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Feeding behavior of F1 Holstein x Zebu lactating cows fed increasing levels of banana peel

Paulo Roberto Silveira Pimentel, Vicente Ribeiro Rocha Júnior*, Marco Túlio Parrela de Melo, Joyce Cipriana Pacheco Ramos, Lucas Gabriel Cardoso and Jéssica Jordane Pereira Silva

*Universidade Estadual de Montes Claros, Avenida Reinaldo Viana, 2630, 39440-000, Janaúba, Minas Gerais, Brazil. *Author for correspondence. E-mail: vicente.rocha@unimontes.br*

ABSTRACT. This study evaluated the feeding behavior of F1 Holstein x Zebu cows fed increasing levels of banana peel. Diets contained 0, 15, 30, 45 and 60% replacement of sorghum silage with banana peel. The experimental design was two 5x5 Latin squares. Cows were subjected to visual observation after adaptation of each trial period. The times spent in feeding (4.13 to 5.58 hours day^{-1}) and in idle (10 to 12.53 hours day^{-1}) presented quadratic effect. The time spent ruminating, number and duration of rumination periods, chews per cud, and numbers of cuds per day were not affected by treatments. The total chewing time showed a quadratic effect, with peak at 18.58% replacement. The banana peel levels did not affect consumption, rumination and chewing neutral detergent fiber. Intake, rumination and chewing of dry matter showed a decreasing linear effect. The replacement of sorghum silage with banana peel up to 60% in the diet for lactating cows reduces the time spent in feeding and improves feeding and rumination efficiencies of dry matter, keeping the milk production of cows.

Keywords: banana plantations, co-product, ethology, animal nutrition.

Comportamento ingestivo de vacas F1 Holandesas x Zebu em lactação alimentadas com crescentes níveis de casca de banana

RESUMO. Este trabalho foi realizado para avaliar o comportamento ingestivo de vacas F1 Holandesas x Zebu alimentadas com crescentes níveis de casca de banana. As dietas foram constituídas de 0, 15, 30, 45 e 60% de substituição da silagem de sorgo pela casca. O delineamento experimental foi dois quadrados latinos 5 x 5. As vacas foram submetidas à observação visual após período de adaptação de cada período experimental. Os tempos despendidos com alimentação (4,13 a 5,58 horas dia^{-1}) e ócio (10 a 12,53 horas dia^{-1}) apresentaram efeito quadrático. O tempo gasto com ruminação, número e duração dos períodos de ruminação, mastigações por bolo e bolos ruminados por dia não foram influenciados pelos níveis de casca. O tempo total de mastigação apresentou efeito quadrático, com ponto máximo no nível de 18,58%. Os níveis de casca de banana não influenciaram consumo, ruminação nem mastigação da fibra em detergente neutro. Consumo, ruminação e mastigação da matéria seca apresentaram efeito linear decrescente. A substituição da silagem de sorgo em até 60% por casca de banana na dieta de vacas em lactação reduz o tempo de alimentação e melhora as eficiências de alimentação e ruminação da matéria seca, mantendo a produção de leite das vacas.

Palavras-chave: bananicultura, coproduto, etologia, nutrição animal.

Introduction

Supplementation of animals during scarcity periods with the supply of conserved forages and/or concentrates, aiming to correct nutritional deficiencies, usually increases production costs and reduces profitability (Nunes, Zanine, Machado, & Carvalho, 2009; Silva et al., 2010). In this way, an option that has been explored is the replacement of conventional food with agribusiness co-products.

Banana peel has high nutritional value, representing a rich source of carbohydrates, especially pectin (10-21%), highly rumen-fermentation carbohydrate (Mohapatra, Mishra, & Sutar, 2010). It has also high content of soluble carbohydrates, which can reach 32.4% dry matter depending on the cultivar (Emaga et al., 2011); fats with a relevant fatty acid profile and ether extract content ranging from 2 to 10.9% (Mohapatra et al., 2010), consisting mainly of linoleic and α-linolenic acids (Emaga, Andrianaivo, Wathelet, Tchango, & Paquot, 2007; Emaga et al., 2011). Its composition has a high content of flavonoid compounds, in particular gallocatechin (Someya, Yoshiki, & Okubo, 2002), which has anti-inflammatory, antimicrobial and antioxidant activities (Havsteen, 2002).

Besides the use of banana peel as an alternative food source in ruminant feed (Souza et al., 2016), one of the most important aspects of its use is associated with reduced environmental impact caused by the disposal of this waste in nature, since the small agribusinesses lack resources for treatment and proper disposal, which is often discarded in the open (Monção et al., 2014; Oliveira et al., 2014). Brazil is the world's leading consumer of banana and ranks fourth in world production, behind India, China and the Philippines.

