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ANIMAL SCIENCE

Nutritional performance, hepatic and renal function in goats fed diets containing detoxified castor cake at different stages of pregnancy

RICARDO A. DE ARAÚJO, JOSÉ N.M. NEIVA, MAGNO JOSÉ D. CÂNDIDO, MARCOS CLÁUDIO P. ROGÉRIO, LUIZA DE N.C. DA SILVA, ROBERTO CLÁUDIO F.F. POMPEU

Abstract: We evaluated the influence of the substitution of soybean meal by detoxified castor cake on performance, digestibility of nutrients, nitrogen balance, hepatic and renal functions of pregnant goats fed with diets containing detoxified castor cake by alkaline solutions during the stages (first two-thirds and final third) of pregnancy. Three diets were provided: one based on soybean meal and the other two based on castor cake detoxified with whit calcium hydroxide or sodium hydroxide. Goats fed detoxified castor cake sodium hydroxide had lower consumption. Was no effect ($P>0.05$) of diets or stages on the digestibility of dry matter and nutrients. The goats that received the diets based on soybean meal and detoxified castor cake calcium hydroxide consumed larger amounts of nitrogen. The goats fed with diet the basis of SM had greater weight in the parturition day. The average levels of enzymes for hepatic and renal functions were within normal patterns. Of enzymes related to liver metabolism, only the gamma-glutamyl transferase increased in the final third of pregnancy. The present study demonstrated that detoxified castor by sodium hydroxide reduces the consumption of goats during gestation, but did not affect negatively the renal and hepatic parameters.

Key words: Anglo Nubian, byproducts of biodiesel, final third, ricin, Saanen.

INTRODUCTION

In the production of goats milk, as in any animal production system, barriers are found in the nutritional management of animals, being essential the use of balanced diets, thus avoiding financial waste, especially when it comes to confined animals, given that the costs are higher (Araújo et al. 2020). The ideal is to use diets appropriate to the physiological stage and the level of production of the animals. However, the high cost of some foods hinders the productivity of these systems, often making them inefficient from a nutritional and economic point of view.

There has been a growing interest in the use of alternative food and regional (Menezes et al. 2012, Pompeu et al. 2012, Gionbelli et al. 2014) in the diets of ruminants, aiming at the reduction of costs with food supplies, among which we can highlight the castor cake, with its high protein content. However, the presence of antinutritional factors, such as the ricin, ricinina, ricinus agglutinin and complex allergenic renders it unfit for animal feed. However, after detoxification process (Anandan et al. 2005), this problem can be circumvented requiring, therefore, studies proving its use effectively in the diet of ruminants in different physiological situations.

In this sense, the pregnant goats require special attention, because the nutrients required by the body of the female at this stage do not meet only the maintenance of the body, but mainly will be directed to the pregnant uterus and mammary gland, being that during pregnancy. There is a great variation in the metabolism of pregnant goats, in virtue of fetal growth (Konyali et al. 2007).

During the first and second third of gestation, which begins with the design, the requirements of protein, energy, minerals and vitamins may be similar to the requirements of maintenance for the goats (NRC 2007). Already in the final third of the pregnancy is observed reduction in the relative rate of growth of the fetus, possibly because the fetus is entering the linear phase of growth (Greenwood & Bell 2003, Hafez & Hafez 2004), at the same time, at this stage there is a strong mobilization of body tissues and the goats are more susceptible to the occurrence of metabolic diseases. In addition, the nutrition of the female during the gestation period will affect the production of milk, the composition and weight gain of their descendants (Liden et al. 2009), and highlighted the importance of adequate nutritional plans the goats.

On the basis of claims raised and considering the importance of diet on the pregnancy period, the aim of this research was to evaluate the possibility of use of the detoxified castor by two alkaline solutions in lactating Saanen goats and Anglo Nubian and in confinement during stages of pregnancy and observe the effects on intake and digestibility of dry matter and nutrients, nitrogen balance and hepatic and renal functions.

