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Intake and performance of confined bovine fed fresh or ensilaged sugar cane based diets and corn silage[1]

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ABSTRACT - It was evaluated intake, total apparent digestibility, performance and feeding behavior of bovine fed diets constituted of corn silage, crushed sugar cane given fresh or crushed and given 72 hours after storage, ensilaged sugar cane with or without 1% of calcium oxide and concentrate at the proportion of 1% of the body weight. It was used 35 bovines, distributed in a random block design, with 5 treatments and 6 repetitions. The animals were housed in collective stalls with troughs individualized by electronic gates. The animals fed diet with corn silage presented greater intake of all nutrients and greater total digestibility of dry matter, organic matter, neutral detergent fiber and total digestible nutrients, as well as greater weight gain and subcutaneous fat thickness. Animals fed diet with fresh sugar cane presented greater nutrient intake as well as better dry matter digestibility, ether extract and TDN content and a superior performance in relation to animals fed ensilaged sugar cane diets. Animals fed silage of sugar cane with calcium oxide presented greater digestibility of organic matter, NFC and content of TDN but they did not differ on performance in relation to the use of silage of sugar cane without calcium oxide. Intake and performance of animals did not change with or without storage of sugar cane. It was concluded that animals fed diets with corn silage present performances superior to the ones which are fed sugar cane based diets, and animals fed fresh sugar diet are superior to the animals fed diets with sugar cane silage.

Key Words: bovine, carcass, digestibility, electronic gates, feedlot, weight gain

Consumo e desempenho de bovinos confinados com dietas à base de cana-de-açúcar fresca ou ensilada e silagem de milho

RESUMO - Avaliaram-se o consumo, digestibilidade aparente total, desempenho e comportamento alimentar de bovinos alimentados com dietas constituídas de silagem de milho, cana-de-açúcar triturada e fornecida *in natura* ou triturada e fornecida após 72 horas de armazenamento, cana-de-açúcar ensilada sem ou com 1% de cal e concentrado fixado em 1% do peso corporal. Utilizaram-se 35 bovinos, distribuídos em delineamento com blocos casualizados, com 5 tratamentos e 6 repetições. Os animais foram alojados em baias coletivas com cochos individualizados por portões eletrônicos. Os animais alimentados com dieta contendo silagem de milho apresentaram maior consumo de todos os nutrientes e digestibilidade total da matéria seca, matéria orgânica, fibra em detergente neutro e teor de nutrientes digestíveis totais, assim como maior ganho de peso e espessura de gordura subcutânea. Os animais alimentados com dietas de cana-de-açúcar *in natura* apresentaram maior consumo dos nutrientes assim como melhor digestibilidade da matéria seca, extrato etéreo e teor de NDT e desempenho superior em relação aos alimentados com dietas de cana-de-açúcar ensilada. Os animais alimentados com dietas de silagem de cana-de-açúcar com cal apresentaram maior digestibilidade da matéria orgânica, CNF e teor de NDT, no entanto, não diferiram quanto ao desempenho produtivo em relação ao uso da silagem de cana-de-açúcar sem cal. Com ou sem armazenamento da cana-de-açúcar, o consumo e desempenho dos animais não alteraram. Concluiu-se que animais alimentados com dietas contendo silagem de milho apresentam desempenhos superiores aos que recebem dietas à base de cana-de-açúcar, sendo os alimentados com dietas de cana-de-açúcar ofertada *in natura* superiores aos alimentados com dietas de silagem de cana-de-açúcar.

Palavras-chave: bovinos, carcaça, confinamento, digestibilidade, ganho de peso, portões eletrônicos

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Introduction

Sugar cane (*Saccharum officinarum L.*) has been used for a long time as forage culture by Brazilian farmers, assuming an important role as source of supplemental roughage. The great propagation of this culture through traditional or great food producer centers, the technological advances and launching of cultivars fitted for animal production, the low cost per unit of produced dry matter and its maturity coinciding with period of shortage of pastures, justify the expansion and use of sugar cane in animal production systems.

The use of fresh sugar cane, by daily cuts, is traditional and widely known by the producers. However, this management requires daily manpower for cuts, removal of straw, disintegration and shipping, and it establishes logistic constraints when it is intended to supplement a bigger herd. Therefore, ensilage of sugar cane constitutes an alternative for this situation, but because of its high content of soluble carbohydrates and a high population of epiphyte yeast, it results in alcoholic fermentation, causing excessive losses of dry matter and nutritive value of the silage (Schmidt, 2006). Perhaps, in detriment to nutritive value of sugar cane silage, ethanol production is the principal difficulty presented by this technology and the greatest challenge of research searching for specific processes which control properly the population and activity of yeast, without harming quality of silage and animal performance (Nussio et al., 2003). To solve this problem, calcium oxide (CaO) has been used at different levels, being the level 0.5% able to promote improvement in the quality of ensilaged material (Baleiro Neto et al., 2009).

