Livestock Science 188 (2016) 55–60

Contents lists available at ScienceDirect

Livestock Science

journal homepage: www.elsevier.com/locate/livsci

Intake, total and partial digestibility of nutrients, and ruminal kinetics in crossbreed steers fed with multiple supplements containing spineless cactus enriched with urea

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ARTICLE INFO

Article history:
Received 15 May 2015
Received in revised form
7 April 2016
Accepted 11 April 2016

Keywords:
Digestion
Nitrogen
Rearing
Ruminal digestibility
Supplementation

ABSTRACT

Multiple supplements are used in pasture-based systems to manage deficits in the forage, and they can be composed of a controller mixture (e.g. urea+mineral mixture) to regulate the intake of the animals. The effect of using spineless cactus enriched with urea in place of traditional multiple supplements was evaluated for nutrient intake, partial and total digestibility, and ruminal kinetics in crossbred steers. Five steers, 1/2 Holstein x Zebu, with permanent cannulas in the rumen and with an average initial body weight of 240 ± 22.1 kg, were used in a 5×5 Latin square. The treatments consisted of four levels of inclusion of urea (0%, 1%, 2%, and 3%) in dry matter (DM) and a control treatment with a traditional multiple supplement. The Tifton-85 hay, used as forage, had high neutral detergent fiber (659 g NDF kg^{-1} of DM) and low crude protein (62 g CP kg^{-1} of DM) content. There was a linear increase in the intake of CP and a quadratic effect in intake of dry matter (DM), organic matter (OM), non-fiber carbohydrates (NFC), NDF, and digestible OM according to the urea inclusion level. The maximum point for total OM digestibility (645 g kg^{-1}) was with the inclusion of 2% urea. There was an improvement in ruminal digestibility of DM, NDF, and CP when spineless cactus was enriched with urea. The ruminal pool of DM, NDF, and iNDF did not change with the inclusion of urea in the diets. Increased intake rate (*ki*) was observed when spineless cactus was enriched with urea. The passage rate (*kp*) of spineless cactus enriched with 3% urea was similar to the control diet. The rate of NDF degradation increased in the diets enriched with spineless cactus. It is suggested that spineless cactus enriched with up to 2% urea efficiently replaces traditional multiple supplements.

1. Introduction

The animal production system based on the pastures is considered the most economical source of nutrients in the tropics, but the growth of animals change according to availability and quality of their constituents, mainly in the dry season (Rocha et al., 2016). The forage scarcity causes moderate weight gains and sometimes weight loss, with consequently delay of the development of cattle in the rearing phase. In order to maintain the adequate growth a proper supplementation is necessary, which must be designed to maximize intake and digestibility of available forage. The basic objective is to prevent the substitution effect of pasture with a supplement, but in some cases this effect is an advantage – it may improve animal performance while also stretching the pasture and increasing carrying capacity.

In efficient production systems, supplementation is adopted as a technological practice to complement the pasture, aiming at an output compatible with the genetic potential of animals, since concentrated supplements such as corn and soybean meal have high prices on the market, compromising the economic efficiency of the system. The supplementation of beef cattle allows correcting nutrient deficiencies, improving forage utilization and animal performance, increasing economic return (Kunkle et al., 2000), and possibly shortening reproductive, growth, and fattening cycles. From this premise, it is possible to use local foods in the form of supplements for dairy cattle.

Spineless cactus is an important food resource for dairy cattle, especially during periods of prolonged drought. Regardless of the genus (*Opuntia* or *Nopalea*), the spineless cactus has low crude protein ($4.81 \pm 1.16\%$) and fiber concentration ($26.8 \pm 5.07\%$)

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http://dx.doi.org/10.1016/j.livsci.2016.04.008

(Ferreira et al., 2012) compared to traditional sources of protein and roughages. For protein correction of spineless cactus, the inclusion of urea is an alternative to reduce the costs in supplements, due to its lower cost per unit of nitrogen in relation to the sources of true vegetable protein (Santiago et al., 2013). In addition, spineless cactus is an important energy source from non-fiber carbohydrates (58.6 ± 8.13%), differentiating itself from other bulky feed due to a better degradability of nutrients (Nefzaoui and Ben Salem, 2001). This characteristic has been highlighted because it maximizes the capacity of rumen fermentation, thus increasing the synthesis of microbial protein, the production of volatile fatty acids, and the subsequent transport of nutrients for the animal.

Due to the low digestive energy content in the forage during the dry period, there is a possibility of low use of urea by cattle, evidencing the need for inclusion of an energy source (such as spineless cactus: SC) with the urea. Almeida et al. (2015) evaluating multiple supplements containing SC+urea (ranging from 1.33% to 2.13%) replacing of corn, reported that average daily gains in dairy cattle fed 33% and 66% of replacement were close to diets with only corn; showing that the SC+urea can be an alternative to traditional and more expensive supplements. Thus, multiple supplements are used in pasture-based systems to manage deficits in the forage, and they can be composed of a controller mixture (e.g. urea+mineral mixture) to regulate the intake of the animals (Valente et al., 2011a). Considering this, we hypothesized that spineless cactus enriched with urea, in the form of a multiple supplement, could replace traditional supplements composed of corn, wheat bran, and soybean meal for cattle.

