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Yeast culture in the diet of feedlot steers: performance, carcass traits and feeding behavior

[*Cultura de leveduras na dieta de novilhos confinados: desempenho, características da carcaça e comportamento ingestivo*]

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ABSTRACT

This study aimed to evaluate the performance, apparent digestibility of diet, ingestive behavior which occurred in two moments, carcass traits, being evaluated constituent and non-carcass components, and also the effect the yeast culture could promote in the peripheral temperature of rumen, hull and body temperature. The diets consisted of a constant ratio of 50% forage (maize silage) and 50% concentrate. Thirty-six steers, ½ Angus Nelore, with average age of 11 months and average initial body weight of 339.5±10kg were used in the experiment. The inclusion of yeast culture promoted a higher daily dry matter intake (8.83 vs 9.35kg day^{-1}) and, consequently, a better daily weight gain (1,143 vs. 1,325kg day^{-1}) in the initial feedlot phase, with no difference in other periods. The apparent digestibility of the diet containing yeast culture was higher than the control diet (69.69 versus 68.32%, respectively), and its use did not interfere with the feeding behavior of the animals. Based on our findings, supplementation with yeast culture may bring positive results in the initial feedlot phase.

Keywords: β-glucans, animal performance, apparent digestibility, dead yeast, ingestive behavior

RESUMO

O objetivo deste estudo foi avaliar o desempenho; a digestibilidade aparente da dieta; o comportamento oral ingestivo, o qual ocorreu em dois momentos, as características de carcaça, sendo avaliados componentes integrantes e não integrantes da carcaça; bem como o efeito que a cultura de leveduras pudesse promover perante a temperatura periférica de rúmen, casco e temperatura corpórea, sendo aferida por meio da temperatura retal. As dietas foram constituídas em uma constante relação de 50% de volumoso (silagem de milho) e 50% de concentrado. Utilizaram-se no experimento 36 novilhos, ½ sangue Angus Nelore, com idade média de 11 meses e peso vivo médio inicial de 339,5 ± 10kg. O uso de cultura de leveduras promoveu maior consumo diário de matéria seca (8,83 contra 9,35 kg dia-1) e consequentemente melhor ganho de peso diário (1,143 contra 1,325kg dia-1) na fase inicial do confinamento, não havendo diferença nos demais períodos. A digestibilidade aparente da dieta que continha cultura de leveduras foi superior à da dieta controle (69,69 contra 68,32%, respectivamente), e seu uso não interferiu no comportamento ingestivo dos animais. Com base nos resultados do presente estudo, a suplementação com cultura de leveduras pode trazer resultados positivos na fase inicial de confinamento.

Palavras-chave: β-*glucanos, comportamento ingestivo, desempenho animal, digestibilidade aparente, levedura morta*

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INTRODUCTION

The use of yeasts is widespread among nutritionists worldwide, with emphasis on *Saccharomyces cerevisiae*. These feed additives are the second most commonly used additive in ruminant nutrition, less used than buffering foods. An important factor for their wide use is related to the fact that they are recognized as safe by the international regulatory agencies (GRAS status - *Generally recognized as safe*), gaining evidence in this period of scrutiny and restriction to the use of various food additives.

From the industrial autolysis of yeasts, the wall of yeasts and/or extract of yeasts is obtained by means of centrifugation and filtration. The first one has as main interest factor its ability to act as adsorbent of mycotoxins, while the yeast extracts are rich in B vitamins, amino acids, peptides, nucleotides, mananoligosaccharides and β-glucans, as well as organic acids and microminerals, giving nutritional support to the microorganisms in the rumen, potentiating the ruminal fermentation (Keller *et al*., 2012; Tun *et al*., 2015).

It has also been described that the use of yeast culture promotes aids in the stabilization of ruminal pH (Gomide, 2012), besides minimizing the intensity of inflammatory processes (Dias *et al*., 2014). Sanchez *et al*. (2015) reported improvement in productive performance and reduction of rectal temperature in dairy cows during times of heat stress. In this context, the goal of this study was to evaluate the performance, carcass traits and feeding behavior of finishing feedlot steers supplemented with yeast culture (*Saccharomyces cerevisiae*) at a dose of 7g per animal per day^{-1}.

