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Supplementation of yeast culture combined with an enzyme complex in the diet for confined steers

Suplementação de cultura de leveduras em associação com complexo enzimático na dieta de novilhos confinados

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Abstract
The objective was to evaluate the productive performance, apparent digestibility of the diet and ingestive behavior of beef cattle finished in feedlot under the effect of the inclusion of yeast culture or enzyme complex. The treatments were: diet without additives (control); diet with enzyme complex (7 g animal day-1); diet with yeast culture (7g animal day-1) and diet with the association of enzymatic complex (7 g animal day-1) and yeast culture (7g animal day-1). The experimental design was completely randomized, with five replications. Forty ½ Angus ½ Nellore steers, with an average initial body weight of 362 kg ± 6 kg, were used. Regardless of the evaluation period, non-supplementation caused the animals to gain less weight (0 to 21 days: 1.267 kg day-1; 0 to 42 days: 1.377 kg day-1; 0 to 63 days: 1.368 kg day-1) compared to supplemented animals, feed conversion for non-supplemented animals was also worse. Starch apparent digestibility showed higher averages when steers were supplemented with yeast culture alone and yeast culture combined with enzyme complex (97.30% and 97.07%, respectively). Supplementation using a combination of yeast culture with enzyme complex did not cause additional effects on weight gain, but resulted in the lowest averages for feed conversion.
Keywords: additives; diet apparent digestibility; feed conversion; weight gain.

Resumo
Objetivou-se avaliar o desempenho produtivo, digestibilidade aparente da dieta e comportamento ingestivo de bovinos de corte terminados em confinamento sob efeito da inclusão de cultura de leveduras ou de complexo enzimático. Os tratamentos foram assim constituídos: dieta sem aditivos (controle); dieta com complexo enzimático (7 g animal dia-1); dieta com cultura de levedura (7g animal dia-1) e dieta com a associação de complexo enzimático (7 g animal dia-1) e cultura de levedura (7g animal dia-1). O delineamento experimental foi o inteiramente casualizado, com cinco repetições. Utilizou-se 40 novilhos inteiros, ½ sangue Angus ½ sangue Nelore, com peso vivo médio inicial de 362 kg ± 6kg. Independente do período de avaliação, a não suplementação fez com que os animais ganhassem menos peso (0 a 21 dias: 1,267 kg dia-1; 0 a 42 dias: 1,377 kg dia-1; 0 a 63 dias: 1,368 kg dia-1) em relação aos animais suplementados, a conversão alimentar para os animais não suplementados também foi pior. A digestibilidade aparente do amido apresentou maiores médias quando os novilhos foram suplementados com cultura de levedura isolada e com cultura de levedura associada com complexo enzimático (97,30% e 97,07% respectivamente). A suplementação na forma de associação da cultura de leveduras ao complexo enzimático não apresentou efeitos adicionais sobre o ganho de peso, mas possui as menores médias para conversão alimentar.
Palavras-chave: aditivos; conversão alimentar; digestibilidade aparente da dieta; ganho de peso.

1. Introduction

Productive efficiency is closely related to the growing demand for intensive production systems in Brazilian feedlots, where high energy density diets are used, in order to obtain good results in average daily weight gain, feed efficiency, carcass finishing and quality of the final product ([1]).

The challenges in the inclusion of high energy diets, with lower forage and/or fiber contents, are related to the increased risk of gastrointestinal disorders in ruminants ([2,3]), which result in loss of nutrients in the feces and compromise the well-being of finishing animals. For this, technologies are used with the aim of improving the digestibility of foods, avoiding economic and environmental losses ([4]). Among these tools, the use of additives that modulate ruminal fermentation, such as enzymes and yeasts, has shown interesting results as possible strategies to be adopted.

Yeasts (*Saccharomyces cerevisiae*) are added to ruminant feed, positively modifying the ruminal environment and intestinal health, as it can be a source

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of various nutrients, thus promoting improved digestion and increased animal production ([5]). They come from biomass of different fermentations, such as bread making, wine, sugar cane and corn, and may also undergo different processes. They are characterized in live dry yeast, autolyzed yeast, yeast extract, cell wall and yeast culture ([6]), and all forms can be used as tools for animal nutrition, each with its specific characteristics.

The culture contains the yeast and the medium in which it was grown ([7]), and all material is dried without destroying or processing the components combined with yeast, such as B vitamins, peptides, amino acids and nucleotides ([7,8]), providing an increase in the concentration of volatile fatty acids and in the molar proportion of propionate, causing a decrease in the concentration of lactic acid in the rumen fluid and less variation in pH after meals, thus resulting in an improvement in the rumen environment ([9]), reducing the variations of the microbiota during the day, which consequently provides a productive increase.

Exogenous enzymes are also indicated as an enhancer of dietary digestibility and productive efficiency ([10]). The production of short-chain fatty acids from enzyme supplementation increases subcutaneous fat deposition, improving carcass finishing ([11]). Better feed conversion and weight gain of cattle supplemented with enzymes are indicated, but in other performance parameters there are no variations, which sharpens the search for more information on the subject ([12,13]).

Thus, the objective of this study was to evaluate the effect of supplementation with yeast culture and/or enzyme complex, alone or in combination, on the productive performance, ingestive behavior and apparent digestibility of the diet of steers finished in feedlot.

