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Ingestive behavior of lactating cows fed sugarcane and crude glycerin levels on the diet

Comportamento ingestivo de vacas em lactação alimentadas com cana de açúcar e níveis de glicerina bruta na dieta

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Abstract

The crude glycerin used as feed for ruminants has drawn attention of the researchers for dealing with environmental aspects. Considering current legislation did not establish how to treat this product, this is a low cost alternative of great amount of a residue of the biodiesel production. In this study we evaluated different crude glycerin levels on ingestive behavior which were studied as the diet of lactating cows fed with sugarcane. The glycerin levels were 0, 4, 8 and 12% of the dry matter; the diet was balanced to contain enough nutrients for the maintenance and milk production of 15 kg.dia^{-1}. Sixteen (16) crossbred Holstein x Zebu cows were distributed into four 4x4 Latin Squares. The animals were submitted to observation of 24 hours every five minutes to evaluate ingestive behavior. The observation of the activities was recorded. The animal´s behavior was visually determined with five minutes of intervals to determine the times spent in idle, feeding, rumination, and were calculated patterns of feeding and rumination. The addition of glycerin to the diet did not affect the ingestive behavior parameter in lactating cows fed sugarcane, might be explained by the similarity in NDF content of diets, and up to 12% may be added of the diet's dry matter.
Key words: Feeding, rumination, idleness, time

Resumo

A utilização de glicerina bruta na alimentação de ruminantes tem atraído a atenção dos pesquisadores principalmente quanto aos aspectos ambientais. Considerando que a legislação em vigor não estabelece como tratar deste produto. Esta é uma alternativa de baixo custo e grande quantidade sendo este um resíduo da produção de biodiesel. Neste estudo foram avaliados diferentes níveis de glicerina bruta sobre o comportamento ingestivo em dietas de vacas leiteiras alimentadas com cana de açúcar. Os níveis de glicerina foram de 0, 4, 8 e 12 % de matéria seca. A dieta foi equilibrada para conter nutrientes suficientes para a mantença e produção de leite de 15 kg.dia^{-1}. Dezesseis (16) vacas mestiças Holandês x Zebu foram distribuídos em quatro quadrados latinos 4x4. Os animais foram submetidos à observação de 24 horas a cada cinco minutos para avaliar o comportamento ingestivo. O comportamento animal foi determinado visualmente com cinco minutos de intervalos para determinação do tempo despendido em

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ócio, alimentação e ruminação, e foram calculados os padrões de alimentação e ruminação. A adição de glicerina na dieta não afetou os parâmetros de comportamento ingestivo das vacas em lactação alimentadas com cana de açúcar, pode ser explicado pela semelhança no teor de FDN das dietas, e até 12% pode ser adicionado de matéria seca da dieta.
Palavras-chave: Alimentação, ruminação, ócio, tempo

Introduction

Sugarcane has been an excellent alternative for filling the fodder shortage during the dry year's season, for presenting advantages as high production of dry matter per area, low cost production in relation to the maize and sorghum cultures, and ease cultivation. Moreover, the knowledge on the use and correction of the nutritional deficiencies of this fodder has an important role on the dissemination of its use in the feeding of dairy cattle (OLIVEIRA et al., 2007).

The use of crude glycerin as feed for ruminants has drawn the attention of researchers because of the environmental aspects and considering the current legislation did not establish how to treat this product, which is an alternative of low cost and great amount as a residue of the biodiesel production.

The study of the ingestive behavior is an important tool in the evaluation of diets, making it possible to adjust the alimentary handling of the animals for attainment of better productive performance (MENDONÇA et al., 2004).

The animal performance is determined by the nutrients intake, digestibility and metabolism. The food intake might be influenced by food-related factors such as palatability, texture, visual appearance and other factors related to the animals, such as emotional state, social interactions and learning (MERTENS, 1994).

The time and the periods spent with feeding, rumination and idleness might also be influenced by physical and chemical characteristics of the diets such as time and frequency of the feed supply (MENDES NETO et al., 2007).