MATERIAL AND METHODS

The experiment was carried out at the Animal Production Center (NUPRAN), Master's Degree Course in Veterinary Science, Sector of Agricultural and Environmental Sciences, Midwestern *State University* (Unicentro), located in Guarapuava, State of Paraná, Brazil. The experimental procedures were previously submitted to the Animal Ethics Committee (Ceua/Unicentro), and approved for execution under document 035/2016 from October 07, 2016.

Thirty-six intact steers, ½ Angus Nellore blood, with average initial weight of 339.5kg ± 10kg, and average initial age of 11 months, were used in the experiment. This was a randomized complete block design, consisting of two treatments: yeast culture diet (control) and yeast culture diet, where it was already included in the concentrate, (7g/animal/day^{-1}), with nine replicates, where each replicate corresponded to a pen with two animals.

The facilities were 18 feedlot pens, with an area of 15m^2 each (2.5m x 6.0m). Each pen had a concrete feeder measuring 2.30m long, 0.60m wide and 0.35m high and an automatic metal drinking fountain.

The experiment lasted 112 days, with periodic evaluations every 28 days, from the arrival of the animals to the confinement they have already been submitted to the treatment with the yeast culture in order to evaluate the animals from the arrival that is considered a stressful period until the moment that they reach the ideal weight for slaughter. The animals were fed *ad libitum* twice daily at 6:00 am and 4:00 p.m. In those moments, voluntary intake was recorded, by weighing the amount offered and the leftovers from the previous day.

Samples of corn silage and concentrate were taken to a forced air oven at 55°C for 72 hours to determine the partially dry matter content. The pre-dried samples were ground in a Wiley mill with a 1mm diameter sieve and analyzed for mineral matter content (MM), ether extract (EE) and crude protein (CP) according to techniques described in AOAC (Official…, 1995). Neutral detergent fiber (NDF) content was obtained according to the method of Van Soest *et al*. (1991) with thermostable γ-amylase and acid detergent fiber (ADF) content, according to Goering and Van Soest (1970). The total digestible nutrient (TDN) content was calculated according to the equations proposed by Weiss *et al*. (1992). For the determination of the total dry matter, samples were taken to the oven at 105ºC for 16 hours (Silva and Queiroz, 2009) and for determination of P and Ca contents, analyses were performed according to the methodology described by Tedesco *et al*., 1995.

Table 1 lists the chemical composition of the feed supplied to the animals and the mean values

of the experimental diet, based on total dry matter. The diets were composed of corn silage in a constant ratio of 50 % forage and 50 % concentrate.

The performance assessments were performed every 28 days, totalizing four evaluations. These were carried out after solid fasting for 12 hours, for the individual weighing of the animals. The variables evaluated were body weight (BW), average dry matter intake expressed in kg animal day^{-1} (DMID), percentage of body weight (DMIP), average daily weight gain (DGA, kg day^{-1}) and feeding efficiency (FE, kg day^{-1}).

Table 1. Chemical composition of feed used in animal feeding and mean values of experimental diet, based on total dry matter

Parameter	Corn silage	Concentrate	Experimental diet[1]
Dry matter,%	33.83	90.40	62.12
Mineral matter,% DM	2.51	6.36	4.44
Crude protein,% DM	8.44	20.20	14.32
Ethereal Extract,% in DM	2.65	2.05	2.35
Neutral detergent fiber,% DM	46.14	31.47	38.80
Acid detergent fiber,% DM	25.98	13.08	19.53
Lignin,% DM	8.43	4.73	6.58
Total digestible nutrients,% DM	68.66	78.68	74.17
Ca, % MS	0.14	1.67	0.91
P, % MS	0.22	0.58	0.40

[1] Premix guarantee level per kg of concentrate: vit. A: 16000IU; vit D3: 2000IU; vit. E: 25IU; S: 0.36g; Mg: 0.74g; Na: 3.6g; Co: 0.52mg; Cu: 22.01mg; F: 18.00mg; I: 1.07mg; Mn: 72.80mg; Se: 0.64mg; and Zn: 95.20mg.

