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Sunflower cake from biodiesel production fed to crossbred Boer kids[1]

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ABSTRACT - The intake of the dry matter (DM), the crude protein (CP) and the metabolizable energy intake (ME) in megacalories per day (Mcal/day) were not affected by the diets. In contrast, the intake of neutral detergent fiber (NDF), in g/kg BW, increased linearly. An increasing linear effect was also observed for the ether extract (EE) intake, whereas a decreasing linear performance was observed for the non-fibrous carbohydrate (NFC) intake. The digestibility of DM, organic matter and NFC decreased linearly with the sunflower cake inclusion, whereas the digestibility of CP, NDF, and EE were not influenced by the diets. No effect was observed for the concentration of serum glucose or urea nitrogen serum. No effect was observed on the urea nitrogen serum in the hours after feeding; however, including sunflower cake in the diets resulted in a quadratic performance for the serum glucose concentrations in the hours after feeding. The average daily gain (ADG) had a decreasing linear effect, and the food conversions of the DM, CP, NDF, NFC and ME had increasing linear effects. The feeding costs decreased with the level of sunflower cake.

Key Words: byproducts, digestibility, intake, performance, ruminants

Introduction

Goat farming in the Northeast of Brazil has an important socio-economic role and is mainly focused on meat and milk production. These products are an important nutritional and income source, especially for small producers (Simplício, 2003).

The Northeast of Brazil is home to 91% of the national goat population, and the state of Bahia has the largest national herd (IBGE, 2007). Although the number of animals is impressive, the breeding system adopted by the producers is predominantly extensive. In addition to this, producers are faced with limitations in obtaining feed for the animals that is rich in protein and energy, especially during the dry season, when the supply of forage is scarce, resulting in low animal performance (Dantas Filho, 2007).

To overcome this adversity, producers make use of concentrated feeds, which are expensive. Therefore, the byproducts of agroindustry have been investigated as an option to reduce the costs of animal feed (Alcade et al., 2009; Pires et al., 2009; Borja et al., 2010; Nunes et al., 2010).

Recent studies indicate that the byproducts from the biodiesel production have nutritional characteristics that render them suitable for the inclusion in the diet of ruminants (Abdalla et al., 2008; Correia et al., 2011; Ribeiro et al., 2011; Silva et al.; 2011; Sanders et al., 2011). Sunflower cake is a byproduct obtained after the extraction of the oil from the seeds (Domingues, 2006; Palmieri et al., 2011), and, according to Santos (2008), it presents values for crude protein above 22.9% and ether extract up to 6.75%.

The present study was conducted to evaluate the inclusion of sunflower cake from the biodiesel production in the diet of crossbred Boer kids through the study of productive performance, apparent digestibility, blood parameters and feeding costs.

Material and Methods

The experiment was conducted in the Escola de Medicina Veterinária of the Universidade Federal da Bahia in Salvador, Bahia. Thirty-two uncastrated male crossbred Boer kids, aged 4.5 months (± 15 days) and weighing

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22±2.75 kg were used; the animals had been dewormed and vaccinated against clostridial diseases.

Animals were housed individually in pens measuring 1.0 × 1.0 m on a suspended wooden floor and were provided with water troughs and feeders. The experiment was conducted from October to December of 2008, and the experimental period lasted 68 days and was preceded by 7 days of animal adaptation to the environment, management and diets.

Diets were formulated according to the NRC (2001) to meet the requirements of Boer kids with 15 kg of body weight and a daily gain of 100 g per animal. Diets were isonitrogenous. Roughage was supplied as Tifton-85 hay (*Cynodon* sp.) ground into particles of approximately 5 cm. The proportion of the concentrate and roughage was 50:50 (Table 1). The treatments consisted of the inclusion of sunflower cake in proportions of 0, 8, 16 or 24% of the dry matter of the diet.

Animals were fed twice daily with a total mixed ration. The feed was supplied in quantities that ensured between 10% and 20% leftovers. Water was supplied *ad libitum*. The estimation of the water intake was performed twice a week by calculating the difference between the offered and remaining.

