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Influence of urea calcium mixture supplementation on ruminal fermentation characteristics of beef cattle fed on concentrates containing high levels of cassava chips and rice straw

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ABSTRACT

The purpose of this study was to evaluate the effects of various N sources in concentrates containing high levels of cassava chips, with rice straw as the basal forage, on rumen ecology, rumen microbial counts, microbial crude (CP) protein synthesis, and digestibility of nutrients. Four ruminally fistulated crossbred (Brahman × native) beef steers with initial body weight (BW) of 400 ± 40.2 kg were randomly assigned according to a 4 × 4 Latin square design. The dietary treatments were different sources of N in the concentrates and were: T1 = urea (control; urea); T2 = soybean meal (SBM); T3 = urea $CaCl_2$ mixture (U-Cal); T4 = urea $CaSO_4$ mixture (U-Cas). All steers were kept in individual pens and supplemented with concentrate at 5 g/kg of BW daily. The experiment was 4 periods, and each lasted 21 d. During the first 14 d, all steers were fed their respective diets *ad libitum* and for during the last 7 d, they were moved to metabolism crates for total urine and fecal collection. Dry matter intake ranged from 9.8 to 10.5 kg daily and was not altered by diet, while digestibility of NDF differed among treatments and was highest with U-Cas supplementation ($P<0.05$). Ruminal NH_3 N and plasma urea N with U-Cal, U-Cas, and SBM diets were lower compared with the urea supplemented group ($P<0.05$). Ruminal volatile fatty acid concentrations were not altered by treatments. Total viable, and cellulolytic bacteria, differed among treatments and were highest with U-Cas (9.1×10^{11}, and 4.0×10^{9} cfu/mL, respectively). In addition, efficiency of rumen microbial CP synthesis based on organic matter (OM) truly digested in the rumen was increased by SBM or U-Cal supplementation, and was highest with U-Cas supplementation (18.2 g of N/kg of OM truly digested in the rumen). Supplementation of U-Cas to a concentrate containing a high level of cassava chips improved rumen ecology and microbial CP synthesis in beef cattle, suggesting that urea calcium mixtures can replace soybean meal or urea in beef cattle diets without adverse affects on rumen fermentation and other rumen parameters.

Abbreviations: ADF, acid detergent fiber; BW, body weight; DM, dry matter; NDF, neutral detergent fiber; NPN, non-protein N; SBM, soybean meal; VFA, volatile fatty acid; UCM, urea calcium mixtures; U-Cal, urea-$CaCl_2$ mixture product; U-Cas, urea-$CaSO_4$ mixture product.

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1. Introduction

Substitution of traditional feeds in diets of ruminants is common in response to changes in economic conditions (Devendra, 2007; Wanapat et al., 2009). Use of soybean meal (SBM) as a source of protein in animal feeding is well established. However, high feed prices in some parts of the world, and fluctuation in feedstuff production, have raised interest in alternative N sources for livestock feeding. Use of urea as a non-protein N (NPN) replacement is attractive in ruminant diets, because of its low cost compared with other protein feeds, such as SBM, with high rumen degradability (Wanapat, 2009; Cherdthong et al., 2010a,b; Xin et al., 2010). Urea is converted via ruminal ammonia into microbial protein, thereby supplying additional microbial protein to the host (Nocek and Tamminga, 1991; Calsamiglia et al., 2008; Cherdthong and Wanapat, 2010). However, the amount of urea that can be used in diets is limited, due to its rapid hydrolysis to NH_3 in the rumen by microbial enzymes (Golombeski et al., 2006; Highstreet et al., 2010). This rapid hydrolysis to NH_3 can occur at a much faster rate than NH_3 utilization by rumen bacteria, with as effects accumulation in the rumen and absorption through the rumen wall. The net result is that a potentially large part of the N from feed NPN sources is excreted in the urine, which can contribute to environmental pollution (Broderick et al., 2009).