DMID was measured by the difference between the daily amount of food supplied and the amount of leftovers from the previous day. DMIP was obtained by the ratio of DMID to average BW of the period, multiplied by 100. G DGA was calculated by the difference between the final (BW_f) and the initial (BW_i) BW of the experimental period divided by the evaluated days, FE was calculated by the ratio of DGA to DMID.

The analysis of the feeding behavior of the animals was performed in two moments in continuous time of 48 hours, on days 28 and 84 of the feedlot period. The observations were performed by nine observers, in shifts of 6 hours, with readings taken every 3 minutes. The data evaluated in the feeding behavior were represented by the activities of idle, rumination, water intake and food intake, expressed in hours day^{-1} and water intake, food intake, solid and liquid excretion, and xylophagy, expressed in times per day^{-1}. The digestive behavior was based on the determination of the apparent digestibility of the diet, which was performed during the evaluation of the termination of the animals in confinement.

For this, composite samplings of the diets of each treatment during the experimental period were made. Food samples were collected once a day, following the methodology of collection of two consecutive days, and stored in a freezer. After completion of the evaluation, the samples were thawed, homogenized to form a composite sample per well and treated, and stored at -15°C. The daily consumption of food and leftovers of two consecutive days (48 hours) was measured together with the total collection of feces produced by the animals from each bay.

During the apparent digestibility assay, a homogenous sample of the feces produced was collected and stored under cooling at six hour intervals. After two consecutive days of collection, these were mixed and homogenized to obtain a composite sample. The weight of the stool sample from each six hour interval was proportional to the total stool volume produced. Samples of the diets and feces were dried in a forced air oven at 55°C until constant weight.

The apparent digestibility coefficient (DC) of DM of experimental diets was determined according to the following formula: DC (%) = [(g of nutrient ingested - g of nutrient excreted) ÷ g of ingested nutrient] x 100. Measurement of the temperature of the left anterior limb (hull region) and central region on the animal rumen was performed every 7 days, at a pre-established

time (2:00p.m), using a FLUKE thermographic camera model Ti100. On the other hand, the rectal temperature was measured every 28 days, when the animals were weighed using a Bioland digital thermometer.

At the end of the feedlot period, after solid fasting for 12 hours, the animals were weighed before transportation to the slaughterhouse, obtaining the farm weight. The carcass gain in the feedlot period (CG) expressed in kg was obtained by the difference between the hot carcass weight at slaughter and the initial body weight (BW_i) of the animals under theoretical carcass yield of 50%. Based on the 112-day feedlot period, the average carcass gain (ACG), expressed in kg day^{-1}, was also calculated, which is obtained by the ratio of CG to BW, as well as the efficiency of transformation of the dry matter consumed into carcass (TEC), expressed in kg DM kg $carcass^{-1}$ and the efficiency of transformation of weight gain into carcass, which is obtained by the ratio of ACG to DGA (ACG ÷ DGA), expressed in %. For the calculations, we used the hot carcass weights.

In the carcasses, four development measures were taken: carcass length, which is the distance between the medial cranial edge of the pubic bone and the medial cranial edge of the first rib; arm length, which is the distance between the tuberosity of the olecranon and the radiocarpal joint; arm perimeter, obtained in the median region of the arm encircled with a measuring tape; and the cushion thickness, measured by means of a compass, perpendicular to the carcass length, taking the greatest distance between the cut that separates the two half carcasses and the lateral thigh muscles, according to the methodologies suggested by Muller, 1987.

At the time of slaughter, the non-carcass body parts of the slaughtered steers were also characterized by collecting the weights of the following components: head, tongue, tail, leather and legs (external components); and heart, kidneys, liver, lungs, spleen, empty rumen-reticulum, filled rumen-reticulum, and filled intestines (vital organs).