Considering the different chemical and physical composition from conventional foods, the use of alternative food should be accompanied by assessments of the feeding behavior of the animals, as these serve as a tool for evaluating diets, allowing feeding management to achieve better performance, as cattle respond differently to various types of food, changing the feeding habits and production levels (Antunes et al., 2014; Pina et al., 2006; Riaz, Südekum, Clauss, & Jayanegara, 2014; Campana et al., 2015; Pimentel et al., 2015; Silva et al., 2005a; b).

Given the above, this study was conducted to evaluate the feeding behavior of F1 Holstein x Zebu lactating cows fed increasing levels of banana peel in the diet.

Material and methods

The experiment was conducted at the Experimental Farm of the State University of Montes Claros – UNIMONTES, in the municipality of Janaúba, northern state of Minas Gerais. We used 10 F1 Holstein x Zebu cows with 70 ± 11 days in milking at the beginning of the experiment. The experimental design consisted of two 5X5 Latin squares, simultaneous, each composed of five animals, five treatments and five experimental periods. Five experimental diets were used, as follows: sorghum silage without the inclusion of banana peel; inclusion of 15, 30, 45 and 60% of the banana peel replacing sorghum silage. The replacement of sorghum silage with banana peel was made on a dry matter basis. The forage: concentrate ratio was 70: 30 for the five diets.

The experiment lasted 80 days, divided into five periods of 16 days; the first 12 days of each period were used for adaptation of animals to diets and the last four days, to collect data and samples. Diets were prepared to be isonitrogenous, for cows with an average of 500 kg body weight and average milk production of 15 kg corrected for 3.5% fat day^{-1}, and were given to the cows twice a day at 07h00 and 14h00, in a complete diet system.

Banana peels were obtained from Nutrephos Norte Indústria e Comércio Ltda, in the municipality of Janaúba, and were characterized by being derived from mature fruit and mostly from the cultivar Prata – Anã, which had a dry matter content of 10.32 ± 1%. Peels were previously dehydrated by sun exposure for 12 ± 3 days, in the period between August and November, with average temperature, average relative humidity and average rainfall of 25.4°C, 44.6% and 0.91 mm, respectively. After the dehydration, peels were ground in a stationary shredder to 3 to 4 centimeters particle size and stored in nylon bags for storage in a shed.

Feed offered daily was weighed on a digital scale (Micheletti, *e* = 0.05 kg) and the supply was adjusted to allow 5% leftovers. The proportion of ingredients used in the diets and the chemical composition are listed in Table 1 and the composition of ingredients in Table 2.

Table 1. Proportion of ingredients of the experimental diets and chemical composition of the diets, on a dry matter basis.

Ingredients	Levels of replacement of sorghum silage with banana peel (%)				
	0	15	30	45	60
Sorghum silage	70	59.5	49	38.5	28
Banana peel	0	10.5	21	31.5	42
Soybean meal	17.31	17.29	17.27	17.24	17.22
Ground corn	11.73	11.75	11.77	11.8	11.82
Mineral supplement(1)	0.96	0.96	0.96	0.96	0.96
Chemical Composition (%)					
Dry matter	50.55	56.26	61.97	67.68	73.39
Mineral matter	6.64	7.33	8.02	8.71	9.4
Crude protein	13.65	13.89	14.12	14.35	14.58
NDIN(2)	0.35	0.39	0.43	0.47	0.51
ADIN(3)	0.19	0.21	0.23	0.25	0.27
Ether extract	2.83	3.28	3.74	4.19	4.64
NFC(4)	20.70	22.16	23.61	25.07	26.52
NDF(5)	57.30	55.05	52.79	50.54	48.28
NDFcp(6)	56.38	53.55	50.72	47.90	45.07
ADF(7)	30.81	29.75	28.70	27.65	26.59
Lignin	7.51	7.59	7.66	7.74	7.82

(1)Guarantee levels per kg product: calcium (128 g min)(157 g max), phosphorus (100 g min^{-1}), sodium (120 g min.$^{-1}$), magnesium (15 g), sulfur (33 g), cobalt (135 mg), copper (2160 mg), iron (938 mg), iodine (160 mg), manganese (1800 mg), selenium (34 mg), zinc (5760 mg), fluorine (1000 mg); (2)NDIN = neutral detergent insoluble nitrogen; (3)ADIN = acid detergent insoluble nitrogen; (4)NFC = Non-fiber carbohydrates; (5)NDF = Neutral detergent fiber; (6)NDFcP = Neutral detergent fiber corrected for ash and protein; (7)ADF = Acid detergent fiber.

Cows were kept in individual stalls and milked with milking machine (Balde ao Pé DeLaval Model DVP 340) twice a day, at 8h00 and 15h00. We used the presence of the calf to stimulate the flow of milk and immediately after milking the calves remained with their dams for feeding the residual milk.

