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GOATS FED DETOXIFIED CASTOR CAKE IN DIFFERENT PHYSIOLOGICAL STAGES: II. NUTRITIONAL PARAMETERS, HEPATIC AND RENAL

Ricardo Alves Araújo[1*], Roberto Cláudio Fernandes Franco Pompeu[2], Luiza de Nazaré Carneiro da Silva[3], José Neuman Miranda Neiva[3]

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ABSTRACT - Evaluated the influence of the substitution of soybean meal (SM) by detoxified castor cake (DCC) on the intake and digestibility of dry matter and nutrients, nitrogen balance and function hepatic and renal of goats fed with diets containing DCC by alkaline solutions in confinement regime during different stages of biological development (growth, pregnancy and lactation). The treatments consisted of three diets, a formulated with corn and soybean meal (SM) and the others were formulated with detoxified castor cake by calcium hydroxide [$Ca(OH)_2$ DCC] and another composed by detoxified castor by DCC of sodium hydroxide (NaOH). In relation to the biological stages, we observed higher intakes of DM and all the nutrients by goats during lactation, representing up to 4% of body weight. In relation to renal and hepatic parameters showed that there was interaction between the diets and biological stages on the levels of total proteins, direct bilirubin, albumin, alanine aminotransferase, aspartate aminotransferase, gamma glutamyl transferase. In a general way, the goats fed with both castor cake, regardless of the stage evaluated had higher levels. The detoxified castor cake by alkaline solutions in replacement of soybean meal proved to be a viable alternative in the feeding of goats in the three-stage biological, because it does not affect the functionality of the liver and kidney function and the nitrogen balance, in spite of the diets formulated with detoxified castor by sodium hydroxide decrease the intake of dry matter and nutrients.
Keywords: consumption of dry matter, growth, nitrogen, pregnancy, lactation.

CABRAS ALIMENTADAS COM TORTA DE MAMONA DESTOXIFICADA DURANTE DIFERENTES ESTÁGIOS FISIOLÓGICOS: II. PARÂMETROS NUTRICIONAIS, RENAIS E HEPÁTICOS

RESUMO - Avaliou-se a influência da substituição do farelo de soja (FS) por torta de mamona destoxificada (TMD) sobre o consumo e digestibilidade da matéria seca e nutrientes, balanço de nitrogênio e função hepática e renal de cabras alimentadas com dietas contendo TMD por soluções alcalinas em confinamento regime durante as diferentes fases do desenvolvimento biológico (crescimento, gestação e lactação). Os tratamentos consistiram em três dietas, uma formulada com milho e FS e as demais formuladas com torta de mamona destoxificada por hidróxido de cálcio [TMD $Ca(OH)_2$] e outra composta por mamona destoxificada por hidróxido de sódio (TMD NaOH). Em relação às fases biológicas, observou-se maiores consumos de MS e de todos os nutrientes pelas cabras durante a lactação, representando até 4% do peso corporal. Em relação aos parâmetros renais e hepáticos, evidenciou-se que houve interação entre as dietas e os estágios biológicos nos níveis de proteínas totais, bilirrubina direta, albumina, alanina aminotransferase, aspartato aminotransferase, gama glutamiltransferase. De forma geral, as cabras alimentadas com ambas as tortas de mamona, independente da fase avaliada, apresentaram teores superiores. A torta de mamona desintoxicada por soluções alcalinas em substituição ao farelo de soja mostrou-se uma alternativa viável na alimentação de caprinos nos três estágios biológicos, pois não afeta a funcionalidade hepática e renal e o balanço de nitrogênio, apesar das dietas formuladas com mamona destoxificada pelo hidróxido de sódio diminuem a ingestão de matéria seca e nutrientes.
Palavras-chave: consume de matéria seca, crescimento, nitrogênio, gestação, lactação.

INTRODUCTION

Among the biological stages of ruminants there is a great variation in each phase, marked mainly by the variation of the intake of dry matter and nutrients (FORBES, 2007). In each stage occurs an intense cascade of hormonal variations which influence directly the consumption of foods for these animals. Another factor, in addition to the hormonal action is the activation of receptors of tension due to the ruminal compression exerted by the increase in size of the organs (MELLADO et al., 2011).

In dairy goats, for example, in order for the lactation phase to be efficiently productive, there is a need for physiologically well-developed goats. Therefore, the rearing phase is of paramount importance, since the formation of healthy, well-nourished and physiologically developed matrices will later reflect healthy pregnancies and lactations. Based on this, the use of these by-products

[1]Universidade Estadual do Maranhão, UEMA, Balsas, MA, Brasil. E-mail: ricardo_zoo@hotmail.com. *Corresponding author.
[2]Pesquisador Empresa Brasileira de Pesquisa Agropecuária, EMBRAPA Caprinos e Ovinos, Sobral, CE, Brasil.
[3]Universidade Federal do Tocantins (UFT), Araguaína, TO, Brasil.

can make this phase more efficient and reflect on the others, as the rearing determines the productive potential of the future dairy goat (ARAÚJO et al., 2020).

