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Performance and Carass Potential of Pantaneiro Lambs Supplemented with *Saccharomyces cerevisiae*

Potencialidades do Desempenho e da Carcaça de Cordeiros Pantaneiros Suplementados com *Saccharomyces cerevisiae*

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Abstract

The aim of this study was to evaluate the effect of a feed additive for feedlot Pantaneiro lambs on weight gain, dry matter intake, carcass and meat characteristics, in addition to the comparison between males and females. Eleven males and eight females were used, with a mean weight of 19.52 ± 3.536 kg. The animals were divided into two groups, in which the treatment group received a diet with a food additive composed of amino acids, vitamins, prebiotics, and probiotics, while the control group received the same diet without the additive. Weight gain and hot and cold carcass weight were superior in males. Carcass yield was similar for males and females, but was higher for animals in the control group. There were no significant differences in conformation, fat coverage, fat thickness and loin eye area. For colorimetric parameters of the meat, differences were obtained between sexes in the intensity of red (a*), intensity of yellow (b*), and chroma (C*), in which the values of a* and C* were higher for males. For the centesimal composition of the meat, there was an interaction for the meat protein levels, in which higher values were obtained for the males that received the additive, and for the females in the control group. The levels of ether extract did not change due to the use of the additive, with only a sex effect. Thus, the use of feeds with supplemental additives containing amino acids, vitamins, prebiotics, and probiotics in lamb production does not influence the quantitative and qualitative characteristics of the carcass.
Keywords: Prebiotic. Probiotic. Sheep. Weight Gain.

Resumo

O objetivo deste estudo foi avaliar o efeito de um aditivo alimentar para cordeiros Pantaneiros confinados no ganho de peso diário, ingestão de matéria seca, e características quantitativas e qualitativas de carcaça, além da comparação entre machos e fêmeas. Foram utilizados 11 machos e 8 fêmeas, com peso médio de 19,52 ± 3,536 kg. Os animais foram divididos em dois grupos, em que o grupo tratamento recebeu uma dieta contendo um aditivo alimentar composto por aminoácidos, vitaminas, prebióticos e probióticos; e o grupo controle recebeu a mesma dieta sem o aditivo. Houve superioridade dos machos em relação as fêmeas nas variáveis ganho de peso e pesos de carcaça quente e fria. O rendimento de carcaça foi semelhante para machos e fêmeas, porém foi maior para os animais do grupo controle. Não houve diferenças significativas na conformação, cobertura de gordura, espessura de gordura e área de olho de lombo. Os parâmetros colorimétricos da carne, foram observadas diferenças entre os gêneros, na intensidade de vermelho (a), intensidade de amarelo (b*) e croma (C*), em que os valores de a* e C* foram superiores para machos. Na composição centesimal da carne, houve uma interação para os níveis de proteína da carne, em que foram obtidos valores maiores para os machos que receberam o aditivo, e para as fêmeas do grupo controle controle. Os níveis de extrato etéreo não se alteraram em função do uso do aditivo, com efeito apenas do gênero. Conclui-se que a suplementação com aditivo alimentar contendo aminoácidos, vitaminas, prebióticos e probióticos para cordeiros não influencia as características quantitativas e qualitativas de carcaça.*
Palavras-chave: *Ganho de Peso. Prebiótico. Probiótico. Ovino.*

1 Introduction

A confinement system is used to enhance lamb production by reducing the finishing period and making the system more profitable, resulting in greater productivity and better carcass and meat attributes, along with greater value and acceptability to the consumer (Cirne *et al.*, 2014).

In ruminant nutrition, the use of live yeasts as probiotics has been widely studied (Sbizera *et al.*, 2018; Tavares *et al.*, 2021; Zamboti *et al.*, 2023), and *Saccharomyces cerevisiae* stands out due to its digestive benefits, including ruminal pH control, fiber degradation, and ruminal maturity, in addition to improving productive performance (Mohammed *et al.*, 2018).