The data collected for each variable were tested by analysis of variance with a comparison of the means at 5% of significance by the F-test, through the statistical program SAS (version 6.4). The analysis of each variable followed the statistical model: $Y_{ij} = \mu + S_i + E_{ij}$; where: Y_{ij} = dependent variables; μ = Overall mean of all observations; S_i = Effect of the inactive yeast culture of order "i"; and E_{ij} = Residual random effect.

RESULTS AND DISCUSSION

From the data in Table 2, it can be seen that the addition of yeast culture promoted higher DGA (1,325 *vs* 1,143kg day^{-1}), DMID (9.35 *vs* 8.83kg day^{-1}) and DMIP (2.60 *versus* 2.49% BW) when compared to the control diet during the initial feedlot period (0 to 28 days), with no difference for FE for the same evaluation period.

This positive difference observed in the initial phase for steers supplemented with yeast culture can be justified either by the auxiliary action in the digestibility of certain nutrients or by the indirect benefits of this additive to the immune system of the animals. According to Broadway *et al*. (2015), the first days after entering the feedlot is considered very stressful, making the animals susceptible, resulting in lower rates of dry matter intake and reduced performance.

Other authors have also highlighted performance improvements of cattle in the initial phase of feedlot (Finck *et al*., 2014; Sanchez *et al*., 2015). Supported by Volman *et al*. (2008), these authors also described an increase in the immune response of cattle receiving yeast culture supplement, arguing that the presence of β-glucans plays a key role in this. These inferences corroborate with the values obtained in the present study, reinforcing the efficiency that the yeast culture possesses in periods where the animals are subjected to stressful conditions, which in this case would be the arrival at the confinement.

Freitas *et al*. (2015) observed that the addition of yeast culture in the diet of dairy cows did not affect the dry matter intake, but identified an increase in the intake of non-fiber carbohydrates. As this variable was not measured in the present study, it cannot be inferred that this is the justification for our findings, but this point must be taken into consideration. The differences in performance observed only in the initial confinement period were not sufficient to extrapolate to the parameters related to final carcass gains Table 3.

Table 2. Performance of calves finished in confinement with yeast culture included in the diet

Parameters	Experimental diet		Average	P value	SEM
	Control	Yeast culture			
DGA, kg day^{-1}					
0 to 28 days	1.143 b	1.325 a	1.234	0.0515	0.0440
0 to 56 days	1.190 a	1.270 a	1.230	0.2851	0.0346
0 to 84 days	1.325 a	1.388 a	1.356	0.4591	0.0398
0 to 112 days	1.328 a	1.384 a	1.356	0.4795	0.0377
DMID, kg day^{-1}					
0 to 28 days	8.83 b	9.35 a	9.09	0.0512	0.1140
0 to 56 days	8.82 a	9.32 a	9.07	0.1107	0.1401
0 to 84 days	9.09 a	9.54 a	9.32	0.1982	0.1622
0 to 112 days	9.35 a	9.71 a	9.53	0.3220	0.1735
DMIP, % live weight					
0 to 28 days	2.49 b	2.60 a	2.55	0.0594	0.0301
0 to 56 days	2.38 a	2.48 a	2.43	0.1665	0.0309
0 to 84 days	2.34 a	2.42 a	2.38	0.2619	0.0321
0 to 112 days	2.29 a	2.35 a	2.32	0.4170	0.0316
FE (DGA:DMID), kg kg^{-1}					
0 to 28 days	0.129 a	0.141 a	0.135	0.1541	0.0037
0 to 56 days	0.135 a	0.135 a	0.135	0.9057	0.0027
0 to 84 days	0.146 a	0.144 a	0.145	0.8526	0.0032
0 to 112 days	0.142 a	0.142 a	0.142	0.8984	0.0029

Averages in the line, followed by different lowercase letters, differ from each other by the F Test at 5%.
SEM: Standard error of the mean.