To control operational problems caused by sugar cane cut management, it can be adopted an alternative feeding system, as storage of sugar cane and posterior supply to animals, an option evaluated by Pina et al. (2011). After sugar cane crushing and storage during three days, this author observed that performance and intake by the animals were similar among control group, what can constitute an alternative for reducing costs with logistic. So, it was carried out an experiment with the objective to evaluate productive and nutritional performances of beef cattle fed fresh or ensilaged sugar cane and corn silage based diets.

Material and Methods

Field stage was carried out from August to November 2008 by using 35 crossbred European-Zebu steers at 24 to 36 months of age with initial body weight of 350 ± 32 kg, in a random block design with five treatments and six repetitions, adopting weight as block criterion. It was evaluated four manners of sugar cane supply (crushed and given fresh; crushed and stored for 72 hours before supply ensilaged without treatment; and ensilaged with 1% of calcium oxide) in comparison to corn silage (control). All roughage (Table 1) were corrected to contain 10% of crude protein in the dry matter (DM), by using urea/ammonium sulfate (9:1) mixture distributed on the forage immediately before being given to the animals. The same concentrate containing 23% of crude protein (CP) was given at the

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

Evaluated parameters	Roughage					Concentrate
	Corn silage	*Fresh* sugar cane	Sugar cane stored for 72 hours	Silage of sugar cane without treatment	Silage of sugar cane 1% treated	
Dry matter	26.31	27.21	28.21	21.90	23.14	89.76
Organic matter	95.40	94.57	95.04	95.40	94.00	94.50
Crude protein	12.20	10.80	10.40	11.70	11.40	23.14
Non-protein nitrogen	6.08	7.73	7.52	6.65	6.77	-
Urea	1.15	2.30	2.28	1.92	2.02	-
Ether extract	3.60	2.28	2.60	2.68	2.80	3.24
Neutral detergent fiber correct for protein and ash	51.42	46.92	53.04	62.00	54.50	17.89
Non fibrous carbohydrate	38.66	43.33	39.68	38.69	39.70	50.23
Acid detergent fiber (sequential)	33.45	33.29	35.52	43.82	42.76	7.02
Indigestible neutral detergent fiber	15.00	22.88	22.31	25.29	22.85	1.60
Indigestible acid detergent fiber	9.08	13.07	14.13	14.16	11.01	0.90
Lignin	5.21	6.51	6.13	8.41	7.28	1.20
Ethanol	-	-	-	3.57	0.56	-
Acetic acid	-	-	-	2.59	2.35	-
Butyric acid	-	-	-	0.04	0.07	-
Lactic acid	-	-	-	4.33	4.83	-
Propionic acid	-	-	-	0.79	0.97	-
pH	-	-	-	3.53	4.20	-

proportion of 1% of body weight to all the animals. The ingredients of the concentrate mixture, in percentage of total mixture were: corn meal (87.60), soybean meal (11.10), limestone (0.80), salt (0.65) and mineral mixture (0.65), composed by (per kg of the product): calcium - 240 g; phosphorus - 174 g; magnesium - 2.00 mg; iodine - 90 mg; zinc -5,270 mg; selenium - 15 mg; cobalt - 100 mg; fluorine - 1.740 mg; copper - 1.250 mg; iron - 1,795 mg; vehicle q.s.p. - 1,000 g. The animals were confined in collective stalls with a total area of 50 m^2 (8.0 m^2 covered with zinc tiles), all with individual feeders, with access controlled by electronic gates, and collective drinkers. Animals fed the diet were grouped in the same collective stall.

At the beginning of the experiment, all animals were weighted and dewormed and after being weighted they were grouped in the blocks according to the weight and after according to the diet.

The experiment lasted 84 days, divided into three 28-day periods, after 15 days of adaptation. In the adaptation phase, food was given ad libitum, twice daily, in the morning and in the afternoon and intake was measured daily. After adaptation period, animals were weighed again, after 16 hours of solid fast, which was repeated every 28 days.

Weight of the animals were used to adjust quantity of the concentrate given the next period, inasmuch as they were adjusted in function of the body weight. Quantity of roughage given daily was calculated to allow leftovers of approximately 10% of what was given. Five animals were slaughtered after adaptation period, for determination of empty body weight (EBW) and for carcass yields and commercial cuts.

