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Intake and performance of feedlot cattle fed diets based on high and low Brix sugar cane with or without calcium oxide and corn silage[1]

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ABSTRACT - The objective of this study was to evaluate low and high Brix diets, treated or not with 5 g of calcium oxide per kg of natural matter, and corn silage on intake, digestibility and performance of beef cattle. Forty cattle with initial body weight (BW) of 350 kg were used: five composed the control group, 30 were distributed into random blocks (control) and the other five were distributed in a 5 × 5 incomplete Latin square, with the objective of determining digestibility. The 30 animals evaluated for performance were slaughtered and empty body weight (EPW), carcass dressing and meat cuts were determined. The diet with corn silage (CS) presented the best intake of the other ingredients and the best weight gain, except for neutral detergent fiber intake in g/kg of BW. Only carcass dressing, in relation to BW and EBW, was not affected by the treatments, and the others were greater for animals fed diets with sugar cane silage. Animals fed diets with high brix sugar cane silage and treated high brix sugar cane silage presented lower intake of indigestible neutral detergent fiber and neutral detergent fiber corrected for ash and protein (g/kg of BW) in relation to diets with low and high brix sugar cane silage, respectively. Animals fed diets with corn silage presented higher digestibility, except for crude protein and non-fibrous carbohydrates. Animals subjected to diets with corn silage presented low excretion of nitrogen compounds and higher microbial crude protein synthesis. Animals fed sugar cane silage present greater intake, performance and digestibility. The use of lime during 15 or 20º Brix sugar cane ensilage does not alter intake, digestibility or performance of beef cattle.

Key Words: digestibility, ethanol, fermentation, treatment

Introduction

Sugar cane ensilage represents an operational solution (Valvasori et al., 1995). However, the greatest obstacles are the losses resulting from high production of ethanol, carbonic gas and water by yeast. Therefore, the use of additives such as calcium oxide is vital for reducing fermentative losses (Roth et al., 2010). Another alternative would be to ensilage low content of soluble carbohydrate material (low Brix degree) because the low level of substrate would limit yeast growth. This would make two cuts of the sugar plantation per year possible, resulting in a higher yield per area and a higher digestibility fiber of the green sugar cane (low Brix) when compared with mature sugar cane (high brix) (Ferreira et al., 2007).

Despite the increasing demand for information on sugar cane ensilage, little is the scientific development concerning the use of additives for control of ethanol production and increase of aerobic stability of those silages, essential aspects for forage preservation.

Therefore, the objective of this experiment was to evaluate the effect of low and high Brix sugar cane ensilage, with or without 5 g of lime per kg of sugar cane on a natural matter basis, and corn silage on intake, total apparent digestibility, performance, yields or retail cuts of carcass, ribeye area, fat thickness, urea nitrogen in the urine and ingestive behavior of beef cattle in feedlots.

Material and Methods

The experiment was conducted in the Animal Science Department at Universidade Federal de Viçosa. Forty European-Zebu (Girolando) crossbred male cattle were used. Thirty-five animals had initial average body weight (BW) of

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350 kg±32.96 kg, used for determining performance, and the remaining 5 animals with initial average weight of 350 kg±18.99 kg were used for the digestibility assay.

Thirty animals were confined in five common pens with total area of 50 m^2. Each pen contained six electronic Calan type gates with individualized trough where the roughage and concentrates offered to the animals were weighed daily as well as the leftovers after 24 hours, so intake for each animal, as well as the number of accesses to the trough and the time animals stayed there were obtained through random block design with five treatments and six replicates, and initial body weight was used for the formation of blocks. Five treatments were distributed in a 2x2+1 factorial arrangement, in which the roughage was constituted of sugar cane silage with two levels of calcium oxide (0 or 5 g of calcium oxide per kg of natural matter), two Brix degrees (15 and 20^{o}) and corn silage given *ad libitum*, and concentrate given at the proportion of 10 g/kg of the body weight (BW). The urea/ammonium sulfate mixture (9:1) was used to correct crude protein contents of all roughages for approximately 110 g/kg on a dry matter basis, and the average percentages of 16.7 and 33.3 g/kg were used on a dry matter basis, for corn silage and sugar cane silages, respectively. All diets presented around 120 g of crude protein per kg of dry matter, a value recommended by BR-CORTE (Valadares Filho et al., 2006) to meet protein requirements for a 1.2 to 1.5 kg/day gain.

Sugar cane with different Brix degree measured by refractometer, was ground (1 cm) immediately after harvest by an ensiling machine coupled to the power command of the tractor, and the material was placed on a cart, which was weighed empty and loaded (treatment without lime), obtaining the average weight of the ground sugar cane on each cart. The amount of lime needed for each cart was evenly distributed at the exit of the chopping machine. Bunker silos (3 m of width on the baser × 20 m of length and 1.5 m height) were tractor-compacted and covered with polyethylene blade followed by earth layer of 5 cm on the surface and 20 cm on the sides and opened 30 days after for feeding animals with silage.

The ingredients proportion on the basis of concentrate dry matter was: ground sorghum (794.0 g/kg), soybean meal (173.7 g/kg), limestone or sand (12.5 g/kg), NaCl (9.8 g/kg) and mineral mixture (10.0 g/kg); the mixture composition was expressed by kg of the product, composed of: Ca - 240 g; P - 174 g; Mg - 2000 mg; I - 90 mg; Zn - 5270 mg; Se - 15 mg; Co - 100 mg; F - 1740 mg; Cu - 1250 mg; Fe - 1795 mg; excipient q.s. - 1000 g (Table 1).

