Effects of a slow-release coated urea product on growth performance and ruminal fermentation in beef steers

Juan Manuel Pinos-Rodríguez, Luz Yoshandhi Peña, Sergio S. González-Muñoz, Ricardo Bárcena, Abdel Salem

Instituto de Investigación de Zonas Desérticas, Universidad Autónoma de San Luis Potosí, México
Colegio de Postgraduados en Ganadería, Montecillo, México
Universidad Autónoma del Estado de México, Temascaltepec, México

Abstract

The objective of this study was to evaluate the effects of a slow-release coated urea product (CU, 1% as dry matter of diet) on ruminal disappearance and fermentation, as well as on growth performance of beef steers. Soybean meal in control diet was replaced by CU and steam-rolled corn. For the growth performance trial, 20 beef steers (330±20 kg) were used. For the ruminal trial, four ruminally cannulated steers (230±20 kg) were used.

Dry matter intake, daily gain, feed efficiency and carcass dressing were not affected (P>0.05) by CU. Ruminal ammonia N was higher (P<0.05) by CU. Slow-release urea products have effectively mitigated rapid ammonia release in the rumen (Huntington et al., 2006) and enhanced feed efficiency in dairy cows, when soybean meal was replaced (Golombeski et al., 2006). Coated urea products are comprised of closely sized central particles of concentrated rumen-degradable nitrogen compounds and a non-rumen-degradable semi-permeable membrane coating, which covers the central particles and allows their diffusion through the semi-permeable membranes into the rumen fluid.

It was hypothesized that a slow-release coated urea product (CU) would not affect ruminal variables and growth performance in beef cattle. To test this hypothesis, the objectives of this study were to evaluate the effects of feeding CU (1% as dry matter of diet) on ruminal fermentation and disappearance, as well as on growth performance and dressing carcass in beef cattle.

Materials and methods

This experiment was conducted under the supervision and with the approval of the Academic Committee of Animal Science of the Colegio de Postgraduados according to regulations established by the Animal Protection Law enacted by the Estado de México.

For the growth performance trial, 20 cross-breed (3/4 Brown Swiss x 1/4 Brahman 75:25) steers (330±50 kg body weight) were dewormed (ivermectin, Ivjerict ADE, Avilab, Jalisco, México), vaccinated (Clostridium chauvoei, septicum, sordelli and perfringes C and D and Pasteurella multocida type A and D, Mannheimia haemolytica A-1, Bobact8, Intervet, México), implanted (Tembolona acetate plus 17 β-estradiol, Sinovex plus, Fort Dodge, Overland Park, Kansas, USA), housed in individual metabolic pens in dry lot, and finally randomly assigned to the following treatments: 1) Control (standard diet with soybean meal as protein source); 2) a slow-release coated urea product (CU, Optigen 1200, Alltech Inc. Nicholasville, KY USA).

Introduction

The most common non-protein nitrogen (NPN) source used in ruminant feeding is urea, due to its low cost; thus, when prices of protein feeds escalate (i.e., soybean meal), it is economical to use urea as a nitrogen supplement in ruminant diets. Using the protein equivalent of 281%, incorporation of one unit of urea in a diet can replace five units of soybean meal. However, the final decision is not just a matter of a mathematical substitution. The amount of NPN that can be used is limited due to the rapid hydrolysis of this N source, which causes accumulation and escape of ammonia from the rumen (Satter and Roffler, 1975).

Slow-release NPN compounds fed to domestic tuminants (Forero et al., 1980; Owens et al., 1980; Löest et al., 2001) have shown variable responses, probably because the release of N is too fast to optimize microbial protein production (Galo et al., 2003). Although some slow-release urea products have effectively mitigated rapid ammonia release in the rumen (Huntington et al., 2006) and enhanced feed efficiency in dairy cows, when soybean meal was replaced (Golombeski et al., 2006). Coated urea products are comprised of closely sized central particles of concentrated rumen-degradable nitrogen compounds and a non-rumen-degradable semi-permeable membrane coating, which covers the central particles and allows their diffusion through the semi-permeable membranes into the rumen fluid.