It was carried out daily collections of the food given and food scraps, per animal, and they were placed in plastic bags properly identified and stored in a freezer (–15°C). Composed samples of food scraps per animals, samples of the concentrate and roughages were produced weekly and dried in air forced oven (60ºC). After that, a composed sample was made for food scraps of each animal, for the concentrate and roughages of every 28-day period.

For evaluation of digestibility of the diets, collection of feces was carried out in the third week of the last experimental period, twice daily (in the morning and in the afternoon) during three consecutive days. The feces were identified and dried in an air forced ventilation oven (60ºC) for around 72 hours and crushed in a knife mill with 1-mm sieve.

From the ground feces samples, a composed sample was made per animal based on the air-dried weight. The composed sample was stored in plastic containers for further laboratory analyses. During the digestibility trial week, roughages, food scraps and concentrate ingredients were sampled and analyzed separately. For estimation of fecal dry matter, indigestible fiber (ADFi) was used as internal marker. ADFi was obtained after 264-hour incubation as described by Casali et al. (2008), in F57 bags (Ankon).

Analyses of dry matter, organic matter, total nitrogen, non-protein nitrogen (NPN), ether extract and lignin (H2SO4 72% p/p) were carried out following technique described by Silva & Queiroz (2002) whereas evaluations of NDF and ADF followed methods described by Mertens (2002) and Van Soest & Robertson (1985), respectively. Non-fibrous carbohydrates (NFC) were calculated as proposed by Hall (2000): NFC = 100 – [(%CP - % urea derived CP + urea %) + %NDFap + % EE + %ash]. Total digestible nutrients (TDN) were calculated by using the equation: TDN = % digestible CP+ % digestible NDF + % digestible NFC + (2.25* % digestible EE), according to NRC (2001).

Contents of ethanol, volatile fatty acids (VFA) and lactic acid were determined in water extract of the silage samples, obtained according to the method described by Kung Júnior (1996). For that, 25 g of wet sample were processed with 225 mL of Ringer solution, in a blender for 1 minute. After that, the material was filtrated in Whatman® 54 filter-paper, acidified with sulfuric acid at 50% and centrifuged (5,000 g) for 15 minutes and the liquid extract stored in a freezer (–5ºC) until analyses. Determination of pH was carried out before filtering by using digital pH meter.

Content of ethanol was determined by using a gas chromatographer model CG-17A Shimadzu, equipped with FID detector. For record and analyses of chromatograms, the gadget was coupled to a microcomputer, by using the program GC Solution. The compounds were separated and identified in a PAG capillary column (30 m × 0.25 mm).

For chromatographic separation, 1 µL of the sample was injected by using a 10-µL syringe (Hamilton®) in Split = 30 system. Nitrogen gas was used as a carrier with a linear velocity programmed for 24.64 cm/s and hydrogen gas and synthetic air formed the flame in the detector. Temperatures in the injector and in the detector were isothermally controlled between 200ºC and 220ºC. The initial temperature in the column was 100°C (kept for 6 minutes), increasing at 30°C per minute until reaching 180ºC (kept for 24 minutes) totaling 11.06 minutes of analysis. Flow drag gas in the column was at 0.8 mL/minute.

Contents of lactic acid were determined by high performance liquid chromatography (HPLC) by using a Shimadzu gadget, SPD-10 A VP model, coupled to an ultraviolet detector by using a wave length of 210 nm. It was used a SCR-101 H column, with 30 cm × 7.9 mm of diameter with a flow in the column of 0.8 mL/minute at 24 kgf. The mobile phase was constituted of water in 1% of orthophosphoric acid at a rate of 20 μL.

Acetic, propionic and butyric acid were determined in a gas chromatograph, CG-17a model, Shimadzu, equipped with a FID detector. For registration and analyses of chromatograms, the equipment was coupled to a microcomputer by using the GC Solution program. The compounds were separated and identified in a Nukol capillary column (30 m × 0.25 mm). For chromatographic separation, 11 μL of sample was injected with a syringe of 10 μL (Hamilton®) in a Split = 5 system. Nitrogen gas was used as a carrier with a linear velocity programmed for 43.2 cm/s and nitrogen gas and synthetic air formed the flame in the detector. Temperatures of the injector and detector were isothermally controlled from 220ºC to 250ºC. Initial temperature in the column was 100°C (kept for 5 minutes), increasing at 10°C per minute up to 185ºC kept for 20 minutes) totaling 33.5 minutes of analyses. Flow drag gas in the column was 1.0 mL/minute.