Pantanal sheep were a genetic group originated from the natural selection of sheep breeds introduced in Brazil, and therefore are considered as animals adapted to the central west region of Brazil (Hirata *et al.*, 2019; Vargas Junior *et al.*, 2011). For this reason, it is of great importance to study and evaluate these characteristics, especially in relation to adapted animals, as these animals can contribute to the development of the production chain.

This study aimed to evaluate weight gain, dry matter intake, carcass and meat characteristics of male and female Pantaneiro lambs finished in confinement and supplemented with a food additive containing *Saccharomyces cerevisiae*, mannan-oligosaccharides, fructo-oligosaccharides, vitamins, and minerals. Additionally, the objective was to compare the differences between males and females regardless treatments.

2 Material and Methods

The experiment was conducted at the Centro Tecnológico de Ovinocultura (CTO) of the Fazenda Escola Três Barras da UNIDERP, located in the municipality of Campo Grande, Central region of Mato Grosso do Sul State, Brazil (20º26'34"S, 54º38'47"W), following the ethical principles of animal experimentation, and approved by the institution ethics committee (CEUA) for the use of animals, with the number 3113/20.

A total of nineteen Pantaneiro lambs were used, 11 males and 8 females, with a mean weight of 19.52 ± 3.536 kg. Lambs were housed in individual pens containing feeders and drinkers and were randomly divided into control and treatment groups. The control group consisted of 4 females and 5 males, and the treatment group consisted of 4 females and 6 males. The animals in both groups received the same diet, but the treatment group received a food additive, and the control group did not receive this additive. The food additive contained amino acids, vitamins, prebiotics, and probiotics, and the manufacturer's recommendation is 2.5–5.0 g/animal/day. The food additive was gradually supplied to the lambs in the treatment group as follows: 2.5 g/animal/day the first week, 3.5 g/animal/day from the second to fourth week, and 5 g/animal/day from the fifth week until the end of the experiment.

The animals' diet was composed of corn silage, corn broken and a pelletized commercial concentrate. For the treatment group, the additive was mixed into the corn broken, that was used as a vehicle. During the adaptation period, the animals received a diet containing 65% concentrate, 30% roughage and 5% corn broken. The silage proportion was diminished 5% weekly, increasing the amount of the feed, maintaining the protein and total digestible nutrientes (TDN) of the feeding. The total grains feeding was reached in the 56th day until the end of the experiment.

Animals were fed five times a day for better control of leftovers. At 7:00 and 14:30 they received commercial concentrate, at 9h00 a.m. and 05h00 p.m. forage, and at 12h00 a.m. they received corn broken and food additive for the treatment group. Each day, food leavings were weighed to do adjustments in the feed intake until the maximum of 5% of leftovers. Diets were formulated according to the requirements for lambs of the NRC (2007), to achieve gains of 200 g per day. Chemical analysis of the diet (Table 1) was performed according to methodologies described by Mizubuti *et al*. (2009), and TDN was obtained according to Capelle *et al*. (2001).

Table 1 - Chemical composition of dietary ingredients

Ingredients1	**DM**	**MM**	**CP**	**EE**	**NDF**	**ADF**	**NDIN**	**ADIN**	**TDN²**	**LIG**
Corn Silage	88.54	5.49	3.24	1.03	57.97	33.90	0.14	0.14	61.12	21.28
Corn Broken	86.79	1.25	2.79	2.90	12.51	3.06	0.25	0.60	73.27	3.71
Commercial Concentrate	87.15	9.53	5.53	1.45	29.08	15.17	0.20	0.57	68.54	8.71

[1]Data described in percentage of dry matter; DM: dry matter; MM: mineral matter; CP: crude protein; EE: ether extract; NDF: neutral detergent fiber; ADF: acid detergent fiber; NDIN: neutral detergent insoluble nitrogen; ADIN: acid detergent insoluble nitrogen; TDN: total digestible nutrients; LIG: lignin. [2]TDN were estimated according to Capelle *et al.* (2001).
Source: research data.