It was hypothesized that a slow-release coated urea product (CU) would not affect ruminal variables and growth performance in beef cattle. To test this hypothesis, the objectives of this study were to evaluate the effects of feeding CU (1% as dry matter of diet) on ruminal fermentation and disappearance, as well as on growth performance and dressing carcass in beef cattle.
B1 = true protein - insoluble N with BCP (true soluble protein); B2 = insoluble N with BCP - insoluble protein in neutral detergent (NDIP); B3 = NDIP - insoluble protein in acid detergent (ADIP); C = ADIP.

Steers had free access to feed and water. Feed was offered daily at 7:00 h. Body weight (BW) was recorded every experimental period (i.e., 21 d during 84 d), and then average daily gain (ADG) was calculated. Dry matter intake (DMI) and ADG were used to calculate feed efficiency (FE). At the end of the growth performance trial (i.e., 48 d), all steers were slaughtered in an authorized slaughterhouse (Los Reyes, Estado de México). Hot carcass weights were recorded and carcass dressing percentage calculated.

Data (i.e., carcass) were analyzed as a completely randomized design with the MIXED procedure of SAS (1999) using steer as a random in the model; continuous data collected over time (i.e., BW, DMI) were analyzed as repeated measurements according to Littell et al. (1998) using the MIXED procedure. Initial body weight was tested as a covariate in the model, but it was not significant (P>0.05). Because the interaction treatment x time was not significant, only overall values were shown. Significant differences were accepted at P≤ 0.05.

For the ruminal trial, four Holstein steers (230±20 kg body weight) fitted with ruminal cannulas, housed in metabolic pens in a naturally ventilated barn were completely randomized to both diets described previously (control or CU). Experimental periods were 14-d with 12-d for adaptation and 2-d for sample collection and ruminal incubations.

For the in sacco disappearance trial, bags (10 x 20 cm; pore 52±10 µm) with 5 g DM of diet (ground 2 mm, Thomas Willey) were placed in the rumen at 8:00 h and removed at 0 h; b = the insoluble but potentially degradable fraction; and k = rate of degradation (h⁻¹). The DM remaining at each incubation time was fitted to the nonlinear regression model using the procedure “NLIN” of SAS (1999). The experimental design was a cross over design as follows: Yijk = µ + sequencei + steerj + periodk + treatmenth + eijk where Yijk = the measurement during the kth period of the jth steer in the ith group (i = 1,2; j = 1, 2, 3, 4; k = 1,2); µ = the overall mean effect; sequence = the effect of the sequence group (i= 1,2); steerj = the effect of the jth steer on the ith sequence (j = 1, 2, 3, 4); steerij = N(0, σ²steer); periodk = the effect of the kth period (k = 1,2); trth = the effect of the hth treatment (h = 1,2; being a function of i and k); eijk = the random error, eijk N(0, σ²e).

Parameters of the model are the mean (µ), the effect of the sequence group (seq.), the variance amongst animals (experimental units) (σ²steer), the effect of periods, the effect of the treatment (treatment), and the random errors (σ²e).
residual variation \((\sigma^2_e)\). Period was considered as a fixed component in the model. Ruminal variables collected over time were analyzed as repeated measurements by the MIXED procedure of SAS (1999) according to Littell et al. (1998). Ruminal disappearance kinetic was analyzed with MIXED option using the cross-over model described previously. Because the interaction treatment x time was not significant, only overall values were showed. Significant differences were accepted when \(P \leq 0.05\).

**Results**

The DM, CP, NDF, ADF, ash and NEg were similar for experimental diets (Table 1). There were apparently differences in CP fractions; the CU diet had a higher A protein fraction than control.

The DMI was increased and ADG and FE were decreased by time. There were no time x treatment interactions for FE, hot carcass weight and carcass dressing percentage. The CU treatment did not affect final BW, DMI, FE, or carcass weight as compared to the control diet (Table 2).

