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Research article

Live yeasts as a non-hormonal alternative to improve the performance of dairy cows

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Abstract

The present study aimed to evaluate live yeast dietary supply instead of rbST application in lactating dairy cows. Thirty-five Holstein cows (37.1 ± 7.8 kg/d of milk yield and 524 ± 27 kg of body weight; mean ± SD) were used in a completely random trial to evaluate: 1) rbST: animals treated with 500 mg of rbST every 14 d; and 2) Yeast: animals fed diets containing 40 g/d of live yeast. The trial lasted for five subsequent 14-d periods. Treatments showed no effects on cows' feed intake. Yeast reduced large and small particles selection indexes compared, feed residue and starch in feces compared to rbST. Cows treated with rbST had increased glucose, triglycerides, and AST, and decreased cholesterol and urea serum concentration. In addition, yeast reduced somatic cells count and increased milk yield and cows' production efficiency. Although treatments showed no effects on milk chemical composition, yeast increased saturated to unsaturated fatty acids ratio. Yeast increased saturated and short-chain fatty acids, whereas reduced unsaturated and cis-9 trans-11 C18:2 FA content in milk fat. Thus, yeast could be used instead of rbST to improve milk yield and the productive efficiency of cows in a short-term evaluation.

Keywords: Clean production, Dairy cows, Hormones free, Saccharomyces *cerevisiae*, Somatotropin

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INTRODUCTION

As the world population grows, humans need to improve food production without using more resources or exerting more pressure on the environment (Westerveld, 2017). Among techniques used by farmers to improve milk production by dairy cows, recombinant bovine somatotropin (rbST) applications have been one of the most accessible and effective. According to St-Pierre et al. (2014), rbST increases by 4 kg/d the milk yield of each cow through lactation. Morais et al. (2017) reported an average rbST effect of + 3.48 kg/d (10.5%) and + 5.00 kg/d (14.5%) in primiparous and multiparous milk yield, respectively. Besides the positive effect observed on milk yield (+5.5%), rbST reduces production costs (Tauer, 2016).

The action mechanism of rbST is associated with insulin-like growth factor (IGF-1). Animals treated show increased IFG-1 blood and milk concentration, which is the first responsible for enhanced profitability of lactating cows (McGuire et al., 1992; Castigliego et al., 2009). There is no evidence that rbST could affect dairy cows' illness, including mastitis (FAO, 2014; St Pierre et al., 2014) and human illness (Singer et al., 2017). However, the European Food Safety Authority (2015) hypothesized that rbST-treatment increases the incidence of mastitis and antimicrobials usage, which can lead to antimicrobial resistance in humans. Therefore, considering the European Union's relevance on the dairy international market, it is essential to discuss potential natural replaces of rbST.

Dell'Orto et al. (1993) hypothesized that rbST application could reduce dairy cows' welfare because nutritional management is not always adjusted by increased cows' yield. It is essential to consider the potential negative effect of the subsequent applications on cows' and humans' welfare, besides the health questions. Non-antibiotics and live feed additives could improve animal welfare and maintain the performance of lactating dairy cows. Live yeast has been used to improve cows' productive performance by increasing nutrient digestibility (Dias et al., 2018; Perdomo et al., 2020) or by changing animals' feeding behavior (Bach et al., 2007). Live yeasts are able to change ruminal fermentation, improve N utilization, and stabilize ruminal pH (Decoyers et al., 2009).

The positive effects of live yeast on dairy cows' productive performance are nutritionally mediated and could attenuate the negative effects of rbST on dairy cows' welfare. However, to the best of our knowledge, there is no study performing a direct comparison between rbST and live yeast in dairy cows. We hypothesized that live yeast instead of rbST reduces fecal large-particle and starch and changes metabolic parameters, and milk fatty acid profile, with no effects on feed intake and performance. This aimed to evaluate DM and nutrients intake, digestibility, sorting index, biochemical parameters, milk yield and composition, and milk fatty acids profile of Holstein cows treated with rbST or live yeast.

MATERIALS AND METHODS

The trial was performed from May to July 2018 in a commercial farm located in Pejuçara, Brazil. All procedures using animals were previously approved by the Ethics Committee of Dourados Federal University (2017/028).