The total period of the experiment was 96 days, with 14 days for adaptation and 82 days of animal evaluation. Animals were weighed weekly until slaughter, and the initial weight was obtained on the first day of the experimental period. On the last day of the experiment, the lambs were fasted for 16 hours of solid and liquid diet and then weighed to obtain the body weight at slaughter. From these weights the daily live weight gain (kg), total weight gain (kg) and intake by body weight (LWI) were obtained.

Animal's slaughter occurred at the Flor da Serra slaughterhouse, located in the city of Campo Grande, MS, considering all the guidelines that guarantee animal welfare, according to federal inspection laws.

After the evisceration and cleaning of the carcasses, the hot carcass weight (HCW) and the hot carcass yield (HCY= HCW/BW*100) were obtained. Carcasses were individually identified and transferred to a forced-air refrigeration chamber (4°C), where they remained for 24 h. After the cooling period, the cold carcasses were weighed to obtain the cold carcass weight (CCW) and to calculate the cold carcass yield (CCY = CCW/BW × 100) and the weight loss by cooling (WLC= HCW - CCW/HCW* 100) (Osório; Osório, 2005). The conformation and finishing scores of the carcasses were visually evaluated using photographic standards, with scales from one (very low) to five (very abundant) and from one (deficient) to five (excessive), respectively (Cañeque; Sañudo, 2000).

A transversal cut was made between the 12th and 13th ribs, allowing the measurement of the loin eye area in the *longissimus dorsi* muscle, which was obtained by the formula (A/2 × B/2)π proposed by Cezar and Souza (2007), where A is the maximum length and B is the maximum depth of the muscle in centimeters. The subcutaneous fat thickness was obtained with a digital caliper (ZAAS Precision) as the minimum thickness of fat covering the muscle.

Meat pH was measured in the *longissimus dorsi* muscle, with the aid of a portable digital pH meter. Meat color was measured according to the methodology described by Houben *et al.* (2000), using a colorimeter (Konica Minolta®) to evaluate the luminosity (L* 0 = black; 100 = white), the intensity of the red-green color (a*), and the intensity of the yellow-green color blue (b*) after 15 minutes of exposure of the meat surface to oxygen, with three evaluations performed per sample. Chroma (C*) and shade angle (H*) values were determined using the luminosity coordinates (L*), red content (a*), and yellow intensity (b*), obtained from colorimetric determinations (Macdougal, 1994). After performing the analyses on the meat, samples of the *longissimus dorsi* muscle was placed in plastic packaging, identified, and frozen for later laboratory analysis.

Laboratory analyses to evaluate meat quality were performed at the Bromatology Laboratory (Campus Arapongas, Unopar). The meat samples were weighted and after thawed in a domestic refrigerator to obtain the thawing loss (TL). After this, the samples were separated to carry out analyzes of water holding capacity (WHC), cooking loss (CL), and proximate analyses. WHC was measured using the pressure method, as described by Cañeque and Sañudo (2000), whereas CL was measured according to the methodology described by Fernandes *et al.* (2009).

For proximate analyses, subcutaneous fat was removed, and after the meat samples were ground in a food processor for homogenization and the samples were divided into duplicates, which were then dried in an oven at 105 °C for 24 h to reduce the humidity. The samples were then ground to determine crude protein (CP) and ether extract (EE) content according to the methodology described by AOAC (2012).

The experimental design was completely randomized in a factorial arrangement with two factors: diet with or without the food additive, and sex. Analyses of variance were performed using SAS statistical software (University Edition, SAS Institute Inc., Cary, NC, USA). The initial weight covariate was the slaughter weight variable. The assumptions of homogeneity of variance and normality of residuals were verified using the covtest homogeneity statement and Shapiro-Wilk test, respectively. The means were compared using Tukey's test. For all tests, the critical level considered was 5% probability.

3 Results and Discussion

The inclusion of the feed additive in the diet of Pantaneiro lambs finished in confinement did not influence the animals' performance (Table 2). However, there was a significant difference by sex in final weight, total weight gain, mean daily weight gain and consumption, in which the best results were obtained in males. Males had an initial weight of 20.04 kg and a final weight of 41.60 kg, which were 1.25 kg and 6.47 kg greater than those obtained in females, respectively. Furthermore, the total weight gain was also higher for males at 6.52 kg.