Table 3. Mean carcass gain of finishing bulls in confinement with yeast culture included in the diet

Parameters	Experimental diet		Average	P value	SEM
	Control	Yeast culture			
CG, kg	98.6a	102.6a	100.6	0.3587	2.0631
ACG, kg day^{-1}	0.880a	0.916a	0.898	0.3573	0.0183
ACG DGA^{-1}, %	66.4a	66.9a	66.7	0.8128	1.0654
TEC, kg of DM kg of carcass^{-1}	10.65a	10.63a	10.64	0.9717	0.1668

Averages in the column, followed by different lowercase letters, differ from each other by the F Test at 5%. SEM: Standard error of the mean.

Thrune *et al*. (2009) emphasize that there is no conclusive evidence that yeast supplementation is beneficial at all times. These authors also report that most of the data available in the literature were generated in in vitro conditions (Lila *et al*., 2004) or for small ruminants (Brossard *et al*., 2004), but there are only few reports on performance of beef steers, hindering the exploitation of these results.

The fecal output and dry matter content of feces were not altered by the inclusion of yeast culture. However, the apparent dry matter digestibility of the diet improved significantly (69.69 % versus 68.32 %, Table 4).

This improvement in apparent digestibility may be related to the hydrolytic capacity of cellulose and hemicellulose by yeast enzymes and also for the prevention of injuries of the digestive tract due to the action of β-glucans, a component responsible for the maintenance of the immune system as mentioned above and inferred by Volman *et al*. (2008). Öhgren *et al*. (2006) characterized the corn straw as a highly fiber material, and yet they described positive results of the increase of *Saccharomyces cerevisiae* in the hydrolysis of this material.

Table 4. Stool production in kg day^{-1}, dry matter content of feces and apparent digestibility of the dry matter of the diet of finishing steers confined with yeast culture included in the diet

Parameters	Experimental diet		Average	P value	SEM
	Control	Yeast culture			
Feces production, kg NM day^{-1}	16.41 a	16.51 a	16.46	0.8813	0.4687
Dry matter of feces, %	17.69 a	17.33 a	17.51	0.1541	0.1717
Feces production, kg DM day^{-1}	2.90 a	2.85 a	2.87	0.6650	0.0788
Apparent digestibility of DM, %	68.32 b	69.69 a	69.00	0.0459	0.5595

Averages in the column, followed by different lowercase letters, differ from each other by the F Test at 5%. SEM: Standard error of the mean.

Even though the effects of yeast culture are not consistent, several modes of action have been proposed for its effects on the rumen. In a similar assay, Gomide (2012) reports that the use of this additive stimulates the development of fibrolytic bacteria, increasing the utilization of the fiber fraction of the diet, while Ponce *et al*. (2012) described an improvement in the ruminal microbiota profile of animals supplemented with yeast culture, encouraging the synthesis of microbial protein.

The results of apparent digestibility of DM in the present study are in agreement with the aforementioned statements, suggesting that this increase promoted by the addition of yeast culture in the diet provided improvements regarding the immune system and promoted good conditions in the ruminal environment.

The time spent in the activities of food intake, water intake, rumination and idle were not altered by the use of yeast culture, as well as the frequency of the same activities (Table 5). Similarly, Neumann *et al*. (2013) also showed that the inclusion of yeast in the diet for confined steers did not restrict feeding behavior.

Table 5. Ingestive behavior of bulls finished in confinement with yeast culture included in the diet

Parameters	Experimental diet		Average	P value	SEM
	Control	Yeast culture			
Consuming food, hours day^{-1}	2.98 a	3.14 a	3.06	0.5212	0.1737
Consuming water, hours day^{-1}	0.27 a	0.26 a	0.27	0.7522	0.0108
Rumination, hours day^{-1}	5.97 a	6.36 a	6.17	0.3044	0.2597
Idleness, hours day^{-1}	14.82 a	14.29 a	14.56	0.3456	0.3910
Feed, times day^{-1}	14.75 a	15.00 a	14.88	0.8579	1.1962
Water consumption, times day^{-1}	7.05 a	7.05 a	7.05	0.9999	0.3310
Solid excretions, times day^{-1}	7.25 a	7.85 a	7.55	0.4946	0.5664
Liquid excretions, times day^{-1}	5.20 a	5.80 a	5.50	0.8444	0.4924
xylophagy, times day^{-1}	4.00 a	4.35 a	4.17	0.6741	0.4601

Averages in the column, followed by different lowercase letters, differ from each other by the F Test at 5%. SEM: Standard error of the mean.