The efficiency of protein use by ruminants has gained attention by environmentalists and government regulators in many parts of the world (Robinson, 2010). Many groups have suggested that ruminant production systems should be designed and managed in ways that minimize adverse effects on resource conservation and the environment. A partial solution could be to modify urea to control its rate of rumen release so that NH_3 production more closely parallels carbohydrate digestion (Pinos-Rodríguez et al., 2010). Ruminal slow release urea compounds, which have been fed to ruminants, include biuret, starea, urea phosphate, formaldehyde treated urea and polymer-coated urea (Taylor-Edwards et al., 2009). These compounds have not been as advantageous as urea because a part of their NPN may leave the rumen without being converted to NH_3, thereby reducing its incorporation into microbial protein (Galo et al., 2003; Firkins et al., 2007). More recently, slow urea release properties have been achieved by binding urea to substrates such as calcium chloride (Huntington et al., 2006; Golombeski et al., 2006). In an earlier *in vitro* experiment, urea calcium sulphate mixtures were shown to reduce ruminal NH_3 concentrations, as well as increase the cellulolytic bacterial population, when compared with urea (Cherdthong et al., 2010a). Since urea is inexpensive, it could be used for tropical ruminant production provided its ruminal release is controlled to slow ammonia production and/or synchronized with soluble carbohydrates in the rumen. This should be of value in improving the efficiency of rumen N utilization (Nocek and Tamminga, 1991; NRC, 2001).

Cassava (*Manihot esculenta*, *Crantz*) is grown widely in tropical areas and the price is generally relatively low. Cassava chips contain high levels of nonstructural carbohydrate and are highly degradable in the rumen compared with other energy sources, including corn meal (Chanjula et al., 2003). Recently, Wanapat and Khampa (2007) showed that a concentrate based on a high proportion of cassava chips with a high urea level could improve rumen fermentation efficiency and rumen microbial crude protein (CP) synthesis in dairy steers. However, no data has been reported on supplementation of slow release NH_3 products in concentrate cassava chips based diets of steers. Our study was conducted to evaluate effects of different urea N sources in concentrates containing high levels of cassava chips with rice straw as basal forage on rumen ecology, rumen microbial counts, microbial CP synthesis, and digestibility of nutrients in beef cattle.

2. Materials and methods

2.1. Animals, diets and experimental design

Four ruminally fistulated crossbred (Brahman × native) beef cattle steers with initial body weight (BW) of 400 ± 40.2 kg were randomly assigned to a 4 × 4 Latin square design. The dietary treatments were: T1 = urea (control); T2 = soybean meal (SBM); T3 = urea $CaCl_2$ mixture (U-Cal); T4 = urea $CaSO_4$ mixture (U-Cas), respectively. The urea calcium mixture (UCM) products were prepared according to Cherdthong et al. (2010a) by, in brief, providing an aqueous solution (23 g $CaCl_2$ or $CaSO_4$ + 17 mL H_2O) of $CaCl_2$ or $CaSO_4$ at 50 °C for 10 min and dissolving solid urea (60 g urea) in aqueous $CaCl_2$/$CaSO_4$ and then heating and agitating the mixture at 50 °C for 10 min prior to reducing the temperature of the solution to about 25 °C. Concentrates containing 161 to 162 g/kg of CP and 11 MJ/kg dry matter (DM) were fed at 5 g/kg of BW daily of concentrates, and rice straw was fed *ad libitum* allowing for 100 g/kg refusals. All steers were kept in individual pens, and clean fresh water and mineral blocks were available at all times. The experiment was 4 periods, and each lasted 21 d. During the first 14 d, all steers were fed their respective diets with *ad libitum* intake, whereas the last 7 d they were moved to metabolism crates for total urine and fecal collection during These days they were restricted to 900 g/kg of the previous voluntary feed intake of straw, but still supplemented with concentrate at 5 g/kg of BW daily. Table 1 shows the chemical composition of the concentrates and rice straw.

2.2. Data collection and sampling procedures

Feeds were sampled and fecal samples were collected by total collection of each individual steer during the last 7 d of each period at the morning and afternoon feeding. Feeds, refusals and fecal samples were dried at 60 °C and ground (1 mm screen using the Cyclotech Mill, Tecator, Sweden) and analyzed using standard methods of AOAC (1995) for DM (ID 967.03), N (ID 984.13), EE (ID 954.02) and ash (ID 942.05). Acid detergent fiber (ADF) was determined according to an AOAC method (1995;