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Saccharomyces cerevisiae as a yeast culture with a fermentation medium improves the performance of feedlot cattle

Saccharomyces cerevisiae como cultura de levedura com meio fermentativo melhora o desempenho de bovinos confinados

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Highlights

Feed digestibility increased with the inclusion of yeast culture.
Yeast culture supplementation increased animal weight gain.
Yeast culture increased feed conversion in the finishing phase.
Greater effectiveness of yeast culture occurred from 28 days of feedlot.

Abstract

Increasing the energy content of animal feed aims to enhance productive performance and improve carcass finishing. However, when randomly performed, this action can result in gastrointestinal dysfunctions that impair performance. One way to avoid such dysfunctions is to supplement the animal feed with *Saccharomyces cerevisiae* yeast. The present study aimed to evaluate the effect of *Saccharomyces cerevisiae*, as a yeast culture or autolyzed yeast, on ingestive behavior, apparent feed digestibility, productive performance, and carcass traits of feedlot finished steers. Thirty-six ½ Angus x ½ Nellore animals with 369 ± 4 kg average initial body weight were used. The experiment lasted 133 days:

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28 days for adaptation to the experimental diets and facilities, four evaluation periods, three of which with 28 days, and a fourth period with 21 days. The experimental design was a completely randomized block with three treatments and six replications. The treatments were a yeast-free diet (Control), a diet with yeast culture (7 g animal^{-1} day^{-1}), and a diet with autolyzed yeast (7 g animal^{-1} day^{-1}). The experimental diet consisted of 400 g kg^{-1} corn silage and 600 g kg^{-1} concentrate on a dry matter basis. Animals supplemented with yeast culture spent more time ruminating and showed higher apparent digestibility of dry matter (5.94 hours day^{-1} and 74.67%, respectively). Supplementation with yeast culture resulted in greater daily weight gains in animals from 0-56, 0-84, and 0-105 experimental days (1.661, 1655, and 1.667 kg day^{-1}, respectively) than animals that received autolyzed yeast, and those that received no additive, as well as feed conversion was better for these animals. Daily and experimental carcass gains were higher for animals that received yeast culture (1.119 kg day^{-1}, and 117.5 kg, respectively). Animals supplemented with yeast culture had greater fat thickness in the *Longissimus dorsi,* in the rib region, and greater subcutaneous fat gain throughout the finishing period (5.61, 6.25, and 3.04 mm, respectively). The supply of yeast culture is recommended during the finishing phase as it improves feed digestibility and promotes greater weight gain, carcass gain, and greater subcutaneous fat deposition.
Key words: Carcass traits. Feed conversion ratio. Ingestive behavior. Subcutaneous fat deposition.

Resumo

Elevar o teor energético da ração dos animais tem por intuito potencializar o desempenho produtivo e promover melhor acabamento nas carcaças. No entanto, esta ação quando realizada ao acaso pode gerar disfunções no trato gastrointestinal que comprometem o desempenho. Uma forma de evitar tais disfunções é administrar leveduras *Saccharomyces cerevisiae* de forma suplementar na ração dos animais. O objetivo do presente estudo foi avaliar o efeito do uso de *Saccharomyces cerevisiae,* como cultura de leveduras ou como levedura autolisada, no comportamento ingestivo, digestibilidade aparente da ração, desempenho produtivo e as características de carcaça de novilhos terminados em confinamento. Foram utilizados 36 animais ½ Angus x ½ Nelore com peso corporal médio inicial de 369 ± 4 kg. O experimento teve duração de 133 dias divididos em 28 dias de adaptação às rações e instalações experimentais, e quatro períodos de avaliação, sendo três períodos de 28 dias e um quarto período de 21 dias. O delineamento experimental foi de blocos inteiramente casualizados com três tratamentos e seis repetições. Os tratamentos foram: ração sem leveduras (Controle); ração com cultura de leveduras (7 g animal^{-1} dia^{-1}); e ração com levedura autolisada (7 g animal^{-1} dia^{-1}). A ração experimental foi constituída por 400 g kg^{-1} silagem de milho e 600 g kg^{-1} concentrado em base de matéria seca. Os animais suplementados com cultura de leveduras permaneceram mais tempo ruminando e apresentaram maior digestibilidade aparente da matéria seca em relação aos demais (5,94 horas dia^{-1} e 74,67%, respectivamente). O uso de cultura de leveduras promoveu maiores ganhos de peso diário de 0-56, 0-84 e de 0-105 dias (1,661, 1655 e 1,667 kg dia^{-1}, respectivamente) em relação aos animais que receberam levedura autolisada e aos que não receberam nenhum aditivo, assim como a conversão alimentar foi melhor para estes animais. Os ganhos de carcaça diário e do período experimental foram superiores para os animais que receberam cultura de leveduras em suas rações (1,119 kg dia^{-1} e 117,5 kg respectivamente). Os animais suplementados com cultura de leveduras possuíram maior espessura de gordura no Longissimus dorsi, na região do costilhar e maior ganho de gordura subcutânea ao longo

