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Effects of including autolyzed yeast in the finishing of feedlot steers

Efeitos da inclusão de leveduras autolisadas na terminação de novilhos confinados

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Highlights

Autolyzed yeast (4 g animal day^{-1}) resulted in greater ADG in the adaptation period.
Supplementation regardless of dose did not affect ingestive behavior.
The apparent digestibility of nutrients in the diet was higher using autolyzed yeast.

Abstract

Functional additives, such as autolyzed yeasts, have been used to achieve greater production efficiency and animal health. These compounds are also alternatives to the use of performance-enhancing antimicrobials. The objective was to evaluate the productive performance, ingestive behavior, apparent digestibility of feed DM and the carcass characteristics of beef steers finished in feedlot receiving autolyzed yeasts in the diet. The experimental design was randomized blocks, consisting of three treatments and six repetitions, where each repetition was represented by a stall with two animals. 36 bulls, ½ Angus × ½ Nelore blood, from the same herd, with an average age of 11 months and an average body weight of ± 330 kg were used.

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The treatments were as follows: CON - yeast-free diet; Y4 - yeast diet (4 g animal day^{-1}) and Y7 - yeast diet (7 g animal day^{-1}). The product used is a functional ingredient containing the yeast *Saccharomyces cerevisiae.* The inclusion of autolyzed yeasts resulted in greater daily body weight gain and better feed conversion in the initial feedlot phase. The apparent digestibility of DM of diets containing autolyzed yeast was superior to the control diet, and its use did not interfere with the animal ingestive behavior. Supplementation with autolyzed yeasts at the inclusion level of 4 g da^{y-1} promoted better results in the finishing of feedlot steers, and that the supplemented groups (4 g animal day^{-1} and 7 g animal day^{-1}) achieved the same degree of carcass finishing, higher than the control group.
Key words: Carcass finishing. Digestibility. Food additive. Prebiotics. *Saccharomyces cerevisiae.*

Resumo

Os aditivos funcionais como as leveduras autolisadas têm sido usados com objetivo de proporcionar maior eficiência produtiva e saúde animal. Tais compostos são também alternativas ao uso de antimicrobianos melhoradores do desempenho. Objetivou-se avaliar o desempenho produtivo, o comportamento ingestivo, a digestibilidade aparente da MS da ração e as características de carcaça de novilhos de corte terminados em confinamento sob efeito da inclusão de levedura autolisada na dieta. O delineamento experimental foi em blocos casualizados, constituído de três tratamentos e seis repetições, onde cada repetição foi representada por uma baia com dois animais. Utilizou-se 36 novilhos inteiros, ½ Angus × ½ Nelore, provenientes de mesmo rebanho, com idade média de 11 meses e peso corporal médio inicial de 330 ± 9,8 kg. Os tratamentos foram assim designados: CON - dieta sem leveduras; Y4– dieta com leveduras (4 g animal dia^{-1}) e Y7 – dieta com leveduras (7 g animal dia^{-1}). O produto utilizado é um ingrediente funcional obtido a partir da levedura *Saccharomyces cerevisiae.* O uso de leveduras autolisadas promoveu maior ganho de peso corporal diário e melhor conversão alimentar na fase inicial do confinamento. A digestibilidade aparente da MS das dietas que continham levedura autolisada foi superior a dieta controle, e seu uso não interferiu no comportamento ingestivo dos animais. Pode-se concluir que a suplementação com leveduras autolisadas ao nível de inclusão de 4 g dia^{-1} determinou melhores resultados na terminação dos novilhos confinados, e que os grupos suplementados com 4 g animal dia^{-1} e 7 g animal dia^{-1} alcançaram o mesmo grau de acabamento de carcaça, superiores ao grupo controle.
Palavras-chave: Acabamento de carcaça. Aditivo alimentar. Digestibilidade. Prebióticos. *Saccharomyces cerevisiae.*

Introduction

The use of autolyzed yeasts has grown because their use does not imply the generation of residues in meat for human consumption and also, for their capacity to provide greater productive and sanitary efficiency to the herd.

Yeasts are used as a functional food additive and can be supplied as probiotics, where yeast cells are viable (Fuller, 1989), or as prebiotics, where animals are provided with some components derived from yeast cells (Mattila-Sandholm et al., 2002). The autolysis process itself favors the release of mannan oligosaccharides (MOS) and β-glucans that constitute the yeast cell wall (Song et al., 2014), as well as intracellular components, such as vitamins and nucleotides, which, according to Sauer, Mosenthin and Bauer (2011), assist in liver function and growth performance.

The autolysis process, to which yeasts are subjected, can be defined as the degradation occurring through the activation of cellular enzymes, and this process can be induced by exogenous enzymes, acids or solutions with a high concentration of salts. Regardless of the method, a product is generated that contains the intracellular and cell wall components (Hassan, 2011).