The experiment lasted 84 days, divided into three 28-day periods after fifteen days for adaptation. After adaptation, animals were weighed again after a 16-hour solid fasting, which was repeated every 28 days. Before the start of the experiment, five animals, representing the others, were slaughtered to obtain carcass dressing and initial empty body weight, and those animals were denominated the control animals. Weight of the animals was used for adjustment of the amount of concentrate given in the next year, since it was adjusted in function of body weight of the animals. The amount of roughage given daily

Table 1 - Composition of urea-corrected roughage and concentrate used in the experimental diets

Item	CS	HBTSC	HBSC	LBTSC	LBSC	Concentrate
Dry matter^1	318.7	235.6	232.5	204.2	218.7	890.0
Organic matter^2	942.5	928.6	954.8	923.5	946.3	960.2
Crude protein^2	111.8	118.6	122.2	123.0	121.2	170.3
NNP^3	82.2	98.0	102.2	100.2	102.9	-
Ether extract^2	26.1	15.1	16.1	15.4	15.5	28.0
NDFap^2	481.0	576.4	606.2	634.3	673.4	143.0
NFC^2	447.4	419.9	417.0	349.6	335.9	618.9
ADFap^2	254.4	370.6	376.9	403.0	433.3	-
NDFi^2	188.0	303.9	349.9	328.9	383.3	58.1
ADFi^2	115.1	200.8	215.4	220.4	270.2	17.0
Lignin^2	52.1	65.1	61.3	84.1	72.8	12.0
Ethanol^2	0.9	9.2	50.0	7.8	43.3	-
Acetic acid^2	22.6	20.5	22.6	24.6	22.0	-
Butyric acid^2	0.2	0.1	0.1	0.1	0.1	-
Lactic acid^2	89.7	81.3	89.2	106.7	63.7	-
Propyonic acid^2	4.9	5.3	7.2	5.4	6.6	-
pH	3.50	4.00	3.50	3.90	3.45	-

CS - corn silage; HBTSC - treated high Brix sugar cane silage; HBSC - high Brix sugar cane silage, LBTSC - treated low Brix sugar cane silage; LBSC - low Brix sugar cane silage.

NNP - non-protein nitrogen; NDFap - neutral detergent fiber corrected for ash and protein; NFC - non-fibrous carbohydrates; NDFi - indigestible NDF; ADFap - acid detergent fiber corrected for ash and protein; ADFi - indigestible ADF.

[1] g/kg natural matter.

[2] g/kg dry matter.

[3] g/kg total nitrogen.

was calculated to allow leftovers at a maximum of 50 g/kg of natural matter.

Samples of feed and leftovers were collected daily per animal, and placed in plastic bags properly identified and stored at -20 °C. Samples of leftovers and roughages were placed in forced ventilation oven at 55 °C for 72 hours and then they were ground in a 1 mm mill. After ground, the samples of the leftovers per animal were proportionally weighed and homogenized, making a composite sample per animal and for a period of 28 days.

To determine indigestible neutral detergent fiber (NDFi), samples of all roughages, leftovers and concentrate were incubated in the rumen of an animal for 264 hours, as suggested by Casali et al. (2008), using Ankom bags (F57). Analyses of dry matter (DM), total nitrogen (TN), ether extract (EE) and ash were done following procedures described by Silva & Queiroz (2002). Neutral detergent fiber (NDF) and acid detergent fiber (ADF) were calculated by autoclave technique, according to Rennó et al. (2002), in which contents of crude protein (CP) and ash of NDF and ADF were quantified as described by Silva & Queiroz (2002), for determination of corrected NDF and ADF (NDFap and ADFap). Non-fibrous carbohydrates (NFC) were calculated as proposed by Hall (2000): NFC = 100 – [(%CP - %CP urea derivative + % urea) + %NDFap + % EE + %ash].

Eventually, all animals were slaughtered after 16-hour solid fasting; the blood was collected in a plastic container and weighed. After slaughter, the gastrointestinal tract (rumen, reticulum, abomasum, and small and large intestine) of each animal was emptied and washed. Weights of heart, lungs, liver, spleen, kidneys, inner fat, industrial meat, mesenteries, tail and trimmings along with washed gastrointestinal tract were added to the other parts of the body (carcass, head, skin, feet and blood) for empty body weight (EBW). The ratio between EBW and body weight (BW) obtained of control animals was used to estimate the initial EBW of animals which remained in the feeding.

After slaughter, the carcass of each animal was divided into two halves, which were weighed and then cooled in a cold chamber at 4 °C, for 18 hours. Afterwards, the half-carcasses were taken from the cold chamber for being weighed. A transversal cut was made between the 12th and 13th ribs to measure ribeye area and then the tracing was removed from the piece in tracing paper and the area was measured. Subcutaneous fat thickness was determined in the third-quarter muscle from the vertebral column, perpendicular to the *longissimus dorsi* muscle, with the aid of a precision ruler. The right half carcass of each animal was detached from the fifth and sixth ribs, on forequarter and hindquarter. The posterior was comprised of the complete whole shoulder, spare ribs, whole chuck as well, whereas the special hindquarter was represented by round and complete rump.

Contents of ethanol, acetic acid, propionic acid, butyric acid and lactic acid were determined according to the method described by Kung Jr. (1996). Briefly, 25 g of the silage wet samples were processed in 225 mL of Ringer solution (Oxoid), using a blender for 1 minute. Afterwards, the material was filtered in Whatman® 54 filter paper, acidified with sulfuric acid at 50% and centrifuged (5000 *g*) for 15 minutes, and the resulting liquid extract was stored in a freezer (-5 °C) until analyses. The pH was determined in the extracts before being filtered by a digital pH meter.

Contents of ethanol, acetic, propionic and butyric acids were determined in gas a chromatographer, model CG – 17A, Shimadzu, equipped with a FID detector. A PAG capillary column (30 m × 0.25 mm) was used for ethanol and Nukol capillary column (30 m × 0.25 mm) was used for acetic, propionic and butyric acids. Contents of lactic acid were determined by high performance liquid chromatography (HPLC) (Shimadzu, model SPD-10A VP) coupled to a ultra-violet detector, by using 210 nm wave length. Column SCR – 101 H, with 30 cm × 7.9 mm of diameter with column flow of 0.8 mL/minute at 24 kgf was used.

