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REGULAR ARTICLES

Peanut cake can replace soybean meal in supplements for lactating cows without affecting production

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Abstract

This study evaluated the total replacement of soybean meal with peanut cake in the concentrate supplement of lactating cows grazing. Eight crossbred 5/8 Holstein × 3/8 Zebu cows between the 45th and 60th day of lactation and 507 ± 35 kg BW were distributed in a 4 × 4 double Latin square design with four levels of peanut cake (0, 110, 220, and 330 g/kg of the dry matter—DM) as a replacement of soybean meal in the concentrate supplement. The intake of pasture, total (pasture + concentrate), crude protein (CP), neutral detergent fiber (NDF), total digestible nutrients, and digestibility of the DM, CP, ether extract (EE), and NDF was not affected by the replacement of soybean meal with peanut cake. However, the EE ($P = 0.83$) intake and non-fiber carbohydrate digestibility ($P = 0.09$) exhibited an increasing linear trend by the peanut cake inclusion. The NDF exhibited a decreasing linear trend ($P = 0.07$) as the level of peanut cake increased. Production, corrected production, and protein, fat, lactose, total solid, and non-fat solid composition concentrations in the cows' milk were not affected ($P > 0.05$) by the peanut cake inclusion. The protein/fat ratio exhibited an increasing linear trend ($P = 0.082$) by the peanut cake inclusion. Peanut cake can completely replace soybean meal in the concentrate mixture because it does not alter dry matter intake, production, and composition of milk, and in addition it can reduce the cost of feeding.

Keywords *Arachis hypogaea* · Blood · By-products · Dairy cattle · Pasture

Introduction

Intensively managing the use of concentrate supplementation to complement nutrition that is generally not provided to lactating cows by tropical pastures can increase production costs and reduce the producers' income. Thus, to reduce the cost of conventional ingredients (such as corn grain and soybean meal) in cows' diets, studies have focused on using agro-industrial by-products in ruminant feeding in tropical countries, and the use of agro-industrial by-products has increased due to environmental, economic, and social factors, including the increased politics regarding the use of biofuels (Cerutti et al. 2016). The inclusion of cakes derived from palm fruits in ruminant diets has attracted the attention of the scientific community and stimulated research studies focusing on the influence of these new dietary components on the quality of the milk and meat (Oliveira et al. 2015a; Silva et al. 2016); in particular, studies have focused on the replacement of conventional ingredients in livestock diets and methods to reduce feeding costs while maintaining productivity, product quality, and well-balanced diets that meet nutritional requirements (Gonzaga Neto et al. 2015).

The peanut (*Arachis hypogaea*), which is an important crop that is grown worldwide, is used commercially mainly for oil production. The by-products of peanut contain many other functional compounds, such as proteins, fibers, polyphenols, antioxidants, vitamins, and minerals, which can be added as functional ingredients into many processed feeds (Arya et al. 2016). Peanut cake is obtained by pressing the seeds during the oil extraction process (Gonzaga Neto et al. 2015); it has a

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high nutritional value, especially in proteins (410 to 450 g/kg in dry matter (DM) basis) and lipids (80 to 90 g/kg in DM basis) (Gonzaga Neto et al. 2015). Peanut cake can be included as a beneficial protein source in the diets of lactating cows in managed pastures and could replace conventional ingredients (Cerutti et al. 2016). Thus, peanut cake may represent an eventual replacement that can reduce dietary costs, improve the digestibility of nutrients, and, consequently, improve milk production. Thus, the objective of this experiment was to test the hypothesis that peanut cake can replace soybean meal in balanced diets without affecting the intake, digestibility, or nitrogen balance while improving the milk production and composition and reducing the dietary costs in crossbred 5/8 Holstein × 3/8 Zebu lactating cows.

