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Nutritional value of babassu cake as a substitute for sugarcane in feeding heifers[1]

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ABSTRACT - The aim of this study was to evaluate intake, digestibility and performance in dairy heifers fed diets containing increasing levels of babassu cake (0, 100, 200 and 300 g kg^{-1} dry matter - DM) as a substitute for sugarcane treated with calcium oxide. Twenty-four heifers with an initial mean weight of 190.8 $\pm$ 40.8 kg were used, distributed in a completely randomised design. The dry matter intake (DMI), neutral detergent fibre intake (NDFI) and acid detergent fibre intake (ADFI), as %BW and g $BW^{-0.75}$, showed an increasing linear response. The organic matter intake (OMI) showed a linear increase of 40 g day^{-1}, 0.017%BW and 0.66 g $BW^{-0.75}$ for each 10 g kg^{-1} increase in babassu cake in the diet. The apparent digestibility of the dry matter (ADDM) and organic matter (ADOM) showed a quadratic response ($P < 0.05$), with a minimum of 493 g kg^{-1} DM for 150 g kg^{-1} DM and 526.5 g kg^{-1} DM for 320 g kg^{-1} DM as a substitute for the sugarcane, respectively. The final mean weight was not altered, presenting a value of 299.7 $\pm$ 45.5 kg. Daily weight gain (DWG) showed a quadratic response, with the highest value at a substitution level of 190 g kg^{-1} DM. The feed conversion rate of the DM was not affected by the addition of babassu cake, with an average of 4.6 $\pm$ 0.74 kg DM kg^{-1} in weight gain. Babassu cake can substitute hydrolysed sugarcane in heifer diets up to 300 g kg^{-1} DM, with the greatest weight gain seen at a substitution level of 190 g kg^{-1} DM.

Key words: Agro-industrial by-product. Alternative feeds. Nutritional value. *Orbignya speciosa*. Weight gain.

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INTRODUCTION

The success of dairy farming is entirely dependent on good performance during all stages of production, such as breeding heifers. According to Santos and Lopes (2014), raising heifers should be considered one of the most important activities of dairy farming, since the genetic improvement of the herd depends on the voluntary and involuntary culling of old or problematic cows that reduce production efficiency, and their substitution with young animals of greater genetic potential. To achieve adequate growth rates in dairy heifers under intensive production systems, these must be submitted to a rigorous nutritional plan, which will guarantee a younger age at first calving.

In this respect, malnutrition of the herd, among other factors limiting production efficiency, aggravated by the seasonal availability of forage, is considered one of the main barriers to livestock farming in the tropics (DETMANN *et al*., 2014). Moreover, feeding the herd represents the most important component in operational costs, and may affect the profitability of milk and/or meat production. It therefore becomes very difficult to maintain the growth category, particularly due to the high cost of feed and the long-term financial return (SANTOS; LOPES, 2014).

The high fluctuating price of traditional energy and protein concentrates makes it necessary to evaluate replacing them with other low-cost feeds of good nutritional value that maintain the production of the herd. The use of agro-industrial co- or by-products is an important option. According to Bringel *et al*. (2011), in order to be economically attractive, one of the characteristics that the by-product should have to justify its addition to the diet and reduce feeding costs is low nutrient cost per unit of dry matter (DM).

If we consider animal feed as the link between biodiesel production and livestock, use of by-products in feeding ruminants has the aim of increasing productivity and generating fewer greenhouse gas emissions by the animals (ABDALLA *et al*., 2008). The use of by-products in ruminant nutrition helps reduce the dependence of these animals on cereal grain and reduces waste disposal in the environment thereby cutting feeding costs, transforming products of low economic value into animal products of high biological value, (CARRERA *et al*., 2012).

