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The Performance of Steers Fed on Sugarcane *in natura* or Ensiled with Concentrate

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Abstract

The aim of this study was to evaluate the performance of crossbred Holstein × Zebu steers fed on the diets containing sugarcane *in natura* or ensiled with two levels of concentrate (30% and 70%). A total of 32 males of 394 kg of body weight were used in a completely randomized experimental design with four treatments and seven repetitions. The animals reported a high dry matter intake (DMI) ($P < 0.05$) when fed on the high concentrate levels. The increase in concentrate levels resulted in an approximately 25% to 60% higher DMI as compared to the lowest level offered by silage-based diets and sugarcane *in natura*. The highest apparent digestibility coefficients of dry matter were observed in the diets based on sugarcane *in natura* ($P < 0.05$). The sugarcane based diets also affected ($P > 0.05$) the digestibility of organic matter, neutral detergent fiber, crude protein, ether extract, and non-fiber carbohydrates. There were no differences ($P > 0.05$) between the diets for average daily weight gain, carcass dressing, carcass gain, and feed conversion. The diets based on sugarcane *in nature* or ensiled with 30% and 70% concentrates do not influence the performance of crossbred Holstein × Zebu cattle.

Keywords: apparent digestibility coefficients, dry matter intake, weight gain

1. Introduction

Sugarcane (*Saccharum officinarum*) is used in cattle feed in the tropical climate owing to its high production of dry materno (DM) (Silva Junior et al., 2015). Sugarcane *in natura* requires daily management, which increases the cost and hampers the management of the farm, especially the feedlots (Andrade, 2013; Siqueira et al., 2012). Although sugarcane silage is the main ingredient of the cattle diet in feedlots, the ensiling of sugarcane predominantly leads to alcoholic fermentation, which causes losses in its nutritional value. These losses are related to the high content of soluble carbohydrates and an increasing population of the epiphytic yeast (Mendes et al., 2008; Schmidt, 2006). In this regard, the use of numerous additives to control the population of yeast to reduce such losses is under study (Cezário et al., 2015). However, the addition of an inoculant may be unable to reduce the fermentation losses. According to Nússio and Scmidt (2005), an earlier study, reducing alcohol accumulation improves animal performance due to an increase in DMI, as a result of improved palatability to bovine. Therefore, the silage of sugarcane may result in a better animal performance when the fermentation is controlled (Queiroz et al., 2008).

The objective of this study was to evaluate the performance of Holstein × Zebu steers fed on the diets containing sugarcane *in natura* or ensiled with two concentrate levels.

2. Materials and Methods

2.1 Study Location

The experiment was performed at the Experiment, Research and Extension Center of Mineiro Triangle (CEPET) in the Federal University of Viçosa (UFV) in Capinopolis city, Minas Gerais State, Brazil (average altitude of 620 m, at 18°41′01″S, 49°34′00″W). The climate of the region is classified as type Aw by the Köppen classification, with hot and humid summers, dry winters, and an average annual rainfall of 1200-1600 mm.

2.2 Animal Management, Feeding, and Treatment

In total 32 crossbred Holstein × Zebu steers with a mean initial live weight (ILW) of 394 kg were studied. The animals were randomly allocated into four treatment groups with seven repetitions, totaling a trial of 99 days. The animals were identified and dewormed before the beginning of the trial.

The experimental diets are shown in (Table 1). In the sugarcane silage, 0.5% of limestone was added. Diets were isoproteic and balanced to balanced to allow a daily gain of 1.0 kg of body weight (NRC, 1996). The animals were kept in individual pens (10 m²), equipped with drinkers and feeders, and with an adaptation period of 15 days to diets. During the experimental period, animals were weighed every 28 d, after a 14-h solid food fasting to assess the mean daily weight gain (DWG). This was calculated as the difference between the latest and actual live weights divided by the number of days in the respective period.

