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Economic-financial analysis of the use of the detoxified castor by alkaline solutions I: production of arrays of dairy goats

Análise econômico-financeira do uso da torta de mamona destoxificada por soluções alcalinas I: produção de matrizes de cabras leiteiras

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Highlights:
The use of detoxified castor cake (DCC) reduces feed costs during the growth phase.
Use of DCC does not compromise the financial viability of systems over the long term.
DCC can replace soybean meal without compromising the income of producers that rear goats.

Abstract

We evaluated the influence of totally substituting soybean meal (SM) with detoxified castor cake (DCC) and two alkaline products on the economic and financial viability of producing Saanen and Anglo-Nubian goat dairy breeds with initial body weights of 16.22 ± 0.67 kg that had been confined until they were capable of reproduction (70% of total body weight). The goats were subjected to six simulated production systems (PS). These were PS_1, rearing Saanen goats that were fed with a standard diet based on SM; PS_2, rearing Anglo-Nubian goats that were fed with a standard diet based on SM; PS_3, rearing Saanen goats that where fed with a standard diet based on DCC $Ca(OH)_2$; PS_4, rearing Anglo-Nubian goats that were fed with a standard diet based on DCC $Ca(OH)_2$; PS_5, rearing Saanen goats fed with a standard diet based on DCC NaOH; and PS_6, rearing Anglo-Nubian goats that were fed with a standard diet based on DCC NaOH. A descriptive economic and financial evaluation of the data was carried out using AVETEC® software. The SM based diets cost approximately 58.70% and 66.22% more for the Saanen and the Anglo-Nubian goats than the other diets, respectively. The results showed that all the scenarios had a point of leveling (PL) values of less than 144 goats, which is the number of animals that can be produced annually by each system simulated in this research. The net revenue for all the systems

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was greater than zero, which indicated that their activities were stable and that the internal rates of return were high. The profitability indices were also very good, especially the systems that used Saanen goats, because the NPV were higher than 1 million reais. Sensitivity analyzes showed that the indicators of performance were only economically unviable under the least favorable situations, such as 30% reductions in both production and market price. The use of the DCC does not compromise the economic viability of the systems and produces higher returns than the systems that used the standard (SM) diet.
Key words: Anglo Nubian. Coproducts of biodiesel. Saanen.

Resumo

Avaliou-se a influência da total substituição do farelo de soja (FS) pela torta de mamona destoxificada (TMD) por dois produtos alcalinos sobre a viabilidade econômico-financeira na produção de matrizes leiteiras das raças Saanen e Anglo Nubiana, com peso corporal inicial de 16,22 ± 0,67 kg confinadas até a formação de matrizes aptas a reprodução (70% do peso vivo corporal). Foram simulados seis sistemas de produção (SP), sendo: SP_1, criação de cabritas Saanen alimentadas com dieta padrão à base de FS; SP_2, criação de cabritas Anglo Nubianas alimentadas com dieta padrão à base de FS; SP_3, criação de cabritas Saanen alimentadas com dieta à base de TMD $Ca(OH)_2$; SP_4, criação de cabritas Anglo Nubianas alimentadas com dieta à base de TMD $Ca(OH)_2$; SP_5, criação de cabritas Saanen alimentadas com dieta à base de TMD NaOH; SP_6, criação de cabritas Anglo Nubianas alimentadas com dieta à base de TMD NaOH. A avaliação econômico-financeira dos dados foi realizada de forma descritiva, utilizando-se o software AVETEC®. Os maiores custos com alimentação foram observados nos sistemas que utilizaram as dietas a base de FS, cerca de 58,70% para as cabras Saanen e 66,22% para as Anglo Nubianas. A simulação para produção de 144 matrizes leiteiras proporcionou receita superior aos custos de produção, resultando em indicadores econômicos positivos para todos os cenários avaliados. Observou-se que todos os cenários tiveram ponto de nivelamento (PN) inferior a 144 cabras que é a quantidade de animais que podem ser produzidas anualmente para cada sistema simulado nesta pesquisa. A receita líquida de todos os sistemas foi maior que zero, o que indica que a atividade é estável, apresentando altas taxas internas de retorno. Da mesma forma, os índices de lucratividade são bem atrativos, principalmente os sistemas que optarem pela cria de cabras da raça Saanen, onde os VPLs são superiores há um milhão de reais. As análises de sensibilidade mostraram que apenas nas situações mais desfavoráveis, tais como a redução de 30% tanto na produção quanto no preço de mercado, os indicadores são economicamente inviáveis. O uso das TMD não compromete a viabilidade econômica dos sistemas, porém quando comparados aos sistemas que utiliza a dieta padrão, apresentam menor rentabilidade.
Palavras-chave: Anglo Nubiana. Coprodutos do biodiesel. Saanen.

Introduction

In the goat milk production, so that the phase of lactation is efficiently productive, there is a need of goats as well developed. Thus, the phase of rearing is of utmost importance, since the formation of healthy, well-nourished arrays and developed physiologically will reflect, subsequently, healthy pregnancies and lactations. It is worth mentioning that, within a dairy property, the goat's kids, during the phase of recreates, represent a major source of spending, especially with food, considering that they are not yet in production (Araújo et al., 2018). On this basis, the use of animal coproducts can make this phase more efficiently from an economic point of view, because the coproducts can reduce production costs.