A study conducted by Neubauer et al. (2018) demonstrated that the use of autolyzed yeasts caused an increase in ruminal pH and stimulation of chewing activity, positively affecting the structure of the microbial population of cattle through the higher concentration of bacteria of the family Ruminococcus, which are mainly responsible for the degradation of the fiber portion of the diet. In addition, according to Mao, Mao, Wang, Liu and Yoon (2013), yeast compounds act as a substrate for cellulolytic bacteria.

MOS act by binding to gram-negative bacteria, preventing their colonization in the intestinal epithelium and, therefore, helping to maintain its integrity (Nocek, Holt, & Oppy, 2011). In addition, they have been shown to adsorb or bind to toxins and viruses (Vetvicka, Vannuci, & Sima, 2014). Spring, Wenk, Connolly and Kiers (2015) analyzed studies in which MOS was supplied to birds, rabbits, pigs and calves, and reported improvements in feed conversion and weight gain, in addition to reductions in mortality rates.

The efficiency of yeast supplementation for ruminants, according to López-Soto et al. (2013), varies in relation to the dose of the components used and also based on the proportion between roughage and concentrate in the diet. Armato et al. (2016) pointed out that there is a wide field of research in the search for the best way to use yeast compounds with a view to maximizing animal health and performance. Taking into account the various commercial products based on yeast and the different possibilities of combinations with other classes of additives, it becomes evident the need for studies that seek to elucidate the possible effects of a product composed solely of autolyzed yeast on the performance of feedlot steers.

In this context, the objective of this study was to evaluate the effect of a product composed of autolyzed yeasts supplemented to finishing steers, through different levels of inclusion (0, 4 and 7 g day^{-1}), on the productive performance, ingestive behavior, apparent digestibility of the diet, and carcass characteristics.

Material and Methods

The experiment was carried out at the Animal Production Center/Nucleus (NUPRAN, Núcleo de Produção Animal), with the Master's Program in Veterinary Sciences, Agricultural and Environmental Sciences Sector at the State University of the Midwest (UNICENTRO), located in Guarapuava, state of Paraná. All experimental procedures were approved by the UNICENTRO Committee for Ethical Conduct in Animal Experimentation (CEUA) (Official Letter 037/2018).

The experiment used 36 whole ½ Angus × ½ Nellore steers, with an average initial body weight of 330 ± 9.8 kg and an average initial age of 11 months, with the animals previously dewormed. The experimental design was a randomized block, consisting of three treatments: CON - yeast-free diet (control); Y4 - yeast diet (4 g animal

day^{-1}) and Y7 - yeast diet (7 g animal day^{-1}) and six repetitions. Animals were distributed in the stalls according to their average weight and phenotypic characteristics, in order to form homogeneous repetitions. Animals were assigned to the blocks according to their body weight at the onset of the experiment.

The product used was RumenYeast®, composed of 100% autolyzed yeast based on *Saccharomyces cerevisiae,* from the fermentation of sugar cane, produced by the company ICC Brazil.

The experiment lasted 105 days for finishing the animals in a feedlot, with 14 days for adaptation to the diets and experimental facilities and, sequentially, three evaluation periods, two periods of 28 days and a third of 35 days. The facilities consisted of 18 feedlot stalls, in which two animals were housed in each stall, with each treatment having 6 repetitions, each repetition represented by a stall. Stalls had an area of 15 m^2 (2.5 m x 6.0 m), a concrete feeder measuring 2.30 m long, 0.60 m wide and 0.35 m deep, and a metal drinking fountain regulated by float.

Feed was supplied twice a day, at 06h: 00 a.m. and at 17 h: 30 p.m. s a total mixed ration (TMR). Diets consisted of 5% pre-dried ryegrass, 35% corn silage and 60% commercial concentrate, on a dry basis. The concentrate was prepared in the commercial feed factory of Cooperativa Agrária (Guarapuava, state of Paraná, Brazil), formulated based on soybean meal, soybean hull, malt root, ground corn, calcite limestone, dicalcium phosphate, common salt, livestock urea and vitamin-mineral premix.

Voluntary feed intake was recorded daily by weighing the amount offered and the leftovers from the previous day, considering daily consumption adjustment, in order to keep the leftovers at 5% dry matter (DM). Additives were weighed and pre-mixed in concentrate, distributed over the total diet at the meal time, in order to guarantee the ingestion of the additive in its entirety. The control diet received only 50 g ground concentrate.

In order to adjust the supply of the diet, samples of the pre-dried ryegrass, corn silage and concentrate were taken weekly to a forced-air oven at 55 °C for 72 hours to determine the partially dry matter. By determining the partial DM, it was possible to adjust the food supply.