Table 2 - Performance variables for Pantanal lambs with or without a food additive in the diet

Variables[1]	S	Treatment		Total sex	P – value		
		Control	Food Additive		T	S	T*S
Initial BW (kg)	M	21.08 ± 5.11	18.81± 2.76	20.04 ± 4.18	0.581	0.45	0.6037
	F	19.18 ± 3.47	18.75 ± 2.56	18.78 ± 2.46			
Final BW (kg)	M	41.02 ± 1.06	42.18 ± 0.94	41.60 ± 0.70	0.1409	0.0001	0.6299
	F	34.02 ± 1.15	36.24 ± 1.15	35.13 ± 0.82			
TWG (kg)	M	21.28 ± 2.69	23.05 ± 1.36	22.24 ± 2.16	0.072	0.0001	0.8257
	F	14.60 ±3.20	16.84 ± 1.28	15.72 ±2.55			
ADG (kg/day)	M	0.25 ±0.03	0.28 ± 0.01	0.27 ±0.02	0.0736	0.0001	0.8202
	F	0.17 ± 0.03	0.20 ± 0.01	0.19 ±0.03			
LWI (% BW)	M	6.79 ± 0.94	6.88 ± 0.94	6.84± 0.92	0.3073	0.0001	0.1597
	F	5.06 ± 0.62	4.53 ± 0.54	4.80 ± 0.63			

[1]M: male; F: female; T: treatment; S: sex; BW: body weight; TWG: total weight gain; ADG: average daily weight gain; LWI: intake by live weight (% BW).
Source: research data.

The mean daily weight gain of males was 80 g greater than that of females, possibly due to the different growth physiology of males. The mean daily gain of the males was 270 g, which is higher than the value estimated by the NRC (2007) of 200 g, indicating that it underestimated the Pantaneiro males used in this study. On the other hand, the mean daily weight gain of females was 190 g, and thus female performance was lower than estimated by the NRC (2007). The mean dry matter intake was 2.04% higher in males than in females.

For HCW and CCY, males had mean values of 3.67 kg and 3.42 kg, respectively, higher than females (Table 3). On the other hand, HCY and CCY were similar for both sexes; however, for these variables, the mean values obtained in the control group were higher than that of the treatment group.

Table 3 - Carcass variables for Pantanal lambs with or without a food additive in the diet

Variables[1]	S	Treatment		Total Sex	P – value		
		Control	Food Additive		T	S	T*S
HCW (kg)	M	20.64 ± 2.89	19.33 ± 2.42	19.92 ± 2.59	0.5578	0.0037	0.5578
	F	16.25 ± 0.86	16.25 ± 2.38	16.25 ± 1.66			

Variables[1]	S	Treatment		Total Sex	P – value		
		Control	Food Additive		T	S	T*S
CCW (kg)	M	20.00 ± 2.18	17.78 ± 2.23	18.79 ± 2.39	0.2835	0.0013	0.1881
	F	15.25 ± 0.74	15.48 ± 1.75	15.36 ± 1.25			
HCY (%)	M	48.63 ± 2.88	46.07 ± 1.54	47.23 ± 2.51	0.0139	0.7661	0.7861
	F	48.60 ± 1.98	45.48 ± 2.25	47.04 ± 2.57			
CCY (%)	M	47.21 ± 1.36	42.37 ± 1.38	44.57 ± 2.84	0.0001	0.6480	0.0322
	F	45.60 ± 1.14	43.45 ± 0.69	44.53 ± 1.44			
WLC (%)	M	5.38 ± 2.34	8.01 ± 1.25	6.96 ± 2.12	0.7139	0.2152	0.0746
	F	6.10 ± 2.67	4.33 ± 3.36	5.21 ± 2.96			

[1]M: male; F: female; T: treatment; S: sex; HCW: hot carcass weight; CCW: cold carcass weight; HCY: hot carcass yield; CCY: cold carcass yield; WLC: weight loss on cooling.
Source: research data.