Therefore, this study aimed to evaluate the effect of using spineless cactus enriched with urea to replace a traditional multiple supplements on ruminal digestibility of dry matter and other dietary constituents using samples obtained from the omasum, and also to assess the nutrient intake, total and intestinal digestibility, and ruminal kinetics in 1/2 Holstein x Zebu steers.

2. Material and methods

2.1. Experimental area

This study was carried out in the Department of Animal Science at the Federal Rural University of Pernambuco, located in Recife, Pernambuco State, Brazil.

2.2. Experimental diets

The diets were formulated to meet dairy cattle requirements according to the National Research Council (NRC, 2001). The forage:concentrate ratio was 80:20 on a dry matter (DM) basis with Tifton-85 (*Cynodon* spp.) hay as the forage, which was used to simulate the pasture. The diets consisted of four levels of inclusion of urea/ammonium sulfate (0%, 1%, 2%, and 3% on DM basis), and a control treatment consisting of a traditional multiple supplement (composed by wheat bran, soybean meal, urea, and mineral). The urea+ammonium sulfate was used to correct the spineless cactus (SC) protein. The mixture of ingredients was performed manually in the feeders, highlighting that the SC mucilage allowed a uniform aggregation of urea. The feed was provided in two daily meals at 6:00 a.m. and 6:00 p.m. as a total mixed ration (TMR) and the orts were weighed daily to obtain a maximum of 5–10% orts. The proportions of ingredients of the diets are shown in Table 1, and the chemical composition of the diets is shown in Table 2.

2.3. Animals and experimental design

The management and care of animals were performed in accordance with the guidelines and recommendations of the Committee of Ethics on Animal Studies at the Federal Rural University of Pernambuco (License N°009/2015), Recife, Brazil. Five rumen fistulated steers (1/2 Holstein x Zebu) with an average initial body weight (BW) of 240 ± 22.1 kg were used in a 5 × 5 Latin square design. The trial lasted 80 days, with five consecutive 16-day periods, and was divided into a 7-day adaptation (Storry and Sutton, 1969; Menezes et al., 2011) and 9-day sampling.

Table 1
Ingredient proportion of experimental diets (g kg^{-1}, DM basis).

Ingredients	Diets				
	Control	Urea levels (%)			
		0	1	2	3
Tifton-85 hay	800	800	800	800	800
Wheat bran	150	0	0	0	0
Soybean meal	30	0	0	0	0
Spineless cactus	0	190	180	170	160
Urea/AS[a]	10	0	10	20	30
Mineral mix[b]	10	10	10	10	10

[a] Proportion between urea and ammonium sulfate (AS): 9 parts of urea and 1 part of AS.
[b] Nutrients per kg of product: Ca (min.) – 98 g, Ca (max.) – 113 g, P – 45 g, S – 40 g, Mg – 44 g, K – 61.5 g, Na – 114.5 g, Co – 48.5 mg, Cu – 516 mg, I – 30 mg, Mn – 760 mg, Se – 9 mg, Zn – 2516 mg, F – 450 mg.

Table 2
Chemical composition of ingredients of concentrate and each treatment (g kg^{-1} dry matter).

Item	Ingredients[b]				Diets				
					Control	Urea levels (%)			
	TH	WB	SBM	SC		0	1	2	3
Dry matter[a]	894	880	874	101	893	355	366	378	392
Organic matter	928	947	935	842	913	903	894	885	877
Crude protein	62	150	484	51	115	60	87	115	143
Ether extract	15	34	25	11	18	14	14	14	14
Neutral detergent fiber[c]	659	360	153	201	586	565	563	561	560
Acid detergent fiber	319	114	59	132	274	279	278	277	276
Total carbohydrates	851	763	426	780	780	829	793	756	720
Non-fiber carbohydrates	181	403	228	579	212	255	249	243	237

[a] g kg^{-1} as fed.
[b] TH – Tifton hay; WB – wheat bran; SBM – soybean meal; SC – spineless cactus.
[c] Corrected for ash and nitrogenous compounds.

2.4. Experimental procedures and sampling

Six collections of omasal digesta were performed at 12-h intervals between day 11 and day 13. On day 11, samples were collected at 10:00 a.m. and 10:00 p.m. On day 12, they were collected at 8:00 a.m. and 8:00 p.m. On day 13, they were collected at 6:00 a.m. and 6:00 p.m. At these same sample collection times, the fecal dry matter output was estimated using the total collection of feces, used to estimate the total apparent digestibility of nutrients. Also, approximately 200 g of feces was collected from each animal and the indigestible neutral detergent fiber (iNDF) content was used to estimate partial digestibility, ruminal pool, and passage rate. Fecal samples were partially dried in a forced ventilation oven at 60 °C. Subsequently, these samples were milled to a size of 1–2 mm in a Wiley-type laboratory mill.

Briefly, to collect the omasal digesta, the technique reported by Huhtanen et al. (1997) was adapted as follows: the collection of