Each ingredient in the total mixed ration was collected three times a week, packed in plastic bags and stored at -10 ºC. At the end of the experiment, samples were analyzed to determine their chemical composition.

The chemical composition of the ingredients was determined according to the AOAC (1990) for the analysis of the dry matter (DM), ash (AS), crude protein (CP) and ether extract (EE) (Tables 2 and 3). The analyses for the determination of the neutral detergent fiber (NDF) and acid detergent fiber (ADF) were carried out according to Van Soest et al. (1991). The non-fibrous carbohydrates (NFC) were calculated according to Sniffen et al. (1992).

Table 1 - Ingredient proportions in the experimental diets fed to crossbred Boer kids

Ingredient	Sunflower cake (DM %)			
	0	8	16	24
Corn	32.91	30.17	27.41	24.69
Soybean meal	15.40	10.22	5.08	0.00
Sunflower cake	0.00	7.94	15.84	23.65
Minerals[1]	1.68	1.68	1.67	1.66
Tifton-85 hay (*Cynodon* sp.)	50.00	50.00	50.00	50.00

DM = dry matter.
[1] Levels guaranteed (per kg in active elements): 120.00 g calcium; 87.00 g phosphorus; 147.00 g sodium; 18.00 g sulfur; 590.00 mg copper; 40.00 mg cobalt; 20.00 mg chromium; 1800.00 mg iron; 80.00 mg iodine; 1,300.00 mg manganese; 15.00 mg selenium; 3,800.00 mg zinc; 300.00 mg molybdenum; and maximum 870.00 mg fluoride.

The digestibility trial was performed between the 40th and 43rd day of the experimental period. The diet offered and orts were weighed daily and samples were collected for chemical analysis and determination of the feed intake. To determine the apparent digestibility of the DM, OM, CP, NDF, NFC and EE, the method of the total collection of the feces was performed with collection bags attached to the animals. There were two days for adaptation to the feces collection bags.

After collection, feces were weighed, placed in identified plastic bags and then stored at -10 ºC. For analysis, samples were then thawed, weighed, and oven-dried (55 ºC, 72 hours). Orts and dried feces samples were ground and passed through a 1-mm screen and homogenized for later chemical analysis.

The apparent digestibility coefficients (ADCs) were obtained by the following equation:
ADC = ([nutrient consumed – nutrient in feces]/[nutrient consumed]) × 100.

The amount of total digestible nutrients was calculated from the proportion of digestible nutrients using the following equation, according to Weiss (1999): TDN = (digestible crude protein + digestible neutral detergent fiber + digestible non-fibrous carbohydrates+ [2.25×digestible ether extract]).

The metabolizable energy (ME) was calculated following the NRC recommendations (2001), using the following equations: Digestible Energy (DE) = TDN × 0.04409 (Mcal/kg) and ME = DE × 0.82.

Blood samples were collected on the 44th day, by jugular vein puncture: four blood samples were taken in intervals of two hours, the first was performed at 8:00 a.m. using fasted animals. Samples were centrifuged at 2000 x g for 15 minutes to separate the blood plasma, which was stored in Eppendorf tubes and frozen at -10 °C. At the end of the experiment, samples were thawed at room temperature, and the levels of blood urea nitrogen and blood glucose were determined using commercial enzymatic kits. These analyses were performed using a spectrophotometer, considering that the blood urea contains 45% nitrogen.

Animals were weighed at the beginning of the experiment and every 14 days, preceded by 16 hours of fasting of solid food. At the end of the experiment, they were weighed and slaughtered following sanitary standards. After slaughter, animals were skinned and eviscerated, and their carcasses were refrigerated (4 °C) for 24 h.

