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Short communication

Effects of slow-release urea and molasses on ruminal metabolism of lambs fed with low-quality tropical forage

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ABSTRACT

The effects of two sources of slow-release urea (SRU) with a source of soluble carbohydrates on ruminal fermentation in lambs fed with a low-quality forage hay were evaluated. Optigen is a commercial source of slow-release urea, whereas Surelease is an ethyl cellulose-coated urea prepared in the Laboratorio de Farmacotecnia at the Metropolitan Autonomous University. Five Pelibuey lambs cannulated in the rumen and duodenum (24.8 ± 0.4 kg BW) were used in a Latin Square design. Lambs were fed a basal diet that consisted of *Brachiaria brizantha* hay and concentrate (ratio 67:33) with the following treatments: (1) feed-grade urea; (2) Surelease-coated urea (SRU-S); (3) SRU-S + molasses; (4) SRU Optigen (OPT); and (5) OPT + molasses. All sources of urea were dosed daily intra-ruminally (0.6 g/kg/BW), and molasses was fed at 1.2 g/kg BW. Compared to feed-grade urea, both sources of SRU decreased ruminal pH between 3 and 6 h after dosing ($P < 0.05$). At 3 and 9 h after dosing and at 15 and 21 h, both sources of slow-release urea reduced the rumen ammonia compared to urea ($P < 0.05$). The two sources of slow-release urea did not improve the total tract or rumen digestibility of dry matter (DM) and neutral detergent fiber (NDF) or the rate of microbial protein synthesis in growing lambs fed low quality forage.

1. Introduction

Urea is rapidly hydrolyzed to NH_3 in the rumen in the first hour post-ingestion, and when fed in excess, it may be partially responsible for the low efficiency of N capture in the rumen by ruminal bacteria (Johnson and Clemens, 1973; Calsamiglia et al., 2010). This excess NH_3 may be detrimental to the animal (Bartley et al., 1981) and can contribute to environmental pollution (Broderick et al., 2009). To improve the utilization of ammonia released from urea, slow-release sources have been designed to promote the constant availability of N-NH_3 over long periods of time (Taylor-Edwards et al., 2009a). The combination of urea with soluble carbohydrates has also been recognized as an important factor in the utilization of ammonia by ruminal microbes (Hristov and Ropp, 2003).

Polymer-coated urea is effective at reducing the ammonia concentration compared to urea. However, its use does not necessarily reduce N excretion or improve the performance of steers (Taylor-Edwards et al., 2009b). The potential benefits of slow-release urea (SRU) sources could be manifested in low-quality diets such as those based on tropical forages. Steers grazing tropical pastures supplemented with slow rumen degradation rate protein sources have shown better productive performance than those supplemented with urea (Ramos et al., 1998). Ribeiro et al. (2011) were able to increase dry matter intake in cattle fed low-quality hay and given a slow-release polymer-coated urea source.

Given that most evaluations of SRU have been conducted in intensive beef production systems based on

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temperate forages (Kononoff et al., 2006), corn silage (Taylor-Edwards et al., 2009b), 50% concentrate diets (Galo et al., 2003; Golombeski et al., 2006) with conventional urea and have shown no response, the aim of this experiment was to evaluate the effect of two SRU sources and urea mixed with molasses on N metabolism and ruminal digestibility in lambs fed a low-quality tropical forage.

2. Materials and methods

This experiment was conducted under the supervision and approval of the Ethics and Animal Welfare Committee of the Autonomous University of Yucatán, Mérida, México.

2.1. Slow-release urea sources

Two sources of SRU were evaluated. The first was Optigen® II (Alltech, Inc.), a commercial blended urea product that involves coating urea pills with vegetable oil. The second source consisted of urea cores (Fermex®) with a size fraction between 2 and 2.38 mm that were coated with a polymer of ethyl cellulose (Surelease® Colorcon de México). The coating was carried on an aqueous dispersion of Surelease® prepared at 15% as described by Melgoza et al. (2007). The Surelease-coated urea was prepared in the Laboratorio de Farmacotenia from the Universidad Autonoma Metropolitana, Mexico.