Subsequently, pre-dried samples were ground in a Wiley mill with a 1-mm sieve and subsequently sent for chemical analysis. From the pre-dried food samples, the levels of mineral matter (MM), ether extract (EE) and crude protein (CP) were determined according to Association of Official Analytical Chemists [AOAC] (1995). The contents of neutral detergent fiber (NDF) were obtained according to Van Soest, Robertson and Lewis (1991), using thermostable α-amylase, and the contents of acid detergent fiber (ADF) and lignin (LIG), according to Goering and Van Soest (1970). The contents of total digestible nutrients (TDN) were calculated according to the equations proposed by Weiss, Conrad and Pierre (1992). To determine the total DM, samples were taken to an oven at 105ºC for 4 hours (Silva & Queiroz, 2009), and to determine the levels of P and Ca, analyses were performed according to the methodology described by Tedesco, Gianello, Bissani, Bohnen and Volkweiss (1995). Table 1 lists the chemical composition of ingredients used for animal feeding and the mean values of the experimental diet, on a total DM basis.

Table 1
Chemical composition of ingredients used in animal feed and mean values of the experimental diet, on a total dry matter basis

Parameter	Pre-dried ryegrass	Corn silage	Concentrate[1]	Experimental diet
Dry matter, % NM	57.35	40.63	90.40	71.33
Mineral matter, % DM	5.59	2.51	6.36	4.97
Crude protein, % DM	12.43	8.44	20.20	15.70
Ether extract, % DM	3.28	2.65	2.05	2.32
Neutral detergent fiber, % DM	48.89	46.14	31.47	37.48
Acid detergent fiber, % DM	37.89	25.98	13.08	18.84
Lignin, % DM	6.90	3.43	4.73	4.38
Total digestible nutrients, % DM	54.74	68.66	78.68	73.98
Ca, % DM	0.58	0.14	1.67	1.08
P, % DM	0.26	0.22	0.58	0.44

[1]Guarantee level of the mineral-vitamin premix per kg concentrate: vit. A: 16,000 IU; vit D3: 2,000 IU; vit. E: 25 IU; S: 0.36 g; Mg: 0.74 g; Na: 3.6 g; Co: 0.52 mg; Cu: 22.01 mg; F: 18.00 mg; I: 1.07 mg; Mn: 72.80 mg; Se: 0.64 mg; and Zn: 95.20 mg.

Performance evaluations were carried out in the adaptation phase of animals to the feedlot and, sequentially, in the three evaluation periods. Before the adaptation period, animals were already consuming corn silage and concentrate. When starting to adapt to the experimental conditions, animals suffered stress due to the transport and the formation of new lots. Therefore, in addition to adapting to diets, supplementation with yeasts was expected to minimize animal stress, improving animal performance. Variables evaluated were body weight (BW), average dry matter intake, expressed in animal kg^{-1} day^{-1} (DDMI) and as a percentage of body weight day^{-1} (DMIP), average daily weight gain (ADG, kg day^{-1}) and feed conversion (FC, kg kg^{-1}). Individual weighings of the animals were carried out after fasting for solids for 10 hours.

DDMI was measured by the difference between the daily amount of food provided and the amount of leftovers from the previous day. DMIP was obtained by the ratio of DDMI to the average BW of the period, multiplied by 100 [DMIP = (DDMI÷BW)*100]. ADG was calculated by the difference between the final (BWf) and initial (BWi) BW of the experimental period divided by the days (D) evaluated [ADG = (BWf-BWi) ÷ D]. FC was obtained by the ratio of DDMI to ADG (FC = DDMI ÷ ADG).

Ingestive behavior was analyzed according to the methodology described by Santos (2019), being carried out in two periods in a continuous time of 48 hours, at the end of the first to the second (1st period, starting on the 42nd and ending on the day 44 of the experiment) and at the end of the second to the third feedlot period (2nd period, starting on the 70th and ending on the 72nd of the experiment), beginning at 12 noon on the first day and ending at 12 noon hours of the third evaluation day (at each period). Observations were made by six observers per shift lasting 6 hours, with readings taken at regular intervals

of 3 minutes. The results of ingestive behavior, represented by the activities of idle, rumination, food and water intake, were expressed in hours day^{-1}. The frequency of non-ingestive oral behavior (NIOB), food, water intake, liquid excretion and defecation were also observed, following the same methodology, expressed in number of times day^{-1}.

The apparent digestibility of the diet was also evaluated at the end of the first and third evaluation periods, with the first period, starting on day 42 and ending on day 44 of the experiment, and the second period, starting on day 70 and ending on day 72 of the experiment, following the methodology of Santos (2019). For this, diet composite samples were made for each treatment during the experimental period. Food collections were carried out once a day, on two consecutive days, and were freeze-stored. After the end of the evaluation, samples were thawed, homogenized to form a composite sample, by stall and treatment, being stored at -15°C.

Together, the daily intake of food and leftovers for two consecutive days (48 hours) was measured, together with the total collection of feces produced by animals in each stall, using scrapers and metal shovels, being stored in identified plastic bags. During the apparent digestibility test, a homogeneous sample of 500 g feces produced was collected from the stall and stored under cooling at -15°C, at intervals of six hours. After two consecutive days of collection, these were mixed and homogenized to obtain a composite sample for laboratory analysis.

