J. Agr. Sci. Tech. (2018) Vol. 20: 13-22

Nutritional Performance and Metabolic Characteristics of Cattle Fed Spineless Cactus

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ABSTRACT

The effect of the inclusion of spineless cactus [0, 14.7, 29.4, 44.1, and 58.8% of Dry Matter (DM)] basis in replacement of Tifton hay on the intake and digestibility of nutrients, feeding behavior, and nitrogen compounds balance were evaluated. Five crossbred steers, rumen fistulated, with average body weight of 380±5.3 kg were assigned to a 5×5 Latin square design. The time spent with rumination activity linearly decreased (P< 0.05) with the inclusion of spineless cactus; and the feeding time showed a quadratic effect (P< 0.05), with a minimum time of 195 min d^{-1} estimated with 35.7% of spineless cactus inclusion. The nutrient intake showed a quadratic effect (P< 0.05), with a maximum intake of DM (8.9 kg d^{-1}), Crude Protein (CP; 1.4 kg d^{-1}), and Digestible Organic Matter (DOM; 5.8 kg d^{-1}) estimated with 33.9, 29.9, and 41.8% of spineless cactus inclusion, respectively. Except (P> 0.05) to Neutral Detergent Fiber corrected to ash and protein (apNDF), the total digestibility of DM linearly increased (P< 0.05) with spineless cactus inclusion replacing Tifton hay. Except for plasma and urinary urea nitrogen, which were not affected (P> 0.05), there was a quadratic effect (P< 0.05) on nitrogen balance, with a maximum value of 170 g d^{-1} estimated with 33.2% of spineless cactus inclusion. It is recommended to include 41.8% spineless cactus in replacement of Tifton hay for crossbred cattle, due to the higher DOM intake without altering the nitrogen efficiency use.

Keywords: Alternative feed, Drought, Fiber, Intake, *Nopalea cochenillifera* Salm-Dyck, Rumination time.

INTRODUCTION

Climate variability in semiarid regions is responsible for yield and sustainability constraints in animal production systems. During the dry season, nutritional quality of tropical grasses is reduced due to increased cell wall lignification and decreased crude protein concentration, resulting in fiber intake and digestion limitations (Detmann and Valadares Filho, 2010).

In an attempt to maintain animal production during forage shortage, producers use large quantities of alternative concentrates and roughages, such as agro-industrial residues, silage, hay, and straw. Feedstuffs as Tifton hay are usually imported from temperate regions, being considered an expensive ingredient for ruminant's nutrition, and despite its good nutritional value, their inclusion in the diet is indicated only to meet the effective fiber requirements for cattle. Thus, supplying forage that adapts to semiarid soil and climate conditions, such as spineless cactus (*Nopalea cochenillifera* Salm-Dyck), is a strategy used to reduce acquisition costs of

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concentrate and roughage ingredients used in animal feed (Ben Salem, 2010).

Regardless of a genus (*Opuntia* and *Nopalea*), the spineless cactus has a low crude protein [48.1±11.6 g kg^{-1} of Dry Matter (DM)] and neutral detergent fiber (268±5.1 g NDF kg^{-1} DM) content (Ferreira *et al*., 2012). Non-protein nitrogen compounds, such as urea, used in spineless cactus diets is justified to increase dietary protein content, due to its low cost compared to true protein sources (Felix *et al*., 2014).

Due to the high fraction of non-fiber carbohydrates (585.5±81.3 g kg^{-1} DM) and soluble fiber compared to other forage, the spineless cactus has a high nutrient degradability in the rumen, allowing microbial protein synthesis, volatile fatty acids production, and an increase in nutrient absorption (Ferreira *et al*., 2012). However, Mertens (1994) reported that diets rich in energy and with reduced NDF content might regulate feed intake about energy demand. According to the NRC (2001), diets should contain at least 25% NDF in total DM, and 19% of this constituent in DM should be from roughage with high effectiveness.

Several studies have been conducted to assess the inclusion of a fiber source in spineless cactus-based diets. However, the focus has always been to maximize animal performance. Nevertheless, the ideal roughage to the spineless cactus ratio that could maximize spineless cactus use in severe drought is still unknown. This ratio would avoid herd nutritional deficits in semiarid regions while reducing roughage and concentrate costs due to importation from other areas.

