Economic aspects of the use of castor meal in supplements for grazing heifers

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Abstract

The objective was to evaluate the replacement of castor meal by soybean meal detoxified with calcium hydroxide in supplemented diets for grazing heifers. Forty Holstein × Zebu crossbred heifers with an initial body weight of 257±26 kg were kept on *Brachiaria decumbens* pastures under continuous grazing for 140 days in a randomized complete design with five levels of replacement of soybean meal by castor meal (0, 200, 500, 750, and 1000 g/ kg), each with eight replicates. The area was divided into five paddocks measuring 07 ha each, remaining throughout the experimental period with free access to water and supplement that was provided daily in uncovered plastics troughs, at 11.00 h, at 0.7 kg 100 kg^{-1} body weight, for all supplemented animals. The highest level of castor meal provided an internal rate of return of 2.6% vs. 0.7% obtained without inclusion of castor meal. The use of supplement containing up to 1000 g kg^{-1} of castor meal replacing soybean meal supplied at a rate of 0.7 kg 100 kg^{-1} body weight to heifers on pasture provides better economic indices, making it a recommended strategy.

Key words: by-product, cost of production, protein

1. Introduction

Although Brazil has the second largest commercial herd in the world, inefficient production systems still predominate, both productively and economically. There is a low speed of development and reduced productivity of cattle raised extensively due to the negative influence of seasonality. During the dry season, when forage availability is low, pastures have low quality, low concentration of crude protein (CP), and a highly lignified material, thereby compromising the digestibility and interfering with the performance of animals (Detmann et al., 2014).

A strategy to reduce the beef cattle production cycle in the country is the supplementation of animals during the critical phase of forage production, thus allowing the nutritional adjustment and good performance throughout the year with a linear growth of animals, which culminates in earlier slaughter and yields greater working capital (Cabral et al., 2014).

Among the main sources of supplementation in the formulation of ruminant diets, the soybean meal has stood out for its high-quality nutritional protein. However, the high costs of this ingredient from distant regions of the country and from abroad has fostered the development of research aimed at the discovery of alternative feedstuffs and lower commercial values, as a way to minimize feed costs and make production feasible (Gunn et al., 2010).

Castor meal, a byproduct of biodiesel production derived from the chemical process of solvent extraction, considerable protein content (344 g kg^{-1}), roughly equivalent to that of soybean meal (Diniz et al., 2011). However, to be used as a food source, the castor seed meal must be subjected to a detoxification process to inactivate toxic substances such as ricin and ricinine, which can cause health risks to animals (Oliveira et al., 2010).

The detoxified castor seed meal can be a promising protein source to reduce production costs, since the northeast region is the leading producer of castor seed, holding 90% of the national production, and it can be grown in various regions of the country (Conab, 2011), which can reduce the cost of transportation. The replacement of soybean meal by detoxified castor meal up to 45 % in the feed of lambs did not negatively affect the intake, digestibility, performance, and main carcass features. However, studies on the economic viability of the use of detoxified castor meal replacing soybean meal are recommended (Menezes et al., 2016).

The knowledge of production costs involved in a production system allows an economic analysis of the activity and, through this, it is possible to know in detail the production factors (Lopes e Magalhães, 2005). From the correct calculation of these costs it is possible to plan and control the system operations, analyze the profitability of the activity, determine the sales price, decrease the controllable costs and identify the breakeven point of the production system (Memari Neto, 2009).

In this context, the economic analysis of the replacement of soybean meal by detoxified castor seed meal provides information that can help in making decisions about the choice of ingredients to be used in animal supplementation. Thus, the economic analysis of the replacement of soybean meal by detoxified castor bean meal is fundamental to make feed costs feasible, since the byproducts of castor bean present high nutritional value and are less expensive.

The objective of this study was to evaluate the economic feasibility of levels of replacement of soybean meal by detoxified castor meal on the performance of heifers on pasture.

2. Production Costs

The production cost is an auxiliary element in the administration of any enterprise. For livestock activity, it corresponds to the sum of the values of all fixed and variable costs, as well as the operational costs used in the production process (Lopes and Carvalho, 2002).

Fixed costs are those represented by resources whose values do not change over a production cycle. In meat husbandry, can be cited as an example fixed labor, taxes, fuel, facilities and equipment depreciation. The variable costs vary depending on the volume produced and may change in the short term or have a duration equal to or less than the production cycle. Examples of these are electricity, animal feed, temporary labor. There is also the concept of operational cost that includes the value of consumed inputs, the cost of using machines and implements (Melz, 2013). Among these costs, food is a more significant component, corresponding to 70 to 80% of the amount spent on the activity (Barros et al., 2009).