Fiver other animals (digestibility) were kept in individual pens, with feeders and individual drinkers, distributed in a 5 × 5 incomplete Latin square. The experiment was conducted in four periods, each one with 21 days, 18 days for adaptation to the diets and three for the collections, by using treatments, diets and feeding procedures of animals similar to the ones described for animals at performance.

Total fecal and urine collections were carried out from day 18 to day 21 of each experimental period. Urine collection was done by using a collector funnel fitted to the animal, where a rubber hose coupled with the funnel conducted the urine to a plastic container with 250 mL of sulfuric acid (H_2SO_4) solution at 20% to avoid nitrogen losses. One sample of urine was diluted in 40 mL of H_2SO_4 0.036 N and frozen at -20 °C for further determination of purine derivatives according to Valadares et al. (1999), at the end of each collection day.

One homogeneous sample of feces was pre-dried and ground at the end of each day, in which a composite of three days of collection was done proportionally to the dry matter weight of feces excreted by the animal on each day. A urine sample was frozen with no dilution for urea determination.

Blood samples were collected four hours after feeding, through tubes with coagulation accelerator gel, being immediately centrifuged at 500 for fifteen minutes and the serum was stored at -15 °C to evaluate urea concentrations.

Concentrations of urea were determined in the serum and in the urine by using a colorimetric-enzymatic system by urease method, with commercial kits (Labtest Diagnóstica S.A.). Total urine nitrogen was determined by the Kjeldahl method. Analyses of purine derivatives were done in the diluted urine samples. Analyses of allantoin were done by the colorimetric method, according to the technique described by Chen & Gomes (1992). Uric acid was analyzed by Trinder-enzymatic method using commerical kits (Labtest Diagnóstica S.A.). Absorbed microbial purines (X, mmol/day) were calculated by excretion of purine derivatives in the urine ($\hat{Y}$, mmol/day) through the equation: $\hat{Y} = 0.80X + 0.301\ BW^{0.75}$ in which 0.89 is the recovery of absorbed urine as purine urinary derivatives and $0.301\ BW^{0.75}$ is the endogenous contribution for purine excretion (Barbosa et al., 2010).

Synthesis of microbial nitrogen compounds ($\hat{Y}$, g N/day) was calculated in relation of the absorbed purines (X, mmol/day), through the equation: $\hat{Y} = 70X \div (0.93*0.137*1000)$, in which 70 is the nitrogen contend (N) in purines (mg N/mmol); 0.93 is the digestibility of microbial purines and 0.137 is the N-purine: total N in the bacteria ratio (Barbosa et al., 2010). Microbial efficiency was expressed in g microbial CP/kg of ingested TDN (g CPmic/kg TDN).

Comparisons between means were made through orthogonal contrasts by using the significance level of 0.05 for all procedures and the software SAS (Statistical Analysis System, version 8.0) was used for the statistical analyses. The contrasts evaluated were: 1 - diet with corn silage versus diets with sugar cane silages; 2 - diets with high Brix sugar cane silage versus diets with low Brix sugar cane silage; 3 - diets with high Brix sugar cane treated with lime versus diets with high brix sugar cane silage; 4 - diets with low Brix sugar cane treated with lime versus diets with low Brix sugar cane.

Results and Discussion

The intake of all nutrients, regardless of the expression manner, was higher ($P<0.05$) for diets with corn silage in relation to diets with sugar cane silage, except for NDFap (%BW). Higher intakes of organic matter (OM), CP, EE, NDFap and NFC were a consequence of the greater ingestion of dry matter by animals fed diets with corn silage ($P<0.05$) (Table 2).

The greater ingestion of DM obtained by the diet with sugar cane silage can be understood by the lower content of NDFi in this diet (Table 1), considering that ruminal filling is directly proportional to the NDF intake. Junqueira (2006) stated that DM ingestion can be negatively affected in function of the fibrous portion in the feeds and its digestibility. Alcohol produced in the alcoholic fermentation in sugar cane silages can also cause rejection or reduction in the DM intake by the animal.

Limitation in DM ingestion by animals fed sugar cane silages can be understood especially by the greater content of NDFi in those diets, 341.5 and 188.0 g/kg of dry matter in diets with sugar cane silage and corn silage, respectively. Therefore, indigestible fiber causes ruminal filling, in which the full rumen makes it impossible for the animal to consume more feed (Allen, 1997).

The average DM intake found by Schmidt et al. (2007) in animals fed silage of sugar cane with no treatment, treated with urea or benzoate was 7.2 kg DM/day, which is a value

Table 2 - Intake of diets with sugar cane and corn silages for cattle in feedlots

Item	Treatments					CV%	Contrasts			
	CS	HBTSC	HBSC	LBTSC	LBSC		1	2	3	4
Total dry matter[1]	9.82	7.52	7.73	7.58	7.76	8.9	<0.0001	0.5140	0.9400	0.8835
Organic matter[1]	9.21	6.98	7.29	7.05	7.28	8.9	<0.0001	0.3335	0.9776	0.8522
Crude protein[1]	1.12	1.00	1.03	1.03	1.02	6.88	0.0062	0.6117	0.8105	0.4269
Ether extract[1]	0.27	0.16	0.17	0.16	0.16	8.1	<0.0001	0.5109	0.7319	0.5560
NDFap[1]	3.31	2.78	3.00	3.03	3.28	1.0	0.0468	0.0707	0.1165	0.1791
NFC[1]	4.84	3.62	3.70	3.38	3.38	8.7	<0.0001	0.7764	0.1022	0.2241
NDFi[1]	1.31	1.38	1.61	1.44	1.74	9.3	0.0013	<0.0001	0.1096	0.5025
TDN[1]	7.14	5.41	5.59	5.44	5.62	-	-	-	-	-
Total dry matter[2]	25.2	19.8	20.3	20.0	20.8	5.4	<0.0001	0.1957	0.4740	0.7661
NDFap[2]	8.5	7.3	7.9	8.0	8.8	8.0	0.0946	0.0219	0.0223	0.0813
NDFi[2]	3.4	3.7	4.2	3.8	4.7	7.7	<0.0001	<0.0001	0.0198	0.3818