Ruminants, as other species, try to adjust their feed intake to the nutritional needs, especially as regards to the energy, controlled by the amount of blood metabolites and ruminal distension signaling the interruption of the momentary intake (SILVA, 2006).

This work was carried out to evaluate the ingestive behavior parameters of lactating cows fed sugarcane-based diets with different crude glycerin levels.

Materials and Methods

The experiment was carried out at Paulistinha farm, which is located in Macarani, BA. Sixteen (16) crossbred Holstein x Zebu cows were used (blood degree varying from ½ to ¾ of Holstein blood), of third or fourth lactation, with previous milk production between 3000 and 4000 kg adjusted to 300 days and with 80 to 120 days of lactation at the beginning of the experimental period. The 16 lactating cows were distributed into four 4x4 Latin squares.

The four treatments were constituted of different crude glycerin levels in the total diet. Sugarcane roughage was used (*Saccharum officinarum*), variety RB 72454, treated with 1% of a urea:ammonium sulfate mixture (9:1), in the experimental phase, after an adaptation period of all the animals with sugarcane and 0.5% of this mixture. The concentrate supplementation level was defined by the balancing of the diets to contain enough nutrients for maintenance and milk production of 15 $kg.day^{-1}$, in accordance with NRC (2001), based on bromatological analysis of the sugarcane previously made at the beginning of the adaptation period. The sugarcane total digestible nutrients (TDN) was estimated by the regression equation 74.49 TDN =

- 0.5635*FDA (r2 = 0.84), described by Cappelle et al. (2001), for roughage. All diets were calculated to be isonitrogenous and isoenergetic. The tested diets were: control (without glycerin addition); 4.00% of glycerin in the dry matter of the total diet; 8.00% of glycerin in the dry matter of the total diet and 12.00% of glycerin in the dry matter of the total diet.

The ratios of the ingredients in the concentrates are presented in Table 1, in the base of the natural matter. 70:30 roughage: concentrate ratio was found in the dry matter base for diets with estimate production of 15 kg milk.day^{-1}.

Table 1. Ratio of the ingredients in the concentrates, on the base of the natural matter.

Ingredient (%)	Glycerin level (%)			
	0	4	8	12
Maize fine flour	52.83	36.66	20.06	3.02
Crude glycerin	0	12.52	25.37	38.56
Soy bran	39.98	43.49	47.10	50.80
Mineral salt[1]	3.05	3.09	3.13	3.17
Dicalcium Phosphate	3,13	3,31	3,49	3,68
Calcitic limestone	1.01	0.93	0.85	0.77

[1]Composition: Calcium, 18.5%; Phosphorus, 9%; Magnesium, 0.4%; Sulfur, 1%; Sodium, 11.7%; Selenium, 30 ppm; Copper, 1500 ppm; Zinc, 4000 ppm; Manganese, 1200 ppm; Iodine, 150 ppm; Cobalt, 150 ppm.
Source: Elaboration of the authors.

The experiment was composed of four experimental periods with duration of 15 days; the first 10 days were considered as adaptation as recommended by Oliveira et al. (2001).

The animals were placed in individual pens provided with trough and water. The food offered was a complete mixture, two times a day, at 6am and 3pm, *ad libitum*, to allow 5% of surplus.

From 10th to the 15th day of each experimental period, the food offered and surplus were sampled. The sampled surplus and offered food, sugarcane and concentrate, were pre-dried and composed by animal based on dry weight. At the end of the experimental period the samples were ground with 1mm sieve and placed in lidded glass jar and stored for posterior analyses.

From 10th to the 15th day of each experimental period, the food offered and the surplus were weighted for intake estimate.

The chemical compositions of the diets are presented in table 2.

Table 2. Chemical composition of the diets.

