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Soybean meal replaced by slow release urea in finishing diets for beef cattle

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ABSTRACT

Eight crossbred steers (average body weight of 418 kg) fitted with ruminal and abomasal cannula were used to evaluate the effects of replacing soybean meal (SBM) with slow-release urea (SRU) in beef cattle diets containing two concentrate levels. The experimental design included two 4 × 4 Latin squares, which were run simultaneously. Each Latin square received one level of concentrate [400 or 800 g/kg on a dry matter (DM) basis]. Within each Latin square, the four replacement levels of soybean meal protein with slow-release urea were applied to the animals (0%, 33%, 66% and 100% of substitution on N basis). The DM intake as well as organic matter (OM) intake and crude protein (CP) intake decreased linearly ($P<0.05$) as SBM was replaced with SRU. Ruminal digestibility coefficient of OM tended to be greater ($P=0.074$) for the 40 % concentrate diet. DM and OM passage rate (k_p) were greater ($P<0.05$) on the 80% concentrate diet. A cubic effect ($P<0.10$) of SBM replacement with SRU on ruminal ammonia (NH_3–N) concentration in relation to time was detected. A quadratic effect on pH was observed ($P<0.10$) when replacing SBM with SRU. Nitrogen intake, nitrogen excreted in the feces, nitrogen balance and efficiency of nitrogen use decreased linearly ($P<0.10$) as SRU increased in the diet, whereas the total nitrogen excreted in urine increased linearly ($P=0.007$). The production of microbial nitrogen and microbial efficiency were not affected by the experimental treatments ($P>0.10$). A lower intake of DM, OM, and CP was observed when cattle were fed SRU compared to SBM. However, the use of SRU did not change the digestibility and digestion rate (k_d) and k_p of DM, OM, CP and neutral detergent fiber corrected for ash and protein (NDFap). In summary, SRU provides higher concentrations of NH_3–N throughout a day than SBM in cattle fed low concentrate diets.

1. Introduction

High concentrate diets (HCD) have been intensively used in feedlots in Brazil as it improves intake, body weight gain and carcass weight gain in beef cattle (Keane et al., 2006). Most of these feeding systems use high grain diets and soybean meal (SBM) as a crude protein (CP) source (Millen et al., 2009). However, due to the high costs of soybean, beef producers have been seeking for an alternative protein source that would reduce the feeding costs. As such, the use of non-protein nitrogen (NPN) in ruminant diets appears as a viable strategy to enhance ruminal microbial protein (Storm and Ørskov, 1983) and consequently reduce feeding costs.

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Urea is the main NPN source used in beef cattle diets in Brazil (Millen et al., 2009). However, there are still concerns regarding its use due to rapid release of ammonia (NH_3–N), which can be faster than its use by microorganisms for protein synthesis. The efficiency of protein synthesis from urea depends, among other factors, on energy availability in the rumen (Russell et al., 1992). Further, a fast release of nitrogen may cause an asynchrony of NH_3–N and energy in the ruminal environment. As a consequence, excessive NH_3–N can decrease animal performance and, in some cases, cause ammonia toxicity (Bartley et al., 1976; Huntington et al., 2006; Owens et al., 1980).

The use of slow-release urea (SRU) may improve the synchrony of energy and NH_3–N in the rumen, leading to a better efficiency of ruminal bacteria growth. Improving the NH_3–N and energy synchrony in the ruminal environment using SRU would reduce use of true protein sources in beef cattle diets. Moreover, since fiber digestion may be improved as a consequence of continuous release of nitrogen in the ruminal environment (Alvarez-Almora et al., 2012), the use of SRU appears as a great strategy to enhance the efficiency of use of fibrous feed sources. Consequently, the use of SRU may reduce feeding costs without compromising animal performance. Studies have reported efficacy in reducing NH_3–N release in the rumen (Highstreet et al., 2010; Huntington et al., 2006; Owens et al., 1980), ruminal fermentation (Owens et al., 1980), microbial protein synthesis (Cherdthong et al., 2011; Xin et al., 2010), pH (Taylor-Edwards et al., 2009), digestibility, and intake (Cherdthong et al., 2011) when SRU replaced conventional urea. However, the consequences of replacing sources of true protein with SRU in diets with different levels of concentrate remain unclear. Therefore, this study was performed to evaluate the effects of replacing SBM with SRU in beef cattle diets containing two concentrate levels on ruminal parameters of beef cattle.