2. Material and methods

This study was approved by the Committee for Ethical Animal Experimentation (CEUA/UNICENTRO) (official letter 002/2021), and was carried out at the Animal Production Center (NUPRAN) at the Graduate Program in Veterinary Sciences from the Agricultural and Environmental Sciences Sector of the State University of the Midwest (UNICENTRO), located in the municipality of Guarapuava, state of Paraná, Brazil. The climate in the region is subtropical humid mesothermal (Cfb), without a dry season, with cool summers and mild winters. According to the Köppen classification, Guarapuava is located at an altitude of approximately 1,100 m, with an average annual rainfall of 1,944 mm, an annual average minimum temperature of 12.7ºC and an annual average maximum of 23.5ºC, with a relative humidity of 77.9%.

Forty ½ Angus ½ Nellore steers, with an average initial body weight of 362 kg ± 6 kg, and average initial age of 11 months ± 1.5 months were used. The facilities consisted of 20 feedlot pens (2 animals per pen), with an area of 15 m^2 each (2.5 m x 6.0 m). Each pen had a concrete feeder measuring 2.30 m in length, 0.60 m in width and 0.35 m in height, and a metallic drinker with automatic filling. The experimental period was 80 days, divided into 17 days for adaptation to the experimental diets and facilities and three periods of 21 days of evaluation.

The experimental design was completely randomized, consisting of four treatments, as follows: T1 – control diet (without additives); T2 – diet with enzyme complex (7 g animal day^{-1}); T3 - diet with yeast culture (7 g animal day^{-1}) and T4 - diet with the combination of enzyme complex (7 g animal day^{-1}) and yeast culture (7 g animal day^{-1}), with five replications, where each repetition corresponded to a pen with two animals (Experimental unit).

The enzyme complex Potenzya® (Safeeds – Nutrição Animal Ltda.) is composed of a combination of enzymes containing proteases, phytases and NSPases, obtained from the fermentation of *Aspergillus niger* and *Trichoderma reesei* fungi. The enzyme complex was previously analyzed for enzymatic activity, by assay with 3,5-dinitrosalicylic acid (DNS) adapted from Miller ([14]), showing activities of 3,117; 2,870; 2,210; 372; 11 and 21 U g^{-1} xylanase, cellulase, β-glucanase, mannanase, α-galactocidase and amylase, respectively. Conditions of pH and temperature of the tests: xylanase: pH 4.5 and 40ºC; cellulase: pH 4.8 and 50ºC; β-glucanase, mannanase and amylase: pH 5.0 and 40ºC; and α-galactocidase: pH 5.5 and 37°C. Cultron® (Aleris – Comércio e Exportação de Produtos para Nutrição Ltda.) is characterized as a yeast culture (*Saccharomyces cerevisiae*) obtained from fermentation in a controlled nutrient medium, containing sugarcane molasses and sequentially corn derivatives. This technological process maximizes the metabolic activity of the yeast, which increases the biological value of the final product. Its average composition is characterized by: 92% DM, 45% CP, 5% ether extract, 7% CF, 4% MM, 0.05% Ca, 0.78% P, 0.38% K, 15 to 17% β-glucans, 8 to 10% mannanoligosaccharides plus fermentation metabolites with different amino acids, vitamins, enzymes and organic acids.

Diets consisted of 45% corn silage and 55% concentrate on a dry matter basis. The concentrate was composed of 20% wheat bran, 15% malt root, 14.28% corn grains, 12% fatted corn germ, 12.20% soybean hull, 14% forage barley, 5.52% soybean meal, 3.84% calcitic limestone, 1.80% livestock urea, 0.60% common salt, and 0.76% mineral vitamin premix, whose guaranteed levels are described in Table 1. Samples of corn silage

and concentrate were collected in each experimental period and taken to a forced air oven at 55°C for 72 hours for determination of partial dry matter. The pre-dried samples were ground in a Wiley mill containing a 1 mm diameter sieve and subsequently analyzed for chemical composition.

From the pre-dried samples of corn silage and concentrate, the dry matter (DM), mineral matter (MM), ether extract (EE) and crude protein (CP) contents were determined, according to techniques described in AOAC ([15]). The content of neutral detergent fiber (NDF) was obtained according to Van Soest *et al.* ([16]) with thermostable α-amylase and acid detergent fiber (ADF) and lignin according to Goering & Van Soest ([17]). Total digestible nutrients (TDN) were calculated according to equations proposed by Weiss *et al.* ([18]). To determine the P and Ca contents, analyses were carried out according to the methodology described by Tedesco ([19]).

Starch was analyzed considering the hydrolysis of starch contained in the Hendrix sample ([20]), after extraction of soluble carbohydrates with successive washes in 80% alcohol and colorimetric analysis of reducing sugars (glucose), with subsequent conversion of the result into starch. Table 1 shows the chemical composition of the foods used in animal feed and the average values of the experimental diet, on a total dry matter basis.

