

# Productive performance and carcass characteristics of feedlot lambs fed corn grain silage rehydrated with different solutions

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**ABSTRACT** - This study aimed to assess the productive performance and carcass characteristics of feedlot lambs fed corn grain silage rehydrated with different solutions. Twenty-eight Santa Inês ram lambs, approximately 75 days of age and with an average weight of 17.05±3.75 kg, were randomly assigned to one of four dietary treatments: dried corn grains (control); whey-rehydrated corn grain silage; water-rehydrated corn grain silage; and water + additive-rehydrated corn grain silage. For animal performance, dry matter intake, average daily weight gain, and feed conversion were evaluated. After 76 days on feedlot, with an average body weight of 31.76±3.44 kg, animals were slaughtered and carcass yield and morphometric measurements were measured. Particle size selection was evaluated by the Penn State Particle Separator for the refusals. Silage samples were also analyzed for pH, buffer capacity, and ammonia nitrogen content. Performance results were not affected by dietary treatments. On the other hand, differences were observed for dry matter intake per unit of metabolic weight, in which whey-rehydrated corn grain silage (69.58 kg/LW<sup>0.75</sup>) and dried corn grains (76.21 kg/LW<sup>0.75</sup>) exhibited the lowest intakes. The overall mean for dry matter intake was 0.949 kg/day. Since there were no differences in the results for performance and carcass characteristics of the animals among the experimental diets, the use of rehydrated silage is not recommended, as it could increase production costs when compared with dry corn grain. Regarding the lower feed intake observed when rehydrated corn grain silage with whey was used, further studies need to be carried out.

**Keywords:** byproduct, digestibility, particle selection, Santa Inês, whey

## 1. Introduction

Among the ingredients used in animal feed, corn grain is one of the most widely used energy concentrates. Although the grain is generally used unprocessed, processing can benefit its use by

animals. One way to process the grain is through rehydration and ensiling (Pereira et al., 2017), which can bring some advantages such as increasing the digestibility of the grain (Ferraretto et al., 2013; Soares et al., 2023).

Rehydrating and ensiling corn grain is a valuable alternative method when there is an overproduction, disease outbreaks, rodent infestations, mycotoxins, and other factors (Silva et al., 2024).

An alternative for rehydrating grain is whey (Oliveira et al., 2012). Whey is obtained by processing cheese and contains soluble proteins, lactose, minerals, and vitamins, which contribute to fermentation and consequently improve the nutritional value of the silage (Rezende et al., 2014). Utilizing whey also provides a solution for small dairy industries, as this co-product is usually discarded and could contaminate the environment (Souza et al., 2005).

Another alternative approach to positively modify the fermentation process is the use of inoculants. Bacterial silage inoculants enhance silage fermentation (Faustino et al., 2018).

In this study, we hypothesized that rehydrated corn grain silage would improve the utilization of the corn grain by animals, improving their performance while also providing sustainable use for whey. As such, this study aimed to assess the performance and morphometric characteristics of the carcasses of feedlot lambs fed corn grain silage rehydrated with different solutions.

## 2. Material and methods

### 2.1. Ethics committee and location

The experiment was approved by the Ethics Committee on Animal Research (CEUA) of the Universidade Estadual de Londrina (UEL) under the number 12.2022 and was conducted at the Experimental Farm Station of UEL, Londrina, Paraná State, Brazil (Lat. S. 23°20'10" and Long. W. 51°09'15") at an altitude of 610 meters (Maack, 1981).

### 2.2. Treatments and animals

The evaluated dietary treatments were: dry corn grains (DCG - control); whey-rehydrated corn grain silage (WRCS); water-rehydrated corn grain silage (WaRCS); and water + additive-rehydrated corn grain silage (Wa+ARCS) (Table 1).

Corn grains used to make the silages were of an unknown cultivar and obtained from the storage silos of the Cocamar® Cooperativa Agroindustrial in Londrina, Paraná, Brazil. The whey was obtained from Volpato® Laticínios in the city of Arapongas, Paraná, during milk processing to produce derivatives, and was then transported to the university in milk tanks and used fresh to rehydrate the grains. The dry corn grains used for silage were processed with an average particle size of 1.5 mm and rehydrated (with water or whey) until reaching a moisture content of 370 g/kg.