Materials and methods

Location and ethical considerations

This experiment was conducted after obtaining institutional approval from the Federal University of Bahia (12° 25′ S and 38° 58′ W), and all protocols were conducted according to the Ethical Principles of Animal Experimentation adopted by the Animal Use Ethics Committee of Brazil, Protocol 17/2014.

Animals, experimental treatments, and diets

The experiment lasted 80 days and was divided into the following four periods (20 days each): during the first 13 days of each period, the animals were adapted to the diets, and during the final 7 days of each period, the data were collected.

Eight multiparous crossbred 5/8 Holstein × 3/8 Zebu cows, with an average body weight (BW) of 507 ± 35 kg (mean ± SD) between the 45th and 60th day of lactation, were distributed according to a 4 × 4 double Latin squares design in which eight animals formed the columns of the double 4 × 4 Latin square, and the same four periods formed the rows of both squares. The cows were fed four experimental supplements, and each supplementation involved the substitution of soybean meal by peanut cake at various concentrations (0, 110, 220, and 330 g/kg DM of concentrate). The roughage utilized was *Panicum maximum* cv. Tanzania in an 8 × 1000-m^2 grazing area, which was divided into ten pickets sized 0.8 × 1000 m^2 each and enclosed by electrified wire with a trough containing mineral salt and a water cooler. The pasture was managed, and a rotational system was used in which each experimental group spent 3 days in the picket and 27 days at rest; an average forage of 100 g/kg of body weight was dried freely and offered in the field, and the animals consumed the desired amount.

Dry matter pasture and fodder was available in five square areas (1.0 m^2) located in random points at the entry and exit of each paddock. The forage was cut and weighed for the determination of the DM and, consequently, of their income to adjust the grazing pressure to optimize intake.

To evaluate the forage quality ingested by the animals, the samples were collected from simulated grazing to obtain a sample that is similar to the ingested content. Thus, each animal was treated for 30 min, and each animal's grazing action was observed, while a sample similar to that ingested was collected. After weighing the collected samples, an aliquot was separated and stored at − 20 °C; then, the samples were assembled into a composite to analyze the chemical composition and estimated intake.

The ingredients in the concentrate mixture included corn bran, soybean meal, mineral-vitamin core, and peanut cake (the respective levels were previously described). The diets were formulated according to the National Research Council (NRC 2007) to meet the potential milk production of 15 kg/day with 3.5% fat. The chemical composition of the feed ingredients and pasture is shown in Table 1. The percentage of ingredients in the diet and its chemical composition is shown in Table 2.

Dietary analysis

Samples of the ingredients, forage, and diets were pre-dried at 55 °C for 72 h to determine the DM concentration (method 967.03) according to the Association of Official Analytical Chemists (AOAC 2012), and then the samples were ground using a Wiley mill (Tecnal, Piracicaba City, São Paulo State, Brazil) with a 1-mm sieve, stored in airtight plastic containers (ASS, Ribeirão Preto City, São Paulo State, Brazil), and analyzed for ash (method 942.05), crude protein (CP, method 981.10), and ether extract (EE, method 920.29). The neutral detergent fiber (NDF) was determined according to the methodology proposed by Van Soest et al. (1991) using heat-stable alpha-amylase and sodium sulfite, and the acid detergent fiber (ADF) was determined according to the AOAC (method 954.01) using an ANKOM 2000 Fiber Analyzer (ANKOM Tech. Corp., Fairport, NY, USA). The ADL was determined using the AOAC methods (method 973.18) in which the ADF residue was treated with 72% sulfuric acid. The NDF was corrected for ash and protein (NDFap). The NDF residue was incinerated in an oven at 600 °C for 4 h, and a correction for the protein content was applied by subtracting the neutral detergent insoluble nitrogen content.

