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Supplementation levels for non-lactating cows grazing during the rainy season

Níveis de suplementação em vacas não-lactantes em pastejo no período das águas

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Abstract

This study aimed to evaluate levels of concentrate supplementation (1.5, 3.0, 4.5 and 6.0 kg day^{-1}) for grazing dairy cows kept on *Panicum maximum* Jacq. cv. Tanzania pasture during the rainy season on nutrient intake and digestibility and rumen parameters. Four rumen cannulated non-lactating Holstein × Zebu crossbred cows were used in this study by a 4X4 Latin square design, which presented an average initial body weight of 521.69±31.98 kg. Each period lasted 17 days, being the first 10 days were used for animal adaptation and the remaining seven days for data collection. There was no effect ($P > 0.05$) of supplementation levels on total dry matter intake, although forage dry matter intake has been linearly decreased ($P < 0.05$). Treatments have no effect ($P > 0.05$) on the digestibility coefficients of dry matter, organic matter, crude protein, or ether extract. There was a linear increase ($P < 0.05$) on daily rumination time and total rumination times according to supplementation levels. There was no significant effect of supplementation levels ($P > 0.05$) or time after supplementation on rumen pH. Rumen ammonia nitrogen concentration responded quadratically ($P < 0.05$) to times after supplementation, with a maximum estimated concentration of 17.61 mg dL^{-1} at 3.87 h after supplementation. Increasing supplementation levels for grazing dairy cows reduces forage intake but has no negative effects on total dry matter intake or rumen-fluid pH.
Key words: Concentrate. Herbage intake. Rumen parameters.

Resumo

Objetivou-se avaliar o efeito de níveis de suplementação concentrada (1,5; 3,0; 4,5 e 6,0 kg dia^{-1}) em vacas leiteiras mantidas em pasto de *Panicum maximum* Jacq. cv. Tanzânia no período das águas, sobre o consumo e a digestibilidade dos nutrientes e parâmetros ruminais. Foram utilizadas quatro vacas mestiças Holandês x Zebu, não lactantes, com peso corporal médio de 521,69±31,98 kg no início do experimento distribuídas aleatoriamente em delineamento em quadrado latino 4X4. Cada período teve

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duração de 17 dias, sendo os 10 dias iniciais para adaptação dos animais aos tratamentos e os sete dias restantes para coletas de dados. Não houve efeito ($P > 0,05$) dos níveis de suplementação sobre o consumo de matéria seca total com redução linear ($P < 0,05$) no consumo de matéria seca de forragem. Não houve efeito ($P > 0,05$) dos tratamentos nos coeficientes de digestibilidade da matéria seca, matéria orgânica, proteína bruta e extrato etéreo. Houve aumento linear ($P < 0,05$) do tempo de ruminação diurna e total com o aumento dos níveis de suplementação. Não houve efeito significativo dos níveis de suplementação ($P > 0,05$) e tempo após a suplementação sobre o pH ruminal. A concentração de nitrogênio amoniacal ruminal apresentou comportamento quadrático ($P < 0,05$) em relação aos tempos após a alimentação, sendo estimado valor máximo de 17,61 mg dL^{-1} no tempo 3,87 horas após a alimentação. O aumento dos níveis de suplementação para vacas leiteiras mantidas a pasto reduz o consumo de forragem, sem afetar negativamente o consumo de matéria seca total e sem alterar os valores de pH do líquido ruminal.
Palavras-chave: Concentrado. Consumo de forragem. Parâmetros ruminais.

Introduction

The use of pastures in the feeding of dairy cows generates a low-cost production system, since the pasture is the cheapest of roughage feedstuffs for ruminants (BARGO et al., 2002). However, according to Santos et al. (2003), exclusive use of grasses may not fully meet the nutritional requirements of animals.

Therefore, the use of concentrate supplements represents the main strategy to increase the milk yield of dairy cows reared on pasture. Exclusive use of concentrate supplements may, however, lead to expressive changes in the rumen environment, which may include a decline in pH, passage rate of solids and fluids, and volume of secreted saliva; alterations in the growth of microorganism species and microbial groups; and alterations in nutrient digestion (protein, fiber, etc.).

Amidst these changes, in general, variations in the rumen pH are more frequent, because concentrate feeds have a high rate of rumen digestion, and the end products of their fermentation, when in excess, may reduce the rumen pH and compromise the fiber digestion and the animal's health (ØRSKOV, 1986). According to this researcher, the rumen pH may range from 6.2 to 7.0 when animals are fed roughage-only diets, but it may be lower than 5.5 when diets containing over 70% concentrate are used.