Samples of the diets and feces were dried in a forced air oven at 55 °C to constant weight. The DM of leftovers and feces from each experimental unit were determined using the same procedures adopted in the analysis of the diet. The apparent digestibility coefficient (DMD) of the experimental diets was determined according to the following formula: DMD (%) = [(g ingested nutrient - g excreted nutrient) ÷ g ingested nutrient] x 100.

In order to assess the influence of yeast on possible inflammatory conditions or clinical signs of diseases, the temperature of the left anterior limb (hull region), central superficial skin region of the rumen and the orbit of the left eyeball of the animals was measured, twice a week, at a pre-established time (14h00) with a FLUKE® Ti100 infrared camera. At the end of each experimental period, at the time of weighing, the rectal temperature was also measured with a Bioland® digital thermometer.

At the end of the feedlot, animals were fasted for solid fast for 10 hours for weighing before shipment of the slaughterhouse, obtaining the farm body weight. The carcass gain in the confinement period (GCC) 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%. Taking the 105-day feedlot period as a basis, the average carcass gain (ACG), expressed in kg day^{-1}, was also calculated, obtained by the ratio of GCC to BW, as well as the efficiency of conversion of dry matter consumed into carcass (ECC), expressed in kg DM kg carcass^{-1} and the efficiency of conversion of weight gain into carcass, which was obtained by the ratio of ACG to ADG (ACG ÷ ADG), being expressed in %. Hot carcass weight was used for the calculations.

Four measures of development were measured in carcasses: carcass length, which is the distance from the medial cranial edge of the pubic bone to the medial cranial edge of the first rib; arm length, which is the distance

from the tuberosity of the olecranon to the radiocarpal joint; arm perimeter, obtained in the median region of the arm surrounding it with a measuring tape; and the leg thickness, measured with a compass, perpendicular to the carcass length, taking the greatest distance between the cut separating the two half carcasses and the lateral thigh muscles. The subcutaneous fat thickness on the longissimus muscle was also measured between the 12th and 13th ribs, as well as on the forequarters, rib and hindquarters, using a digital caliper, according to Muller (1987).

For parameters related to animal performance, carcass performance, carcass characteristics at slaughter and thermographic variables, the experimental design was randomized block, composed of three treatments, with six repetitions, where each repetition corresponded to a stall with two animals. Data collected for each variable were tested by analysis of variance with comparison of means by Tukey's test at 5% significance, using the statistical software Statistical Analysis System Institute [SAS Institute] (1993).

The analysis of each variable was performed using the statistical model: $Y_{ijk} = \mu + Ye_i + B_k + \mathcal{M}_{ijk}$; where: Y_{ijk} = dependent variables; μ = overall mean of all observations; Ye_i = Effect of yeast of order "i", being 1 = diet without yeast, 2 = diet with 4 g day^{-1} yeast, and 3 = diet with 7 g day^{-1} yeast; B_k = Effect of block of order "k", with 1 = first, 2 = second, 3 = third, 4 = fourth, 5 = fifth and 6 = sixth; and $_{ijk}$ = residual random error.

For the parameters of apparent digestibility and ingestive behavior of the animals, the experimental design was randomized blocks composed of three treatments, with measures evaluated in two periods, and six repetitions, where each repetition corresponded to a stall with two animals (18 sampling units). Data collected for each variable were tested by analysis of variance with comparison of means at 5% significance by Tukey's test, using the statistical software SAS Institute (1993).

The analysis of each variable was performed using the statistical model: $Y_{ijk} = \mu + Ye_i + P_j + B_k + (Ye*P)_{ij} + \mathcal{M}_{ijk}$; where: Y_{ijk} = dependent variables; μ = overall mean of all observations; L_i = Effect of yeast of order "i", being 1 = diet without yeast, 2 = diet with 4 g day^{-1} yeast, and 3 = diet with 7 g day^{-1} yeast; Pj = Effect of feedlot period of order "j", being 1 = 1st period and 2 = 2nd period; B_k = Effect of block of order "k", with 1 = first, 2 = second, 3 = third, 4 = fourth, 5 = fifth and 6 = sixth; $(Ye*P)_{ij}$ = Effect of the interaction between additive and feedlot period of order "ij" and $_{jk}$; and $\mathcal{M}_{ijk}$ = residual random error.

Results and Discussion

In Table 2, the adaptation phase of the animals to the feedlot for 14 days, yeast supplementation at a dose of 4 g day^{-1} promoted a greater (P<0.05) ADG (1.66 kg day^{-1} against 1.45 kg day^{-1}) and FC (5.58 against 6.42 kg DM ingested daily weight gain^{-1}) compared to the control diet, while supplementation with yeast at the dose of 7 g day^{-1} resulted in intermediate values and similar (P> 0.05) to the control diets or with supplementation with 4 g day^{-1}. ADG and FC of the Y7 group were not expected because autolyzed yeasts act by selecting microorganisms in depreciation of some genera that could contribute to the synthesis of fatty acids and to energy generation.