At the end of the experimental periods, all animals were submitted to a 14-hour fast with water *ad libitum* and then slaughtered. Slaughter was carried out by brain concussion and bleeding, done through jugular vein section. All procedures of slaughter and data collection were identical for reference animals slaughtered at the beginning of the experiment. After slaughter of each animal, it was carried out weighing of blood, head, feet, leather, empty rumen-reticule-omasum-abomasum, intestine and viscera.

To obtain empty body weight (EBW), full gastrointestinal tract (GIT) was removed, weighed, emptied and washed in running water, weighed again, and weight of empty body of each animal was obtained.

Internal measurement of the carcass was done by considering the maximal distance among the medial anterior portion from the first rib to the medium point of pubis bone curvature.

At slaughter, it was measured hot carcass weight and carcass yield, through relationship between hot carcass weight and slaughter weight. After cooling in a cold storage chamber at 4°C for 24 hours, carcasses were weighed again for obtaining weight of cold carcass. After that, left half-carcass was removed from a section of the *longissimus dorsi* muscle between the12th and 13th ribs to measure eye-loin area and subcutaneous fat thickness. Yields of sparerib, thigh, rump, shoulder and rib of each animal were also measured.

To measure loin-eye area, a transversal cut was made in the region between the 12th and the 13th rib, and after, the plant-paper tracing was removed and the area measured. Subcutaneous fat thickness was determined on the third quarter of muscle, from the vertebral column, perpendicular to the *longissimus dorsi* muscle by using a precision ruler, according to recommendations by Tullio (2004). Calculation of loin-eye area was done in the following manner:

LEA = (sample weight × graph paper area) / paper weight, and sample weight considered as weight of the circumvented area of the loin-eye on the paper.

Animal behavior in function of the experimental diet was evaluated by the number of times that each animal went to the trough and by the permanence time. Data of access and permanence time at the trough were obtained from the electronic system of gates, which was recorded and stored in processing unit of data (CPU). Data collection was done every day always in the morning.

Means were compared by orthogonal contrasts, by using the level of significance at 5% for all procedures and for statistical analyses, the SAS program (1999).

The following contrasts were used: 1- diets with corn silage *versus* the other diets; 2- diets with *fresh* sugar cane or stored for 72 hours *versus* diets with sugar cane treated with calcium oxide or without treatment; 3- sugar cane silage *versus* sugar cane silage with 1% of calcium oxide (1% sil sugar cane); and 4 – sugar cane stored for 72 hours *versus* fresh sugar cane (sugar cane).

Results and Discussion

Nutrient intake of diet was greater (P<0.05) among animals fed diets with corn silage, probably because of the better diet composition, with lower content of indigestible neutral detergent fiber (NDFi) (Table 1), which resulted in lower (P<0.05) intake of NDFi, which in turn is directly related to rumen filling (Undersander et al., 1993). The greater neutral detergent fiber digestibility (Table 2) is also a factor that can result in a higher rumen passage rate, increasing animal intake capacity.

Diets with fresh or 72-hour stored sugar cane led the animals to a greater intake of nutrients (P<0.05) compared to diets with ensilaged sugar cane, except for intake of ether extract and NDFap in percentage of the body weight (%BW). This superiority may be attributed to a greater (P<0.05) intake of indigestible fiber (NDFi) by the animals fed ensilaged sugar cane, which was 13% superior to those fed diets with fresh sugar cane. This result can be related to products from fermentation of sugar cane during ensilage, which led to a low acceptability because of the odor or strong taste as well as because of the pH of sugar cane silage (Table 1).

The use of calcium oxide did not affect animal intake (P>0.05) of diets with sugar cane silage. Storage of sugar

Table 2 - Intake and total apparent digestibility of diets with fresh or ensilaged sugar cane or corn silage for confined bovine