Thus, the growing participation of biodiesel in the world energy matrix (Ladeira et al., 2016) enables the production of ruminants through the supply of meal or cakes obtained after the extraction of oil from oilseeds, constituting the main coproducts of the biodiesel production chain. Thus, there is

the possibility of integrating the chains renewable energy and agribusiness, generating employment and income, in addition, of course, possible to minimize the environmental problems caused by such coproducts and decreased food costs.

Between the coproducts generated in the chain of biodiesel are the bran and the castor bean cake, since the cultivation of this crop grows each year, mainly by low demands on water and nutrients in the soil (Severino et al., 2012). One of the main attractions for the use of castor coproducts for ruminant feeding is the high protein content, reaching 33% crude protein and with high digestibility (Araújo et al., 2020). However, the coproducts of castor bean feature a nutritional limitation due to the presence of toxic proteins as the ricin and ricinus agglutinin, besides alkaloids of ricinina and complex allergenic, triggering inactivation of ribosomes, hemolysis, diarrhea and allergic attacks, respectively (Dang & Vam Damme, 2015). However, after the detoxification process of the castor bean cake can be a viable alternative to circumvent this situation and thus use it in animal feed (Araújo et al., 2020).

In this way, after the detoxification process, the use of this product in the diet of goat's kids in the growth phase can make the system more efficient economically. The studies that perform economic analysis of the rearing of dairy goats are scarce and, in most cases, present incomplete not composing the total cost of production. These manuscripts are of utmost importance to evaluate better the activity and that it is possible to reduce costs, increase productivity, and establish goals with the aim of achieving high profitability with efficiency and sustainability of the business.

In this context, the coproducts from biodiesel industry, in particular the castor cake, emerge as an alternative feed for ruminants in the Brazil, may replace soybean meal, which is a noble food, which increases production costs. Given the above, this study aimed to evaluate the influence of the detoxified castor by alkaline solutions economic-financial feasibility of goats saanen and Anglo Nubian recreated in confinement until the formation of arrays suitable for reproduction.

Material and Methods

The information of the technical parameters for financial analysis of this research were obtained in the Technological Center of production of goat milk from Embrapa Goats and Sheep (3º44'57.42" south and 40°20'43.50" West) located in the city of Sobral-CE, Brazil. 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.

The economic and financial evaluation of the data was carried out in a descriptive way, using the software AVETEC® (Evaluation of the economic viability of technology in agricultural production systems) developed by Embrapa, which enables the analysis of the cost of production and the economic viability indicators derived from the same (Guiducci, Alves, Lima, & Mota, 2012). The investments relating to the implementation of the system of production were: fold with a total area of 144 m^2, with 50% of this area, covered, and the other 50%, constituting a solarium (Table 1). In addition, were part of the investment in the acquisition of equipment for production of arrays, such as forage and balance and a concrete mixer for detoxification of castor cake.

Table 1
Cost of materials and labor for construction of a shed of masonry with 72 m² and capacity for 72 goats

Items	Quantity	Unity	Unity price (R$)	Total price (R$)
Wooden	240	Linear meter	7.00	1,680.00
Roof	72	Square meter	120.00	8,640.00
Trough	18	Linear meter	17.00	306.00
Fountain	8	Bucket	6.00	48.00
Workmanship	6	Diary	100.00	600.00
Balance	1	Piece	200.00	200.00
Wire	1.000	Linear meter	0.50	500.00
Total price				11,974.00

The economic analysis was based on the calculation of cost of production, which is represented by the sum of all resources (inputs) and operations (services) used in the production process. The variable cost was composed by food, health, labor, equipment maintenance, depreciation, opportunity costs, and other costs (power of the wielder, specifications on zootechnics and electrical energy) (Guiducci et al., 2012). These expenses were raised on the basis of quotations of prices of products in Sobral-CE, in January 2020. Feed costs were composed unbeatable prices and quantities supplied the ingredients of diets, based on dry matter. As the cost of labor, we considered the maintenance of an employee on temporary scheme to deal with a lot of 72 confined animals. The remuneration was based on the minimum wage in January 2020 (R$ 1,039.00).

The purchase price of goat's kids was R$ 500.00 for the Saanen and R$ 450.00 for the Anglo Nubian, considered as an investment and not as cost of production and the selling price was R$ 2,000.00 for the Saanen arrays and R$ 1,850.00 the Anglo Nubian. Thus, the total revenue was formed from the commercialization of goats suitable for reproduction, whereas for the sale of the goats of the body weight of 70% of the weight of adult.

The indicators of economic efficiency were: total revenue (RV), total cost (TC), family income (FI), point of leveling (PL), rate of return the entrepreneur (RRe) and total factor productivity (TFP), calculated as Guiducci et al. (2012). The financial indicators considered were: net present value (NPV), annualized net present value (VPLa), term of return on investment (Payback), internal rate of return (IRR), modified internal rate of return (IRRm) and profitability index (PI), calculated as Guiducci et al. (2012). For both, it simulated cash flows for the period of ten years.