MATERIALS AND METHODS

All animal procedures were conducted according to the regulations of the Ethics Committee on the Use of Animals of the Brazilian Agricultural Research Corporation, National Center for Research with goats, protocol no. 005/2015. The experiment was conducted at the Technological Center of production of goat milk from Embrapa Goats and Sheep (3°44'57.42"S, 40°20'43.50'W) located in the town of Sobral-CE, Brazil.

Were used 24 goats, being 12 of the Saanen goats and 12 Anglo Nubian, staying in each treatment, 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), consisting of four goats with double gestation and two with single gestation in each treatment. All tests were performed on two occasions, the first when the goats were between 30 and 100 days of gestation (first and second third) and the second between 110 and 140 days of pregnancy, representing the final third of pregnancy.

The experimental design was completely randomized, in plots subdivided in time, getting in the gestational phase plots and subplots the diets. Before the trial period, the goats were evaluated in another study where it was analyzed the performance in the growth phase with the use of the detoxified castor, therefore, the goats were already adapted to the foods used, changing only the proportion of ingredients due to the demands of the category in assessment.

In pre-experimental conditions, the reproductive management adopted involved " natural, with an average duration of breeding season of 30 days. Once identified the estro, the coverage was performed by natural mounts directed. For both, were used for breeding of the same breed, without any degree of kinship with the arrays. From the coverage, 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 35 days of gestation of the latest coverage, was held the confirmation of pregnancy all the goats, with the use of ultrasound device KX 5000®. The 96 days of gestation, the access to the solarium was closed with screens of protection due to the large slope of the ramp access, staying with 2.19 m^2 per bay.

The measurement of live weight was performed fortnightly. 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 (DCC) by calcium hydroxide [$Ca(OH)_2$] and another composed by detoxified castor by sodium hydroxide (NaOH), both in total substitution of soybean meal, was used as roughage hay Tifton 85 (Cynodon spp.). The goats began to receive the diets on the day of coverage.

The diets were formulated to meet the needs of pregnant goats with two fetuses, according to the NRC (2007) for goats with body weight of 42 kg and in early pregnancy. The chemical composition of foods is presented in Table I and the proportion of the ingredients and the chemical composition of diets are shown in Table II.

The castor cake used in this study was obtained after collecting oil, by mechanically pressing castor bean seeds at temperatures between 90 and 100 °C. After mixing the cakes, reagents and water for 3 h (mixing for 10 min and resting for 30 min, alternately), the cake was placed outdoors on a plastic canvas for a period of 48 h and constantly rolled with a squeegee manual adapted for homogeneous drying. After drying, the cake was chopped using a forage machine to reduce the material size (5 mm) and to facilitate its homogenization with the other ingredients.

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, respectively, per kilogram, which were diluted in 2 L of water using a stationary mixer (Fischer® MOB 400 G2) equipped with a three-phase motor, according to the methodology described by Araújo et al. (2020). No hemagglutinating activity was observed at those concentrations; i.e., ricinus agglutinin was no longer active. Therefore, these two concentrations were used to formulate the diets.

Table I. Chemical composition of the ingredients used for the preparation of the experimental diets.

Item (g/kg DM)	Ingredients				
	Tifton 85 hay	Ground corn	Soybean meal	DCC[1] $Ca(OH)_2$	DCC NaOH
Dry matter (g/kg 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[2]	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[3]	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

[1]DCC: Detoxified castor cake; [2]$Ca(OH)_2$ DCC: 0.90 g/kg Na DM and 2.25 g/kg Ca DM; NaOH DCC: 29.20 g/kg Na DM and 0.63 g/kg Ca DM. [3] Corrected for ash and protein.

Diets were supplied daily at 8h00 and 16h00, allowing a 10% leftover. 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 −18 °C.

At the end of the trial, the samples were thawed and separated between the two stages of pregnancy (first two-thirds and final third) and submitted to pre-drying in forced ventilation oven at 55 °C for 24 h. The dried samples were ground in knife mills (Wiley mill, Arthur H. Thomas, Philadelphia, PA, USA). Feed and leftovers were screened using a 1.0-mm sieve for chemical analyses, and a 2.0-mm sieve was used for evaluating apparent digestibility (Nocek, 1988).