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

Parameter	Corn silage	Concentrate[1]	Experimental diet
Dry matter, % NM*	35.89	91.83	66.66
Mineral matter, % DM	3.64	6.36	5.14
Crude protein, % DM	5.89	20.20	13.76
Ether extract, % DM	1.96	2.05	2.01
Starch, % DM	34.11	42.13	38.52
Neutral detergent fiber, % DM	44.06	31.47	37.14
Acid detergent fiber, % DM	22.51	13.08	17.32
Lignin, % DM	3.97	3.89	3.93
Total digestible nutrients, % DM	72.08	78.68	75.71
Ca, % DM	0.14	1.71	1.00
P, % DM	0.26	0.54	0.41

Premix guaranteed level per kg of concentrate: vit. A: 16,000 IU; vit D3: 2,000 IU; vit. E: 25 IU; S: 0.36g; Mg: 0.74g; 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; *NM: Natural Matter.

Diets were provided twice a day, at 6:00 am and 5:00 pm, as a total mixed ration (TMR). Additives were homogenized in 80 g ground concentrate to facilitate their supply on the diet at the time of each meal. Voluntary feed intake was recorded daily, by weighing the amount offered and leftovers from the previous day, considering the adjustment of daily consumption in order to keep leftovers at 5% of the total supplied.

Body weight (BW) was measured on day 0, obtaining the Initial Weight (IW), and thereafter every 21 days by weighing the animals individually, totaling four weighings in the three evaluation periods, after solid fasting for ten hours, and in the last weighing, the Final Weight (FW). The evaluated variables were average dry matter intake, expressed in kg animal day^{-1} (DMI), average dry matter intake, expressed as a percentage of body weight (DMI, % BW), average daily weight gain (ADG, kg day^{-1}) and feed conversion (FC, kg kg^{-1}). Through the IW and FW of the animals, the weight gain along the experimental period was obtained (WGP), and from the average daily gain, it was possible to estimate the time necessary for the animals to gain 100 kg body weight.

For the analysis of ingestive behavior, one animal was randomly chosen per pen, duly identified for correct observation and marking by the evaluator. This analysis was carried out in a continuous time of 48 hours, on experimental days 31, 32 and 33, such evaluation began at 12:00 on the first day and ended at 12:00 on the third day. Observations were carried out by 9 observers per shift, in a rotation system every 6 hours. Readings were taken at regular 3-minute intervals. Animal behavior data, represented by idleness, rumination, water consumption and food intake, were expressed in hours per day. On that same occasion, following the same methodology, the frequency of occurrence of feeding, watering, urination and defecation activities, expressed in number of times per day, were also observed. In the nocturnal observation, the environment was kept under artificial lighting, a condition that occurred since the arrival of the animals in the experimental unit.

Concomitant with the behavioral evaluation, the apparent digestibility of the diet was evaluated, for which the total fecal collection of each experimental unit was carried out at the end of each shift, with the aid of scrapers, during the 48 hours of evaluation, and to avoid influence of dirtiness, the pens were washed to remove any and all impurities that might interfere with the collection. Feces were weighed and sampled at each 6-hour shift, and then stored in a freezer at -18ºC until analysis. After the end of the evaluation, samples were thawed, homogenized to form a composite sample, corresponding to each experimental unit.

The daily feed intake and leftovers were measured and a sample of the diet was collected and stored in a freezer. After the end of the evaluation, samples were thawed and homogenized to form a composite sample, per pen and treatment, and stored at -15°C. Samples of diets, leftovers and feces were dried in a forced air oven at 55°C for 72 hours and corrected for total dry matter at 105°C.

In these, DM and starch contents were evaluated, following the same procedures adopted in the analysis of ingredients foods.

Coefficients of apparent digestibility (AD) of DM and starch in the experimental diets were determined according to the following formula: AD (%) = [(g ingested nutrient – g excreted nutrient) ÷ g ingested nutrient] x 100. Fecal score for each pen was analyzed daily, based on the methodology adapted from Looper *et al.* ([21]) and Ferreira *et al.* ([22]), ranging from 1 to 6, being: 1 = watery feces, not very consistent; 2 = liquid feces, not very consistent, with small piles of up to 2.5 cm; 3 = intermediate feces with a concentric ring and 3 to 4 cm pile (ideal); 4 = pasty feces with concentric rings and pile of more than 5 cm; 5 = drier feces without concentric rings and pile of more than 5 cm; and 6 = hard or dry feces.

Data on animal performance, dry matter intake, and apparent digestibility referred to the mean of the experimental unit, and data on ingestive behavior referred to the animal chosen in the experimental unit. Both were tested by ANOVA, with subsequent comparison of means at 5% significance by Tukey's test, through the GLM procedure of the SAS statistical program ([23]).

The following statistical model was used: $Yij = \mu + Ti + Eij$, where: Yi = response criterion; μ = overall mean common to all observations (constant); Ti = effect of the i-th treatment, in which: T1 – control diet, T2 – diet with enzyme complex, T3 – diet with yeast culture, and T4 – diet with enzyme complex and yeast culture; and Eij = random error common to all observations.