The feeding costs were calculated using the price of each ingredient as it was in September 2008 in Salvador, Bahia, Brazil. The revenue corresponds to the price paid per kg of cold carcass, multiplied by cold carcass weight obtained in each treatment. The price per kg of meat in the regional

Table 2 - Chemical composition of the ingredients in the diets fed to crossbred Boer kids

Item	Ingredient			
	Corn	Soybean meal	Sunflower cake	Tifton-85 hay (*Cynodon* sp.)
Dry matter (%)	88.57	89.17	91.85	86.81
Organic matter[1]	98.86	94.41	94.90	9.65
Ash[1]	1.14	5.59	5.10	7.35
Crude protein[1]	7.83	48.73	33.73	6.16
Ether extract[1]	4.11	1.93	6.85	1.12
Neutral detergent fiber[1]	10.91	10.17	32.23	79.52
Acid detergent fiber[1]	3.58	7.79	26.61	47.60
Hemicellulose[1]	7.33	2.38	5.62	31.91
Cellulose[1]	2.72	7.16	19.56	38.19
Lignin[1]	0.82	0.63	7.05	9.41
Non-fibrous carbohydrates[1]	76.01	33.58	22.09	5.85
NDIN (% total N)[2]	10.36	3.84	9.11	39.18
ADIN (% total N)[3]	3.15	2.18	3.70	18.77

[1]% of the DM; [2]Neutral detergent insoluble nitrogen; [3]Acid detergent insoluble nitrogen.

Table 3 - Chemical composition of the experimental diets fed to crossbred Boer kids

Item	Sunflower cake (DM %)			
	0	8	16	24
Dry matter (%)	87.97	88.20	88.43	88.65
Organic matter[1]	93.41	93.32	93.53	93.18
Ash[1]	6.59	6.68	6.75	6.82
Crude protein[1]	13.16	13.10	13.04	12.99
Ether extract[1]	2.21	2.54	2.87	3.19
Neutral detergent fiber[1]	44.92	46.65	48.37	50.08
Acid detergent fiber[1]	26.18	27.79	29.39	30.98
Hemicellulose[1]	18.73	18.86	18.98	19.09
Lignin[1]	5.07	5.58	6.08	6.57
Non-fibrous carbohydrates[1]	33.11	31.04	28.96	26.92
NDIN (% total N)[2]	23.61	23.83	24.06	24.30
ADIN (% total N)[3]	10.75	10.85	10.94	11.03
ME (Mcal/kg)[4]	2.30	2.10	2.21	1.96

DM = dry matter; CV = coefficient of variation.
[1] % of DM.
[2] Neutral detergent insoluble nitrogen.
[3] Acid detergent insoluble nitrogen.
[4] Metabolizable energy.

market, at the time of the experiment, was R$ 7.00. After obtaining the values of revenue and feeding costs, the calculation of the profitability (or gross margin) from the sale of the animals was found. The cost-benefit analysis was used to calculate the economic rate of return and to compare the carcass weight multiplied by the price of the carcass (in kg) in relation to the amount spent on the feed. The break-even point (equilibrium) and the cost of the carcass per kilogram were determined as described by Hernandez Perez Junior et al. (2001).

The experiment was a completely randomized design with four treatments and eight repetitions. The data were submitted to an analysis of variance (GLM procedure, Statistical Analysis System, versão 9.1) and a regression test. The significance was defined at $P<0.05$.

Results and Discussion

The dry matter intake was not influenced by the inclusion of the sunflower cake in the diets (Table 4), even with the increase in the neutral detergent fiber percentage in the diets (Table 3). It is likely that the size of the fiber fraction of sunflower cake, which was finely ground for subsequent mixing in the rations, promoted a normal transit in the digestive tract without causing ruminal-reticular filling. The inclusion of the sunflower cake in the diets did not promote changes in the crude protein intake (Table 4) because the diets were isonitrogenous and the dry matter intake was similar between the treatments. The average crude protein intake was 99 g/day, which is higher than the amount recommended by the NRC (2007).