Table 2
Performance characteristics of steers finished in feedlot with or without autolyzed yeast included in the diet

Parameter[I]	Experimental feed			Mean	SEM	P-value
	Control	4 g day^{-1}	7 g day^{-1}			
ADG, kg day^{-1}						
0 to 14 days	1.452 b	1.667 a	1.536 ab	1.552	0.048	0.0266
0 to 42 days	1.220	1.304	1.248	1.257	0.060	0.7846
0 to 70 days	1.335	1.392	1.357	1.361	0.050	0.8472
0 to 105 days	1.375	1.448	1.425	1.416	0.050	0.7636
DDMI, kg day^{-1}						
0 to 14 days	9.04	8.77	8.94	8.92	0.09	0.3181
0 to 42 days	9.49	9.25	9.33	9.36	0.11	0.5836
0 to 70 days	9.65	9.42	9.40	9.49	0.12	0.5637
0 to 105 days	9.87	9.59	9.65	9.70	0.15	0.6473
DMIP, % body weight						
0 to 14 days	2.56	2.49	2.54	2.53	0.02	0.4640
0 to 42 days	2.54	2.48	2.51	2.51	0.03	0.5728
0 to 70 days	2.45	2.40	2.40	2.42	0.03	0.4900
0 to 105 days	2.36	2.29	2.30	2.32	0.02	0.4140
FC: DDMI:ADG, kg kg^{-1}						
0 to 14 days	6.42 a	5.58 b	5.99 ab	6.00	0.24	0.0496
0 to 42 days	8.02	7.67	7.94	7.88	0.36	0.8819
0 to 70 days	7.55	7.15	7.34	7.35	0.24	0.7045
0 to 105 days	7.50	6.90	7.07	7.16	0.23	0.4518

[I] ADG: average daily weight gain; DDMI: dry matter intake expressed in kg day^{-1}; DMIP: dry matter consumption expressed in 100 kg body weight; and FC: feed conversion. Mean values, in the same row, followed by different lowercase letters are significantly different by Tukey's test at 5%. SEM: standard error of the mean.

The arrival of the animals to the feedlot is considered stressful, making them susceptible to the occurrence of respiratory and metabolic problems, thereby reducing the DM intake and the performance indices of cattle (Broadway, Carroll, & Sanchez, 2015). In the present study, the action of autolyzed yeast in the adaptation period of the animals is justified because, according to Kumar, Prasad and Prasad (2013), the influence of yeasts on intestinal morphology favors greater absorption of nutrients from the diet (Spring et al., 2015). Although the Y7 group did not show a higher ADG in the adaptation, at the end of the experiment, it showed carcass quality in terms of fat coverage similar to the Y4 group, that is, the effects of supplementation with 7 g day^{-1} were observed indirectly in the course of the experiment.

According to Gifford et al. (2012), the action of MOS in the immune system and reduction of the release of pro-inflammatory cytokines that stimulate muscle catabolism as a way to supply the needs of the immune system, avoids the diversion of energy that can be directed to animal production.

Armato et al. (2016) evaluated Charolais steers with an average weight of 350 kg supplemented with yeast cell wall, a product rich in β-glucans at a dose of 25 g day^{-1}, and observed no differences in the ADG of these animals compared to the control group (1.14 kg day^{-1} versus 1.15 kg day^{-1}). Unlike the present study in which autolyzed yeasts were able to promote an increase in ADG in the adaptation period in group Y4.

Pukrop, Brennan, Funnell and Schoonmaker (2018) stated that in addition to the origin of the yeasts, the health and stress condition, to which the animals are at the moment they receive the supplementation influences its efficiency. Young et al. (2017) examined animals from different origins, and found that only animals from one of the properties showed a response to supplementation with different sources of yeast cell wall. These animals showed higher DDMI and ADG in the first 42 days. According to the authors, the fact that the animals arrived at the facilities in worse conditions, due to long-term transport, may have favored the results found. In the present study, the challenge imposed on animals during the adaptation may have provided conditions for the autolyzed yeast (4 g day^{-1}) to provide greater ADG and better FC, precisely in the period when the animals are more susceptible to fluctuations in performance.

In an experiment conducted by Salinas-Chavira et al. (2015), there was an improvement in the ADG of feedlot steers through the supply of yeast cell wall after the initial period of 139 days, which was attributed by the authors to the increase in DDMI caused by the action of the yeast. In Table 2, in the adaptation phase, the DDMI and IMSP did not vary (P> 0.05) due to the dose of inclusion of yeasts in the diet, and the greater uptake of nutrients from the diet may have provided better performance without affecting the DDMI.