The recent increase in the inclusion of biodiesel in the world energy matrix has led to the production of ruminant feeds from by-products or cakes obtained after extraction of oil from oilseeds, which constitute the main by-products of the biodiesel production chain. Thus, a possibility of integrating the agroenergy and agricultural chains, and generating employment and income has emerged, in addition to possibly minimizing the environmental problems caused by these residues (ARAÚJO et al., 2020).

Thus, considering the possibility of using by-products from the biodiesel chain in diets for ruminants, giving these by-products an efficient destination and incorporating them into the dairy goat production chain, the objective was to evaluate the influence of detoxified castor cake by alkaline solutions on intake, digestibility, nitrogen balance, renal and hepatic metabolic profile of Saanen and Anglo Nubian goats during different biological stages (growth, pregnancy and lactation).

MATERIAL AND METHODS

The study was conducted at the Technological Center of production of goat milk from Embrapa Goats and Sheep (3º44'57.42" S and 40°20'43.50" W) located in the city of Sobral-CE (Brazil), in the period from June 2015 to May 2017. All procedures involving animals were carried out in accordance with the regulations of the Commission of Ethics in the use of animals in the Empresa Brasileira de Pesquisa Agropecuária, Centro Nacional de Pesquisa with goats, protocol no. 005/2015.

Eighteen goats were evaluated in each stage, being 9 Saanen and 9 Anglo Nubian. The same goats were evaluated in each stage biological. In the growth phase (270 days), they had the following characteristics: goats with 43±2.97 kg body weight and body condition scores of 2.5±0.5 were used. In pregnancy (160 days): goats with body weight of 42.08 ± 5.33 kg of body condition score of 3.6±0.3 according to the classification of Morand-Fehr (2005). All tests were performed on two occasions, the first when the goats were with 30 to 100 days of gestation (first and second third) and the second from 110 to 140 days of pregnancy, representing the final third of pregnancy and performed the averages to represent this stage. In lactation (150 days): goats with 43±2.97 kg body weight and body condition scores of 2.5±0.5. In this way, the experiment had a duration of 580 days without interruption.

The goats were placed in individual stalls, suspended and with floor ripped of 5.06 m², being 2.87 m² solarium area composed of beaten floor, provided with drinkers, feeders and salt shakers. The measurement of live weight was performed fortnightly in proper balance. The animals were weighed always at the same time and in fasting. The treatments consisted of three diets, a formulated with corn and soybean meal (SM) and the others were formulated with detoxified castor cake by calcium hydroxide [$Ca(OH)_2$ DCC] and another composed by detoxified castor by DCC of sodium hydroxide (NaOH), having the same levels of protein and energy and was used as roughage hay tifton-85.

The chemical composition of foods is presented in Table 1. For the stage of growth, the diets were formulated according to the NRC (2007), for daily gains of 100 g (Table 2). For the stage of pregnancy, the animals were fed with balanced diet to meet the requirements of pregnant goats with two fetuses, according to the NRC (2007) for goats with body weight of 42 kg and in early pregnancy, the proportion of the ingredients and the chemical composition of diets are shown in Table 3. To the lactation, the experimental diets were formulated based on the isonitrogenous and isoenergetic diet recommendations of the NRC (2007) for goats with 45 kg body weight and daily milk production of 1.5 L (Table 4).

Castor cakes used in this study were obtained after collecting oil, by mechanically pressing castor bean seeds at temperatures between 90 and 100°C. After mixing the cakes with reagents and water for 3 h (mixing for 10 min. and resting for 30 min, alternately), the cakes were placed outdoors on a plastic canvas for 48 h and constantly rolled with a squeegee adapted for homogeneous drying. After drying, the cakes were chopped using a forage machine to reduce the material size and to facilitate its homogenization with the other ingredients.

TABLE 1 - Chemical composition of the ingredients used for the preparation of the experimental diets.

Item (g kg DM^{-1})	Ingredients				
	Tifton 85 hay	Ground corn	Soybean meal	$Ca(OH)_2$ DCC	NaOH DCC
Dry matter (g kg^{-1} fresh matter)	872.52	889.24	870.21	904.22	904.82
Organic matter	911.34	965.92	956.90	867.77	855.63
Mineral matter[a]	88.75	34.11	43.10	132.32	144.42
Crude protein	104.12	79.50	443.30	315.41	309.01
Ether extract	14.52	36.83	28.84	52.10	47.53
Non-fiber carbohydrates	277.80	722.41	320.81	103.95	132.44
Neutral detergent fiber[b]	514.90	123.28	163.84	396.18	360.12
Acid detergent fiber	472.22	69.07	117.93	379.22	388.74
Hemicellulose	248.44	115.53	99.82	104.13	54.70
Cellulose	413.65	60.22	105.60	328.50	342.63
Lignin	60.62	8.80	12.21	50.73	46.15
Total digestible nutrients	546.83	848.75	822.52	620.54	627.93

[a]$Ca(OH)_2$ DCC = 0.90 g Na kg^{-1} DM and 2.25 g Ca kg^{-1} DM; NaOH DCC: 29.20 g Na kg^{-1} DM and 0.63 g Ca kg^{-1} DM. [b]Corrected for ash and protein.