To obtain the desired moisture content, the methodology described by Zanin et al. (2021) was used. Thus, for silages rehydrated with water (WaRCS and Wa+ARCS), 39 L of water was added for every 100 kg of corn grain. As for WRCS, 43 kg of whey was added for every 100 kg of corn grain. The ensiled mass was packed into 250-L drum-type silos.

Due to conditions unrelated to the experiment (Covid19 pandemic), the silages had to be stored for a period of two years before being used. For the same reason, the corn grains used in the DCG treatment, despite coming from the same supplier, did not belong to the same batch as the other treatments. The DCG is a standard treatment used in the farm. All dietary treatments had similar protein and energy contents (Table 1).

For water + additive-rehydrated silage, the microbial inoculant was pre-diluted at a ratio of 2.5 mL of product per 7 L of chlorine-free water for every 20 kg of ground corn, and then manually homogenized.

**Table 1** - Ingredients and chemical composition of experimental diets

Chemical composition of the ingredients (g/kg DM)								
	DM (g/kg NM)	MM	CP	EE	NDF	ADF	TDN	pH
Corn grain	885.70	18.90	97.70	42.70	187.40	26.90	812.90	-
Soybean meal	907.00	71.10	487.80	13.80	182.60	83.80	806.50	-
WRCS	679.60	15.80	95.40	39.00	88.90	29.70	800.80	3.83
WaRCS	682.30	15.30	94.80	39.10	90.80	30.40	800.00	3.64
Wa+ARCS	689.20	15.50	94.30	39.50	90.40	29.60	800.20	3.66
Oat silage	280.70	12.20	110.00	46.30	628.00	404.20	57.58	4.2
Whey	60.00	3.40	865.00	3.50	-	-	-	6.30
Mineral salt	100.00							-
Calcitic limestone	100.00							-
Bicalcic phosphate	100.00							-
Proportion of ingredients (g/kg DM)								
Proportion according to treatments				DCG	WRCS	WaRCS	Wa+ARCS	
Corn grain				461.10	-	-	-	
Soybean meal				249.60	254.30	254.30	254.30	
Rehydrated silage				-	438.80	438.80	438.80	
Oat silage				268.70	283.60	283.60	283.60	
Mineral salt <sup>1</sup>				8.80	9.30	9.30	9.30	
Calcitic limestone				7.40	7.80	7.80	7.80	
Bicalcic phosphate				4.40	6.20	6.20	6.20	
Nutritional feed composition (g/kg DM)				DCG	WRCS	WaRCS	Wa+ARCS	
DM (g/kg NM)				619.54	537.40	538.40	540.90	
MM				29.74	28.47	28.25	28.34	
CP				196.98	197.10	196.70	196.60	
EE				33.81	33.76	33.80	33.98	
NDF				299.83	263.60	264.40	264.30	
ADF				141.94	149.00	149.30	149.00	
TDN				733.50	746.30	746.00	746.00	

DM - dry matter; NM - natural matter; MM - mineral matter; CP - crude protein; EE - ethereal extract; NDF - neutral detergent fiber; ADF - acid detergent fiber; TDN - total digestible nutrients; DCG - dried corn grain; WRCS - whey-rehydrated corn grain silage; WaRCS - water-rehydrated corn grain silage; Wa+ARCS - water + additive-rehydrated corn grain silage.

<sup>1</sup> Mineral salt (Beephós): calcium (140.00 g), cobalt (85.00 mg), sulfur (20.00 g), fluoride (65.00 g), phosphorus (65.00 g), iodine (54.00 mg), manganese (1700.00 mg), magnesium (20.00 mg), selenium (25.00 mg), sodium (170.0 g), zinc (3400.00 mg).

Whey chemical analysis was conducted according to the methodology described by Zenebon et al. (2008).