In the north and northeast of Brazil, babassu (*Orbygnia* sp.) is one of the principal plants used as a source of raw material for oil production, generating various by-products, including babassu cake (MIOTTO *et al*., 2012). The use of babassu cake in ruminant feeding is quite common, especially among producers in these regions, however, little is known about its nutritional value or its effect on animal performance. Its use in ruminant feeding may reduce production costs, as well as avoid environmental pollution generated by incorrect disposal (FREITAS; SIQUEIRA; SIQUEIRA, 2014). The authors note that the cakes and meals derived from agribusiness have the proper nutritional characteristics for use in ruminant diets, but point out that care should be taken with possible problems caused by the bioactive antinutritional factors found in some materials, and recommend careful study for their safe use in animal feed.

This aim of this study was to evaluate the intake, nutrient digestibility and productive performance of dairy heifers fed diets containing increasing levels of babassu cake as a substitute for sugarcane treated with calcium oxide.

MATERIAL AND METHODS

The experiment was conducted at the School of Veterinary Medicine and Animal Science of the Federal University of Tocantins (UFT) in Araguaína. The laboratory analyses were carried out at the Animal Nutrition Laboratory of the Department of Animal Science, at the Veterinary School of the Federal University of Minas Gerais (UFMG), in Belo Horizonte. The experiment evaluated the substitution of sugarcane (*Saccharum officinarum L.*) by babassu cake (0, 100, 200 and 300 g kg^{-1} DM) in feeding dairy heifers.

The experimental design was completely randomised, with four treatments and six replications. Twenty-four crossbred heifers (Holstein x Zebu) were used, with an initial mean body weight (BW) of 190.8 $\pm$ 40.8 kg. At the start of the experiment, each animal was identified, dewormed and supplemented with ADE injectable vitamin complex.

The trial period was 91 days, including 21 days for adaptation and 70 days of experimental evaluations. Each animal was housed in an individual stall (with an area of 12 m^2) partially covered, with an individual feeding trough and one drinking trough for every two stalls.

The diets were formulated using the RLM 3.2® software to be isoenergetic (DM with 65% total digestible nutrients - TDN) and isoproteic (DM with 130 g crude protein - CP), predicting a daily dry matter intake (DMI) of 2.17%BW and average daily gain of 750 g. However, despite being formulated to be isoenergetic and isoproteic, due to the chemical variation of the ingredients, the final diets had a different composition than the formulated diets.

The chemical composition of the ingredients used to formulate the diets is shown in Table 1.

As babassu cake was included in the diet, the level of sugarcane was reduced (Table 2).

Table 1 - Chemical composition of the ingredients

Item	Ingredients				
	Babassu Cake	Ground Maize	Wheat Meal	Soybean Meal	Sugarcane
Dry matter[1]	914.5	885.8	888.3	896.4	268.7
Crude protein[2]	288.6	99.9	175.3	535.4	30.3
Neutral Detergent Fibre[2]	595.0	164.8	379.5	164.8	588.5
Acid Detergent Fibre[2]	303.9	23.7	115.3	68.0	333.4
Hemicellulose[2]	291.2	141.1	264.2	96.7	255.1
NDIN3, g kg^{-1} total N	184.2	125.6	102.8	266.3	35.2
ADIN4, g kg^{-1} total N	7.1	17.4	7.1	10.4	3.0
Ether extract[2]	88.2	31.3	28.4	14.9	11.0
Ash[2]	51.3	19.8	47.8	66.0	43.4
Ca	1.7	1.0	1.6	3.2	11.3
P	8.4	3.0	10.0	6.7	0.5

[1]g kg^{-1} natural matter; [2]g kg^{-1} dry matter; [3]NDIN - neutral detergent insoluble nitrogen; [4]ADIN - acid detergent insoluble nitrogen

Table 2 - Proportion of ingredients and chemical composition of the experimental diets