The neutral detergent fiber intake, expressed in g/kg BW, increased linearly ($P<0.05$) with the inclusion of the sunflower cake in the diets (Table 4). Using sunflower cake in the diet of dairy cows, Santos (2008) observed no effect on the neutral detergent fiber or acid detergent fiber intake, which was also observed in the present study. The neutral detergent fiber intake, expressed in g/kg BW (Table 4), is consistent with the values cited by Van Soest (1994), who suggested an intake between 8.0 and 22.0 g/kg BW for ruminants.

A linear decreasing effect on the non-fibrous carbohydrate intake was observed, with a reduction of 2.45 g for each percentage unit of sunflower cake added in the diet (Table 4). This result may be due to the reduction of the non-fibrous carbohydrate in the diets (Table 3). Such result was also observed by Silva (2006), when feeding lactating cows a diet that included babassu cake. The babassu cake has a high fiber content, which provides the least amount of non-fibrous carbohydrates, similar to sunflower cake (Silva, 2006).

The ether extract intake showed a linear increase (P<0.05) due to the increase of this fraction with the inclusion of the sunflower cake in the diets (Table 3). However, the inclusion of the sunflower cake did not affect (P>0.05) the metabolizable energy intake (Table 4), even with the decrease in the intake and digestibility of the non-fibrous carbohydrates (Tables 4 and 5). Possibly, the increased intake of ether extract components offset the reduction in the intake and digestibility of the non-fibrous carbohydrates.

The intake of water has a relationship with the amount of dry matter intake. In the present study, the water intake was not influenced by the addition of the sunflower cake in the diet due to the similarity in the dry matter intake (Table 4).

A linear effect (P<0.05) was observed for the dry matter and organic matter digestibility, with an estimated reduction of 0.306 and 0.308%, respectively, per percentage unit of sunflower cake added in the diet (Table 5). This behavior can be attributed to the reduction of the digestibility of the non-fibrous carbohydrates. The linear decrease in the digestibility of the non-fibrous carbohydrates (P<0.05) with the inclusion of the sunflower cake (Table 5) probably occurred due to the increase in the levels of acid detergent fiber in the diet (Table 3), as the digestibility of the feed is more related to the content of the acid detergent fiber, and the fraction of indigestible fiber, lignin, represents a higher proportion in this component (Eastridge, 1997).

The inclusion of the sunflower cake in the diets did not change (P>0.05) the digestibility of the crude protein (Table 5). The mean of the digestibility obtained (80.6%) was higher than the 72.5% reported by Santos et al. (2009) by feeding sheep rapeseed cake and the 58.0% observed by Silva et al. (2007) for diets containing palm kernel cake.

Table 4 - Dry matter (DM), crude protein, neutral detergent fiber, non-fibrous carbohydrates, ether extract, metabolizable energy and water intake by crossbred Boer kids fed diets containing sunflower cake

Variable	Sunflower cake (% DM)				CV (%)	Regression equation	R^2
	0	8	16	24			
			Dry matter				
g/day	699	674	643	690	18.37	$\hat{Y}$ = 676	-
g/kg BW	35.90	36.40	34.40	38.20	14.51	$\hat{Y}$ = 36.9	-
g/kg $BW^{0,75}$	75.30	75.30	75.40	78.70	13.52	$\hat{Y}$ = 76.2	-
			Crude protein				
g/day	105	100	88	100	17.17	$\hat{Y}$ = 99.0	-
			Neutral detergent fiber				
g/day	247	253	237	286	18,58	$\hat{Y}$ = 256	-
g/kg BW	12.70	13.60	13.50	15.80	13.50	$\hat{Y}$ = 0.012*X+12.5	0.80
			Non-fibrous carbohydrate				
g/day	245	219	180	192	18.05	$\hat{Y}$ = -2.449*X+239.1	0.76
			Ether extract				
g/day	16.90	18.80	19.00	24.50	17.30	$\hat{Y}$ = 0.288*X+16.3	0.83
			Metabolizable energy				
Mcal/day	1.60	1.41	1.42	1.35	18.48	$\hat{Y}$ = 1.44	-
			Water				
l/day	1.41	1.50	1.25	1.55	23.23	$\hat{Y}$ = 1.43	-

CV = coefficient of variation; R^2 = coefficient of determination.

