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Banana peel in the diet for F1 Holstein x Zebu cows

Casca de banana em dieta para vacas F1 Holandês x Zebu

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Abstract

This study aimed to evaluate the effects of includingsun-dried banana peel in diets for F1 Holstein x Zebu cows on intake, digestibility and milk production. Diets were composed of 0, 15, 30, 45 and 60% replacement of sorghum silage with banana peel provided to 10 cows in two simultaneous 5 x 5 Latin squares, with the experiment divided into five periods of 16 days. The dry matter intake showed a quadratic effect with maximum level at 38.30% substitution as well as intake of crude protein expressed in kg^{-1} day and percentage of body weight, with maximum at the levels of 50.09 and 45.69% inclusion of the peel, respectively. The intake of neutral detergent fiber and the digestibility of neutral detergent fiber and crude protein showed a decreasing linear effect. Variation in weight and body condition score, milk production and feed conversion were not affected. The replacement of 60% sorghum silage with banana peel represents a viable alternative as it causes no change in cows with average production of 16.49 kg milk with 3.5% fat day^{-1}, reducing feeding costs.
Key words: Co-product. *Musa paradisiaca*. Performance. Productivity.

Resumo

Objetivou-se avaliar os efeitos da inclusão de casca de banana seca ao sol na dieta de vacas F1 Holandês x Zebu, sobre consumo, digestibilidade e produção de leite. As dietas foram constituídas de 0, 15, 30, 45 e 60% de substituição da silagem de sorgo pela casca de banana. Foram utilizadas 10 vacas e o delineamento experimental foi em 2 quadrados latinos 5 x 5 simultâneos, sendo o período experimental dividido em cinco períodos de 16 dias. O consumo de matéria seca apresentou efeito quadrático com valor máximo no nível de 38,30% de substituição, assim como o consumo de proteína bruta expresso em kg dia^{-1} e em porcentagem do peso corporal, com valor máximo nos níveis de 50,09 e 45,69% de inclusão da casca, respectivamente. O consumo de fibra em detergente neutro e as digestibilidades da fibra em detergente neutro e da proteína bruta apresentaram efeito linear decrescente. As variações de peso e escore corporal, produção de leite e conversão alimentar não foram influenciados. A substituição de 60% da silagem de sorgo por casca de banana pode ser uma alternativa viável já que não altera produção de vacas com produção média de 16,49 kg de leite com 3,5% de gordura dia^{-}1, reduzindo os custos com a alimentação.
Palavras-chave: Co-produtos. Efeito fisiológico. *Musa paradisíaca*. Nutrição.

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Introduction

The reduction of costs in animal production has been directed towards the rational use of all available food resources. The use of agroindustrial co-products and/or by-products in animal feed has been disseminated among cattle ranchers, appearing as a possibility of economic viability for the production system (MURTA et al., 2011; URBANO et al., 2012).

In addition to the use of banana peel as an alternative food source for ruminant feed, one of the most important aspects of its use is associated with the reduction of the environmental impact caused by the disposal of this residue in nature, since the small agroindustries do not have the resources to treatment and proper destination, and it is often discarded in the open field (OLIVEIRA et al., 2014; FERREIRA et al., 2015). Brazil is the world's largest banana consumer and ranks fourth in world production, behind India, China and the Philippines (FAO, 2014).

Banana peel has high nutritional value, it is a rich source of carbohydrates, mainly pectin (10 to 21%) (MOHAPATRA et al., 2010), as well as high soluble carbohydrate content, which can reach 32.4% dry matter, depending on the cultivar (EMAGA et al., 2007). It has 2 to 10.9% ether extract (MOHAPATRA et al., 2010), mainly composed of linoleic and α-linolenic acids (EMAGA et al., 2007) and presents a high content of flavonoid compounds, especially gallocatechin, which has anti-inflammatory, antimicrobial and antioxidant activities (SOMEYA et al., 2002).