Ingredient	Levels of babassu cake as substitute for sugarcane (g kg^{-1} DM)			
	0	100	200	300
Sugarcane	600.0	500.0	400.0	300.0
Babassu cake	0.0	100.0	200.0	300.0
Soybean meal	183.4	170.6	133.0	88.7
Wheat meal	159.7	27.9	0.0	0.0
Corn grain	35.8	169.0	238.9	291.7
Limestone	6.2	2.5	4.1	5.0
Mineral supplement[1]	15.0	30.0	24.0	14.5
Chemical composition				
Dry matter[2]	501.8	562.4	621.7	620.3
Organic matter[3]	935.7	930.3	935.9	948.2
Crude protein[3]	140.4	143.8	147.3	130.4
Neutral detergent fibre[3]	458.1	440.0	437.8	457.4
Acid detergent fibre[3]	233.3	223.6	224.8	236.2
Hemicellulose[3]	224.8	216.3	213.0	221.3
NDIN4, g kg-1 total N	68.4	100.2	110.9	106.8
ADIN5, g kg^{-1} total N	4.8	4.7	5.2	4.9
Total carbohydrates[3]	780.1	767.0	763.0	793.7
Non-fibre carbohydrates[3]	322.0	327.1	325.2	336.2
Ether extract[3]	15.2	19.6	25.6	24.2
Ash[3]	64.3	69.7	64.1	51.8
Ca[3]	10.0	10.4	9.2	7.7
P3	3.8	4.6	5.1	4.3

[1]Composition (g kg^{-1} natural matter): Na – 150 g, Ca – 118 g, P – 90 g, Mg – 7 g, S – 12 g, N – 10 g, Zn – 3600 mg, Cu – 1730 mg, Co – 200 mg, Mn – 1000 mg, I – 150 mg, Se – 20 mg; [2]g kg^{-1} natural matter; [3]g kg^{-1} dry matter; [4]NDIN - neutral detergent insoluble nitrogen; [5]ADIN - acid detergent insoluble nitrogen

To facilitate handling and storing, the sugarcane was hydrolysed with 1% calcium oxide (CaO, as fed). The sugarcane was cut to guarantee up to three days' supply, and was chopped following cutting. The hydrolysis process was then carried out, dissolving the limestone in water. This was done to avoid the presence of bees and to allow the sugarcane to be stored for up to 60 hours, eliminating the need for daily cutting. The babassu cake was obtained by mechanically extracting the babassu oil, grinding the kernels in a mill using 5-mm mesh sieves.

After the period of adaptation, the animals remained confined for 70 days to determine voluntary consumption and individual performance. The experiment was divided into five periods of 14 days. Half of the daily total mixed feed was offered at 08:30 and 16:00. The leftovers were collected and weighed daily to determine feed intake and to ensure that 10% of the total remained as leftovers.

Once a week, samples of the leftovers of each animal and of the feed provided (concentrated and bulk) were collected. The samples were packed in plastic bags, frozen and then grouped into periods of 14 days, forming a composite sample by period. Each of the samples was pre-dried in a 55 °C ventilated oven for 72 hours, ground in a mill with 1-mm mesh sieve, packed in capped polyethylene flasks and stored for further analysis.

The heifers were weighed on the first day of each period (14 days) in the morning, before the diet was offered, so that weight gain and feed conversion could be determined. The daily weight gain (DWG) per period was obtained by taking the weight at the beginning and end of each experimental period divided by the time elapsed in days. The total weight gain (TWG) was calculated as the difference between the first and last weighing over the 70 days of the experiment. To calculate the feed conversion (FC) of the DM, the ratio between the DMI and the DWG was considered.

The nutrient intake was expressed in kilograms per day (kg day^{-1}), grams per unit of metabolic size (g $BW^{-0.75}$) and percentage body weight (%BW).

The samples of the feed and leftovers were analysed in duplicate. The dry matter (DM) at 105 ºC, CP level, neutral detergent insoluble nitrogen (NDIN) and acid detergent insoluble nitrogen (ADIN) were determined as per the Association of Official Analytical Chemists (1995). The ether extract (EE) and ash content were determined based on the method described by Silva and Queiroz (2002).