Apparent digestibility coefficients were estimated indirectly using the internal iADF indicator. To do so, feces were collected directly from the rectal bulb for five 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 –18 °C. At the end of data collection, composite samples were made and then dried in a forced ventilation oven at 55 °C until constant weight was reached. The feces (2.0-mm) and feed samples (2.0-mm) were incubated *in situ* for a period of 240 h, according to the methodology described by Casali et al. (2008).

For evaluating nitrogen balance, total urine production was estimated by the concentration of creatinine in the urine. Spot urine samples were obtained approximately 4 h after feeding,

Table II. Proportion of ingredients and chemical composition of the experimental diets.

Ingredients	**Diets**		
	Soybean meal	**DCC $Ca(OH)_2$**	**DCC NaOH**
Item (g/kg DM)	**Proportion of ingredients**		
Tifton 85 hay	433.10	421.70	509.10
Ground corn	528.00	529.20	424.70
Soybean meal	33.50	--------	--------
Detoxified castor cake	--------	49.10	61.50
Limestone	5.4	--------	4.7
Mineral Premix[1]	Ad libitum	Ad libitum	Ad libitum
Chemical Composition (g/kg DM)			
Dry matter (g/kg 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[2]	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

[1]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%. [2] Corrected for ash and protein.

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 proposed by Fonseca et al. (2006), where:

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

Feces were collected directly from the rectal bulb for five days at different times (0, 3, 6 and 9 hours 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.

Blood samples were collected using 9.0 mL vacutainer tubes (Grainer Bio-One, Vacuette® Americana, SP, BRA), by puncturing the jugular vein, 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. Blood collections were made on two occasions, the first when the goats were 60 days pregnant and the second at 120 days.

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, without the use of sodium sulfite (Mertens 2002).

The concentration of NDF was corrected for ash as proposed by Mertens (2002), and for proteins (NDFan) according to Licitra et al. (1996). The ADL fraction was extracted with 72% sulfuric acid (Van Soest et al. 1991). Non-fibrous carbohydrate content (NFC) was calculated with an adaptation of the method proposed by Hall (2003) and NDF corrected for ashes and protein. 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 total digestible nutrient values were converted into net energy (NE) for production (maintenance and growth) and digestible energy (DE), according to the equations suggested by the NRC (2001). The intake of TDN (TDNI) was calculated according to the methodology described by Sniffen et al. (1992), as follows: $TDNI = (CPI-CPf)+2.25(EEi-EEf)+(TCi-TCf)$. Where, CPI, EEI, and TCI correspond to the intakes of CP, EE, and TC, respectively; and CPf, EEf, and TCf represent the respective excretion of CP, EE, and TC in the feces. In the conversion of TDNI into metabolizable energy (ME), 1 kg of TDN was assumed to be equivalent to 4.409 Mcal DE, and ME = 0.82 × DE (NRC 2001).

Nitrogen intake (NI), faecal nitrogen excretion (FN), and urinary nitrogen excretion (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:

$$NB = \left(\frac{NI - (FN + UN)}{NI} \right) \times 100$$

Retained nitrogen (RN) was calculated as:

$$RN = NB\,(g/day) - BEN\,(g/day) - dermal\,losses\,(g/day)$$

Where BEN (basal endogenous nitrogen) = 0.35 × BW0.75, and dermal losses = 0.018 × BW0.75, according to the recommendations of the AFRC (1993).

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

$$Yijk = \mu + \propto i + \beta j + (\propto \beta)ijk + eijk$$

Where Yijk is the dependent variable corresponding to the experimental observation; μ is the overall mean; αi is the fixed effect of the diets; βj is the fixed effect of stages of pregnancy; (αβ)ij is the interaction effect; and eijk is the random error, assuming an independent normal distribution. Interaction between stages of pregnancy and diet was only deployed when significant at 5% probability by Tukey test. Statistical analyses were performed using the GLM procedure of SAS software version 9.4 (SAS INSTITUTE 2005).

