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ECONOMIC ANALYSIS OF THE USE OF WET BREWERY RESIDUE IN SHEEP DIETS

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Abstract

The objective of this study was to evaluate the production costs involved in sheep confinement fed diets containing different inclusion levels of wet brewery residue (WBR). The diets were constituted by different WBR proportions in the concentrate (0, 10, 20 and 30%). A total of 20 sheep were used, with an average body weight of 17.5 ± 1.5 kg, at 8 months of age. The experimental period lasted 77 days. The prices of feed ingredients, purchase and sale values of kg of body weight (BW) of the animals practiced in the local market and the interest rate were considered in the economic analysis, using the year 2015 as a reference. In addition, production performance, zootechnical and economic data, and investment and costing expenses were considered to determine the economic indicators. A linear response was observed in terms of average daily gain (P=0.0035) and feed efficiency (P=0.0042) in diets consisting of 20 and 30% WBR, with 0.196 kg of BW/day and 0.291 kg of BW/intake, respectively. The diet containing 20% WBR resulted in greater total production (7,503.07 kg of BW/year), greater daily production (9.78 kg of BW), and lower total expenditure on investments (R$ 0.371/kg of BW). The lowest total expenses (R$ 64,368.99) and the highest profit (R$ 1.32/kg of BW) were observed in the diet with 30% of WBR. The economic analysis showed the financial feasibility of including 20% and 30% WBR in diets for confined sheep.

Key words

Alternative feeds, Barley, Production costs, Small ruminants.

ANÁLISE ECONÔMICA DO USO DE RESÍDUO ÚMIDO DE CERVEJA EM DIETAS DE OVINOS

Resumo

O objetivo deste estudo foi avaliar os custos de produção envolvidos no confinamento de ovinos alimentados com dietas contendo diferentes níveis de inclusão de resíduo úmido de cervejaria (RUC). As dietas foram constituídas por diferentes proporções de RUC no concentrado (0, 10, 20 e 30%). Foram utilizados 20 ovinos, com peso corporal médio de 17,5 ± 1,5 kg, aos 8 meses de idade. O período experimental durou 77 dias. Os preços dos ingredientes da ração, valores de compra e venda em kg de peso corporal (PV) dos animais praticados no mercado local e a taxa de juros foram considerados na análise econômica, tendo como referência o ano de 2015. Além disso, o desempenho da produção, os dados zootécnicos e econômicos e as despesas de investimento e custeio foram considerados para determinar os indicadores econômicos. Uma resposta linear foi observada em termos de ganho médio diário (P = 0,0035) e eficiência alimentar (P = 0,0042) em dietas consistindo de 20 e 30% RUC, com 0,196 kg de PV / dia e 0,291 kg de PV / ingestão, respectivamente. A dieta contendo 20% de RUC resultou em maior produção total (7.503,07 kg de PV / ano), maior produção diária (9,78 kg de PV) e menor gasto total com investimentos (R$0,371 / kg de PV). Os menores gastos totais (R $ 64.368,99) e o maior lucro (R$1,32 / kg de PV) foram observados na dieta com 30% de RUC. A análise econômica mostrou a viabilidade financeira da inclusão de 20% e 30% de RUC em dietas para ovinos confinados.

Palavras-chave

Alimentos alternativos, Cevada, Custos de produção, Pequenos ruminantes.

INTRODUCTION

Nutrition is one of the bases of animal production systems, as it is directly correlated with the quantity and quality of nutrients that are ingested by animals, which makes feed management the costliest component of animal production. In addition, the seasonality in forage production throughout the year leads producers to seek new alternatives to feed the herd in order to not compromise the productive performance.

The search for alternative feeds from local agro-industries residues enables reducing animal production costs due to greater availability and lower cost when compared to traditional feeds. However, some of these residues may have limited use due to anti-nutritional effects, therefore the nutritional properties included in the ruminants' diet must be known.

In this context, oilseed pies (POMPEU et al., 2012) and residues from the extraction of fruit juices (LEITE et al., 2014) have been studied in order to assess their contribution to ruminant production. In addition to these, there is also wet brewery residue which has high nutritional quality, and allows its partial or total use in the diet formulation for these animals.