When analyzing Table 3, animals that received 4 g day^{-1} autolyzed yeast showed higher (P <0.05) ADG (0.912 kg day^{-1}) and, consequently, higher CGF (95.8 kg) compared to the control diet or with the inclusion of 7 g day^{-1} autolyzed yeast. This result may be related to the greater apparent digestibility of the diet combined with the greater ADG of the Y4 group in the initial feedlot period.

Table 3
Performance in carcass production of steers finished in feedlot with or without autolyzed yeast included in the diet

Parameter[I]	Experimental feed			Mean	SEM	P-value
	Control	4 g day^{-1}	7 g day^{-1}			
ACG	0.873 b	0.912 a	0.884 b	0.890	0.028	0.0417
CGF	91.7 b	95.8 a	92.8 b	93.4	2.9	0.0490
ACG:ADG	63.7	63.2	62.0	63.0	1.3	0.8019
ECC	11.38	10.57	11.01	10.98	0.31	0.4686

[I] ACG: average carcass gain, expressed in kg day^{-1}; CGF: carcass gain in kg equivalent to the total feedlot period; ACG:ADG^{-1}, %: efficiency of conversion of weight gain into carcass; and ECC: efficiency of conversion of dry matter consumed into carcass. Mean values, in the same row, followed by different lowercase letters are significantly different by Tukey's test at 5%. SEM: standard error of the mean.

In Table 4, it can be seen that the production of feces (kg day^{-1}), both in DM and NM, and the DM content of feces did not change with the inclusion of autolyzed yeasts in the diet, which are directly related to digestibility levels. As for DMD, it improved (P <0.05) with the supplementation of autolyzed yeasts either at the inclusion dose of 4 g day^{-1} (73.96%) or 7 g day^{-1} (74.02%) compared to control diet (73.11%). On the other hand, Phillip and Iskander (2016) supplemented buffaloes in the post-weaning period with 7 g day^{-1} or 10 g day^{-1} autolyzed yeasts and reported no significant improvement in DMD and digestibility of organic matter in relation to the control group. Although the DM contents of the feces and the production of feces in NM were not influenced, the higher DMD observed in the supplemented groups was reflected in the composition of the carcasses at the end of the experiment.

Table 4
Fecal production in kg day^{-1}, natural or dry basis, dry matter content of feces and apparent digestibility of dry matter in steers finished in feedlot with autolyzed yeast included in the diet, according to the feedlot period

Experimental feed	Feedlot period[I]		Mean	SEM[II]	P-value[III]		
	Period 1	Period 2			Yeast	Period	Y × P
Fecal production, kg day NM^{-1}							
Control	13.25	14.42	13.84	0.47	0.9259	0.0496	0.6594
4 g day^{-1}	13.62	13.58	13.60				
7 g day^{-1}	13.53	14.08	13.81				
Mean	13.47 b	14.03 a					
Dry matter of feces, %							
Control	20.31	18.48	19.39	0.29	0.0759	0.1667	0.4585
4 g day^{-1}	19.87	18.86	19.36				
7 g day^{-1}	18.96	18.10	18.53				
Mean	19.71	18.48					
Fecal production, kg day DM^{-1}							
Control	2.68	2.66	2.67	0.08	0.5794	0.0725	0.7840
4 g day^{-1}	2.70	2.54	2.62				
7 g day^{-1}	2.56	2.54	2.55				
Mean	2.65	2.58					
Apparent digestibility of DM, %							
Control	73.66	72.55	73.11 B	0.58	0.0503	0.0051	0.6024
4 g day^{-1}	73.76	74.15	73.96 A				
7 g day^{-1}	74.52	73.52	74.02 A				
Mean	73.98 a	73.41 b					

[I]Period 1: experimental days 42, 43 and 44; Period 2: experimental days 70,71 and 72. [II]SEM: standard error of the mean. [III]Yeast: effect of the inclusion of yeasts; Period: effect of the period of collection; Y × P: interaction between yeast inclusion and period of collection. Means followed by different uppercase letters, in the same column, are significantly different by Tukey's test at 5%. Means followed by different lowercase letters, in the same row, are significantly different by F-test at 5%.

According to Ponce, Schutz, Elrod, Anele and Galyean (2012), the yeast extract stimulates the development of ruminal microbial flora, which favors the digestion of dietary fiber. The autolysis process that yeasts pass through favors the availability of malate for microorganisms (Ungerfeld & Forster, 2011). This component is readily captured by ruminal bacteria and favors the sequestration of H2 from the medium, which is intended for reactions that will convert malate into propionate. In this way, there is an improvement in the use of energy from organic matter that is fermented in the rumen (Carro, López, Valdés, & Ovejero, 1999), factors that may be responsible for the improvement of DMD verified in the treatments that received the yeasts.