RESULTS

There was effect (P<0.05) of diets and the stages of pregnancy on dry matter intake (DMI) and nutrients (Table III). The DMI was greater for the goats fed with SM and DCC $Ca(OH)_2$, for both the values expressed in g/day and for those expressed in % of body weight (% BW), but the goats fed diets based on SM also did not differ from those who consumed a diet with DCC NaOH, when expressed in % BW. As well as the DMI, the intake of CP, EE, NDF and NDT were higher for the goats fed the diets based on SM and DCC $Ca(OH)_2$. In relation to the effect of the stages of pregnancy, it was observed that, with the passing of the stages, the intake decreased significantly. Similarly, the intake of CP, EE, NDF and TDN decreased in 73.55; 42.11; 235.81 and 404.43 g/day, respectively.

It has been observed that during pregnancy, the weight of the goats was amended by the diets (P<0.05). The goats fed with diet the basis of SM had greater weight in the parturition day. However, the postpartum weight was equal to the other (P>0.05). In addition, the weight of the goats generated was not influenced by the diets, nor was the body condition score in the pre and postpartum period and the weight of the young goats (Table IV).

There was no effect (P>0.05) of diets or stage of pregnancy on the digestibility of DM and nutrients during the gestational period of goats (Table V).

The diets influenced (P<0.05) the consumption of nitrogen and the amount of nitrogen retained (Table VI). The goats fed the diets based on SM and DCC $Ca(OH)_2$ consumed larger amounts of nitrogen, with average values of 17.13 and 16.78 g/day, respectively, while the goats fed with diet containing DCC NaOH consumed less quantity (15.01 g/day). Similarly, the content of nitrogen retained was lower for latter (10.28 g/day). The stages of pregnancy influenced (P<0.05) all the variables related to the nitrogen balance. In summary, during the first two-thirds of pregnancy, the goats presented larger values, with reductions of 42.56, 49.55, 49.74 and 39.14% for the nitrogen consumed, faeces, urine and nitrogen retained, respectively.

We observed effect (P<0.05) of diets on the values of total protein, albumin, urea and

Table III. Dry matter intake and nutrients of goats fed with detoxified castor cake (DCC) at different stages of pregnancy.

Stages of pregnancy	Diets			Mean	MSE[2]	P-value		
	SM[1]	DCC $Ca(OH)_2$	DCC NaOH			Diet (D)	Stage (S)	D x F
	Dry matter (g/day)							
Two-thirds	1,540.31	1,514.32	1,387.15	1,480.59A	18.88	0.016	0.027	0.065
Final-third	911.81	885.82	758.65	852.09B				
Mean	1,226.06a	1,200.75a	1,072.90b					
	Dry matter (% BW)							
Two-thirds	2.97	3.15	2.80	2.97A	0.05	0.037	0.042	0.054
Final-third	1.65	1.74	1.45	1.61B				
Mean	2.31ab	2.44a	2.13b					
	Crude protein (g/day)							
Two-thirds	179.98	175.85	162.30	172.71A	2.13	0.038	0.010	0.896
Final-third	105.59	103.93	87.97	99.16B				
Mean	142.78a	139.89a	125.14b					
	Ether extract (g/day)							
Two-thirds	103.59	100.94	93.67	99.40A	1.25	0.049	0.021	0.984
Final-third	61.59	59.08	51.22	57.29B				
Mean	82.50a	80.01a	72.45b					
	Neutral detergente fiber (g/day)							
Two-thirds	567.69	570.71	528.52	555.64A	8.74	0.030	0.041	0.766
Final-third	341.98	332.22	285.30	319.83B				
Mean	454.83a	451.46a	406.91b					
	Total digestible nutrients (g/day)							
Two-thirds	1,174.17	1,191.02	1,107.78	1,157.66A	22.17	0.017	0.026	0.076
Final-third	695.07	696.69	605.86	665.88B				
Mean	934.62a	943.85a	856.82b					