Evaluated parameter	Roughage					CV%	Contrast			
	Corn silage	*Fresh* sugar cane	Sugar cane stored for 72 hours	Silage of sugar cane without treatment	Silage of sugar cane 1% treated		1	2	3	4
				Intakes (kg/day)						
Dry matter	10.09	9.03	8.86	7.63	7.20	7.7	<0.0001	<0.0001		
Organic matter	9.44	8.42	8.23	7.01	6.58	7.6	<0.0001	<0.0001		
Crude protein	1.33	1.07	1.01	1.00	0.92	6.5	<0.0001	0.0077		
Ether extract	0.32	0.16	0.19	0.17	0.17	7.3	<0.0001			
NDFap	3.94	3.16	3.20	2.63	2.63	8.9	<0.0001	0.0022		
Non-fibrous carbohydrates	4.08	4.44	4.26	3.14	3.14	7.4	0.0192	<0.0001		
Total digestible nutrients (kg)	7.58	6.81	6.31	5.25	5.15	8.3	<0.0001	<0.0001		
NDFi	1.00	1.16	1.12	1.36	1.25	6.9	<0.0001	0.0007		
Supply of concentrate	3.76	3.62	3.57	3.65	3.37	6.61				
				Intakes (%BW)						
Dry matter	2.40	2.20	2.19	1.89	1.90	9.3	0.0011	0.0011		
Neutral detergent fiber	0.93	0.77	0.79	0.73	0.70	11.5	0.0002			
NDFi	0.24	0.28	0.29	0.35	0.33	12.1	0.0002	0.0062		
				Total apparent digestibility (%)						
Dry matter	68.68	68.08	67.60	61.26	64.43	3.4	0.0040	<0.0001		0.0253
Organic matter	73.22	72.16	68.32	67.91	71.19	2.8	0.0011		0.0025	0.0083
Crude protein	74.78	71.58	74.10	73.78	74.52	2.8				
Ether extract	77.76	77.05	79.72	72.20	72.11	4.1		<0.0001		
NDFap	66.35	57.42	54.71	55.79	55.36	7.0	<0.0001			
Non-fibrous carbohydrates	80.50	85.24	79.98	79.78	85.89	4.3			0.0181	0.0070
Total digestible nutrients, %	75.12	75.35	71.25	68.82	71.42	2.6	0.0007	0.0005	0.0012	0.0289

NDFap = neutral detergent fiber corrected for ash and protein; NDFi = indigestible neutral detergent fiber. Contrasts 1 - corn silage *vs*. other treatments; 2 – fresh sugar cane *vs*. sugar cane silage (sugar cane silage + sugar cane silage with 1% of calcium oxide); 3 - sugar cane silages (sugar cane silage *vs*. sugar cane silage with 1% of calcium oxide); 4 – fresh sugar cane *vs*. sugar cane stored for 72 hours.

cane for 72 hours before supply also did not affect (P>0.05) intake of nutrients in relation to the supply of fresh sugar cane. Intakes of indigestible fiber (NDFi) were greater (P<0.05) among animals fed diets with sugar cane silage.

Considering that supply of concentrate did not differ (P>0.05) among diets, it can be inferred that differences among diets are caused by intake of roughages.

Total apparent digestibility of dry matter, organic matter, NDFap and TDN was greater (P<0.05) in animals fed diets with corn silage. However, digestibility of crude protein did not differ (P>0.05) among diets. The greatest digestibility of nutrients among animals fed diets with corn silage can be explained by the lowest contents of lignin (Table 1) of these diets, by the better quality of NDFap and by the lowest intake of NDFi, which in turn caused a greater intake.

Diets with fresh sugar cane and stored for 72 hours caused animals to present greater (P<0.05) digestibility of dry matter, ether extract and TDN in relation to those with sugar cane silage, and there was no difference (P>0.05) for digestibility of organic matter, crude protein, NDFap and non fibrous carbohydrates. Ensilage of sugar cane resulted in lower intake of NFC and greater intake of NDFi by the animals, what possibly justify the negative effect on digestibility. Sugar cane ensilaged and added with calcium oxide led animals to present greater digestibility (P<0.05) of organic matter, of non fibrous carbohydrates and of total digestible nutrients in relation to the diet without this additive. This fact evidences the action of the additive on the ensilaged material, avoiding losses of carbohydrates during fermentation and resulting in a greater content of non-fibrous carbohydrates.

Diets with fresh and crushed sugar cane and immediately given to the animals resulted in greater digestibility (P<0.05) of dry matter, organic matter, NFC and TDN in relation to that one with sugar cane stored for 72 hours, therefore, there was no effect of sugar cane storage (P>0.05) on digestibility of crude protein, ether extract and NDFap. Possibly, storage of sugar cane for 72 hours caused fermentation, resulting in losses of soluble carbohydrates and reducing content of TDN of the diet.

The best results obtained for dry matter digestibility of animals with supply of fresh sugar cane in relation to ensilaged sugar cane are in agreement with the ones reported by Baleiro Neto et al. (2009), who found greater digestibility of dry matter for fresh sugar cane (60.6%) in relation to sugar cane ensilaged with calcium oxide (51.9%) whereas digestibility of ether extract of the silage was superior to fresh sugar cane when 0.5% of calcium oxide was used in the ensilaged material.

The results obtained with ensilaged sugar cane evidence the low efficiency of calcium oxide, although the use of additives in the ensilage of sugar cane has the objective of keeping the quality of the ensilaged material, the results differ regarded to efficiency of those additives.