No significant differences were found for conformation, fat finishing, subcutaneous fat thickness, and loin eye area (Table 4) for groups of animals supplemented with food additives and between sexes. In Pantaneiro sheep, the ideal fat thickness has not yet been determined, but according to Osório and Osório (2001), for each carcass weight that exists, adequate fat thickness can vary from 2 to 5 mm. Therefore, the means in this study were within this range and can be considered as an adequate amount of fat.

Table 4 - Subjective and objective measurements of the carcass and proximate composition of the meat for Pantanal lambs with or without a food additive in the diet

Variables[1]	S	Treatment		Total Sex	P – value		
		Control	Food Additive		T	S	T*S
Conformation[2]	M	4.80 ± 1.64	3.83 ± 1.16	4.27 ± 1.42	0.5773	0.9273	0.3487
	F	4.25 ± 1.25	4.50 ± 1.29	4.37 ± 1.18			
Finishing[2]	M	4.00 ± 1.00	4.16 ± 0.75	4.09 ± 0.83	0.6179	0.9202	0.9202
	F	4.00 ± 0.81	4.25 ± 0.95	4.12 ±0.83			
SFT (mm)	M	5.26 ± 2.82	4.15 ± 1.82	4.61 ± 1.96	0.6824	0.7381	0.3651
	F	4.08 ± 0.77	4.60 ± 1.58	4.37 ± 1.60			
LEA (cm^2)	M	11.50 ± 1.45	10.67 ± 2.03	11.04 ± 1.76	0.9464	0.363	0.3796
	F	9.93 ± 1.16	10.64 ± 2.08	10.28 ± 1.76			
MC	M	72.68 ± 0.27	72.26 ± 0.65	73.00 ± 0.57	0.1789	0.0002	0.9357
	F	70.81 ± 1.23	71.32 ± 0.91	71.03 ± 1.05			
CP	M	21.79 ± 0.38	21.85 ± 0.31	21.82 ± 0.33	0.0159	0.0093	0.0077
	F	21.80 ± 0.07	20.86 ± 0.45	21.33 ± 0.58			
EE	M	11.13 ± 1.62	11.18 ± 1.41	11.16 ± 1.43	0.3690	0.0115	0.3451
	F	14.86 ± 3.71	13.02 ± 0.98	13.94 ± 2.70			

[1]M: male; F: female; T: treatment; S: sex; LEA: loin eye area; SFT: subcutaneous fat thickness; MC: moisture content; CP: crude protein; EE: ether extract. [2]Carcass conformation was on a scale from 1 (poor) to 5 (excellent); carcass finishing degree was obtained with a scale from 1 (absent fat cover) to 5 (abundant fat cover).
Source: research data.

The mean pH values measured 24 hours after slaughter (Table 5) were 5.10 to 5.19. pH measured after 24 hours of slaughter above 6.0 is related to low quality meat (YALCINTAN et al. 2017), while Gallo et al. (2019), measured pH values around 5.45, which were considered normal, as they were close to 5.5. Thus the values obtained in the present study are indicative that the pre- and post-slaughter management of farm animals in the present study was adequate. For colorimetric parameters of the meat (Table 5), differences were obtained only between sexes for the intensity of red (a*), yellow (b*), and chroma (C*). In males, the intensity of red (a*) and chroma (C*) was higher than that in females, where a* was 17.96 in males and 16.65 in females. The C* values were 21.01 for males and 19.49 for females. The values of luminosity (L*) and hue angle (H*) were similar for both treatments and sexes.