3. Results and discussion

In Table 2, there was no statistical difference between the three feedlot periods (P>0.05), for dry matter intake, whether expressed in kg day^{-1} or % body weight. Average daily gain, feed conversion and fecal score differed (P<0.05) between evaluated treatments (Table 2). In general, the average daily gain was higher for the animals that received enzyme complex and yeast culture in their diets, either alone or in combination, compared to the control treatment. Regarding the efficiency of converting the ingested dry matter into weight gain, in the first 21 days of feedlot, this was better (P<0.05) in animals supplemented with the combination of yeast culture and enzyme complex (5.47 kg kg^{-1}), compared to non-supplemented animals (7.18 kg kg^{-1}), but did not differ (P>0.05) from animals that received yeast culture or enzyme complex alone (5.85 and 5.81 kg kg^{-1}, respectively).

Table 2. Average daily weight gain, dry matter intake expressed in kg day^{-1} or per 100 kg body weight, feed conversion and fecal score, of steers in feedlot supplemented with enzyme complex or yeast culture, alone or in combination.

Parameter	Experimental diet.				Average	CV	Prob
	Control	Enzyme complex	Yeast culture	Combination		(%)	
Average daily gain, kg day^{-1}:							
0 to 21 days	1.267 b	1.638 a	1.662 a	1.605 a	1.543	12.74	0.0493
0 to 42 days	1.377 b	1.629 a	1.698 a	1.579 a	1.570	12.05	0.0164
0 to 63 days	1.368 b	1.584 a	1.644 a	1.581 a	1.544	10.55	0.0529
Dry matter intake, kg dat^{-1}:							
0 to 21 days	9.08 a	9.42 a	9.36 a	8.73 a	9.15	9.62	0.5996
0 to 42 days	9.52 a	9.69 a	9.66 a	8.99 a	9.47	8.66	0.5181
0 to 63 days	9.59 a	9.76 a	9.57 a	9.05 a	9.49	7.73	0.4765
Dry matter intake, % body weight:							
0 to 21 days	2.32 a	2.37 a	2.35 a	2.22 a	2.31	6.55	0.4450
0 to 42 days	2.34 a	2.34 a	2.32 a	2.20 a	2.30	5.97	0.3107
0 to 63 days	2.28 a	2.28 a	2.22 a	2.13 a	2.23	5.36	0.1868
Feed conversion, kg kg^{-1}:							
0 to 21 days	7.18 a	5.81 ab	5.85 ab	5.47 b	6.07	12.15	0.0106
0 to 42 days	6.95 a	5.98 ab	5.78 b	5.72 b	6.11	10.16	0.0213
0 to 63 days	7.05 a	6.16 ab	5.94 b	5.78 b	6.23	11.41	0.0521
Fecal score:							
0 to 21 days	2.89 b	3.00 a	3.01 a	3.02 a	2.98	1.78	0.0044
0 to 42 days	2.85 b	3.01 a	3.02 a	3.03 a	2.98	2.10	0.0006
0 to 63 days	2.86 b	3.01 a	3.02 a	3.04 a	2.99	2.80	0.0137

Means in the same row, followed by different lowercase letters, are significantly different by Tukey's test at 5%; CV: Coefficient of variation.

When evaluating the feed conversion, with the advance of the finishing period, either from 0 to 42 days and/or from 0 to 63 days, animals supplemented with yeast culture, whether alone or in combination, showed better (P<0.05) efficiency of converting the ingested dry matter into weight gain compared to the control diet, but did not differ from animals supplemented with enzyme complex alone.

Exogenous enzymes are indicated as an enhancer of dietary digestibility and productive efficiency, when

they are associated with microorganisms present in the animal digestive tract, they assist in the release of sugars and other components of complex carbohydrates ([24,25]). However, data in the literature regarding this food additive are somewhat variable, given that its activity is dependent on the substrate available, the volume of enzyme administered and the enzyme-substrate ratio ([10]).

The yeast culture ([26]), on the other hand, assists in the fermentation and absorptive processes in a secondary way. This, when administered to animals, can stabilize the rumen environment, making the fermentation process more efficient, giving animals better performance, in addition to improving the immune system due to the presence of β-glucans and mannan oligosaccharides ([27]). It is suggested that these mechanisms of action mentioned above were responsible for ensuring the animals made better use of the nutrients in the diet, which led to a better feed conversion and greater average daily weight gain, compared to animals that did not receive any additive. In the different periods, animals supplemented with yeast culture or enzyme complex, alone or in combination, had better fecal score, where they presented scores closer to 3, considered ideal.

The improvement in the fecal score for animals supplemented with yeast culture suggests an effect of β-glucans and mannan oligosaccharides. These components help in the development of the gastrointestinal tract, in the growth of the intestinal villi, and in the regulation of the intestinal flora, which results in a greater absorption of nutrients and water by reducing the rate of passage of the diet, making feces less watery ([28,29]).

The improvement in the fecal score for animals supplemented with exogenous enzymes may be the effect of a possible lower rate of passage of the diet. According to Khademi *et al.* ([30]), fibrolytic enzymes prolong the retention time of the diet in the rumen, which also reduces the rate of passage, and increases the absorption of water from the intestinal lumen. When analyzing Table 3, for the variables final weight, weight gain in the feedlot period, days to gain 100 kg body weight, fecal output (kg day^{-1}), apparent digestibility of dry matter and starch there was no difference (P<0.05).

Table 3. Fecal output in kg day^{-1}, on natural or dry basis, fecal dry matter content and apparent digestibility of dry matter and starch in feedlot steers supplemented with enzyme complex or yeast culture, alone or in combination.