2.2. Animals and treatments

Five Pelibuey lambs (24.8 ± 0.4 kg BW) cannulated in the rumen and duodenum were used in a Latin Square design (sheep and periods) and fed a basal diet that consisted of *Brachiaria brizantha* hay and concentrate (67:33) with the following additions: (1) feed-grade urea; (2) ethyl cellulose Surelease®-coated urea (SRU-S); 3) SRU-S + cane molasses; (4) SRU Optigen (SRU-O); and (5) SRU-O + cane molasses. The concentrate was elaborated from Nutrimentos Peninsulares S.A. de C.V (Yucatán, México). All sources of urea were dosed daily intraruminally (0.6 g/kg BW), and molasses was fed at 1.2 g/kg BW. Forage, concentrate, molasses and minerals were mixed as a total mixed ration. Sheep were housed in metabolic crates supplied with a feeder and water was available at all times. Feed was offered in the morning at 3.7% of BW, and minerals were added at 0.5 g/kg BW daily. Each period consisted of 10 days of adaptation and 5 sample collection days. The composition (%) of the forage and concentrate was 91.6 dry matter (DM), 3.4 crude protein (CP) and 76.5 neutral detergent fiber (NDF) 41.4 acid detergent fiber (ADF) and 12.0 lignin, and 88.0 DM, 15.3 CP, 24.2 NDF, 10.9 FDA and 1.5 lignin, respectively. Mineral premix (Fogysal Ovino®) contained the following per kg: Ca 60 g, P 40 g, Mg 20 g, Se 3 mg, Co 5 mg, Mn 1000 mg, Cu 2 mg, I 25 mg, Zn 1000 mg, vitamin A 60 IU, vitamin D2 1 IU and vitamin E 120 UI.

2.3. Sample collection and analyses

Feed, feces and orts were collected daily during the collection period, rumen fluid (60 mL) was sampled on day 4 at 0, 1.5, 3, 6, 9, 12, 15, 18, 21 and 24 h after feeding and pH was measured immediately. Samples were acidified with 1 mL of sulfuric acid (30%) and then frozen at −20 °C until laboratory analyses. Ten milliliters of rumen fluid were prepared with metaphosphoric acid and centrifuged (40,000 × *g* × 10 min), and the supernatant was used in measurements of the proportion of volatile fatty acids (VFA) via gas chromatography (Erwin et al., 1961). Ammonia N was measured using the indophenol method (McCullough, 1967). Duodenal samples were collected according to Stock et al. (1987) from day 1 to day 5 of the collection period to estimate ruminal digestion and N duodenal flow. Feed and duodenal samples were analyzed according to AOAC (1990) for dry matter (DM, method number 981.10), crude protein (CP, method number 967.03) and NDF and ADF fractions according to Van Soest et al. (1991) with a heat-stable amylase and expressed include residual ash. Feed, orts, feces and duodenal contents were used to determine acid insoluble ash as an internal marker to estimate digestibility (Van Keulen and Young, 1977). The amount of microbial protein synthesis was measured using purines (Zinn and Owens, 1986).

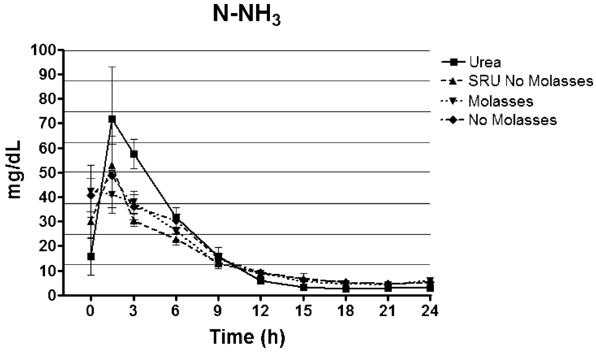

Fig. 1. Effect of slow release urea (SRU) and cane molasses on ruminal ammonia nitrogen in lambs fed tropical forage. Contrast I: urea vs. SRU sources (without molasses); Contrast II: molasses vs. no molasses.

2.4. Statistical analyses

The data were analyzed as a 5 × 5 Latin Square design using the GLM procedure SAS Inc. (2007). If the response variable was measured more than once, data were analyzed using the repeated analyses from GLM (SAS, 2007), and the following contrasts were tested: CI. urea vs. slow-release urea sources (without molasses) and CII. molasses vs. no molasses.