As stated by González et al. (2012), the maintenance of the rumen pH depends on buffering events, including the action of saliva, which has a high buffer capacity and contributes with approximately 30% of the total buffering of volatile fatty acids in the rumen; the absorptive capacity of the rumen epithelium, which neutralizes around 50% of volatile fatty acids in the rumen; the action of lactate-using bacteria (*Megasphaera elsdenii* and *Selenomonas ruminantium*); and the passage of volatile fatty acids from the rumen to the other compartments of the gastrointestinal tract. For these reasons, the importance of evaluating parameters associated with digestion and fermentation of feeds must be stressed.

The aim of this study was to evaluate the intakes of total dry matter, herbage dry matter, and nutrients; digestibility; feeding behavior; and nutritional parameters of non-lactating dairy cows supplemented with increasing levels of concentrate, grazing on a Tanzania grass pasture.

Material and Methods

The experiment was conducted at the Milk Production and Processing Unit of the Experimental Farm at the Federal University of Mato Grosso, located in the municipality of Santo Antônio do Leverger, MT, Brazil, between December and March.

Four rumen-cannulated, non-lactating Holstein × Zebu crossbred cows with an average body weight of 521.69±31.98 kg were distributed in a 4 × 4 Latin square. The experiment consisted of four experimental periods, each lasting 17 days, the first 10 of which were used for the adaptation of animals to the diets and the remaining seven for data collection.

Treatments consisted of four supplementation levels (1.5, 3.0, 4.5, and 6.0 kg day^{-1}, corresponding to 0.29, 0.57, 0.86, and 1.17% body weight day^{-1}). Supplements were formulated based on the composition of commercial supplements for dairy cows used in the region (Table 1); they were provided twice daily, in equal amounts, in the morning (06h30) and in the afternoon (15h30). Possible leftovers were weighed to determine individual intake.

Table 1. Centesimal composition of supplement ingredients.

Ingredient	%
Ground corn	48.5
Soybean meal	26.0
Sunflower cake	20.0
Urea	1.0
Mineral-vitamin mixture[1]	4.5

[1]Provides per kg of product: 195 g calcium; 85 g phosphorus; 20 g magnesium; 20 g sulfur; 72 g sodium, 75 mg cobalt, 1,500 mg copper; 65 mg iodine, 27 g selenium, 1,800 mg manganese; 4,500 mg zinc; 130,000 IU kg^{-1} vitamin A; 12,000 IU kg^{-1} vitamin D; 1,000 IU kg^{-1} vitamin E, 850 mg (maximum) fluorine. [2]Neutral detergent insoluble fiber corrected for ash and protein.

Cows were kept in a single lot in the experimental unit, which consisted of 10 *Panicum maximum* Jacq. cv. Tanzania paddocks measuring 2,500 m^2, managed in a rotational grazing system. During the experiment, the average length of occupation of each paddock was 1.04 days, with 11.2 days of rest, under a stocking rate of 6.3 AU ha^{-1}. The pasture was managed based on the pasture entry height of 70 cm, corresponding to 95% light interception (CARNEVALLI et al., 2006) and expected exit at 40 and 50 cm in height. Throughout the experimental period, the pasture was fertilized with 88 kg nitrogen and 88 kg potassium per hectare.

Data pertaining to climatic conditions were obtained from the meteorological station at the Federal University of Mato Grosso (UFMT). Average temperature was 27.54 ºC; average air relative humidity was 74.20%; and accumulated precipitation in the period was 404.5 mm.

The pre- and post-grazing herbage mass was determined by measuring 20 points in the paddock and sampling it with a 0.5 × 0.5 m square at the average height of each paddock (cut near the soil level) on the 5th, 10th, and 14th days of each experimental period. Two aliquots were homogenized and collected: one to determine the herbage mass (kg DM ha^{-1}) and another for fractionation and analysis of the availability of DM from green and dry leaf (leaf blades) and green and dry stem (stem + sheath) per hectare in each experimental paddock.

The pasture consumed by the animals was sampled via manual grazing simulation. Collections were performed by a single sampler on the 10th and 12th days of each experimental period. Concentrate ingredients and the concentrate itself were sampled when the ingredients were mixed.

Herbage intake was estimated by using an internal and an external marker. First, fecal excretion was obtained using the external marker chromium oxide (15 g), which was provided individually in paper bags between the 4th and 11th days of each experimental period. Samples of feces (200 g) were collected directly from the rectum between the 10th and 12th days of the period, according to the following distribution: 10th day (17h00), 11th day (11h00), and 12th day (06h00).