do período de terminação (5,61, 6,25 e 3,04 mm, respectivamente). O uso da cultura de leveduras na fase de terminação é recomendado, pois melhora a digestibilidade da ração e promove maior ganho de peso, ganho de carcaça e maior deposição de gordura subcutânea.
Palavras-chave: Características de carcaça. Comportamento ingestivo. Conversão alimentar. Deposição de gordura subcutânea.

Introduction

Increasing the energy content and reducing the proportions of fiber in animal feed, on the one hand, aims to increase performance, on the other hand, increases the incidence of gastrointestinal disorders (Chang et al., 2015). Feeds with low fiber content can reduce ruminal pH, which alters the microbiota and promotes damage to the rumen and intestinal epithelium, causing a reduction in nutrient absorption and a drop in productive performance. With the supply of these feeds, acidotic conditions with clinical signs are not commonly observed, but subacute ruminal acidosis occurs where, in this case, the pH remains below 5.6 for short periods, modifying the microbiota and reducing the population of fibrolytic bacteria and protozoa (Xiao et al., 2016; Khalouei et al., 2020; Amin & Mao, 2021).

One way to avoid acidotic conditions and the reduction of microbiota with fibrolytic action is to include yeast in animal feed, especially Saccharomyces cerevisiae, which has benefits in modulating the ruminal environment, pH stability, and improves the profile of short-chain fatty acid production (Parapouli et al., 2020). These yeasts reduce the redox potential of the rumen due to competition for H+ ions and promote the development of a more favorable environment for fibrolytic bacteria (Noschang et al., 2019).

Yeasts are used in different ways in animal nutrition, including autolysate. In this form, the yeast culture goes through an autolysis process, which ruptures the cell wall and increases the availability of cytoplasmic content and the cell wall (Shurson, 2018). According to Neumann et al. (2020), supplementing steers with autolyzed yeast in the finishing phase improves feed digestibility and results in greater weight gain in the early feedlot phase. Volman et al. (2008) and Dias et al. (2018) reported that supplementation with autolyzed yeast reduces the ruminal concentration of lactate produced from highly fermentable feeds, and activates immune cells due to the availability of mannan oligosaccharides and β-glucans present in their cell wall.

Combined with a fermentation medium, the autolyzed yeast culture undergoes a controlled fermentation, which produces metabolites capable of stimulating the growth of ruminal microorganisms (Alves et al., 2015), mainly microorganisms that digest fiber and consume lactic acid (Wagner et al., 2016). In the study of Alves et al. (2015), 257 metabolites were found, and some compounds are related to the metabolic pathways of amino acids, carbohydrate, and fatty acid metabolism, as well as mono- and sesquiterpene biosynthesis. Yeast culture provides, in addition to yeast cells and their constituents, a rich fermentation medium (Alves et al., 2015; Shurson, 2018).

In this context, the goal was to evaluate the effect of including Saccharomyces cerevisiae as a yeast culture with a fermentation medium or as autolyzed yeast in the diet for feedlot finished steers on ingestive behavior, apparent feed digestibility, productive performance, and carcass traits of feedlot finished steers.

Material and Methods

This study was approved by the Animal Research Ethics Committee (CEUA/UNICENTRO) (Letter 011/2020) and carried out at the Animal Production Center (NUPRAN) of the State University of the Midwest (UNICENTRO), Guarapuava, state of Paraná.

Experimental design, animals, and facilities

This was a randomized block experimental design consisting of three treatments, six blocks, and six repetitions. The treatments were: (1) yeast-free diet (Control), (2) diet with yeast culture (7 g animal^{-1} day^{-1} Cultron®), and (3) diet with autolyzed yeast (7 g animal^{-1} day^{-1} Cultron Pro®). Daily doses of the yeast-containing products were administered according to the manufacturer's recommendations. The blocks were defined based on the animals' body characteristics, obtained by individual weighing, and carcass ultrasound data. The repetitions were pens containing two animals. Thirty-six whole ½ Angus x ½ Nellore animals with 369 ± 4 kg average initial body weight and an average initial age of 12 ± 2 months were used.