During the last four days of each experimental period, milk production per cow was recorded. Milk yield corrected for 3.5% fat was estimated using the equation proposed by Sklan, Ashkenazi, Braun, Devorin, and Tabori (1992). Also in the last four days of each period, samples of the diet provided and the leftovers were collected each morning and stored in a freezer. At the end of the experiment, a composite sample was made per animal and per period, which was pre-dried in a forced ventilation oven (Nova Ética) at 55°C for 72 hours. Subsequently, all samples were ground in a Wiley knife mill (TE-6500/Tecnal) with a 1 mm sieve, for laboratory analysis.

Table 2. Chemical composition of ingredients of the experimental diets, on a dry matter basis.

	Chemical Composition (%)			
Items	Sorghum silage	Sun dried banana peel	Ground corn	Soybean meal
Dry matter	33.39	87.76	90.44	90.32
Mineral matter	6.13	12.71	1.53	7.00
Crude protein	5.99	8.28	9.10	48.50
NDIN(1)	0.31	0.69	0.42	0.49
ADIN(2)	0.22	0.41	0.06	0.18
Ether extract	1.94	6.25	4.76	5.29
NFC(3)	1.94	31.46	46.92	16.33
NDF(4)	69.45	47.92	22.53	15.22
NDFcp(5)	68.27	41.3	22.29	14.99
ADF(6)	39.84	29.83	6.18	12.67
Lignin	9.52	10.25	3.13	2.76

(1)NDIN = neutral detergent insoluble nitrogen;(2)ADIN = acid detergent insoluble nitrogen; (3)NFC = Non-fiber carbohydrates; (4)NDF = Neutral detergent fiber; (5)FDNcp = Neutral detergent fiber corrected for ash and protein; (6)ADF = Acid detergent fiber.

The chemical composition of food provided and the leftovers were determined at the Food Analysis Laboratory, Department of Agricultural Sciences of UNIMONTES, Campus Janaúba. Analyses of dry matter, crude protein, lignin by acid hydrolysis method, ether extract, ash, neutral detergent fiber and acid detergent fiber, with the necessary corrections for ash and protein, neutral and acid detergent insoluble nitrogen were performed according to procedures described by Detmann et al. (2012). The non-fiber carbohydrates (NFC) were calculated according to the equation described by Detmann and Valadares Filho (2010).

The ten cows were subjected to visual observation by a single observer for evaluation of the feeding behavior in two consecutive days of each trial period, after adaptation for 12 days. On the first day, it was made visual observation of each animal every 5 minutes, when it was recorded the activities of feeding, rumination or idle. This assessment was performed for 24 hours for determination of time spent in feeding (AT), ruminating (RT) and idle (IT). The number of periods feeding (NPF), ruminating (NPR) and in idleness (NIP) and the duration of periods feeding (DPF), ruminating (DPR) and in idleness (DPI) were calculated from the data recorded, according to the methodology described by Johnson and Combs (1991) and used by Silva et al. (2008).

On the next day, we counted the number of chews per cud and determined the time spent ruminating each cud, for each animal, using a digital stopwatch. The values of the time spent and the number of chews per cud were obtained from observations made during rumination of three cuds in three different periods of the day (10 to 12h; 13 to 15h and 18 to 20h) according to the methodology described by Bürger et al. (2000). During the night observation, the environment was maintained with artificial lighting, set three days before the feeding behavior assessment for adaptation of the animals. The time of dry matter intake (TCDM) was calculated by dividing AT by dry matter intake (DMI) and time of neutral detergent fiber intake (TCNDF) was calculated by dividing AT by neutral detergent fiber intake (NDFI), given in minutes kg^{-1}. Rumination of dry matter (RDM) was calculated by dividing RT by DMI; rumination of neutral detergent fiber (RNDF) by dividing the RT by NDFI; chewing of dry matter (CDM) by dividing the total chewing time (TCT) by DMI, and the chewing of neutral detergent fiber (CNDF) by dividing TCT by NDFI, in minutes kg^{-1}.

Feeding efficiency (FE), rumination efficiency (RE), the number of cuds ruminated per day (NCR), TCT and the number of cud chews per day (NCC day^{-1}) were obtained according to Burger et al. (2000). Data on the feeding behavior were obtained by the relationship: FEDM= DMI (g)/AT (h); FENDF= NDFI (g)/AT (h); REDM= DMI (g)/RT (h); RENDF= NDFI (g)/RT (h); TCT = AT (h day^{-1}) + RT (h day^{-1}); NCC = RT (h day^{-1}) /TCC(h cud^{-1}); NC day^{-1} = NRC x NC cud^{-1}.