NDFap - neutral detergent fiber corrected for ash and protein; NFC - non-fibrous carbohydrates; NDFi - indigestible NDF; TDN - total digestible nutrients (estimated by average dry matter intake multiplied by the content of TDN obtained in the digestibility assay, Table 6); CV - coefficient of variation; CS - corn silage; HBTSC - treated high Brix sugar cane silage; HBSC - high Brix sugar cane silage, LBTSC - treated low Brix sugar cane silage; LBSC - low Brix sugar cane silage.

Contrasts: 1 – corn silage vs. other treatments; 2 – high Brix sugar cane silage vs. low Brix sugar cane silage; 3 – treated high Brix sugar cane silage vs. high Brix sugar cane silage; 4 – treated low Brix sugar cane silage vs. low Brix sugar cane silage.

[1] Intake in kg/day.

[2] Intake in g/kg of the body weight.

close to 7.65 kg DM/day, the value found by this study for treatments with sugar cane silages (Table 2).

Effects for average intake of total DM, OM, CP, EE, NDFap and NFC were not found ($P>0.05$) in diets with high or low Brix sugar cane silages, except for intakes of NDFap (g/kg of BW) and NDFi, which were higher ($P<0.05$) for diets with low Brix sugar cane silage (Table 2). This fact can be understood because the high Brix sugar cane silage presented lower contents of NDFap and NDFi.

According to Van Soest (1994), the process of physiological maturation of the plant generally results in accumulation of cell wall structural carbohydrates and its lignification, reducing the nutritional value of the feed. However, it was found that digestibility increases as the maturation of sugar cane advances, which is a consequence of the increase of soluble carbohydrates as plants gets mature, increasing energy value represented by cell content. Nevertheless, when only fiber is evaluated, maturation decreases its digestibility due to lignification. Therefore, it can be inferred that although high Brix sugar cane presents lower content of NDFi, its fiber is more digestible than diets with low Brix sugar cane because of the lower ruminal digestion rate of NDFap.

No difference was found in intakes of DM and the other nutrients ($P>0.05$) in the diets based on high Brix treated sugar cane silage and high Brix sugar cane silage, except for intakes of NDFap and NDFi, both in g/kg of BW, which were higher ($P<0.05$) for diet with high Brix sugar cane (Table 2). This greater intake can be understood by lower contents of NDFap and NDFi in the dry matter of treated high Brix sugar cane (Table 1). This fact is probably due to the lower loss of soluble carbohydrates during the fermentative process of high Brix treated sugar cane.

There was no difference ($P>0.05$) between diets with low Brix sugar cane silage treated with lime and low Brix sugar cane silage not treated with lime for intakes of all nutrients, and the means of 7.58 and 7.76 kg/day or 20.0 and 20.8 g/kg of BW, respectively, were found for DM intake (Table 2). Schmidt et al. (2007) did not find differences in dry matter intake, when they compared silage of pure sugar cane and silage of sugar cane with additives. Thus, it can be inferred that the use of lime during low Brix sugar cane ensilage does not affect nutrient intake.

Animals fed diets with corn silage presented greater ($P<0.05$) daily weight gain, carcass gain, final body weight, final empty body weight (EBW), carcass weight, EBW/BW ratio and organs/EBW ratio in comparison with those subjected to diets with sugar cane silage (Table 3). Superiority of diet with corn silage can be understood by the greater intake of nutrients (Table 2), which resulted in better performances. Chizzotti et al. (2009) found average daily weight gain of 0.89; 1.13; 0.89 and 1.34 kg when evaluating diets with 500 g of roughage per kg, constituted of sugar cane silages with 0, 5 and 10 g of calcium oxide per kg of natural matter and corn silage, respectively. Those values are close to the ones found in this study for silage of sugar cane without treatment, treated and corn silage, which were 0.95; 0.91 and 1.48 kg/day, respectively.

Superiority of corn silage over the other treatments was not found ($P>0.05$) in carcass dressing (Table 3). This shows that even with greater gain of weight and carcass, animals fed diets with corn silage did not obtain greater carcass dressing, which is, proportional to total body gain, carcass gain was similar in relation to animals fed diets with sugar cane silage.

Table 3 - Performance of cattle in feedlots fed diets with sugar cane silage and corn silage

Item	Treatments					CV%	Contrasts			
	CS	HBTSC	HBSC	LBTSC	LBSC		1	2	3	4
Daily wight gain[1]	1.48	0.89	0.93	0.95	0.96	16.1	<0.0001	0.7147	0.7517	0.5571
Carcass gain[1]	1.01	0.58	0.64	0.61	0.61	24.0	<0.0001	0.6776	0.7951	0.7951
Final body weight, kg	507.67	444.92	450.67	449.75	436.75	8.8	0.0023	0.8269	0.5540	0.8366
Final EBW, kg	450.56	383.95	389.78	383.81	371.51	9.3	0.0004	0.8314	0.3981	0.9949
Carcass weight, kg	278.75	235.48	241.15	237.65	230.80	11.2	0.0022	0.9581	0.5177	0.8918
EBW/BW[2]	887.5	862.4	865.9	852.4	850.8	2.6	0.0081	0.9109	0.2557	0.4468
Carcass dressing/BW[2]	561.7	542.6	549.5	540.5	542.4	4.4	0.1131	0.6589	0.6133	0.8828
Carcass dressing/EBW[3]	632.6	629.0	634.6	633.8	637.4	2.4	0.8789	0.4606	0.7493	0.5807
Organs/EBW[3]	16.64	15.20	14.87	15.38	15.26	10.8	<0.0001	0.6183	0.7487	0.8668

EBW - empty body weight, BW - body weight; CV - coefficient of variation; CS - corn silage; HBTSC - treated high Brix sugar cane silage; HBSC - high Brix sugar cane silage, LBTSC - treated low Brix sugar cane silage; LBSC - low Brix sugar cane silage.