The non-fiber carbohydrate (NFC) content in the ingredients was determined using the methods proposed by Mertens (1997) and calculated using the equation NFC = 100 − NDFap − CP − EE − ash, and the result was considered in the calculation of the NDF value after correcting for the ash and protein content. The neutral detergent insoluble nitrogen

Table 1 Chemical composition of the ingredients used in the experimental diets of crossbred Holstein × Zebu cows

Analytic fraction (g/kg DM)	Experimental ingredients			
	P. maximum cv. Tanzânia	Corn ground	Soybean meal	Peanut cake
Dry matter (g/kg as fed)	266	881	885	909
Ash	88.1	13.8	65.3	52.0
Crude protein	116	50.1	484	447
Ether extract	17.8	46.9	20.9	185
Neutral detergent fiber$_{ap}$ [a]	590	107	112	118
Acid detergent fiber	410	34.6	81.6	70.0
Neutral detergent insoluble nitrogen[b]	359	206	79.8	68.5
Acid detergent insoluble nitrogen[b]	75.6	35.5	41.2	35.7
Non-fiber carbohydrates	129	758	280	155
Cellulose	316	40.4	88.5	79.9
Hemicellulose	266	77.9	52.1	52.2
Acid detergent lignin	68.2	13.4	12.7	29.5

[a] Neutral detergent fiber corrected for ash and protein

[b] Crude protein basis

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

Variables	Peanut cake levels (% DM)			
	0%	11%	22%	33%
Pasture availability (kg DM)	2362	2330	2602	2135
Pasture offering (kg DM)	9.59	9.66	10.56	8.58
Composition of concentrate supplementation (g/kg DM)				
Corn ground	657	652	648	647
Soybean meal	321	216	109	0.00
Peanut cake	0.00	110	220	330
Mineral mixture[a]	22.6	22.6	22.5	22.5
Chemical composition of concentrate (g/kg DM)				
Dry matter (g/kg as fed)	885	888	891	893
Ash	52.6	51.4	50.1	48.8
Crude protein	188	186	184	182
Ether extract	37.5	55.6	73.8	92.4
Neutral detergent fiber$_{ap}$ [b]	106	107	107	108
Acid detergent fiber	67.8	68.9	70.1	71.3
Neutral detergent insoluble nitrogen[c]	161	159	157	155
Acid detergent insoluble nitrogen[c]	36.5	35.9	35.4	34.8
Non-fiber carbohydrates	586	570	554	538
Cellulose	54.9	54.2	53.5	52.8
Hemicellulose	67.9	67.7	67.6	67.5
Acid detergent lignin	12.9	14.7	16.6	18.5

[a] Assurance levels (per kg of product): calcium, 200 g; phosphorus, 60 g; magnesium, 20 g; sulfur, 20 g; sodium, 70 g; potassium, 35 g; copper, 700 mg; iodine, 40 mg; cobalt, 15.00 mg; iron, 700 mg; manganese, 1600 mg; zinc, 2500 mg; selenium, 19 mg; chromium, 10.00 mg; fluorine (max), 600 mg; vitamin A, 200,000 international units (IU); vitamin E, 1500 IU; vitamin D3, 50,000 IU

[b] Neutral detergent fiber corrected for ash and protein

[c] Crude protein basis

and acid detergent insoluble nitrogen were obtained according to the recommendations by Licitra et al. (1996).

Intake and digestibility

Cows were fed at 06:00 and 16:00 h with a daily adjustment to ensure approximately 5 to 100 g/kg of refusals. The daily intake was measured on the 13th to 20th day of each period by weighing the food provided and the refusals per animal.

The supplement intake was directly determined according to the difference between the amount of feed offered and the amount refused. The estimated grass intake was calculated according to the following equation for dry matter intake: DMI (kg/day) = {[(FP × CIF) IS]/CIFO} + DMIS, where DMI = dry matter intake (kg/day), FP = fecal production (kg/day), CIF = NDFi concentration (kg/kg DM) in the feces, IS = NDFi in the supplement (kg/day), CIFO = NDFi forage (kg/kg DM), and DMIS = dry matter intake of the supplement (kg/day) according to Casali et al. (2008).