For the realization of sensitivity analysis, the items that compose the cash flows from each system were studied individually. In this work, to perform sensitivity analysis, we adopted the discount rate of 6% per year, whereas a variation of 30%, both favorable and unfavorable to the results of each system, i.e., the price of each item that compose the cash flow. From there, it was possible to observe what item had a greater effect on the indicator of economic outcome. The results of the zootechnical parameters obtained were extrapolated to a system of creation with 72 goat's with initial age of 3 months are confined during different periods according to the time needed to reach the weight of coverage, totaling two cycles of production and 144 goats produced per year. This extrapolation was performed to ensure that the economic/financial analysis could be performed on scientific basis and in economies of scale.

The zootechnical data used in the economic analysis were derived from a survey in which they were used 24 goats with average body weight of 16.22 ± 0.67 kg, being 12 Saanen and 12 Anglo Nubian (Table 2), which were obtained from Araújo et al. (2018). The animals were divided into six treatments that consisted of three diets, the first was formulated with corn and soybean meal (SM) and the others were formulated with detoxified castor by calcium hydroxide ($Ca(OH)_2$ DCC) and another composed by detoxified castor by sodium hydroxide (NaOH DCC), both in the total substitution of soybean meal. It was used as roughage hay Tifton 85.

The goats were subjected to a regime of confinement in individual stalls, suspended and with floor ripped of 5.06 m², being 2.87 m² composed by solarium, provided of drinkers, feeders and salt shakers. In pre-experimental conditions, the goats were identified, treated against ecto and endoparasites and received vaccine against rabies.

Table 2
The average values of the productive performance of goat's kids fed with diets containing detoxified castor by different alkali replacing soybean meal during the growth phase

Breed	Diets			Mean
	Soybean meal	$Ca(OH)_2$ DCC	NaOH DCC	
	Average daily weight (g day^{-1})			
Saanen	109.08	115.13	98.43	107.54
Anglo Nubian	110.20	99.43	100.56	103.40
Mean	109.64	107.28	99.49	
	Intake DM (g day^{-1})			
Saanen	1,039.33	904.20	867.36	936.96
Anglo Nubian	1,004.65	914.61	816.69	911.98
Mean	1,021.99	909.40	842.02	
	Feed conversion (kg kg^{-1})			
Saanen	9.34	8.58	8.65	8.86
Anglo Nubian	9.37	8.54	8.52	8.81
Mean	9.36	8.56	8.59	

In food samples were determined levels of DM method (method 934.01), organic matter (method 942.05), crude protein method (method 954.01), ether extract method (method 920.39) in accordance with the Association of Analytical Chemists [AOAC] (2003). For the analysis of neutral detergent fiber (NDF), samples were treated with alpha-amylase thermostable, without the use of sodium sulphite and corrected for residual ash (Mertens, 2002). The estimate of the content of nitrogenous compounds are insoluble in neutral detergent (IDN) and acid (IDA) was performed according to Licitra, Hernandez and Van Soest (1996). The lignins were obtained with the residue of the ADF treated with sulfuric acid to 72% (Van Soest, Robertson, & Lewis, 1991). The content of non-fibrous carbohydrates (NFC) was calculated with adaptation to proposed by Hall (2003), using the NDFap. The content of total carbohydrates (TC) was obtained by the equation proposed by Sniffen, O'Connor, Van Soest, Fox and Russell (1992). The content of total digestible nutrients (TDN) was calculated according to Weiss (1999). The TDN values were converted into net energy (NE) and digestible energy (DE), using the

equations suggested by National Research Council [NRC] (2001).

The experimental diets were formulated based on the recommendations of the NRC (2007), isonitrogenous with roughage:concentrate ratio of 43:57, 40:60 and 36:64 for the SM, Diet $Ca(OH)_2$ DCC and NaOH DCC, respectively. The chemical composition of the ingredients is found in Table 3 and the proportion of ingredients and their chemical composition based on roughage:concentrate ratio are shown in Table 4.

The castor bean cake used was obtained by mechanical pressing, using temperatures between 90 and 100 ºC, castor seed, for obtaining the castor oil. For the detoxification of crude castor were used two alkali, calcium hydroxide $Ca(OH)_2$ and sodium hydroxide (NaOH) in the proportions of 60 and 90 g kg^{-1} of castor cake. For the dilution and effectiveness of reagents, was used 2000 ml of water kg^{-1} of castor cake. The castor was detoxified through the adaptation of a semi-automatic mixer for homogenization of destoxificante solution. For the mixture of the solution was used a stationary mixer (Fischer® MOB 400 G2) equipped with three-phase motor. After three hours of mixture (ten minutes by mixing and thirty minutes at rest, alternately, the pie was placed on a plastic canvas, outdoors, for a period of 48 hours, constantly being rolled away to a drying of homogeneous way. After drying, the pie was crushed in machine harvester, to allow a reduction in the size of the material and facilitate its blending with other ingredients. All costs necessary to destoxificar both castor bean pies are represented in Table 5.

Table 3
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[1]	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[2]	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] $Ca(OH)_2$ 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. [2] Corrected for ash and protein.