The facilities consisted of 18 feedlot pens, 15 m2 each (2.5 m x 6.0 m). Each pen had a concrete feeder 2.30 m long, 0.60 m wide, and 0.35 m deep, and a metal drinker regulated by an automatic float.

The distribution of animals in the experimental units was based on body weight (BW), rib eye area (REA), marbling, and rump fat thickness. The last three measurements were obtained using ultrasound (Aloka® SSD-500 Vet) consisting of an echo camera coupled to a 17 cm, 3.5 MHz probe. Images were interpreted by the laboratory responsible for ensuring data quality (Designer Genes Technology) using the "BIA/DGT Brasil" software. Marbling was assessed by means of intramuscular fat pads in the *Longissimus dorsi* and scored using increasing indices ranging from 1 (non-existent) to 5 (excessive) adapted from the system proposed by Müller (1987).

The experiment lasted 133 days for finishing cattle in feedlot: 28 days for adaptation to the experimental diets and facilities and, sequentially, four evaluation periods, three of which with 28 days, and the fourth period with 21 days. The shorter time in the last period did not harm data collection and was necessary due to a request to anticipate the slaughter of animals by seven days, as the meatpacking plant would undergo adjustments and audit by the Ministry of Agriculture, Livestock and Supply (*Ministério da Agricultura, Pecuária e Abastecimento* - MAPA). The experimental period was divided into four sub-periods to identify the moment in which supplementation with autolyzed yeast or yeast culture started to have an effect on the performance variables measured.

Experimental diets and food management

The diets consisted of 400 g kg^{-1} corn silage and 600 g kg^{-1} concentrate. To produce the concentrate, the following were used: 60 g kg^{-1} soybean meal, 100 g kg^{-1} wheat bran, 220 g kg^{-1} barley radicle, 78.7 g kg^{-1} ground corn grain, 80 g kg^{-1} ground oat grain, 280 g kg^{-1} ground barley grain, 120 g kg^{-1} corn germ, 31 g kg^{-1} calcitic limestone, 6 g kg^{-1} common salt, 16.3 g kg^{-1} livestock urea, and 8 g kg^{-1} vitamin-mineral premix. These isoprotein diets were formulated based on the Nutrient Requirements of Beef Cattle [NRC] (2016) to provide the animals with an average daily weight gain (ADG) of 1.700 kg day^{-1}.

Samples of corn silage, concentrate, and experimental diet were collected weekly during the experimental period, pooled, and homogenized, and a subsample of each food was collected and dried in a forced air oven at 55°C for 72 hours, for the determination of partial dry matter. These samples were ground in a Wiley mill with a 1 mm sieve and sent for chemical and starch analysis.

Food samples were analyzed for the contents of dry matter (DM), mineral matter (MM), ether extract (EE), and crude protein (CP) according to techniques described in Association of Official Analytical Chemists [AOAC] (1995). Neutral detergent fiber (NDF) content was obtained according to Van Soest et al. (1991) using thermostable α-amylase, and the acid detergent fiber (ADF) and lignin (LIG) contents, according to Goering and Van Soest (1970). Total digestible nutrient (TDN) content was calculated according to equations proposed by Weiss et al. (1992). The contents of P and Ca were estimated according to Tedesco et al. (1995). The starch content in the feed was determined using the enzymatic method proposed by Bach Knudsen et al. (1997).

Table 1 lists the average DM, nutrient, and energy contents of corn silage, concentrate, and experimental diet, and the composition of the food additives used, on a total DM basis.

The Cultron® product, from the Aleris Nutrition company, is characterized as a yeast culture (Saccharomyces cerevisiae) obtained from the fermentation of corn in a controlled nutrient medium for more than 24 hours, containing sugar cane molasses. This technological process concentrates and maximizes the metabolic activity of the yeast, providing an increase in the biological value of the final product. Its greatest biological value is related to the highest concentration of metabolites produced by yeast cells, among which amino acids, organic acids, and B complex vitamins stand out.

The Cultron Pro® product, also from the Aleris Nutrition company, is characterized as an autolyzed yeast (*Saccharomyces cerevisiae*) developed for ruminants, originating from the fermentation of sugar cane. It is a protein source with a high availability of cytoplasmic constituents, which contribute to fermentation processes in the rumen.

