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Communication

[*Comunicação*]

Economic viability of feedlot of sheep fed diets containing corn grain or extra-fat whole corn germ associated or not with spineless cactus

[*Viabilidade econômica do confinamento de ovinos alimentados com dietas contendo grão de milho ou gérmen de milho integral extragordo associado ou não à palma forrageira*]

F.G. *Souza*[1], S.O.L. *Silva*[1], E.R.V. *Moreno*[1], T.G.P. *Silva*[2*], K.C. *Santos*[1], M.A. *Ferreira*[1], F.F.R. de *Carvalho*[1], L.F.P. *Soares*[1]

[1]Universidade Federal Rural de Pernambuco, Recife, PE, Brasil
[2]Instituto Federal de Educação, Ciência e Tecnologia do Piauí, Paulistana, PI, Brasil

Dry environments, such as the semi-arid region of the Brazilian Northeast, represent many challenges to produce ruminants, mainly due to fluctuations in forage production caused by limiting climatic conditions, such irregular rainfall. In this context, spineless cactus (SC) is a strategic feed option, being a forage crop rich in water and non-fibrous carbohydrates (Silva *et al*., 2021). However, the need to combine this cactus with sources of physically effective fiber and nitrogen is already well established.

An ingredient that has been studied as a source of protein and lipids in diets for ruminants is extra-fat whole corn germ (EFWCG), which represents a byproduct of the bioethanol production process. Silva *et al.* (2022) evaluated the impact of replacing ground corn with EFWCG on the intake, digestibility of nutrients, water balance, ruminal dynamics and blood variables of sheep and recommended the total replacement of ground corn by EFWCG. According to Morais *et al*. (2021), corn is an international commodity that can increase ruminant production costs. On the other hand, there are still few studies demonstrating the performance and economic viability of using EFWCG in feedlot lamb diets.

The supply of dietary ingredients adapted to local conditions and available in the region constitutes a strategy to reduce feed costs, guaranteeing a greater economic return and reducing production instability. In addition, the use of the feedlot for lambs' termination enables the exploitation of the animal earning potential, mainly due to the seasonality in the supply of forage (Lima *et al*., 2017). Thus, it was hypothesized that the replacement of corn grain by EFWCG, as well as the use of SC, positively influence the performance of animals and the reduction of production costs. Therefore, it was possible to determine the costs of the production cycle of lambs fed diets based on replacing corn grain with EFWCG, associated or not with SC.

All procedures involving animals were previously approved by the Committee of Ethics in the Use of Animals (CEUA) of the Federal Rural University of Pernambuco (UFRPE) (License 4992250221). The study was conducted in the Animal Science Department of UFRPE, Recife, Brazil. For this purpose, a total of forty Santa Inês lambs, uncastrated male, with four months old and average initial body weight of 22.2±1.71kg. Before the beginning of the experiment, all animals were identified and submitted to endo- and ectoparasites control and vaccinated against clostridiosis.

The lambs were housed in individual pens (1.0m x 1.8m), arranged in a covered shed and equipped with drinker and feeder. The trial was carried out in a completely randomized design with an experimental period of 75 days (15 days for the adaptation of the animals to the facilities, diets and management, and the remaining 60 days for evaluation and data collection). The

*Corresponding author: tomasguilherme91@gmail.com
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experimental diets were formulated to be isonitrogenous, consisting of Orelha de Elefante Mexicana (*Opuntia stricta* [Haw.] Haw.), Tifton-85 hay (*Cynodon* spp.), corn grain, soybean meal, wheat bran, urea, mineral mix and EFWCG. The EFWCG was used at a level of 10% of dry matter. Diets were calculated to meet weight gains of 200 g/day (Nutrient…, 2007; Tab. 1).