Animals, treatments, and management

It was used thirty-five Holstein cows (37.1 ± 7.8 kg/d of milk yield; 524 ± 27 kg of body weight, and 2.56 ± 0.82 body score condition; mean ± SD) in a completely random design to evaluate the following treatments: 1) rbST: animals (n = 20) treated with 500 mg of rbST (Lactotropin®, União Química, São Paulo, Brazil), every 14 days, as recommended by manufactory; 2) Yeast: animals (n = 20) fed diets containing 40 g/d of live yeast (Levumilk®, 20 × 10^9 colony-forming units of *Saccharomyces cerevisiae* KA 500 per g, Kera Animal Nutrition, Bento Gonçalves, Brazil). Yeast level was defined to maintain the same cost of rbST purchase. The trial lasted for five subsequent 14-days periods, totaling 70 days in length.

Cows were housed in a compost barn, being one barn for each treatment, adjusted to maintain the same stoking rate. Animals was fed five times daily as a total mixed ratio (TMR), using a mixer (CASALI TX345®). Orts were weighed once daily and the amount of offered TMR was adjusted to maintain 5% of fresh offered. Cows had free access to water and more than 50 cm/cow of bunk space. The basal diet was formulated for a 30-kg producing cow, using the NRC (2001). Cows were milked twice daily (4:30 and 16:00 h).

Sampling and data record

The orts and TMR were weighed and sampled on D 12, D 13, and D 14 of every experimental period. Samples were analyzed for particle size (Kononoff et al., 2013) and stored for chemical analysis. On D 13 of each experimental period, fecal samples were collected. Fecal samples were obtained from every cow rectum and samples of three animals of each treatment were pooled to obtain five composite samples of each treatment every period. Feces (500 g) were used to access larger particles: it was washed in current water using a 2-mm sieve and residue was corrected by dry matter. Another feces subsample was stored for DM and starch analysis.

Serum samples were obtained four hours after the morning milking every D 13 of each experimental period. Samples were collected from the coccygeal vein using tubes without conservators. Blood was centrifuged (500 × g) and frozen until analysis. Body condition score was analyzed according to Edmonson et al. (1989) and body height was accessed using a weighing tape every D 13 of the experimental period. Milk yield was evaluated every week and samples of morning and evening milking were sampled and stored in Bronopol (2bromo-2nitropropano-1,3diol) before composition evaluation. Milk samples to access fatty acids profile was sampled only in the last evaluation period: 200 mL of milk was collected from every cow in both milkings of the day.

Chemical analysis

The orts and TMR samples were analyzed for DM, organic matter, starch, neutral detergent fiber, acid detergent fiber, acid detergent lignin, crude protein, neutral detergent insoluble protein, acid detergent insoluble protein, and ether extract using near-infrared reflectance (NIR) spectroscopy method. Starch content was determined according to Hendrix (1993), with enzymatic degradation (Amyloglucosidase®, Novozymes, Curitiba, Brazil). Glucose content was analyzed using a colorimetric kit (Bioclin®, Belo Horizonte, Brazil). Biochemical analysis of serum was performed using a semi-automatic analyzer (BIO-200®, Bioplus, Barueri, Brazil) and commercial kits (Bioclin®) to access glucose, total cholesterol, triglycerides, total protein, albumin, urea, and aspartate aminotransferase (AST).

Milk composition was analyzed by lactose, fat, and protein, urea, and casein, using the infrared method. Somatic cells count (SCC) was analyzed by flux cytometry. Milk fatty acids profile was analyzed after Feng et al. (2004) extraction: 17,800 × g for 30 min., and 19,300 × g for 20 min. Isolated fat was methylated according to Kramer et al. (1997). Fatty acids were quantified using a gas chromatograph (GC Shimatzu 2010) with automatic injection and a capillary column (SP-2560 Supelco, Bellefonte, PA) of 100 m, 0.25 mm of diameter, and 0.02 mm of thickness. It was used the following standards to identify fatty acids: C4-C24 (Supelco® TM 37), vaccenic acid C18:1 *trans*-11 (V038, Sigma®), C18:2 CLA *trans*-10, *cis*-12 (UC-61M), and C18:2 *cis*-9, *trans*-11 (UC-60M), (NU-CHEK-PREP®).

Calculations and statistical analysis

Non-fiber carbohydrates (NFC) was calculated according to the following equation:

$$NFC\left(\frac{g}{kg}DM\right) = 1000 - (Ash + NDF + CP + EE)$$

Net energy was calculated considering a cow consumption of 3 times the maintenance level, using NRC (2001) equations. The selection index was calculated by the ratio between observed to expected intake of each particle size. Expected intake was calculated considering DMI and TMR composition. Observed intake was obtained considering offered and orts amount of each particle size.