It was hypothesized in this study that there is a level of spineless cactus that maximizes the intake and digestibility of dry matter and nutrients, ingestive behavior and nitrogen balance in cattle. Therefore, this study aimed to assess the effect of spineless cactus inclusion replacing Tifton hay on nutrient intake and digestibility, feeding behavior, and nitrogen compounds balance in crossbred cattle.

MATERIALS AND METHODS

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. The semiarid region is characterized by Bs'h climate (Koppen, 1948), the altitude of 614 meters, latitude of 08º 31' 22 "S and longitude of 36º 26' 40" W. The annual average temperature ranges from 25 to 28°C, with annual rainfall between 400 and 600 mm during 3 or 4 months of the year.

Animals and Diets

The management and care of animals were performed by the guidelines and recommendations of the Committee of Ethics on Animal Studies at the Federal Rural University of Pernambuco (License Nº009/2015), Recife, Brazil. Five rumen fistulated steers (½ Holstein-Zebu) with an average initial Body Weight (BW) of 380±5.3 kg were assigned in a 5×5 Latin square design. The animals were weighed, identified and vermifuged before the start of the experiment and housed in individual pens fitted with feeders and waterer. The trial lasted 70 days, with five consecutive 14-day periods that were divided into a seven-day adaptation according to literature reference (Machado *et al*., 2016) and seven-day sampling.

The chemical composition of the ingredients and proportion of the ingredients in the concentrate mixture and the chemical composition of the diets are shown in Tables 1 and 2. The experimental diets consisted of the inclusion of spineless cactus (*Nopalea cochenillifera* Salm-Dyck; 0, 14.7, 29.4, 44.1, and 58.8% of Dry Matter (DM)) replacing Tifton hay (*Cynodon* spp.). Urea and ammonium sulfate were added to the diets to adjust the Crude Protein (CP) content to 150 g kg^{-1} DM, to meet the

[DOR: 20.1001.1.16807073.2018.20.1.14.6]

Table 1. Chemical composition of ingredients used in the experimental diets (g kg^{-1} dry matter).

Item	Ingredients			
	Tifton hay	Spineless cactus	Ground corn	Soybean meal
Dry matter [a]	839	139	859	888
Organic matter	914	860	987	931
Crude protein	94.6	41.0	88.2	508.2
Ether extract	19.4	15.7	48.4	16.5
apNDF [b]	654	277	76.8	92.8
iNDF [c]	229	94.7	23.3	21.1
Non-fiber carbohydrates	147	523	774	312

[a] g kg^{-1} as fed; [b] Neutral Detergent Fiber assayed with a heat stable amylase and corrected for ash and nitrogenous compounds, [c] Indigestible Neutral Detergent Fiber.

Table 2. Proportion of ingredients and chemical composition of the experimental diets.

Item	Inclusion of spineless cactus in replacement of Tifton hay (%)				
	0	14.7	29.4	44.1	58.8
Ingredients (g kg^{-1})					
Tifton hay	690	540	390	240	90.0
Spineless cactos	0	147	294	441	588
Ground corn	155	155	155	155	155
Soybean meal	140	140	140	140	140
Urea/AS [a]	0	3.00	6.00	9.00	12.0
Mineral [b]	15.0	15.0	15.0	15.0	15.0
Diet composition (g kg^{-1} of DM)					
Dry matter [c]	852	466	326	252	209
Organic matter	929	922	914	906	899
Crude protein	150	150	150	149	149
Ether extract	23.1	22.5	21.9	21.3	20.7
apNDF [d]	476	419	361	304	247
iNDF [e]	165	145	124	103	82.9
NFC [f]	280	329	376	422	471

[a] Nine parts of Urea and 1 part of Ammonium Sulfate (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; [c] g kg^{-1} as fed; diet composition obtained from laboratory analysis of ingredients; [d] Neutral Detergent Fiber assayed with a heat stable amylase and corrected for ash and nitrogenous compounds; [e] Indigestible Neutral Detergent Fiber, [f] Non-Fiber Carbohydrates.

requirements of crossbred cattle (½ Holstein-Zebu), with an average daily gain of 1.0 kg (Valadares Filho *et al*., 2010).