Due to the increase in sheep farming in the Brazil, it is essential that studies be carried out in order to assess genetics, nutrition, health and financial viability, so that techniques are designed for the maximum use of the productive potential of animals and feed in order to minimize production costs, advocating the sustainability of the property and making the sheep farming more competitive. Therefore, knowledge of production costs represents an indispensable condition for producers for assertive management to be adopted.

In view of the above, the objective of this study was to evaluate the production costs and determine the economic indicators for using different proportions of wet brewery residue in the diets of sheep in a confinement system.

MATERIAL AND METHODS

The study was approved by the Animal Ethics and Experimentation Commission (*AEEC/CMV/UEMA*) under the number 21/2011. The experiment was carried out at the Sheep and Goats Culture Sector of the Federal Institute of Education, Science and Technology of Maranhão, Campus São Luís, Maracanã, located at 35 meters of altitude, south latitude of 2º 37' 01" and west longitude of 44º 16' 19". It presents a hot and semi-humid tropical climate, with a rainy season from January to June and an average rainfall of 1800 mm year^{-1}.

The confinement was conducted in a masonry shed hollowed out on its sides, with a roof provided with lanterns and covered with asbestos tiles. The experimental animals were allocated in individual stalls of 1.50 x 1.70 m with a concrete floor covered with sawmill residue (wood shavings), and with a 5% slope.

The diets were formulated with different inclusion levels (0, 10, 20 and 30%) of wet brewery residue (WBR). The experimental design was completely randomized, with four treatments and five replications. A total of 20 lambs undefined breed sheep (10 male castrated lambs and 10 male non-castrated lambs) with an average body weight (BW) of 17.5 ± 1.51 kg were used in the experiment. All animals were dewormed with Closantel sodium (Diantel) at a dose of 1 mL for every 10 kg of BW.

Water and mineral mixture were provided *ad libitum* to the animals. The diets were calculated based on natural matter (NM), composed of roughage feed (Tifton-85 hay) and concentrate (formulated with ground corn, soy and different levels of wet brewery residue) (Table 1), formulated for animals of late maturity, with body weight of 20 kg for an average daily weight gain of 150g/day according to NRC (2007). Daily

Table 1. Ingredients and chemical composition of experimental diets.

Ingredients (kg)	Diets			
	0%	10%	20%	30%
Tifton-85 hay	45.90	39.62	33.30	26.52
Ground corn	43.47	43.74	44.05	43.11
Soybean meal	10.38	6.36	2.33	0.0
Limestone	0.25	0.28	0.32	0.37
WBR[1]	0.0	10.0	20.0	30.0
Total	100.0	100.0	100.0	100.0
Chemical composition (% dry matter)				
Dry matter	80.81	80.41	74.03	67.67
Crude Protein	12.76	12.76	12.76	12.76
Neutral Detergent Fiber	41.27	39.26	37.22	34.94
Acid Detergent Fiber	22.90	22.38	21.84	21.18
Total Digestible Nutrients	65.80	65.80	65.80	65.80
Calcium	0.40	0.40	0.40	0.40
Total Phosphorus	0.28	0.28	0.29	0.30

[1]Wet brewery residue. Data in kg/100 kg of feed.

adjustments were carried out allowing leftovers of up to 15%, and diets were provided at 8:00 am and at 5:00 pm.

The experimental period lasted 77 days, with the first 14 days to adapt the animals to the stalls and diets. At the end of the confinement period, the animals were slaughtered by stunning in the atlanto-occipital region. The average daily weight gain and feed efficiency were measured, and the data were submitted to regression analysis using the InfoStat statistical program (DI RIENZO et al., 2018).

The average daily weight gain (DWG) obtained during the experimental period was taken into account for the economic analysis. The calculations were based on the year 2015 (reference year) for the commercialization prices practiced in the regional market, adopting the purchase and sale value of sheep of R$8.00 and R$11.00 kg of body weight, respectively.