For economic analysis purposes, the production cost plays an important role as manegement information system for the decision-making of the producer, determining the profitability or not of the production system. Thus, the economic analysis is fundamental for the producer to obtain knowledge about cost accounting, allowing the efficient management of the production factors and, consequently, ensuring profit maximization or minimization of costs.

In the case of production of ruminant in pasture, the production cost is a decisive factor in the elaboration of diets and supplements. Studies evaluating the economic analysis of glycerin, one of the by-products of transesterification of biodiesel, in the supplementation of cattle in pasture, replacing corn showed a positive financial return to levels of 60% (Silva-Marques et al., 2015) and 66% of crude glycerin inclusion (Socreppa, 2015). Strada et al. (2015) found that glycerin decreased the cost of meat production when the price of this ingredient represented up to 70% of the price of corn. However, studies on the economic analysis of castor bean meal are still an unexplored field.

3. Material and Methods

The experiment was conducted in Cruz das Almas, BA, Brazil (12º40'39"S latitude and 39º06'23" W longitude; 225.87 m altitude). Meteorological data were recorded over the entire experimental period (Figure 1).

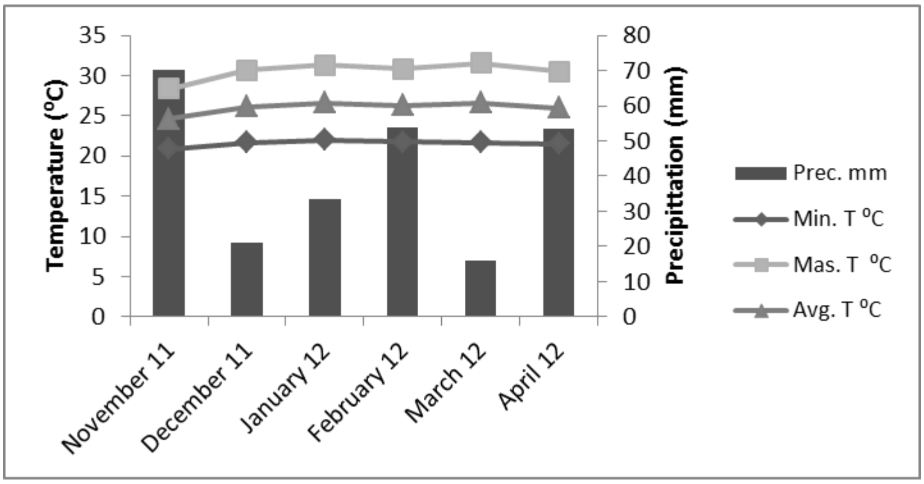

Figure 1: Maximum, minimum, and average temperatures and monthly precipitation recorded during the experimental period.
Fonte: Data obtained from research.

Forty Holstein × Zebu crossbred heifers with an initial body weight of 257±26 kg were distributed in a randomized complete design with five treatments and eight replicates. Diets were formulated to meet the requirements for maintenance and to provide a gain of 1.0 kg d^{-1} according to NRC (2000) (Table 1).

Table 1: Chemical composition of the pasture and experimental supplements

Item (g/ kg)	Pasture	Castor meal replacing soybean meal (g/ kg)				
		0	200	500	750	1000
Dry matter	602.0	881.0	878.0	878.0	881.0	883.0
Organic matter	921.0	961.0	954.0	953.0	947.0	937.0
Crude protein	150.0	228.0	238.0	218.0	217.0	218.0
Ether extract	34.0	58.0	48.0	49.0	30.0	40.0
NDFap	620.0	295.0	301.0	289.0	299.0	339.0
Non-fiber carbohydrates	116.0	329.0	284.0	330.0	288.0	300.0
Total carbohydrates	739.0	626.0	588.0	622.0	618.0	634.0
iNDF	174.0	41.0	63.0	86.0	109.0	149.0
TDN	-	706.0	678.0	662.0	675.0	660.0

NDFap - neutral detergent fiber corrected for ash and protein; iNDF - indigestible neutral detergent fiber; TDN - total digestible nutrients.

Treatments were five levels supplementation (0, 200, 500, 750, and 1000 g kg^{-1}) formulated with detoxified castor seed meal replacing soybean meal (Table 2).