Table 1
Chemical composition of food, experimental diet, and additives used in animal feeding during the feedlot period

Parameters[1]	Silage	Concentrate[2]	Experimental diet	Cultron	Cultron Pro
Dry matter	342.2	919.7	631.0	920.0	945.0
Mineral matter	26.4	63.6	45.0	40.0	55.0
Crude protein	65.7	202.0	133.9	420.0	330.0
Ether extract	24.3	20.5	22.4	60.0	28.0
Starch	286.3	365.2	333.6	-	-
Neutral detergent fiber	453.0	314.7	383.9	-	-
Acid detergent fiber	265.7	130.8	198.3	-	-
Lignin	38.5	47.3	42.9	-	-
Total digestible nutrients	692.4	786.8	739.6	-	-
Crude fiber	-	-	-	70.0	15.0
Calcium	1.3	16.7	9.0	5.0	9.0
Phosphorus	2.5	5.8	4.2	7.0	7.0
Potassium	-	-	-	3.0	7.0
β-glucans	-	-	-	-	250.0 - 300.0
Mannan oligosaccharides	-	-	-	-	120.0 - 130.0

[1] Dry matter expressed in g/kg natural matter (NM) and others expressed in g/kg dry matter (DM)
[2] Premix guarantee level per kg of 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.

Food was provided twice a day, at 06h00 and 17h30, as a total mixed ration (TMR), with daily adjustment of the amount supplied to allow for leftovers at 5% of the total supplied, seeking to maximize the performance of the animals and avoid wasting feed. The additives were diluted and homogenized in 50 g ground concentrate and, when supplied, they were spread over the TMR, preventing them from coming into contact with the sides of the feeder. Then, this was homogenized with a superficial portion of the feed so that the animals could ingest it completely.

Ingestive behavior, apparent feed digestibility, and evaluation of productive characteristics

During the experiment, ingestive behavior was evaluated twice over a continuous period of 48 hours at the middle and end of the experiment, starting at noon on the first day and ending at noon on the third day of evaluation (at each time point). Observations were made by 27 properly trained evaluators, divided into groups of 9 evaluators so that each group evaluated the animals per 6-hour shift. There was a rotation of groups each shift, with the

recording of behavioral activities carried out at regular intervals of 3 minutes. Ingestive behavior data, represented by behaviors of idling, ruminating, drinking, and feeding, were expressed in hours day^{-1}. Furthermore, following the same methodology, the daily frequency of activities (number of events per day) of feeding, drinking, urinating, and defecating was determined. During night observation, the environment was maintained with artificial lighting, a condition that has been maintained since the arrival of the animals in the experimental area.

For the apparent feed digestibility, the daily feed intake and leftovers in the trough were measured for two consecutive days (48 hours), together with the total collection of feces produced by the animals in each pen, followed by their weighing to determine the daily fecal output. Samples of 500 g of the total feces produced at six-hour intervals were taken and stored under refrigeration. After two consecutive days of collection, they were pooled per pen, homogenized to form a composite sample, and sent for laboratory analysis. The weight of this sample was also 500g. Samples of feed, leftovers, and feces from each pen were dried in a forced air oven at 55°C to constant weight and corrected for total DM at 105°C, following the same methodology as Michels et al. (2018).

The apparent digestibility coefficient (AD) of the feed DM was determined according to the formula: AD (%) = [(g dry matter ingested - g dry matter excreted) ÷ g dry matter ingested] x 100.

Animal performance was assessed in four moments, after solid fasting for 10 hours to individually weigh the animals. The variables evaluated were BW, and dry matter intake (DMI), which was measured by the difference between the daily amount of feed supplied and feed leftovers in the trough from the previous day, expressed in kg animal^{-1} day^{-1}. DMI was also expressed in relation to the animal BW (DMI_{BW}), calculated by the equation DMI_{BW} = (DMI ÷ mean BW of the period) x 100. The ADG (kg animal^{-1} day^{-1}) was calculated by the difference between the final BW (BWf) and initial (BWi) recorded in each period divided by the days of each period (ADG = BW_f - BW_i ÷28 and/or 21). Feed conversion (FC, kg DM kg gain^{-1}) was obtained by the ratio: FC = DMI ÷ ADG.