For calculation purposes, investment and costs were simulated for a recommended production scale of plots with 50 animals, given that this number is the average herd size of rural properties in the State of Maranhão according to IBGE (IBGE, 2019).

The calculated technical parameters were:

- Daily production (kg BW) = DWG x area/animal;
- Total area (ha);
- Supplied roughage (kg NM/month) = roughage (kg NM/year)/12 months
- Supplied concentrate (kg NM/month) = concentrate (kg NM/year)/12 months;
- Cost of roughage (R$/kg) = supplied hay (kg NM) x price of hay (R$/kg);
- Cost of concentrate (R$/kg) = supplied concentrate (kg NM) x price of concentrate (R$/kg);
- Cost of diet (R$/kg) = cost of roughage (R$/kg) + cost of concentrate (R$/kg).
- The zootechnical indicators determined were:
- Total animal production (kg BW/year) = total animals (no./year) x final slaughter weight (kg);
- Total lots (no./year) = 365 days/confinement time (days) + sanitary empty time (days);
- Total animals (no./year) = total lots (no./year) x lot with 50 animals;

- Land productivity (kg BW/ha/month) = daily production (kg BW x sales price)/area used (ha);
- Labor productivity (kg BW/day/person) = daily production (kg BW)/total monthly manpower (day/man);
- Concentrate productivity (kg BW/kg NM) = daily production (kg BW)/ concentrate supplied (kg NM).

The cost analysis was performed according to Hoffman et al. (1987), which considers the operating cost and the total production cost. For this study, expenses costs (family labor, feeding of lambs, maintenance and fuel for machinery and equipment, medicine, electricity, technical assistance, stalls maintenance and costs of acquiring the lambs) were considered, along with investments (stalls and equipment), stalls , machinery and equipment depreciation, in addition to the return on invested capital, thus obtaining the total expenses of the confinement production system.

The time horizon considered in the analysis for the projection was 10 years, thus enabling an evaluation of the activity in the long term according to the classification by Varian (2000). During this period, it is possible to monitor and characterize the production cycles and consider the depreciation of improvements, machinery and equipment. The linear method or fixed quotas was used for the depreciation calculation, which provides a constant depreciation. All costs involved in the activity were determined based on the purchase prices practiced in the local market. Labor remuneration was based on the amount paid to the minimum wage in force in 2015, which was R$788.00 taking into account all labor charges.

The economic-financial indicators followed the same composition of the Integrated System of Agricultural Costs as developed by the Institute of Agricultural Economics (IEA), in partnership with the National Center for Technological Research in Informatics for Agriculture (CNPTIA/Embrapa), which guides calculations of the following parameters:

- Gross revenue (GR) (R$/month) = total production in kg of BW x selling price in the market;
- Effective operating cost of the activity (EOC) (R$/month) = expenses on operations (maintenance of facilities and machinery) + expenses for contracted labor + expenses for inputs (feed, medicines, energy);
- Total operating cost of the activity (TOC) (R$/month) = EOC + other

operating costs (family labor, stalls and machinery depreciation). The linear method proposed by Hoffman et al. (1987) was used to calculate depreciation;

- Total activity cost (TC) (R$/month) = TOC + other fixed costs (return on capital invested in lambs, stalls, machinery and land);
- Gross margin of activity (GMA) (R$/month) = GR - EOC;
- Net margin of activity (NMA) (R$/month) = GR - TOC;
- Activity profit (R$/month) = GR - TC;
- Effective operating cost per kg BW (R$/month) = (EOC x (GR/GR x 100))/ monthly production in kg;
- Total operating cost per kg BW (R$/month) = (TOC x (GR/GR x 100))/ monthly production in kg;
- Total cost per kg BW (R$/month) = (TC x (GR/GR x 100))/monthly production in kg;
- Gross margin per kg BW (R$/month) = price of kg BW - EOC;
- Net margin per kg BW (R$/month) = price of kg BW - TOC;
- Profit per kg BW (R$/month) = price of kg BW - TC;
- Share of the cost of medicine in the EOC (%) = monthly cost of medicine/ EOC x 100;
- Expenditure on labor in relation to the production value (%) = monthly expenditure on labor/GR x 100;
- Participation of EOC in GR (%) = EOC/GR x 100;
- Participation of TOC in GR (%) = TOC/GR x 100;
- Rate of return on invested capital (% a.a) = NMA/(stalls + machinery + hay + land);
- Total capital invested in relation to production per kg BW (R$/month) = (capital invested in stalls + machinery + land)/daily production in kg;
- Profitability (%) = (NMA/GR) * 100 (LOPES et al., 2011);
- Return on investment (%) = (NMA/total capital invested in stalls + machinery + land) * 100 (LOPES et al., 2011).