3. Results and discussion

3.1. Ammonia N and ruminal pH

Rumen ammonia N concentrations from the contrasts tested are presented in Fig. 1. Between 3 and 6 h after dosing and at 15 and 21 h, both sources of slow-urea release reduced the rumen ammonia compared to urea (Contrast I: $P < 0.05$). There was a time × treatment interaction ($P < 0.018$). There were no effects of molasses on ammonia N concentration in all sampling times. The mean value of rumen $N\text{-}NH_3$ was 18.8 mg/dL, a value that allows fibrolytic activity in the rumen (Satter and Slyter, 1974). As shown in this study, other authors have also reported an increase in rumen $N\text{-}NH_3$ concentration within 1–3 h post-ingestion and its late gradual decline with slow-release urea sources (Pinos-Rodriguez et al., 2010; Xin et al., 2010). Tikofsky and Harrison (2006) evaluated the effect of two levels of non-protein nitrogen (urea or Optigen II) in an in vitro experiment with single-flow rumen-simulating fermenters and found no effect on pH or ammonia. In agreement with our results, no significant differences were found between polymer-coated urea and feed-grade urea in terms of $N\text{-}NH_3$ release (Galo et al., 2003) in most of the incubation times.

Ruminal pH readings from the contrasts tested are presented in Fig. 2. Compared to feed-grade urea, both sources of SRU decreased the ruminal pH between 3 and 6 h after dosing (Contrast II: $P < 0.05$). In hour 3, the ruminal pH was reduced by molasses; however, between 15 and 21 h ruminal pH was higher with molasses (Contrast II: $P < 0.05$). Most of the time, ruminal pH values were above 6.2 (Fig. 2). As observed in other studies, there were no major differences in ruminal pH between different sources of urea (Taylor-Edwards et al., 2009b; Tedeschi et al., 2002). Puga et al. (2001) found no differences in the pH and ammonia concentration between treatments in a ruminal

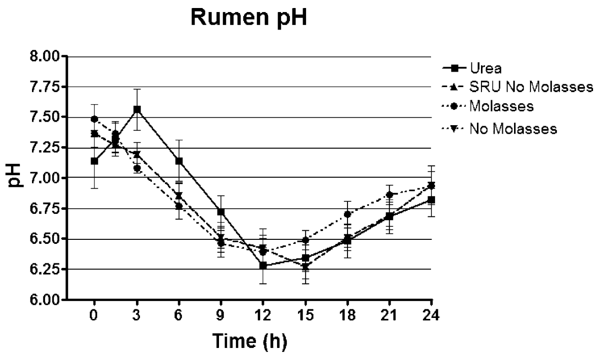

Fig. 2. Effect of slow release urea (SRU) and cane molasses on ruminal pH in lambs fed tropical forage. Contrast I: urea vs. SRU sources (without molasses); Contrast II: molasses vs. no molasses.

fermentation study evaluating the addition of a controlled-release urea supplement. As observed in this study, the increase in pH lasted for up to 6 h; however, it was higher in the SRU sources, perhaps due to the greater amount of N. The mean pH in this experiment (6.8) was considered optimum for cellulose degradation and is consistent with the results observed in experiments with low-quality forage diets (Bohrer et al., 2010).

Other slow-release urea sources have also been assessed (urea–calcium), with no differences in pH between treatments in steers fed an all forage diet (Huntington et al., 2006). SRU sources could provide continuous NH_3-N for microbial growth, over the minimum of 15–30 mg NH_3-N/dL found in rumen fluid, thus maximizing microbial growth (Leng and Nolan, 1984).