Morrison, Dawson and Carson (2010) also justified the improvement of DMD of the diet due to the impact that components of the yeast cell wall have on the bovine immune system. The factors mentioned above can work together, especially at times that generate stress to animals, as observed in the adaptation period, where the action of yeasts in the immune system combined with the balance of microbial flora favored the greater productive efficiency of the Y4 group.

In the comparison between the feedlot periods, regardless of the presence of yeast, there was an increase in the production of fresh feces (13.47 against 14.03 kg day NM-1) and reduction ($P<0.05$) of DMS (73.98% against 73.41%) with the advance of the feedlot period, due to the growth physiology of cattle. This may also be related to the greater action of yeast in the initial feedlot period, as according to Frizzo et al. (2011), vitamins, enzymes and some unidentified cofactors contained in yeast cells may be responsible for increasing the digestion rate and the performance of growing animals.

The results of the ingestive behavior (Table 5) show that the times spent in food and water intake, rumination and idle were not altered ($P> 0.05$) with the supplementation of autolyzed yeast. Freitas et al. (2011) inferred that autolyzed yeast does not cause restriction on the feeding that could alter their consumption rhythm.

Table 5
Ingestive behavior (hours day^{-1}) of steers finished in feedlot with autolyzed yeast included in the diet, according to the feedlot period

Experimental feed	Feedlot period[I]		Mean	SEM[II]	P-value[III]		
	Period 1	Period 2			Yeast	Period	Y × P
Feeding, hours day^{-1}							
Control	2.28	2.50	2.39	0.15	0.4417	0.3062	0.2487
4 g day^{-1}	2.56	2.10	2.33				
7 g day^{-1}	2.75	2.44	2.60				
Mean	2.65	2.27					
Water intake, hours day^{-1}							
Control	0.12	0.25	0.19	0.02	0.8223	0.0064	0.6357
4 g day^{-1}	0.13	0.25	0.19				
7 g day^{-1}	0.14	0.19	0.17				
Mean	0.13 b	0.22 a					
Rumination, hours day^{-1}							
Control	4.93	5.03	4.98	0.22	0.3214	0.6049	0.8095
4 g day^{-1}	5.55	5.33	5.44				
7 g day^{-1}	5.23	4.93	5.08				
Mean	5.39	5.13					
Idle, hours day^{-1}							
Control	16.74	16.24	16.49	0.27	0.4095	0.6110	0.3429
4 g day^{-1}	15.74	16.19	15.97				
7 g day^{-1}	15.94	16.48	16.21				
Mean	15.84	16.34					

[I]Period 1: experimental days 42, 43 and 44; Period 2: experimental days 70,71 and 72.
[II]SEM: standard error of the mean.
[III]Yeast: effect of the inclusion of yeasts; Period: effect of the period of collection; Y × P: interaction between yeast inclusion and period of collection.

When evaluating the ingestive behavior, expressed in frequency of activities in times day^{-1} (Table 6), in the same way, it can be observed that there was no difference (P> 0.05) between the treatments and the experimental periods for the evaluated parameters.

Table 6
Ingestive behavior, represented by the frequency of activities developed (times day^{-1}), of steers finished in feedlot with autolyzed yeasts included in the diet, according to the feedlot period

Experimental feed	Feedlot period[I]		Mean	SEM[II]	P-value[III]		
	Period 1	Period 2			Yeast	Period	Y × P
Feeding, times day^{-1}							
Control	14.3	17.9	16.1	0.9	0.3669	0.0059	0.7842
4 g day^{-1}	13.3	15.4	14.4				
7 g day^{-1}	13.9	17.7	15.8				
Mean	13.8 b	17.0 a					
Water intake, times day^{-1}							
Control	6.0	8.6	7.3	0.5	0.3531	0.0001	0.9055
4 g day^{-1}	5.8	8.7	7.3				
7 g day^{-1}	5.3	7.6	6.5				
Mean	5.7 b	8.3 a					
Defecation, times day^{-1}							
Control	5.5	6.7	6.1	0.4	0.4257	0.0748	0.5568
4 g day^{-1}	6.0	8.2	7.1				
7 g day^{-1}	6.8	7.2	7.0				
Mean	6.1	7.4					
Liquid excretions, times day^{-1}							
Control	4.3	7.8	6.1	0.4	0.9483	0.0001	0.7572
4 g day^{-1}	4.6	7.7	6.2				
7 g day^{-1}	4.7	7.1	5.9				
Mean	4.5 b	7.5 a					
Non-ingestive oral behavior, times day^{-1}							
Control	4.8	4.0	4.4	0.3	0.8389	0.0210	0.5745
4 g day^{-1}	4.9	4.1	4.5				
7 g day^{-1}	5.1	3.3	4.2				
Mean	4.9 a	3.8 b					

[I]Period 1: experimental days 42, 43 and 44; Period 2: experimental days 70,71 and 72.
[II]SEM: standard error of the mean.
[III]Yeast: effect of the inclusion of yeasts; Period: effect of the period of collection; Y × P: interaction between yeast inclusion and period of collection.