The inoculant used was Biotrato SLO<sup>®</sup> (Slo Biotecnologia & Agropecuária, Cambé, Paraná, Brazil), composed of *Propionibacterium acidipropionici*, *Lactobacillus plantarum*, *Lactobacillus acidophilus*, *Pediococcus acidilactici*, *Enterococcus faecium*, *Lactobacillus buchneri*, *Lactobacillus curvatus*, and *cellulolytic enzymes*. It has a minimum guaranteed *Lactobacillus* spp level of  $70 \times 10^9$  CFU/g and a cellulolytic enzyme complex of 8%.

Twenty-eight Santa Inês ram lambs, approximately 75 days old and with an average weight of  $17.05 \pm 3.75$  kg, were randomly assigned to one of four dietary treatments (seven lambs per treatment). Animals were allocated to individual pens (2 m<sup>2</sup>) and adapted to diets and management for 15 days. Subsequently, the trial lasted 75 days, totaling 91 days. Before the start of the trial, animals were dewormed and vaccinated against clostridial diseases.

### 2.3. Feeding management

Diets were formulated with oat silage, soybean meal, mineral salt, calcitic limestone, and bicalcic phosphate. Treatments DCG, WRCS, WaRCS and Wa+ARCS were included in the respective dietary treatments (Table 1). A total mixed ration was offered with a ratio of 28:72 (forage:concentrate) and

was formulated to meet the protein and energy requirements of the lambs for a potential gain of 300 g per day according to NRC (2007).

Animals were fed twice a day (7:00 and 17:00 h), and refusals were allowed at 10% as fed basis. Feed refusals were collected and weighted daily just before feeding at 17:00 h and adjusted every three to four days to maintain the preferred daily refusal rate of 10%. Samples of the total mixed ration, taken daily, and of the refusals were pre-dried at  $55 \pm 5$  °C and subsequently analyzed to calculate nutrient intake. Animals also had *ad libitum* access to water in each pen.

#### 2.4. Laboratory analysis

Feed and refusal samples were analyzed at the Laboratório de Nutrição Animal (LANA) of UEL. Dry matter (DM), organic matter, ether extract, and crude protein were determined following the AOAC methodology adapted by Mizubuti et al. (2009). Neutral detergent fiber (NDF) and acid detergent fiber were determined according to Detmann's methodology (2012). Total digestible nutrients (TDN) were estimated using the equation proposed by Capelle et al. (2001): TDN concentrate =  $9.6134 + 0.8294 * \text{DMD}$  ( $r^2 = 0.98$ ;  $P < 0.01$ ) and TDN Roughage =  $10.43 + 0.8019 * \text{DMD}$ , in which DMD (dry matter digestibility) =  $82.5353 - 0.3333 * \text{NDF}$  ( $r^2 = 0.87$ ;  $P < 0.05$ ).

#### 2.5. Silage characteristics

Buffer capacity (BC) and ammoniacal nitrogen ( $\text{N-NH}_3$ ) content were analyzed following the methodology proposed by Playne and McDonald (1966). Hydrogen ion potential (pH) was measured using a pH meter (AZ Temp Meter; AZ Instrument Corp.; Taichung City, Taiwan) at the time of silo opening and during the experimental period (AOAC, 2000).

#### 2.6. Particle size selectivity

Refusal samples were collected daily from each animal. Immediately after weighing the refusals, 10% of the total weight was removed. All samples were identified, stored, and refrigerated to prevent moisture loss and preserve their characteristics. At the end of each period (21 days), a composite sample was removed and homogenized, and a subsample was obtained with a standardized measure, with an average wet weight of 400 g, for particle separation.

Particle separation was performed using the Penn State Particle Separator (PSPS), which consists of four stackable sieves. Each sieve has openings that become progressively smaller towards the bottom. The bottom pan, which has no openings, stores the smallest particles. The diameter opening of the upper, middle, and lower sieves was 19, 8, and 4 mm, respectively.

Ten clockwise and counterclockwise rotations were performed for each side of the sieve. The percentage of leftover weight retained on each sieve and the mean particle size (MPS) of the refusals were calculated according to the formulas established by Heinrichs and Kononoff (2002). The particle size distribution of the total mixed ration provided to the lambs was obtained three times during the experimental period, every 21 days (Table 2), using the PSPS.