3.2. Intake, digestibility, nitrogen balance and ruminal fermentation

The use of SRU or molasses had no effect on DM intake or total tract digestibility (Table 1). Intake was on average 3.1% of BW. No differences in DM intake have been reported in previous studies using coated urea (Galo et al., 2003, Pinos-Rodriguez et al., 2010, Highstreet et al., 2010), or urea–calcium sources (Cherdthong et al., 2010). However, Ribeiro et al. (2011) recorded an increase in DM intake in cattle fed low-quality hay when they supplied a slow-release polymer-coated urea source intraruminally. One difference that may explain why there was positive response in the experiment of Ribeiro et al. (2011) is because their forage had a limited amount of nitrogen compared with our forage. Regarding digestibility measurements, Tikofsky and Harrison (2006) did not find effects in in vitro experiments using Optigen and others (Xin et al., 2010; Highstreet et al., 2010) did not find responses in in vivo experiments when using coated urea and found no differences in DM digestibility.

The use of coated urea or the addition of cane molasses did not affect the urinary and fecal N excretion or the N retained (Table 1). There were no changes in the efficiency utilization of the N body among treatments. Furthermore, N can be recycled by ruminants to compensate for differences in the release time of N in the rumen (Reynolds and Kristensen, 2008).

In the current study, the pattern and level of VFA production did not differ significantly between SRU sources or following the addition of molasses in the diet (Table 1). In this context, Garret et al. (2005) showed that total VFA production in continuous culture fermenters was not affected by the source of urea (urea or oil-coated SRU). Xin et al. (2010) evaluated the effects of polyurethane-coated urea on the ruminal VFA concentration of Holstein dairy cows fed with a steam-flaked corn-based diet and found no significant differences in total VFA. Ruminal VFAs are derived mainly from dietary carbohydrate fermentation; consequently, the results of the present study suggest that the source of urea or the addition of molasses at the supplemented level has no effect on the ruminal fermentation.

3.3. Microbial protein synthesis

Data on the microbial nitrogen supply to the duodenum showed no difference between treatments (Table 1). Rihani

Table 1
Effect of slow-release urea and molasses on intake, N balance, and digestion of lambs fed a tropical forage.

	Urea	SRU	SRU-S + molasses	Optigen	Optigen + molasses	SEM	C I	CII
DM intake, g/d	766	779	758	779	776	8.26	0.23	0.18
N intake, g/d	14.7	14.8	14.7	14.8	14.8	0.04	0.14	0.06
N feces, g/d	10.4	10.2	10.8	9.04	10.16	0.63	0.31	0.19
N urine, g/d	1.0	1.1	0.8	1.05	0.99	0.13	0.79	0.17
N retained, g/d	3.3	3.5	3.1	4.62	3.60	0.68	0.35	0.32
Microbial N, g/d	3.3	3.1	3.5	3.3	3.3	0.10	0.64	0.14
Rumen digestibility, %								
DM	25.40	29.20	22.40	29.30	25.30	2.46	0.22	0.06
NDF	37.32	34.28	33.83	36.73	37.40	1.22	0.25	0.93
Total tract digestibility, %								
DM	51.06	47.64	45.72	45.72	52.46	2.05	0.39	0.97
NDF	44.09	43.91	42.42	44.93	44.92	1.03	0.79	0.48
VFA, mM/L	54.03	49.43	55.82	46.64	57.84	8.86	0.64	0.65
VFA, mol/100 mol								
Acetate	73.34	74.72	74.89	73.88	75.08	1.35	0.57	0.59
Propionate	17.9	17.15	17.64	18.52	15.98	0.91	0.95	0.29
Butyrate	8.76	8.12	7.45	7.6	8.93	0.99	0.92	0.76

SEM: standard error of the mean; SRU-S: slow-release urea Surelease; Optigen: commercial source of SRU; Probability of contrasts: CI. urea vs. slow-release urea sources (without molasses); CII. molasses vs. no molasses.

et al. (1993) evaluated the effect of high levels of ruminal ammonia and continuous N release in high fiber diets in sheep, and found no differences in microbial net synthesis. In agreement with these results, Galo et al. (2003) reported that feeding polymer-coated urea (Optigen 1200®) to dairy cows did not alter the rumen microbial crude protein synthesis.

4. Conclusions

The results showed that the use of slow-release urea, regardless of its source (Surelease or Optigen), did not improve the total tract or rumen digestibility of nutrients or microbial protein synthesis in growing sheep fed low-quality hay. There was no clear improvement in nitrogen utilization by the ruminants, and the addition of fermentable sugars in combination with a slow-release urea source did not demonstrate any synergistic response.

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