Chromic oxide, which was administered daily for 20 days at 9:00 h in a single 10.0-g dose, was used to estimate the fecal output, which was used an external indicator. Thirteen days were provided for the adaptation and regulation of the excretion marker, and 7 days were provided for the collection of the stool. The feces were collected directly from the rectum once per day and stored at − 10 °C. The dry matter fecal production was determined using the following equation: FP (kg/day) = supplied Cr_2O_3 (g/day)/Cr_2O_3 feces (g/kg DM), where FP = fecal production. The samples were analyzed using atomic absorption spectrophotometry (Perkin-Elmer®, Überlingen, Alemanha) for chromium dosage as proposed by Willians et al. (1962).

To determine the indigestible neutral detergent fiber (iNDF), samples of the fodder concentrates and feces were incubated in the rumen of four fistulated animals for 144 h, and the residue was assumed to be indigestible using the method described by Cochran et al. (1986). The digestibility and DMI were estimated from the fecal production and verified using chromium oxide (Cr_2O_3) as an external marker and iNDF as an internal marker.

The digestibility coefficients (DC, g/kg) of DM, CP, NDF, NFC, and EE were calculated as follows: DC = [(kg of the portion ingested − kg of the portion excreted)/(kg of the portion ingested)] × 1000. The intake of total digestible nutrients (TDN) was calculated as described by Sniffen et al. (1992) using the following equation: ITDN = [(ICP − CPf) + 2.25 (IEE − EEf) + (INDF − NDFf) + (INFC − NFCf)], where ICP, IEE, INDF, and INFC represent the intake of CP, EE, NDF, and NFC, respectively, and where CPf, EEf, NDFf, and NFCf refer to the excretion of CP, EE, and TC, in the feces. The concentrations of TDN were calculated using the following equation: TDN (g/kg) = (TDN intake/DM intake) × 1000.

Production and composition of milk

The milk samples from each animal (collected at 06:00 and 16:00 h) were mixed (50:50% morning and afternoon production) to yield a composite sample, which was placed in plastic containers with Bronopol® preservative and stored in a freezer at − 20 °C until the analysis of the chemical composition (100 ml sample) at the end of the experimental period. A slow Pasteurization method (Brazil 2011) was used, and the efficiency of this method was evaluated using the alkaline phosphatase and peroxidase tests that were included in the Laborclin kit® (Vargem Grande city, Paraná State, Brazil). At the end of each sampling period, approximately 100 ml of milk were preserved with Bronopol, and the pH and chemical composition were determined. To determine the chemical composition, the crude protein, fat, lactose, total solids, and non-fat solids were assessed by MilkoScan 203 (Foss Electric DK-3400, Hillerød, Denmark) in the Laboratory of Milk Clinic, the College of Agriculture Luiz of Queiroz (ESALQ), Piracicaba City, São Paulo State, Brazil.

The following formula, which was proposed by Leiva et al. (2000), was utilized to calculate the milk production after correcting for 0.035 fat ($MPC^{0.035}$): $MPC^{0.035}$ = (12.82 × Pfat) + (7.13 × Pprot) + (0.323 × PM), where MP = milk production, kg/day; Pfat = production of fat, kg/day; and Pprot = production of protein, kg/day. The milk fat and milk urea nitrogen content were obtained by AOAC (2012).

Statistical analysis

The statistical model included the concentration of peanut cake (0, 110, 220, and 330 g/kg) that replaced the soybean meal in the concentrate as fixed effects, and the period (4), animals (8), and residue were included as random effects. Milk production was used as a covariate. The data were subjected to an analysis of variance and regression analyses (linear and quadratic) using the GLM and REG procedures implemented in the SAS® statistical software (version 9.1.2. Cary, NC, USA) (SAS 2014).