Carcass characterization

The same ultrasound evaluations carried out at the onset of the experiment for the distribution of animals in the pens were made on the last day of the experimental period, to obtain data on REA, marbling, ratio, subcutaneous fat thickness on the Longissimus dorsi muscle, and rump fat thickness before slaughter. The increase in values of these measurements during the finishing period was calculated by the difference between the final and initial values.

Before shipment to the slaughterhouse, animals were individually weighed to obtain the farm weight. The establishment where the animals were slaughtered is registered with the Federal Inspection Service (SIF). The slaughter strictly followed good animal welfare practices, in which the animals were stunned, bled by cutting the jugular and carotid blood vessels, skinned, and eviscerated. After slaughter, carcasses were weighed to obtain the hot carcass weight (HCW).

Carcass yield (CY, %) was calculated using the ratio: CY = (HCW ÷ Farm weight) x 100. Carcass gain for the feedlot period (CG, kg^{-1}) was obtained by the difference: CG = HCW - Initial carcass weight ($ICarc_w$), which was estimated considering a theoretical carcass yield of 50% ($ICarc_w = BW_i \times 0.50$), according to the methodology described by Michels et al. (2018). Taking the period of 105 feedlot days as a basis, the average daily carcass gain (ACG, kg $animal^{-1}$ day^{-1}) was also calculated using the ratio: ACG = (CG ÷ 105). The efficiency of conversion of dry matter consumed into carcass (ECDMC, kg day^{-1}) was calculated by the ratio ECDMC = DMI ÷ ACG; and the efficiency of conversion of weight gain into carcass (ECWGC, %) was obtained by the equation ECWGC = (ACG ÷ ADG) x 100.

The subcutaneous fat thickness on the *Longissimus* dorsi muscle between the 12th and 13th ribs was also measured on the carcass, as well as in the forequarter, ribs, and hindquarter immediately after slaughter. These measurements were taken using a digital caliper (Müller, 1987).

Statistical analysis

Data were analyzed using the Statistical Analysis System (SAS) software version 9.3. The UNIVARIATE procedure was adopted to check for outliers in all variables in the database. Then, data relating to animal behavior, apparent feed digestibility, animal performance, and carcass traits were tested by ANOVA, using the GLM procedure, adopting a significance level of 5% ($P \leq 0.05$). The statistical model used was:

$$Yijk = \mu + A_i + B_j + \varepsilon_{ij};$$

where: Yij = dependent variables; μ = overall mean of all observations; Ai= Effect of additives of order "i", with 1 = control diet, 2 = diet with autolyzed yeast, and 3 = diet with yeast culture; Bk= Effect of block of order "k"; and Eij = Residual random effect. Subsequently, data were subjected to orthogonal contrast analysis with a comparison of means at 5% significance. To define the moment in which supplementation with autolyzed yeast or yeast culture began to have an effect on the performance variables, the statistical model was applied for feedlot times from 0 to 28, 0 to 56, 0 to 84, and 0 to 105 days.

Results and Discussion

Behaviors of feeding and drinking expressed in hours day^{-1} and times day^{-1} were not changed ($P>0.05$) by supplementation with different types of yeast (Table 2). The rumination time was altered ($P<0.05$), where the animals supplemented with yeast culture spent longer ruminating compared to those fed the control diet (5.94 versus 4.69 hours day^{-1}) and less time in idling (15.58 versus 16.77 hours day^{-1}), respectively.

The longer rumination time may be related to a change in the animal eating behavior, that is, it is suggested that these animals have consumed more of the fiber portion of the diet. This food fraction is directly related to the stimulus to rumination due to its greater capacity to activate mechanoreceptors located in the rumen wall (Mobiglia et al., 2013). In the present study, the longer rumination time can be characterized as beneficial, since this action promotes a reduction in the particle size of the feed ingested, increases its contact

surface, and favors bacterial colonization, which increases feed digestibility.

In fact, the apparent digestibility of dry matter improved (P<0.05) with the inclusion of yeast culture in the diet (74.67%) compared to non-inclusion (73.00%), whereas the inclusion of autolyzed yeast in the diet did not improve the apparent digestibility of dry matter (Table 2).