Contrasts: 1 – corn silage vs. other treatments, 2 – high Brix sugar cane silage vs. low Brix sugar cane silage, 3 – treated high Brix sugar cane silage vs. high Brix sugar cane silage, 4 – treated low Brix sugar cane silage vs. low Brix sugar cane silage.

[1] Gain in kg/day.

[2] kg/100 kg of body weight.

[3] kg/100 kg of empty body weight.

No difference (P>0.05) was found in average daily weight gain, carcass gain, final body weight, empty body weight, carcass weight, EBW/BW ratio, carcass dressing or organs/EBW ratio between animals fed diets with sugar cane silage (Table 3). This can be a consequence of the lack of differences in intake of DM, CP and NFC among diets with sugar cane silage (Table 2). Moraes (2010, data not published yet) when studying diets with 800 g of roughage per kg, found that performance was superior for diets with corn silage and did not differ between diets with silage of sugar cane treated with 7.5 or 15.0 g of calcium oxide per kg of natural matter of calcium oxide or fresh sugar cane.

The higher (P<0.05) organs/EBW ratio (Table 3) found in diets with corn silage is because animals fed diets with corn silage presented greater average daily weight gain (P<0.05) associated with a carcass dressing (P>0.05), which did not differ when compared with animals fed diets with sugar cane silage.

No differences (P>0.05) were found between the evaluated diets for carcass length and subcutaneous fat thickness (Table 4). Animals fed diets with corn silage should have presented greater subcutaneous fat thickness in relation to animals in the other treatments, in function of greater intake, digestibility and energy density for this diet. One explanation for that would be the fact that uncastrated animals with predominance of Holstein breed were used, whose weight at slaughter was insufficient to reach a proper fat thickness.

The subcutaneous fat thickness found in this study presented results superior to the ones found by Moletta & Restle (1996), who recorded values of 1.16 mm.

Carcass of animals fed diets with corn silage resulted in (P<0.05) smaller weight loss after cooling, in relation to sugar cane diets (Table 4), probably in function of the greater weight and size of the carcasses (Table 5 and 6), resulting in a smaller contact surface for loss of liquids during cooling.

Carcasses of animals fed diets with corn silage presented greater ribeye area (P<0.05) in relation to the animals in the other treatments, with means of 94.12 and 79.79 cm^2, respectively. This difference can be a result from the positive ratio between carcass and ribeye area.

Diets with sugar cane silage did not differ (P>0.05) for variables evaluated in Table 4. This shows that the use of lime or utilization of sugar cane with high Brix was not sufficient to alter any of those variables, i.e., there was no advantage in using lime in sugar cane ensilage.

Animals fed diets with corn silage presented lower yield (P<0.05) of cushion, shoulder and greater yield of spare ribs. There was no difference (P>0.05) for yields of chuck and rump between treatments. Those differences can be understood because animals were crossbred, which can lead to a different carcass conformation for each animal, so the interference of a possible difference with cut yields is hard to occur.

No differences (P>0.05) were found for time of permanence at the trough per visit in all treatments, expressed in minutes, meaning that all animals were consuming feed at the trough for the same period of time, each time they sought for feed (Table 5). However, for the number of accesses and total daily time of permanence at the trough, animals fed diets with corn silage had fewer accesses (54.17 and 186.33 min/day, respectively), in relation to diets with sugar cane silage (68.75 accesses and 246.50 min/day). This shows that despite the duration of the stay at the trough (P>0.05), the diet with corn silage was in fact more palatable

Table 4 - Carcass dressing and meat cuts of cattle in feedlots fed diets with sugar cane silage and corn silage

Item	Treatments					CV%	Contrast			
	CS	HBTSC	HBSC	LBTSC	LBSC		1	2	3	4
Losses by cooling^1	2.27	2.71	2.61	2.57	2.61	10.0	0.0052	0.7701	0.9822	0.3462
Carcass length^2	134.83	132.33	130.67	132.17	129.67	3.0	0.0557	0.2091	0.6654	0.9424
Ribeye area^3	94.12	83.87	87.70	73.38	74.22	14.4	0.0143	0.6358	0.0614	0.1403
SFT^4	1.64	1.08	1.16	1.43	1.10	47.6	0.1172	0.6340	0.8734	0.3296
Chuck^5	240.2	235.3	235.3	230.4	232.2	7.6	0.4046	0.9085	0.7696	0.6380
Cushion^5	271.6	287.0	283.8	281.4	286.2	4.8	0.0471	0.8858	0.7632	0.4800
Rump^5	176.2	177.8	178.2	175.8	175.6	3.5	0.8206	0.9637	0.4787	0.5920
Shoulder^5	174.8	179.3	182.6	187.1	185.7	4.6	0.0303	0.7734	0.5315	0.1203
Spare ribs^5	137.7	121.5	120.8	125.2	120.1	3.5	<0.0001	0.1182	0.7760	0.1520

SFT - subcutaneous fat thickness; CV - coefficient of variation; CS - corn silage; HBTSC - treated high Brix sugar cane silage; HBSC - high Brix sugar cane silage, LBTSC - treated low Brix sugar cane silage; LBSC - low Brix sugar cane silage.