The neutral detergent insoluble fibre (NDF) and acid detergent insoluble fibre (ADF) were analysed using the Ankom fibre analyser as per the sequential method of Van Soest, Robertson and Lewis (1991) with the addition of thermo-resistant amylase.

The organic matter content (OM) was calculated as the difference between the DM and ash content. The hemicellulose content was determined from the difference between the NDF and ADF. To estimate the total carbohydrates (TC) and non-fibre carbohydrates (NFC) the equations proposed by Sniffen *et al.* (1992) were used:

$$TC = 100 - (\%CP + \%EE + \%ash) \quad (1)$$

$$NFC = 100 - (\%NDF + \%CP + \%EE + \%ash) \quad (2)$$

To determine the apparent digestibility of the DM (ADDM) and OM (ADOM) in the diets, the Purified and Enriched Lignin external indicator (LIPE®) was used to estimate faecal egestion (RODRÍGUEZ; SALIBA; GUIMARÃES-JUNIOR, 2007).

LIPE® was administered to each animal during the final week of the trial, once a day (in the morning) for five days, including two days for adaptation and three days for sampling.

Faecal sampling began at 06:00 by observing the animals, and ended by collecting, with the aid of a plastic collector, one final sample of 300 g from the animal during defecation before the faecal pat reached the ground.

The faecal samples were pre-dried in a forced ventilation oven (55 ºC for 72 hours), ground in a mill with a 1-mm sieve and packed in plastic containers for further analysis at the Animal Nutrition Laboratory of the UFMG Veterinary School to estimate faecal production by LIPE® using an infrared spectrometer. Faecal production was calculated as described by Ferreira *et al.* (2009).

The data were tested for normality and evaluated by regression analysis using the SAS software (SAS INSTITUTE, 2003). In the regression, choice of the most appropriate model for each variable was based on the significance of the linear, quadratic, and cubic coefficients, at a significance level of 0.05. The assumptions of normal distribution and homoscedasticity of the data were verified earlier.

RESULTS AND DISCUSSION

The DM intake (DMI), expressed as kg day^{-1}, showed no statistical differences ($P > 0.05$; Table 3). When measured as %BW and g $BW^{-0.75}$, there was an increase in DMI as the babassu cake replaced the sugarcane in the diet ($P < 0.05$), of 0.16 g kg^{-1} BW and 0.65 g $BW^{-0.75}$ for each 10 g of added babassu cake ($P < 0.05$). The greatest intake was seen in the animals fed the diet containing 200 g kg^{-1} DM babassu cake (3.11 $\pm$ 0.23%BW and 121.25 $\pm$ 9.5 g $BW^{-0.75}$). These values are, respectively, 20.5% and 19.7% higher than those seen for the diet without added babassu.

Table 3 - Dry matter and organic matter intake in heifers fed diets containing babassu cake as a substitute for hydrolysed sugarcane

Variable	Level of substitution (g kg^{-1} DM)				Equation	CV (%)	R^2
	0	100	200	300			
Dry matter							
kg day^{-1}	6.21	7.15	7.32	7.56	$\hat{Y} = 7.06 + 1.22^{ns}$	16.72	-
%BW	2.58	2.88	3.11	3.04	$\hat{Y} = 2.656 + 0.0016X$	10.96	0.79
g BW$^{-0,75}$	101.33	113.83	121.25	120.65	$\hat{Y} = 104.46 + 0.065X$	10.05	0.83
Organic matter							
kg day^{-1}	5.81	6.65	6.85	7.18	$\hat{Y} = 5.98 + 0.004X$	16.76	0.91
%BW	2.41	2.67	2.91	2.88	$\hat{Y} = 2.47 + 0.0017X$	11.06	0.86
g BW$^{-0,75}$	94.75	105.90	113.48	114.30	$\hat{Y} = 97.17 + 0.066X$	11.15	0.89

ns = P > 0.05

Testing the effect of different levels of babassu cake (0%, 7.5%, 15% and 22.5%) on the intake of sheep, Sá *et al.* (2015) found no effect on the DMI, demonstrating the possibility of including this by-product in the diet of the animals. Due to the high NDF content found in babassu cake, the authors recommend the addition of up to 15% of the total diet. They also pointed out that by adding this by-product to the diets, the amount of silage was reduced; the NDF in the cake is effective in stimulating chewing, showing the potential of this feed for substituting bulk in the diets of ruminants.