Tabela 1. Mean chemical composition of experimental diets for organic matter (OM), crude protein (CP), ether extract (EE), non-fiber carbohydrates (NFCs), neutral detergent fiber (aNDFom-NDF), mineral matter (MM) and total carbohydrates (TC) used in different treatments

Item	Diets			
	Sugarcane *in natura*		Sugarcane silage	
	30% concentrate	70% concentrate	30 % concentrate	70% concentrate
OM	93.57	92.92	93.17	93.02
CP	11.69	11.41	11.83	11.20
EE	3.14	2.72	3.02	2.67
MM	6.43	7.08	6.83	6.98
aNDFom-NDF	38.91	36.49	39.26	35.85
NFCs	39.83	42.34	39.06	43.30
TC	78.74	78.75	78.33	79.15

Samples of the experimental diets, sugarcane, and concentrate were collected every day, and composite samples were obtained for a 28-day period. These were placed in plastic bags and stored in a freezer (-4 °C). After thawing, the samples of feed and forage were weighed and oven dried at 60 °C for 72 h. Then, the samples were processed in a Wiley® knife mill, passed through 1-mm screen sieves, and stored in plastic bags. The samples were analyzed for DM, crude protein (CP), MM according to AOAC, (1990) and EE (Thiex, 2003). The samples were also checked for neutral detergent fiber (NDF) assayed with heat stable amylase and expressed exclusive of residual ash (aNDFom-NDF), acid detergent fiber expressed exclusive of residual ash (ADFom-ADF) (Van Soest & Wine, 1967), and acid method of fiber analysis LIG (sa) (Gomes et al., 2011), after sequential extractions with neutral detergent followed by acid detergent (Van Soest, 1994). In the aNDFom-NDF analysis, a thermostable α-amylase was used without sodium sulfite (Mertens, 2002), using an Ankom® fiber extractor (Valente et al., 2015). The total carbohydrates (TC), as proposed earlier (Sniffen et al.,1992) and non-fiber carbohydrates (NFCs) in the ingredients of the diets were determined by the following equation: NFC = 100 − (%aNDFom − NDF + %CP + %EE + %MM) (Hall, 2000).

The total digestibility nutrient (TDN) was determined as mentioned earlier (Weiss, 1999), using the following equation: TDN = DCP + DaNDFom-NDF + DNFCs + 2.25DEE, where DCP stands for digestibility of crude protein); DaNDFom-NDF (digestibility of NDF); DNFCs (digestibility of non-fiber carbohydrates); DEE (digestibility of ether extract).

The apparent digestibility coefficient of nutrients with total feces collection was estimated (Schneider & Flatt, 1975).

2.3 Hot Carcass Dressing

Hot carcass dressing (HCD) was determined by calculating the ratio between hot carcass weight (HCW) (immediately after carcass trimming) and final live weight (FLW) (Lima et al., 2016) obtained at the last time when the animals were weighed after a 14-h solid food fasting (Lima et al., 2015).

2.4 Statistical Procedures and Model Evaluation

A completely random design with four treatments and seven repetitions was applied according to the Yij = μ + Ti + eij model, where Yij is the value observed in the jth experimental unit (animal) that received the ith treatment; μ is the overall mean; Ti is the fixed effect of the ith treatment; and eij is the experimental error related to the experimental unit. Data were analyzed by GLM (generalized linear models) of the SAS/STAT 9.0 software (SAS, 2001), and means were compared using Tukey's test at a 5% significance level.

3. Results and Discussions

The DMI for the cattle fed on sugarcane *in natura* with 70% concentrate was higher (P < 0.05) as compared to the DMI observed when the steers were fed on sugarcane silage with 30% concentrate as depicted in (Table 2). The lower DMI may be explained by the production of compounds from the anaerobic fermentation during the ensiling process, leading to a low acceptability of the feedstuff due to a strong flavor. High levels of acids in silage along with the lower concentration of soluble carbohydrates cause a reduction in the energy availability for microbial growth in the rumen, which results in decreased digestibility, thereby decreasing the passage rate and DMI of the animal (Russell, 2002; Krause et al., 2014; Valente et al., 2016).