In addition to being a consequence of longer rumination time, better digestibility of the diet may also be related to the stability of the ruminal environment of animals fed the diet with yeast culture. This provides organic acids, B vitamins, and amino acids as a source of substrate for *Selenomonas ruminantium*, which consumes the lactic acid produced from the degradation of the feed and, thus, generates smaller variations in pH, smaller changes in the bacterial flora, and maintenance of a favorable rumen environment to the growth of protozoa and fibrolytic bacteria (Silberberg et al., 2013; Vyas et al., 2014; Geng et al., 2015; Shen et al., 2019). According to Xiao et al. (2016), the provision of yeast culture also enhances the development of papillae in the gastrointestinal tract of ruminants, increasing their absorptive area, and the use of dietary nutrients.

Table 2
Ingestive behavior in hours day-1 or times day-1, and apparent digestibility of the feed dry matter of feedlot finished steers supplemented with different types of yeast

Parameters	Experimental diet			Mean	SEM	Contrast analysis	
	Control	Yeast culture	Autolyzed yeast			Yeast culture	Autolyzed yeast
Ingestive behavior, hours day^{-1}:							
Feed intake	2.32	2.26^{NS}	2.41^{NS}	2.33	0.13	0.7980	0.4470
Water intake	0.28	0.27^{NS}	0.21^{NS}	0.25	0.02	0.8697	0.3732
Rumination	4.69	5.94*	5.04^{NS}	5.22	0.35	0.0169	0.0771
Idle	16.77	15.58*	16.41^{NS}	16.25	0.42	0.0504	0.1637
Ingestive behavior, times day^{-1}:							
Feeding	6.4	6.6^{NS}	6.3^{NS}	6.4	0.42	0.8672	0.8104
Drinking	14.1	14.7^{NS}	15.9^{NS}	14.9	1.17	0.7257	0.4688
Defecation	5.2	5.7^{NS}	5.3^{NS}	5.4	0.42	0.6898	0.7798
Urination	4.4	4.4^{NS}	4.4^{NS}	4.4	0.23	0.9615	0.9615
Apparent DM digestibility:							
Fecal output, kg day^{-1} NM	13.61	13.52^{NS}	14.23^{NS}	13.78	0.58	0.9162	0.3959
Fecal DM, %	18.06	17.90^{NS}	17.52^{NS}	17.83	0.34	0.7467	0.4253
Fecal output, kg day^{-1} DM	2.45	2.41^{NS}	2.48^{NS}	2.45	0.09	0.7689	0.6087
DM Digestibility, %	73.00	74.67*	73.18^{NS}	73.61	0.43	0.0099	0.200

Mean of each treatment compared to the control based on orthogonal contrast analysis, using the F-test, at a 5% level of probability, * P<0.05, NS: non-significant.
SEM: Standard error of the mean.

The supply of yeast culture did not change DMI but resulted in higher ADG in the evaluations of 0 to 56, 0 to 84, and 0 to 105 days, and better FC throughout the feedlot period compared to animals fed the control diet ($P<0.05$) (Table 3). The use of autolyzed yeast in the diet caused no difference ($P>0.05$) from the control diet.

Shi et al. (2019) and Olagaray et al. (2019) evaluated the DMI of lactating cows supplemented with yeast culture and, as in the present study, no significant difference was detected for this parameter. The higher ADG and better FC (Table 3) indicate a possible greater stability in the rumen environment of animals fed the diet containing yeast culture, and the greater digestibility of the dry matter of their feed (Table 2). When evaluating the performance of newly weaned beef steers, Deters et al. (2018) observed higher ADG when animals were supplemented with yeast culture.

The non-occurrence of a difference in the ADG of the animals in the early feedlot phase may be related to the time required for the ruminal environment to be completely stable following the change in diet, and for the symbiotic relationship between the microbial community and the host to be established. It is worth mentioning that before the 28-day adaptation period, the animals evaluated were on pasture.

The exact time for the bacterial community composition in finishing cattle to stabilize following a change in diet is still unknown (Qiu et al., 2019). Nevertheless, Clemmons et al. (2019) observed that the ruminal bacterial community of growing steers did not reach complete stability until eight weeks after changing the diet. Based on the results of the present study, ingestion of yeast culture via feed probably made this stabilization faster and enhanced microbial development in the rumen, and, from the second to the last experimental period, promoted better use of dietary nutrients, which resulted in greater weight gain.

Neumann et al. (2020), working with ½ Angus x ½ Nellore steers fed a diet containing or not autolyzed yeast, reported a positive difference for ADG only in the initial feedlot phase (0 to 28 days). This period is challenging, as the animals go through stress during transport from one location to another, they are not adapted to the new facilities, the management used in the feedlot, and other animals with which they will live inside the feeding pen. These factors depress the immune system and compromise production performance, so the authors related the positive result at this stage to the action that yeasts have in stimulating the immune system due to their cellular constituents (mannan oligosaccharides and β-glucans). However, these results were not evidenced in the present study.