Fat corrected milk (FCM) yield was obtained using Sklan et al. (1994) equation:

$$FCM\left(\frac{kg}{d}\right) = \left(0.432 + 0.0165 \times Milk\ fat\left(\frac{g}{kg}\right)\right) \times milk\ yield\left(\frac{kg}{d}\right)$$

Energy corrected milk (ECM) was obtained using the following equation (Dairy Records Management System, 2014):

$$ECM\left(\frac{kg}{d}\right) = 0.327 \times milk\ yield\left(\frac{kg}{d}\right) + 12.86 \times fat\ yield\left(\frac{kg}{d}\right) + 7.65 \times potein\ yield\left(\frac{kg}{d}\right)$$

Data was analyzed using PROC MIXED of SAS (Version 9.4, SAS Institute, Cary, NC 2015). Variables that were sampled n each period were analyzed according to the following statistical model:

$$Y_{ijk} = \mu + T_i + c_{j:i} + P_k + T \times P_{ik} + e_{ijk}$$

With: $c_{j:i} \approx (0, \sigma_c^2)$ and $e_{ijk} \approx MRN(0, R)$; where: Y_{ijk} is the observed value of the dependent variable; μ is the overall mean; T_i is the fixed effect of treatment (i = 1 and 2); $c_{j:i}$ is the random effect of cow within treatment (j = 1 to 35); P_k is the fixed effect of the period of evaluation (k = 1 to 5); $T \times P_{ik}$ is the fixed interaction effect between treatment and time; e_{ijk} is the random residue; σ_c^2 is the variance associated with random effect of a cow; MRN stands for multivariate analysis with distribution almost normal; R is a variance and covariance matrix due to repeated measures. The Bayesian method was used to choose the most appropriated matrix.

Fatty acids profile was analyzed using the following model:

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

with $e_{ij} \approx (0, \sigma_e^2)$, where: Y_{ij} is the observed value of dependent variable; μ is the overall mean; T_i is the fixed effect of treatment (i = 1 and 2); e_{ij} is the residual error (j = 1 to 35);

σ_e^2 is the variance associated with random error. It was considered 0.05 of probability for all analyses.

RESULTS

Intake, selection index, and feces analysis

Treatments did not affect ($P \geq 0.53$) dry matter and nutrient intake, regardless ($P \geq 0.37$) of the evaluated period (Table 2). However, Yeast-treated cows showed lower large (> 19 mm) and small (< 8 mm) selection index than rbST-treated animals. There was a treatment and time interaction effect (P = 0.01) on feces large particles (Figure 1). Although yeast increased ($P \leq 0.05$) large particles up to 14 days of evaluation, it consistently reduced ($P \leq 0.05$) large particle content since 28 days of evaluation when compared to rbST-cows. Additionally, rbST-cow showed higher ($P \leq 0.05$) fecal starch content than yeast-cows, regardless (P = 0.12) of evaluation period (Figure 2).

Table 1 Chemical composition and particle size of experimental diet

Ingredients, g/kg DM	
Corn silage	545
Comercial concentrate[1]	382
Whole cottonseeds	40.0
Wheat straw	33.0
Chemical composition, g/kg DM (unless stated)	
Dry matter	413
Organic matter	915
Non-fiber carbohydrate	391
Starch	206
Neutral detergent fiber	361
Acid detergent fiber	224
Acid detergent lignin	25.3
Crude protein	151
Neutral detergent insoluble protein	16.8
Acid detergent insoluble protein	4.87
Ether extract	27.7
Net energy, MJ/kg DM	6.53
Particle size, g/kg DM	
> 19 mm	35.7
8 to 19 mm	577
4 to 8 mm	78.6
< 4 mm	308

Table 2 Nutrients intake and selection index of lactating Holstein cows treated with rbST or live yeast

Item	Treatments[1]		SEM[2]	*P*[3]		
	rbST	Yeast		Treat.	Time	Treat.×Time
Intake, kg/d						
Dry matter	22.5	22.9	0.26	0.55	<0.01	0.46
Non-fiber carbohydrate	8.79	8.94	0.104	0.54	<0.01	0.41
Neutral detergent fiber	8.11	8.25	0.096	0.57	<0.01	0.50
Starch	4.63	4.72	0.062	0.53	<0.01	0.37
Crude protein	3.39	3.45	0.043	0.54	<0.01	0.49
Ether extract	0.622	0.634	0.007	0.54	<0.01	0.44
Selection index						
>19 mm	0.945	0.936	0.002	0.02	<0.01	<0.01
8-19 mm	0.939	0.937	0.003	0.36	<0.01	0.01
4-8 mm	0.938	0.930	0.001	0.03	<0.01	<0.01
<4 mm	0.942	0.931	0.002	0.04	<0.01	<0.01