Where:

FEDM; FENDF = Feeding efficiency (g DM h^{-1}); (g NDF/h); DMI = DM intake; AT = time spent in feeding; REDM; RENDF = rumination efficiency (g DM h^{-1}; g NDF h^{-1}); RT = rumination time; TCT = total chewing time (h day^{-1}); NCR = number of cuds ruminated (number day^{-1}); TCC = time of cud chews per cud; NCC day^{-1} = number of cud chews per day (number day^{-1}); NCC/cud = number of cud chews per cud (number cud^{-1}).

Data were tested by analysis of variance using SISVAR software (Ferreira, 2011); the initial weight of the animals was set as a covariate. Whenever significant, the means of the treatments were subjected to regression analysis at 5% probability.

Results and discussion

Time spent in feeding and idle, expressed in hours day^{-1}, of cows fed increasing levels of sun-dried banana peel showed a quadratic behavior; with the peak for the time spent feeding at the level of

17.3% peel and minimum for time spent in idle at the level of 18.5% peel replacing sorghum silage (Table 3).

The quadratic effect found for the feeding time is explained by the quadratic behavior exhibited by dry matter intake in kg day^{-1} (Table 4). As behavioral activities are mutually exclusive (Santana Junior et al., 2013), the time in idle was opposite to feeding time.

According to Martins et al. (2011), the times spent in feeding and idle have positive and negative correlation, respectively, with milk production. However, this was not evidenced herein, since the milk production of cows was similar for different levels of banana peel (Table 6). This is probably because of cattle ability to adapt to various feeding and management conditions, by modifying the parameters of feeding behavior to reach and maintain a certain level of consumption consistent with the nutritional requirements (Cirne et al., 2014).

Time spent in rumination was similar between the levels of banana peel (Table 3), although the intake of NDF has reduced from 9.62 to 8.51 kg day^{-1} in the diet with 60% peel replacing silage (Table 4). With the reduction in the intake of NDF, it was expected a reduction in rumination time, since the greater the participation of fiber in the diet, the longer the time required for completion of rumination process (Silva et al., 2015).

A possible explanation for this result may be because diets containing banana peel have higher lignin content (Table 1), which reduces the quality of NDF and implies longer rumination time. Hypothetically, this fact associated with lower intake of NDF in the diets with banana peel (Table 4) led to a balance in the time spent with rumination between the levels of banana peel. Similarly, the same was observed with the number and length of periods of rumination, showing no effect depending on the banana peel levels replacing sorghum silage.

The inclusion of banana peel in the diet caused no change in the number of feeding periods. However, the duration of the feeding period was reduced by 0.0878 minutes for each percentage unit banana peel replacing silage (Table 3). The inclusion of banana peel in the diet to replace silage reduced the intake of neutral detergent fiber (Table 4), which probably resulted in shorter feeding periods, since according to Missio et al. (2010), the time spent in feeding increases with the increase of NDF in the diet.

For each percentage unit of banana peel replacing sorghum silage there was an increase of 0.0827 periods in idle (Table 3). The length of period in idleness presented a quadratic effect with the minimum point at the level of 32.9% inclusion of sun-dried banana peel. This was probably due to the adaptation of animals to feeding condition imposed.

There was no significant effect of levels of inclusion of banana peel on the number of chews per cud and per minute, nor on the number of cud chews, and cuds ruminated per day, which can be explained by the rumination time (Table 3), which was not affected by the levels of replacement of sorghum silage with banana peel. Nevertheless, each percentage unit of banana peel added to the diet resulted in a reduction of 0.0768 seconds in the chewing time per ruminated cud (Table 5). This can be explained by lower intake of neutral detergent fiber in diets containing sun-dried banana peel (Table 4) because the smaller the amount of fiber, the lower the need to chew to break the fiber (Santana Junior et al., 2013).

In relation to the total chewing time, this presented a quadratic effect with the addition of banana peel, with a peak at the level of 18.6% substitution. This occurred because of the similarity between the time spent in rumination and quadratic effect presented by the feeding time, once the total chewing time was obtained by the sum of the time spent in feeding and ruminating during 24 hours.

Pereira, Cunha, Cecon and Faria (2007) evaluated the feeding behavior of dairy heifers fed diets containing different levels of fiber and detected longer total chewing time when the animals were given diet with higher content of NDF (60%), corroborating with our findings.

The levels of replacement of sorghum silage with banana peel did not affect intake, rumination and chewing the NDF, expressed in kg min^{-1} (Table 4).

With respect to the dry matter, it showed a decreasing linear effect; for each percentage unit of banana peel replacing silage there was a reduction of 0.0794, 0.0822 and 0.1616 minutes per kilogram in intake, rumination and chewing of dry matter, respectively (Table 4).

The dry matter intake, expressed in minutes per kilogram, followed the same pattern of the feeding time, in hours. This indicates that the higher dry matter content in diets containing banana peel allowed a greater capture of dry matter per bite, which resulted in shorter time in feeding per kilogram of dry matter ingested.

