013), who evaluated the ingestive behavior of Guzerá and Sindhi cows receiving diets with different levels of urea inclusion replacing soybean meal, without differences in feeding, rumination and idle times.

There was a difference between nitrogen sources ($p < 0.05$) for rumination efficiency of both dry matter (ER_{MS}) and neutral detergent fiber (ER_{FDN}) (Table 3). The highest values were observed for steers that consumed diets with soybean meal; while

the urea groups did not differ. This result is because the steers fed with soybean meal had higher intakes of dry matter and neutral detergent fiber, although the latter did not show any statistical difference, associated with a lower rumination time. A similar result was obtained by Pazdiora et al. (2011), who verified that animals with lower intake of dry matter and longer rumination time were less efficient in rumination of these components of the diet.

Steers fed protected urea presented higher daily chewing times, followed by conventional urea, which in turn was superior to soybean meal ($p < 0.05$). Once the steers fed soybean meal presented lower feeding and rumination times, this resulted in shorter daily chewing times, the opposite occurring with steers receiving protected urea.

There was no difference in the behavioral parameters for the physical form of corn grain ($p > 0.05$). This similarity can be attributed to the participation of silage in the diet, at 50% level, because in diets with greater concentrate participation there could be less stimulation to rumination in the group that would be receiving ground corn.

Conclusion

Total replacement of soybean meal with conventional or protected urea in the diet for feedlot steers promotes reduction in performance indices and protein nutritional status and also changes the ingestive behavior. The supply of corn grain, whole or ground, in the diet for feedlot steers, with participation of 50% roughage in the diet does not alter parameters of animal interest.

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