**Table 2** - Particle size of the total mixed rations provided to the lambs during the experimental period

Proportion (%)	DCG	WRCS	WaRCS	Wa+ARCS
S1	15.00	21.25	20.00	23.75
S2	26.25	26.67	30.91	23.75
S3	32.92	26.67	16.67	30.00
Bottom	25.83	25.42	25.42	22.50

DCG - dried corn grain; WRCS - whey-rehydrated corn grain silage; WaRCS - water-rehydrated corn grain silage; Wa+ARCS - water + additive-rehydrated corn grain silage; S1 - sieve 1 (18 mm); S2 - sieve 2 (8 mm); S3 - sieve 3 (4 mm).

## 2.7. Lamb performance

Dry matter intake (DMI) was measured by the difference between the amounts of feed offered and refused. Feed conversion was calculated by dividing feed intake by average daily gain.

For performance, animals were weighed at the beginning (initial weight, IW) and end (final weight, FW) (76 days) of the trial. Intermediate weightings (every 21 days) were also conducted to adjust feed provision and obtain average daily weight gains ( $ADG = (FW - IW) / \text{Days on trial}$ ). Weightings were always preceded by a 16-h fasting period.

## 2.8. Carcass analysis

Animals were fasted for 16 h and slaughtered with an average body weight of  $31.76 \pm 3.44$  kg in a state-inspected facility by cerebral concussion using a captive bolt, followed by exsanguination from the jugular vein, skinning, evisceration, and removal of the head and extremities of the limbs. The carcasses were identified, washed, weighed, and cooled in rooms at 2 °C. The carcasses were weighed immediately after slaughter (hot carcass weight, HCW) and after 24 h of cooling at 2 °C (cold carcass weight, CCW). Carcass yields were calculated as percentages of HCW and CCW in relation to live weight, and carcass cooling loss (CCL) was calculated as  $CCL (\%) = [(HCW - CCW) / HCW] * 100$  (Osório and Osório, 2005).

Carcass conformation (1 - concave to 6 - convex), and carcass fattening degree (1 - fat cover absent to 5 - abundant fat cover), were conducted based on photographic standards (Cañeque and Sañudo, 2000). Carcass length and thoracic depth, length, perimeter, and leg and arm depth were measured according to the methodology proposed by Osório and Osório (2005).

The left half carcasses were sectioned at the 12th rib level to assess the loin eye area, fat thickness, and the depth and width of the *Longissimus lumborum* muscle (Cézar and Souza, 2007).

Color was recorded 24 h after slaughter using the CIE (International Commission on Illumination) system. Lightness ( $L^*$ ), redness ( $a^*$ ), and yellowness ( $b^*$ ) were measured with a CR-10 color reader, Illuminant D65, 10° standard observer angle, 8 mm aperture size (Konica Minolta® Inc., Tokyo, Japan) after 20 min of muscle blooming. The  $a^*$  and  $b^*$  values were used to calculate the saturation index or chroma ( $c^*$ ), by the equation  $c^* = (a^{*2} + b^{*2})^{0.5}$ , and hue ( $h^*$ ) by the equation  $h^* = \tan^{-1} (b^*/a^*)$ . The meter was calibrated by scanning a standard white calibration plate, and three replicate measurements were taken at different positions on the measured surface, and their average was recorded.

## 2.9. Statistical analysis

Data were analyzed as a complete randomized design, with a fixed treatment effect (model 1), considering a 5% significance level. Differences between means were assessed by Tukey's test, using SAS software (Statistical Analysis System, version 9.4). For the traits related to animals, the experimental unit was the animal (seven per treatment); however, for the silage characteristics, the experimental unit was the silo (three per treatment).

$$Y_{ij} = \mu + T_i + \varepsilon_{ij}$$

in which  $Y_{ij}$  = observed value from the j-th observation of the i-th treatment,  $\mu$  = overall mean,  $T_i$  = fixed effect due to the i-th treatment, and  $\varepsilon_{ij}$  = random error of the j-th observation.

## 3. Results

As the lambs had similar weights at the beginning of the trial and obtained consistent ADG, the final weights remained similar and were not affected by dietary treatments ( $P > 0.05$ ; Table 3).