Diets were provided twice a day (08:00 am and 16:00 pm) and water was provided *ad libitum*. To estimate the voluntary intake, the leftovers were collected and weighed before the morning feeding and the intake was measured by the difference between the feed offer and the leftovers of each animal. The amount supplied was adjusted daily, based on the animal's voluntary intake, with an estimate of 15% leftovers. Samples of diets and leftovers were collected, which were pre-dried in an oven with forced ventilation at 55ºC, for 72 hours, processed in a Wiley-type mill (TE-625, Tecnal, SP, Brazil), with a 1 mm sieve, for chemical analysis according to Association of Official Analytical Chemists (Official…, 2000).

At the end of the experiment, the animals were submitted to an eight-hour water diet and solid fasting for 16 hours to be slaughtered, following the rules of the RIISPOA (Brasil, 2000). After obtaining the body weight at slaughter, the animals were stunned with a captive dart pistol (Ctrade®, Tec 10 PP), triggered by a blast cartridge, followed by bleeding by splitting the carotid arteries and jugular veins (Brasil, 2000) and suspended by the hind limbs, being attached to hooks. Hot carcass weight was obtained according to Cezar and Sousa (2007).

Table 1. Proportion of ingredients and nutritional composition of experimental diets (dry matter basis)

Ingredients	Diets			
	C+H[1]	C+H+SC[2]	H+EFWCG[3]	H+SC+EFWCG[4]
	(g/kg dry matter)			
Tifton-85 hay	592.50	300	592.50	300
OEM[5] spineless cactus	0	297.50	0	297.50
EFWCG[6]	0	0	100	100
Corn grain	100	100	0	0
Wheat bran	160	160	160	160
Soybean meal	120	120	120	120
Urea + sulfur flower (18:1)	7.50	2.50	7.50	2.50
Mineral mix[*]	20	20	20	20
Chemical composition (g/kg dry matter)				
Dry matter[#]	901.10	248.50	908.80	249.10
Ash	62.50	89.60	69.20	89.30
Crude protein	149.65	150.78	154.40	155.53
Ether extract	14.00	16.00	59.00	61.00
$_{ap}$NDF[7]	498.30	363.20	507.70	372.70
Non-fibrous carbohydrates	320.00	429.90	254.10	371.10
Total digestible nutrients	621.28	650.80	621.28	650.80

[1]corn + hay, [2]corn + hay + spineless cactus, [3]hay + extra-fat whole corn germ, [4]hay + spineless cactus + extra-fat whole corn germ, [5]Orelha de Elefante Mexicana spineless cactus, [6]extra-fat whole corn germ, [7]neutral detergent fiber assayed with a heat stable amylase and corrected for ash and nitrogenous compounds, [#]fresh matter, [*]Nutrients/kg of product: Calcium (Ca) = 140g; Phosphorus (P) = 70g; Magnesium (Mg) = 1,320mg; Iron (Fe) = 2,200mg; Cobalt (Co) = 140mg; Manganese (Mn) = 3,690mg; Zinc (Zn) = 4,700mg; Iodine (I) = 61mg; Selenium (Se) = 45mg; Sulphur (S) = 12g; Sodium (Na) = 148g; Fluoride (F) = 700mg.

The economic analysis was carried out based on the confinement production cycle of sheep, comprising the analysis of production cost and economic viability indicators (Matsunaga *et al*., 1976). Expenditures were obtained based on product cost quotes in Recife city, Pernambuco state (year 2021). Ration costs were composed of the costs and quantities supplied of diet ingredients (dry matter basis). The values of the dose of medication applied to the animals for the treatment of endo and ectoparasites and immunization against clostridiosis were estimated, in addition to the costs of hiring an employee on a temporary basis to manage a

confined batch of animals and eight-day laborers who worked on the day of slaughter. Remuneration was based on the minimum wage of R$ 1100.00, in force in 2021, with social charges being paid. The cost of a day's work was equivalent to the quotient of the current minimum wage by the number of days in the business month.