The reduction in the time spent in dry matter rumination accompanied the decrease in NDF intake with increasing levels of banana peel in the diet for cows (Table 4).

The reduction in the amount of dry matter chewed per minute is justified by greater consumption in diets containing banana peel associated with shorter time spent in feeding, highlighting that the time spent with rumination was not different between the banana peel levels (Table 3).

Table 3. Average time spent in feeding (AT), ruminating (RT) and idle (IT), in hours day^{-1}; number of periods of feeding (NPF), rumination (NPR) and idle (NPI), in number day^{-1}; duration of periods of feeding (DPF), rumination (DPR) and idle (DPI), in minutes period^{-1}, coefficient of variation (CV) and respective regression equations (RE) according to levels of replacement of sorghum silage with sun-dried banana peel in the diets.

Items	Levels of replacement of sorghum silage with banana peel (%DM)					CV	RE	Pr > Fc
	0	15	30	45	60			
AT	5.35	5.58	5.46	4.98	4.13	9.36	1	0.0001
RT	8.22	8.31	8.39	8.09	7.25	11.85	$\hat{Y}$=8.05	0.0759
IT	10.49	10.00	10.18	11.02	12.53	10.67	2	0.0002
NPF	11.50	12.70	12.60	11.80	11.30	11.03	$\hat{Y}$=11.98	0.0769
NPR	17.10	16.50	17.00	17.90	15.50	18.29	$\hat{Y}$=16.80	0.5185
NPI	20.52	21.76	23.00	24.24	25.48	17.54	3	0.0404
DPF	28.34	27.02	25.70	24.39	23.07	11.68	4	0.0026
DPR	30.07	30.54	30.16	28.09	27.59	17.05	$\hat{Y}$=29.29	0.5780
DPI	32.29	28.06	26.33	27.11	30.39	18.60	5	0.0428

[1]$\hat{Y}$= 5.347144 + 0.027714X – 0.000799 (R^2 = 0.94); [2]$\hat{Y}$= 10.487618 + -0.054571X –0.001476X^2 (R^2 = 0.99); [3]$\hat{Y}$= 20.520000 + 0.082667X (R^2 = 0.83); [4]$\hat{Y}$= 28.338311 – 0.087829X (R^2 = 0.99); [5]$\hat{Y}$= 32.293592 – 0.365620X + 0.005564X^2 (R^2 = 0.75).

Table 4. Dry matter intake, neutral detergent fiber, dry matter rumination, neutral detergent fiber rumination, dry matter chewing and neutral detergent fiber chewing, coefficient of variation (CV) and respective regression equations (RE) according to levels of replacement of sorghum silage with sun-dried banana peel in the diets.

Items	Levels of replacement of sorghum silage with banana peel (%DM)					CV	RE	Pr>Fc
	0	15	30	45	60			
				Intake (Min kg^{-1})				
DM*	19.09	17.90	16.71	15.52	14.33	10.37	1	0.0001
NDF**	34.04	37.96	34.15	32.64	32.78	12.16	$\hat{Y}$ = 34.31	0.0502
				Intake (kg day^{-1})				
DM	17.37	18.64	19.29	19.32	18.74	8.83	2	0.0335
NDF	9.62	9.34	9.07	8.79	8.51	8.75	3	0.0018
				Rumination (Min kg^{-1})				
DM	28.33	27.10	25.87	24.63	23.39	11.38	4	0.0047
NDF	52.39	54.27	52.48	53.91	52.62	11.08	$\hat{Y}$ = 53.13	0.9217
				Chewing (Min kg^{-1})				
DM	47.43	45.00	42.58	40.15	37.73	6.99	5	0.0001
NDF	86.42	92.23	86.63	86.54	85.40	6.85	$\hat{Y}$ = 87.44	0.1092

[1]$\hat{Y}$= 19.094968 -0.079424X (R^2 = 79.81); [2]$\hat{Y}$= 17.365207 + 0.105793X – 0.001381X^2 (R^2 = 0.78); [3]$\hat{Y}$= 9.6224 – 0.0185X (R^2 = 0.87); [4]$\hat{Y}$= 28.331816 - 0.082208X (R^2 = 95.31); [5]$\hat{Y}$= 47.426778 -0.161632X (R^2 = 89.49); *Dry matter; **Neutral detergent fiber.

The replacement levels of silage with banana peel influenced the feeding efficiency of dry matter and neutral detergent fiber, with a linear effect for dry matter, with increase of 20.73 grams hour^{-1} for each percentage unit of banana peel, and a quadratic effect for neutral detergent fiber, with a minimum value at the level of 15.19% replacement (Table 6). The higher feeding efficiency of dry matter in the diets containing banana peel is justified by the increased intake in these diets in a shorter time interval (Table 3), and also by the increase in DM content of diets with increasing levels of replacement of silage with peel (Table 1).