Table 5 - Effect of sunflower cake addition on the coefficients of digestibility of the dry matter (DM), organic matter (OM), non-fibrous carbohydrates (NFC), crude protein (CP), neutral detergent fiber (NDF), ether extract (EE) and metabolizable energy (ME)

Variable	Sunflower cake (% DM)				CV (%)	Regression equation	R^2
	0	8	16	24			
DM	72.48	72.25	68.85	62.86	6.41	$\hat{Y}$ = -0.306*X+71.62	0.61
OM	74.52	68.57	72.36	65.03	5.75	$\hat{Y}$ = -0.308*X+73.82	0.70
NFC	86.73	84.58	83.94	75.70	5.53	$\hat{Y}$ = -0.369*X+86.14	0.79
CP	80.66	78.60	84.72	78.52	4.64	$\hat{Y}$ = 80.61	-
NDF	54.24	47.78	53.88	45.70	14.10	$\hat{Y}$ = 50.40	-
EE	84.18	84.04	87.72	84.26	5.43	$\hat{Y}$ = 85.05	-
ME (Mcal/kg)	2.30	2.10	2.21	1.96	7.83	$\hat{Y}$ = -0.112*X+2.43	0.64

CV = coefficient of variation; R^2 = coefficient of determination.

The high digestibility of the crude protein in the sunflower cake was confirmed by Mupeta et al. (1997) when evaluating the quality of oilseed protein. The authors found that sunflower cake has a high ruminal degradability of crude protein and a high digestibility of rumen non-degradable protein.

In the current study, the levels of sunflower cake in the diets did not influence the digestibility of the neutral detergent fiber or ether extract (Table 5). The mean obtained for the neutral detergent fiber digestibility was lower than that observed by Santos et al. (2009) when evaluating diets containing rapeseed cake.

According to Silva (2004), sunflower cake fiber has low digestibility due to a higher lignin content because this fraction is a major factor limiting the digestion of cell wall polysaccharides. However, the neutral detergent fiber digestibility in the diet was 47.33%, which is higher than that observed by Silva et al. (2005) in diets containing cocoa meal and palm kernel cake.

There was no change in the blood urea nitrogen (BUN) concentration between the hours of post-prandial blood collection. Averages of 23.5, 24.8, 25.3 and 24.9 mg/dL were obtained for 0, 2, 4 and 6 hours, respectively. Similar behavior was observed for the concentration of BUN in the different levels of sunflower cake (Table 6), probably because the crude protein intake (g/day) was similar between the treatments (Table 4), as the protein intake has a direct influence on the concentration of BUN. Furthermore, according to Baker et al. (1995), the energy intake also influences the concentration of BUN, and, in our study, the intake of metabolizable energy (Mcal/day) also did not change between the treatments. The concentration of BUN was close to the normal parameters observed for goats, which are between 10 to 20 mg/dL (Pugh & Dum, 2005).

There was no effect of the inclusion of the sunflower cake on the blood glucose concentration (Table 6). However, there was a quadratic effect ($P<0.05$) between the hours of blood collection (Figure 1).

According to Pugh & Dum (2005), the blood glucose concentration of goats ranges from 50 to 75 mg/dL, thus, the results observed in our experiment are within the normal range (Table 6). The quadratic trend of the postprandial blood glucose was expected, considering that the concentration of glucose in the plasma is related to the hours after feeding. The peak observed was 61 mg/dL at 3.85 hours post-meal.

The inclusion of the sunflower cake in the diets reduced ($P<0.05$) the average daily gain (Figure 2). The regression equation obtained indicates a reduction of 0.002 kg for each increase of 1% of sunflower cake in the diets (Figure 2).

Although a similar metabolizable energy intake in relation to the inclusion levels of the sunflower cake (Table 4) was observed, the reduction in the average daily gain of the kids was probably due to the reduced non-fibrous carbohydrate intake and digestibility. The observed values of the average daily weight gain were 0.142, 0.117, 0.086 and 0.092 kg for the inclusion levels of 0.0, 8.0, 16.0 and 24%, respectively, and are close to the expected values of 0.100 kg/animal/day.