The total amount spent on electricity in the month was calculated by multiplying the value per unit of measurement (R$) and the monthly consumption (Kwh). For maintenance of installations, machinery and equipment, the initial value of the asset (R$) was considered multiplied by the maintenance fee throughout its useful life, divided by its useful life (years). The acquisition of animals involved the purchase of a batch of 40 sheep with an average initial weight of 22.2kg at a cost of R$ 9.00/kg of body weight. The total revenue involved the values of meat sales (R$ 21.00 per kg) + skin sales (R$ 7.00 per unit) + stomach/"bucho" sales (R$ 20.00 per unit).

The economic and financial indicators studied were:
- The effective operating cost (EOC; R$/production cycle) was composed of the item's feed, sanitation, labor, electricity, maintenance of facilities, machinery and equipment, and purchase of animals for finishing.
- The total operating cost (TOC; R$/production cycle) was composed of the EOC plus other operating costs (depreciation).
- The total production cost (TPC; R$/production cycle) represented the sum of the TOC and the remuneration on the capital invested in lambs, machinery and equipment, land and working capital.
- Total revenue (TR; R$/production cycle) = total production in kg multiplied by the market selling cost.
- Gross margin (GM; R$/production cycle) = TR - EOC;
- Net margin (NM; R$/production cycle) = TR - TOC;
- Result (profit or loss; R$/production cycle) = TR - TPC;

The economic indicators EOC, TOC, TPC, GM, NM and profit were also expressed in R$/kg body weight.

As a measure of efficiency, the benefit/cost ratio was used, which expresses the overall performance of all production factors. When the B/C ratio>1, the investment is viable (positive financial return); in the opposite situation, B/C is less than 1, meaning that the total cost is greater than the total revenue and, consequently, the investment is not viable.

The animals were randomly distributed into four treatments with ten repetitions. The experimental design used was completely randomized, with the initial weight of the animals used as a covariate according to the statistical model: $Yij = \mu + Ti + \beta(Xij - X) + eij$, where, Y_{ij} = observed value of the dependent variable; μ = overall mean; T_i = effect of treatment i (i = 1 - 4); β (X_{ij} - X) = covariate effect (initial BW); e_{ij} = trial error. The variables were evaluated as a 2 x 2 factorial (two energy sources and the presence or absence of SC), using the PROC MIXED of the Statistical Analysis System - SAS software version 9.0 (Statistical…, 2009). The data were submitted to ANOVA and the Fisher's test, at 5% probability, was used to compare the averages between treatments.

Diets composed by the association of hay with SC as roughage sources were more efficient ($P<0.05$) when compared to diets containing hay as roughage exclusively, showing higher values for DM intake, body weight at slaughter and hot carcass weight. Diets containing hay as exclusive source of roughage may have regulated intake due to physical limitations, in view of the higher NDF contents of these tested diets (Tab. 1). Regarding the concentrate, the animals that consumed the diets with corn as the main source of energy showed higher DM intake, but with body weight at slaughter and carcass weight similar to fed with EFWCG ($P<0.05$) (Tab. 2).

There was interaction between the energy sources (EFWCG and corn) with the use or not of SC ($P<0.05$) for DM intake, body weight at slaughter and weight of hot carcass (Tab. 2). According to the unfolding of the interaction (Tab. 3), it was found that diets containing SC and EFWCG as the main source of energy promoted higher production rates than diets with SC and corn as an energy source. The EFWCG has a high ether extract level (Silva *et al*., 2022), and the SC is rich in non-fiber carbohydrates (starch, for example) (Silva *et al*., 2021).

Table 2. Dry matter intake and performance of sheep fed diets based on replacing corn with extra-fat whole corn germ, associated or not with spineless cactus

Item		Parameters		
		DMI[1]	BWS[5]	HCW[3]
Energy source (ES)	EFWCG	0.98b	31.92	14.73
	Corn grain	1.09a	32.32	14.84
Roughage	With cactus	1.18a	35.17a	16.84a
	Without cactus	0.89b	29.07b	12.73b
SEM[4]	ES	0.0214	0.5253	0.2798
	Cactus	0.0214	0.5253	0.2798
P-Value	ES	0.0008	0.5912	0.7682
	Cactus	<.0001	<.0001	<.0001
	ES*Cactus	<.0001	0.0096	0.0026

[1]dry matter intake, [2]body weight at slaughter, [3]hot carcass weight, [4]standard error of the mean. Means followed by different letters for the same variable differ by Fisher's test (5%).