Despite the potential use of banana peel in ruminant feed, handling this by-product has complicated its use by farmers because of the high moisture content. Therefore, it is necessary the processing of this material to reduce the moisture content, allowing nutrient concentration and inhibition of the proliferation of deteriorating microorganisms, allowing a longer storage time and reduction of transportation costs (EMAGA et al., 2011; MONÇÃO et al., 2014, 2016).

In this context, the goal of this study was to evaluate the inclusion of sun-dried banana peel in diet for F1 Holstein x Zebu cows on intake, digestibility of nutrients, milk productionand feed costs.

Material andMethods

The experiment was conducted at the Experimental Farm of the State University of Montes Claros – UNIMONTES, located in the municipality of Janaúba, northern state of Minas Gerais. Ten F1 Holstein x Zebu cows with 70 ± 11 days of lactation at the beginning of the experiment were distributed in two simultaneous 5 x 5 Latin squares, each composed of five animals, five treatments and five experimental periods. Five experimental diets were used: diet with sorghum silage (without banana peel) and diets with replacement of sorghum silage with banana peel in 15, 30, 45 and 60% 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 for adaptation of the animals to the diets and the last four days for data collection and samplings. The diets were formulated to be isoproteic for cows with an average of 500 kg body weight and average milk production of 15 kg corrected to 3.5% fat day^{-1} and were supplied to the cows twice a day at 07h and 14h, in a complete diet system.

Banana peels were obtained from Nutrephos Norte Indústria e Comércio Ltda., located in the municipality of Janaúba, from mature fruit and most of the Prata-Anã cultivar, presenting a dry matter content of 10.32 ± 1%. Peels were previously dehydrated by exposure to the sun for 12 ± 3 days, in the period between August and November, which presented average temperature, relative humidity and average rainfall of 25.37° C, 44.64% and 0.91mm, respectively (INMET, 2014). After dehydration, peels were ground in a stationary chopper to particles of 3 to 4 centimeters and stored in nylon bags in a covered shed.

Foods offered daily were weighed on a digital scale and the supply was adjusted so that the leftovers represented 5% of the amount of dry matter supplied. The proportion of the ingredients used in the diets and the chemical composition are listed in Table 1 and the composition of the ingredients in Table 2.

Table 1. Chemical composition of the ingredients of the experimental diets, on a dry matter basis (g kg^{-1} DM).

	Chemicalcomposition			
g kg^{-1} DM	Sorghumsilage	Sun-dried banana peel	Groundcorn	Soybeanmeal
Drymatter	333.9	877.6	904.4	903.2
Mineral matter	61.3	127.1	15.3	70.0
Crudeprotein	59.9	82.8	91.0	485.0
NDIN (1)	3.1	6.9	4.2	4.9
ADIN(2)	2.2	4.1	0.6	1.8
Etherextract	19.4	62.5	47.6	52.9
NFC (3)	19.4	314.6	469.2	163.3
NDF (4)	694.5	479.2	225.3	152.2
NDFcp(5)	682.7	413	222.9	149.9
ADF(6)	398.4	298.3	61.8	126.7
Lignin	95.2	102.5	31.3	27.6

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

Table 2. Proportion of the ingredients of the experimental diets (g kg^{-1} DM) and chemical composition of diets, on a dry matter basis.

	Replacementlevels (% DM)				
Ingredients	0	15	30	45	60
Sorghumsilage	700	595	490	385	280
Banana peel	0	105	210	315	420
Soybeanmeal	173.1	172.9	172.7	172.4	172.2
Groundcorn	117.3	117.5	117.7	118	118.2
Mineral supplement(1)	9.6	9.6	9.6	9.6	9.6
Chemical composition (g kg^{-1} DM)					
Drymatter	505.5	562.6	619.7	676.8	733.9
Mineral matter	66.4	73.3	80.2	87.1	94
Crudeprotein	140	140	140	140	140
NDIN (2)	3.5	3.9	4.3	4.7	5.1
ADIN(3)	1.9	2.1	2.3	2.5	2.7
Etherextract	28.3	32.8	37.4	41.9	46.4
NFC(4)	207	221.6	236.1	250.7	265.2
NDF (5)	573	550.5	527.9	505.4	482.8
NDFcp(6)	563.8	535.5	507.2	479	450.7
ADF (7)	308.1	297.5	287.0	276.5	265.9
Lignin	75.1	75.9	76.6	77.4	78.2