Regarding the feeding efficiency of NDF, the NDF intake reduced from 9.62 in the control diet to 8.51 kg day^{-1} in the diet with 60% replacement of silage with peel, however, the feeding time also decreased in diets containing peel (Table 3). Possibly, as the reduction in feeding time is more pronounced than the reduction in NDF intake, this has contributed to a greater feeding efficiency of NDF in the diets with 60% of banana peel in relation to the control diet (no banana peel).

The rumination efficiency of NDF was not affected by banana peel levels, in turn, rumination efficiency of dry matter was different between levels of banana peel replacing sorghum silage, with increasing linear effect with an increase of 9.04 grams dry matter ruminated hour^{-1} for every percentage unit of banana peel replacing sorghum silage (Table 6).

The rumination efficiency of dry matter is positively influenced by increasing levels of dry matter in the diet (Silva et al., 2005a; b). Importantly, the DM content increased from 50.55% in the control diet (no banana peel) to 73.39% in the diet with 60% banana peel replacing sorghum silage (Table 1). Furthermore, probably, the lowest NDF intake provided by the inclusion of peel contributed to the higher rumination efficiency of dry matter. Despite the reduction in feeding time (Table 3), the increased inclusion of banana peel in the diet for cows, allowed the increase in feeding and rumination efficiencies of DM in g hour^{-1} and DM intake in kg day^{-1} presented a quadratic behavior with peak at the level of 38.3% replacement (Table 4), which possibly contributed to the maintenance of milk production, which was similar between treatments (Table 6).

Table 5. Chewing time per cud (CT cud^{-1}) expressed in seconds per cud, number of cud chews per cud (NCC cud^{-1}), number of cud chews per minute (NCC min^{-1}), number of cud chews per day (NCC day^{-1}), number of cuds ruminated per day (NCR day^{-1}), total chewing time (TCT) in hours day^{-1}, coefficient of variation (CV) and respective regression equations (RE) according to levels of replacement of sorghum silage with sun-dried banana peel in the diets for F1 Holstein x Zebu lactating cows.

Items	Levels of replacement of sorghum silage with banana peel (%DM)					CV	RE	Pr>Fc
	0	15	30	45	60			
CT cud^{-1}	57.50	56.35	56.20	54.04	52.89	7.32	1	0.0351
NCC cud^{-1}	56.78	55.77	54.30	55.45	52.11	7.69	$\hat{Y}$=54.89	0.1553
NCCmin^{-1}	58.42	59.59	60.07	59.16	59.20	5.45	$\hat{Y}$=59.29	0.8363
NCC day^{-1}	28.910.70	29.958.01	30.340.65	28.782.31	26.138.83	14.00	$\hat{Y}$=28826.10	0.1836
NCR day^{-1}	524.79	546.26	564.63	532.10	499.23	15.66	$\hat{Y}$=533.40	0.5019
TCT h^{-1}	13.51	14.01	13.83	12.97	11.43	8.78	2	0.0001

[1]$\hat{Y}$ = 57.500600 - 0.076807X (R2 = 78.89); [2]$\hat{Y}$ = 13.507382 +0.056238X-0.001513X^2 (R^2 = 99.66).

Table 6. Feeding efficiency of dry matter (DM) and neutral detergent fiber (NDF), rumination efficiency of dry matter, rumination efficiency of NDF expressed in grams $hour^{-1}$, milk production corrected for 3.5% fat day^{-1} (MPC), coefficient of variation (CV) and respective regression equations (RE) according to levels of replacement of sorghum silage with sun-dried banana peel in the diets.

Items	Levels of replacement of sorghum silage with banana peel (%DM)					CV	RE	Pr>Fc
	0	15	30	45	60			
			Feeding efficiency (g $hour^{-1}$)					
DM	3158.2	3469.2	3780.1	4091.1	4402.0	11.3	1	0.0001
NDF	1766.5	1737.1	1765.0	1850.2	1992.6	11.1	2	0.0050
			Rumination efficiency (g $hour^{-1}$)					
DM	2124.3	2259.9	2395.5	2531.1	2666.7	17.8	3	0.0381
NDF	1163.8	1143.2	1152.0	1123.0	1197.5	15.7	$\hat{Y}$=1155.9	0.9174
			Milk production (kg day^{-1})					
MPC	16.80	16.39	16.25	16.54	16.49	7.18	$\hat{Y}$=16.49	0.8812

[1]$\hat{Y}$= 3158.204192 + 20.730186X (R^2 = 82.89); [2]$\hat{Y}$= 1766.458884 - 3.864705X + 0.127238X^2 (R^2 = 68.61); [3]$\hat{Y}$= 2124.313116 + 9.040406X (R^2 = 87.89).