Table 3. Interaction between energy source and cactus for the dry matter intake and performance of sheep fed diets based on replacing corn with extra-fat whole corn germ, associated or not with spineless cactus

Energy source	Roughage	
	With cactus	Without cactus
	Dry matter intake (kg/day)	
EFWCG[1]	1.19Aa	0.77Bb
Corn grain	1.17Aa	1.02Ba
	Body weight at slaughter (kg)	
EFWCG[1]	35.98Aa	27.87Bb
Corn grain	34.37Aa	30.28Ba
	Hot carcass weight (kg)	
EFWCG[1]	17.42Aa	12.04Ba
Corn grain	16.26Aa	13.43Ba

[1]extra-fat whole corn germ. Common uppercase letters within the same row and common lowercase letters within the same columns do not differ statistically (P > 0.05).

Feeding is the basis of livestock activity, which drives the understanding of the most appropriate feeds (nutritious and accessible) for use in animal feed. The treatment containing Corn+SC+Hay had the lowest cost per 1 kg of DM, followed by the diet containing EFWCG+SC+Hay (Tab. 4).

Table 4. Description of costs of diets (dry matter basis), in R$

Feeds	C+H[1]	C+H+SC[2]	H+EFWCG[3]	H+SC+EFWCG[4]
Tifton-85 hay	0.819	0.415	0.819	0.415
OEM[5] spineless cactus	-	0.004	-	0.004
EFWCG[6]	-	-	0.233	0.233
Corn grain	0.121	0.121	-	-
Wheat bran	0.167	0.167	0.167	0.167
Soybean meal	0.271	0.271	0.271	0.271
Urea + SF[7] (18:1)	0.011	0.004	0.011	0.004
Mineral mix	0.113	0.113	0.113	0.113
Total (R$/kg dry matter)	*1.503*	*1.094*	*1.614*	*1.206*

[1]corn + hay, [2]corn + hay + spineless cactus, [3]hay + extra-fat whole corn germ, [4]hay + spineless cactus + extra-fat whole corn germ, [5]Orelha de Elefante Mexicana spineless cactus, [6]extra-fat whole corn germ, [7]sulfur flower.

Diets with higher proportions of Tifton-85 hay showed higher values as a function of the value of this component in the ration. To reduce these costs, one of the alternatives would be to use a cheaper roughage source, such as SC, which had a lower acquisition cost. Feeding accounted for almost 45.7% of the production cycle expenses, followed by the acquisition of lambs (32.8%) and manpower (17.6%), respectively, representing the most significant components of expenses in the EOC. Additionally, in the proportion of expenses, electricity, sanitation, and maintenance accounted for 1.79%; 1.76% and 0.35%, respectively. However, it is not just feeding that makes the system more expensive, there are other items such as greater capital tied up in the activity, investment, maintenance, depreciation, among others, which are rarely mentioned in economic evaluation surveys. It is important to point out that at the time the study was carried out, the concentrated ingredients were at a high price. Thus, in another moment of favorable price these results could be different.

The total revenue of the production cycle was higher for the EFWCG+SC+Hay diet due to greater feed efficiency, weight gain and carcass yield of the animals (Tab. 5).