In ruminants, intake is affected by the digestibility of the feed, which is in turn related to its digestion kinetics and passage through the rumen (DETMANN *et al.*, 2014; DIAS *et al.*, 2011), and is especially associated with the digestion of fibre, as it limits the rate of disappearance of the material from the digestive tract (ZEBELI *et al*., 2012). Thus, when animals are fed on diets with a low energy concentration and high fibre content, intake is limited by a restriction on the capacity of the digestive tract (RIAZ *et al*., 2014).

Despite having a similar fibre content, the diets had a different bulk to concentrate ratio (R:C), which ranged from 60:40 to 30:70. Since bulky foods contain larger fibres, the diets with a higher R:C probably resulted in a lower rate of passage and therefore, a lower DMI, which was regulated by the physical filling of the digestive tract. This aspect would explain the increase in DMI seen when the sugarcane was substituted by babassu cake.

The OM intake (OMI) showed an increasing linear response ($P < 0.05$), increasing by 40 g day^{-1}, 0.017 %BW and 0.66 g BW$^{-0.75}$ for each 10 g increase in babassu cake in the diet (Table 3). This can be explained by the reduction in the mineral content of the diets with the addition of babassu cake, as well as the increase in DMI by the animals fed on these diets.

NDF intake (NDFI) and ADF intake (ADFI) followed the responses observed for DM intake and were not affected by the diets when measured as g day^{-1} ($P > 0.05$; Table 4). However, they presented an increasing linear response ($P < 0.05$) when expressed as %BW and g BW$^{-0.75}$. The diets had a similar NDF and ADF content, so it was not these nutrients that affected the intake, but the variation in DMI. FDNI increased by 0.05 %BW and 21 g BW$^{-0.75}$ for each 10 g of sugarcane replaced by babassu cake ($P < 0.05$).

Miotto *et al.* (2012) evaluated the intake, apparent nutrient digestibility and nitrogen balance of sheep diets containing babassu mesocarp meal to substitute elephant-grass silage (0%, 21%, 38%, 62% and 78%). The authors also saw no changes in DMI, NDFI or ADFI, whereas for OMI, unlike in the present study, there was no effect from substituting the bulk with the by-product. Bringel *et al.* (2011) also evaluated the substitution of bulk with by-product, in this case palm oil cake, and found a quadratic response in the intake of all nutrients, different results from those seen in the present study. The authors point out that the DMI may be affected by the EE content of the diet, and that diets containing increasing levels of EE due to the addition of cakes might negatively affect nutrient intake at higher levels, which would explain the observed quadratic response, albeit not seen in the present study. On the other hand, the addition of by-products with a high fat level in ruminant diets can assist in mitigating enteric methane (ABDALLA *et al.*, 2008).

The apparent digestibility of the DM (ADDM) and OM (ADOM) showed a quadratic response ($P < 0.05$), the minimum ADDM being obtained with 150 g kg^{-1} DM babassu cake as a substitute for the sugarcane (493.0 g kg^{-1} DM). The minimum ADOM (526,5 g kg^{-1} DM) was obtained when 320 g kg^{-1} DM babassu cake was added to the diet as a substitute (Table 5).