The significance level was set at a probability of 5% ($P \leq 0.05$), and $P \leq 0.10$ indicated the presence of trends. The statistical model used was $Y_i = \beta_0 + \beta_1 x_i + \varepsilon_i$, where:

Y_i i-*th* variable observation depending on *Y*;
x_i, i-*th* value of the regression variables;

β_0 independent = representing the intercept of the line at $X = 0$;
β_1 regression variable for treatment x_i; and
ε_i random error associated with each observation.

Results

Intake and digestibility

The nutrients in the pasture intake (kg/day) were not affected by the peanut cake levels that replaced the soybean meal ($P > 0.05$). However, the total ether extract intake (pasture + concentrate) kg/day ($P = 0.83$) increased linearly as the level of peanut cake in the diet increased. The dairy cows' total intake of DM ($P = 0.36$), CP ($P = 0.60$), NDF ($P = 0.33$), and TDN ($P = 0.29$) was not affected by the peanut cake levels that replaced the soybean meal in the concentrate diets in the pasture (Table 3). The total DMI (pasture + concentrate) in %BW ($P = 0.37$) was not affected by the peanut cake levels that replaced the soybean meal. However, the NDF showed a decreasing linear trend ($P = 0.07$) as the peanut cake level increased. The digestibility coefficient of DM ($P = 0.70$), CP ($P = 0.88$), EE ($P = 0.38$), and NDF ($P = 0.52$) was not altered by the levels of peanut cake that replaced the soybean meal in the diet concentrate. The NFC digestibility showed an increasing linear trend ($P = 0.09$) as the peanut cake level increased.

Production and composition of milk

The milk production ($P = 0.93$) and corrected milk production ($P = 0.54$) were not affected by the levels of peanut cake included in the dietary supplement (Table 4). There were no effects of the peanut cake levels on the protein ($P = 0.13$), fat ($P = 0.15$), lactose ($P = 0.72$), total solid ($P = 0.27$), and non-fat solid ($P = 0.16$) content in the milk. The protein/fat rate ($P = 0.08$) exhibited an increasing linear trend ($P = 0.09$) as the peanut cake level increased.

Table 3 Nutrient intake (kg/day; % BW) in pasture, concentrate and total (pasture + concentrate) and nutrient digestibility by lactating crossbred Holstein × Zebu cows supplemented with peanut cake in replacement of soybean meal in the concentrate

Nutrients	Peanut cake levels (% DM)				SEM	*P* value[a]	
	0%	11%	22%	33%		Linear	Quadratic
Pasture intake (kg/day)							
Dry matter	10.1	8.99	9.15	8.53	0.75	0.36	0.75
Crude protein	1.18	1.05	1.07	1.00	0.10	0.60	0.82
Ether extract	0.18	0.17	0.16	0.15	0.18	0.83	0.95
Neutral detergent fiber	6.53	5.82	5.94	5.54	0.48	0.33	0.65
Non-fiber carbohydrates	1.28	1.16	1.17	1.08	0.09	0.39	0.77
Total digestible nutrients	6.04	5.06	5.11	4.50	0.65	0.29	0.32
Total intake (pasture + concentrate) (kg/day)							
Dry matter	12.7	11.7	11.8	11.2	0.75	0.37	0.68
Crude protein	1.69	1.54	1.56	1.49	0.10	0.56	0.27
Ether extract	0.28	0.32	0.36	0.40	0.02	< 0.001	0.17
Neutral detergent fiber	6.89	6.19	6.31	5.91	0.34	0.48	0.36
Non-fiber carbohydrates	2.84	2.68	2.65	2.25	0.09	0.07	0.16
Total digestible nutrients	7.85	6.98	7.06	6.42	0.68	0.40	0.85
Forage:concentrate ratio	79:21	77:23	77:23	76:24	–	–	–
Total intake (pasture + concentrate) (%BW)							
Dry matter	2.51	2.30	2.35	2.23	0.75	0.37	0.68
Neutral detergent fiber	1.36	1.22	1.25	1.18	0.09	0.07	0.16
Digestibility (g/kg)							
Dry matter	461	465	474	439	21.7	0.70	0.57
Crude protein	528	547	551	521	30.8	0.88	0.85
Ether extract	436	558	559	572	59.8	0.38	0.57
Neutral detergent fiber	467	360	366	360	25.8	0.52	0.22
Non-fiber carbohydrates	793	836	833	796	16.6	0.09	0.16