(1)Guarantee levels per kg product: calcium (128g min) (157g max), phosphorus (100g min), sodium (120g min), magnésio (15g), sulfur (33g), cobalt (135mg), copper (2160mg), iron (938 mg), iodine (160mg), manganese (1,800 mg), selenium (34mg), zinc (5,760mg), fluorine (1,000mg); (2) NDIN = neutral detergent insoluble nitrogen;(3) ADIN = acid detergent insoluble nitrogen; (4)NFC = Non-fiber carbohydrates; (5)NDF = Neutral detergent fiber; (6)FDNcP = Neutral detergent fiber corrected for ash and protein0; (7) ADF = Acid detergent fiber.

Cows were kept in individual stalls and milked using a mechanical milking machine twice a day at 8 h and 15 h. The presence of the calf was used to stimulate milk ejection, and after milking, calves remained with the dams for approximately 30 minutes to suckle the residual milk.

During the last four days of each experimental period, milk yields per cow were recorded. The milk yield corrected to 3.5% fat was calculated using the equation proposed by Sklan et al. (1994). Also in the last four days of each period, samples of the food provided, leftovers and feces were collected daily in the morning and stored in a freezer. At the end of the experiment, a composite sample was made per animal and per period, pre-dried in a forced ventilation oven at 55ºC for 72 hours. Afterwards, all samples were ground in a knife mill with a 1 mm sieve for laboratory analysis and part of the sample was ground in sieves with 2 mm diameter for ruminal incubation.

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

Estimates of fecal DM production were made using indigestible acid detergent fiber (iADF) as an internal indicator, and samples of the food provided, leftovers and feces were incubated in a fistulated steer for 288 hours for estimates of fecal output (DETMANN et al., 2012). The animal was confined in the Experimental Farm of UNIMONTES, Campus Janaúba, state of Minas Gerais. After incubation, the samples were removed from the rumen, washed and analyzed for the contents of ADF to determine the remaining fiber fraction, considered iADF. The production of fecal DM was estimated by dividing the consumption of the indicator by its concentration in feces. The apparent digestibility coefficients were calculated by subtracting the fecal excretion of dry matter and nutrients, respectively, from dry matter and nutrient intake. From the digestibility coefficients, we calculated the total digestible nutrients (TDN) according to Sniffen et al. (1992), considering the FDNcpfor the calculation.

Animals were weighed on a mechanical scale and their body condition scores (BCS) were evaluated by a single person at the beginning and end of each experimental period, considering a scale from 1 to 5, according to Wildman et al. (1982).

Blood samples were collected from the coccygeal vein of cows in glass tubes containing sodium fluoride and potassium oxalate on the last day of each experimental period, 4 hours after the morning meal. The samples were centrifuged at 4,000 rpm for 20 minutes and the obtained serum was packed in Eppendorf tubes and frozen at –18°C for further analysis. Plasma concentrations of glucose, total cholesterol, and urea were determined by the colorimetric enzymatic method using commercial kits (Liquid Enzyme Glucose, Doles®, Cholesterol 250, Doles®, Urea 500, Doles®).

The evaluation of costs of concentrates, forages and total diet was calculated by multiplying the consumption by the respective value of each fraction (calculated according to its composition and the price of each ingredient (RENNÓ et al., 2008). The peel was obtained as a residue, that is, without costs for acquisition, being considered only the cost with transportation added to the drying cost. The experimental farm is 11 km far from the agroindustry. Considering this distance, a value of R$ 30.00 per load of transported banana peel was considered. The drying cost was obtained by means of the total number of banana peel loads (16 loads with 2000 ± 240 kg) divided by the total number of hours spent with the drying process (8 daily) considering the value of R$ 40.00 per worked day. The values per kilogram of the dietary ingredients were: sorghum silage, R$ 0.16, concentrate R$ 1.26 (values obtained in local commerce) and banana peel, R$ 0.25.