[1]Treatments: rbST: animals (n = 15) treated with 500 mg of rbST (Lactotropin®, União Química, São Paulo, Brazil), every 14 days; 2) Yeast: animals (n = 20) fed diets containing 40 g/d of live yeast (Levumilk®, 20 × 10^9 colony-forming units of *Saccharomyces cerevisiae* KA 500 per g, Kera Animal Nutrition, Bento Gonçalves, Brazil);
[2]Standard error of mean;
[3]Probabilities: Treatment (rbST *vs.* Yeast); time effect (experimental period); and treatment by experimental period interaction effect.

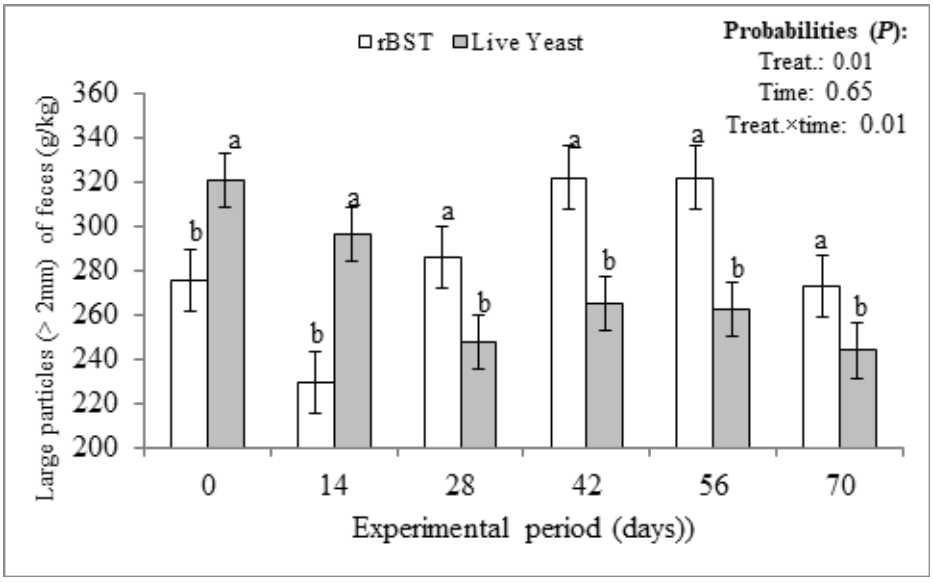

Figure 1 Fecal large particles (> 2-mm) of lactating Holstein cows treated with rbST or live yeast.