TABLE 2 - Proportion of ingredients and chemical composition of the experimental diets during the biological stage of growth of goats.

Ingredients	Diets		
	Soybean meal	DCC $Ca(OH)_2$	DCC NaOH
Item (g kg DM^{-1})	Proportion of ingredients		
Tifton 85 hay	427.31	394.97	363.29
Ground corn	460.83	481.95	504.65
Soybean meal	57.80	--------	--------
Detoxified castor cake	--------	83.31	82.95
Soy oil	45.03	39.94	39.25
Limestone	9.16	0.01	10.10
Mineral Premix[a]	*Ad libitum*	*Ad libitum*	*Ad libitum*
Chemical Composition (g kg^{-1} DM)			
Dry matter (g kg^{-1} fresh matter)	887.71	896.13	891.84
Organic matter	942.37	897.85	938.10
Mineral matter	57.74	102.26	61.98
Crude protein	112.01	112.91	112.32
Ether extract	62.02	63.40	65.43
Non-fiber carbohydrates	471.86	468.64	476.80
Neutral detergent fiber[b]	287.94	297.63	279.24
Acid detergent fiber	349.52	332.05	305.44
Hemicellulose	166.01	163.65	152.67
Cellulose	211.82	221.11	209.33
Lignin	30.86	32.68	30.32
Total digestible nutrients	664.98	658.58	663.61

[a]Guaranteed levels (per kg, in active elements): calcium – 218.00 g; phosphorus – 71.00 g; sulfur – 20.00 g; iron – 1800.00 mg; iodine – 80.00 mg; manganese – 1300.00 mg; selenium – 15.00 mg; zinc – 3800.00 mg; molybdenum – 300.00 mg; maximum fluorine – 870.00 mg; phosphorus (P) solubility in citric acid 2% minimum - 95%. [b]Corrected for ash and protein.

TABLE 3 - Proportion of ingredients and chemical composition of the experimental diets during the biological stage of pregnancy of goats.

Ingredients	Diets		
	Soybean meal	DCC $Ca(OH)_2$	DCC NaOH
Item (g kg DM^{-1})	Proportion of ingredients		
Tifton 85 hay	433.10	421.70	509.10
Ground corn	528.00	529.20	380.30
Soybean meal	33.50	--------	--------
Detoxified castor cake	--------	49.10	61.50
Limestone	5.4	--------	4.7
Mineral Premix[a]	*Ad libitum*	*Ad libitum*	*Ad libitum*
Chemical Composition (g kg^{-1} DM)			
Dry matter (g kg^{-1} fresh matter)	879.10	885.43	850.96
Organic matter	942.14	938.06	933.00
Mineral matter	57.86	61.94	67.00
Crude protein	101.11	100.73	100.35
Ether extract	26.72	28.20	28.74
Non-fiber carbohydrates	512.52	504.58	424.65
Neutral detergent fiber[b]	293.62	301.86	331.19
Acid detergent fiber	245.83	255.18	291.62
Hemicellulose	171.98	171.05	173.80
Cellulose	214.50	222.45	254.56
Lignin	31.33	32.73	37.06
Total digestible nutrients	712.16	709.86	702.21

[a]Guaranteed levels (per kg, in active elements): calcium - 218.00 g; phosphorus - 71.00 g; sulfur - 20.00 g; iron - 1800.00 mg; iodine - 80.00 mg; manganese - 1300.00 mg; selenium - 15.00 mg; zinc - 3800.00 mg; molybdenum - 300.00 mg; maximum fluorine - 870.00 mg; phosphorus (P) solubility in citric acid 2% minimum - 95%. [b]Corrected for ash and protein.

TABLE 4 - Proportion of ingredients and chemical composition of the experimental diets during the biological stage of lactation of goats.

Ingredients	Diets		
	Soybean meal	DCC $Ca(OH)_2$	DCC NaOH
Item (g kg DM^{-1})	Proportion of ingredients		
Tifton 85 hay	525.40	485.80	474.30
Ground corn	414.20	424.60	437.40
Soybean meal	58.70	--------	--------
Detoxified castor cake	--------	89.60	85.70
Limestone	1.70	--------	2.6
Mineral Premix[a]	*Ad libitum*	*Ad libitum*	*Ad libitum*
Chemical Composition (g kg^{-1} DM)			
Dry matter (g kg^{-1} fresh matter)	883.03	890.84	885.76
Organic matter	939.17	933.06	930.90
Mineral matter	62.49	66.94	71.43
Crude protein	113.94	110.13	112.12
Ether extract	26.46	29.22	29.82
Non-fiber carbohydrates	471.80	468.70	477.40
Neutral detergent fiber[b]	416.78	424.98	404.54
Acid detergent fiber	352.80	356.60	337.19
Hemicellulose	166.06	163.67	152.66
Cellulose	211.88	221.19	209.34
Lignin	30.86	32.62	30.32
Total digestible nutrients	674.90	678.80	678.70

[a]Guaranteed levels (per kg, in active elements): calcium – 218.00 g; phosphorus – 71.00 g; sulfur – 20.00 g; iron – 1800.00 mg; iodine – 80.00 mg; manganese – 1300.00 mg; selenium – 15.00 mg; zinc – 3800.00 mg; molybdenum – 300.00 mg; maximum fluorine – 870.00 mg; phosphorus (P) solubility in citric acid 2% minimum - 95%. [b]Corrected for ash and protein.