The feed conversion was calculated by dividing the DM intake (kg day^{-1}) by the milk production corrected to 3.5% fat kg day^{-1}. The feed efficiency was calculated by dividing the average milk yield in kg day^{-1} by the intake of DM kg day^{-1}; the efficiency of dietary nitrogen utilization was calculated by dividing the concentration of nitrogen retained in milk by the ingestion of N kg day^{-1}.

Data were tested by analysis of variance by the software SISVAR (FERREIRA, 2011) and the initial weight of the animals was established as a covariate. When significant, the means of the treatments were subjected to regression analysis at the 5% probability level.

Results and Discussion

The dry matter intake, expressed in kg day^{-1}, presented a quadratic effect with the maximum point at the level of 38.30% replacement of sorghum silage with sun-dried banana peel. However, when expressed as a percentage of body weight, there was no difference between banana peel levels (Table 3).

Table 3. Intake of dry matter (DM), crude protein (CP), ether extract (EE), neutral detergent fiber (NDF), non-fiber carbohydrates (NFC), total digestible nutrients (TDN), expressed in kg day^{-1} and in percentage of body weight (%BW), coefficients of variation (CV) and respective regression equations (RE) according to different replacement levels of sorghum silage with sun-dried banana peel.

Items	Replacementlevels (%DM)					CV (%)	ER	Pr>Fc
	0	15	30	45	60			
				Intake kg day^{-1}				
DM	17.37	18.64	19.29	19.32	18.74	8.83	1	0.0335
CP	2.38	2.58	2.71	2.77	2.76	9.43	2	0.0035
EE	0.52	0.61	0.70	0.80	0.89	12.82	3	0.0001
NDF	9.62	9.34	9.07	8.79	8.51	8.75	4	0.0018
NFC	3.73	4.04	4.36	4.67	4.98	10.72	5	0.0001
TDN	9.39	8.77	8.69	8.59	8.66	14.13	$\hat{Y}$=8.82	0.6065
				Intake (%BW)				
DM	3.32	3.42	3.65	3.62	3.43	8.38	$\hat{Y}$=3.49	0.0719
CP	0.45	0.49	0.51	0.51	0.51	8.84	6	0.0105
EE	0.10	0.12	0.13	0.15	0.16	12.35	7	0.0001
NDF	1.82	1.75	1.69	1.63	1.57	8.68	8	0.0006
NFC	0.71	0.76	0.81	0.86	0.92	9.68	9	0.0001
TDN	1.77	1.66	1.62	1.58	1.59	14.78	$\hat{Y}$=1.64	0.4291

[1]$\hat{Y}$= 17.365207 + 0.105793X – 0.001381X^2 (R^2 = 0.78); [2]$\hat{Y}$= 2.380378 + 0.015727X – 0.000157X^2 (R^2 = 0.89); [3]$\hat{Y}$= 0.5222 + 0.0061X (R^2 = 0.98); [4]$\hat{Y}$= 9.6224 – 0.0185X (R^2 = 0.87); [5]$\hat{Y}$= 3.7309 + 0.0208X(R^2 = 88.61); [6]$\hat{Y}$ = 0.450704 + 0.002833X – 0.000031X^2 (R^2 = 0.92); [7]$\hat{Y}$= 0.0993 + 0.0011X (R^2 = 0.98); [8]$\hat{Y}$= 1.8174 – 0.0041X (R^2 = 0.78); [9]$\hat{Y}$= 0.7100 + 0.0034X (R^2 = 0.85).