SEM standard mean error

[a] Significant at $P < 0.05$ and considered a trend at $P < 0.10$

Table 4 Production and composition of milk and economic evaluation of diets of lactating crossbred Holstein × Zebu cows supplemented with peanut cake in replacement of soybean meal in the concentrate

Item	Peanut cake levels (g/kg DM)				SEM	*P* value[a]	
	0	110	220	330		Linear	Quadratic
Production (kg/day)							
Milk	14.6	14.5	14.2	14.3	1.06	0.93	0.92
Corrected $^{3.5\%\ fat}$	13.4	13.0	13.9	13.3	0.64	0.54	0.62
Composition (g/kg)							
Fat	28.2	28.1	33.1	30.1	2.70	0.15	0.22
Protein	30.1	29.9	29.5	29.7	0.70	0.13	0.16
Lactose	46.9	47.0	46.7	46.6	0.50	0.72	0.31
Total solids	115	115	119	116	2.60	0.27	0.28
Non-fat solids	86.9	86.7	85.7	86.1	0.80	0.16	0.25
Fat:protein ratio	0.94	0.94	1.15	1.02	0.10	0.082	0.23

SEM standard mean error

[a] Significant at $P < 0.05$ and considered a trend when $P < 0.10$

Discussion

Intake, digestibility, and urea nitrogen concentration in the blood and milk

The nutritional requirements will only be fully met if the animals consume sufficient quantities of DM. In this study, an average of 11.8 kg/day of the DMI (Table 3), which is equivalent to 2.35% BW, was observed in all experimental diets, which is the same value recommended by the NRC (2007) for cows with an average production and BW, indicating a DM intake of 12.8 kg/day.

Similar responses to the treatments in terms of the intake of CP, NDF, and TDN may suggest that the diets are isonitrogenous and exhibit similar levels of NDF and TDN (Table 2). Moreover, the concentrates were well accepted by the cows because the animals consumed all offered feed. According to Mertens (1997) and Allen et al. (2009), nutrient intake can be affected by the NDF levels, the reticulo-rumen filling effect, and the energy content in the diet. Intake is regulated by physical mechanisms when the NDF intake, based on the BW of the animal, reaches the value of 1.2%. In this study, the NDF intake values ranged from 1.22 to 1.36 (% BW). Therefore, it is believed that the DMI was limited by the filling effect.

The increase in the intake of the ether extract is associated with the higher ether extract content in the peanut cake (185 g/kg EE in DM basis), which contributed to the increased composition of this nutrient in the experimental diets (Silva et al. 2016). Diets containing oil seed cakes usually reduce the DMI in ruminants by increasing EE, and the nutrient digestibility is negatively influenced by the reduction in the DMI, resulting in a decrease in the rate of passage through the digestive tract (Cerutti et al. 2016). According to the DMI data observed in present study, while the DM digestibility coefficients have shown levels below those reported in the literature, this reduction in digestibility did not change the DMI in the animals. Thus, the EE concentration increased as the peanut cake level increased (92.4 g/kg DM basis), which affected the NFC intake and digestibility but did not affect the DM digestibility and other nutritional fractions.