[1]SM: Soybean meal; [2]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.

gamma-glutamyl transferase (Table VII). The total protein and albumin content was in the goats that consumed the DCC NaOH diet (6.72 and 2.44 g/dL), but it did not differ from the goats fed with a diet based on DCC $Ca(OH)_2$ (6.49 and 2.32 g/dL), which in turn were the values of goats that consumed the soybean meal diet. Urea showed an opposite behavior values of total protein and albumin, where the goats that consumed the diet the basis of SM showed higher content (31.16 mg/dL) and those who consumed the diet DCC NaOH lower content (27.70 mg/dL), however, the goats fed with DCC $Ca(OH)_2$ did not differ from both diets (28.81 mg/dL). On another hand, the latter presented a

Table IV. Weight and body condition score of pregnant goats fed diets containing detoxified castor (DCC) by different alkali replacing soybean meal during gestation and weight of goats generated.

Item	Diets			MSE[1]	P-value
	Soyabean meal	DCC $Ca(OH)_2$	DCC NaOH		
Initial weight (kg)	42.08	41.87	42.15	0.87	0.081
Initial score	3.5±0.42	3.7±0.22	3.6±0.33	0.14	0.152
Birth weight (kg)	55.65a	53.87b	53.90b	1.24	0.023
Postpartum weight (kg)	43.54	43.78	43.98	1.46	0.087
Postpartum score	2.65±0.21	2.70±0.13	2.60±0.16	0.17	0.065
Weight goats' kids (kg)	3.82	3.79	3.75	0.45	0.083

[1]MSE: Mean standard error. Averages followed by common lowercase letters do not differ from one another according to the Tukey test at 5% significance.

higher amount of gamma-glutamyl transferase (65.78 IU/L).

In relation to stages of pregnancy, we observed effect ($P<0.05$) of the same on all blood parameters evaluated, with the exception of the aspartate aminotransferase ($P>0.05$). In summary, we observed a significant reduction in the levels of protein metabolites, which were: 18.95; 32.74; 17.06; 30.26; 17.34 for total proteins, direct bilirubin, albumin, urea, alkaline phosphatase, alanine aminotransferase, respectively, since the content of gamma-glutamyl transferase increased by approximately 30.74% in the final third of pregnancy.

DISCUSSION

The smallest DMI by goats fed with DCC NaOH may be related to the sodium content of the detoxified castor by this alkaline product (Table I), because according Yousfi et al. (2016), the greater inclusion of sodium in the diet of ruminants provides a self-adjusting effect of voluntary intake by the animals. It should be noted that the quantity of sodium in the NaOH DCC (Table I) was 32.4 times higher than that in DCC $Ca(OH)_2$, which highlights even more this effect in the control of DMI.

The DMI recommended by NRC (2007) for non-lactating goats with 42 kg of body weight is of 1593,24 g DM/day for the dual pregnancies. Taking the average of consumption throughout the gestational period, without taking into account the type of pregnancy, it was found that the average DMI was 1166,34 g DM/day. This result is 26.79% lower than the recommended intake by that system. With the passing of the pregnancy, DMI decreases due to factors such as compression of the digestive tract caused by the growth of pregnant uterus and increased serum levels of estrogen (Forbes 2007). On the other hand, in absolute terms, the coefficient of digestibility of diets increases, because the passage rate tends to be lower (Lu et al. 2005). Therefore, despite the diets did not have influenced the digestibility in both periods of pregnancy, there is a slight increase of values in the final third of pregnancy (Table IV).

The effect to DMI influenced the results of consumption of EE, NDF and TDN. This result was expected, since the intake of these nutrients is directly related to the amount of DM ingested. In relation to the consumption of TDN, the highest values observed in goats fed with SM and $Ca(OH)_2$ TDN are justified by the greater

Table V. Digestibility of dry matter and nutrients of goats fed with detoxified castor cake (DCC) at different stages of pregnancy.