Similarly, the reduction of the non-fibrous carbohydrate digestibility (Table 5) reflected in worsening of the feed conversion; therefore, the conversion of the dietary dry matter, crude protein, neutral detergent fiber, non-fiber carbohydrates and total digestible nutrients showed linear increase ($P<0.05$) with the inclusion of the sunflower cake in the diets (Table 7). According to Cardoso et al. (2006), linear reductions in the daily gain and feed conversion

Table 6 - Concentration of blood urea nitrogen (BUN) and blood glucose (mg/dL) in crossbred Boer kids fed diets containing sunflower cake

Variable (mg/dL)	Sunflower cake (DM %)				CV (%)	Regression equation	R^2
	0	8	16	24			
BUN	26.68	25.81	22.67	23.37	19.68	$\hat{Y}$ = 24.63	-
Glucose	58.68	59.26	55.70	55.47	12.84	$\hat{Y}$ = 57.28	-

CV = coefficient of variation; R^2 = coefficient of determination.

Table 7 - Feed conversion of the dry matter (DM), crude protein (CP), neutral detergent fiber (NDF), non-fibrous carbohydrates (NFC) and total digestible nutrients (TDN) in crossbred Boer kids fed diets containing sunflower cake

Feed conversion	Sunflower cake (% DM)				CV (%)	Regression equation	R^2
	0	8	16	24			
DM[1]	5.36	5.87	7.75	7.58	18.06	$\hat{Y}$ = 0.107*X+5.372	0.83
CP[1]	0.81	0.83	1.08	1.11	19.53	$\hat{Y}$ = 0.014*X+0.806	0.90
NDF[1]	1.88	2.21	2.88	3.14	18.75	$\hat{Y}$ = 0.056*X+1.863	0.97
NFC[1]	1.89	1.91	2.19	2.11	19.57	$\hat{Y}$ = 0.012*X+1.888	0.66
TDN[1]	3.44	3.43	4.79	4.15	18.42	$\hat{Y}$ = 0.044*X+3.435	0.48

*P<0.05; [1]kg/kg of gain; CV = coefficient of variation; R^2 = coefficient of determination.

efficiency are due to the reduction of digestible nutrients.

In the economic evaluation, the cost of feed per animal per day was lower in the group fed a diet with 24% sunflower cake (Table 9) because there was less inclusion of corn and soybeans (Table 8). Positive values of the gross margin for all of the treatments were observed (Table 9), and the inclusion level of 8% sunflower cake had the highest gross margin.

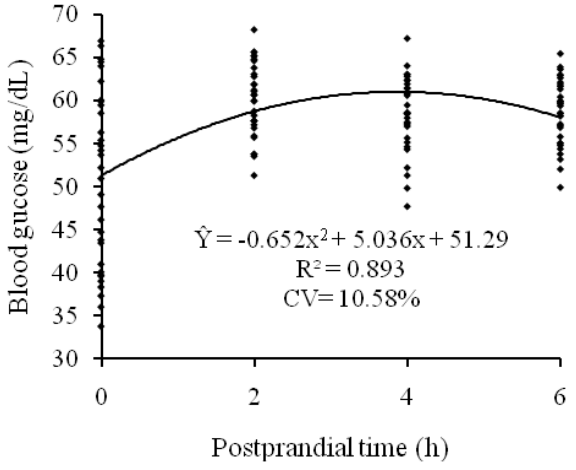

Figure 1 - Blood glucose concentration in crossbred Boer kids fed diets containing sunflower cake.