Herbage intake was estimated using the internal marker indigestible neutral detergent insoluble fiber (iNDF), following Detmann et al. (2001).

The feeding behavior of the animals was evaluated on the 15th day of the experimental period, by monitoring them over 24 h. Grazing, rumination, and idle behaviors were observed at every five minutes. The time expended on the selection or capture of herbage, including the short period used to move and select the herbage, was counted as grazing time. The rest time was considered as an idle activity, and rumination was considered when animals ceased their grazing activity and started chewing.

Samples of herbage, ingredients, leftovers, and feces were pre-dried in forced-air ovens at 60±5 °C for 72 h and ground through 1-mm sieves for analyses of the dry matter (DM), organic matter (OM), mineral matter (MM), crude protein (CP), and ether extract (EE) contents, following AOAC (1990). The neutral (NDF) and acid (ADF) detergent insoluble fiber contents were obtained according to Van Soest et al. (1991). Neutral detergent insoluble nitrogen (NDIN) contents were obtained from the residue (NDF) after the soluble contents were extracted from the samples in neutral detergent (VAN SOEST et al., 1991), via the procedure described by Kjeldahl (AOAC, 1990); the NDF contents were corrected for ash and protein (NDFap) (Table 2).

Table 2. Chemical composition of supplement and Tanzania grass.

Composition, % DM	Supplement	Tanzania
Dry matter	81.32	27.30
Mineral matter	7.61	7.59
Organic matter	92.39	92.41
Crude protein	23.17	15.49
Ether extract	3.80	4.35
Neutral detergent insoluble fiber	13.39	68.12
Acid detergent insoluble fiber	12.48	23.63
NDFap[1]	12.00	59.08
Non-fibrous carbohydrates	46.42	12.24
Indigestible neutral detergent insoluble fiber	7.82	10.64
Neutral detergent insoluble nitrogen (% of total N)	4.29	44.32

[1]NDFap = neutral detergent insoluble fiber corrected for ash and protein.

Because of the presence of urea in the diets, NFC were calculated according to Hall (2000): NFC = 100 – [(%CP – %CP from urea + % urea) + %NDFap + %EE+ %ash. Total digestible nutrients (TDN) were calculated following NRC (2001): TDN = DCP + DNFC + DNDFap + DEE × 2.25, where DCP: digestible crude protein; DNFC: digestible non-fibrous carbohydrates; DNDFap: digestible neutral detergent insoluble fiber corrected for ash and protein; and DEE: digestible ether extract.

On the 16th day of each experimental period, rumen fluid was collected before (0) and 2, 4, 6, and 8 h after the beginning of the morning feeding to determine the pH and the ammonia concentration. The pH was determined immediately using a digital pH meter, and a 50-mL aliquot was obtained for each animal and collection time; 1 mL 50% sulfuric acid was added to the sample, which was stored in a freezer at −20 ºC. Later, the rumen ammonia nitrogen (RAN) concentration was determined.

The evaluated variables were analyzed as a 4 × 4 Latin square using the MIXED procedure of SAS version 9.3 (SAS, 2011). The model included the fixed effect (level of supplement supply) and the random effects (animal, period, and residual height). The LSMEANS option was used to generate the individual means for each supplementation level. Orthogonal contrasts were used for the specific partition of the effects of treatment into linear, quadratic, and cubic. Because of the lack of cubic effects, these were omitted from the table.

The pH and the concentrations of ammonia nitrogen were analyzed as repeated measures over time using the MIXED procedure of SAS version 9.3 (SAS, 2011). The model included supplementation level, collection time, and supplementation level × collection time interaction as fixed effects, and animal, period, and residual height as random effects. pH and initial ammonia nitrogen values were used as co-variables in the models. For the analysis of variables, structures of covariance matrix of the errors were adjusted. Of all structures investigated, ARH (1) (first-order heterogeneous autoregressive) was the most suitable according to the Bayesian information criterion (BIC). Degrees of freedom and tests were adjusted using the Kenward-Roger option. The LSMEANS option was used to generate the individual means for each supplementation level and for the collection times. The same afore-mentioned contrasts were used for the partition of treatment effects. For all procedures, effects were considered significant at $P<0.05$.