In some studies, yeast cultures increased dry matter intake Lehloenya *et al*. (2008), while others showed increased production performance (Zimbelman *et al*., 2013). However, assays that associate performance and behavioral assessments are scarce, making it difficult to obtain more information.

Analyzing Table 6, which shows values referring to carcass traits, it can be observed that there was a significant difference for arm perimeter, which was higher in animals supplemented with yeast culture (40.83 vs 39.61cm), however, the authors believe that such result is not to the evaluations.

Table 6. Carcass characteristics of feedlot-finished steers with yeasts cuture included in the diet

Parameters	Experimental diet		Average	P value	SEM
	Control	Yeast culture			
Live weight of slaughter (kg)	485.3 a	494.3 a	489.8	0.2827	3.9041
Warm carcass weight (kg)	267.5 a	272.9 a	270.2	0.1993	1.9556
Carcass yield (%)	55.1 a	55.3 a	55.2	0.8132	0.2719
Fat thickness (mm)	4.91 a	5.04 a	4.97	0.6986	0.1522
Carcass length (cm)	124.50 a	126.11 a	125.31	0.1166	0.0050
Thigh thickness (cm)	20.61 a	20.22 a	20.42	0.4097	0.2232
Arm length (cm)	38.61 a	38.94 a	38.78	0.4186	0.1946
Arm perimeter (cm)	39.61 b	40.83 a	40.22	0.0113	0.1868

Averages in the column, followed by different lowercase letters differ from each other by the F Test at 5%. SEM: Standard error of the mean.

Information that can be reinforced by Ribeiro *et al*. (2004) inferring that the carcass muscularity is related to the precocity of the animals. In addition, there was no significant difference between treatments for the variables of importance to the slaughterhouse, with mean values of 489.8kg, 270.2kg, 55.2%, 4.97mm, 125.31cm, 20.42cm and 38.78cm, for body weight at slaughter, hot carcass weight, carcass yield, fat thickness, carcass length, cushion thickness and arm length, respectively.

It should be emphasized that yeast wall composition possesses the potential to adsorb mycotoxins due to their rich composition in glucans and mannans (Keller *et al*., 2012); however, along with the binding to mycotoxins, nutrients can be carried, making any result other than loss of productivity, positive, given the secondary benefits brought to animal health.

Studies carried out by Pacheco *et al*. (2005) and Neumann *et al*. (2013) show similar trends for the same variables, evidencing that the addition of yeast culture to the diet does not improve the carcass traits. The analyzed non-carcass components showed no alterations, as listed in Table 7, which is usually evidenced when the animal suffers from some metabolic injury, a fact that did not occur in the present study.

Table 7. Non-carcass yield components, expressed as percentage of live weight, of confinement-finished steers with yeast culture included in the diet

Parameters	Experimental diet		Average	P value	SEM
	Control	Yeast culture			
Vital Organs:					
Heart	0.36 a	0.34 a	0.35	0.3641	0.0075
Liver	1.06 a	0.98 a	1.02	0.3367	0.0353
Lungs	0.75 a	0.79 a	0.77	0.2075	0.0124
kidneys	0.22 a	0.23 a	0.23	0.5754	0.0073
Spleen	0.37 a	0.33 a	0.35	0.3518	0.0204
Full rumen / reticle	6.50 a	7.01 a	6.75	0.2109	0.1874
Empty rumen / reticle	1.71 a	1.83 a	1.77	0.1835	0.0412
Full Intestines	3.67 a	3.70 a	3.68	0.8727	0.0972
External Components:					
Head	2.44 a	2.37 a	2.40	0.2378	0.0261
Language	0.17 a	0.17 a	0.17	0.8337	0.0024
Leather	9.35 a	9.30 a	9.32	0.8844	0.1626
Tail	0.26 a	0.26 a	0.26	0.1981	0.0032
Legs	2.05 b	2.08 a	2.07	0.5624	0.0266

Averages in the column, followed by different lowercase letters differ from each other by the F Test at 5%. SEM: Standard error of the mean.