Table 3
Dry matter intake and productive performance of feedlot finished steers supplemented with different types of yeast in the diet

Parameters	Experimental diet			Mean	SEM	Contrast analysis	
	Control	Yeast culture	Autolyzed yeast			Yeast culture	Autolyzed yeast
DM intake, kg day^{-1}:							
0 to 28 days	8.51	9.08^{NS}	8.78^{NS}	8.79	0.27	0.7979	0.3898
0 to 56 days	8.84	9.48^{NS}	9.00^{NS}	9.12	0.32	0.3762	0.6389
0 to 84 days	9.10	9.64^{NS}	9.18^{NS}	9.31	0.28	0.2712	0.4404
0 to 105 days	9.18	9.74^{NS}	9.30^{NS}	9.40	0.27	0.3124	0.3789
DM intake, % body weight:							
0 to 28 days	2.20	2.30^{NS}	2.23^{NS}	2.24	0.05	0.8833	0.1869
0 to 56 days	2.17	2.27^{NS}	2.19^{NS}	2.21	0.05	0.3019	0.4869
0 to 84 days	2.14	2.20^{NS}	2.12^{NS}	2.15	0.04	0.1870	0.2544
0 to 105 days	2.07	2.13^{NS}	2.06^{NS}	2.09	0.03	0.3136	0.1988
Average daily gain, kg day^{-1}:							
0 to 28 days	1.443	1.685^{NS}	1.500^{NS}	1.543	0.09	0.1382	0.9250
0 to 56 days	1.403	1.661*	1.476^{NS}	1.513	0.05	0.0109	0.3330
0 to 84 days	1.428	1.655*	1.494^{NS}	1.525	0.04	0.0197	0.2416
0 to 105 days	1.407	1.667*	1.476^{NS}	1.517	0.03	0.0225	0.2651
Feed conversion, kg DM kg gain^{-1}:							
0 to 28 days	6.22	5.48*	5.91^{NS}	5.87	0.31	0.0490	0.5756
0 to 56 days	6.52	5.76*	6.18^{NS}	6.16	0.19	0.0120	0.4588
0 to 84 days	6.52	5.87*	6.18^{NS}	6.19	0.25	0.0532	0.4220
0 to 105 days	6.66	5.87*	6.35^{NS}	6.29	0.18	0.0253	0.4117

Mean of each treatment compared to the control based on orthogonal contrast analysis, using the F-test, at a 5% level of probability, * P<0.05, NS: non-significant.
SEM: Standard error of the mean.

Regarding the measurements taken by ultrasound before slaughter (Table 4), the carcasses of animals fed the diet containing yeast culture and autolyzed yeast presented higher (P<0.05) REA values compared to animals fed the control diet (88.51 cm^2 and 89.59 cm^2 versus 81.92 cm^2, respectively). The subcutaneous fat thickness was greater for animals on feed with yeast culture compared to control food (8.15 mm versus 6.96 mm, respectively). As for the ratio, marbling, and rump fat thickness values, there was no significant difference (P>0.05).

Table 4
Ultrasound, performance, and finishing of carcasses of feedlot finished steers supplemented with different types of yeast in the diet