Table 2. The intake of nutrients for cattle in feedlot fed with sugarcane *in natura* or sugarcane silage with two levels of concentrate in the diet

Intake	Diets				CV (%)
	Sugarcane *in natura*		Sugarcane silage		
	30% concentrate	70% concentrate	30% concentrate	70 %concentrate	
DM*	5.03b	8.07a	4.13b	5.20b	14.79
OM*	4.70b	7.52a	3.83b	4.79b	14.82
NDF*	1.35b	2.82a	1.54b	2.57a	13.16
CP*	0.64b	1.02a	0.54b	0.67b	14.86
EE*	0.19b	0.40a	0.13b	0.18b	13.57
TC*	3.87b	6.09a	3.15b	3.93b	14.89
NFCs*	2.52a	3.26a	1.61b	1.36b	16.85
DMI(%BW)	1.30b	1.93a	1.02b	1.20b	16.46

Note. Values with different superscripts in the same line are statistically different according to Tukey's test (P < 0.05); BW = body weight; CV(%) = coefficient of variation. * Kg day^{-1}.

The mean values of DMI (% BW), organic matter (OM), CP, ether extract (EE), and TC were higher (P < 0.05) for steers receiving the diet of sugarcane *in natura* with 70% concentrate. The cattle reported a higher DMI when fed on a higher level of concentrate. These results may be related to the higher digestibility of DM and consequently to the higher rate of passage due to a lower non-degradable fraction as reported by Medeiros et al. (2007). The diets with higher levels of concentrate had a higher NDF intake (P < 0.05) in relation to the others. This could possibly be attributed to the lower content of neutral detergent fiber indigestible (NDFi) in the concentrates offered, resulting in a larger fraction of NDF potential degradability, higher digestibility, and less retention time in the rumen (Figueiras et al., 2015). A study (Rode et al., 1985) reported that increasing the concentrate and reducing the NDF levels in the diet resulted in an increased apparent digestibility of DM and OM. However, another study (Grant & Mertens, 1992) reported that increasing the amount of concentrate may lead to reduced fiber digestion as a consequence of an increase in rapidly fermentable carbohydrates, which contradicts the findings of this study.

The diets with sugarcane *in natura* presented higher NFCs intake (P < 0.05) because of higher coefficients of DM digestibility. In this direction, a study (Van Soest & Wine, 1967) concluded that the intake of cattle may be influenced by the high availability of NFCs (98% to 100%). In a recent study (Missio et al., 2013), similar results were reported with higher intakes for the diets with sugarcane *in natura* in relation to the diets with hydrolyzed sugarcane with different storage times.

In a similar study on intake, the cattle fed on sugarcane *in natura* and silage (Mariz et al., 2013) reported differences in the intake of CP, EE, NDF, and NFCs but no difference for DM, %BW, and MO. Another study (Santos et al., 2011) reported the effect of diet on all intakes measured, except for the intake of ether extract. The animals fed on sugarcane *in natura* presented greater nutrient intake as well as better dry matter digestibility, ether extract, and TDN content, and a superior performance in relation to the animals fed on ensilaged sugarcane diets (Menezes et al., 2011). The diets based on sugarcane *in natura* presented a higher ($P < 0.05$) apparent digestibility of dry matter (DDM). The (Table 3) shows the mean values for nutrient digestibility and their respective coefficients of variation. A study (Pedroso et al., 2005) reported that about 68% of the soluble carbohydrates are consumed during the silage process. The ensiling process reduces the constituents of the cell wall, which results in low digestibility (Coan et al., 2002). According to Landell et al. (2002), the voluntary intake is inversely related to the NDF content of sugarcane and its digestibility. A similar value was observed (Menezes et al., 2011) for the digestibility of dry matter (DDM) of sugarcane *in natura* (68.08%) and a higher value for silage sugarcane (61.26%) than obtained in this study.

Table 3. Mean values for nutrient digestibility, total digestibility nutrient (TDN), and their respective coefficients of variation for steers fed with sugarcane *in natura* ou ensiled.

Item*	Diets					
	Sugarcane *in natura*		Sugarcane silage		Mean	CV (%)
	30% concentrate	70% concentrate	30% concentrate	70% concentrate		
DDM	66.43ab	69.35a	56.41c	57.42bc	62.40	7.64
DOM	78.97	72.62	77.99	67.15	74.18	13.21
DaNDFom-NDF	42.97	50.67	57.80	47.35	49.70	24.30
DCP	82.09	77.90	82.21	76.73	79.74	10.93
DEE	92.56	79.62	84.19	77.25	83.40	15.63
DTC	78.40	75.58	77.96	70.56	75.62	12.53
DNFCs	83.82	87.96	83.97	82.63	84.60	11.88
TDN	65.11	66.71	70.23	63.15	66.30	13.04

Note. The values with different superscripts in the same row are statistically different according to Tukey's test ($P < 0.05$); * % DM.