Parameter	Experimental diet .				Average	CV	Prob
	Control	Enzyme complex	Yeast culture	Combination		(%)	
IW, kg	363.6 a	362.2 a	362.7 a	360.3 a	362.2	3.88	0.9847
FW, kg	449.8 b	462.0 a	466.3 a	459.9 a	469.5	4.26	0.0442
WGP	86.2 b	99.8 a	103.6 a	99.6 a	97.3	8.45	0.0327
100kg weight gain	73 a	63 b	61 b	63 b	65	4.66	0.0029
Feces, kg NM day^{-1}	18.34 a	14.55 ab	13.74 b	13.70 b	15.08	14.60	0.0175
Feces, kg DM day^{-1}	2.97 a	2.37 b	2.34 b	2.39 b	2.52	14.88	0.0564
Feces, % DM	16.19 a	16.28 a	17.26 a	17.51 a	16.81	6.20	0.1584
DMD, %	67.26 b	74.88 a	75.18 a	73.40 a	72.26	3.57	0.0013
SD, %	95.83 b	96.89 ab	97.30 a	97.07 a	96.77	0.61	0.0095

Means in the same row, followed by different lowercase letters, are significantly different by Tukey's test at 5%; IW: Initial Weight; FW: Final Weight; WGP: Weight gain in the trial period; DMD: dry matter digestibility; SD: starch digestibility; CV: Coefficient of variation.

Higher production of feces, either on a natural basis or on a dry basis, was observed when animals were not given additives. Fecal output is closely related to the digestibility of the food, that is, foods with greater digestibility present greater utilization, consequently the fecal output will be lower, an effect observed in the present study (Table 3).

The apparent digestibility of dry matter was higher for animals supplemented with yeast culture or enzyme complex, alone (75.18% and 74.88%, respectively) or in combination (73.40%) compared to animals that received no additive (67.26%). The apparent digestibility of starch was higher when animals were supplemented with yeast culture alone and with the combination of yeast culture plus enzyme complex (97.30% and 97.07%, respectively), but did not differ from animals supplemented with the enzyme complex alone (96.89%).

The better apparent digestibility in animals that received the enzyme complex as a supplement can be explained by its mechanism of action. When exogenous enzymes are administered, they enter into synergy with bacterial enzymes, thus enhancing their effects ([31]). Fibrolytic enzymes promote hydrolysis and greater degradation of polysaccharides present in the food cell wall, which generates greater degradation and consequently greater use of the diet and consequently reduces fecal output ([32,33,34]).

The yeast culture alters the concentrations of some short-chain fatty acids, in particular, it increases the proportion of propionate and reduces lactate, due to its ability to compete for the same substrates used by *Streptococcus bovis* bacteria that are lactate producers, and to stimulate the growth of *Selenomonas ruminantium* bacteria, which are consumers of lactic acid. This reflects

in smaller variations in rumen pH, greater stability in the rumen environment and smaller variations in its microbiota, factors that provide better diet digestibility and better animal performance ([35,36]). Arambel & Kent ([37]) and Moallem *et al*. ([38]) reported that the use of yeast can be more effective under stress than under normal conditions. As well as the use of the enzyme will depend on several conditions, such as rumen pH, concentration of enzymes and the type of substrate present in the rumen([10]).

The highest final weight, weight gain in the confinement period and the shortest time to gain 100 kg body weight of animals supplemented with yeast culture and enzyme complex, alone or in combination, is a reflection of the best ADG of these animals (Table 2) and the best digestibility of dry matter and starch (Table 3). An important point to be highlighted, because, once the feedlot period is shortened, costs also reduce, resulting in greater profitability for the producer. The ingestive behavior data listed in Table 4 indicated no difference (P>0.05) in time and frequency of the parameters evaluated with the supplementation of different types of additives, alone or in combination, compared to the control diet.

Table 4. Ingestive behavior (hours day^{-1}) or represented by the frequency of activities performed (times day^{-1}) of steers in feedlot supplemented with enzyme complex or yeast culture, alone or in combination.

Parameter	Experimental diet .				Average	CV	Prob
	Control	Enzyme complex	Yeast culture	Combination		(%)	
				Hours day^{-1}			
Food intake	2.70 a	2.76 a	2.83 a	2.78 a	2.76	16.61	0.9739
Water intake	0.32 a	0.24 a	0.33 a	0.22 a	0.28	27.08	0.0749
Idleness	14.71 a	14.77 a	15.00 a	15.15 a	14.90	5.21	0.7930
Rumination	6.27 a	6.26 a	5.82 a	5.90 a	6.06	10.78	0.5988
				Times day^{-1}			
Feeding	21.5 a	19.2 a	17.8 a	19.7 a	19.6	14.25	0.2432
Drinking	7.3 a	6.5 a	7.5 a	6.3 a	6.9	19.06	0.4386
Urinating	5.9 a	7.7 a	6.9 a	6.0 a	6.6	15.20	0.0758
Defecating	7.2 a	7.4 a	7.6 a	7.0 a	7.3	19.60	0.9260

Means in the same row, followed by different lowercase letters, are significantly different by Tukey's test at 5%; CV: Coefficient of variation.