The spineless cactus harvest occurred at the second year, from the area with 40,000 plants ha^{-1} and fertilized with 60 ton ha^{-1} of cattle manure, 50 kg P_2O_5, 50 kg of K_2O and 50 kg of N. Later, two cover fertilization were made with 50 kg of N. The spineless cactus were cut and chopped daily and then provided to the animals. The evaluation of DM content of spineless cactus was performed weekly to adjust the amount of feed allowed to the animals. The mixture of ingredients was conducted manually in the feeders, highlighting that the spineless

[DOR: 20.1001.1.16807073.2018.20.1.14.6]

cactus mucilage allowed a uniform aggregation of urea.

Experimental Procedures and Sampling

The diets were supplied *ad libitum*, allowing approximately 100 g kg^{-1} DM of orts. The animals were fed twice a day, at 06:00 am (60%) and 6:00 pm (40%). Forage provided and orts were sampled daily during the collection period and subjected to partial drying in a forced-ventilation oven set at 60ºC for 72 hours. The ingredients that comprised the concentrate were sampled directly from the feed mill silos on the days that they were mixed. All samples were processed in a Wiley mill to pass through a 2-mm screen sieve. After that, each sample was homogenized and divided into two portions. Half of each sample was processed again in the same mill to pass through a 1-mm screen sieve.

Feeding behavior of all steers was evaluated five times during the experiment, during three consecutive days at the seventh day of each adaptation period. Steers were observed every 5 minutes for 24 hours each day starting immediately after the morning feeding, totalizing 72 hours of observation. The activity of each steer was recorded as rumination, feeding, and idling. Each observation was assumed to last 5 minutes, which was the interval between observations. A meal was defined as, at least, one observation of feeding activity occurring after at least 20 minutes without feeding activity, based on the definition of feeding used by Wangsness *et al*. (1976) who defined a meal as at least 1 minute of eating activity after at least 20 minutes without eating activity. A period of rumination was defined as at least 5 minutes of rumination occurring after at least 5 minutes without ruminating activity. The feed and rumination efficiencies (kg h^{-1}) of DM and NDF were calculated by dividing the intake of each of these nutrients by the total feeding time (feed efficiency) or rumination time (rumination efficiency).

The voluntary intake was assessed from eighth to the 14th day each experimental period. From the eighth to the tenth day of each period, the fecal dry matter output was measured using the total collection of feces through spontaneous defecation, used to estimate the total apparent digestibility of nutrients. During these three days, after providing the morning diet, total urine collection was carried out (24 hours), and the pH was measured every six hours to guarantee that it was maintained at below 3.0. Funnel collectors were attached to the steers to collect urine samples, which were conducted into a container containing 500 mL of 20% sulfuric acid. At the end of each collection period, the weight and total volume of urine were determined, and the total N content was determined using the Kjeldahl method cited by AOAC (2000). Plasma urea and urinary urea were measured from commercial kits, using a colorimetric system in a semi-automatic biochemical analyzer D-250Doles®. Four hours after the diet was consumed on the 11th day of each experimental period, blood was collected by jugular vein puncture in a test tube containing a separation gel with a coagulant activator (SST II Advance, BD Vacutainer, Brazil). These samples were stored at −15°C until later urea analysis.

Chemical Analysis

Samples of feeds, orts, and feces were analyzed for Dry Matter (DM; method INCT-CA G-003/1), Crude Protein (CP; method INCT-CA N-001/1), and Ether Extract (EE; method INCT-CA G-004/1). Analysis of NDF was performed using a heat-stable alpha amylase, without using sodium sulfite (NDF; method INCT-CA F-002/1) corrected for residual ash (method INCT-CA M-002/1) and nitrogenous compounds (method INCT-CA N-004/1) according to Detmann *et al.* (2012). Dry matter was analyzed by the gravimetric difference between dry and wet sample weights; OM by ashing at 600ºC for at least 8 hours; CP by using the macro-Kjeldahl procedure and multiplied by a factor of 6.25; and EE by Soxhlet extraction with petroleum ether. All of these chemical analyses were performed in samples processed to pass through a 1-mm screen sieve. The indigestible Neutral Detergent Fiber (iNDF) content was analyzed using the feeds samples processed at 2-mm screen sieve, obtained by using *in situ* procedures with 288 hours of rumen incubation in cattle, as described by Valente *et al*. (2011).