Gross revenue (GR) was calculated by the product resulting from the production in kg of body weight at the price of the product to be marketed. Net revenue was obtained by the difference between gross revenue (GR) and the expenses by the system during the production process.

The linear method or fixed quotas was used to calculate depreciation, which provides constant depreciation (Equation 1).

Equation 1.

$$d = \frac{(iv - fv)}{n}$$

In which: d = depreciation; iv = initial value; fv = final value; n = number of years of duration of the capital (useful life).

The technical, zootechnical and economic indicators obtained were compared by descriptive analysis using an Excel® spreadsheet.

RESULTS AND DISCUSSION

The inclusion of wet brewery residue (WBR) showed a linear response in terms of average daily weight gain (DWG) and feed efficiency (FE). A DWG of 0.196 kg/day was observed when the animals received 20% of the WBR, having surpassed the other diets with 10% and 30% WBR. These results show that the inclusion of WBR can maintain sheep at adequate production levels, observing a higher DWG than the recommendations of the diets formulated based on the NRC (2007), which was 150 g/day.

FE was higher (Table 2) for diets with 30% WBR inclusion (0.291 kg BW gain/kg DM intake). The animals fed diets with 20% WBR had the second best FE (0.263 kg BW gain/kg DM intake). The highest FE was related to the lowest amount of neutral detergent fiber (34.94%) and acid detergent fiber (21.18%) in the diet with 30% WBR (Table 1). In a study carried out by Sormunen-Cristian (2013), lambs that consumed a grain barley diet obtained higher neutral detergent fiber digestibility (302g/kg) than the processed barley diet (66g/kg). This author concluded that in addition to the earlier adaptation of animals to the diet containing the grain which led to maximization in chewing efficiencies and efficiency in the fermentation of fiber in the rumen, they could also compensate for possible decreases in the digestibility of this food when processed; this would justify its use along with traditional ingredients for formulating concentrated diets.

The total production in the diet with 20% WBR was higher (7,503.07 kg BW/year) than the other treatments, as well as the total lots (5 lots/year), and total animals

Table 2. Performance of sheep fed diets containing wet brewery residue.

Variable	Diets				CV[3](%)	Equation	R^2	P value
	0%	10%	20%	30%				
WDG[1]	0.188	0.181	0.196	0.183	20.6	Ŷ[4]	0.38	0.0035
AE[2]	0.246	0.226	0.263	0.291	9.37	Ŷ[5]	0.39	0.0042

[1]Daily weight gain (kg/day); [2]Feed efficiency (kg BW gain/kg DM intake); [3]Coefficient of variation; [4]$\hat{Y} = 3.20728 - 0.03220x$; [5]$\hat{Y} = (22.82781 + 0.18369x) / 100$.

(250 animals/year). Higher land and labor productivity was also noted when 20% WBR was used (34,989.11 kg/ha/year and 1.29 kg/day/person) (Table 3). These responses reveal that the system becomes economically balanced when prioritizing earth-saving technologies even with intensification. These factors take on greater relevance in regions where the amount paid for the area is higher, as well as in those where the ecosystem is more subject to degradation, which is the case in semi-arid areas.

Table 3. Zootechnical indicators for the confined sheep fed diets containing wet brewery residue.