As in the present study, some studies that evaluated the use of enzymes and/or yeasts in ruminant diet also did not find significant difference in the behavioral evaluation of the animals ([39,40]). On the other hand, Vigne *et al*. ([41]) evaluated the same enzyme blend, however with a high-energy diet, and reported a significant effect for rumination time and idle time.

When comparing these data in the literature with our findings, it leads to the belief that the use of the additive alone is not likely to change the animal behavior, which is positive, since changes in the ingestive behavior can lead to a reduction in intake, reduction in weight gain, and for biochemical reasons, trigger a behavior of selection of feeds in the trough. The ingestive behavior of animals can be altered by factors, such as diet composition, especially fiber content, particle size, which directly influences the time of ingestion and rumination ([42,43]). As the diets used in the present study were the same for both evaluated additives, this suggests that this is the main reason for the lack of differences in the evaluated behavioral parameters.

5. Conclusion

The use of yeast culture alone or in combination with an enzyme complex improves the apparent digestibility of dietary dry matter and starch, in addition to promoting higher average daily gain, better feed conversion and providing higher final weight of the animals.

Conflict of interests

The authors declare no conflict of interest

Author Contributions

Conceptualization: M. Neumann; Data curation: M. Neumann, A. M. Souza; Formal Analysis: M. Neumann; Funding acquisition: M. Neumann; Project administration: M. Neumann, L. Melo; Methodology: M. Neumann; Supervision: L. Melo, A. M. Souza, M. Neumann; Investigation: L. Melo, P. E. P, Oliveira, D. C. Plodoviski, L. Costa, C. B. Rosa, E. L. C. Pereira, A. M. Souza; Visualization: A. M. Souza; Writing – original draft: L. Melo; Writing – review & editing: L. Melo, M. Neumann A. M. Souza.

References

1- González LA, Manteca X, Calsamiglia S, Schwartzkopf-Genswein KS, Ferret A. Ruminal acidosis in feedlot cattle: Interplay between feed ingredients, rumen function and feeding behavior (a review). Animal Feed Science and Technology. 2012 Feb;172(1-2):66–79. https://doi.org/10.1016/j.anifeedsci.2011.12.009

2- Calsamiglia S, Blanch M, Ferret A, Moya D. Is subacute ru-

minal acidosis a pH related problem? Causes and tools for its control. Animal Feed Science and Technology [Internet]. 2012 Feb 28 [cited 2022 Apr 1];172(1):42–50. Available from: https://doi.org/10.1016/j.anifeedsci.2011.12.007

3- Chang G, Zhang K, Xu T, Jin D, Seyfert H-M, Shen X, et al. Feeding a high-grain diet reduces the percentage of LPS clearance and enhances immune gene expression in goat liver. BMC Veterinary Research. 2015 Mar 18;11(1). Available from: https://doi.org/10.1186/s12917-015-0376-y

4- Claudino LSD, Darnet LAF, Chapuis RP. Migrando e Construindo Espaços: Pecuária Bovina, Degradação das Pastagens e Agrupamentos Socioeconômicos na Microrregião de São Félix do Xingu – Pará. Revista Geoamazônia. 2016 Jun 12;4(7):1–19. Available from: http://dx.doi.org/10.17551/2358-1778/geoamazonia.v4n7p1-19

5- Rigobelo EC, Pereira MCS, Vicari DVF, Millen DD. Utilização de probiótico e monensina sódica sobre o desempenho produtivo e características de carcaça de bovinos Nelore terminados em confinamento. Revista Brasileira de Saúde e Produção Animal. 2014 Jun;15(2):415–424. Diponível em: http://dx.doi.org/10.1590/S1519-99402014000200011

6- Aa E, Townsend JP, Adams RI, Nielsen KM, Taylor JW. Population structure and gene evolution in *Saccharomyces cerevisiae*. FEMS Yeast Research. 2006 Aug;6(5):702–715. Disponível: https://doi.org/10.1111/j.1567-1364.2006.00059.x

7- Shurson GC. Yeast and yeast derivatives in feed additives and ingredients: Sources, characteristics, animal responses, and quantification methods. Animal Feed Science and Technology [Internet]. 2018 Jan [cited 2020 Dec 12];235:60–76. Available from: https://doi.org/10.1016/j.anifeedsci.2017.11.010

8- Alves Z, Melo A, Figueiredo AR, Coimbra MA, Gomes AC, Rocha SM. Exploring the Saccharomyces cerevisiae Volatile Metabolome: Indigenous versus Commercial Strains. Weir TL, editor. PLOS ONE. 2015 Nov 24;10(11):e0143641. Available from: https://doi.org/10.1371/journal.pone.0143641

9- Schingoethe DJ, Linke KN, Kalscheur KF, Hippen AR, Rennich DR, Yoon I. Feed Efficiency of Mid-Lactation Dairy Cows Fed Yeast Culture During Summer. Journal of Dairy Science. 2004 Dec;87(12):4178–4181. Available from: https://doi.org/10.3168/jds.S0022-0302(04)73561-4

10- Meale SJ, Beauchemin KA, Hristov AN, Chaves AV, McAllister TA. BOARD-INVITED REVIEW: Opportunities and challenges in using exogenous enzymes to improve ruminant production. Journal of Animal Science. 2014 Feb 1;92(2):427–442. Available from: https://doi.org/10.2527/jas.2013-6869