	Glycerin level (%)			
	0	4	8	12
DM (%)	39.3	38.8	38.4	37.9
MO[1]	94.4	94.2	93.9	94.0
CP[1]	13.5	13.7	13.8	14.2
EE[1]	1.7	3.0	4.0	4.8
NDF[1]	52.6	52.8	54.1	53.6
NFC[1]	28.3	26.4	23.4	23.5
NDIP[2]	3.7	4.9	8.8	7.3
Lig[1]	7.7	7.2	7.3	7.9
MM[1]	5.6	5.8	6.7	6.0

DM – dry matter, OM - organic matter, CP – crude protein, EE – ether extract, MM – mineral matter, NDF - neutral detergent fiber, NFC - nonfiber carbohydrates, NDIP - neutral detergent insoluble protein, Lignin
1 - Percentage of the dry matter; 2 - Percentage of the total protein.
Source: Elaboration of the authors.

The analyses of dry matter (DM), organic matter (OM), crude protein (CP), ether extract (EE), Neutral fiber detergent (NDF), non fiber carbohydrates (NFC), neutral detergent insoluble protein (NDIP), lignin (Lig) and mineral matter (MM) of the diets were carried out according to Silva and Queiroz (2002).

All animals were submitted to 24-hour period of visual observation for evaluation of the ingestive behavior. The data collection to know the time spending in feeding, rumination and idleness activities was made on the 15th day of each period with the use of digital chronometers, handled by four observers during the period.

The observation of the activities was recorded at five-minute intervals. The determination of the number of cud chews and time spent in the rumination of each ruminal bolus were assessed on the following day using a digital chronometer. Three ruminal boluses of each animal of the experiment were evaluated by observation, in three different periods of the day (from 10am to 12pm; from 2 to 4pm; and from 7 to 9pm). The environment was maintained with artificial illumination during the night observation of animals.

The feed efficiency (FEF), the rumination efficiency (REF), the number of ruminal boluses per day (NRB), the total chewing time per day (TCT) and the number of cud chews per day (NCCnd) were obtained according to methodology described by Bürger et al. (2000).

The amount of feeding, rumination and idleness periods were calculated by the number of activity sequences observed in the spreadsheet. The daily average duration of these activity periods was calculated dividing the total duration of each activity (feeding, rumination and idleness) by the respective number of discrete periods.

The data related to the time spent with feeding, rumination and idleness, DM and NDF intake, the feeding and rumination efficiency, the total chew time, the amount of ruminal boluses regurgitated per day, the total number of chews per day, the number of chews per bolus, and the rumination time per bolus were evaluated by means of regression and variance analyses, using the Program SAEG, RIBEIRO JUNIOR (2001). The statistical models were chosen according to the significance of the regression models, using the "t" test at 5% level, and determination (R^2); the biological phenomena were also studied.

Results and Discussion

The diets did not interfere (P>0.05) in the times spend with feeding, rumination and idleness, which were 5.75; 8.40 and 9.85 hours.day^{-1}, respectively (Table 3). This result may be explained by the similarity in neutral detergent fiber (NDF) content of diets. According to Pereira et al. (2007) the time spent with feeding and rumination increases with the increase of NDF in the diet and, consequently, decrease the idleness time. Welch and Hooper (1988) affirmed that the rumination time is high related to the NDF intake (R^2=0.96).

Table 3. Means and regression of times spent with feeding, rumination and idleness in relation to the diet's glycerin level and respective determination (R^2) and variation coefficients (VC).

	Glycerin level (%)				Equation	VC
	0	4	8	12		
Feeding (h)	5.90	5.80	5.50	5.80	Ÿ= 5.75	14.12
Rumination (h)	8.18	8.00	8.70	8.71	Ÿ= 8.40	10.58
Idleness (h)	9.92	10.20	9.80	9.49	Ÿ= 9.85	14.48

Source: Elaboration of the authors.

Working with cows fed with sugarcane and different levels of concentrate, Costa et al. (2011) observed similar results to those found in this study, equal to 6.09; 5.80; 6.01 and 6.41 hours.day^{-1} for feeding; 8.80; 8.70; 8.41 and 8.24 hours.day^{-1} for rumination; and 9.11; 9.50; 9.58 and 9.38 hours.day^{-1} for idleness relating to the diets containing 0, 16, 24 and 30% of concentrate, also similar to the other treatments (P>0.05).