Contrasts: 1 - corn silage vs. other treatments; 2 - high Brix sugar cane silage vs. low Brix sugar cane silage; 3 - treated high Brix sugar cane silage vs. high Brix sugar cane silage; 4 - treated low Brix sugar cane silage vs. low Brix sugar cane silage.

[1] Loss by kg.

[2] Length in cm.

[3] Area in cm^2.

[4] Thickness in mm.

[5] kg/100 kg of carcass.

Table 5 - Ingestive behavior of cattle in feedlots fed diets with sugar cane and corn silages

Item	Treatments					CV%	Contrast			
	CS	HBTSC	HBSC	LBTSC	LBSC		1	2	3	4
Access	54.17	69.50	65.17	69.33	71.00	15.5	0.0043	0.7508	0.3301	0.9776
Total time[1]	186.33	224.50	221.33	266.67	273.50	21.4	0.0144	0.9293	0.0834	0.1574
Visit time[2]	3.83	3.50	3.33	3.83	4.00	33.5	0.7710	1.0000	0.3610	0.6458

Access - number of accesses to the trough; Total time - total daily time of permanence in minutes at the trough; Visit time - permanence time in minutes at the trough per visit; CV - coefficient of variation CS - corn silage; HBTSC - treated high Brix sugar cane silage; HBSC - high Brix sugar cane silage, LBTSC - treated low Brix sugar cane silage; LBSC - low Brix sugar cane silage.

Contrast: 1 - corn silage vs. other treatments; 2 - high Brix sugar cane vs. low Brix sugar cane silage; 3 - treated high Brix sugar cane vs. high Brix sugar cane silage; 4 - treated low Brix sugar cane silage vs. low Brix sugar cane silage.

[1] Time in minutes/day.

[2] Time in minutes/access.

and with more energy density, because although they had greater DM average intake (Table 2) in relation to the other diets, the number of accesses were fewer, which reflected a shorter total time at the trough.

Thus, it was found that the number of accesses was negatively correlated to animal performance, because animals fed the corn silage diets had fewer accesses and shorter total time of permanence at the trough per day, greater dry matter intake and weight gain, when compared with those fed sugar cane silage diets (Table 5). This finding indicates that the time spent with feed ingestion does not necessarily determine the magnitude of intake and that other factors influence this variable, e.g., intake rate.

Diets with sugar cane silage did not differ from each other ($P>0.05$) on the number of accesses to trough, total time of permanence at the trough in minutes per day and time of permanence in minutes at trough per visit. The lack of significant effects on ingestive behavior can be explained by the composition of assessed silages, whose average ingestion of DM and NDF in kg/day was similar for all sugar cane silages (Table 2).

When evaluating the ingestive behavior of animals fed sugar cane silage, Schmidt et al. (2007) obtained average daily ingestion times of 230.6 min/day, which is a value similar to the one found in this experiment, for diets with sugar cane silage, whose means varied from 221.33 to 273.50 minutes/day, i.e., animals spent from 3.7 to 4.6 hours per day with feeding (Table 5).

The animals used in the digestibility assay presented greater intake of all nutrients ($P<0.05$) in the diet with corn silage (Table 6), except for CP intake, which did not differ ($P>0.05$) between diets. Those results were similar to the ones obtained by the animals at performance (Table 2). Greater intakes of OM, EE, NFC, and TDN were a consequence of the greater ingestion of DM by animals fed diets with corn silage.

Diets with sugar cane for ruminants cause lower intake of DM, probably in function of low digestibility of the fibrous portion of these feeds, resulting from its lower digestion rate in the rumen (Preston, 1982), or from the high content of NDFi of these diets, which causes rumen fill, showing that the intake is a function of the indigestible fraction of the diet.

Average intake of total DM, OM, CP, EE and NDFap (kg/day) did not differ ($P>0.05$) between diets with high and low Brix sugar cane silage (Table 6). However, intakes of NDFap (g/kg of BW) and NDFi were greater ($P<0.05$) for diets with low Brix sugar cane silage (Table 6). These results were similar to the ones described for animals at performance (Table 2).

Comparing the results obtained by diets with high Brix sugar cane silage and diets with low Brix sugar cane silage, no effect of the treatment with lime ($P>0.05$) was found on the average intakes of DM, OM, CP, EE, NDFap (kg/day) and TDN (Table 6). However, difference($P<0.05$) on NDFap intake (g/kg of BW) and NDFi was found, as well as for NFC (kg/day). Greater intake of NDFap presented by animals fed diet with high Brix sugar cane silage would be expected inasmuch as this roughage had greater fiber content and lower NFC content in relation to diets with treated high Brix sugar cane (Table 1). Ferreira et al. (2007) found an increase in contents of NDF from 553.0 to 697.0 g/kg ensilaged sugar cane with no additives. According to Corrêa et al. (2003), soluble carbohydrates are the biggest fraction of digestible carbohydrates in sugar cane. Soluble carbohydrates intake by microorganisms during fermentation of ensilaged mass causes a proportional rise of the fibrous fraction and reduces the nutritive value of the silage. In fact, silages treated with calcium oxide presented lower content of ethanol in relation to the not treated ones. Animals fed diets with high Brix treated sugar cane silage ingested less NDF and more NFC ($P<0.05$) in relation to the treatment with high Brix sugar cane silage, showing that lime reduces loss of soluble carbohydrates by alcoholic fermentation in a certain way.