The quantification of Non-Fibrous Carbohydrates (NFC) content was performed according to Detmann and Valadares Filho (2010) as follows: *NFC= 1000-[(CP −CPu+U)+NDFap+EE+MM]*; where *CPu*= CP content from urea, *U*= Urea content, and *NDFap*= NDF corrected for residual ash and protein. The other terms were previously defined, and all of them are expressed as g kg^{-1} DM.

The N balance estimate was obtained by subtracting the fecal and urinary excretion values from ingested N. To determine the efficiency of dietary N compound utilization, the following indicators were used: N-urea in plasma, urinary excretion of N-urea, and N balance. The urea-N from plasma and urine was estimated using the factor 0.466, which was also used by Cruz *et al*. (2006).

Statistical Analysis

The variables studied were analyzed with the PROC MIXED option in SAS software (version 9.1), adopting 0.05 as the critical level of probability for a type I error, according to the following model:

$Y_{ijk}= \mu+T_i+a_j+p_k+\varepsilon_{ijk}$

Where, Y_{ijk} is the dependent variable measured in animal *j* that was subject to the *i* treatment in period *k;* μ is the general mean; T_i is the fixed effect of treatment i; a_j is the random effect of animal j; p_k is the random effect of period *k*; and ε_{ijk} is the unobserved random error assuming normal distribution. After analysis of variance, the significance of the linear and quadratic effects obtained with the inclusion of spineless cactus replacing Tifton hay was evaluated.

RESULTS

A quadratic effect was observed for time spent feeding (P< 0.05) and feed efficiency (P< 0.05), with a minimum time of 195 minutes d^{-1} and the maximum value of 2.7 kg DM h^{-1}, estimated with 35.8 and 35.7% spineless cactus inclusion, respectively (Table 3). Ruminating time decreased linearly (P< 0.05) from 446 to 356 minutes d^{-1} with spineless cactus inclusion.

The DM, CP, DOM and DM (kg BW) intake showed a quadratic effect (P< 0.05), with maximum values of 8.9;1.4; 5.8; 2.3 kg d^{-1} estimated with 33.9; 29.9; 41.8, and 35.1% spineless cactus inclusion replacing Tifton hay (Table 4). The NDF intake linearly decreased (P< 0.05) from 3.4 to 2.0 kg d^{-1}, while NFC intake linearly increased (P<0.05)

Table 3. Mean values for feeding behavior in crossbred steers.

Item	Inclusion of spineless cactus (%)					*SEM* [a]	Effect (*P* value)	
	0	14.7	29.4	44.1	58.8		Linear	Quadratic
Time (min d^{-1})								
Feeding [b]	248	206	196	204	212	19.8	0.140	0.045
Idle	746	848	876	860	872	45.7	0.101	0.215
Rumination	446	386	368	376	356	36.4	0.049	0.445
Efficiency								
Feeding [c] (kg DM h^{-1})	1.86	2.36	2.80	2.67	2.37	0.193	0.019	0.003
Rumination (kg DM h^{-1})	1.02	1.26	1.62	1.44	1.41	0.175	0.115	0.128
Rumination (kg NDF h^{-1})	0.54	0.58	0.65	0.52	0.43	0.058	0.143	0.056

[a] Standard Error of the Mean. [b] $y= 244.857–2.796x+0.039x^2$, [c] $y=1.841+0.510–0.0715x^2$.

from 2.1 to 3.8 kg d^{-1} with spineless cactus inclusion. Except *apNDF* (P> 0.05), the total apparent digestibility of DM linearly increased (P< 0.05). However, there was a quadratic effect (P< 0.05) for CP digestibility with a maximum value of 758 g kg^{-1} estimated with 16.2% spineless cactus inclusion replacing Tifton hay.

Nitrogen intake and N balance showed a quadratic effect (P< 0.05), with maximum values of 215 and 170 g d^{-1}, estimated with 29.9% and 33.2% spineless cactus inclusion replacing Tifton hay, respectively (Table 5). Nitrogen Urea concentrations in Plasma (PUN) and Urine (NUU) were not altered (P> 0.05) by spineless cactus inclusion.

DISCUSSION

The increase in DM Intake (DMI) was due to high soluble carbohydrate degradability in spineless cactus, which in turn resulted in an increased digestion rate of this constituent (Table 4). The *DMI* is affected by several physiologic factors; Salomão *et al*. (2015) found that as digestible energy increased in cattle diets, intake increased, since digestion rate increased, releasing rumen capacity faster. Also, the low DM content (139 g kg^{-1}; Table 1) of spineless cactus implies the intake of large amounts of fresh matter.