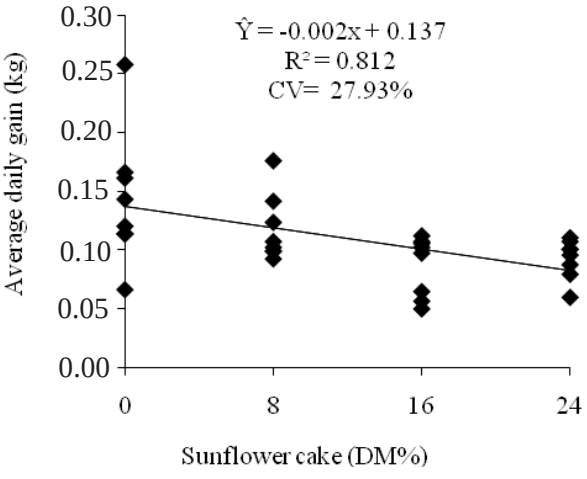

Figure 2 - Average daily gain of crossbred Boer kids fed diets containing sunflower cake.

The cost-benefit analysis was positive in all of the treatments, and the treatment with the inclusion of 8% sunflower cake had a better return, with R$ 1.63 for each R$ 1.00 of the total cost of diets (Table 9). Therefore, the inclusion of 8% sunflower cake in the diet resulted in a better cost-benefit and offers the best option of profitability. By the measure of the cost per kg of carcass produced, the level of an 8% inclusion of sunflower cake in the diet seems to be the most competitive (Table 9). Another financial indicator is the break-even point, which represents the amount of product sales required to cover the total cost. In the present study, this value was 5.40 kg of carcass, observed for the inclusion level of 24% (Table 9), which indicates that the minimum productivity should be 5.40 kg of carcass per animal, which does not cause injuries. From this point of view, the 24% sunflower cake treatment becomes profitable, which was observed for the other treatments.

Table 8 - Feeding costs of the diets containing sunflower cake

Item	Cost (R$/kg)	Sunflower cake (DM %)			
		0	8	16	24
Corn	0.59	0.19	0.18	0.16	0.15
Soybean meal	0.92	0.15	0.09	0.05	0.00
Sunflower cake	0.45	0.00	0.03	0.07	0.10
Minerals	3.00	0.05	0.05	0.04	0.04
Tifton-85 hay (*Cynodon* sp.)	0.65	0.34	0.33	0.33	0.33
Cost per animal/day (R$)	-	0.73	0.68	0.65	0.62

DM = dry matter.

Table 9 - Economic evaluation of the feeding costs of the diets containing sunflower cake

Item	Sunflower cake (DM %)			
	0	8	16	24
Feed cost/animal/day (R$)[1]	0.73	0.68	0.65	0.62
Days in feedlot	61	61	61	61
Total feed cost	44.53	41.48	39.65	37.82
Initial body weight (kg)	15.05	15.40	15.13	15.80
Final body weight (kg)	23.72	22.53	20.40	21.21
Average daily gain (kg)	0.142	0.117	0.086	0.092
Average gain (kg)	8.675	7.137	5.262	5.612
Total revenue (R$)[1]	64.75	67.83	57.12	60.20
Gross margin (R$)[2]	20.22	26.35	17.47	22.38
Benefit/cost[3]	1.45	1.63	1.44	1.59
Cold carcass yield (%)	39.18	43.21	39.65	40.02
Meat price (R$/kg)	7.00	7.00	7.00	7.00
Cold carcass weight (kg/animal)	9.25	9.69	8.16	8.60
Break-even point (kg)[4]	6.36	5.92	5.66	5.40
Cost (R$)/kg of carcass[5]	4.81	4.28	4.85	4.39

DM = dry matter.
[1] Mean price per animal.
[2] Total income (R$) - total cost (R$).
[3] Total income (R$) ÷ total cost (R$).
[4] Total cost (R$) ÷ meat price kg (R$).
[5] Total cost (R$) ÷ cold carcass weight (kg).

Conclusions

The inclusion of sunflower cake in the diets resulted in an increase of the neutral detergent fiber and a reduction of the non-fibrous carbohydrates, which had a negative influence on the growth performance of the animals. However, sunflower cake can be added up to 8% in the diets of crossbred Boer kids, as the expected production level performance and a better gross margin was achieved.

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