Table 4 - Neutral detergent fibre and acid detergent fibre intake in heifers fed diets containing babassu cake as a substitute for hydrolysed sugarcane

Variable	Level of substitution (g kg^{-1} DM)				Equation	CV (%)	R^2
	0	100	200	300			
Neutral detergent fibre							
kg day^{-1}	2.67	2.91	3.12	3.06	$\hat{Y} = 2.94 + 0.44^{ns}$	14.59	-
%BW	1.11	1.17	1.33	1.23	$\hat{Y} = 1.135 + 0.0005X$	10.89	0.50
g $BW^{-0,75}$	43.64	46.49	51.94	48.71	$\hat{Y} = 44.60 + 0.021X$	8.91	0.58
Acid detergent fibre							
kg day^{-1}	1.40	1.58	1.64	1.66	$\hat{Y} = 1.57 + 0.27^{ns}$	16.95	-
%BW	0.58	0.63	0.69	0.68	$\hat{Y} = 0.595 + 0.0003X$	10.90	0.71
g $BW^{-0,75}$	22.81	25.08	27.13	26.44	$\hat{Y} = 23.43 + 0.013X$	10.13	0.77

ns = P > 0.05

Table 5 - Apparent digestibility of the dry matter (ADDM) and organic matter (ADOM) in heifers fed diets containing babassu cake as a substitute for hydrolysed sugarcane

Variable (g kg^{-1} DM)	Level of substitution (g kg^{-1} DM)				Equation	CV (%)	r^2
	0	100	200	300			
ADDM	540.5	500.6	480.1	509.8	$\hat{Y} = 542.1 – 0.063X + 0.0001X^2$	3.28	0.98
ADOM	625.3	578.1	556.2	566.6	$\hat{Y} = 625.7 – 0.063X + 0.0001X^2$	2.46	0.99

The reduction in the ADDM and ADOM of the diets at the highest levels of added babassu cake may have occurred due to the higher DMI observed in these diets, which increases the passage rate, reducing the fermentation, digestion and absorption time of the nutrients in the gastrointestinal tract of the animal, thereby reducing digestibility. Another explanation could be the higher EE content in diets containing babassu cake, which would negatively affect DM digestibility.

Bringel *et al.* (2011), studying palm oil cake as a substitute for bulk, observed similar responses to the present study, with a quadratic effect on digestibility from the addition of the by-product. The authors attributed this effect to the increase in the EE content of the diets that was above the maximum recommended for ruminants, of 50 g kg^{-1} EE in the DM. In the present study, the EE content did not reach this level, but increased with the addition of babassu cake, ranging from 15.2 to 24.2 g kg^{-1} DM. In all ruminant species, the nutrient content of the diet influences intake and digestibility (RIAZ *et al.*, 2014). The CP content generally has a positive effect on these variables, while the fibrous fractions (NDF and ADF) have a negative effect (DETMANN *et al.*, 2014), however, the levels of these nutrients were similar between the treatments containing the different proportions of babassu cake.

Evaluating the apparent digestibility of nutrients in sheep diets containing babassu mesocarp meal as a substitute for elephant grass silage, Miotto *et al.* (2012) found that the addition of the babassu by-product reduced the digestibility of CP and of the fibrous fractions. They also observed a quadratic response for DMD and OMD, with the maximum ADDM with the addition of 10% meal.

The final weight (299.7 $\pm$ 45.5 kg) of the heifers was not altered by the diets (Table 6); however, the DWG of the animals showed a quadratic response, with the highest DWG for 190.0 g kg^{-1} DM babassu cake as a substitute for the sugarcane.

Xenofonte *et al.* (2008) evaluated the performance of lambs fed diets with different levels of added babassu meal (0%, 10%, 20% and 30%, on a DM basis) and saw a decreasing linear response in DWG. The authors found a reduction of 51.4 g day^{-1} for every 10% of added babassu meal, suggesting that this by-product might limit the potential of the animals for gaining weight. According to the authors, the gain response of the animals was linked to DMI, nutrient digestibility and, particularly, energy consumption.