According to Amaral et al. (2009), the main advantage of using calcium oxide (1%) may be related to its fermentation pattern due to the buffer action of the additives, what may promote higher production of weak organic acid and greater control of aerobic deterioration. The superiority of sugar cane given fresh in relation to the ensilaged sugar cane was reported by Coan et al. (2002), who evaluated the chemical composition of the mature sugar cane and ensilaged in PVC microsilos for 55 days and observed a reduction in the value of dry matter (27.3% vs. 20.9%) and an increase on the constituents of the cell wall, with higher concentrations of NDF (42.1% vs. 54.95%), ADF (34.9% vs. 43.8%) and of lignin (6.8% vs. 7.2%) for silages in relation to fresh sugar cane. Thus, the low intake and digestibility of some constituents of the diet with sugar cane silage can be explained by the fermentative losses caused by the process of ensilage and the low effect of this additive.

Sugar cane stored for 72 hours as alternative of feed management provided satisfactory results if compared to sugar cane given fresh daily. Similar result was observed by Pina et al. (2011), who verified greater intake of ether extract and NDFap in the sugar cane stored for 3 days with or without addition of calcium oxide. This author did not observe any differences in the intake of dry matter and organic matter, crude protein and TDN. Regarded to digestibility, Pina et al. (2011) also reported decrease on digestibility of organic matter and on the content of TDN when sugar cane was stored.

The greater intake of nutrients among animals fed diets with corn silage reflected in a greater final weight of the animals, daily weight gain, empty body weight (EBW), empty body weight gain (EBWG), weight gain on the carcass and daily gain on the carcass (DGC, kg/day) in relation to the animals fed sugar cane based diet (Table 3). According to Mertens (1994), animal performance depends on digestible nutrient ingestion, so 60 to 90% of animal performance is explained by variations on the intake and only 10 to 40% are credited to digestibility.

The supply of diets with fresh sugar cane resulted in greater ($P<0.05$) intake of dry matter (%BW) in relation to the supply of ensilaged sugar cane. As a consequence, there was a greater ($P<0.05$) daily weight gain as well as empty body weight. However, there were no differences among the results obtained with the supply of these diets ($P>0.05$) for final body weight and empty body weight and gains on the carcass.

In terms of numbers, carcass gains (kg/day) were approximately 26% greater (0.65×0.52) for animals fed diets with fresh sugar cane in relation to diets with ensilaged sugar cane. The great problem of ensiling sugar cane is its great content of soluble carbohydrates and the high population of epiphyte yeast which leads to alcoholic fermentation, when sugar cane is ensilaged, occurring, in this process, excessive losses of dry matter, which are reflected on the animal performance (Schmidt et al., 2007). In a work carried out by Mari (2008), diets with ensilaged or fresh sugar cane were given to finishing Nellore animals and there were no differences among diets: animal weight gain was 0.930; 0.877 and 0.879 kg/day and dry matter intake was 1.84; 1.93 and 1.83% of body weight.

By analyzing the effects of diets with sugar cane silage, it is observed the lack of significance ($P>0.05$) on performance (Table 3). Those results evidence that the addition of calcium oxide in the ensilaged material do not improve animal performance inasmuch as the intake of nutrients was similar among diets with sugar cane silage.

The greatest EBW observed in animals fed corn silage might be due to the shortest time of permanence of the diet in the gastrointestinal tract of these animals in comparison to those fed sugar cane based diets.

Table 3 - Performance of bovine fed diets with ensilaged or fresh sugar cane and corn silage

Evaluated parameter	Roughage					CV%	Contrast			
	Corn silage	*Fresh* sugar cane	Sugar cane stored for 72 hours	Silage of sugar cane without treatment	Silage of sugar cane 1% treated		1	2	3	4
Final weight (kg)	489.0	455.6	452.7	449.2	417.6	8.6	0.0194			
Weight gain (kg/ day)	1.51	1.03	1.15	0.92	0.94	16.0	<0.0001	0.0316		
Empty body weight (kg)	434.6	393.1	385.3	376.3	357.8	8.7	0.0012			
Empty body weight gain (kg/day)	1.44	0.88	1.00	0.72	0.81	17.7	<0.0001	0.0176		
Carcass gain (kg)	78.53	51.10	59.37	42.60	45.18	24.9	<0.0001			
Carcass daily gain (kg/day)	0.93	0.61	0.70	0.50	0.54	24.9	<0.0001			

Contrast: 1 - corn silage *vs*. other treatments; 2 - fresh sugar cane stored for 72 hours *vs*. silages of sugar cane treated or not treated with 1% of calcium oxide; 3 - sugar cane silage *vs*. silage of sugar cane treated with 1% of calcium oxide; 4 - fresh sugar cane *vs*. sugar cane stored for 72 hours.