Table 2: Centesimal composition of ingredients of experimental supplements

Item (g/ kg)	Castor meal replacing soybean meal (g/kg)				
	0	200	500	750	1000
Urea	15.0	15.0	15.0	15.0	15.0
Ground corn	712.0	672.0	720.0	707.0	693.0
Soybean meal	258.4	238.8	125.0	66.0	0.0
Castor meal	0.0	60.0	125.0	197.0	277.0
Mineral salt[†]	12.0	12.0	12.0	12.0	12.0
Dicalcium phosphate	3.0	3.0	3.0	3.0	3.0
Total	1000.0	1000.0	1000.0	1000.0	1000.0

[†]Contains per 100 g: sodium chloride (NaCl) - 47.15g; dicalcium phosphate - 50 g; zinc sulfate - 1.5 g; copper sulfate - 0.75 g; cobalt sulfate - 0.05 g; potassium iodate - 0.05 g; magnesium sulfate - 0.5 g.

The total duration of the experiment was 140 days, including the first 14 days as an adaptation phase and the 126-day trial period.

The castor seed meal underwent a detoxification process with a Ca $(OH)_2$ solution, formulated with 1 kg of Ca $(OH)_2$ to 10 L water and used in a proportion of 60 g Ca $(OH)_2$ kg^{-1} meal (fresh matter basis), as recommended by Anandan et al. (2005).

Heifers were weighed at the beginning and end of the experiment (Table 3) and every 21 days for adjustment of feed supply. Before each weighing, they were fasted for 12 h to determine the average daily weight gain. Animals were identified, dewormed, and moved to a 35-ha area formed by *Brachiaria decumbens*, under continuous grazing. The area was divided into five paddocks measuring 07 ha each, remaining throughout the experimental period with free access to water and supplement that was provided daily in uncovered plastics troughs, at 11.00 h, at 0.7 kg 100 kg^{-1} body weight, for all supplemented animals.

Table 3: Performance and intake of heifers on pasture receiving supplement containing castor seed meal replacing soybean meal

Animal performance	Castor meal replacing soybean meal (g/kg)				
	0	**200**	**500**	**750**	**1000**
Initial body weight (kg)	262.3	259.5	257.6	255.2	252.6
Average daily gain (g)	932.5	974.9	917.9	857.1	963.5
Final body weight (kg)	379.8	382.3	373.0	363.1	374.0
Carcass dressing (kg/100 kg)	49.7	48.8	47.7	49.7	49.1
Intake					
Pasture dry matter (kg/d)	5.13	4.97	4.82	4.80	4.22
Supplement dry matter (kg/d)	2.27	2.00	2.09	2.16	1.98
Total dry matter (kg/d)	7.40	6.97	6.89	6.96	6.20

To reduce the influence of variation in biomass between paddocks, heifers were kept in each paddock for seven days and then transferred to another in a predefined order at random. The pasture was evaluated at 14, 77, and 140 days of experiment, to estimate the dry matter (DM) availability. Twelve samples were taken per paddock, cut close to the ground with a 0.25 m^2square, according to methodology described by McMeniman (1997).

The average DM production per hectare was 3897.50 kg and the leaf:stem ratio was 0.82, providing an average forage dry matter allowance in relation to body weight of 115 g/kg/d. Dry matter intake and fecal output were estimated using one internal (indigestible neutral detergent fiber) and two external (purified and enriched lignin [LIPE®] and titanium dioxide) markers and two periods of feces collection: at 42 and 84 days of experiment.

Fecal dry matter excretion was estimated using an external marker, in capsule form, containing 500 mg of LIPE®, which was provided daily to the animals for seven days. The first two days of each collection period were used for adaptation and the remaining five days for feces collection (Saliba et al., 2000). Digestibility and dry matter intake were estimated from the fecal output.

During the collection period, animals were driven to a containment corral where the fecal samples were collected directly from the rectum of each animal carefully so as not to contaminate the feces, for five days. Feces were placed in labeled plastic bags and pre-frozen at −10 C. For pre-drying, samples were thawed, weighed, and dried in a forced-air oven at 55 °C for 72 h.

Feces samples were processed in a Wiley mill with a 1-mm mesh sieve. Fecal production was determined using LIPE® and an infrared spectrometer.

To estimate the dry matter intake from the supplement (Table 3), titanium dioxide was used (TiO_2) as a marker, provided in the amount of 10 g per animal, mixed with the supplement daily, for eight days. This period of determination of supplement intake (eight days) was divided into three days for adaptation and five days for collection, according to the procedure described by Titgemeyer et al. (2001).

Dry matter intake from the supplement (DMIS) was calculated as follows:

$$DMIS = (FE \times TiO_2feces)/TiO_2supplement,$$

in which FE = fecal excretion; and TiO_2fecesand TiO_2supplement = concentrations of titanium dioxide in the feces and in the supplement, respectively.