Indicators	Diets			
	0%	10%	20%	30%
Total production (kg BW[1]/year)	7,384.78	6,718.96	7,503.07	7,183.72
Total area (m^2)	85	85	85	85
Total lots (no./year)	4.92	4.48	5.00	4.79
Total animals (no./year)	246	224	250	239
Land productivity (kg/ha/month)	33,583.29	32,305.28	34,989.11	32,717.09
Labor productivity (kg/day/person)	1.23	1.19	1.29	1.20
Concentrate productivity (kg BW[1]/kg NM[2])	0.68	0.42	0.32	0.28

[1]Body weight; [2]Natural matter.

The intensification of confinement systems involves higher costs than extensive systems, as they require a larger number of animals per area to compensate the investments. As a result, the use of alternative feeds has been increasingly used.

In addition to detoxified castor bean cake (GOMES et al., 2018), babassu by-products (PARENTE et al., 2020; SANTOS et al., 2019), cotton cake (NEGRÃO et al., 2020), WBR can favor reduced feed costs, and there is an increase in the number of finished animals per hectare when associated with the feedlot system (GOMES et al., 2018).

The highest concentrate intake occurred in the 0% WBR diet (0.68 kg BW/kg NM). This result corroborates the DWG of the same diet, which was 188 g/day. This result reveals that the diet without the addition of WBR met the nutritional requirements of the animals; however, the viability of using the by-products must be observed, since it is dependent on the nutritional value, the animal response and the costs of the alternative feed compared to traditional ingredients (HALMEMIES-BEAUCHET-FILLEAU et al., 2018). Thus, diets which contained WBR can also meet the requirements and reduce production costs.

Among the technical indicators analyzed, the daily production (kg BW) for the diet containing 20% WBR was higher (9.78 kg BW) than the other diets with 10% and 30% WBR (9.03 and 9.14 kg PC, respectively). The 0% WBR diet had the highest proportion of roughage (Table 1), in which the cost of roughage was higher (Table 4) when compared to diets that contained WBR. As there was an increase in the residue percentage in the diet, there was a decrease in the roughage proportions, causing a reduction in the supply and cost of the concentrate when the diets were formulated with 30% WBR. These data represent the high roughage cost and point to versatility of WBR regarding the availability of nutrients to animals, as it is considered a protein concentrate feed (GERON et al., 2013).

Table 4. Technical indicators for the confinement of sheep fed diets containing wet brewery residue.

Indicators	Diets			
	0%	10%	20%	30%
Daily production (kg BW[1])	9.38	9.03	9.78	9.14
Supplied roughage (kg NM[2]/month)	741.00	544.98	422.89	261.58
Concentrate provided (kg NM[2]/month)	418.07	653.40	928.03	1.009.33
Hay cost (R$/kg)	0.58	0.39	0.27	0.18
Concentrate cost (R$/kg)	0.34	0.38	0.37	0.37
Feed cost (R$/kg)	0.92	0.77	0.64	0.56

[1]Body weight; [2]Natural matter.

Despite the increase in the concentrate cost to the order of R$0.34, 0.38, 0.37 and 0.37 per kg, for diets of 0, 10, 20 and 30% of WBR, respectively, the total ration cost decreased as WBR was added to the diets. It was noted that the treatment with 30% had a kg ration cost equivalent to R$0.56 (Table 4). These results highlight the need for diet formulations with alternative feeds, since the high costs of traditional feeds (corn and soybean meal) increase production costs; therefore, the search for feeds which reduce the costs related to diets, as well as increase efficiency and the competitiveness of the productive system is always important (GOES et al., 2019).

Investment expenses were lower for the diet with 20% WBR to the order of R$0.371/kg BW. The cost dilutions involved resulted from the average total weight gain (12.32 kg) when compared to diets of 0 (11.82 kg), 10 (10.22 kg) and 30% (11.52 kg) WBR, respectively (Table 5).

Table 5. Investment expenses for the confinement of sheep fed diets containing wet brewery residue.