Macitelli et al. (2005) also observed this same trait in a work with diets with sugar cane, corn silage and pasture, because the weights of stomach content and gastrointestinal content were greater for animals fed sugar cane, resulting in a lower empty body weight for those animals, a fact possibly explained by the inferior quality of NDF of the sugar cane and because of its greater content of NDFi in relation to the other grasses which composed the diet.

It was not observed any effects (P>0.05) on performance of animals fed diets with fresh sugar cane and sugar cane stored for 72 hours (Table 3). Pina (2008) also did not observe effect of sugar cane storage time on dry matter intake and weight gain of Nellore heifers. The inconsistency of the results obtained by using sugar cane as roughage was commented by Abrahão et al. (2007), who did not observe any improvement on performance of the animals, even with the increase of supply of concentrate in the diet.

It was not observed any differences among groups (P>0.05) for carcass length, with a mean of 1.32 m, a trait related more to sexual class and to the breed than to the diets themselves (Table 4).

Subcutaneous fat thickness was greater (P<0.05) for animals fed diets with corn silage. This result can be explained by the greater final body weight, which resulted in an anticipated fat deposition in these animals. Animals fed sugar cane silage presented greater (P<0.05) fat thickness than those fed fresh sugar cane.

Fat is an important fraction because it influences carcass visual aspect, the quality and the edible portion of the meat, in addition to serve as a protection (subcutaneous fat) against dehydration during carcass cooling (Moletta & Restle, 1996).

Despite the greater fat thickness on carcass of animals fed corn silage diet, this degree of finishing was not able to influence water loss during carcass cooling, inasmuch as there were no differences (P>0.05) among groups. Smaller losses were observed by Silva et al. (2008), who gave sugar cane based diets for confined bovines and found average losses of 1.91% during carcass cooling, with fat cover of 2.64 mm, whereas Fernandes et al. (2007) and Brondani et al. (2006) obtained averages of 2.11 and 2.40 mm for fat thickness on the carcass. However, those results are considered to be low for market requirement for carcass quality. According to Costa et al. (2002), fat thickness required by Brazilian meat plants is from 3 to 6 mm, because at proportions inferior to 3 mm, there is a darkening of the outer part of muscles which covers the carcass, decreasing its commercial value. Probably, in order to fit subcutaneous fat thickness required by Brazilian meat plants it is necessary to use diets with greater levels of concentrate.

Values found evidenced smaller loin-eye area (P<0.05) in animals fed sugar cane silage compared to those fed fresh sugar cane diet, similar to that found by Pinto et al. (2009) in a work with diets with sugar cane and sorghum silage and concentrate set at 1.2 and 1% of body weight.

Loin-eye area expresses carcass muscularity and it is directly correlated to carcass weight (Costa et al., 2002).

Similar yields of carcass and cut confirm the law of harmony anatomical (Boccard & Dumont, 1960), that is, carcass with similar weights present almost all body regions in similar proportions at any degree of conformation.

The average number of access to the diet per animal during the day differed (P<0.05) among diets (Table 5).

Table 4 - Components and yields of carcass in bovine fed diets with fresh or ensilaged sugar cane and corn silage

Evaluated parameter	Diet roughage					CV%	Contrast		
	Corn silage	*Fresh* sugar cane	Sugar cane stored for 72 hours	Silage of sugar cane without treatment	Silage of sugar cane 1% treated		1	2	3
Carcass length (m)	1.34	1.31	1.33	1.34	1.30	4.1			
Subcutaneous fat thickness (mm)	3.43	1.28	1.37	2.31	1.58	37.1	0.0001	0.0491	
Internal organs (kg)	159.40	141.50	136.70	135.20	130.30	7.8	0.0001		
Loin-eye area (cm^2)	73.34	73.10	73.78	65.66	58.31	13.1		0.0048	
	Loss during carcass cooling								
Liquid loss (%)	2.40	2.14	2.31	2.51	2.48	13.9			
	Yield of cuts and carcass (%)								
Sparerib	23.60	23.27	24.02	23.90	24.62	6.8			
Thigh	26.51	27.83	28.03	28.09	29.11	14.3			
Rump	17.10	18.30	17.34	16.88	16.60	16.2			
shoulder	18.47	17.50	17.40	18.40	18.06	14.8			
Rib	14.41	13.25	13.71	13.61	12.33	15.8			
Carcass yield related to body weight	56.18	55.29	55.45	54.33	54.92	3.4			
Carcass yield related to empty body weight	63.33	64.02	64.32	64.03	63.53	2.6			

Contrasts: 1 - corn silage *vs*. other treatments; 2 - fresh sugar cane and stored for 72 hours *vs*. sugar cane treated or not treated with 1% of calcium oxide; 3 - sugar cane silage without treatment *vs*. silage of sugar cane treated with 1% of calcium oxide; 4 - fresh sugar cane (sugar cane) *vs*. sugar cane stored for 72 hours.