As an example, in a meta-analysis, Wagner *et al*. (2016) found that the use of yeast reduced hepatic abscess rates in feedlot-finished animals, thus reducing the organ weight. The intestine may also present changes, mainly caused by the type of diet, information supported by Moreno *et al*. (2011) inferring that the type of forage and its ratio in the diet mainly influences the gastrointestinal tract, since they are organs responsible for the digestion and absorption of nutrients. As the diets of this study were similar, this effect was not observed.

It has been observed and proven that the use of yeasts in the feeding of dairy cows promotes a reduction in body temperature (Yuan *et al*., 2011). Nevertheless, the short time of supplementation in finishing steers was not sufficient to cause the same response (Figure 1), and it is also indicative that the animals did not undergo insults or inflammatory reactions at the level of hull or rume, as it is known that these promote local temperature rise.

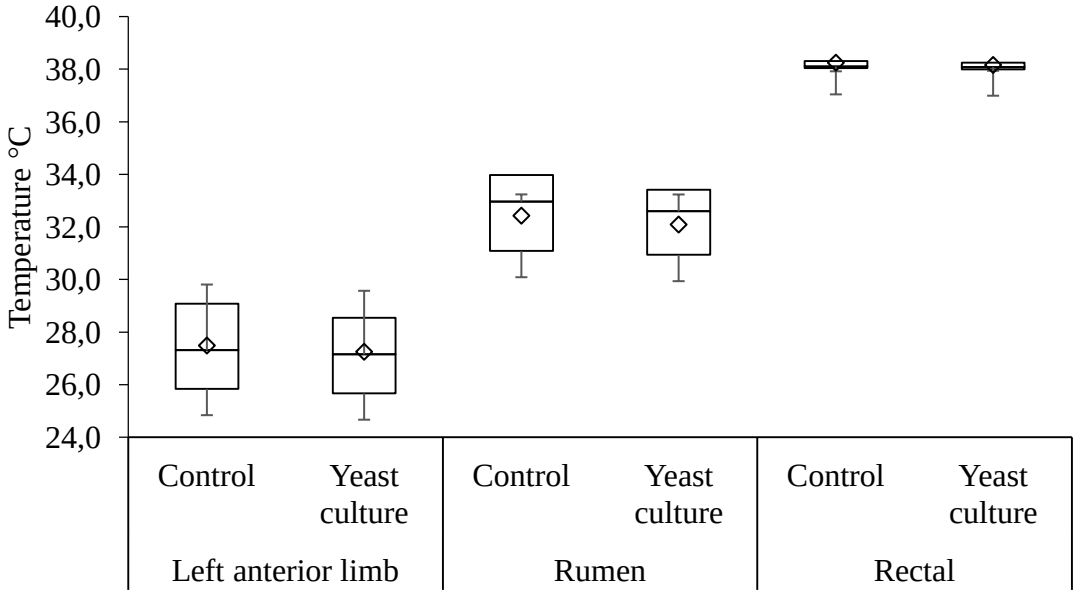

Figure 1. Boxplot of the mean temperatures of the left anterior, rumen and rectal limbs.

CONCLUSIONS

The use of yeast culture promoted greater dry matter intake and weight gain in the initial feedlot phase. The apparent digestibility of the diet containing yeast culture was higher, without interfering with the feeding behavior of the animals. These results allow to infer that the supplementation with yeast culture can bring positive results in the initial feedlot phase.

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