Stages of pregnancy	Diets			Mean	MSE[2]	P-value		
	SM[1]	DCC $Ca(OH)_2$	DCC NaOH			Diet (D)	Stage (S)	D x S
	Dry matter (kg/kg)							
Two-thirds	714.30	702.26	687.65	701.40	12.76	0.349	0.425	0.876
Final-third	726.17	714.23	699.58	713.32				
Mean	720.23	708.62	693.62					
	Crude protein (kg/kg DM)							
Two-thirds	749.35	758.51	738.17	748.68	11.46	0.495	0.266	0.287
Final-third	764.25	773.42	753.98	763.88				
Mean	756.8	765.965	746.075					
	Ether extract (kg/kg DM)							
Two-thirds	800.84	791.98	794.45	795.76	12.69	0.876	0.253	0.764
Final-third	817.93	809.15	811.31	812.80				
Mean	809.385	800.565	802.88					
	Neutral detergent fiber (kg/kg DM)							
Two-thirds	720.95	709.64	669.51	700.04	24.77	0.319	0.606	0.587
Final-third	735.79	724.79	684.54	714.93				
Mean	728.37	717.05	677.04					

[1]SM: Soybean meal; [2]MSE: Mean standard error. Averages followed by common lowercase letters do not differ from one another according to the Tukey test at 5% significance.

amount of EE consumed (Danieli & Ronchi 2018) and higher non-fiber carbohydrates.

The NRC (2007) recommends that the consumption of TDN for goats in this category is 1,089.25 g TDN/day, which indicates that all diets smite TDN requirements during the initial two-thirds of the pregnancy, even the goats fed the diet containing DCC NaOH (1107,78 g TDN/day). The consumption of TDN is directly the energy consumed and destined to the development of the mammary gland and of fetuses (Greenwood et al. 1998). In this way, it can be inferred that the replacement of soybean meal by DCC has not reduced the development of fetuses, considering that the weights of the goats at birth were not affected (Table IV), despite the significant reduction in the consumption of TDN in the final third of pregnancy. However, the same conclusion cannot be attributed to the development of the mammary gland, because milk production was not measured.

The consumption of CP was changed with the replacement of the SM by DCC NaOH. The NRC (2007) recommends that the consumption of CP for goats in this category is 172.41 g/day. In this way, the consumption of CP observed in this experiment has met the requirements of goats fed with diets containing SM and NaOH DCC during the initial two-thirds of pregnancy, being contrary to the goats fed with diets containing DCC NaOH (162.30 g CP/day). On the other hand, the absence of effect on the amount of nitrogen retained (Table VI) demonstrates greater efficiency in the use of this nutrient by goats

Table VI. Nitrogen balance of goats fed with detoxified castor cake (DCC) at different stages of pregnancy.

Stages of pregnancy	Diets			Mean	MSE[2]	P-value		
	SM[1]	DCC $Ca(OH)_2$	DCC NaOH			Diet (D)	Stage (S)	D x S
	Nitrogen intake (g/day)							
Two-thirds	21.59	21.10	19.47	20.72A	0.25	0.014	0.040	0.896
Final-third	12.67	12.47	10.55	11.90B				
Mean	17.13a	16.78a	15.01b					
	Faecal nitrogen excretion (g/day)							
Two-thirds	4.63	4.33	4.53	4.50A	0.12	0.529	0.039	0.554
Final-third	2.37	2.32	2.14	2.27B				
Mean	3.50	3.33	3.33					
	Urinary nitrogen excretion (g/day)							
Two-thirds	1.99	1.86	1.94	1.93A	0.05	0.477	0.041	0.460
Final-third	0.97	0.95	0.84	0.92B				
Mean	1.48	1.40	1.39					
	Nitrogen retention (g/day)							
Two-thirds	14.97	14.89	12.99	14.28A	0.23	0.022	0.032	0.911
Final-third	9.32	9.19	7.56	8.69B				
Mean	12.14a	12.04a	10.28b					

[1]SM: Soybean meal; [2]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.

fed with DCC NaOH, where it can be observed that the amount of nitrogen excreted in feces and urine were lower. In addition, the content of total protein and albumin was greater in the circulation of these goats (Table VII), 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 decreased in the final third of gestation, in percentage terms the content was higher in this phase (31.08%) that during the initial two-thirds (26.97%).