There were no differences ($P > 0.05$) in the digestibility coefficients of the OM, NDF, CP, EE, NFCs, TC, and TDN as shown in Table 3. These results reflected similarities between the feedstuffs in experimental diets (Table 1) and no difference ($P > 0.05$) for the DMO as presented in (Table 3).

There was no effect of the treatments ($P > 0.05$) on daily weight gain (DWG), hot carcass dressing (HCD), carcass gain, and feed conversion (Table 4). The mean for DWG was 0.79 kg day^{-1}. The mean values for HCD, carcass gain, and feed conversion were 53.32%, 0.38 kg day^{-1} and 9.35, respectively. A similar observation was made for Nellore cattle (Missio et al., 2013) with DWG = 0.79 kg day^{-1} for a diet with sugarcane in natura. However, a feed conversion of 4.77 was observed, which is better than that reported in the current study. In another study, Roman et al. (2011) observed higher average values for DWG and feed conversion (1.39 and 7.7 respectively), and similar values for HCD for sugarcane silage.

Table 4. The performance and feed efficiency of cattle fed with sugarcane *in natura* ou ensiled

Animal Performance	Diets					
	Sugarcane *in natura*		Sugarcane silage		Mean	CV (%)
	30% concentrate	70% concentrate	30% concentrate	70% concentrate		
DWG (Kg day^{-1})	0.82	0.72	0.76	0.87	0.79	61.23
HCD (%)	52.33	52.73	54.60	53.63	53.32	3.34
Carcass gain (Kg day^{-1})	0.35	0.31	0.42	0.43	0.38	86.74
Feed conversion (Kg DMI/kg gain)	9.18	12.91	7.40	7.90	9.35	56.29

Note. No statistical differences were found according to Tukey's test ($P < 0.05$).

The carcass gains (kg/day) were approximately 26% greater (0.65 × 0.52) for the animals fed on sugarcane *in natura* than the diets with ensilaged sugarcane (Menezes et al., 2011). The major problem with ensilaged sugarcane is its high content of soluble carbohydrates and a high population of epiphytic yeast, which lead to alcoholic fermentation. During the ensiling of sugarcane, an excessive loss of dry matter occurs, which is reflected in terms of animal performance. However, the evaluation of empty body weight (Macitelli et al., 2005) indicated that the beef cattle fed on sugarcane had higher weights of stomach and gastrointestinal contents, resulting in a lower empty body weight for these animals, a fact possibly could be explained by the inferior quality of NDF of the sugarcane and its greater content of NDFi in relation to the other grasses that composed the diet. However, no improvement in the performance of the animals was observed (Abrahão et al., 2007) when fed on sugarcane *in natura*, not even with a higher concentrate in the diet.

4. Conclusion

The diets based on sugarcane *in nature* or ensiled with 30% and 70% concentrates do not influence the performance of crossbred Holstein × Zebu cattle.

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Abbreviations

ADFom-ADF, acid detergent fiber expressed exclusive of residual ash; aNDFom-NDF, neutral detergent fiber assayed with a heat stable amylase and expressed exclusive of residual ash; aNDFom-NDFI, NDF intake; BW, body weight; CP, crude protein; CPI, crude protein intake; DaNDFom-NDF, digestibility of NDF; DCP, digestibility of crude protein; DEE, digestibility of ether extract; DDM, digestibility of dry matter; DNFCs, digestibility of non-fibrous carbohydrates; DM, dry matter; DMI, dry matter intake; DNFCs, digestibility of non-fiber carbohydrates; DTC, digestibility of total carbohydrates; DWG, daily weight gain; EE, ether extract; HCD, hot carcass dressing; HCW, hot carcass weight; ILW, initial live weight; LIG(sa), lignin determined by solubilization of cellulose with sulfuric acid; MM, mineral matter; NDFi, neutral detergent fiber indigestible; NFCs, non-fibrous carbohydrates; OM, organic matter; TC, total carbohydrates; TDN, total digestibility nutrient.

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