Table 4
Ingredient proportions and chemical compositions of the experimental diets

Ingredient (g/kg dry matter)	Diets		
	Soybean meal	$Ca(OH)_2$ Castor cake	NaOH Castor cake
	Proportion of ingredients in the diets (g kg^{-1} dry matter)		
Tifton 85 hay	427.3	394.9	363.2
Ground corn	460.8	481.9	504.6
Soybean meal	57.8	--------	--------
Detoxified castor cake	--------	83.3	82.9
Soy oil	45.0	39.9	39.2
Limestone	9.1	0.01	10.1
Mineral mixture[1]	Ad libitum	Ad libitum	Ad libitum
Chemical composition (g/kg dry matter)			
Dry matter (g kg^{-1} fresh matter)	887.7	896.1	891.8
Organic matter	942.3	897.8	938.1
Mineral matter	57.7	102.2	61.9
Crude protein	112.0	112.9	112.3
Neutral detergent insoluble protein	13.1	13.2	12.4
Acid detergent insoluble nitrogen	3.7	3.9	4.1
Ether extract	62.0	63.4	65.4
Total carbohydrates	761.4	721.2	751.8
Non-fiber carbohydrates	471.8	468.6	476.8
Neutral detergent fiber (NDF)	408.8	409.0	392.3
NDF corrected for ash and protein	338.0	293.6	318.0
Acid detergent fiber	349.5	332.0	305.4
Lignin	30.8	32.6	30.3
Total digestible nutrients	664.9	658.5	663.6
Digestible energy (MJ kg^{-1} dry matter)	12.3	12.1	12.2
Metabolizable energy (MJ kg^{-1} dry matter)	10.5	10.4	10.5
Net energy[2] (MJ kg^{-1} dry matter)	6.3	6.2	6.3

[1] Guaranteed levels (per kg, inactive elements): calcium - 218 g; phosphorus - 71 g; sulfur - 20 g; manganese - 1.300 mg; potassium - 28.20 mg; cobalt - 30 mg; selenium - 15.30 mg; zinc - 1700 mg; copper = 710 mg. [2]Net energy for production estimated by the NRC (2001).

Table 5
Costs with materials and ingredients used to crude castor with different alkaline solutions

Ingredients	quantity	Unit	Unit Cost	$Ca(OH)_2$ DCC	NaOH DCC
Castor cake	1,000.00	kilogram	1,00	1,000.00	1,000.00
Water[1]	2.00	cubic meter	3,55	7.10	7.10
$Ca(OH)_2$	90.00	kilogram	0,10	9.00	------
NaOH	60.00	kilogram	1,50	------	90.00
Electrical energy[2]	37.40	kilowatt-hour	0,47	17.57	17.57
Cost per tonne	------	------	-------	1,033.67	1,114.67

[1]Drinking water according to the prices passed on to consumers. Source: Companhia de Água e Esgoto do Ceará (Cagece). [2]Considering the capacity of 50 kg per beat in the mixer (20 beats $tonne^{-1}$), with each beat having a duration of 75 minutes. Source: Agência Nacional de Energia Elétrica (Aneel).

Results and Discussion

The results showed that in the scenarios assessed by this study, the feeding, labor, and opportunity costs were the items that most contributed to the costs of production (Table 6). The costs associated with power were higher in systems that used the diets based on SM. These costs were approximately 58.70% higher for the Saanen goats and 66.22% higher for the Anglo-Nubian goats. In monetary terms, the Saanen goats had a higher costs of supply value (R$ 37,191.04 year^{-1}), which corresponded to R$ 516.54 per goat per year. However, rearing Anglo-Nubian goats on the SM diet had a lower opportunity cost (R$ 4,122.70). Therefore, the costs of supply, in percentage terms, were higher than for the Saanen goats who consumed this diet. The annual cost associated with producing milk arrays reported in this study confirmed the results reported by several other studies (Dal Monte et al., 2010; Barros et al., 2015; Pinto, Costa, & Nobrega, 2014; Stivari et al., 2014). They reported that the costs of supply generally have the greatest impact on the total ruminant production cost. The production costs were generally higher for the systems based on the SM diet, regardless of breed. The analysis showed that using DCC reduced feed costs. However, the DCC diet could also lead to a reduction in animal performance (Table 2).

The Saanen goats fed with castor cake had the lowest proportional costs due to food. These were 52.53 and 52.78% for those that consumed the $Ca(OH)_2$ DCC and NaOH DCC, respectively. Therefore, the daily costs associated with each Saanen goat that consumed these diets were R$ 0.62 and R$ 0.53, respectively.

The second factor that contributed most to the system costs was the opportunity costs where, in percentage terms, the Anglo-Nubian animals fed with $Ca(OH)_2$ DCC had a higher opportunity cost (21.48%). In contrast, the Anglo-Nubian goats fed with SM had the lowest opportunity cost (7.50%). It should be emphasized that the opportunity cost should not be understood as an actual disbursement by the producers of goats and cows, but is actually implied income. This means that all the production factors (land, labor, and capital) are accounted for, which improves the economic analysis of each production system. When all these components are included, even if the profit is zero, there is still no reason for the producer to abandon the activity because the production factors are still producing a benefit (Stivari et al., 2014). Therefore, all the systems evaluated during this study showed a profit, which makes the production of Saanen and/or Anglo-Nubian arrays viable because the producer is benefitting from all the production factors.