Item (R$)	FP[1] (R$)	Diets			
		FP[2] (R$/kg BW[3])			
		0%	10%	20%	30%
Installations	15,191.55	0.069	0.075	0.067	0.070
Management center	6,600.00	0.089	0.098	0.088	0.092
Drinking fountain	320.00	0.009	0.010	0.009	0.009
Mixer	3,600.00	0.049	0.054	0.048	0.050
Crusher	6,800.00	0.092	0.101	0.091	0.095
Balance	3,800.00	0.050	0.057	0.051	0.053
Subtotal	36,311.55	0.359	0.394	0.353	0.369
Others	1,815.58	0.018	0.020	0.018	0.018
Total	38,127.13	0.377	0.414	0.371	0.387

[1]Total price; [2]Final price; [3]Body weight.

For the cost calculations to express the real financial situation of a production system, it is essential to consider the depreciation factor of investments, as its inclusion in the gross and net margins defines how the production system should be conducted without decapitalizing the activity, causing financial damage to the producer (FABRÍCIO et al., 2017).

Confinement allows animals to maximize nutrient consumption through well-formulated diets, increasing the resistance of the animals against possible diseases which can affect negatively the animal production. The association of nutritional and sanitary factors also contributes to the increase finishing process of animals, making them spend less time within the system, since a good nutritional status strengthens their productive capacity and increases their resistance to parasites.

In the analysis of the operating costs of the activity, the diet with 30% WBR had the lowest monetary value (R$64,368.99) when compared to diets of 0%, 10% and 20% WBR (R$72,223.33; R$66,023.12 and R$68,801.94), respectively (Table 6).

Expenses with diets containing WBR were lower when compared to the diet without WBR (0%) The diet of 20% WBR presented best production costs, where 58.89% of the expenses (R$40,516.55) were 250 sheep/year and 14.77% (R$10,158.75)

Table 6. Expenses for the cost of confinement of sheep fed diets containing wet brewery residue.

Expenses	Diets							
	0%		10%		20%		30%	
	TP[1]	FP[2]	TP[1]	FP[2]	TP[1]	FP[2]	TP[1]	FP[2]
MP[3]	11,347.20	1.54	11,347.20	1.69	11,347.20	1.51	11,347.20	1.58
FO[4]	14,226.33	1.93	11,663.51	1.74	10,158.75	1.35	7,470.38	1.04
ME[5]	1,378.00	0.19	1,378.00	0.21	1,378.00	0.18	1,378.00	0.19
MD[6]	465.24	0.06	423.29	0.06	472.69	0.06	452.57	0.06
EP[7]	200.75	0.03	200.75	0.03	200.75	0.03	200.75	0.03
TA[8]	4,728.00	0.64	4,728.00	0.70	4,728.00	0.63	4,728.00	0.66
PA[9]	39,877.81	5.40	36,282.37	5.40	40,516.55	5.40	38,792.09	5.40
Total	72,223.33	9.78	66,023.12	9.83	68,801.94	9.17	64,368.99	8.96

[1]Total price (R$/year); [2]Final price (R$/kg of BW); [3]Manpower; [4]Feed; [5]Machines and equipment; [6]Medicines; [7]Electric power; [8]Technical assistance; [9]Purchase of animals.

were invested in the purchase of feed. On the other hand, in the diet without WBR (0%), R$39,877.81 was invested in the purchase of 246 sheep/year and R$14,226.33 spent on feed, corresponding to 55.21% and 19.70% of the total cost, respectively.

The sum of costing expenses for diets of 20% and 30% WBR proved to be able to meet nutritional requirements, maintaining the same weight gain when compared to diets formulated with traditional ingredients (ground corn and soybean meal). These results favored an increase in annual production by providing better use of the containment structure, justifying improvements and equipment acquisition, allowing the dilution of unit costs, and promoting a positive overall result for the production system (SOUZA et al., 2014).

The permanence time of the feedlot in the productive system (confinement) until slaughter can be reduced through acquiring animals with specialized genetics for meat production, and this production can be enhanced by diets with high nutritional value. As a result, the longer time the animal stays in the feedlot seeking to obtain the expected body weight will result in a higher total cost of the production system, while the increase in the final price per kilogram of lamb generates a revenue about three times less than feed costs (PICCOLI et al., 2013).