Results and Discussion

The average pre- and post-grazing Tanzania grass heights were 83.28 and 54.22 cm, respectively, corresponding to an average herbage mass of 8.24 and 5.29 t ha^{-1} DM, respectively (Table 3). Based on these values, an herbage DM availability of 154 kg per animal day^{-1} was estimated.

Table 3. Herbage mass and average structural characteristics of Tanzania grass pasture.

Parameter	Pre-grazing	Post-grazing
Height, cm	83.28	54.22
Herbage mass, t ha^{-1} DM	8.24	5.29
Green leaf, % DM	46.90	35.16
Dry leaf, % DM	2.09	1.95
Green stem, % DM	48.24	60.39
Dry stem, % DM	2.78	2.50
L:S ratio[1]	0.97	0.58

[1]Green leaf:green stem ratio. DM = Dry matter.

At pre-grazing, the average pasture height was above the range of 70 to 75 cm, corresponding to 95% light interception (LI) for the Tanzania grass, as remarked byBarbosa et al. (2006), Carnevalli et al. (2006), and Zanine et al. (2011). According to these authors, at up to 95% LI, the leaf area is larger and leaf growth rates are higher. However, after this point, stems elongate and senescent material accumulates in the pasture, affecting the herbage growth efficiency, the pasture structure, and its nutritional value.

A lower proportion of green leaf (46.90%) was observed as compared with the findings of Difante et al. (2010) (59.6%), who kept the Tanzania grass managed at 95% LI pre-grazing, corresponding to a pasture height of 68.4 cm, which likely contributed to a greater proportion of leaves. The average post-grazing pasture height of 54.33 cm in our study was higher than the 25 and 30 cm recommended by Barbosa et al. (2006) and Zanine et al. (2011), respectively, which contributed to the elongation of stems and their high participation (48.24%) in the pasture.

Average concentrate intake was 1.30, 2.42, 2.94, and 2.95 kg DM day^{-1}, corresponding to 0.25, 0.46, 0.56, and 0.57% of the average body weight day^{-1} (Table 4). These values were lower than the supplementation levels established for the experiment (1.5, 3.0, 4.5, and 6.0 kg day^{-1}), probably because this study involved non-lactating, rumen-fistulated cows, which have a lower nutritional requirement than lactating cows, and because of the high quality and availability of the herbage (Tables 1 and 2).

Table 4. Total dry matter intake, herbage dry matter intake, and nutrients according to supplementation level.

Item[1]	Supplementation level (kg day^{-1})				SEM[2]	P-value	
	1.5	3.0	4.5	6.0		Linear	Quadratic
TDMI, kg day^{-1}	10.35	10.47	7.93	8.67	1.00	0.0546	0.680
TDMI, % BW	1.99	2.04	1.52	1.69	0.20	0.072	0.695
HDMI, kg day^{-1}	9.05	8.06	4.98	5.72	1.05	0.010	0.303
CI, kg day^{-1}	1.30	2.42	2.94	2.95	0.25	<0.001	0.022
Intake of nutritional components							
OM, kg day^{-1}	9.43	9.43	7.02	7.70	0.93	0.043	0.624
CP, kg day^{-1}	1.72	1.86	1.47	1.55	0.17	0.160	0.838
EE, kg day^{-1}	0.45	0.44	0.34	0.35	0.06	0.056	0.765
NDF, kg day^{-1}	6.33	5.67	3.82	4.30	0.69	0.012	0.284
NDF, % BW	1.21	1.10	0.72	0.83	0.13	0.012	0.293
NFC, kg day^{-1}	1.69	2.17	1.92	2.07	0.23	0.252	0.362
TDN, kg day^{-1}	7.48	7.30	5.60	5.98	0.84	0.060	0.662

[1]TDMI = total dry matter intake, BW = body weight, HDMI = herbage dry matter intake, CI = concentrate intake, OM = organic matter, CP = crude protein, EE = ether extract, NDF = neutral detergent insoluble fiber, NFC = non-fibrous carbohydrates, TDN = total digestible nutrients. [2]SEM: standard error of the mean.

The increasing levels of concentrate supplied to grazing cows did not affect (P>0.05) their total dry matter intake (TDMI), which averaged 9.24 kg day^{-1} and 1.79% body weight day^{-1} (Table 4). However, herbage dry matter intake (HDMI) decreased (P<0.05), which demonstrates the substitution effect (MOORE, 1980). There was a substitution rate of 2.23 kg day^{-1} of herbage for each kilogram of concentrate consumed. Similarly, Lima et al. (2001) observed a substitution rate of 1.06 for animals on pasture. In the study conducted by Bargo et al. (2003), the authors observed a 13% decrease in HDMI in animals supplemented with 1.8 to 10.4 kg concentrate DM day^{-1} in relation to control treatment.