Above the 33.9% spineless cactus inclusion replacing Tifton hay, nutrient intake reduction (DM and CP) could be explained by the probable decrease in digest a passage rate through the gastrointestinal tract. Moreover, intake reduction could be related to animal satiety by meeting its energy demand, since diet NFC content exceeded the 40% to 44% limit recommended by the NRC (2001). According to Forbes (2003), when receptors located in the rumen indicate that the energy demand is met, there is a DM intake reduction, going from physical to physiological limitation.

The Figure 1 shows intakes of DM and DOM estimated according to the respective regression equations. It was observed small variation for DOM intake in between the replacements level of 29.4 to 44.1%. The behavior observed before this interval suggests that intake was initially regulated by the filling factor, since high fiber content is controlled by physical factors, such as the passage rate and ruminal fill. Tifton hay is largely responsible for rumen filling due to its high fiber content. In the interval (Figure 1), intake was probably controlled by animal energy requirements, like diet, NFC levels increased, and fiber levels decreased (Table

Table 4. Mean values for the intake and total apparent digestibility of nutrients in crossbred cattle.

Item	Inclusion of spineless cactus (%)					*SEM* [a]	Effect (*P* value)	
	0	14.7	29.4	44.1	58.8		Linear	Quadratic
Intake (kg d^{-1})								
Dry matter [f]	7.56	8.02	9.08	8.85	8.01	0.500	0.145	0.012
Crude protein [g]	1.21	1.25	1.38	1.30	1.20	0.070	0.881	0.018
apNDF [b, h]	3.44	3.14	3.10	2.72	2.04	0.180	< 0.001	0.068
NFC [c, i]	2.06	2.70	3.54	3.77	3.80	0.200	< 0.001	0.079
DOM [d, j]	4.75	5.12	5.72	5.83	5.52	0.290	0.119	0.034
Intake (g kg^{-1} BW [e])								
Dry matter [k]	19.6	20.4	23.2	23.0	20.8	1.180	0.103	0.019
Total apparent digestibility (g kg^{-1})								
Dry matter	691	715	713	751	788	12.7	0.0001	0.1969
Crude protein [l]	765	767	756	792	832	11.7	0.0011	0.0165
apNDF	649	629	564	595	597	22.2	0.0708	0.1140

[a] Standard Error of the Mean; [b] Neutral Detergent Fiber assayed with a heat stable amylase and corrected for ash and nitrogenous compounds; [c] Non-Fiber Carbohydrates; [d] Digestible Organic Matter; [e] Body Weight. [f] $y= 7.404+0.087x–0.001x^2$; [g] $y= 1.196+0.010x–0.0001x^2$; [h] $y= 3.383–0.0006x$; [i] $y= 2.009+0.066x$; [j] $y= 4.677+0.051x–0.0006x^2$; [k] $y= 19.171+0.2074x–0.0029x^2$, [l] $y= 768.056–1.296x+0.040x^2$.

[DOR: 20.1001.1.16807073.2018.20.1.14.6]

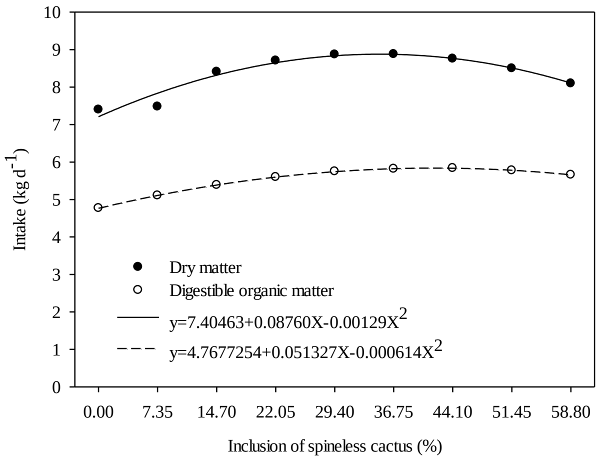

Figure 1. Dry Matter Intake (DMI) and Digestible Organic Matter Intake (DOMI) as a function of different levels of spineless cactus inclusion replacement of Tifton hay.