The quadratic effect of dry matter intake when expressed in kg day^{-1} can be explained by the interaction of nutrients present in the diets with the reduction in the fiber fraction and increase in energy availability, mainly non-fiber carbohydrates and ether extract, making the chemostatic mechanisms of the animal cease the consumption.

The intake of dry matter plays a key role in nutrition, since it determines the level of nutrients ingested and therefore has been considered as one of the most important parameters in the evaluation of diets due to the high correlation with the animal production (RIAZ et al., 2014).

There was a quadratic effect in the intake of crude protein, expressed in kg day^{-1} and percentage of body weight with maximum value at the levels of 50.09 and 45.69% banana peel replacing sorghum silage, respectively (Table 3). This fact was explained by the quadratic effect of the dry matter intake expressed in kg day^{-1}, since the diets were formulated to be isoproteic.

The mean intake of crude protein was 2.64 kg day^{-1}, higher than that recommended by the NRC (2001), which recommends values of 1.74 kg CP for cows with a production of 15 kg milk with 3.5% fat. However, the mean milk production corrected to 3.5% fat in this experiment was 16.49 kg day^{-1}.

Neutral detergent fiber intake, expressed as kg^{-1} and as a percentage of body weight, showed a decreasing linear effect, and for each percentage unit of replacement of sorghum silage with banana peel in the diet there was a reduction of 0.0185 in intake in kg day^{-1} and 0.0041 in intakein percentage of body weight (Table 3).

With increasing levels of replacement, dietary NDF content reduced (Table 2), which justifies the reduction in NDF intake of diets containing banana peel in relation to the diet without this by-product. Although the banana peel in the diet favored the lower intake of NDF, the values found in this study remained close to the overall mean of 1.6% of body weight, reported by Souza et al. (2008).

The increasing levels of replacement of sorghum silage with banana peel in the diet provided higher intake of ether extract and non-fiber carbohydrates, presenting increasing linear effect with an increase of 0.0061 and 0.0208 kg day^{-1} and 0.0011 and 0.0034 %BW, respectively, for each percentage unit of banana peel (Table 3), and were justified by the higher content of ether extract and non-fiber carbohydrates in diets containing banana peel in relation to the diet without this by-product (Tables 1 and 2).

Although the ether extract content in banana peel diets increased, they remained below the limit of 60-70 g kg^{-1} DM recommended by NRC (2001).

The intake of total digestible nutrients (TDN) expressed in kg day^{-1} and percentage of body weight was not affected by the inclusion of banana peel in the diet (Table 3). The overall mean TDN intake was 8.82 kg day^{-1}, higher than that recommended by NRC (2001), which recommends values of 8.11 kg TDN for cows with a production of 15 kg milk with 3.5% of fat. Nevertheless, it should be considered that the mean milk production of the cows was 16.49 kg day^{-1}, indicating that the diets with and without banana peel were efficient in meeting the energy needs of the animals.

The presence of banana peel in the diet did not alter the dry matter digestibility coefficients (Table 4). This can be explained by a probable balance between the lower digestibility of neutral detergent fiber, crude protein and ether extract with the higher digestibility of non-fiber carbohydrates.

NDF digestibility showed a decreasing linear effect ($P = 0.0527$) with the levels of replacement of silage in the diet, with a reduction of 0.17% in NDF digestibility for each percentage unit of banana peel. (Table 4). The higher lignin content in the banana peel reduces the NDF quality of the diets, impairing its digestibility. According to Magalhães et al. (2015), the lignin content has a negative correlation with fiber digestibility.

Table 4. Total apparent digestibility of dry matter (DM), crude protein (CP), ether extract (EE), neutral detergent fiber (NDF), non-fiber carbohydrates (NFC), coefficients of variation (CV) and respective regression equations (RE) according to different replacement levels of sorghum silage with sun-dried banana peel.