Table 5. Economic indexes of the sheep production cycle in feedlot fed diets based on replacing corn with extra-fat whole corn germ, associated or not with spineless cactus

Item	C+H[1]	C+H+SC[2]	H+EFWCG[3]	H+SC+EFWCG[4]
Total revenue	2,917.68	3,632.10	2,680.59	3,893.76
Effective operating cost (EOC)	4,484.18	4,299.65	4,319.05	4,475.15
Total operating cost (TOC)	4,500.85	4,316.32	4,335.72	4,491.82
Total cost of production (TCP)	4,630.75	4,446.22	4,465.62	4,621.84
Gross margin (GM)	-1,566.50	-667.55	-1,638.46	-581.39
Net margin (NM)	-1,583.17	-684.22	-1,655.13	-598.06
Profit	-1,713.07	-814.12	-1,785.03	-728.08
Benefit/cost ratio	0.63	0.82	0.60	0.84
EOC/kg of body weight	13.49	11.38	14.65	11.31
TCP/kg of body weight	13.93	11.77	15.14	11.68
NM/kg of body weight	-4.76	-1.81	-5.61	-1.51
Profit/kg of body weight	-5.15	-2.16	-6.05	-1.84

[1]corn + hay, [2]corn + hay + spineless cactus, [3]hay + extra-fat whole corn germ, [4]hay + spineless cactus + extra-fat whole corn germ.

According to Urbano *et al*. (2014), corn germ improves the nutritional quality of the lipid fraction of sheep meat, enriching it with compounds beneficial to human health. Thus, this aspect could add more value to the product and increase the total revenue. The gross margin, net margin and the profit of the production cycle were negative and indicated that the feedlot costs exceeded the gross income (Tab. 5), but the diets containing SC and smaller amounts of hay presented a higher result for such indexes in relation to the others.

The B/C ratio was less than one (B/C<1) for all diets, indicating that the revenue value was lower than the production costs. The B/C ratio expresses the economic return for each unit of investment, that is, it expresses the revenue obtained for each invested real in reais. Thus, the higher the ratio, the more attractive the activity is for an investor. Considering the economic indices related to the feedlot and sale of the carcass and non-carcass components of these animals, the diet containing EFWCG+SC+Hay provided better results, considering that, due to the greater performance of the animals with this diet, they presented a more expressive economic return than the others. Tifton-85 hay played a major factor in production, making diets more expensive. In this aspect, the participation of the EFWCG and the SC and the decrease in the use of hay resulted in a less expensive diet.

Our results indicate that diets containing lower proportions of hay associated with SC promote superior productive performance. The use of

Tifton-85 hay as an alternative forage for animals in feedlot proved to be unfeasible, since the higher cost of this input is one of the factors that compromise the viability of sheep feedlot.

Keywords: lambs, production costs, Tifton-85 hay, energy sources, *Opuntia stricta* Haw

RESUMO

Objetivou-se determinar os custos do ciclo produtivo de cordeiros alimentados com dietas baseadas na substituição do grão de milho por gérmen de milho integral extragordo (GMIEG), associado ou não à palma forrageira (PF) Orelha de Elefante Mexicana. Quarenta cordeiros machos Santa Inês (22,2±1,71kg de peso corporal) foram distribuídos em delineamento inteiramente ao acaso, em quatro tratamentos dietéticos, em arranjo fatorial 2 × 2, correspondente a duas fontes volumosas (feno de Tifton-85 associado ou não à PF) e duas fontes energéticas (grão de milho ou GMIEG), com 10 repetições e peso inicial como covariável. Para análise econômica, foram considerados os preços de mercado obtidos para os ingredientes das rações e para o peso corporal dos cordeiros. Com base nos custos de cada dieta e do consumo de MS, foram analisados os indicadores zootécnicos e econômicos. Os tratamentos milho+feno+PF e feno+PF+GMIEG apresentaram os menores valores de custo por kg de MS: R$ 1,094 e R$ 1,206, respectivamente. O feno de Tifton-85 e o farelo de soja apresentaram valores de mercado superiores aos dos demais ingredientes, e a dieta feno+PF+GMIEG promoveu melhor desempenho produtivo e econômico. Portanto, as dietas contendo menores proporções de feno associadas à PF proporcionam menores prejuízos financeiros no confinamento de ovinos.

Palavras-chave: cordeiros, custos de produção, feno de Tifton-85, fontes energéticas, Opuntia stricta Haw

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