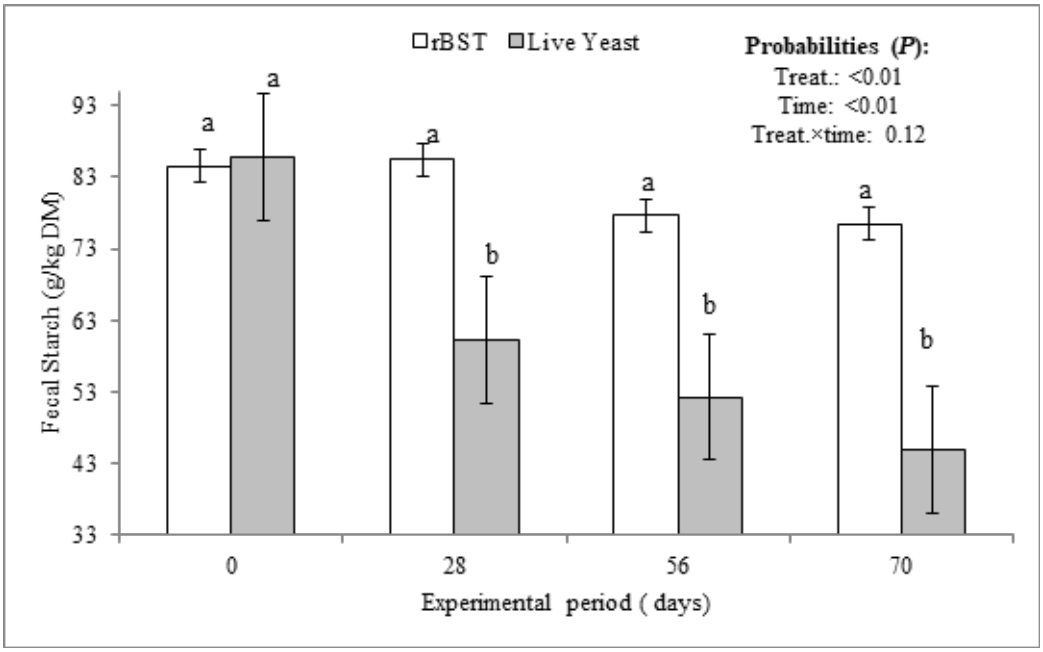

Figure 2 Fecal starch of lactating Holstein cows treated with rbST or live yeast.

Biochemical parameters

There was no treatment by time interaction effect ($P \geq 0.21$) on biochemical parameters (Table 3). Yeast reduced ($P \leq 0.05$) glucose, triglycerides, and AST, whereas increased ($P \leq 0.04$) cholesterol and urea serum concentration compared to rbST. However, treatments showed no effects ($P \geq 0.54$) on serum total protein and albumin.

Table 3 Biochemical parameters of lactating Holstein cows treated with rbST or live yeast

Item	Treatments[1]		SEM[2]	*P*[3]		
	rbST	Yeast		Treat.	Time	Treat.×Time
Glucose (mg/dL)	103	98.1	1.10	0.05	0.01	0.21
Cholesterol total (mg/dL)	106	128	4.6	0.04	<0.01	0.61
Triglycerides (mg/dL)	21.5	16.9	1.46	0.02	<0.01	0.60
Total protein (g/dL)	9.77	10.0	0.18	0.54	0.01	0.26
Albumina (g/dL)	6.68	6.45	1.156	0.93	0.06	0.57
Ureia (mg/dL)	34.1	38.2	0.66	0.03	<0.01	0.52
Aspartato aminotransferase (UI/mL)	23.6	17.3	0.12	0.05	0.16	0.46

[1]Treatments: rbST: animals (n = 15) treated with 500 mg of rbST (Lactotropin®, União Química, São Paulo, Brazil), every 14 days; 2) Yeast: animals (n = 20) fed diets containing 40 g/d of live yeast (Levumilk®, 20 × 10^9 colony-forming units of *Saccharomyces cerevisiae* KA 500 per g, Kera Animal Nutrition, Bento Gonçalves, Brazil);
[2]Standard error of mean;
[3]Probabilities: Treatment (rbST *vs.* Yeast); time effect (experimental period); and treatment by experimental period interaction effect

Cows performance

Yeast increased (P = 0.01) milk yield, fat, and energy corrected milk yield (Table 4). Additionally, animals feeding yeast had lower (P = 0.01) CCS than rbST-treated cows. However, treatments did not affect ($P \geq 0.12$) milk composition, lactose, fat, and protein daily secretion.

Table 3 Productive performenace of lactating Holstein cows treated with rbST or live yeast

Item	Treatments[1]		SEM[2]	P[3]		
	rBST	Yeast		Treat.	Time	Treat.×Time
Production, kg/dia						
Mil yield	35.2	36.8	0.32	0.01	<0.01	0.54
Fat-corrrected mik yield[4]	36.2	38.2	0.32	0.01	<0.01	0.02
Energy-corrected milk yield[5]	36.5	38.4	0.30	0.01	<0.01	0.03
Lactose	1.61	1.72	0.025	0.21	0.01	0.12
Fat	1.30	1.37	0.022	0.31	<0.01	<0.01
Protein	1.16	1.20	0.016	0.38	0.08	0.13
Casein	0.894	0.923	0.012	0.48	0.25	0.07
Milk composition, g/kg unless stated						
Lactose	4.63	4.62	0.011	0.96	0.01	0.55
Fat	3.71	3.70	0.027	0.93	<0.01	0.01
Protein	3.39	3.24	0.024	0.12	<0.01	0.18
Casein	2.61	2.52	0.019	0.26	<0.01	0.01
Ureic nitrogen, mg/dL	12.1	12.0	0.18	0.82	<0.01	0.11
SCC[6] (1.000/mL)	460	337	16.1	0.05	0.37	0.55
Body weight (kg)	667	669	5.7	0.83	<0.01	0.68
BCS[7]	3.27	3.25	0,018	0.80	<0.01	0.05
Eficiency						
MY:DMI[8]	1.57	1.61	0.002	0.02	<0.01	0.22
FCM:DMI[9]	1.61	1.67	0.003	0.03	<0.01	0.24
ECM:DMI[10]	1.63	1.68	0.003	0.03	<0.01	0.25