Parameters	Experimental diet			Mean	SEM	Contrast analysis	
	Control	Yeast culture	Autolyzed yeast			Yeast culture	Autolyzed yeast
Ultrasound at slaughter:							
Rib eye area, cm^2	81.92	88.51*	89.59*	86.68	1.98	0.0178	0.0167
Ratio	0.552	0.559^{NS}	0.552^{NS}	0.554	0.01	0.6839	0.6695
Marbling, score	3.58	3.58^{NS}	3.55^{NS}	3.57	0.10	1.0000	0.8917
Subcutaneous fat, mm	6.96	8.15*	7.32^{NS}	7.48	0.42	0.0581	0.3426
Rump fat, mm	10.58	11.99^{NS}	10.67^{NS}	11.08	0.51	0.1875	0.2139
Carcass performance:							
Initial body weight, kg	369.8	369.5^{NS}	372.1^{NS}	370.5	5.36	0.9756	0.8131
Slaughter weight, kg	522.2	544.5*	527.1^{NS}	531.3	9.60	0.0634	0.3792
Hot carcass weight, kg	284.1	302.3*	293.5^{NS}	293.3	5.50	0.0204	0.4345
Carcass gain, kg	99.2	117.5*	107.4^{NS}	108.1	3.98	0.0366	0.2246
Carcass yield, %	55.53	56.60^{NS}	56.55^{NS}	56.23	0.37	0.1706	0.9421
Carcass gain, kg day^{-1}	0.945	1.119*	1.023^{NS}	1.029	0.04	0.0362	0.2231
ECWGC, %	65.8	67.4^{NS}	69.9^{NS}	67.7	1.58	0.6322	0.4167
ECDMC, kg day^{-1}	9.85	8.73*	9.14^{NS}	9.24	0.26	0.0494	0.4492
Subcutaneous fat thickness:							
Longissimus dorsi, mm	4.82	5.61*	4.67^{NS}	5.03	0.18	0.0112	0.1744
Forequarter, mm	3.92	4.25^{NS}	3.67^{NS}	3.94	0.19	0.5947	0.3565
Rib, mm	5.50	6.25*	5.00^{NS}	5.58	0.22	0.0429	0.1233
Gain during the finishing period:							
Rib eye area, cm^2	17.78	22.08*	19.51^{NS}	19.79	0.65	0.0384	0.3089
Ratio	0.09	0.07^{NS}	0.07^{NS}	0.08	0.01	0.4513	0.8362
Marbling, score	0.42	0.50^{NS}	0.43^{NS}	0.45	0.05	0.4085	0.4385
Subcutaneous fat, mm	2.74	3.04*	2.79^{NS}	2.86	0.21	0.0565	0.6728
Rump fat, mm	5.15	5.72^{NS}	5.19^{NS}	5.35	0.3447	0.4191	0.4586

ECWGC: efficiency of conversion of weight gain into carcass, ECDMC: efficiency of conversion of dry matter consumed into carcass.
Mean of each treatment compared to the control based on orthogonal contrast analysis, using the F-test, at a 5% level of probability, * $P<0.05$, NS: non-significant.
SEM: Standard error of the mean.

As for carcass performance, the animals that received the diet containing yeast culture had higher slaughter weight (544.5 kg), higher HCW (302.3 kg), higher ACG (1.119 kg day^{-1}), higher CG in the total feedlot period (117.5 kg), and better ECDMC (8.73 kg day^{-1}) in relation to those fed the control diet. Animals fed the diet with autolyzed yeast showed carcass performance similar to animals fed the control feed (P>0.05).

The greater carcass gains and better ECDMC in response to the addition of yeast culture are a consequence of the better use of dietary nutrients. If the cost of this additive is affordable, greater carcass gains can guarantee greater profitability for the livestock system, since remuneration is given per kilogram of carcass sold.

The inclusion of yeast culture in the diet also improved (P<0.05) carcass finishing, providing greater fat thickness on the *Longissimus dorsi* (5.61 mm) and in the rib region (6.25 mm) compared to the carcass of animals fed the control diet. Animals that received feed with autolyzed yeast showed no improvements in these variables compared to those on the control feed.

The better carcass finishing in animals on the diet containing yeast culture may be related to the longer rumination time displayed by these animals, which made the digestibility of the feed more efficient (Table 2) since this action reduces the food particle size and favors bacterial colonization. However, colonization is affected by ruminal conditions, in which the stable ruminal environment promotes greater bacterial development, and, consequently, food colonization will also be facilitated. Importantly, the yeast culture can promote stability in the ruminal environment (Silberberg et al., 2013; Vyas et al., 2014; Geng et al., 2015; Shen et al., 2019).

When food digestibility is more intense, it increases the production of short-chain fatty acids (SCFAs) in the rumen, mainly acetic, propionic, and butyric acids, which can meet 60% to 80% of the energy requirements of ruminants (Van Soest, 2018). Some of the acetic acid and all the propionic acid produced from feed fermentation are transported to the liver (Fernandes et al., 2022). These SCFAs become precursors of glucose when entering gluconeogenesis, they stimulate the production of insulin, and when the animal is in positive energy balance, this hormone is responsible for activating lipogenesis, promoting better carcass finishing through deposition of subcutaneous fat (Gonçalves et al., 2012).

Conclusion

The addition of yeast culture with a fermentation medium to the diet was more efficient because it increased diet digestibility and animal performance from 28 days after the beginning of the feedlot period and resulted in greater fat deposition in the carcass of feedlot finished steers.

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