The concentrations of alkaline products (calcium hydroxide and sodium hydroxide) used for 100% detoxification of ricin in crude castor cakes were 90 g $Ca(OH)_2$ and 60 g NaOH per kilogram, respectively, which were diluted in 2 L of water using a stationary mixer (Fischer® MOB 400 G2) equipped with a three-phase motor.

No hemagglutinating activity was observed at those concentrations; i.e., ricinus agglutinin was no longer active (Figure 1), therefore, these two concentrations were used to formulate the diets.

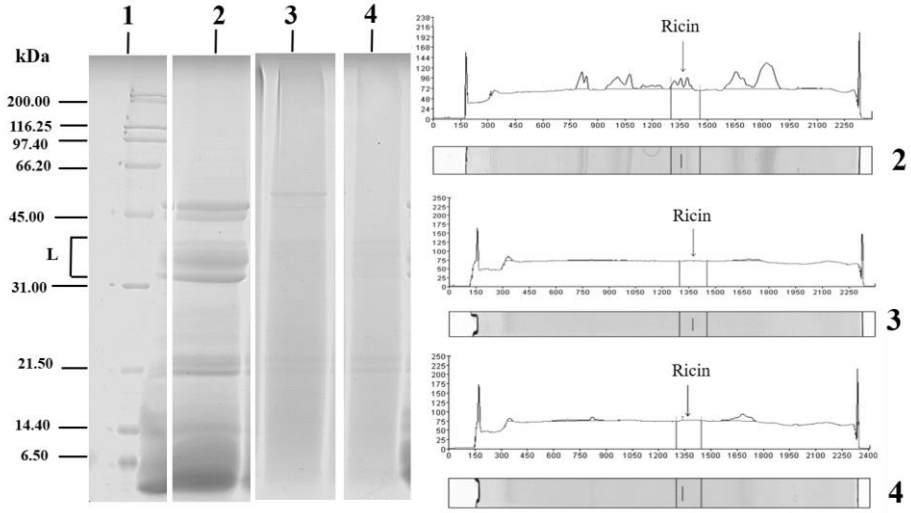

FIGURE 1 - Electrophoretic characterization of castor cake proteins treated with different chemical products. 1 = Molecular weight marker (kDa); L: Lectins; 2 = Crude castor cake; 3 = Detoxified castor cake $Ca(OH)_2$; 4 = Detoxified castor cake NaOH.

Dry matter (DM) (method no. 934.01), organic matter (method no. 942.05), CP (method no. 954.01) and ether extract (EE) (method no. 920.39) levels were determined in the feed samples (leftovers and supplied) according to AOAC (2003). The samples were treated with thermostable alpha-amylase for neutral detergent fiber (NDF) analysis. The concentrations of NDF were corrected for ash and nitrogen as proposed by Mertens (2002). The ADL fraction was extracted with 72% sulfuric acid. Non-fibrous carbohydrate (NFC) content was calculated by an adaptation of the method proposed by Hall (2003), using NDF corrected for ashes and protein (NDFap). Total carbohydrate (TC) content was obtained using the equation proposed by Sniffen et al. (1992).

The quantity of total digestible nutrients (TDN) was calculated according to Weiss (1999). The TDN values were converted into net energy (NE) for production and digestible energy (DE), according to the equations suggested by the NRC (2001). The TDN intake (TDNI) was calculated according to the methodology described by Equation 1 (SNIFFEN et al., 1992).

$$\text{TDNI} = (\text{CPI} - \text{CPf}) + 2.25(\text{EEI} - \text{EEf}) + (\text{TCI} - \text{TCf}) \quad \text{(Equation 1)}$$

Where:
CPI, EEI, and TCI = intakes of CP, EE, and TC, respectively,
CPf, EEf, and TCf = respective excretion of CP, EE, and TC in the feces.

Diets were supplied daily at 07.30 and 14.30 h, allowing a 10% surplus supply. Samples were collected from the bulk, concentrate, and also leftovers during the entire experimental period, then duly packaged in identified plastic bags and stored in a freezer at -8°C. For evaluating nitrogen balance, total urine production was estimated by the concentration of creatinine in the urine. At the end of the growth phase, spot urine samples were obtained approximately 4 h after feeding, from spontaneous urination in colostomy bags (Medsonda®) with a capacity of 200 mL. Samples were prepared according to the methodology of Valadares et al. (1999) and immediately frozen. Urine production was estimated by the Equation 2, proposed by Fonseca et al. (2006).

$$Urinary\ volume\ (L) = \frac{26.05 \times BW\ (Kg)}{\text{creatinine concentration in the spot sample (mg/L)}} \quad \text{(Equation 2)}$$