Items	Replacementlevels (%DM)					CV(%)	RE	Pr>Fc
	0	15	30	45	60			
Total ApparentDigestibility (%)								
DM	53.28	52.31	51.34	50.37	49.40	18.07	Ŷ=51.34	0.2051
CP	50.18	46.36	42.53	38.71	34.88	23.72	1	0.0017
EE	60.98	52.14	43.30	34.47	25.63	18.68	2	0.0001
NDF	45.56	43.08	40.60	38.12	35.63	26.73	3	0.0527
NFC	70.79	74.05	77.32	80.59	80.85	12.29	4	0.0161
TDN	54.19	47.89	44.68	44.55	47.51	15.22	5	0.0329

[1]$\hat{Y}$= 50.182058 – 0.254982X (R^2 = 0.75); [2]$\hat{Y}$= 60.978115 – 0.589069X (R^2 = 0.82); [3]$\hat{Y}$= 45.563278 – 0.165462X (R^2 = 79.77); [4]$\hat{Y}$= 70.791668 + 0.217692X (R^2 = 0.83); [5]$\hat{Y}$= 54.186143 – 0.522395 + 0.006852 (R^2 = 0.96).

For each percentage unit of banana peel in the diet, there was a reduction of 0.2550% in crude protein digestibility (Table 4). This reduction is due to the higher content of acid detergent insoluble nitrogen (ADIN) present in diets containing banana peel (Table 2). According to Maciel et al. (2012), the utilization of crude protein shows a negative correlation with the nitrogen content related to the fiber fraction of the food, which impairs the ruminal degradation of crude protein.

The partial substitution of sorghum silage with banana peel allows an increase in the crude protein content complexed to the cell wall of the diet, precisely because the banana peel has higher ADIN value (0.41%) when compared to sorghum silage (0.19%).

For each 1% replacement of silage with banana peel, there was a reduction of 0.5821% in the digestibility of ether extract (Table 4). The ether extract of banana peel has 62.87% saturated fatty acids in its profile (ANTUNES, 2015), which may contribute to the lower digestibility of ether extract in diets with banana peel, given the negative correlation between intestinal absorption and the amount of saturated fatty acids. Moreover, the peel shows in its profile 56.86% long chain fatty acids, which may also have contributed to the reduced digestibility of the ether extract, once the digestibility decreases with increasing length of the fatty acid chain (MASCARENHAS et al., 2010).

Additionally, the banana peel in the diet provided a 0.2177% increase in non-fiber carbohydrate digestibility for each percentage unit of silage replaced with banana peel (Table 4).

The banana peel is a rich source of pectin and soluble carbohydrates, and can present 10-21% pectin content (MOHAPATRA et al., 2010) and according to Emaga et al. (2007), the ripe banana peel can present up to 32.4% soluble carbohydrates, which are highly fermentable in the rumen and provide a large amount of energy readily available to the ruminal microorganisms. This probably contributed to the higher digestibility of non-fiber carbohydrates with increasing levels of banana peel replacing sorghum silage in the diet.

Regarding the total digestible nutrients, this showed a quadratic effect with the minimum point of 38.12% banana peel replacing the silage. Probably, the reduction in digestibility of crude protein, ether extract and neutral detergent fiber, but with increased digestibility of non-fiber carbohydrates, has provided this effect.

The weights, scores and variations in weight and score were not influenced by banana peel in animal feeding, as can be seen in Table 5. At the beginning of lactation, the cows mobilize body reserves and lose weight because of the negative energy balance. This was not observed in this experiment, since at the beginning of the experiment the animals were already with approximately 70 days of lactation and the intake of nutrients was enough to meet the requirements of maintenance and milk production of cows. Besides that, the animals presented significant weight gain in this period, with an overall mean of 14.69 kg, which can be attributed to the intake of TDN and crude protein.

Table 5. Final weight (PF), weight variation (WV), initial body condition score (IBCS), final body condition score (FBCS), body condition score variation (BCSV), means and coefficient of variation (CV) of lactating cows receiving diets with increasing levels of banana peel replacing sorghum silage.