Table 7 lists the quantitative carcass results, showing a difference (P <0.05) for fat thickness, which is higher in animals supplemented with autolyzed yeasts at doses of 4 and 7 g day^{-1}, compared to the control diet. (4.75 mm). This shows that autolyzed yeast was able to promote a uniform subcutaneous fat deposition regardless of the level of inclusion of the additive, which is a determining factor in carcass quality and also provides greater financial return to the farmer.

In general, for slaughter body weight, hot carcass weight, carcass yield, carcass length, leg thickness, arm length and arm perimeter, there was no difference (P> 0.05) between treatments, with mean values of 479.1 kg, 258.6 kg, 54.6%, 125.98 cm, 22.23 cm, 39.16 cm and 40.18 cm, respectively.

Table 6
Ingestive behavior, represented by the frequency of activities developed (times day^{-1}), of steers finished in feedlot with autolyzed yeasts included in the diet, according to the feedlot period

Parameter	Experimental diet			Mean	SEM	P-value
	Control	4 g day^{-1}	7 g day^{-1}			
Initial body weight (kg)	332.5	328.4	330.3	330.4	2.9	0.9788
Slaughter body weight (kg)	476.9	480.4	479.9	479.1	5.7	0.9472
Hot carcass weight (kg)	258.0	260.0	257.9	258.6	3.4	0.9423
Carcass yield (%)	54.1	54.2	53.7	54.0	0.3	0.7503
Fat thickness (mm)						
Longissimus dorsi	4.75 b	5.50 a	5.42 a	5.22	0.10	0.0151
Forequarter	3.75 b	4.58 a	4.42 a	4.25	0.25	0.0449
Rib	5.17 b	6.00 a	6.17 a	5.78	0.27	0.0432
Hindquarter	5.33 b	5.92 a	5.75 a	5.67	0.26	0.0396
Carcass length (m)	125.47	127.47	125.01	125.98	0.57	0.1248
Leg thickness (cm)	22.38	22.02	22.28	22.23	0.26	0.7642
Arm length (cm)	39.51	39.15	38.82	39.16	0.38	0.6683
Arm perimeter (cm)	39.73	40.63	40.18	40.18	0.29	0.3479

Mean values, in the same row, followed by different lowercase letters are significantly different by Tukey's test at 5%.
SEM: standard error of the mean.

In Table 8, in general, supplementation with autolyzed yeast, regardless of the level of inclusion, caused no (P> 0.05) thermographic changes corresponding to an inflammatory condition. Therefore, in this experiment we were unable to prove the action of autolyzed yeast against recurrent inflammatory cases in feedlots, such as ruminal acidosis and laminitis.

Table 6
Ingestive behavior, represented by the frequency of activities developed (times day^{-1}), of steers finished in feedlot with autolyzed yeasts included in the diet, according to the feedlot period

Parameter	Experimental diet			Mean	SEM	P-value
	Control	4 g day^{-1}	7 g day^{-1}			
Left forelimb, °C						
0 to 14 days	32.19	31.44	32.26	31.97	0.30	0.3532
15 to 42 days	31.20	31.74	31.18	31.37	0.26	0.4769
43 to 70 days	31.03	31.14	30.62	30.93	0.20	0.4113
71 to 105 days	33.77	33.54	33.60	33.64	0.13	0.6558
Left flank, °C						
0 to 14 days	35.81	35.73	35.63	35.72	0.12	0.7714
15 to 42 days	35.91	35.91	35.65	35.83	0.12	0.4923
43 to 70 days	35.49	35.67	35.45	35.53	0.17	0.7999
71 to 105 days	35.65	35.71	35.68	35.68	0.11	0.9534
Left orbital, °C						
0 to 14 days	35.00	34.88	34.65	34.84	0.21	0.7175
15 to 42 days	36.07	36.33	36.37	36.25	0.09	0.2358
43 to 70 days	36.22	36.37	36.21	36.27	0.12	0.7877
71 to 105 days	36.17	36.22	36.17	36.19	0.11	0.9645
Rectal, °C						
0 to 14 days	38.58	38.78	38.63	38.67	0.11	0.6570
15 to 42 days	38.38	38.53	38.50	38.47	0.07	0.5936
43 to 70 days	38.47	38.52	38.55	38.51	0.06	0.7850
71 to 105 days	38.84	38.83	38.93	38.87	0.10	0.7063

SEM: standard error of the mean.

Conclusions

In the adaptation period to the feedlot, animals that received 4g day^{-1} autolyzed yeast showed higher performance indices in relation to the group supplied with 7g day^{-1} and the control. In the following phases, the yeast doses did not cause a direct productive increase, and its effect was observed in the deposition of fat in the carcasses. In general, it can be inferred that supplementation with 4 g day^{-1} autolyzed yeasts led to better results in finishing feedlot steers.

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