Table 5 - pH, color and water loss variables of the meat for Pantanal lambs with or without a food additive in the diet

Variables[1]	S	Treatment		Total Sex	P – value		
		Control	Food Additive		T	S	T*S
pH	M	5.15 ±0.11	5.22 ± 0.09	5.19 ± 0.10	0.7793	0.1107	0.2519
	F	5.12 ± 0.05	5.08 ± 0.13	5.10 ± 0.10			
L*	M	31.48 ± 1.68	33.98 ± 2.26	32.85 ± 2.32	0.5698	0.6689	0.1223
	F	33.98 ± 2.26	31.65 ± 1.90	32.24 ± 2.77			

Variables[1]	S	Treatment		Total Sex	P – value		
		Control	Food Additive		T	S	T*S
a*	M	17.62 ± 1.14	18.23 ± 0.99	17.96 ± 1.06	0.3392	0.0279	0.8612
	F	16.44 ± 1.27	16.86 ± 1.15	16.65 ± 1.14			
b*	M	10.10 ± 0.52	11.56 ± 0.64	10.89 ± 0.94	0.0737	0.0194	0.0042
	F	10.30 ± 062	9.90 ± 0.54	10.10 ± 0.58			
C*	M	20.32 ± 1.14	21.59 ± 1.10	21.01 ± 1.25	0.2090	0.0162	0.3136
	F	19.41 ± 1.19	19.56 ± 1.24	19.49 ± 1.13			
H*	M	30.45 ± 0.54	31.94 ± 0.52	31.28 ± 0.93	0.5479	0.5424	0.0525
	F	31.33 ± 1.83	30.45 ± 0.90	30.83 ± 1.32			
TL	M	8.53 ± 3.32	8.95 ± 2.05	8.76 ± 2.56	0.769	0.3815	0.5368
	F	8.19 ± 1.02	7.03 ± 3.65	7.61 ± 2.55			
CL	M	39.48 ± 5.89	38.88 ± 6.13	39.15 ± 5.72	0.1959	0.7913	0.2909
	F	41.40 ± 1.86	35.72 ± 3.41	38.56 ± 3.96			
WHC	M	76.71 ± 3.34	81.85 ± 3.32	79.51 ± 4.14	0.44	0.7077	0.2579
	F	80.78 ± 7.96	79.78 ± 7.77	80.28 ± 7.30			

[1]M: male; F: female; T: treatment; S: sex; L*: luminosity; a*: red-green color intensity; b*: yellow-blue color intensity; C*: chroma; H*: shade angle; TL: thawing loss; CL: cooking loss; WHC: water-holding capacity.
Source: research data.

The color of sheep meat is very important because consumers relate it to the quality of the meat, which can lead to greater acceptance or rejection of the product (Ripoll *et al*., 2018). The values observed in the present study are within the range proposed by Sañudo *et al.* (2000), of 30.0 to 49.5 for L*; 8.24 to 23.5 for a* and 3.30 to 11.1 for b*; demonstrating that the coloration presented by the product is within the requirements of the consumer.

Regarding the proximate composition of the *longissimus dorsi* muscle, the mean values obtained for males and females, respectively, were 73% and 71.03% for moisture and 21.82% and 21.33% for protein. which are consistent with the literature for lambs (Grecco *et al*., 2020). Santos *et al.* (2015), obtained mean levels of 72.12% for moisture and 22.9% for protein in lamb meat, while Grandis *et al.* (2016), obtained values of 75.56% for moisture and 20.06% for protein. However, for the ether extract, there was a difference only between sexes, with females depositing fat before males; they reach physiological maturity before males (Burin, 2016).

Bhatt *et al*. (2016) did not obtain differences in weight gain, slaughter weight and carcass characteristics in animals that received or did not receive probiotics based on *Saccharomyces cerevisiae*. On the other hand, Gloria-Trujillo *et al*. (2022) did not obtain differences in the carcass of lambs receiving different doses of probiotic based on *Saccharomyces cerevisiae*, but found a quadratic effect for daily weight gain, dry matter intake and slaughter weight of lambs. Thus, these results demonstrate that more studies are needed to understand the effect of probiotics on the performance and carcass characteristics of sheep.

4 Conclusion

Supplementation with amino acids, vitamins, prebiotics, and probiotics as a food additive in the diet of Pantaneiro lambs did not influence performance or quantitative and qualitative carcass characteristics.

Additionally, it is suggested that further studies be carried out to evaluate the role of feed additives on the digestive system of ruminants in order to elucidate its effect on performance parameters and quantitative and qualitative characteristics of carcass and meat.

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