Table 5 - Food behavior of bovine kept with diets with fresh or ensilaged sugar cane and corn silage

Evaluated parameter	Diet					CV%	Contrast			
	Corn silage	*Fresh* sugar cane	Sugar cane stored for 72 hours	Silage of sugar cane without treatment	Silage of sugar cane 1% treated		1	2	3	4
Access (day)	20.26	35.54	14.42	34.28	46.77	20.5	0.0002	0.0001	0.0001	0.0018
Time (minutes)	11.34	3.89	12.73	3.50	2.52	80.4	0.0317	0.0254	0.0097	
Time minutes/day	179.4	137.2	176.4	115.3	112.8	46.8				

Contrasts: 1 – corn silage *vs*. other treatments; 2 -sugar cane fresh or stored for 72 hours *vs*. sugar cane silage without treatment and treated with calcium oxide (1%), 3 - silage of sugar cane without treatment *vs*. silage of sugar cane treated with calcium oxide (1%); 4 - fresh sugar cane *vs*. sugar cane stored for 72 hours.

Animals fed corn silage presented smaller number of average access (P<0.05) than those fed the other diets, and they also presented longer (P<0.05) permanence time per access, a characteristic that may be related to diet palatability. However, in terms of numbers, animals fed diets with sugar cane stored for 72 hours had responses close to corn silage regarded to access time, probably justified by the pleasant smell resulting from fermentation of the material, during its storage, favoring longer permanence per access of the animal to the diet.

In a comparison to animals kept with fresh sugar cane diet, it is observed that the number of access to the trough was greater (P<0.05) among animals fed diets with sugar cane silage, therefore, in this group, the average time per access was shorter (P<0.05). This fact can be explained by the lower palatability of ensilaged sugar cane, as well as by the influence of content of NDFi and by the lower nutrient digestibility, what can justify the few pieces after supply of the diets and the intermittent accesses without significant voracity observed in the groups fed corn silage. Among diets with sugar cane silage, the number of access to trough was greater (P<0.05) in the group fed diet with sugar cane plus calcium oxide, resulting in a shorter (P<0.05) permanence time per access. In the comparison between sugar cane crushed and offered fresh and the sugar cane crushed and stored for 72 hours, the smaller number of access with longer time of permanence per access to the trough (P<0.05) was observed for animals fed sugar cane stored for 72 hours.

In the evaluation of total time of access to the diets, in minutes, there was no difference (P>0.05) among groups. By correlating the number of access to dry matter intake and to weight gain, it was observed that animals fed diets with corn silage presented greater intake, weight gain and smaller number of access. By comparing the animals fed silage sugar cane, those fed fresh sugar cane diet presented greater weight gain despite the smaller number of access and the longer average time per access for the fresh sugar cane diets. Therefore, it can be inferred that diets which lead animals to present better weight gain are those in which animals present smaller number of access to the trough and longer average time for each access daily.

The use of electronic gates allows higher reliability on evaluation of access of the animal to the trough, regardless to registration time. These levels of reliability is lower in the other food behavior evaluations which use daytime notes and are influenced by the evaluators, besides they are done in 10 or 15-minute periodical times and they do not complete the 24-hour cycle, determining variations in the results.

This can be evidenced if it is compared the results obtained by Souza et al. (2007) and by Marques et al. (2007), who, from daytime evaluations observed the time spent with food ingestion by confined crossbred animals of 20, 69 and 87.3 minutes, respectively.

Overall, calcium oxide enables greater recovery of dry matter from the ensilaged material, because it was effective in reducing total losses (80%), resulting in silages with higher nutritional value at the moment of opening of silos (Santos et al., 2008). Thus, by considering economical parameters, and that the use of additive enables greater recovery of dry matter from the ensilaged material, calcium oxide is feasible as additive for ensilage of sugar cane.

Conclusions

In a comparison with sugar cane based diet, corn silage diets promote better performance of confined beef cattle. Fresh sugar cane is superior to sugar cane silage. The use of 1% of calcium oxide in the sugar cane ensilage increases recovery of ensilaged dry matter, but it does not improve animal performance. Crushed sugar cane can be stored for 72 hours before being given to the animals inasmuch as this storage time does not compromise animal performance. The greatest gain weight of confined bovine fed corn silage is correlated to the smaller number of access to trough and to the longest average time per access to the diet.

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