Production and composition of the milk

The similarity in milk production and composition can be explained by the DMI, and therefore, the CP and TDN intakes ($P > 0.05$) were similar among the treatments tested (Table 4). This finding is consistent with a report by Gonzaga Neto et al. (2015) in which the observed milk production was stimulated by the intake of DM, TDN, and CP and inhibited by dietary NDF. Moreover, the similarity in the digestibility coefficients (Table 3) suggests that the peanut cake addition did not affect intake or alter nutrient digestibility (Oliveira et al. 2015b). Therefore, the experimental diets, combined with the pasture quality, were able to meet the nutritional requirements of the animals for the milk production of 14.4 kg/day.

In addition to the previously mentioned factors, the milk production values found in this study (Table 4) are associated with a lower degree of specialization in the experimental flock because of their low genetic potential (Cerutti et al. 2016). These results corroborate Cerutti et al. (2016) who found, by studying peanut cake levels, that there were no effects on milk production in Holstein × Gir crossbred cows, but supplementation with peanut cake resulted in changes in the nutritional quality of their milk products.

This finding is important because the total solid content in milk is important for the dairy industry; the total solid content is an important income source and was within the established standards (Stoffel et al. 2015). In addition to its benefits to human health, positive influences in inhibiting the growth of neoplastic cells in the prevention of osteoporosis and important physiological processes (Mills et al. 2011), it has a direct influence on the production of dairy products. Thus, it is important to know the composition of this portion, which is generically referred to as crude protein and fat.

In addition, the cost reduction of the diet substituting soybean meal with biodiesel by-product peanut cake increases the profit margin and can be considered significant, considering that the price per liter of milk is low, and the current price of milk on the market determines how much one should invest in the farm to produce it; in contrast, the cost of production does not determine the price of the product (Hills et al. 2015).

Conclusions

It is recommended that in concentrate supplements for lactating cows, soybean meal can be replaced with peanut cake, because this does not alter dry matter intake, milk production, or composition of milk, and it reduces the cost of feeding and increases producers' profit margins.

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Compliance with ethical standards This experiment was conducted after obtaining institutional approval from the Federal University of Bahia (12° 25′ S and 38° 58′ W), and all protocols were conducted according to the Ethical Principles of Animal Experimentation adopted by the Animal Use Ethics Committee of Brazil, Protocol 17/2014.

Conflicts of interest The authors declare that they have no conflicts of interest.

References

Allen, M. S., Bradford, B. J., and Oba M., 2009. Board-Invited Review: The hepatic oxidation theory of the control of feed intake and its application to ruminants. Journal of Animal Science, 87, 3317–3334.

Arya, S. S., Salve, A. R., and Chauhan, S. J., 2016. Peanuts as functional food: a review. Food Science and Technology, 53, 31–41.

Association of Official Analytical Chemists (AOAC), 2012. Official method of analysis. 19th ed. Gaithersburg, MD (USA): Association of official analytical chemists.

Brazil, 2011. Instrução Normativa n° 62, de29 de dezembro de 2011. Aprova o Regulamento Técnico de Identidade e Qualidade do Leite Cru Refrigerado. Diário Oficial da União, Brasília, DF, 30 dez. de 2011. Seção 1.

Casali, A. O., Detmann, E., Valadares Filho, S. C., Pereira, J. C., Henriques, L. T., de Freitas, S. G. , and Paulino, M. F., 2008. Influence of incubation time and particles size on indigestible compounds contents in cattle feeds and feces obtained by *in situ* procedures. Revista Brasileira de Zootecnia, 37, 335–342.

Cerutti, W. G., Viegas, J., Barbosa, A. M., Oliveira, R. L., Dias, C. A., Costa, E. S., Nornberg, J. L., de Carvalho, G. G., Bezerra, L. R., and Silveira, A. M., 2016. Fatty acid profiles of milk and *Minas* frescal cheese from lactating grazed cows supplemented with peanut cake. Journal of Dairy Research, 83, 42–51.

Cochran, R. C., Adams, D. C., Wallace, J. D., and Galyean, M. L., 1986. Predicting digestibility of different diets with internal markers: evaluation of four potential markers. Journal of Animal Science, 63, 1476–1483.