The soluble fraction and disappearance rate were similar for both diets. The potentially disappearing fraction and total disappearance of DM was lower for the CU diet (Table 3). The potentially disappearing fraction for NDF was also lower for CU than control. There were no differences for NDF disappearance rate.

As post-feeding time increased, ruminal pH values and lactate concentrations decreased. Volatile fatty acid proportions were not affected by time. Ruminal pH, lactate, volatile fatty acid concentration and molar proportion of acetate, propionate and butyrate were not different with experimental diets (Table 4). The CU diet induced higher ammonia N concentrations than control diet (Figure 1).

**Discussion**

Growth performance was not affected by CU, such as was previously found by Tedeschi et al. (2002) and Wahrmund and Hersom (2007) using the same CU for beef steers. Other slow-release NPN products also did not affect growth performance in lambs (Virk et al., 1989) and cattle (Campbell et al., 1963; Løest et al., 2001). The negative effects of CU on in sacco disappearance were contrary to the findings from Harrison et al. (2007), who found that NPN contained in a CU product increased apparent DM digestion in rumen-simulating fermenters. Maybe the high ammonia N concentrations in the rumen with CU could affect the in sacco degradation. These findings suggest that N from the CU diet could be degraded faster than N from control diet with soybean meal, but probably slower than common urea. Indeed, the chemical analysis of diets confirmed that protein fraction A was higher for CU than control diet. This idea was in part confirmed by Garcia-Gonzalez et al. (2007) and Harrison et al. (2007), who found that ruminal N ammonia concentrations with CU were lower than those from common urea. Peyton and Conrad (1982) found that digestible DM intake in cows fed on soybean meal was higher than those fed on urea. Lana et al. (1997) showed that steers fed on soybean meal had higher DM intake, ADG and feed efficiency than those fed urea. This result is consistent with the effect of amino nitrogen on bacterial growth rate (Van Kessel and Russell, 1996).

The CU did not affect ruminal fermentation patterns (i.e. pH and AGV) as compared to the

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**Table 3. Ruminal disappearance of DM and NDF of diets with soy bean meal or coated urea.**

|                      | Control | Coated urea | SEM  |
|----------------------|---------|-------------|------|
| Dry matter, %        | 29.6    | 31.7        | 3.54 |
| Soluble fraction, a  | 53.1a   | 49.1b       | 5.41 |
| Total disappearance, a+b | 84.8a  | 78.7b       | 6.12 |
| Disappearance rate, k, /h | 4.4    | 4.9         | 0.52 |
| Neutral detergent fibre, % | 65.9a  | 62.1b       | 5.62 |

**Table 4. Overall ruminal pH, lactate and volatile fatty acids (VFA), of steers fed diets with soybean meal or coated urea.**

|                        | Control | Coated urea | SEM  |
|------------------------|---------|-------------|------|
| pH*                   | 5.6     | 5.5         | 0.14 |
| Lactic acid, mmol/L   | 2.4     | 2.5         | 0.32 |
| Total volatile fatty acids, mmol/L | 97.6 | 94.8 | 7.97 |
| Acetate, mol/100 mol | 32.0 | 32.3 | 1.55 |
| Propionate, mol/100 mol | 34.9 | 35.2 | 2.04 |
| Butyrate, mol/100 mol  | 13.0    | 12.5        | 1.33 |
| Acetate:propionate ratio° | 1.5    | 1.5         | 0.14 |

\(^{a,b}\) means bearing different superscripts in a row differ significantly \((P<0.05)\).

**Figure 1. Overall ruminal ammonia N concentrations of steers fed diets with coated urea or soybean meal (Time= P<0.001; treatment = P<0.001).**

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control diet, which agree with previous studies using the same CU product (García-González et al., 2007; Harrison et al., 2007).

Conclusions

The analysis of the results suggests that CU can replace soybean meal in diets for beef steers without any negative effect on growth performance. Besides, the high ruminal ammonia concentration and the reduction of in sacco degradation could be associated with the increase in the soluble N in the CU diet.

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