It is interesting to observe the efficiency of nitrogen use by goats fed with DCC NaOH, as they had the lowest nitrogen consumption, however the excretion of this nutrient, both in urine and faeces, was the same as goats fed with soybean meal and DCC $Ca(OH)_2$ (Table VI). According to Araújo et al. 2020, the DCC NaOH has a higher protein content of fraction A. Thus, it can be inferred that the DCC NaOH diet presents greater degradation of soluble proteins, favoring the availability of non-protein nitrogen, which justifies the positive nitrogen balance.

The largest proportion of nitrogen retention is derived from the intense protein metabolism of the fetus in the final third of the pregnancy, because according to Härter et al. (2017). The growth of the fetus in this period of gestation can match up to 93.6% of the total weight of the fetus, absorbing large quantities of proteins that are in circulation (Bell et al. 2005), which may be related, including, in does not change the content of total proteins in the circulation of

Table VII. Blood Parameters of goats fed with detoxified castor cake (DCC) at different stages of pregnancy.

Stages of pregnancy	Diets			Mean	SEM[2]	P-value		
	SM[1]	DCC $Ca(OH)_2$	DCC NaOH			Diet (D)	Stage (S)	D x F
	Total proteins (g/dL)							
Two-thirds	6.07	7.14	7.37	6.86A	0.33	0.012	0.030	0.764
Final-third	4.77	5.84	6.07	5.56B				
Mean	5.42b	6.49ab	6.72a					
	Direct bilirubin (mg/dL)							
Two-thirds	1.08	1.19	1.12	1.13A	0.13	0.831	0.013	0.883
Final-third	0.73	0.72	0.84	0.76B				
Mean	0.91	1.02	0.92					
	Albumin (g/dL)							
Two-thirds	2.36	2.54	2.66	2.52A	0.05	0.049	0.044	0.478
Final-third	1.93	2.11	2.22	2.09B				
Mean	2.14b	2.32ab	2.44a					
	Urea (mg/dL)							
Two-thirds	36.43	35.08	32.97	34.83A	0.81	0.027	0.032	0.435
Final-third	25.89	24.54	22.43	24.29B				
Mean	31.16a	28.81ab	27.70b					
	Alkaline phosphatase (UI/L)							
Two-thirds	7.33	6.89	7.24	7.15A	0.41	0.726	0.037	0.843
Final-third	6.08	5.64	6.01	5.91B				
Mean	6.71	6.26	6.62					
	Alanine aminotransferase (UI/L)							
Two-thirds	17.83	14.00	14.25	15.36A	1.57	0.157	0.040	0.547
Final-third	13.16	9.43	9.33	10.64B				
Mean	15.49	11.71	11.79					
	Aspartate aminotransferase (UI/L)							
Two-thirds	98.68	73.29	88.99	86.99	7.52	0.071	0.685	0.743
Final-third	95.28	69.89	85.13	83.43				
Mean	96.98	71.59	87.06					
	Gamma-glutamyltransferase (UI/L)							
Two-thirds	52.16	62.15	62.15	55.94B	2.92	0.027	0.037	0.617
Final-third	59.41	69.40	60.75	63.19A				
Mean	55.79b	65.78a	57.13b					

[1]SM: Soybean meal; [2]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.

goats fed with DCC NaOH (Table VII), despite the smaller intake of CP (Table III) during the final third of pregnancy.

The average levels of enzymes for hepatic and renal functions are within the standards for species, according to Smith & Sherman (2009). It is interesting to observe that, in spite of the diets did not affect the levels of these enzymes, there was a decrease in the final third of gestation, except the aspartate aminotransferase, which was not altered (Table VII).