11- Colombatto D, Mould FL, Bhat MK, Owen E. Use of fibrolytic enzymes to improve the nutritive value of ruminant diets. Animal Feed Science and Technology. 2003 Jun;107(1-4):201–209. Available from: https://doi.org/10.1016/S0377-8401(03)00126-3

12- DiLorenzo N, Smith DR, Quinn MJ, May ML, Ponce CH, Steinberg W, Engstrom MA, Galeano ML. Effects of grain processing and supplementation with exogenous amylase on nutrient digestibility in feedlot diets. Livestock Science. 2011 May;137(1-3):178–184. Available from: https://doi.org/10.1016/j.livsci.2010.11.003

13- LG, Ferreira RN, Padua JT, Ulhoa CJ, Cysneiros CDSS, Arnhold E. Performance of beef cattle bulls in feed lots and fed on diets containing enzymatic complex. Acta Scientiarum Animal Sciences. 2015 May 21;37(2):181. Available from: https://doi.org/10.4025/actascianimsci.v37i2.26446

14- GL. Use of Dinitrosalicylic Acid Reagent for Determination of Reducing Sugar. Analytical Chemistry. 1959 Mar;31(3):426–428. Available from: https://doi.org/10.1021/ac60147a030

15- Helrich K, Association Of Official Analytical Chemists. Official methods of analysis of the Association of Official Analytical Chemists. Arlington (Va.): Association Of Official Analytical Chemists, Cop; 1990. Available from: https://nla.gov.au/nla.cat-vn1097163

16- Van Soest, PJ, Robertson, JB, Lewis, BA. Symposium: carbohydrate methodology, metabolism, and nutritional implications in dairy cattle. J Dairy Sci. 1991;74(10):3583-3597. Available from: https://doi.org/10.3168/jds.S0022-0302(91)78551-2

17- Goering HK, Van Soest PJ. Forage fiber analyses: (apparatus, reagents, procedures, and some applications). Washington, D.C.: Agricultural Research Service, U.S. Dept. of Agriculture; 1970. Available from: https://handle.nal.usda.gov/10113/CAT87209099

18- WP, Conrad HR, St. Pierre NR. A theoretically-based model for predicting total digestible nutrient values of forages and concentrates. Animal Feed Science and Technology. 1992 Nov;39(1-2):95–110. Available from: https://doi.org/10.1016/0377-8401(92)90034-4

19- Tedesco MJ, Gianello C, Bissani CA, Bohnen H, Volhweiss SJ. Análises de solo, plantas e outros materiais. 2 ed. Porto Alegre: Universidade Federal do Rio Grande do Sul; 1995. 173p.

20- Hendrix DL. Rapid Extraction and Analysis of Nonstructural Carbohydrates in Plant Tissues. Crop Science. 1993 Nov;33(6):1306–1311. Available from: https://doi.org/10.2135/cropsci1993.0011183X003300060037x

21- Looper ML, Stokes SR, Waldner DN, Jordan ER. Managing Milk Composition: Evaluating Herd Potential. Cooperative Extension Service College of Agriculture and Home Economics. 2001;104(sn). Available from: http://AgriLifebookstore.org

22- Ferreira, SF, Guimarães, TP, Moreira, KKG, Alves, VA, Lemos, BJM, Souza, FM. Caracterização fecal de bovinos. Revista Científica Eletrônica de Medicina Veterinária. 2013;11(20):1-22. ISSN: 1679-7353

23- SAS Institute. Statistical Analysis System: Sas Institute Inc; 1993.

24- Neumann M, Leão GFM, Horst EH, Stuani OF, Sangali CP, Castilho R. Exogenous enzymes improve performance and carcass traits of feedlot cattle fed high-grain diet. Revista Brasileira de Zootecnia. 2018 Nov 23;47(0). Available from: https://doi.org/10.1590/rbz4720170308

25- Vigne GLD, Neumann M, Santos LC, Dochwat A, Venancio BJ, Heker Junior JC, Ueno RK, Souza AM. Doses of enzyme complex in a high-energy diet on performance and carcass traits of feedlot steers. Revista Brasileira de Zootecnia. 2018 Nov 23;47(1):1-9. Available from: https://doi.org/10.1590/rbz4720170317

26- Geng CY, Ren LP, Zhou ZM, Chang Y, Meng QX. Comparison of active dry yeast (Saccharomyces cerevisiae) and yeast culture for growth performance, carcass traits, meat quality and blood indexes in finishing bulls. Animal Science Journal. 2015 Oct 16;87(8):982–988. Available from: https://doi.org/10.1111/asj.12522

27- Volman JJ, Ramakers JD, Plat J. Dietary modulation of immune function by β-glucans. Physiology & Behavior. 2008 May;94(2):276–84. Available from: https://doi.org/10.1016/j.physbeh.2007.11.045

28- Zhou Z, Diao QY, Tu Y, Yun Q. Effects of yeast β-glucan and Bacitracin zinc on growth Performance and Gastrointestinal Development of Early-weaned Calves. Chinese Journal of Animal Nutrition 2011;23(5):813–820.