2; Mertens, 1994).

Another factor that could affect the *DMI* was the increased NFC on diets containing higher levels of spineless cactus. Ruminal fermentation pattern of diets with spineless cactus seems to affect pH drop slightly with the different values of 6.45 to 6.05, for no addition and the higher inclusion of spineless cactus, respectively. The reduction of ruminal pH observed was not enough to limit or inhibit the digestibility of *apNDF* (Table 4), i.e., fiber degradation may be adversely affected when ruminal pH reaches values below 6.0 (Slyter, 1986). The maintenance of ruminal pH above 6.0 is ideal for the activity of fibrolytic microorganisms since the bacterial adhesion process is severely inhibited by the initial pH below 5.5 (Mourino *et al*., 2001).

In search of the ideal Tifton hay to spineless cactus ratio, it was noted that the NDF ratio from hay decreased as spineless cactus inclusion increased since this forage has a low physically effective fiber content. Nevertheless, with maximum intake of 5.7 kg DOM d^{-1}, estimated with 41.8% spineless cactus inclusion and 30% concentrate (based on corn and soybean meal; Table 2), 32.2% diet total NDF, 18.3% NDF coming from Tifton hay and 41.2% NFC were recorded, values close to those recommended by the NRC (2001).

Spineless cactus inclusion replacing Tifton hay provided a DM digestibility increase, which could be explained by NDF content reduction and by high NFC and spineless cactus soluble fiber fraction, showing high nutrient degradability in the rumen (Nefzaoui and Ben Salem, 2001; Batista *et al*., 2009). The quadratic effect for CP digestibility does not represent a biologic response since the increase in total digestibility of CP can be related to urea increase in the diets with higher levels of spineless cactus (Table 2), necessary for promoting the same N content for all experimental diets. Non-protein nitrogen compounds, such as urea, are degraded immediately, quickly releasing NH_3 in the rumen for microorganism use (Calomeni *et al*., 2015), allowing for higher nutrient degradation and increase in digestibility. Other aspects observed are related to a Neutral Detergent Insoluble crude Protein (NDIP) content of Tifton hay (406 g kg^{-1}), which is greater than spineless cactus (273 g kg^{-1}), allowing more available N to the rumen, thus, being coherent assuming a significant effect on CP digestibility response.

Regardless of genus (*Opuntia* or *Nopalea*), spineless cactus has low DM levels (116.9±25.6 g kg^{-1} DM; Ferreira *et al*., 2012), implying the supply of large fresh matter

Table 5. Mean values for the nitrogen compounds balance in crossbred steers.

Item	Inclusion of spineless cactus (%)					*SEM* [a]	Effect (*P* value)	
	0	14.7	29.4	44.1	58.8		Linear	Quadratic
N balance (g d^{-1})								
Total N intake [b]	194	201	222	209	192	12.23	0.881	0.018
N_{feces}	25.1	27.1	29.6	24.8	22.8	2.21	0.294	0.058
N_{urine}	19.8	17.1	20.8	14.3	15.0	4.16	0.332	0.815
Balance [c]	149	157	172	170	154	9.91	0.329	0.038
Balance (%N intake)	77.0	78.2	77.0	81.3	80.4	2.28	0.192	0.876
Plasma (mg dL^{-1})								
Urea-N (PUN)	15.1	15.3	14.1	13.2	14.0	1.54	0.308	0.746
Urine (mg kg^{-1} BW)								
Urea-N	259	205	203	286	358	51.82	0.114	0.107

[a] Standard Error of the Mean; [b] N: Nitrogen; BW: Body Weight, PUN: Plasma Urea Nitrogen.[b] $y= 191.41493+1.60888x–0.02692x^2$, [c] $y= 140.96970+1.78327x–0.0269 x^2$.

amounts to meet animal requirements, which could theoretically require more time for feed apprehension and mastication, although it was not verified in practice. It was found that the time spent feeding had an inverse relationship with dry matter intake, showing higher feed efficiency by animals. Spineless cactus, mainly Miúda cultivar, is highly palatable and, if provided in the total mixed ration, helps in the intake of other dietary nutrients (Ferreira *et al*., 2012).