Working with cows fed with sugarcane, Oliveira et al. (2007) did not find differences in the cow's behavior as regards to feeding, rumination and idleness, with values equal to 4.1, 4.6 and 4.6; 7.3, 7.4 and 7.3; and 12.7, 12.0 and 12.5 hours.day^{-1}, respective diets with 0, 25 and 50% of coffee peel and soy peel in replacement to corn, respectively, in diets with 60% of roughage. The mean time found by these authors for feeding and rumination is shorter than that observed in this work, what may be caused by the high concentrate: roughage ratio, 40:60, used by the mentioned authors.

DM and NDF intake did not vary (P>0.05) with the addition of glycerin to the feed (Table 4), probably due to the low contents in the diets and because the animals did not reject glycerin – a viscous liquid that contains little palatable contaminants. Preliminary studies have shown that the addition of glycerin to diets did not affect DM and NDF intake (DONKIN et al., 2009; ZACARONI, 2010).

The absence of differentiation of DM and NDF intakes, and the time spent with feeding and rumination caused the feeding (FEF) and rumination (REF) efficiencies, both as regards DM and NDF, not differ (P>0.05). Costa et al. (2011) found a linear increase (P<0.05) for feeding and rumination efficiency, explained by the increase DM and NDF intake, and the lack of difference of the times spent with feeding and rumination.

Researching the total replacement of corn by glycerin, reaching 12.3% of glycerin in the diet, Zacaroni (2010) found an increase feeding efficiency that did not affect the intake, concluding that glycerin did not affect the palatability of dairy cows.

Pereira et al. (2007), working with different NDF contents in diet, reported that the FEF was lower when the NDF content was higher, decreasing from 2980 to 2210 g DM.h^{-1} when NDF was increased from 30 to 60% of NDF in the diet. Similar values were found in this study. The same authors found

different results when different genetic groups were compared, with lower values for purebred heifers per breeding (PC), 2260; 2780 and 2750 g of DM.h^{-1} to PC, 15/16 and 7/8 Holstein/Zebu, respectively, showing a possible difference with increased zebu blood.

Table 4. Mean values and regression equation for DM intake (DMI), NDF intake (NDFI), DM feeding efficiency (FEF) and NDF efficiency (FEF_{NDF}), DM rumination efficiency (REF) and NDF rumination efficiency (REF_{NDF}), total chewing time (TCT), number of ruminal boluses (NRB), number of cud chews per day (NMM_d) and per bolus (NMM_b), and time of rumination per bolus (TRB), in view of glycerin levels in the diet, and their respective determination coefficients (R^2) and variation coefficients (VC).

	Glycerin levels (%)				Equation	VC
	0	4	8	12		
DMI (kg.day^{-1})	16.14	16.69	16.19	15.91	Ÿ= 16.23	12.09
CNDF (kg.day^{-1})	8.48	8.72	8.69	8.45	Ÿ= 8.59	12.11
FEF (g DM.h^{-1})	2727.11	2948.46	2965.13	2691.47	Ÿ= 2833.04	18.76
FEF_{NDF} (g NDF.h^{-1})	1434.27	1557.33	1592.92	1428.38	Ÿ= 1503.22	18.90
REF (g DM.h^{-1})	1990.62	2122.22	1876.97	1851.23	Ÿ= 1960.26	16.96
REF_{NDF} (g NDF.h^{-1})	1045.62	1121.19	1008.40	983.48	Ÿ= 1039.67	16.93
TCT (h.day^{-1})	14.43	13.84	14.27	14.67	Ÿ= 10.30	10.36
NRB (n°.day^{-1})	533.37	504.08	497.70	515.56	Ÿ= 512.68	24.54
NMM_d (n°.day^{-1})	30321.15	28227.26	30886.22	30650.86	Ÿ= 30021.37	14.07
NMM_b (n°.bolus^{-1})	59.95	56.82	60.20	60.84	Ÿ= 59.45	12.57
TRB (seg.bolus^{-1})	60.65	58.71	61.61	61.19	Ÿ= 30.70	11.30

Source: Elaboration of the authors.

The total chew time (TCT), the number of rumination boluses (NRB), the number of cud chews per day (NMM_d), the number of cud chews per bolus (NMM_b) and the rumination time per bolus (TRB), did not suffer changes with the increase of glycerin in the diet (P>0.05).