29- Xie MX, Wang HR, Yang JL, Wang GC, Li JJ, Li CR. Effects of yeast mannan oligosaccharides on Growth performance, serum immune and inflammatory indices and Antioxidant indices of Mongolian sheep. Chinese Journal of Animal Nutrition 2018;30(1):219–226.

30- Khademi AR, Hashemzadeh F, Khorvash M, Mahdavi AH, Pazoki A, Ghaffari MH. Use of exogenous fibrolytic enzymes and probiotic in finely ground starters to improve calf performance. Scientific Reports 2022;12(1):1-14. Available from: https://doi.org/10.1038/s41598-022-16070-0

31- Alves A, Pascoal L, Cambuí G, Trajano J, Silva C, Gois G. Fibra para ruminantes: Aspecto nutricional, metodológico e funcional. Pubvet. 2016 Jul;10(7):568–579. Available from: https://doi.org/ 10.22256/pubvet.v10n7.568-579

32- Antonio G, Filla MG, Del Valle TA, Campana M, Morais JPG. Efeitos de enzimas fibrolíticas sobre a degradação in situ da matéria seca e da fibra de forrageiras. Agrarian. 2018 Nov 7;11(42):363–370. Available from: https://doi.org/10.30612/agrarian.v11i42.7488

33-Salem AZM, Gado HM, Colombatto D, Elghandour MMY. Effects of exogenous enzymes on nutrient digestibility, ruminal fermentation and growth performance in beef steers. Livestock Science. 2013 Jun;154(1-3):69–73. Available from: https://doi.org/10.1016/j.livsci.2013.02.014

34- Gado HM, Salem AZM, Robinson PH, Hassan M. Influence of exogenous enzymes on nutrient digestibility, extent of ruminal fermentation as well as milk production and composition in dairy cows. Animal Feed Science and Technology. 2009 Oct;154(1-2):36–46. Available from: https://doi.org/10.1016/j.anifeedsci.2009.07.006

35- Vyas D, Uwizeye A, Mohammed R, Yang WZ, Walker ND, Beauchemin KA. The effects of active dried and killed dried yeast on subacute ruminal acidosis, ruminal fermentation, and nutrient digestibility in beef heifers1. Journal of Animal Science. 2014 Feb 1;92(2):724–732. Available from: https://doi.org/10.2527/jas.2013-7072

36- Silberberg M, Chaucheyras-Durand F, Commun L, Mialon MM, Monteils V, Mosoni P, Morgavi DP, Martin C. Repeated acidosis challenges and live yeast supplementation shape rumen microbiota and fermentations and modulate inflammatory status in sheep. Animal. 2013;7(12):1910–1920. Available from: https://doi.org/10.1017/S1751731113001705

37- Arambel MJ, Kent BA. Effect of Yeast Culture on Nutrient Digestibility and Milk Yield Response in Early- to Midlactation Dairy Cows. Journal of Dairy Science. 1990 Jun;73(6):1560–1563. Available from: https://doi.org/10.3168/jds.S0022-0302(90)78825-X

38- Moallem U, Lehrer H, Livshitz L, Zachut M, Yakoby S. The effects of live yeast supplementation to dairy cows during the hot season on production, feed efficiency, and digestibility. Journal of Dairy Science. 2009 Jan;92(1):343–351. Available from: https://doi.org/10.3168/jds.2007-0839

39- Bowman GR, Beauchemin KA, Shelford JA. Fibrolytic Enzymes and Parity Effects on Feeding Behavior, Salivation, and Ruminal pH of Lactating Dairy Cows. Journal of Dairy Science. 2003 Feb;86(2):565–575. Available from: https://doi.org/10.3168/jds.S0022-0302(03)73635-2

40- LR, Viגgas J, Freitas L da S, Brondani IL, Argenta FM, Binotto J. Behavior patterns of cows with Charolais or Nellore breed predominance fed diets with plant extract or monensin sodium. Revista Brasileira de Zootecnia. 2011 Dec;40(12):2954–2962. Available from: https://doi.org/10.1590/S1516-35982011001200044

41- Vigne GLD, Neumann M, Santos LC, Stadler Júnior ES, Pontarolo GB, Petkowicz K, Cristo FB. Digestibility of starch and ingestive behavior of feedlot steers by effect of enzymatic complex doses in high-energy diets. Arquivo Brasileiro de Medicina Veterinária e Zootecnia. 2019 Jun;71(3):1015–1026. Available from: https://doi.org/10.1590/1678-4162-10538

42- Carvalho S, Dias FD, Pires CC, Brutti DD, Lopes JF, Santos D, et al. Comportamento ingestivo de cordeiros Texel e Ideal alimentados com casca de soja. Archivos de Zootecnia. 2014 Mar;63(241):55–64. Available from: https://dx.doi.org/10.4321/S0004-05922014000100006

43- Vidal MP, Pereira ASC, Cação MMF, Silva SL, Henrique W, Fuzikawa IHS, Aferri, G. Desempenho e características da carcaça de cordeiros alimentados com dietas contendo grãos de diferentes de cereais. Boletim de Indústria Animal. 2016 Jun; 73(2):134-142. Available from: https://doi.org/10.17523/bia.v73n2p134.