Items	Levelsof banana peel					CV	RE	Pr>Fc
	0	15	30	45	60			
FW	534.5	532.9	541.4	544.4	543.8	2.32	$\hat{Y}$=539.38	0.1481
WV	7.85	10.60	17.25	12.95	24.80	46.84	$\hat{Y}$=14.69	0.2301
IBCS	3.00	2.93	3.0	3.0	2.95	3.19	$\hat{Y}$=2.98	0.2591
FBCS	3.00	2.98	3.0	3.03	3.00	2.8	$\hat{Y}$=3.00	0.7756
BCSV	0.0	0.05	0.00	0.03	0.05	5.21	$\hat{Y}$=0.72	0.1576

Milk yield, milk production corrected for 3.5% fat, feed conversion and efficiency of dietary nitrogen utilization were not affected by the sun-dried banana peel in the diet supplied for cows. The feed efficiency exhibiteda quadratic behavior according to the substitution levels, with a minimum point of 37.95% of banana peel replacing silage in the diet (Table 6).

Table 6. Milk production (kg day^{-1}, MP), milk production corrected for fat (kg day^{-1}, MPC), feed conversion (FC), feed efficiency (FE), and efficiency of dietary nitrogen utilization (NE), means and coefficient of variation of lactating cows receiving diets with increasing levels of banana peel replacing sorghum silage.

Itens	Levelsof banana peel					CV(%)	RE	Pr>Fc
	0	15	30	45	60			
MP	13.60	13.39	13.57	13.64	13.11	6.28	$\hat{Y}$=13.46	0.6247
MPC	16.80	16.39	16.25	16.54	16.49	7.18	$\hat{Y}$=16.49	0.8812
FC	1.11	1.19	1.27	1.21	1.22	14.51	$\hat{Y}$=1.22	0.3377
FE	0.78	0.73	0.70	0.70	0.73	8.12	1	0.0218
NE	0.17	0.18	0.20	0.18	0.19	23.47	$\hat{Y}$=0.18	0.7747

[1]$\hat{Y}= 0.779085 - 0.004326X + 0.000057X^2$ (R^2 = 88.08).

The lack of effect of banana peel in the diet on milk yield and milk production corrected demonstrates that the nutritional requirements for the animal category studied were sufficiently met. It can be inferred that ruminal microorganisms were able to take advantage of nutrients from the diets offered, since milk production was similar in all treatments.

In relation to the efficiency of dietary nitrogen utilization, the values found in this study were below the values usually reported, which is 25 to 30% (ALVES et al., 2010). Probably, the higher consumption of crude protein obtained in this work in relation to that recommended by the NRC (2001) has made this possible.

The quadratic effect verified for the feed efficiency of cows fed increasing substitutions of silage with banana peel in the diet is justified by the similar effect in the dry matter intake, in kg day^{-1}, provided by these diets (Table 3), with no difference in production in relation to the diet without banana peel (Table 6).

The intake of dry matter is the major factor affecting animal performance, since it influences the total amount of nutrients that the animal ingests (ARRIGONI et al., 2013) and is highly correlated with milk production. Nonetheless, in the present study, the higher intake of dry matter did not result in higher milk production, thus negatively influencing feed efficiency. This fact may be related to the genetic potential of cows for milk production.

Furthermore, plasma glucose levels were not altered by the inclusion of banana peel (Table 7), even with the higher consumption of non-fiber carbohydrates in these diets (Table 3).

Table 7. Plasma levels of glucose (mg dL^{-1}, GLU), total cholesterol (mg dL^{-1}, TC) and urea nitrogen (mg dL^{-1}, UN), means and coefficient of variation of lactating cows receiving diets with increasing levels of banana peel replacing sorghum silage.