In literature review, Allen (1997) reported the results of 132 treatments, average of 32 experiments to TCT, mentioning the value of 11.13 h/day, lower than the reported in this work, 14.43; 13.84; 14.27 and 14.67 for 0, 4, 8 and 12% of glycerin respectively, which may be justified by the low sugarcane quality. According to Dulphy, Remond and Theriez (1980), when the feed's cell wall constituent decreases increasing the starch content, the TCT decreases due to the resulting reduction of fiber in the diet.

Zacaroni (2010) also did not find differences in TCT with the addition of glycerin to the diet.

The number of ruminated boluses is in accordance with the amounts found in previous studies (COSTA et al., 2011; PEREIRA et al., 2007; MENDONÇA et al., 2004), not different between treatments for the lack of divergence of the time spent with rumination and the rumination time per bolus.

Pereira et al. (2007) suggested that the increased NDF level in the diet increased the feeding and rumination time, the number of cud chews per day and per bolus and the rumination time per bolus. The glycerin levels in the diet did not affect any of these parameters probably due the similarity of diets in relation to the NDF level.

The data relating to the number and time spent per period in feeding, rumination and idleness activities, and DM and NDF intake per feeding period did not differ with treatments (P>0.05). (Table 5).

Table 5. Number and average time spent per period in feeding, rumination and idleness activities and DM and NDF intake per feeding period of cows fed sugarcane and different glycerin levels.

Item	Glycerin level (%)				Equation	VC
	0	4	8	12		
	Number of periods (n/day)					
Feeding	12.75	13.13	13.31	13.31	Ÿ= 13.13	21.11
Rumination	14.25	15.56	14.94	13.56	Ÿ= 14.58	14.98
Idleness	20.50	21.31	20.81	20.81	Ÿ= 20.86	15.88
	Time spent per period (hours)					
Feeding	0.53	0.54	0.44	0.47	Ÿ= 0.50	30.46
Rumination	0.61	0.55	0.60	0.67	Ÿ= 0.60	17.75
Idleness	0.52	0.53	0.51	0.50	Ÿ= 0.52	23.85
	Average intake per feeding period (kg)					
DM	1.43	1.60	1.31	1.28	Ÿ= 1.40	30.22
NDF	0.63	0.60	0.59	0.65	Ÿ= 0.62	18.91

Source: Elaboration of the authors.

The number of feeding, rumination and idleness periods presented mean values equal to 13.13; 15.58 and 29.86 n/day, respectively, were not influenced by the diet, which can be explained by the similar chemical composition of the diet (Table 2). According to Thiago, Gill and Sissons (1992) there is an interaction between the number of feedings and the physical-chemical properties of the feeds, as feeds with similar properties need similar rumen permanence time for digestion and, therefore, the same time for ruminal filling. The ruminal emptying is one of the main feeding stimuli. Another factor to consider are the feeding times, as according to Mendes Neto et al. (2007) the change of time or frequency for the providing of the feed affects the behavior of these animals; this work strictly followed the hours of 6am and 3pm for providing the feeds.

The times spent per period of feeding, rumination and idleness were 0.50; 0.60 and 0.52 hours respectively, with no variation among diets (P>0.05). This fact may be explained by the lack of variation in the number of periods and the same amount of times spent with feeding, rumination and idleness (Table 3). Likewise, the average DM and NDF intake per period, 1.40 and 0.62 kg respectively, did not differ between the diets, which may be explained by lack of differentiation in DM and NDF intake (Table 4) and the number of feeding periods; it shall be pointed out that the animal may regulate its intake through the number of feedings and its duration, and the ingestion rate (DADO; ALLEN, 1995; GRANT; ALBRIGHT, 1995), which in terms are easily influenced by the physical-chemical characteristics of the diets, which in this work did not differ probably due to their similarity.

Therefore, the addition of glycerin to the diet did not affect the ingestive behavior of lactating cows fed sugarcane, and may be added to the level of 12% of the diet's dry matter.

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