Evaluating diets with low Brix treated sugar cane silage and diets with low brix sugar cane silage, no difference

Table 6 - Intake and total apparent digestibility of nutrients of cattle in feedlots fed diets with sugar cane and corn silages[1]

Item	Treatments					CV%	Contrasts			
	CS	HBTSC	HBSC	LBTSC	LBSC		1	2	3	4
			Intake							
Total dry matter[2]	8.55	7.13	6.74	6.33	6.93	4.1	<0.0001	0.4990	0.3894	0.0055
Organic matter[2]	7.97	6.63	6.38	5.95	6.47	3.8	<0.0001	0.3419	0.6568	0.0058
Crude protein[2]	0.95	0.90	0.92	0.87	0.92	4.0	0.3913	0.2838	0.9460	0.6064
Ether extract[2]	0.23	0.14	0.14	0.14	0.15	8.0	<0.0001	0.6669	0.2867	0.7866
NDFap[2]	3.05	2.59	2.58	2.47	2.89	6.7	0.0039	0.0602	0.3943	0.0468
NFC[2]	4.17	3.74	3.52	3.83	3.22	3.3	0.0004	0.0026	0.0115	0.6251
TDN[2]	6.16	5.08	4.86	4.67	4.95	3.2	<0.0001	0.4317	0.3367	0.3025
NDFi[2]	1.23	1.36	1.40	1.20	1.59	6.6	0.0138	0.0015	0.0170	0.0358
Total dry matter[3]	23.5	19.5	18.6	17.4	19.1	4.1	<0.0001	0.3674	0.4350	0.0064
NDFap[3]	8.4	7.0	7.1	6.8	8.0	6.7	0.0038	0.0495	0.0456	0.4005
NDFi[3]	3.4	3.7	3.8	3.3	4.3	6.9	0.0153	0.0017	0.0180	0.0392
			Total apparent digestibility							
Dry matter[4]	0.669	0.596	0.597	0.598	0.614	2.9	0.0002	0.3949	0.2409	0.8960
Organic matter[4]	0.678	0.627	0.625	0.638	0.634	2.7	0.0016	0.7388	0.4724	0.4147
Crude protein[4]	0.692	0.753	0.725	0.753	0.725	2.2	0.5271	0.6692	0.9753	0.1071
Ether extract[4]	0.767	0.735	0.715	0.741	0.696	4.6	0.0472	0.0972	0.4757	0.8288
NDFap[4]	0.563	0.447	0.430	0.468	0.490	5.5	0.0001	0.8611	0.0145	0.3162
NFC[4]	0.789	0.793	0.820	0.820	0.813	2.0	0.4144	0.4393	0.5432	0.3255
TDN[4]	0.725	0.708	0.725	0.718	0.723	2.2	0.4320	0.6786	0.8757	0.1403

[1] Experimental data evaluating intake and digestibility.

NDFap - neutral detergent fiber corrected for ash and protein; NFC - non-fibrous carbohydrates; NDFi - indigestible NDF; TDN - total digestible nutrients; CV - coefficient of variation CS - corn silage; HBTSC - treated high Brix sugar cane silage; HBSC - high Brix sugar cane silage, LBTSC - treated low Brix sugar cane silage; LBSC - low Brix sugar cane silage.

Contrasts: 1 - corn silage vs. other treatments; 2 - high Brix sugar cane silage vs. low Brix sugar cane silage; 3 - treated high Brix sugar cane silage vs. high Brix sugar cane silage; 4 - treated low Brix sugar cane silage vs. low Brix sugar cane silage.

[2] Intake in kg/day.

[3] Intake in g/kg body weight.

[4] Digestibility in kg/kg.

(P>0.05) was found for intakes of CP, EE, NFC and TDN (Table 6). However, animals fed diets with low brix sugar cane silage presented higher intake of DM, OM, NDFap and NDFi (P<0.05) than animals fed diets with low Brix treated sugar cane (Table 6). This greater intake of DM can be understood because silage probably presents greater nutritional losses during fermentation, when compared with treated high Brix sugar cane silage. The greater intake of OM and NDFi is the result of the greater intake of DM associated to the lower content of ash and the greater content of NDFi in high Brix sugar cane silage in comparison with treated high Brix sugar cane silage (Table 1).

Apparent digestibility of DM, OM, EE and NDFap was greater (P<0.05) for the diet with corn silage than diets with sugar cane silage (Table 6). The greater apparent digestibility of DM of the diet with corn silage can be understood by the lower lignin content (Table 1) of this diet, which probably would result in the improvement of the NDFap digestibility, when compared with diets with sugar cane silage.

By evaluating apparent digestibility of CP and NFC, it was found that they did not differ (P>0.05) across the diets evaluated (Table 6). This can be understood because of content of CP of roughage was corrected for approximately 110 g/kg on the dry matter basis, which resulted in greater percentages of urea/ammonium sulfate in diets with sugar cane silage, which resulted in no differences of CP across the diets. The lack of effect of total apparent digestibility of NFC was probably due to the high amount of soluble carbohydrates present in the sugar cane silage.

The lack of difference in the content of TDN between treatment with corn silage and diets with sugar cane silage might have been caused by the longer ruminal retention time, greater content of urea/ammonium sulfate and smaller roughage/concentrate ratio for diets with sugar cane silage.

No differences were found for total digestibility of all nutrients and for contents of TDN when diets with sugar cane silage were compared (high Brix sugar cane silage × low Brix sugar cane silage or high Brix treated sugar cane silage × high Brix sugar cane silage or low Brix treated sugar cane silage × low Brix sugar cane silage), except for digestibility of NDFap, which was greater (P<0.05) for high Brix treated sugar cane silage in comparison with the diet with high Brix sugar cane silage (Table 6). This can be understood because lime may cause increase of NDFap digestibility. According to Klopfenstein (1980), the content of lignin and silica may increase according to the additive action, but the lignin content is not usually changed.

When diets of low Brix sugar cane treated or not with lime were compared, lack of difference was found for NDFap digestibility. This might have resulted from smaller content of lignin, in terms of percentage in relation to fiber (Table 1).