At the end of the growth phase, feces were collected directly from the rectal bulb for five days at different times (0, 3, 6 and 9 h after the first feeding) for a representative sampling Furthermore, the feces samples used for digestibility tests were collected on different days, so two samplings were performed. Due to the small amount of feces collected per day, we chose to make two separate collections. Consumed nitrogen (CN), nitrogen excreted in the feces (FN), and nitrogen excreted in the urine (UN) were determined using the micro Kjeldahl technique (method no. 954.01) of the AOAC (2003). Nitrogen balance (NB) was calculated according to the Equation 3:

$$NB = \left(\frac{CN-(FN+UN)}{CN}\right) \times 100 \quad \text{(Equation 3)}$$

Retained nitrogen (RN) was calculated according to equation 4:

$$RN = NB(g/day) - BEN(g/day) - dermal\ losses\ (g/day) \quad \text{(Equation 4)}$$

Where:

BEN (basal endogenous nitrogen) = 0.35 × $BW^{0.75}$, and dermal losses = 0.018 × $BW^{0.75}$, according to the recommendations of the AFRC (1993).

Blood samples were collected using 9.0 mL vacutainer tubes (Grainer Bio-One, Vacuette® Americana, SP, BRA), by puncturing the jugular vein, five days before the end of the rearing phase, and 4 h after the morning feed. Two blood samples were collected from each animal; one in a tube containing an anticoagulant (EDTA) and another in a tube without the anticoagulant. The tubes with the anticoagulant were used for analyzing urea and total protein concentration, while samples without the anticoagulant were used for analyzing creatinine, total and direct bilirubin, albumin, alkaline phosphatase, alanine aminotransferase (ALT), aspartate aminotransferase (AST), and gamma-glutamyltransferase (GGT) levels.

To determine urea and total protein concentration, serum was obtained by centrifuging the tubes at 3,293 × g for 15 min, identified and stored in Eppendorf® mini-tubes, and frozen for analysis. Blood parameters and urine creatinine were analyzed with commercial Labtest® kits using colorimetric procedures.

Apparent digestibility coefficients were estimated indirectly using the internal iADF indicator. To this end, feces were collected directly from the rectal bulb for 5 days at different times (0, 3, 6, and 9 h after the first feeding), aiming for greater daily representativeness. Next, they were identified and stored in a freezer at -8°C. At the end of data collection, composite samples were prepared and then dried in a forced ventilation oven at 55°C until a constant weight was reached. The fecal and food samples were incubated *in situ* for a period of 240 h, according to the methodology described by Casali et al. (2008). Fecal samples were collected directly from the rectal bulb for 5 days at different times (0, 3, 6, and 9 h after the first feeding) for a representative sampling.

Data were initially subjected to normality tests (Shapiro-Wilk) and homoscedasticity tests (Levene), and were also submitted to analysis of variance by the F test when the presuppositions were met, by using the following the Equation 5:

$$Y_{ijk} = \mu + \propto_i + \beta_j + (\propto\beta)_{ij} + e_{ijk} \quad \text{(Equation 5)}$$

Where:

Y_{ijk} = dependent variable corresponding to the experimental observation,

μ = overall mean,

αi = effect of the diets,

β_j = effect different stages physiological,

$(\alpha\beta)_{ij}$ = interaction effect and

e_{ijk} = random error, assuming an independent normal distribution.

Interaction between diet and at different stages physiological was only considered when significant at 5% probability. A comparison of means was carried out by Tukey test at 5% probability to evaluate the effects of breed, diet and different stages physiological. Statistical analyses were performed using the GLM procedure of the SAS software version 9.3 (SAS INSTITUTE, 2005).

RESULTS AND DISCUSSION

There was interaction ($P<0.05$) between the diets and physiological stages on the consumption of DM and other nutrients (Table 5). In three stages was observed greater DMI for the goats fed with SM (1522.05 g day^{-1}) and $Ca(OH)_2$ DCC (1443.48 g day^{-1}), and lower DMI for the goats fed with NaOH DCC (1292.10 g day^{-1}). The intakes of CP, EE, NDF and TDN showed the same behavior observed for the DMI, where the goats fed with SM and NaOH DCC consumed larger quantities, with the exception of DMI based on body weight during pregnancy and lactation, where the goats fed with $Ca(OH)_2$ DCC did not differ from the DMI %BW of goats with NaOH DCC. In relation to the physiological stages, we observed higher intakes of DM and all the nutrients by goats during lactation, representing up to 4% of body weight.

TABLE 5 - Dry matter intake (DM), crude protein (CP), ether extract (EE), neutral detergent fiber (NDF) and total digestible nutrients of goats fed with detoxified castor cake at different stages physiological.