The economic viability analysis was performed after collection of productive performance data, especially supplement intake and average daily weight gain relative to the five treatments. Economic performance indicators were calculated according to Silva et al. (2010); labor, in R$/@; drugs, in R$/@; maintenance of fences, in R$/@; maintenance of pastures, in R$/@; taxes, in R$/@ and monthly average price of *arroba* of cattle marketed in the state of Bahia between the years 2011 and 2013, were calculated according Anualpec (2013).

For the economic analysis, the internal rate of return (IRR) and the net present value (NPV) indicators were used. Economic and financial analyses of production costs of castor meal replacing soybean meal were conducted from the descriptive statistics on Excel® software spreadsheets.

4. Results and Discussion

Regardless of the diet adopted, animals had an average daily weight gain of 0.94 kg day^{-1}. This average daily weight gain was higher than the 0.65 kg day^{-1} found by Lima II (2015) with bulls receiving supplementation with castor seed meal in the proportion of 40 g kg^{-1} body weight.

The average supply in relation to the body weight of 115 g kg^{-1} day^{-1} of forage and high levels of dietary supplement reflected in large individual meat production (Table 4), indicating the weight gain efficiency of the animals. All variables related to stocking rate and production of meat in kilograms or *arroba* in the area used was similar between the groups receiving supplements with different levels of castor seed meal (Table 4). This is because we used the same number of animals in a homogeneous area with the same size for all the groups, which obtained similar weight gains (Table 4).

Table 4: Productivity and quantitative indicators used for the structuring of the models that characterize the tested supplements

Item	Castor meal replacing soybean meal (g/ kg)				
	0	200	500	750	1000
Initial body weight (kg)	262.3	259.5	257.6	255.0	257.8
Final body weight (kg)	379.8	382.3	373.0	363.0	386.3
Average weight for the period (kg)	321.1	320.9	315.3	309.0	322.0
Average weight (AU/head)	0.7	0.7	0.7	0.7	0.7
Pasture area (ha)	7.0	7.0	7.0	7.0	7.0
Stocking rate (AU/ha)	0.7	0.7	0.7	0.7	0.7
Number of animals	7.0	7.0	7.0	7.0	7.0
Average daily gain (g)	930.0	970.0	920.0	860.0	1000.2
Production (kg/ha)	117.5	122.8	115.4	108.0	128.5
Carcass yield (kg/100 kg)	49.7	48.8	47.7	49.7	48.8
Meat production (kg/ha)	58.4	59.9	55.1	53.6	62.7
Meat production (@/ha)	3.9	4.0	3.7	3.6	4.2
Days of the experiment	126.0	126.0	126.0	126.0	126.0

@ - arroba = 14.7 kg.

As expected, the cost of supplement represented the largest share in the production costs, representing 77% of the average total cost. The replacement of soybean meal by castor seed meal provided an estimated reduction in total cost from R$84.69 to R$60.70 per hectare (Table 5). Supplementation with 1000 g kg^{-1} of castor seed meal provided a reduction of 20.35% compared with the level 0 g kg^{-1} of castor seed meal. This result was similar to that found by Lima II (2015), who obtained a reduction of 22.62% in the cost using the highest level of substitution, of 900 g kg^{-1}, compared with the level 0 g kg^{-1} of castor seed meal.

Table 5: Operating costs used to calculate the composition of the total production costs of the tested supplements

Item	Castor meal replacing soybean meal (g /kg)				
	0	200	500	750	1000
Meat production (@/ha)	3.9	4.0	3.7	3.6	4.2
Supplement intake (kg/animal day)	2.3	2.0	2.1	2.2	2.0
Supplement intake (kg/ha)	286.0	252.0	263.3	272.2	249.5
Estimated price of supplement (cents/kg)	92.4	90.1	83.1	78.6	73.6
Cost of supplement (R$/ha period)	264.3	227.1	219.0	214.0	183.7
Cost of supplement (R$/@)	67.9	56.9	59.6	59.9	43.9
Hand labor (R$/@)	6.2	6.2	6.2	6.2	6.2
Medications (R$/@)	2.1	2.1	2.1	2.1	2.1
Fences maintenance (R$/@)	2.3	2.3	2.3	2.3	2.3
Pasture maintenance (R$/@)	5.6	5.6	5.6	5.6	5.6
Taxes (R$/@)	0.6	0.6	0.6	0.6	0.6
Total cost (R$/@)	84.7	73.7	76.4	76.6	60.7

@ - arroba = 14.7 kg.