Items	Levelsof banana peel					CV	RE	Pr>Fc
	0	15	30	45	60			
GLU	53.70	52.78	52.34	50.91	49.93	12.04	$\hat{Y}$=51.93	0.6801
TC	125.5	121.5	126.6	116.2	105.8	18.81	$\hat{Y}$=119.01	0.2179
UN	22.77	19.91	19.69	22.50	18.84	19.15	$\hat{Y}$=20.74	0.1190

The plasma concentration of glucose is usually very low, due to the homeostatic mechanisms of the organism (PEIXOTO et al., 2010), and as a result, plasma glucose levels are within the normal range,from 35 to 55 mg dL^{-1} (BlOOD; RADOSTITS, 1989).

The levels of total cholesterol and urea nitrogen in the plasma were not influenced by the banana peel in the diets. The higher intake of ether extract propitiated by banana peel in the diet did not imply an increase in total cholesterol (Table 3). However, the digestibility of ether extract in these diets was lower (Table 4), which results in a lower absorption of fat by the organism, thus justifying the similarity in cholesterol levels between the animals of all treatments.

With respect to urea nitrogen in the plasma, values were above the levels reported by Santos et al. (2011) (17.6-18 mgdL^{-1}) for lactating cows. In agreement with Fonseca et al. (2016), values above 18 mgdL^{-1} represent energy losses for elimination of urea, reproductive problems, immunological deficiency, protein losses and environmental contamination. The highest urea nitrogen level in the plasma found in our study is associated with crude protein intake, considering the high positive correlation between these variables (VASCONCELOS et al., 2010).

Table 8 presents the dietary costs with forage and concentrate foods as well as the total cost of the diet. Although milk production showed no difference with the inclusion of banana peel in the diets, there were differences in costs.

Although the banana peel had an influence with the higher dry matter intake, the costs with forage foods were lower in the diets with banana peel, once the use of forage without addition of banana peel increased by 53.68% the costs of forage foods, being more economical the use of 60% banana peel instead of sorghum silage. On the other hand, the costs with concentrate had opposite effects to the ones with forage, being the smaller cost found in the diet without banana peel.

Nevertheless, when considering that diets were formulated and supplied with the same forage: concentrate ratio (70: 30), the higher proportion of forage in the diets favored the use of banana peel as part of the forage fraction of diets, leading to a lower cost (Table 8).

The substitution of 15% sorghum silage with banana peel increased costs by 16.25%, precisely due to the quadratic effect presented in the DM intake, in kg day^{-1} (Table 3). In this sense, it is more economical to use forage with 60% banana peel replacing sorghum silage.

Table 8. Costs of forage, concentrate and total diet according to increasing levels of sun-dried banana peel replacing sorghum silage in diets for lactating cows.

Levelsof banana peel	Forage intake (kg DM day^{-1})	Forage cost (R$/kg DM)	Total forage cost (Reais/ cow day^{-1})	Increase in the cost by using forage (%)
0	12.16	0.48	5.84	53.68
15	13.05	0.43	5.61	47.63
30	13.50	0.38	5.13	35.00
45	13.52	0.34	4.60	21.05
60	13.12	0.29	3.80	0.00
	Concentrate intake (kg DM day^{-1})	Concentrate cost (R$/kg DM)	Total concentrate cost (Reais/cowday^{-1})	Increase in the cost by using concentrate(%)
0	5.21	1.26	6.56	0.00
15	5.59	1.26	7.04	7.32
30	5.79	1.26	7.30	11.28
45	5.80	1.26	7.31	11.43
60	5.62	1.26	7.08	7.93
	Diet intake (kg DM day^{-1})	Diet cost (R$/kg DM)	Total diet cost (Reais/ cow day^{-1})	Increase in the cost by the diet(%)
0	17.37	0.71	12.40	13.87
15	18.64	0.68	12.66	16.25
30	19.29	0.64	12.42	14.05
45	19.32	0.62	11.90	9.27
60	18.74	0.58	10.89	0.00

Conclusions

The replacement of sorghum silage with sun-dried banana peel changes the patterns of intake and digestibility of certain nutrients. Nevertheless, this replacement at the level of 60% is feasible as it cause no alteration in milk production, with a mean value of 16.49 kg with 3.5% fat day^{-1}, reducing feeding costs.

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