Stages of physiological	Diets			Mean	MSE	P-value		
	SM	$Ca(OH)_2$ DCC	NaOH DCC			D	S	D x F
	DM (g day^{-1})							
Growth	1021.99Ca	909.403Ca	842.023Cb	924.47				
Pregnancy	1226.06Ba	1200.75Ba	1072.90Bb	1166.57	87.76	*	*	*
Lactation	2318.10Aa	2220.28Aa	1961.38Ab	2166.59				
Mean	1522.05	1443.48	1292.10					
	DM (% BW)							
Growth	2.90Ba	2.61Bb	2.39Bb	2.63				
Pregnancy	2.31Cab	2.44Ba	2.13Cb	2.29	0.54	*	*	*
Lactation	4.53Aa	4.17Aab	3.99Ab	4.23				
Mean	3.25	3.07	2.84					
	CP (g day^{-1})							
Growth	117.69Ca	106.743Cb	98.26Cb	107.56				
Pregnancy	142.78Ba	139.89Ba	125.14Bb	135.94	45.98	*	*	*
Lactation	259.62Aa	255.50Aa	219.67Ab	244.93				
Mean	173.36	167.38	147.69					
	EE (g day^{-1})							
Growth	65.88Ca	60.76Cb	58.52Cb	61.72				
Pregnancy	82.50Ba	80.01Ba	72.45Bb	78.32	21.52	*	*	*
Lactation	122.82Aa	120.01Aa	101.99Ab	114.94				
Mean	90.40	86.93	77.65					
	NDF (g day^{-1})							
Growth	394.92Ca	346.36Cb	315.34Cb	352.21				
Pregnancy	454.83Ba	451.46Ba	406.91Bb	429.19	78.31	*	*	*
Lactation	1398.86Aa	1334.35Aa	1216.05Ab	1316.42				
Mean	896.89	710.72	646.10					
	TND (g day^{-1})							
Growth	676.33Cb	741.67Ca	717.14Ca	711.71				
Pregnancy	934.62Ba	943.85Ba	856.82Bb	911.76	76.09	*	*	*
Lactation	1460.40Aa	1443.18Aa	1294.51Ab	1399.36				
Mean	1023.78	1042.90	956.16					

MSE: mean standard error. Averages followed by common lowercase letters in the lines and by uppercase letters in the columns do not differ from one another according to the Tukey test at 5% significance.

The goats fed with NaOH DCC presented smaller intake of DM (DMI) in three physiological stages evaluated. The reduction in the DMI can be associated to the presence of sodium in the diet, which serves as a controller of consumption (YOUSFI et al., 2016). The amount of the present in the NaOH DCC was 32.4 times higher than that in the $Ca(OH)_2$ DCC (Table 1), which highlights even more this effect in the control of DMI. In addition, it is interesting to note also that the diet with NaOH DCC has in its composition a greater quantity of ricinoleic acid (8.23%) derived from castor cake (ARAÚJO et al., 2020). This fatty acid may also have contributed to the lower intake by goats fed with this cake, because it offers besides the Carboxylation, one hydroxyl at carbon number 10 of the molecule. These two functional groups when they are inside the rumen have their ionized oxygen and thus may potentiate the negative effect of this acid on the ruminal microorganisms, thus reducing the microbial attack the food particles in the rumen (ALVES et al., 2017), causing reductions in DMI and in nutrients.

The effect to the DMI influenced the results of intake of EE, NDF and NDT which maintain a direct relationship, mainly because the diets were isonitrogenous (Tables 2, 3 and 4), as soon as the selectivity was crucial in the consumption of these components of the diet. In relation to the consumption of TDN, the highest values by goats during the stage of lactation are justified by the greater amount of EE consumed (DANIELI; RONCHI, 2018).

According to the NRC (2007), intake of TDN for goats at this stage is to 1200 g of TDN day^{-1}, which indicates that all diets provide TDN requirements, even those who consumed the ration the basis of NaOH DCC (1294 g TDN day^{-1}). The TDN consumption has a direct relationship with the energy consumed and directed to products generated by ruminants, therefore it can be inferred that the increased consumption in the shew of lactation is result of milk production in this do, considering that in the stage of pregnancy the goats were not producing milk, because all were primiparous.

In relation to nutrient digestibility of DM and there was interaction ($P>0.05$) of diets with the physiological stages. The stages influenced only the digestibility of crude protein, EE and neutral detergent fiber (Table 6). During the lactation, the goats decreased digestibility of CP

(701.36 g kg^{-1} DM) and EE (751.92 g kg^{-1} DM), while for the other two stages were equal among themselves. On the other hand, the digestibility of NDF was greater during lactation (736.92 g kg^{-1} DM) and pregnancy (707.49 g kg^{-1} DM).

TABLE 6 - Digestibility apparent of dry matter (DM), crude protein (CP), ether extract (EE) and neutral detergent fiber (NDF) of goats fed with detoxified castor cake at different stages physiological.