The concentration of serum urea nitrogen and the urinary excretion of urea nitrogen were smaller ($P<0.05$) for diets with corn silage. This result is a consequence of the lower ingestion of urea/ammonium sulfate mixture, which shows a better use of N by the animals fed diets based on corn silage (Table 7). According to Harmeyer & Martens (1980), urea plasma concentration is the main determinant of urinary urea excretion. There is an increasing linear ratio between ureic N excretion and plasma urea N concentration (Rennó et al., 2000).

Concentration of serum ureic nitrogen and excretion of ureic nitrogen did not differ ($P>0.05$) across the diets with sugar cane silage inasmuch as they had the same content of urea in the roughage. Valadares et al. (1997), in a study with heifers fed diets with 120 g of CP per kg, found a mean level of serum urea nitrogen of 15.70 mg/dL, which is a value close to the mean value of 15.72 mg/dL for the diets with sugar cane silage found in this study.

It was found that animals fed diets with corn silage presented greater ($P<0.05$) excretions of allantoin, total purine derivatives, absorbed microbial purines and greater production of microbial nitrogen compounds in the rumen and of ruminal microbial crude protein (micCP)in relation to diets with sugar cane silage (Table 8). This behavior can be understood because the greater intake of DM and TDN by animals fed diets with corn silage (Table 6) resulted in higher energy availability for microbial growth. Microbial efficiency did not differ ($P>0.05$). This may be explained because diets with sugar cane presented lower synthesis of microbial protein and also because of the lower intake of TDN, in relation to the diet with corn silage.

There was no difference ($P>0.05$) for all variables analyzed in Table 8, when diets with corn silage were compared. This similarity in the result may be understood because intake of DM and TDN did not differ across those diets (Table 6), resulting in a similar microbial growth. The mean value obtained for microbial efficiency, considering all treatments, was 120.2 g micCP/kg of TDN ingested, which is similar to the mean of 120.2 g micCP/kg of TDN recommended by Valadares Filho et al. (2006) for tropical conditions and inferior to the value of 130 g micCP/kg of TDN adopted by NRC (2001).

The mean ALA:PD ratio was 0.983 g/g, which is close to the value reported by Leal et al. (2007) of 0.922. According to Verbic (1990), excretion of allantoine may represent 0.850g/g of the total purine derivatives.

Table 7 - Blood concentration and nitrogen urinary concentration of cattle in feedlots fed diets with sugar cane and corn silages

Item	Treatments					CV%	Contrast			
	CS	HBTSC	HBSC	LBTSC	LBSC		1	2	3	4
SUN[1]	10.42	15.72	15.77	14.69	16.71	17.9	0.0081	0.4652	0.6392	0.6066
UNE[2]	136.67	176.54	198.03	181.52	229.71	18.4	0.0156	0.0814	0.2358	0.8454

SUN - serum urea nitrogen; UNE - urinary excretion of urea nitrogen; CV - coefficient of variation; CS - corn silage; HBTSC - treated high Brix sugar cane silage; HBSC - high Brix sugar cane silage; LBTSC - treated low Brix sugar cane silage; LBSC - low Brix sugar cane silage.

Contrasts: 1 - corn silage vs. other treatments; 2 - high Brix sugar cane silage vs. low Brix sugar cane silage; 3 - treated high Brix sugar cane silage vs. high Brix sugar cane silage; 4 - treated low Brix sugar cane silage vs. low Brix sugar cane silage.

[1] Concentration in mg/dL.

[2] Excretion in mg/kg body weight.

Table 8 - Urinary excretion, synthesis of microbial nitrogen compounds in the rumen and microbial efficiency of cattle in feedlots fed diets with sugar cane and corn silages

Item	Treatments					CV%	Contrasts			
	CS	HBTSC	HBSC	LBTSC	LBSC		1	2	3	4
ALA[1]	182.01	146.00	147.67	139.69	174.60	12.5	0.0300	0.1104	0.0986	0.6729
PD[1]	185.19	148.20	150.56	142.23	177.21	12.4	0.0287	0.1073	0.1045	0.6927
Pabs[1]	199.33	153.24	156.15	145.63	189.32	14.8	0.0292	0.1086	0.1066	0.6878
ALA:DP[2]	0.984	0.985	0.980	0.982	0.986	0.6	0.8237	0.9205	0.2172	0.4874
Nmic[3]	109.51	84.19	85.79	80.01	104.01	14.8	0.0292	0.1086	0.1067	0.6877
CPmic[3]	684.44	526.19	536.19	500.08	650.08	14.8	0.0292	0.1086	0.1066	0.6878
Efic[4]	113.79	110.34	118.27	119.17	139.30	12.9	0.3989	0.1179	0.1004	0.4578

ALA - allantoin; PD - total purine derivatives; Pabs - absorbed microbial purines; ALA:PD - allantoin:total purine derivatives ratio; Nmic - synthesis of microbial nitrogen compounds in the rumen; CPmic - synthesis of ruminal microbial crude protein; Efic - microbial synthesis efficiency; CV - coefficient of variation; CS - corn silage; HBTSC - treated high Brix sugar cane silage; HBSC - high Brix sugar cane silage, LBTSC - treated low Brix sugar cane silage; LBSC - low Brix sugar cane silage.

Contrasts: 1 - corn silage vs. other treatments; 2 - High Brix sugar cane silage vs. low Brix sugar cane silage; 3 - treated high Brix sugar cane silage vs. high Brix sugar cane silage; 4 - treated low Brix sugar cane silage vs. low Brix sugar cane silage.

[1] Excretion in mmol/day.

[2] Ratio in g/g.

[3] Synthesis in g/day.

[4] Efficiency in g of CPmic/kg of TDN.

Conclusions

Diet with corn silage provides higher intake, performance and digestibility than diets with sugar cane silage. Lime does not affect intake or digestibility of nutrients in 15 Brix or 20 Brix sugar cane. Better performance is related to the fewer accesses and shorter time of permanence at the trough.

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