As there was no difference in daily DMI (kg/day) and ADG, feed conversion also did not differ, presenting an overall average of 3.0. This result is not consistent with the values observed for metabolic DMI (kg/LW<sup>0.75</sup>).

Dry matter intake (kg/LW<sup>0.75</sup>) (Table 3) showed statistical differences among dietary treatments. The lowest intake (P = 0.025) was observed for the treatment WRCS but it did not statistically differ from DCG. Similarly, DCG also did not statistically differ from the other two treatments, WaRCS and Wa+ARCS.

The results obtained in the PSPS for the proportions of different particle sizes showed statistical differences (P = 0.013) only for the sieve 3 (Table 4). The dietary treatment DCG presented the highest proportion of leftovers (30.18%). The other three treatments, which used rehydrated grain corn (WRCS, WaRCS, and Wa+ARCS), did not statistically differ from each other. The average particle size was similar in the four treatments, with an overall average of 6.74 mm.

In the fermentative analysis of the three rehydrated grain corn silages (Table 5), it was observed that rehydration with whey (WRCS) caused greater (P = 0.001) pH value (3.8). Dietary treatments that used water for rehydration did not statistically differ from each other, with values of 3.64 and 3.66 for WaRCS and Wa+ARCS, respectively.

**Table 3 - Productive performance of lambs fed dried corn grain and silages rehydrated with different solutions**

Variable	DCG	WRCS	WaRCS	Wa+ARCS	P-value
IW (kg)	17.43±1.42	16.85±1.68	16.99±1.42	16.85±1.42	0.990
FW (kg)	39.83±1.90	40.50±2.25	40.21±1.90	41.61±1.90	0.920
ADG (kg)	0.295±0.0097	0.311±0.0114	0.305±0.0097	0.326±0.0097	0.174
FCR	3.19±0.12	2.80±0.14	3.13±0.12	3.11±0.11	0.191
DMI (kg/day)	0.937±0.04	0.865±0.05	0.957±0.04	1.01±0.04	0.159
DMI (kg/LW <sup>0.75</sup> )	76.21±2.28ab	69.58±2.70b	77.61±2.28a	81.33±2.28a	0.025
DM intake (kg/100 kg LW)	3.31±0.13	3.00±0.15	3.37±0.13	3.52±0.13	0.102

DCG - dried corn grain; WRCS - whey-rehydrated corn grain silage; WaRCS - water-rehydrated corn grain silage; Wa+ARCS - water + additive-rehydrated corn grain silage; IW - initial weight; FW - final weight; ADG - average daily weight gain; FCR - feed conversion ratio; DMI - dry matter intake; LW - live weight.

a-b - Different letters in the same row indicate a difference in treatments.

**Table 4 - Leftover feeds according to the Penn State Particle Separator**

Variable	DCG	WRCS	WaRCS	Wa+ARCS	P-value
S1 (%)	26.32±3.51	31.78±3.51	33.46±3.51	36.32±3.51	0.257
S2 (%)	20.89±1.30	17.93±1.30	16.64±1.30	20.68±1.30	0.078
S3 (%)	30.18±1.51a	24.64±1.51b	26.82±1.51ab	22.86±1.51b	0.013
Bottom (%)	22.61±2.80	25.65±2.80	23.08±2.80	20.14±2.80	0.589
MPS (mm)	6.02±0.81	6.34±0.81	6.82±0.81	7.76±0.81	0.466

DCG - dried corn grain; WRCS - whey-rehydrated corn grain silage; WaRCS - water-rehydrated corn grain silage; Wa+ARCS - water + additive-rehydrated corn grain silage; S1 - sieve 1 (18 mm); S2 - sieve 2 (8 mm); S3 - sieve 3 (4 mm); MPS - mean particle size.

a-b - Different letters in the same row indicate a difference in treatments.