Table 6
Costs for the production of 144 dairy goats kids during the first year fed with standard diet formulated the basis of bran and soy diets containing detoxified castor with different alkaline solutions

Iten	Saanen			Anglo Nubian		
	Soybean meal	$Ca(OH)_2$ DCC	NaOH DCC	Soybean meal	$Ca(OH)_2$ DCC	NaOH DCC
Alimentation	37,191.04 (58.70%)	29,201.99 (52.53%)	29,543.52 (52.78%)	36,404.13 (66.22%)	34,730.88 (56.73%)	32,579.22 (55.24%)
Sanity	504.00 (0.80%)	504.00 (0.91%)	504.00 (0.90%)	504.00 (0.92%)	504.00 (0.82%)	504.00 (0.85%)
Labor	11,448.00 (18.07%)	11,448.00 (20.59%)	11,448.00 (20.45%)	11,448.00 (20.82%)	11,448.00 (18.70%)	11,448.00 (19.41%)
Other Costs [1]	106.00 (0.17%)	106.00 (0.19%)	106.00 (0.19%)	106.00 (0.19%)	106.00 (0.17%)	106.00 (0.18%)
Support	582.15 (0.92%)	582.15 (1.05%)	582.15 (1.04%)	582.15 (1.06%)	582.15 (0.95%)	582.15 (0.99%)
Depreciation	1,806.35 (2.85%)	1,806.35 (3.25%)	1,806.35 (3.23%)	1,806.35 (3.29%)	1,806.35 (2.95%)	1,806.35 (3.06%)
Opportunity Costs	11,720.31 (18.50%)	11,942.21 (21.48%)	11,988.80 (21.42%)	4,122.70 (7.50%)	12,045.41 (19.67%)	11,952.64 (20.27%)

[1]Tax on Rural Land Ownership and Incra.

In general, the costs associated with animal production were below 1% of all capital required for goat production. The maintenance of the installations and the improvement costs associated with all the systems were also low and ranged from 0.95 to 1.06%. Finally, the land costs required the least amount of capital. The labor cost results showed that although the remuneration was equal for all systems, the percentage associated with this factor was greater in the system that used $Ca(OH)_2$ DCC to produce Saanen goats (20.59%). In contrast, the production of Anglo-Nubian goats using the same type of feed had smaller percentage labor costs (18.70%).

The production system where Saanen goats were fed with SM had the second highest feed costs. The average cost of 1 kg of diet was R$ 1.28 (Table 7). The components of the ration, the tifton hay and corn, contributed most to the price of the diet needed to feed 144 goats over a year at 37.91 and 38.01%, respectively. When Anglo-Nubian and Saanen goats were fed with SM, the quantity of feed needed for 144 goats was 28,422.72 kg $year^{-1}$ (Table 8). The hay and corn costs contributed most to the price of an annual ration. However, there was a slight reduction in the cost percentage for Anglo-Nubian goats compared to Saanen goats when they consumed the same diet. The increase for Saanen goats was due to the limestone costs, which were slightly higher.

The cost of the diet containing $Ca(OH)_2$ DCC was R$ 1.23 kg^{-1} (Table 8), which was 5 cents cheaper than the standard diet based on SM. Over a year, the goats needed 23,715.36 kg of feed and the ingredient that cost the most was maize (R$ 12,119,61 $year^{-1}$). Furthermore, the soya oil in the standard diet made a greater contribution to costs (12.96%) than the protein ingredient (9.00%).

Table 7
Average annual cost of the diet according to the total quantity supplied (dry matter) for 144 Saanen dairy goats kids and Anglo Nubian fed with diet formulated the basis of soybean meal

Ingredients	Annual quantity (kg)	Cost per kilogram (R$)	Annual Cost (R$)	Cost per animal (R$)	(%)
			Saanen		
Hay	12,367.78	1.14	14,099.26	97.91	37.91
Ground corn	13,337.39	1.06	14,137.63	98.18	38.01
Soybean meal	1,672.96	2.12	3,546.67	24.63	9.54
Soya oil	1,302.48	4.00	5,209.92	36.18	14.01
Limestone	263.39	0.75	197.54	1.37	0.53
Total	28,944.00	1.28	37,191.04	258.27	100
			Anglo Nubian		
Hay	12,054.24	1.14	13,741.83	95.43	37.75
Ground corn	12,998.88	1.06	13,778.81	95.69	37.85
soybean meal	1,630.08	2.12	3,455.76	24.00	9.49
Soya oil	1,268.64	4.00	5,074.56	35.24	13.94
Limestone	470.88	0.75	353.16	2.45	0.97
Total	28,422.72	1.28	36,404.14	252.81	100

Table 8
Average annual cost of the diet according to the total quantity supplied (dry matter) for 144 Saanen dairy goats kids and Anglo Nubian fed diets formulated the basis of detoxified castor by calcium hydroxide

Ingredients	Annual quantity (kg)	Cost per kilogram (R$)	Annual Cost (R$)	Cost per animal (R$)	(%)
			Saanen		
Hay	9,360.00	1.14	10,670.40	74.10	36.54
Ground corn	11,433.60	1.06	12,119.61	84.16	41.50
$Ca(OH)_2$ DCC	1,975.68	1.13	2,627.65	18.25	9.00
Soya oil	946.08	4.00	3,784.32	26.28	12.96
Total	23,715.36	1.23	29,201.99	202.79	100
			Anglo Nubian		
Hay	11,139.84	1.14	12,699.41	88.19	36.57
Ground corn	13,593.60	1.06	14,409.21	100.06	41.49
$Ca(OH)_2$ DCC	2,348.64	1.13	3,123.69	21.69	8.99
Soya oil	1,124.64	4.00	4,498.56	31.24	12.95
Total	28,206.72	1.23	34,730.88	241.19	100

In the Anglo-Nubian goats fed with NaOH DCC system, the roughage accounted for 33.86% of the annual costs. However, in absolute terms, the overall costs were lower in the system where Anglo-Nubian goats were fed with NaOH DCC (Table 9). A kilo of diet formulated with NaOH DCC cost R$ 1.22.