Stages of physiological	Diets			Mean	MSE	P-value		
	SM	$Ca(OH)_2$ DCC	NaOH DCC			D	S	D x S
	DM (g kg^{-1} fresh matter)							
Growth	657.00	722.50	732.00	703.83				
Pregnancy	720.23	708.62	693.62	707.49	65.98	0.098	0.321	0.067
Lactation	702.33	690.29	675.69	689.44				
Mean	693.19	707.14	700.44					
	CP (g kg^{-1} DM)							
Growth	720.50	767.50	768.50	752.17A				
Pregnancy	756.80	76596	746.07	756.28A	54.09	0.132	*	0.098
Lactation	714.20	702.26	687.62	701.36B				
Mean	730.50	745.24	734.06					
	EE (g kg^{-1} DM)							
Growth	777.00	813.50	825.50	805.33A				
Pregnancy	809.385	800.565	802.88	804.27A	60.23	0.231	*	0.054
Lactation	752.28	761.46	742.01	751.92B				
Mean	779.55	791.84	790.13					
	NDF (g kg^{-1} DM)							
Growth	610.00	648.50	642.00	633.50B				
Pregnancy	728.37	717.05	677.04	707.49A	56.76	0.109	*	0.231
Lactation	737.28	746.46	727.01	736.92A				
Mean	691.88	704.00	682.02					

MSE: Mean standard error. Averages followed by common lowercase letters in the lines and by uppercase letters in the columns do not differ from one another according to the Tukey test at 5% significance.

We observed interaction (P<0.05) between the diets offered and the different stages of physiological agents (Table 7). In a general way, the goats fed with NaOH DCC had the lowest intakes of nitrogen in three stages evaluated. As well as the consumption, the FN and UN were lower in goats fed the diet the basis of NaOH DCC. In relation to stages, we can observe that the RN was higher during lactation, with an average of 24.40 g day^{-1}. The consumption of nitrogen was amended by the physiological stages, being higher during lactation, influencing the effect of the amount of nitrogen retained, demonstrating the greater efficiency in the use of this nutrient by goats during this stage, considering that the diets did not influence during this phase.

In addition, the content of total protein and albumin was greater in the circulation of these goats (Table 8), which may be related to the greater utilization of nitrogen consumed. Under another perspective, it is important to note that in spite of the content of nitrogen retained have been lower during the growing stage, in percentage terms the content was higher at this stage. The largest proportion of nitrogen retention during lactation is derived from the intense protein metabolism for the production of milk, because there is an intense absorption of large quantities of proteins that are in circulation (BELL et al., 2005). In relation to renal and hepatic parameters (Table 8) showed that there was interaction between the diets and physiological stages on the levels of total proteins, direct bilirubin, albumin, alanine aminotransferase, aspartate aminotransferase, gamma glutamyl transferase.

TABLE 7 - Consumed nitrogen (CN), fecal nitrogen (FN), urinary nitrogen (UN) and retained nitrogen (RN) of goats fed with detoxified castor cake during the physiological stage.

Stages physiological	Diets			Mean	MSE	P-value		
	SM	$Ca(OH)_2$ DCC	NaOH DCC			D	S	D x S
			CN (g day^{-1})					
Growth	19.17Ba	17.27Bb	16.80Bc	17.75				
Pregnancy	17.13Ba	16.78Ba	15.01Bb	16.31	1.02	*	*	*
Lactation	55.79Aa	52.12Ab	51.87Ab	53.26				
Mean	30.70	28.72	27.89					
			FN (g day^{-1})					
Growth	4.39Bab	4.79Ba	3.88Bb	4.35				
Pregnancy	3.50Ba	3.33Ba	3.33Ba	3.39	0.78	*	*	*
Lactation	15.69Aa	15.43Aa	14.10Ab	15.07				
Mean	7.86	7.85	7.10					
			UN (g day^{-1})					
Growth	2.11Ba	2.18Ba	1.75Bb	2.01				
Pregnancy	1.48Ba	1.40Ba	1.39Ba	1.42	0.97	*	*	*
Lactation	6.95Aa	5.94Aab	5.88Ab	6.26				
Mean	3.51	3.17	3.01					
			RN (g day^{-1})					
Growth	6.97Ca	5.15Cb	6.01Cb	6.04				
Pregnancy	12.14Ba	12.04Ba	10.28Bb	11.49	1.02	*	*	*
Lactation	25.26Aa	23.39Aa	24.55Aa	24.40				
Mean	14.79	13.53	13.61					

MSE: Mean standard error. Averages followed by common lowercase letters in the lines and by uppercase letters in the columns do not differ from one another according to the Tukey test at 5% significance.

In a general way, the goats fed with both castor cake, regardless of the stage evaluated had higher levels of total proteins in the bloodstream (7.87 g dL^{-1} and 8.06 g dL^{-1} to $Ca(OH)_2$ DCC and NaOH DCC, respectively). In relation to the content of direct bilirubin can be observed higher levels during gestation and lactation (0.95 and 1.23 mg dL^{-1}, respectively). The blood urea was higher during the stage of lactation (38.85 mg dL^{-1}), being twice the growth stage (19.42 mg dL^{-1}), as well as the alkaline phosphatase, which was 10.98 UI L^{-1} during lactation of goats. In relation to ALT, AST and GGT, one can observe a wide variation, both in terms of diets, much of the physiological stage. The ALT was greater for the goats fed with the diet during the three stages, being that during lactation did not differ from goats fed with diet based $Ca(OH)_2$ DCC. On the other hand, AST was lower during lactation of goats, already the GGT was higher during the shew of lactation for the goats fed with both diets the basis of DCC.