**Table 5 - Characteristics of corn grain silages rehydrated with different solutions**

Variable	WRCS	WaRCS	Wa+ARCS	P-value
pH	3.82±0.02a	3.64±0.02b	3.66±0.02b	0.001
BC (e.mg/100 g DM)	12.67±0.33c	16.67±0.33a	15.33±0.33b	0.0004
N-NH <sub>3</sub> (total % N)	13.02±2.60	10.07±2.60	12.86±2.60	0.681

DCG - dried corn grain; WRCS - whey-rehydrated corn grain silage; WaRCS - water-rehydrated corn grain silage; Wa+ARCS - water + additive-rehydrated corn grain silage; BC - buffer capacity; N-NH<sub>3</sub> - ammoniacal nitrogen.

a-c - Different letters in the same row indicate a difference in treatments.

For buffer capacity (Table 5), statistical differences ( $P = 0.000$ ) were observed among the three treatments, with a lower value for WRCS (12.67) and a higher value for WaRCS (16.67). The averages for  $N-NH_3$  were similar ( $P > 0.05$ ) for the three treatments.

The results obtained for HCW (17.29), CCW (16.83), hot (42.53) and cold (41.41) carcass yields, and CCL (2.65) were statistically similar ( $P > 0.05$ ) among dietary treatments (Table 6). Carcass morphometric measurements (Table 7), and measurements for the *Longissimus lumborum* characteristics (Table 8) also did not statistically differ among dietary treatments ( $P > 0.05$ ).

**Table 6 - Carcass weight (kg) and yields (%) of lambs fed dried corn grain and silages rehydrated with different solutions**

Variable	DCG	WRCS	WaRCS	Wa+ARCS	P-value
HCW (kg)	17.44±1.01	17.02±1.20	17.14±1.01	17.47±1.01	0.988
HCY (%)	43.55±0.77	41.95±0.91	42.56±0.77	41.88±0.77	0.430
CCW (kg)	17.03±0.99	16.50±1.17	16.67±0.99	17.03±0.99	0.979
CCY (%)	42.51±0.79	40.67±0.94	41.42±0.79	40.82±0.79	0.398
CCL (kg)	2.39±0.25	3.05±0.30	2.76±0.25	2.52±0.25	0.363

DCG - dried corn grain; WRCS - whey-rehydrated corn grain silage; WaRCS - water-rehydrated corn grain silage; Wa+ARCS - water + additive-rehydrated corn grain silage; HCW - hot carcass weight; HCY - hot carcass yield; CCW - cold carcass weight; CCY - cold carcass yield; CCL - carcass cooling loss.

**Table 7 - Carcass morphometric measurements of lambs fed dried corn grain and silages rehydrated with different solutions**

Variable	DCG	WRCS	WaRCS	Wa+ARCS	P-value
LEA (cm <sup>2</sup> )	12.32±0.62	11.20±0.73	11.93±0.62	11.36±0.62	0.600
ECL (cm)	58.71±1.08	59.10±1.28	59.07±1.08	58.71±1.08	0.990
RC (cm)	58.29±1.31	57.70±1.56	58.57±1.31	58.57±1.31	0.971
ICL (cm)	60.64±0.75	61.20±0.87	61.29±0.75	60.64±0.75	0.892
CW (cm)	22.21±0.65	22.84±0.77	22.57±0.65	23.24±0.65	0.726
CD (cm)	26.04±0.85	26.60±1.01	26.29±0.85	26.10±0.85	0.975
LD (cm)	9.87±0.36	9.70±0.42	9.99±0.36	9.46±0.36	0.746
LL (cm)	36.36±1.08	35.70±1.28	36.11±1.08	36.91±1.08	0.900
LC (cm)	38.71±1.07	38.30±1.26	38.71±1.07	38.43±1.07	0.991
AD (cm)	4.61±0.12	4.56±0.14	4.40±0.12	4.64±0.12	0.502
AL (cm)	18.86±0.31	18.50±0.37	19.21±0.31	18.43±0.31	0.306
AC (cm)	18.07±0.36	17.30±0.44	17.57±0.38	18.11±0.36	0.431
Conformation	2.86±0.25	2.80±0.29	2.71±0.25	2.71±0.25	0.971
Finishing	2.71±0.22	3.00±0.26	2.79±0.22	3.00±0.22	0.740

DCG - dried corn grain; WRCS - whey-rehydrated corn grain silage; WaRCS - water-rehydrated corn grain silage; Wa+ARCS - water + additive-rehydrated corn grain silage; LEA - loin eye area; ECL - external carcass length; RC - rump circumference; ICL - internal carcass length; CW - chest width; CD - chest depth; LD - leg depth; LL - leg length; LC - leg circumference; AD - arm depth; AL - arm length; AC - arm circumference.