Gonzaga Neto, S., Oliveira, R. L., Lima, F. H., Medeiros, A. N., Bezerra, L. R., Viégas, J., Nascimento Jr, N. G., and Freitas Neto, M. D., 2015. Milk production, intake, digestion, blood parameters, and ingestive behavior of cows supplemented with by-products from the biodiesel industry. Tropical Animal Health Production, 47, 191–200.

Hills, J. L., García, S. C., Dela Rue, B., Clark, C. E. F., 2015. Limitations and potential for individualised feeding of concentrate supplements to grazing dairy cows. Animal Production Science, 55, 922–930.

Leiva, E., Hall, M. B., and Van Horn H. H., 2000. Performance of dairy cattle fed citrus pulp or corn products as source of neutral detergent-soluble carbohydrates. Journal Dairy Science, 83, 2866–2875.

Licitra, G., Hernandez, T. M., and Van Soest, P. J., 1996. Standardization of procedures for nitrogen fractionation of ruminant feeds. Animal Feed Science Technology, 57, 347–358.

Mertens, D. R., 1997. Creating a system for meeting the fiber requirements of dairy cows. Journal of Dairy Science, 80, 1463–1481.

Mills, S., Ross, R., Hill, C., Fitzgerald, G., and Stanton, C., 2011. Milk intelligence: Mining milk for bioactive substances associated with human health. International Dairy Journal 21, 377–401.

National Research Council - NRC, 2007. Nutrient Requirements of Small Ruminants: Sheep, Goats, Cervids and New World Camelids. Natl. Acad. Press, Washington, DC. (USA)

Oliveira, R. L., Faria, M. M. S., Bezerra, L. R., Carvalho, G. G. P., Pinheiro, A., Simionato, J., and Leao, A. G., 2015a. Fatty acid profile of milk and cheese from dairy cows supplemented a diet with palm kernel cake. Molecules. 20, 15434–15448.

Oliveira, R. L., Palmieri, A. D., Carvalho, S. T., Leão, A. G., Abreu, C. L., Ribeiro, C. V. D. M., Pereira, E. S., Carvalho, G. G. P., and Bezerra, L. R., 2015b. Commercial cuts and chemical and sensory attributes of meat from crossbred Boer goats fed sunflower cake-based diets. Animal Science Journal, 86, 557–562.

Silva, T. M., Oliveira, R. L., Nascimento Júnior, N. G., Pellegrini, C. B., Trajano, J. S., Rocha, T. C., Bezerra, L. R., Borja, M. S., 2016. Ingestive behavior and physiological parameters of goats fed diets containing peanut cake from biodiesel. Tropical Animal Health Production, 48, 59–66.

Sniffen, C. J., O'Connor, J. D., Van Soest, P. J., Fox, D. G., and Russell, J. B., 1992. A net carbohydrate and protein system for evaluation of cattle diets. II Carbohydrate and protein availability. Journal of Animal Science, 70, 3562–3577.

Statistical Analysis System - SAS Institute, 2014. SAS Systems for Windows User's Guide. SAS Institute Inc., Cary, NC, (USA).

Stoffel, C. M., Crump, P. M., and Armentano, L. E., 2015. Effect of dietary fatty acid supplements, varying in fatty acid composition, on milk fat secretion in dairy cattle fed diets supplemented to less than 3% total fatty acids. Journal of Dairy Science, 98, 431–442.

Van Soest, P. J., Robertson, J. B., and Lewis, B. A., 1991. Methods for dietary fiber, neutral detergent fiber, and nonstarch polysaccharides in relation to animal nutrition. Journal of Dairy Science, 74, 3583–3597.

Willians, C. H., David, D. J., and Iilma, O., 1962. The determination of cromic oxide in faeces samples by atomic absorption spectrophotometry. Journal of Agriculture Science, 59, 381–385.