Conclusion

The replacement of sorghum silage up to 60% with banana peel in the diet for F1 Holstein x Zebu lactating cows, with 70:30 forage: concentrate ratio, reduces the time spent in feeding, however, improves feeding and rumination efficiencies of dry matter, maintaining milk production of the cows.

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References

Antunes, A. P. S., Rocha Junior, V. R., Ruas, J. R. M., Caldeira, L. A., Oliveira, L. M., Souza, V. M., ... Silva, D. A. (2014). Characteristics of the ingestive behavior and milk production of F1 Holstein x Zebu cows fed with diets containing increasing levels of urea. *Revista Brasileira de Ciência Veterinária, 21*(3), p.192-198.

Bürger, P. J., Pereira, J. C., Queiroz, A. C., Coelho, J. F., Agostini, P. S., Valadares Filho, S. C., ... Casali, A. D. P. (2000). Comportamento ingestivo em bezerros holandeses alimentados com dietas contendo diferentes níveis de concentrado. *Revista Brasileira de Zootecnia, 29*(1), 236-242.

Campana, L. L., Modesto, E. C., Barros, A. C. C. d., Zanella, P. G., Carvalho, C. A. B., & Camargo Filho, S. T. (2015). Ingestive behavior of crossbred heifers in four seasons related to the structure of stargrass pasture. *Acta Scientiarum. Animal Sciences, 37*(1), 67-72.

Cirne, L. G. A., Oliveira, G. J. C., Jaeger, S. M. P. L., Bagaldo, A. R., Leite, M. C. P., Rocha, N., ... Oliveira, P. A. (2014). Comportamento ingestivo de cordeiros em confinamento, alimentados com dieta exclusiva de concentrado com diferentes porcentagens de proteína. *Arquivo Brasileiro de Medicina Veterinaria e Zootecnia, 66*(1), 229-234.

Detmann, E., & Valadares Filho, S. C. (2010). On the estimation of non-fibrous carbohydrates in feeds and diets. *Arquivo Brasileiro de Medicina Veterinaria e Zootecnia, 62*(4), 980-984.

Detmann, E., Souza, M., Valadares Filho, S., Queiroz, A., Berchielli, T., Saliba, E., ... Azevedo, J. (2012). *Métodos para análise de alimentos*. Viçosa, MG: Suprema.

Emaga, T. H., Andrianaivo, R. H., Wathelet, B., Tchango, J. T., & Paquot, M. (2007). Effects of the stage of maturation and varieties on the chemical composition of banana and plantain peels. *Food Chemistry, 103*(2), 590-600.

Emaga, T. H., Bindelle, J., Agneesens, R., Buldgen, A., Wathelet, B., & Paquot, M. (2011). Ripening influences banana and plantain peels composition and energy content. *Tropical Animal Health and Production, 43*(1), 171-177.

Ferreira, D. F. (2011). SISVAR: A Computer Statistical Analysis System. *Ciencia e Agrotecnologia, 35*(6), 1039-1042.

Havsteen, B. H. (2002). The biochemistry and medical significance of the flavonoids. *Pharmacology & Therapeutics, 96*(2), 67-202.

Johnson, T. R., & Combs, D. K. (1991). Effects of prepartum diet, inert rumen bulk, and dietary polyethylene glycol on dry matter intake of lactating dairy cows. *Journal of Dairy Science, 74*(3), 933-944.

Martins, S. C. S. G., Rocha Júnior, V. R., Caldeira, L. A., Pires, D. A. A., Barros, I. C., Sales, E. C. J., ... Oliveira,

C. R. (2011). Consumo, digestibilidade, produção de leite e análise econômica de dietas com diferentes volumosos. *Revista Brasileira de Saúde e Produção Animal, 12*(3), 691-708.

Missio, R. L., Brondani, I. L., Filho, D. C. A., Silveira, M. F., Freitas, L. S., & Restle, J. (2010). Comportamento ingestivo de tourinhos terminados em confinamento, alimentados com diferentes níveis de concentrado na dieta. *Revista Brasileira de Zootecnia, 39*(7), 1571-1578.

Mohapatra, D., Mishra, S., & Sutar, N. (2010). Banana and its by-product utilization: an overview. *Journal of Scientific & Industrial Research, 69*(5), 323-329.

Monção, F. P., Tavares, S. R., Rigueira, J. P. S., Sales, E. C. J., Geraseev, L. C., Alves, D. D., ... Oliveira, E. R. (2014). Caracterização físico-quimica da casca de banana tratada com óxido de cálcio. *Revista Agrarian,* 7(24), 339-347.