When the production of 144 dairy goats was simulated, the results showed that revenue was

higher than the cost of production, resulting in positive economic indicators for all of the scenarios assessed (Table 10). The revenues generated by the systems that utilized the Saanen goats were larger because the product generated had a higher market value, i.e., the Saanen goats have a higher market price. In contrast, the Anglo-Nubian goats had a lower market value (R$ 1,850.00), which meant that they generated lower revenues. Furthermore, their production costs were very similar to the Saanen goats, although the Anglo-Nubian goats that were fed $(OH)_2$ DCC had slightly higher costs than the Saanen goats fed on the same diet. These increases meant that the Anglo-Nubian systems produced lower revenues (R$ 121,675.99).

Table 9
Average annual cost of the diet according to the total quantity supplied (dry matter) for 144 Saanen dairy goats' kids and Anglo Nubian fed diets formulated the basis of detoxified castor by sodium hydroxide

Ingredients	Annual quantity (kg)	Cost per kilogram (R$)	Annual Cost (R$)	Cost per animal (R$)	(%)
			Saanen		
Hay	9,144.00	1.14	10,424.16	72.39	35.28
Ground corn	11,433.60	1.06	12,119.61	84.16	41.02
NaOH DCC	2,098.08	1.22	2,979.27	20.69	10.08
Soya oil	1,005.12	4.00	4,020.48	27.92	13.61
Total	23,680.80	1.22	29,543.52	205.16	100
			Anglo Nubian		
Hay	9,675.36	1.14	11.029.91	76.60	33.86
Ground corn	13,392.00	1.06	14.195.52	98.58	43.57
NaOH DCC	2,217.60	1.22	3.148.99	21.87	9.67
Soya oil	1,051.20	4.00	4.204.80	29.20	12.91
Total	26.336.16	1.22	32.579.22	226.24	100

Table 10
Economic indicators of production goats' kids fed with diets containing detoxified castor by different alkali in substitution to soybean meal

Diet	TR[1] (R$)	TC[2] (R$)	FI[3](R$)	PL[4]	RRe[5] (%)	TFP[6]
			Saanen			
Soybean meal	288,000.00	124,572.05	163,427.95	62.29	131.19	2.31
$Ca(OH)_2$ DCC	288,000.00	128,504.77	159,495.23	64.25	124.12	2.24
NaOH DCC	288,000.00	129,323.90	158,676.10	64.66	122.7	2.23
			Anglo Nubian			
Soybean meal	266,400.00	124,205.73	142,194.27	67.14	114.48	2.14
$Ca(OH)_2$ DCC	266,400.00	130,324.01	121,675.99	74.47	93.36	1.93
NaOH DCC	266,400.00	128,685.18	137,714.82	69.56	107.02	2.07

[1]TR: total revenue = Revenue with the sale of milk, revenue from the sale of weaned goats for slaughter and revenue from the sale of young goats weaned for reproduction; [2]TC: total costs; [3]FI: family income; [4]PL: Point leveling; [5]RRe: rate of return the entrepreneur; [6]TFP: total factor productivity.

The point of leveling (PL) results for the systems showed that all scenarios had PL values that were less than 144 goats, i.e., the number of animals that can be produced annually by each type of system. The Saanen goats fed with SM had a lower PL (62.29 goats). In contrast, the system using a diet based on $Ca(OH)_2$ DCC and Anglo-Nubian goats required a greater quantity of animals to produce sales values that were higher than the total costs (74.47 goats). These data are important because goats tend to be reared by small producers.

The selling price of the matrices produced was the item that most influenced the economic analysis of the six systems that were evaluated. The acquisition of kids can be considered, regardless of breed or diet, to be a highly viable investment. However, for selling price to have a high economic impact on the profitability of the systems, it must be assumed that the production of goats depends on the behavior of the local economy. Therefore, unfavorable changes in the price of goats for reproduction can cause significant losses to goat producers. Furthermore, the market for goats that will be used for reproduction is still not well established compared to dairy cattle. Even so, the family income for all systems was greater than zero, which indicated that the activity could potentially expand (Rogério et al., 2013). However, even if the family income was equal to zero, the results suggested that competition would tend toward equilibrium over the longer term and that producers of matrices goats would be able to pay all costs, i.e., be able to fund all costs associated with production.

Family income is a good economic indicator because it helps explain, in large part, the resistance of family farmers to change. They continue productive activity even when the income from the activity is less than zero. This often occurs because there was still an overall positive family income. Another interesting indicator was total factor productivity (TFP). Basically, all the systems had TFPs greater than 2, with the exception of the Anglo-Nubian goats fed with $Ca(OH)_2$ DCC. This indicated that returns of more than R$ 2.00 in gross income were achieved for every R$ 1.00 invested in the activity.

The financial analysis of the diets showed that the systems were viable over 10 years when the interest rate was 6% per year (Table 11). Both the NPV and the NPVa values were positive for a small herd of goats. The systems that used the diet based on SM had higher NPVs (R$ 987,398.04 and R$ 1,200,251.00 for the Saanen goats and Anglo-Nubian, respectively).