The results observed in the evaluation of the balance (gross income minus total costs) demonstrate the importance of research involving the use of supplements with alternative ingredients to increase the profitability of the system. This study revealed that the replacement of soybean meal by castor seed meal reduced the production cost, providing expected weight gains. It is also noted that the total replacement for soybean meal by castor seed meal (1000 g kg^{-1}) yielded more favorable economic results, including a balance of R$103.34 per hectare (Table 6).

Table 6: Gross income, total operating expenses, and balance of the activity with the tested supplements

Item	**Castor meal replacing soybean meal (g/ kg)**				
	0	**200**	**500**	**750**	**1000**
Meat production (@/ha)	3.9	4.0	3.7	3.6	4.2
Average heifer price (R$/@)	95.0	95.0	95.0	95.0	95.0
Gross income (R$/ha)	369.7	379.2	348.8	339.7	397.3
Gross income (R$/animal)	369.7	379.2	348.8	339.7	397.3
Gross income (R$ total)	2587.9	2654.7	2441.9	2378.2	2781.2
Total cost (R$/@)	84.7	73.7	76.4	76.6	60.7
Total cost (R$/ha)	329.6	294.0	280.5	274.0	253.9
Balance (R$/ha)	40.1	85.2	68.3	65.8	143.5

@ - arroba = 14.7 kg.

The contrasting results between revenue and expenditure show that both the operating profit and the profitability ratio improved with the inclusion of castor meal in the supplement, since the meal cost is directly related to these variables, increasing the efficiency of use of castor meal replacing soybean meal (Table 7).

Table 7: Rates of return obtained with the activity considering all costs, invested capital, and profits obtained with the tested supplements

Item	**Castor meal replacing soybean meal (g/ kg)**				
	0	**200**	**500**	**750**	**1000**
Heifer acquisition price (R$/@)	95.0	95.0	95.0	95.0	95.0
Purchase of heifers (R$/ha/ period)	830.7	821.8	815.7	807.5	816.2
Production operating costs (R$ /ha)	329.6	294.0	280.5	274.0	253.9
Invested capital (R$/ha)	1160.3	1115.8	1096.3	1081.5	1070.1
Net income from the activity (R$/ha)	40.1	85.2	68.3	65.8	143.5
Operating income (R$/ha)	105.4	152.2	129.9	125.7	213.6
Profitability index (%)	28.5	40.1	37.2	37.0	53.8

@ - arroba = 14.7 kg.

In analyzing the net revenue, considering all operating costs and invested capital (Table 7), a higher rate of return was obtained for the use of castor seed meal, especially for the replacement level of 1000 g kg^{-1}, in which case the response of animals and economic performance was the most profitable. These results corroborate Silva et al. (2010), who pointed out that the nutritional requirements must be met consistently with the economic aspect, to ensure the development of self-sustainable production systems.

The net present value and IRR of the activity are used as criteria for evaluation for production systems, and the development of production system becomes more attractive as their value increases (Table 8). Thus, addition of castor meal in the diet increased those rates, making it more economically interesting for the producer. These data showed similar behavior in IRR and NPV to those found by Almeida et al. (2014), who worked with glycerin levels in supplements replacing soybean meal, emphasizing the positive impact of the use of alternative foods lowering the production cost.

Table 8: Monthly internal rate of return (IRR) and net present value (NPV) for return rates of 4, 8, and 12%, respectively, for one year

Item	Castor meal replacing soybean meal (g/ kg)				
	0	200	500	750	1000
IIR %	0.7	1.5	1.2	1.5	2.6
NPV, 4%	20.7	65.8	49.4	47.2	123. 8
NPV, 8%	2.2	47.3	31. 6	29.6	105.2
NPV, 16%	−15.3	29.8	14.6	12.8	87.5

The results presented in this paper provide relevant information about the economics of pasture supplementation using castor meal replacing soybean meal to be considered in projections of cost and profitability preceding livestock planning, especially in decision-making strategies for nutritional management during the dry period of the year. However, it should be stressed that the break-even point is the one in which the cost of inputs employed in the formulation of the supplement used in the plan of nutritional management for the herd is equal to the additional performance gain (kg body weight) provided by the plan (Figueiredo et al., 2007).

5. Conclusions

The use of castor seed meal treated with calcium hydroxide as a substitute for soybean meal in the supplement provided at the rate of 0.7 kg 100 kg^{-1} of body weight to heifers on pasture is a strategy that increases the internal rate of return and net present value and can thus be recommended.

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