The decrease in HDMI stemming from the greater concentrate intake led to a reduction of NDF intake in kg day^{-1} and in % BW day^{-1}, which decreased by 1.37 kg day^{-1} and 0.26% day^{-1}, respectively, with each kilogram of concentrate consumed. Silva et al. (2009) observed an NDF intake of 1.57% of body weight day^{-1}. Neutral detergent fiber intake is important for ruminants, since it maintains adequate rumen function. However, according to Mertens (1987), a maximum NDF intake of 1.20% BW day^{-1} is recommended so that dry matter intake is not limited due to rumen fill. Thus, the NDF intake observed in this study might be limiting the dry matter intake of the animals due to the effects of the lower passage rate of particles resulting from the longer time the feed remains in the rumen.

The reduction in the intakes of OM and TDN (P<0.05) with the higher supplementation levels may be related to the decrease in HDMI (Table 4) as a consequence of the elevated nutritional quality of the grazed grass (Table 2).

There was no effect (P>0.05) on the apparent digestibility of DM with the increase in concentrate intake. An increase in the digestibility coefficient of this nutrient was expected, given the higher supply of nitrogen to the cellulolytic rumen microorganisms, resulting in improved degradation of the dietary polymers in the rumen (VAN SOEST, 1994). Providing 0, 1, 3, and 5 kg of concentrate day^{-1} to dairy cows, Silva et al. (2009) observed DM digestibility coefficients of 54.6, 54.5, 57.5, and 59.8, which are lower values than those found in the current study.

The reduction (P<0.05) of the digestibility coefficient of NDF with the higher concentrate intake may be due to the lower NDF intake caused by the decrease in HDMI and the increase in concentrate intake (Table 5). This decrease in digestibility may be related to the greater growth of amylolytic microorganisms and competition with cellulolytic microorganisms (MERTENS, 1994).

Table 5. Apparent digestibility coefficients of dry matter and nutrients according to supplementation level.

Item[1]	Supplementation level (kg day^{-1})				SEM[2]	P-value	
	1.5	3.0	4.5	6.0		Linear	Quadratic
DM	65.84	66.15	67.73	65.31	2.58	0.999	0.164
OM	68.85	68.46	69.49	67.33	2.51	0.416	0.365
CP	75.44	73.48	77.25	74.35	2.47	0.895	0.590
EE	75.16	81.80	80.19	76.67	4.26	0.859	0.196
NDF	75.87	74.03	68.61	69.80	2.38	0.031	0.434
NFC	33.27	47.06	63.22	54.76	6.58	0.001	0.015

[1]DM = dry matter OM = organic matter, CP = crude protein, EE = ether extract, NDF = neutral detergent insoluble fiber, NFC = non-fibrous carbohydrates. [2]SEM: standard error of the mean.

In the present study, the observed NDF digestibility was above the average 63.80% reported by Goularte et al. (2011), who increased the concentrate content (30, 40, 50, and 60%) in the diet of non-lactating dairy cows in the feedlot receiving corn silage, and 49.31% cited by Bürger et al. (2000), who increased the dietary concentrate content (30, 45, 60, 75, and 90%) of feedlot Holstein calves fed coast-cross grass hay. Despite this discrepancy in NDF digestibility values observed in the present study and some described in the literature, and considering the very high values obtained here, it should be stressed that the Tanzania grass used had an elevated nutritional value (Table 2), and its supply allowed great selectivity by the animals, unlike studies cited previously. In these studies, researchers used confined animals subjected to total diets, in which roughage and concentrate are mixed, thereby reducing selectivity by the animal.

The increase observed in the apparent digestibility coefficient of NFC may be attributed to their increased intake, which reduces the proportion of endogenous excretion of these nutrients (VAN SOEST, 1967). However, this researcher reported that the NFC have an almost complete digestibility in the gastrointestinal tract of ruminants – of 98%, on average. Cabral et al. (2006) worked with rumen-fistulated cattle receiving diets with 90% roughage (corn silage, elephant grass silage, or Tifton 85 grass hay) and found an apparent NFC digestibility of 85.58, 65.96, and 41.86%, for these roughage feeds, respectively. However, when they estimated the true digestibility by subtracting the metabolic excretion of NFC from the NFC found in the feces, they found an average true digestion of 96.6%.