The reduction of these enzymes in the final third of pregnancy is common, because Huy (2005), says that all the enzymes related to liver function are usually reduced in the course of the pregnancy of mammals, due to the expansion of the extracellular fluid. This author affirms that only exception is for alkaline phosphatase, which is high during this period due to same be of placental origin, but the values observed, besides not having been influenced by the diets (Table VII) decreased in the final third of pregnancy. Despite this, the values were within the reference range for the species (Contreras et al. 2000), thus discarding a possible deficit in protein metabolism, which is common due to increased metabolic demand during pregnancy (Radin et al. 2015), which could be observed with the greatest concentration of urea in the blood, but the amount of this metabolite decreased with the passage of the pregnancy (Table VII).

In relation to the effect of the stages of pregnancy, Kalhan (2000) asserts that it is common for decrease of the concentration of urea in pregnant, 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), otherwise you may be related to pregnancy toxemia. Since the reduction of albumin in the final third is related to the effect of dilution, due to the increase of other plasma proteins near the delivery (Rodríguez et al. 2009).

The enzymes related to liver metabolism, only the gamma-glutamyl transferase increased in the final third of the pregnancy. According to Radin et al. (2017), the levels of this enzyme increase physiologically next to childbirth. This behavior can be explained by fact that in ruminants there is transfer of this enzyme to fetuses. Therefore, there is an increase of this compound in maternal blood concentration, so that this enzyme is transferred to their offspring, mainly through the colostrum (Kaneko 2008). In this way, you can also that diet with DCC $Ca(OH)_2$ presented higher content of gamma-glutamyl transferase, which can passive immunity in calves (Silva et al. 2007).

CONCLUSION

During the final third of gestation, the Saanen goats and Anglo Nubian diminish considerably the intake. The detoxified castor cake by alkaline solutions in replacement of soybean meal proved to be a viable alternative in the feeding of goats in pregnancy, 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 negatively affecting the weight of the offspring.

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RICARDO A. DE ARAÚJO[1*]
https://orcid.org/0000-0001-9696-5680

JOSÉ N.M. NEIVA[2]
https://orcid.org/0000-0001-7817-8210

MAGNO JOSÉ D. CÂNDIDO[3]
https://orcid.org/0000-0003-3573-6053

MARCOS CLÁUDIO P. ROGÉRIO[4]
https://orcid.org/0000-0003-3567-5211

LUIZA DE N.C. DA SILVA[2]
https://orcid.org/0000-0001-8922-8455

ROBERTO CLÁUDIO F.F. POMPEU[4]
https://orcid.org/0000-0002-4099-3575

[1]Universidade Estadual do Maranhão/UEMA, Departamento de Agronomia, Praça Gonçalves Dias, s/n, 65055-970 Balsas, MA, Brazil

[2]Universidade Federal do Tocantins/UFT, Escola de Medicina Veterinária e Zootecnia, Rodovia TO - 421, Km 6, 65907-230 Araguaína, TO, Brazil

[3]Universidade Federal do Ceará/UFC, Departamento de Zootecnia, Campus Pici, Av. Humberto Monte, s/n, Pici, 60440-593 Fortaleza, CE, Brazil

[4]Embrapa Caprinos e Ovinos – CNPC/EMBRAPA, Estrada Sobral - Groaíras, s/n, Km 04, Zona Rural, 62010-970 Sobral, CE, Brazil

Correspondence to: **Roberto Cláudio Fernandes Franco Pompeu**
E-mail: roberto.pompeu@embrapa.br
**in memoriam*

Author contributions

Ricardo A. de Araújo: Investigation, Data curation, Formal analysis, Methodology, Writing – original draft, Writing – review & editing. José N.M. Neiva: Investigation, Supervision, Writing – original draft. Magno José D. Cândido: Conceptualization, Investigation, Methodology, Writing – original draft. Marcos Cláudio P. Rogério: Conceptualization, Investigation, Methodology, Validation, Writing – original draft. Luiza de N.C. da Silva: Investigation, Writing – original draft. Roberto Cláudio F.F. Pompeu: Conceptualization, Data curation, Formal analysis, Funding acquisition, Investigation, Methodology, Project administration, Supervision, Writing – original draft, Writing – review & editing.