Table 6 - Performance variables in heifers fed diets containing increasing levels of babassu cake as a substitute for sugarcane

Variable	Level of substitution (g kg^{-1} DM)				Equation	CV (%)	r^2
	0	100	200	300			
IW (kg)[1]	194.6	191.4	180.5	196.8	$\hat{Y} = 190.8 + 40.8^{ns}$	22.64	-
FW (kg)[2]	286.8	311.4	293.2	307.3	$\hat{Y} = 299.7 + 45.5^{ns}$	15.85	-
UMS[3]	60.97	62.97	60.15	63.12	$\hat{Y} = 61.80 + 8.1^{ns}$	13.85	-
DWG (kg d^{-1})[4]	1.32	1.71	1.61	1.58	$\hat{Y} = 1.346 + 0.0038x – 0.00001x^2$	15.34	80.52
FC[5]	4.79	4.19	4.57	4.83	$\hat{Y} = 4.6 + 0.74^{ns}$	16.15	-

[1]IW = initial weight; [2]FW = final weight; [3]UMS = unit of metabolic size (kg $BW^{0.75}$); [4]DWG = daily weight gain (kg day^{-1}); [5]FC = dry matter feed conversion (kg DM consumed.kg of weight gain^{-1}); ns = P > 0.05

Similar responses to those of Xenofonte *et al.* (2008) were obtained by Maciel *et al.* (2012), who evaluated the effect on performance of adding palm oil cake to the diet (0%, 11.9%, 22.9% and 34.2% DM) of dairy heifers, and found that the DWG showed a linear reduction with the addition of the palm oil cake, with values of 1.06, 0.99, 0.89 and 0.54 kg day^{-1} seen for diets containing 0%, 11.9%, 22.9% or 34.2% palm oil cake, respectively. These values were lower than those found in the present study, which ranged from 1.32 $\pm$ 0.26 kg to 1.71 $\pm$ 0.17 kg day^{-1}, showing the productive potential of using babassu cake compared to other by-products. The addition of palm oil cake reduced the consumption and digestibility of the DM, which possibly led to a reduction in DWG. The authors point out that such reductions could be due to the type and content of the fat in palm oil cake, where the levels were 10.8% of the DM, higher than the value found for babassu cake (8.8% EE in the DM).

It should be noted that the values for DWG obtained in the present study were up to 2.28 times higher than expected when the diet was formulated (750 g). Excessive weight gain at this stage can impair correct development of the mammary tissue, thereby affecting future production. Compensatory gains may also have occurred as, despite the 21-day period of adaptation, the heifers had experienced mild dietary restriction before the start of the study.

The FC rate of the DM was not affected by the addition of babassu cake, showing an average intake of 4.6 $\pm$ 0.74 kg DM for each kg gain in body weight. Although the FC rate did not differ between the treatments, DMI increased with the addition of babassu cake, with a quadratic response for DWG, which showed the highest value at 190 g kg^{-1} babassu cake as a substitute for the sugarcane. Maciel *et al.* (2012) also found that FC was not affected by the added levels of palm oil cake in the diet, with an average of 5.68 kg DM consumed per kg of weight gained, a higher value than that found in the present study, which suggests that palm oil cake is less efficient than babassu cake, probably due to its chemical composition and nutrient digestibility. In addition to the higher EE content, palm oil cake presented higher levels of NDF, ADF, NDIN and ADIN than babassu cake, which could negatively affect the DMI, nutrient digestibility and FC rate. It is worth mentioning that feed is the main item in production costs for both crossbred and purebred heifers (SANTOS; LOPES, 2014), it being essential to optimise the feed conversion rate to increase the profitability of the system.

CONCLUSION

Babassu cake can substitute hydrolysed sugarcane in the diet of heifers by up to 300 g kg^{-1} DM. However, greater weight gains can be seen by substituting 190 g kg^{-1} DM, without affecting feed conversion.

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