The day-time and total rumination times increased linearly (P<0.05), by approximately 3.72 and 2.48% for each kilogram of concentrate consumed, respectively, while the duration of day-time grazing decreased ($P<0.05$) by 3.99% for each kilogram of concentrate consumed (Table 6). This increase in the time expended on the rumination activity may be related to the lower HDMI and trends ($P=0.078$; $P=0.059$) towards a reduction of the time expended on the day-time and total grazing activity, respectively, considering that the activities are mutually exclusionary.

Table 6. Feeding behavior according to supplementation level.

Item	Supplementation level (kg day^{-1})				SEM[1]	P-value	
	1.5	3.0	4.5	6.0		Linear	Quadratic
Day-time idleness, %	32.02	34.65	36.84	28.07	5.95	0.497	0.105
Night-time idleness, %	49.65	44.79	49.65	48.27	3.49	0.919	0.279
Total idleness, %	41.86	40.31	43.99	39.34	3.63	0.653	0.430
Day-time rumination, %	22.81	23.68	25.88	32.02	3.84	0.027	0.295
Night-time rumination, %	34.03	38.19	35.76	37.15	3.05	0.409	0.457
Total rumination, %	29.07	31.78	31.39	34.88	2.96	0.030	0.782
Day-time grazing, %	45.18	41.67	37.28	39.91	4.24	0.078	0.198
Night-time grazing, %	16.32	17.01	14.58	14.58	1.59	0.209	0.784
Total grazing, %	29.07	27.91	24.61	25.77	2.36	0.059	0.395

[1]SEM: standard error of the mean.

No effects of supplementation levels ($P>0.05$) were observed on the rumen pH values, which averaged 6.24±0.19 (Table 7). This may be related to the observed concentrate intake, which was below the value considered ideal for this study. The rumen pH is known to be influenced by concentrate intake levels, collection time after feeding, rate of VFA absorption by the rumen epithelium, nature of the diet, and saliva production (GONZÁLEZ et al., 2012). However, according to Bargo et al. (2002), a significant decrease in the rumen pH of dairy cows on pasture, supplemented with concentrate, occurs when more than 8 kg day^{-1} of concentrate DM are provided.

Table 7. Rumen pH and rumen ammonia nitrogen (RAN) concentration according to supplementation level.

Item	Supplementation level (kg day^{-1})				SEM[1]	P-value		
	1.5	3.0	4.5	6.0		Sup[2]	Time	Sup × Time[3]
pH	6.26	6.32	6.17	6.22	0.19	0.599	0.660	0.965
RAN (mg dL^{-1})	11.99	14.60	16.03	18.75	1.72	0.006	0.006	0.978

[1]SEM: standard error of the mean, [2]Sup: supplementation, [3]Sup × Time: effect of the interaction between supplementation levels and collection times.

Supplementation of dairy cows on pasture is an efficient technique to increase animal production; however, a decline in the rumen pH may reduce the fiber digestibility. Ørskov (1986) stated that the rumen pH decreases after concentrate feeds are consumed, due to their rapid fermentation. Mertens (1992) stressed that the fiber digestion declines when the rumen pH is below 6.7, which occurred in this study. Thus, pH values below those cited by Mertens (1992) were observed, which likely reduced the NDF digestibility observed in this study.

The higher concentrations of RAN ($P<0.05$; linear effect) with the increasing supplementation levels are related to the increased concentrate intake and the increasing proportion of rumen protein originating from the concentrate, which has a faster degradation in relation to the protein from the herbage (Table 7). The RAN is known to originate from the dietary non-protein nitrogen, degradation of the dietary true protein, and recycling via saliva or diffusion through the rumen wall, as well as through the proteolysis of microbial protein caused by autolysis or predation by protozoa (VAN SOEST, 1994).

Leng (1990) and Detmann et al. (2010) reported values between 8 and 10 mg dL^{-1} RAN to optimize the rumen digestion of the fiber from the herbage, and 15 to 20 mg dL^{-1} for optimal voluntary intake by cattle under tropical conditions. In this way, considering that fibrolytic microorganism use the ruminal $N\text{-}NH_3$ as the main nitrogen precursor for protein synthesis and growth (RUSSELL, 2002), concentrate intakes higher than 2.9 kg day^{-1} allow for an adequate rumen digestion and maximization of intake in grazing animals.

Conclusions

Increasing the supply of concentrate to dairy cows on pasture reduces their herbage intake without compromising total dry matter intake or changing rumen-fluid pH values.

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