Nunes, H., Zanine, A. M., Machado, T. M. M., & Carvalho, F. C. (2009). Foods alternative in diet of sheep. *Archivos Latinoamericanos de Producción Animal, 15*(4), 141-151.

Oliveira, E. R., Monção, F. P., Gordin, C. L., Araújo, G. A. M., Lempp, B., Santos, M. V., ... Moura, L. V. (2014). Degradabilidade ruminal da matéria seca de folhas e colmo de genótipos de *Cynodon spp*. em quatro idades de rebrota. *Semina: Ciências Agrárias, 35*(5), 2659-2672.

Pereira, J. C., Cunha, D. d. N. F. V. d., Cecon, P. R., & Faria, E. d. S. (2007). Comportamento ingestivo e taxa de passagem de partículas em novilhas leiteiras de diferentes grupos genéticos submetidas a dietas com diferentes níveis de fibra. *Revista Brasileira de Zootecnia, 36*(6), 2134-2142.

Pimentel, L. R., Silva, F. F., Silva, R. R., Schio, A. R., Rodrigues, E. S. d. O., & Oliveira, P. A. (2015). Feeding behavior of lactating cows fed palm kernel cake in the diet. *Acta Scientiarum. Animal Sciences, 37*(1), 83-89.

Pina, D. S., Valadares Filho, S. C., Valadares, R. F. D., Detmann, E., Campos, J. M. d. S., Fonseca, M. A., ... Oliveira, A. S. (2006). Síntese de proteína microbiana e concentrações de uréia em vacas alimentadas com diferentes fontes de proteína. *Revista Brasileira de Zootecnia, 35*(4), 1552-1559.

Riaz, M. Q., Südekum, K. H., Clauss, M., & Jayanegara, A. (2014). Voluntary feed intake and digestibility of four domestic ruminant species as influenced by dietary constituents: A meta-analysis. *Livestock Science, 162 (April)*, 76-85.

Santana Junior, H. A., Figueiredo, M. P., Santana, E. O. C., Mendes, F. B. L., Abreu Filho, G., Pinheiro, A. A., ... Ferreira, A. H. C. (2013). Glicerina bruta na dieta de vacas lactantes mantidas em pastagem tropical: comportamento ingestivo. *Semina: Ciências Agrárias, 34*(3), 1339-1352.

Silva, A. E. M., Lira, A. T., Ferreira, M. A., Barros, L. J. A., Melo, T. T. d. B., Siqueira, T. D. Q., ... Costa, C. T. F. (2015). Bagaço de cana-de-açúcar como volumoso exclusivo em dietas para ovinos. *Revista Brasileira de Saúde e Produção Animal, 16*(1), 118-129.

Silva, R. R., Carvalho, P. C. F., Magalhães, F., Prado, I. N., Franco, S. L., Veloso, C. M., ... Panizza, J. C. J. (2005). Comportamento ingestivo de novilhas mestiças de holandês em pastejo. *Archivos de Zootecnia, 54*(205), 63-74.

Silva, R. R., Prado, I. N., Carvalho, G. G. P., Junior, H. A. S., Silva, F. F., & Dias, D. L. S. (2008). Efeito da utilização de três intervalos de observações sobre a precisão dos resultados obtidos no estudo do comportamento ingestivo de vacas leiteiras em pastejo. *Ciencia Animal Brasileira, 9*(2), 319-326.

Silva, R. R., Prado, I. N., Silva, F. F., Almeida, I. C. C., Santana Júnior, H. A., Queiroz, A. C., ... Barroso, D. S. (2010). Comportamento ingestivo diurno de novilhos Nelore recebendo níveis crescentes de suplementação em pastejo de capim-braquiária. *Revista Brasileira de Zootecnia, 39*(9), 2073-2080.

Silva, R. R., Silva, F. F., Carvalho, G. G. P., Franco, I. L., Veloso, C. M., Chaves, M. A., ... Almeida, V. S. (2005). Comportamento ingestivo de novilhas mestiças de Holandês x Zebu confinadas. *Archivos de Zootecnia, 54*(205), 75-85.

Sklan, D., Ashkenazi, R., Braun, A., Devorin, A., & Tabori, K. (1992). Fatty acids, calcium soaps of fatty acids, and cottonseeds fed to high yielding cows. *Journal of Dairy Science, 75*(9), 2463-2472.

Someya, S., Yoshiki, Y., & Okubo, K. (2002). Antioxidant compounds from bananas (*Musa Cavendish*). *Food Chemistry, 79*(3), 351-354.

Souza, C. F., Rocha Júnior, V. R., Reis, S. T., Antunes, C. R., Rigueira, J. P. S., Sales, E. C. J., ... Souza, G. R. (2016). Casca de banana em dietas para vacas mestiças em lactação. *Revista Brasileira de Saúde e Produção Animal, 17*(1), p. 86-100.

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