Table 11
Financial analysis of production of dairy goats' kids fed diets containing detoxified castor by different alkali in substitution to soybean meal

Diets	NPV[1]	PB[3]	IRR[4]	IRRm[5]	PI[6]	RP[7]
	Saanen					
Soybean meal	1,208,251.00	0.56	189.09	38.41	14.40	1,340.37
$Ca(OH)_2$ DCC	1,181,031.04	0.57	184.99	38.11	14.10	1,310.17
NaOH DCC	1,175,315.64	0.58	184.13	38.05	14.04	1,303.83
	Anglo Nubian					
Soybean meal	987,398.04	0.68	155.80	35.85	11.95	1,095.37
$Ca(OH)_2$ DCC	904,998.04	0.71	149.10	35.27	11.46	1,045.72
NaOH DCC	937,994.99	0.98	120.21	22.17	9.84	1,083.85

[1]NPV: Net Present Value; [2]PB: Payback; [3]IRR internal rate of return; [4]IRRm: modified internal rate of return (%); [5]PI: Profitability Index; [6]RP: Rate of profitability.

Generally, the systems used to rear the Anglo-Nubian goats had lower NPV values (R$ 943,463.69) than the Saanen goat (R$ 1,188.199.23) systems. Furthermore, all the diets had low times of return on investment with values of less than one year. Payback is the period of time necessary for the recovery of an investment. In other words, it is the time required for negative cash flows (Investment) to be canceled out by positive cash flows (profits). Therefore, in all the systems evaluated, the sale of matrices made a return on the investment applied in the first year.

The marketing of dairy goats can be singled out as one of the main bottlenecks in the systems. Despite the fact that this market is still developing, the trend is favorable, because the creation of dairy goats shows a positive growth trend, particularly in the northeast region of Brazil (Lôbo et al., 2017). Another limitation is the determination of risk. Apart from the economic risk, there is the risk due to climatic conditions because even if the animals are confined, the ability to acquire the foods that make up the diets of these goats may significantly change, which can compromise the production of arrays. The results showed that the feeding costs significantly affected the production costs (Table 6).

A sensitivity analysis of the Saanen goats fed with SM production system showed that the economic performance indicators were economically viable despite the larger variations in the costs associated with goat production and the quantity produced (Table 12). In a simulation of the most unfavorable system in this study, the NPV was R$ 127,201.41 with a payback of 4.48 years, a positive internal rate of return of 25.78%, a profitability index of 2.41 and a rate of return of 141.11%, which was still a very attractive proposition. The performance indices were even more positive, with a payback of 0.26 years and PI of 30.63% when an environment with a recovery rate of 30% of the matrices and a 30% increase in productivity was analyzed,

Table 12
Sensitivity analysis of production of Saanen and Anglo Nubian goats' kids fed with diets based on soybean

Combination		Saanen goats					
Price	Quantity	NPV[1]	PB[2]	IRR[3]	IRRm[4]	PI[5]	TR[6] (%)
30%	30%	2,670,847.50	0.26	409.54	49.25	30.63	2,962.90
20%	20%	2,140,921.23	0.32	329.67	46.1	24.75	2,375.03
10%	10%	1,653,389.06	0.41	256.19	42.55	19.34	1,834.18
-10%	-10%	805,507.04	0.83	128.39	33.36	9.94	893.59
-20%	-20%	445,157.17	1.46	74.04	26.67	5.94	493.83
-30%	-30%	127,201.41	4.48	25.78	15.75	2.41	141.11
		Anglo Nubian goats					
30%	30%	2,340,299.81	0.29	359.72	47.36	26.96	2,596.21
20%	20%	1,850,118.01	0.37	285.84	44.08	21.52	2,052.43
10%	10%	1,399,150.75	0.49	217.87	40.32	16.52	1,552.15
-10%	-10%	614,859.88	1.07	99.64	30.21	7.82	682.09
-20%	-20%	281,536.26	2.23	49.3	22.13	4.12	312.32
-30%	-30%	-12,572.82	9.30	4.42	4.01	0.86	-13.95

[1]NPV: Net Present Value; [2]PB: Payback; [3]IRR internal rate of return; [4]IRRm: modified internal rate of return (%); [5]PI: Profitability Index; [6]RP: Rate of profitability.

The production of Anglo-Nubian goats fed with SM was more variable than the system that used Saanen goats fed on this diet. In a simulation of a more pessimistic scenario, i.e., with production and product price reductions of 30%, then some of the performance indicators were negative, such as the NPV (R$ -12,572.82) and the rate of return (-13.95%). In addition, the payback time was very high (9.30 years). The IRR under the pessimistic scenario was 4.01%, a value that was lower than the rate of attractiveness (6%).

A sensitivity analysis of the Saanen goats fed with $Ca(OH)_2$ DCC production system showed that the use of alternative foods was generally a viable alternative to SM feeds when producing Saanen goats (Table 13). Furthermore, the economic viability indicators were still positive even though there were reductions in the price and quantity of goats produced. The Saanen and Anglo-Nubian goats fed with $Ca(OH)_2$ DCC systems were also shown to be feasible. However, in the worst case scenario, feeding Anglo-Nubian goats with this feed proved to be economically unviable because the NPV was negative (R$ -40,920.35), and the Modified IRR (IRRm) and TR percentages were low (-0.57% and -47.28, respectively), whereas it remained viable when Saanen goats were fed this diet under the worst case scenario.