Rumination time reduction with spineless cactus inclusion could be explained by dietary NDF content decrease (Table 2) and lower intake of this constituent (Table 4). Feeding efficiency followed the same effect observed for DM intake and, as expected, showed the opposite effect on feeding time, i.e., animals consumed more DM in less time.

Nitrogen intake (Table 5) showed the same quadratic effect observed for crude protein intake (Table 4), influencing N balance. Maximum N balance of 170 g d^{-1}, estimated with 33.2% spineless cactus inclusion replacing Tifton hay, followed the effect on DM intake, which increased to 33.9% inclusion level. Nitrogen balance positive values indicated protein retention in the animal organism, providing conditions to prevent weight loss since there was an average daily gain of 1.0 kg with 31.2% spineless cactus in the diet.

Plasma urea and urinary excretion of nitrogen compounds may be affected by dietary protein sources. Therefore, incorrect protein and amino acid balance may increase these parameters (Chizzotti *et al*., 2006). Thus, it was found that diets were well balanced since plasma and urinary urea concentrations were not changed as spineless cactus added with urea were added to replace Tifton hay in diets. Also, Monteiro *et al*. (2014), using higher urea levels (ranging from 0.8 to 2.4% DM) in diets containing spineless cactus replacing wheat bran (0, 33, 67, and 100% of DM), did not observe effects on urea excretion in the plasma and urine of dairy heifers.

In conclusion, it is recommended to include 41.8% spineless cactus in replacement of Tifton hay for crossbred cattle, due to the higher DOM intake without altering the nitrogen efficiency use.

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عملکرد تغذیه ای و ویژگی های متابولیکی گاو ها ی تعلیف شده با کاکتوس بدون خار(*Spineless cactus*)

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چکیده

در این پژوهش، اثر افزودن مقادیر مختلف کاکتوس بدون خار (۰، ۱۴/۷٪، ۲۹/۴٪، ۴۴/۱٪، ۵۸/۸٪ بر حسب ماده خشک DM) به خوراک گاو به جای کاه Tifton از نظر دریافت (intake) و هضم پذیری مواد غذایی، رفتار غذایی، و توازن در ترکیبات نیتروژن ارزیابی شد. به این منظور، ۵ گوساله نراخته شده دورگ که دارای فیستولا بودند و وزنشان 380 ± 5.3 kgبود در یک طرح آماری مربع لاتین 5x5 مطالعه شد. زمان صرف نشخوار به طور خطی و معنادار(P<0.05) با اختلاط کاکتوس بدون خار کاهش یافت و زمان تغذیه تاثیری درجه دومی (quadratic) در سطح P<0.05 نشان داد که کمینه زمان آن برای اختلاط ۳۵/۷٪ کاکتوس برابر ۱۹۵ دقیقه در روز برآورد شد. مواد غذایی دریافتی اثر درجه دومی نشان داد(P<0.05) و مقدار بیشینه ماده خشک دریافتی (۸/۹ کیلوگرم در روز) ، پروتئین خام(CP) ۱/۴ کیلوگرم در روز، و مواد آلی قابل هضم(DOM) ۵/۸ کیلو گرم در روز برای تیمارهای، به ترتیب، ۳۳/۹٪، ۲۹/۹٪، و ۴۱/۸٪ کاکتوس بدون خار برآورد شد. به جز در مورد فیبر مواد پاک کننده خنثی اصلاح شده بر حسب خاکستر و پروتئین (apNDF)، قابلیت هضم DM با افزایش مقدار کاکتوس به جای کاه Tifton به طور خطی افزایش یافت (P<0.05). همچنین، به استثنای پلاسما و نیتروژن اوره در ادرار که تحت تاثیر قرار نگرفتند(P<0.05)، تاثیری درجه دومی (P<0.05)روی توازن نیتروژن مشاهده شد که مقدار بیشینه آن در تیمار اختلاط ۳۳/۲٪ کاکتوس بدون خار برابر ۱۷۰ گرم در روز برآورد شد. به این قرار، توصیه می شود که به جای کاهTifton ، ۴۱/۸٪ کاکتوس بدون خار در خوراک گاو های دو رگ افزوده شود چون که دریافت آن ها از مواد آلی قابل هضم (DOM) بیشتراست بدون آن که تغییری در کارآیی مصرف نیتروژن پدید آید.

[DOR: 20.1001.1.16807073.2018.20.1.14.6]