2. Materials and methods

The work described was carried out in accordance with EC Directive 86/609/EEC for animal experiments.

2.1. Animals, experiment design and diets

Eight *Bos indicus* steers, with an average body weight (BW) of 418 ± 40 kg and 24 months of age, were used. All animals were cannulated in the rumen and abomasum (Kehl®). The animals were kept in a tie stall. All animals were initially weighed, treated for elimination of internal parasites, and then fed the experimental diets during 15 days for adaptation prior to the beginning of the experiment. Cattle adaptation to the experimental diets was performed gradually from 1% of BW followed by an increase of 0.2% of BW as dry matter (DM) every 3 days until the remaining unconsumed feed reached 10% of the DM offered. After the adaptation period, the animals were submitted to a total of four experimental periods of 15 days with 7 days for animal adaptation (Storry and Sutton, 1969) and 8 days for sample and data collection.

The experimental design included two 4 × 4 Latin squares, which were run simultaneously. Each Latin square had one of the two concentrate levels evaluated (60:40 roughage:concentrate ratio for low concentrate diet (LCD), and 20:80 roughage:concentrate ratio for HCD. Within each Latin square, the four replacement levels of soybean meal protein with SRU (Optigen® 1200 controlled-release N, Alltech®, Araucária-PR, Brazil) were applied to the animals (0%, 33%, 66% and 100% of substitution on an N basis) totaling eight treatments with four replicates each.

Experimental diets were composed of corn silage, corn meal, SBM and mixture mineral. Diets were formulated to be isonitrogenous containing 120 g/kg CP on a DM basis, in order to meet the nutritional requirements of beef steers with 400 to 500 kg of BW (Valadares Filho et al., 2010). Ingredient proportion and chemical composition of the experimental diets are presented in Table 1.

2.2. Experimental procedures and sample collections

Animals were fed once daily at 0700 h, allowing for up to 10% of orts. Dry matter intake was determined from day 8 to day 15. A total feces collection was performed during three consecutive days (days 8, 9 and 10 of each experimental period) to estimate digestibility of dietary constituents, as suggested by Barbosa et al. (2006), Ferreira et al. (2009), Mezzomo et al. (2011) and Paixão et al. (2007). The variation of DM intake during the fecal collection period is presented in Fig. 1. From day 8 to 11 of each experimental period, abomasal digesta was sampled at intervals of 15 h as follows: day 8, sampling at 0800 h and 2300 h; day 9, sampling at 1400 h; day 10, sampling at 0500 h and 2000 h; and day 11, sampling at 1100 h as described by Allen and Linton (2007). Samples were frozen at −80 °C, freeze-dried for 72 h, and then ground through a 1-mm screen in a Wiley Mill. At the end of the process, a composite sample was prepared for each animal in each sampling period. Dry matter flux was determined by adding an external marker (Cr_2O_3) in the rumen and their concentration was measured in abomasal digesta. A daily dose (15 g) of the marker was added through the ruminal cannula at 1200 h from day 3 to 10 and the chromic oxide (Cr_2O_3) concentration was determined as described by Savastano (1993). Rumen evacuations for determining rumen pool size and digesta kinetics were carried out on day 12, four hours after feeding and on day 14 immediately before feeding (Allen and Linton, 2007; Mezzomo et al., 2011). Rumen contents were collected into a plastic container and separated into primarily liquid and particulate fractions by filtering through screening. Solid and liquid fractions were placed in different containers, individually weighed and sub-sampled (500 g for solids, and 2 kg for the liquid fraction) for further analysis.

From day 8 to 10 urine was collected over a 24 h period using funnel collectors attached to animals with a polyethylene flexible tube that transported the urine to containers containing 250 ml of a 20% H_2SO_4 solution (vol:vol) to avoid loss of nitrogenous compounds (Valadares et al., 1997). Microbial biomass was determined by purine bases quantification according to Ushida et al. (1985). Ruminal liquids were sampled on day 11 to determine pH and NH_3–N. Approximately 50 mL of liquid samples were manually collected from the ruminal cannula at 0, 2, 4, 6,

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