Table 13
Sensitivity analysis of production of Saanen and Anglo Nubian goats kids fed with diets based on detoxified castor by $Ca(OH)_2$

Z		Saanen goats					
Price	Quantity	NPV[1]	PB[2]	IRR[3]	IRRm[4]	PI[5]	TR[6] (%)
30%	30%	2,643,627.54	0.26	405.44	49.1	30.33	2,932.70
20%	20%	2,113,701.27	0.33	325.57	45.93	24.45	2,344.83
10%	10%	1,626,169.11	0.42	252.08	42.32	19.04	1,803.99
-10%	-10%	778,287.08	0.85	124.28	32.95	9.63	863.39
-20%	-20%	417,937.22	1.55	69.93	26.01	5.64	463.64
-30%	-30%	99,981.46	5.46	21.59	14.21	2.11	110.91
		Anglo Nubian goats					
30%	30%	2,340,299.81	0.29	359.72	47.36	26.96	2,596.21
20%	20%	1,850,118.01	0.37	285.84	44.08	21.52	2,052.43
10%	10%	1,399,150.75	0.49	217.87	40.32	16.52	1,552.15
-10%	-10%	614,859.88	1.07	99.64	30.21	7.82	682.09
-20%	-20%	281,536.26	2.23	49.3	22.13	4.12	312.32
-30%	-30%	-12,572.82	9.30	4.42	4.01	0.86	-13.95

[1]NPV: Net Present Value; [2]PB: Payback; [3]IRR internal rate of return; [4]IRRm: modified internal rate of return (%); [5]PI: Profitability Index; [6]RP: Rate of profitability.

In terms of payback time, the return on investment for the worst-case scenario was much greater than ten years, so the value was zero. The IRR was less than 6%, which is the rate of attractiveness. These values indicated that when the price of the matrices was R$ 1,295.00, the producer had to rear more than 100 goats and the system was economically unfeasible (Hartman & Schafrick, 2004). When the IRR is not a reliable indicator of economic viability for investment, which was the case in this simulation, then the IRRm, which includes all the negative flows, should be used (Rogério et al., 2019). In this study, the IRRm results made the situation worse because the IRRm was negative (-0.57).

A sensitivity analysis of the Saanen goats fed with NaOH DCC system and the Saanen fed with the standard diet showed that even when market price variability increased, the economic performance indicators still showed that the systems were economically viable (Table 14). In a simulation where there was a considerable reduction in the price of goats and a simultaneous 30% fall in production, the NPV was R$ 94,266.05, the payback time was 5.72 years, and there was a positive internal rate of return of 20.71%, a profitability index of 2.05, and a rate of return of 104.57%. The Anglo-Nubian goats fed with NaOH DCC system was more variable that the system where the Saanen goats were fed on the same diet. In general, the performance indicators were not negative, even in the simulation were there were the greatest negative variations in prices and quantities produced. Among the indicators evaluated, the NPV was probably the most important and its value was around R$ 22,391.57.

Table 14
Sensitivity analysis of production of Saanen and Anglo Nubian goats' kids fed with diets based on detoxified castor by NaOH

Combination		Saanen goats					
Price	Quantity	NPV[1]	PB[2]	IRR[3]	IRRm[4]	PI[5]	TR[6] (%)
30%	30%	2,637,912.14	0.26	404.58	49.07	30.26	2,926.36
20%	20%	2,107,985.87	0.33	324.71	45.89	24.38	2,338.49
10%	10%	1,620,453.70	0.42	251.22	42.27	18.98	1,797.65
-10%	-10%	772,571.68	0.86	123.42	32.86	9.57	857.05
-20%	-20%	412,221.81	1.57	69.07	25.87	5.57	457.3
-30%	-30%	94,266.05	5.72	20.71	13.87	2.05	104.57
		Anglo Nubian goats					
30%	30%	2,375,264.19	0.28	379.92	48.15	28.45	2,744.61
20%	20%	1,885,082.40	0.35	302.97	44.90	22.78	2,178.20
10%	10%	1,434,115.14	0.46	232.17	41.18	17.57	1,657.11
-10%	-10%	649,824.27	0.97	109.03	31.31	8.51	750.87
-20%	-20%	316,500.64	1.92	56.62	23.63	4.66	365.71
-30%	-30%	22,391.57	9.52	9.68	8.47	1.26	25.87

[1]NPV: Net Present Value; [2]PB: Payback; [3]IRR internal rate of return; [4]IRRm: modified internal rate of return (%); [5]PI: Profitability Index; [6]RP: Rate of profitability.

Conclusions

A simulation of six production systems showed that 144 dairy goats provided revenues that were above the cost of production, which resulted in positive economic indicators for all the scenarios evaluated. All the scenarios had a leveling point that was less than 144 goats, which is the number of animals that can be produced annually by each type of system. The sensitivity analyzes showed that the indicators of economic performance only became economically unviable under the least favorable conditions, such as a reduction of 30% in both production levels and market prices. The use of DCC feeds does not compromise the economic viability of the systems, but they are not as profitable as the systems that use the standard diet. The use of the DCC diet that lacked the alkaline product used for detoxification or with breeding goats does not compromise the economic viability of the systems, but the systems are not as profitable as the standard diet systems.

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