The use of agro-industrial by-product can be a viable alternative to reduce feed expenses, however it is necessary to take into account availability, quality and transport which can increase costs, making the enterprise unfeasible (SOUZA et al., 2014). Residues available in the region and which have a lower purchase value must be selected in using these alternative feeds.

Regarding the economic indicators, despite diets with 30% WBR only reaching the third highest gross revenue (GR) (R$6,585.08), they were able to cover possible variations presented in the EOC and provided a greater gross margin (GMA) (R$2,166.59). These results point to the great influence of spending on feed on the EOC. Therefore, the selling price of the kg of WBR used in this study makes the producer more competitive, enabling to capture new markets. In this sense, the results show the need to constantly monitor prices in the local market, as their fluctuations significantly affect the value of inputs and can determine more expressive profit margins (GASPAR et al., 2018) (Table 7).

Table 7. Economic efficiency indicators for the confinement of sheep fed diets containing wet brewery residue.

Indicators	Diets			
	0%	10%	20%	30%
GR[1] (R$/ month)	6,769.38	6,159.04	6,877.81	6,585.08
SP[2] (R$/kg)	11.00	11.00	11.00	11.00
EOC[3] (R$/ month)	5,073.01	4,556.33	4,787.90	4,418.48
TOC[4] (R$/ month)	6,233.29	5,716.60	5,948.17	5,578.76
TC[5] (R$/ month)	6,451.56	5,934.88	6,166.45	5,797.04
GMA[6] (R$/ month)	1,696.37	1,602.72	2,089.91	2,166.59
NMA[7] (R$/ month)	536.10	442.44	929.64	1,006.32
Profit (R$/ month)	317.82	224.16	711.36	788.04
EOC[3] (R$/kg BW)	9.78	9.83	9.17	8.96
TOC[4] (R$/kg BW)	10.13	10.21	9.51	9.32
TC[5] (R$/kg BW)	10.48	10.60	9.86	9.68
GMA[6] (R$/kg BW)	1.22	1.17	1.83	2.04
NMA[7] (R$/kg BW)	0.87	0.79	1.49	1.68
Profit (R$/kg BW)	0.52	0.40	1.14	1.32
Profitability (%)	7.92	7.18	13.52	15.28
Return on investment (%)	16.87	13.93	29.26	31.67

[1]Gross revenue; [2]Selling price; [3]Gross margin. [4]Net margin; [5]Effective operating cost; [6]Total operating Cost; [7]Total cost.

The depreciation of the equipment directly affects the total operating cost (TOC), and was amortized by the efficiency of using the WBR (Table 2) since animals fed with a 30% WBR diet only remained for 66 days in confinement until slaughter, resulting in a more expressive net margin (R$1,006.32), and also due to the lower proportions of soy and hay. Therefore, the roughage production itself would be an alternative in reducing dietary costs.

The gross revenue (GR) obtained in all diets formulated with the WBR were able to cover the total production costs (TC), consequently generating profit for the confinement system, highlighting those that received 20% (R$711.36) and 30% (R$ 788.04) of the residue. Such results enabled diets with 20 and 30% WBR to reach 71% and 93% profitability respectively, being superior to the diet without WBR. In addition, the return on investment shows that the financial return obtained with the use of 20 and 30% WBR in the sheep diet surpassed the average income of the savings account by 4,501% and 4,872% in 2015 (0.65% per month).

However, it is clear that the partial replacement of some feeds by WBR is a viable alternative in sheep confinement systems. However, it is necessary to find adequate levels for each production system, aiming at efficiency in the productive response of the herd in the presence of a new feed so that the balance between production costs and profitability is maintained.

CONCLUSIONS

The technical and zootechnical indicators showed better rates for diets with 20% WBR. However, economic efficiency indicators were more attractive in diets with 30% WBR. In this sense, the availability and the price paid for the residue are important factors for the adequacy of the ideal inclusion level of WBR in diets for confined sheep.

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