**Table 8 - *Longissimus thoracis et lumborum* characteristics of lambs fed dried corn grain and silages rehydrated with different solutions**

Variable	DCG	WRCS	WaRCS	Wa+ARCS	P-value
L*	37.51±0.73	38.37±0.86	38.52±0.73	36.98±0.73	0.429
a*	10.98±0.66	11.30±0.79	11.56±0.66	11.01±0.66	0.918
b*	12.85±0.43	13.41±0.51	13.06±0.43	12.67±0.43	0.728
c*	23.84±1.06	24.71±1.26	24.62±1.06	23.69±1.06	0.880
h*	0.87±0.02	0.87±0.02	0.85±0.02	0.86±0.02	0.837
Degrees	40.99±0.57	41.05±0.68	40.35±0.57	40.58±0.57	0.816
pH	6.08±0.08	6.13±0.09	5.92±0.08	6.03±0.08	0.328

DCG - dried corn grain; WRCS - whey-rehydrated corn grain silage; WaRCS - water-rehydrated corn grain silage; Wa+ARCS - water + additive-rehydrated corn grain silage; L\* - lightness; a\* - green-red component; b\* - blue-yellow component; c\* - chroma; h\* - hue.

## 4. Discussion

In this study, despite the lower intake ( $\text{kg/LW}^{0.75}$ ) observed for WRCS (Table 3), none of the other variables, such as ADG and final live weight, and feed conversion were affected. The regulatory mechanism can be activated by high-digestibility diets, in which the greater the digestibility, the lower the feed intake, thereby allowing the animal to meet its energy requirements with low intake (Ferreira et al., 2013). Energy efficiency through physiological effects regulates intake, thereby favoring a reduction in feed intake, meeting the animal's nutritional requirements (Oliveira et al., 2013).

Diets containing corn grain and rehydrated silages met the nutritional requirements and/or energy demands of the animals, given that the initially stipulated weight gains (300 g per day) were observed. Even in the treatment WRCS, which showed a lower DMI per unit of metabolic weight, ADG was adequate. Their weight gains were similar to those of the other dietary treatments, with an overall mean of 0.309 kg.

The feed sorting of the animals was assessed using the PSPS, and the results showed differences only in sieve 3 (Table 4). According to Teixeira et al. (2021), the largest fraction of physically effective fiber is present in sieve 2, indicating that reducing the intake of this part is a strategy adopted by animals to decrease fiber intake. The authors reported that this strategy aims to increase concentrate intake to efficiently meet nutritional requirements in a feedlot system.

For fermentative analyses (Table 5), Silva et al. (2018) found that pH values for rehydrated silages after 120 days of ensiling were 3.91 for fine and 3.98 for coarse corn, with greater fluctuation observed in coarse corn-rehydrated silage during the assessment period. Similar values were found in the present study, with an average pH of 3.71 after two years of ensiling. The lactic acid bacteria from whey used the soluble carbohydrates from silage to grow, resulting in higher lactic acid production and a lower pH (Souza et al., 2020), compared with the standard pH range between 3.8 and 4.2.

Zanin et al. (2023), using the same silages from this experiment, observed the following pH at silo opening after 90 days of closure: 4.14 for WaRCS, 4.17 for Wa+ARCS, and 3.89 for WRCS. The BC for WRCS was 23.52, 24.15 for Wa+ARCS, and 24.18 for WRCS. Despite the slight reduction in pH and BC values after two years of ensiling, the silages remained within good standards for quality and use. The reduction in pH follows BC, given that this factor indicates the ability of the feed to withstand pH variations.