The average levels of enzymes for hepatic and renal functions are within the standards for species, according to Smith and Sherman (2009) on the three physiological stages evaluated. Menezes et al. (2008) found similar values to this work, to evaluate the response of the liver-kidney in Saanen goats fed with castor bean meal. The reduction of AST during lactation is common, because Huy (2005), says that all the enzymes related to liver function are generally reduced during the lactation period, due to the expansion of the extracellular fluid. Despite this, the values were within the reference range for the species (CONTRERAS et al., 2000), thus discarding a possible deficit in protein metabolism in three stages of development, which is not common due during pregnancy, because the greater metabolic demand during pregnancy (RADIN et al., 2015) could decrease the concentration of some enzymes in blood, but the quantity of nontoxic metabolites decreased physiological at this stage.

In relation to the higher concentration of urea in goats fed with SM and $Ca(OH)_2$ DCC may be related the highest levels to lower filtration of nitrogen after detoxification of ammonia in the liver, considering that the goats fed with SM and $Ca(OH)_2$ DCC had a higher consumption of CP. In relation to the effect of the physiological stages on the urea, Kalhan (2000) asserts that it is common for the decrease of the concentration of urea during growth, because this reduction is not only a result of increased glomerular filtration, but also due to a reduction in the hepatic synthesis. With the increase of progesterone and estrogen concentrations, the activity of the enzymes decreases the urea cycle (ISMAIL et al., 2008).

TABLE 8 - Total proteins (TP), direct bilirubin (DB), albumin (ALB), urea (URE), alkaline phosphatase (AP), alanine aminotransferase (ALT), aspartate aminotransferase (AST) and gamma-glutamyltransferase (GGT) of goats fed with detoxified castor cake during the physiological stage.

Stages physiological	Diets			Mean	MSE	P-value		
	SM	$Ca(OH)_2$ DCC	NaOH DCC			D	S	D x S
			TP (g dL^{-1})					
Growth	5.50Bb	6.27Aa	6.95Ba	6.24				
Pregnancy	5.42Bb	6.49Aab	6.72Ba	6.21	1.25	*	*	*
Lactation	8.93Ab	10.84Aa	10.50Aa	10.09				
Mean	6.62	7.87	8.06					
			DB (mg dL^{-1})					
Growth	0.14Ba	0.08Bb	0.10Bb	0.11				
Pregnancy	0.91Aa	1.02Aa	0.92Aa	0.95	0.09	*	*	*
Lactation	1.18Aa	1.29Aa	1.22Aa	1.23				
Mean	0.74	0.80	0.75					
			ALB (g dL^{-1})					
Growth	2.05Ba	1.97Ba	2.21Ba	2.08				
Pregnancy	2.14Bb	2.32Bab	2.44Ba	2.30	0.12	*	*	*
Lactation	4.34Ab	5.42Aa	5.00Aa	4.92				
Mean	2.84	3.24	3.22					
			URE (mg dL^{-1})					
Growth	21.67Ca	19.52Cab	17.06Cb	19.42				
Pregnancy	31.16Ba	28.81Bab	27.70Bb	29.22	3.65	*	*	*
Lactation	40.67Aa	39.29Aab	36.60Ab	38.85				
Mean	31.17	29.21	27.12					
			AP (UI L^{-1})					
Growth	4.65	5.33	4.74	4.91C				
Pregnancy	6.71	6.26	6.62	6.53B	1.23	0.236	*	0.154
Lactation	11.18	10.61	11.15	10.98A				
Mean	7.51	7.40	7.50					
			ALT (UI L^{-1})					
Growth	19.75Ba	13.62Bb	11.57Bb	14.98				
Pregnancy	15.49Ba	11.71Bb	11.79Bb	13.00	2.43	*	*	*
Lactation	102.63Aa	76.22Ac	92.55Ab	90.47				
Mean	45.96	33.85	38.64					
			AST (UI L^{-1})					
Growth	112.09Aa	67.66Bb	67.03Bb	82.26				
Pregnancy	96.98Ba	71.59Ac	87.06Ab	85.21	8.76	*	*	*
Lactation	19.18Ca	15.06Bb	15.06Cb	16.43				
Mean	76.08	51.44	56.38					
			GGT (UI L^{-1})					
Growth	70.71Aa	62.65Bab	55.57Bb	62.98				
Pregnancy	55.79Bb	65.78Ba	57.13Bb	59.57	11.54	*	*	*
Lactation	64.19Bb	77.73Aa	64.40Ab	68.77				
Mean	63.56	68.72	59.03					

MSE: Mean standard error. Averages followed by common lowercase letters in the lines and by uppercase letters in the columns do not differ from one another according to the Tukey test, at 5% significance.

The use of any of these cakes can be at the producer's discretion given the variations that occur in each of the production phases. Thus, knowing the physiological variations of dairy goats is essential for the adequacy of any production system, since the efficiency achieved in each phase is a condition for the success of the subsequent production phases.

CONCLUSIONS

The detoxified castor cake by alkaline solutions in replacement of soybean meal proved to be a viable alternative in the feeding of goats during the three-stage physiological, because it does not affect the functionality of the liver and kidney function and the nitrogen balance.

Diets formulated with detoxified castor by sodium hydroxide decrease the intake of dry matter and nutrients, but without affecting in a negative way.

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