Corn exhibits favorable fermentation characteristics in reducing pH (Bolson et al., 2021). This ingredient also has an adequate concentration of soluble carbohydrates, a substrate used by lactic acid bacteria during fermentation, ensuring rapid fermentation and lower nutrient loss (Li et al., 2022).

The results for  $\text{N-NH}_3$  (Table 5) in this study corroborate with the ones published by Kung Jr et al. (2018), who classified good-quality silage when the levels of  $\text{N-NH}_3$  are below 100 g/kg. The values indicate the action of *Lactobacillus* bacteria, which allows efficient lactic acid production and inhibition of undesirable microorganisms in the fermentation process, thus preserving the nutritional value of the silage (Oliveira et al., 2021).

The dietary treatments did not affect HCW and CCW, and, consequently, carcass yields ( $P > 0.05$ ) (Table 6). Thus, rehydrated corn grain silages could be provided to feedlot lambs without affecting carcass production. The values in this study are close to those found by Batista et al. (2023), assessing diets with whole corn grain for lambs.

The results found for morphometric measurements (Table 7), as well as conformation and carcass fattening degree, are close to those reported by Grandis et al. (2016) and by Silva et al. (2024). In the study by Silva et al. (2024), Santa Inês lambs were fed rehydrated corn silage, showing no statistical differences between the levels of silage inclusion in the diet in replacement of corn grains. The values reported by the authors for a level of 1000 g/kg of DM in the diet with rehydrated corn grain silage were 2.75 for conformation and 2.75 for carcass fattening degree. Both values are very similar to the ones observed in this trial.

For external carcass length and chest depth measurements, the overall averages were 58.89 and 26.23 cm, respectively (Table 7). These results corroborate those reported by Fernandes Júnior et al. (2013). In their study, also using Santa Inês lambs, carcass length values were between 58.2 and 62.3 cm and chest depth values between 24.6 and 26.3 cm.

The averages obtained for color attributes in this study are:  $L^* = 37.80$ ,  $a^* = 11.21$ , and  $b^* = 12.97$  (Table 8), and corroborate with the results reported by Fernandes Júnior et al. (2013) using similar diets. In their study,  $L^*$  values were lighter (35.73 to 37.70),  $a^*$  redder (13.95 to 15.33), and  $b^*$  paler (10.15 to 10.9) than the ones obtained in this study. The lighter color of the meat found in both studies is explained by the high-concentrate diets. Meat color attributes are also related to the similar young age of the lambs and the feedlot feeding management system (Abreu et al., 2019).

The pH after 24 h of slaughter should not exceed 6.2, since it indicates that the meat will retain a large amount of water (Cruz et al., 2016). A comparison of the values in this study shows that the pH is below 6.2 for all dietary treatments, with an overall average of 6.04 (Table 8).

## 5. Conclusions

Given that there were no differences in the performance or carcass characteristics of the animals, the use of corn grain silage rehydrated with whey or with water plus inoculants is not recommended. However, since the use of whey in rehydration showed a decrease in feed intake without affecting weight gain, further studies using this product are recommended.

## Data availability

All data generated and analyzed during this study are included and published in the manuscript itself.

## Author contributions

**Conceptualization:** Freitas, T. C.; Bumbieris Junior, V. H. and Rodrigues, L. C. F. **Data curation:** Freitas, T. C. and Ribeiro, E. L. A. **Formal analysis:** Ribeiro, E. L. A.; Castro, F. A. B.; Paula, G. R.; Fernandes Junior, F. and Grandis, F. A. **Investigation:** Freitas, T. C.; Bumbieris Junior, V. H. and Rodrigues, L. C. F. **Methodology:** Rodrigues, L. C. F.; Paula, G. R. and Massaro Junior, F. L. **Project administration:** Massaro Junior, F. L. **Software:** Ribeiro, E. L. A. **Supervision:** Ribeiro, E. L. A.; Bumbieris Junior, V. H. and Castro, F. A. B. **Validation:** Ribeiro, E. L. A. **Visualization:** Ribeiro, E. L. A.; Castro, F. A. B.; Fernandes Junior, F. and Grandis, F. A. **Writing - review & editing:** Freitas, T. C. and Giotto, F. M.

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