[1]Treatments: rbST: animals (n = 15) treated with 500 mg of rbST (Lactotropin®, União Química, São Paulo, Brazil), every 14 days; 2) Yeast: animals (n = 20) fed diets containing 40 g/d of live yeast (Levumilk®, 20 × 10^9 colony-forming units of *Saccharomyces cerevisiae* KA 500 per g, Kera Animal Nutrition, Bento Gonçalves, Brazil);
[2]Standard error of mean;
[3]Probabilities: Treatment (rbST *vs.* Yeast); time effect (experimental period); and treatment by experimental period interaction effect;
[4]Fat-corrected milk (3.5%) according to Sklan et al. (1994);
[5]Energy correcte milk yield accorsding to (Dairy Records Management System, 2014);
[6]Somatic cells count;
[7]Body condition score according to Edmonson et al. (1989);
[8]Milk yield by dry matter intake ratio;
[9]fat corrected milk yield by dry matter intake ratio;
[10]Energy corrected milk yield by dry matter intake.

Milk fatty acids profile

Yeast-treated cows showed higher ($P \leq 0.02$) C16:0, C17:0, C17:1, and *cis*-9, *cis*-12, *cis*-15 C18:3 FA, and lower ($P \leq 0.01$) C4:0, *cis-9* C18:1, and *cis*-9 *trans*-11 C18:2 compared to rbST-cows (Table 5). In general, yeast increased ($P \leq 0.04$) 4 to 14 carbon FA, saturated FA, odds-chain, and saturated to unsaturated FA ratio. Finally, rbST increased ($P \leq 0.02$) higher than 16 carbon FA, unsaturated FA, and the ratio between *cis*-9 C18:1 and C18:0 FA.

Table 5 Milk fatty acids profile of Holstein cows treated with rbST or live yeast

Fatty acids (g/100 g FA)	Tratamento[1]		SEM[2]	*P*[3]
	rBST	LV		
C4:0	1.60	1.58	0.004	0.01
C6:0	1.65	1.65	0,007	0.68
C8:0	2.89	2.89	0,001	0.82
C10:0	0.106	0.107	0,002	0.87
C12:0	0.104	0.106	0,002	0.45
C14:0	11.5	11.5	0,009	0.93
C14:1	0.863	0.865	0,006	0.73
C15:0	0.193	0.193	0,005	0.95
C15:1	0.196	0.197	0,003	0.94
C16:0	25.1	25.3	0,002	<0.01
C16:1	1.58	1.57	0,003	0.38
C17:0	0.423	0.440	0,006	0.02
C17:1	0.415	0.430	0,005	0.02
C18:0	18.2	18.3	0,042	0.19
cis 9,C18:1	32.6	32.3	0,031	<0.01
cis-9,cis-12 C18:2	3.58	3.54	0,032	0.16
cis-9,cis-12,cis-15 C18:3	0.169	0.174	0,002	<0.01
cis-9,trans-11 CLA	0.430	0.409	0.003	0.01
C20:0	0.108	0.110	0.004	0.30
cis-11 C20:1	0.104	0.102	0.022	0.19
cis-11,cis-14 C20:2	0.104	0.104	0.002	0.92
cis-8,cis-11,cis-14 C20:3	0.104	0.104	0.001	0.70
cis-8,cis-11,cis-17 C20:3	1.52	1.51	0.003	0.64
cis-5,cis-8,cis-11,cis-14 C20:4	0.192	0.193	0.002	0.70
cis-5,cis-8,cis-11,cis-14, cis-17 C20:5	0.104	0.103	0.004	0.81
cis-11 22:1	0.885	0.884	0.005	0.97
Summary				
Σ 4- to 14-C	18.7	18.4	0.03	<0.01
Σ more than16-C	59.0	58.3	0.03	0.01
Σ saturated FA	61.9	62.2	0.05	<0.01
Σ unsaturated FA	42.8	42.5	0.04	<0.01
Σ mono unsaturated FA	36.6	36.4	0.04	<0.01
Σ poli unsaturated FA	6.21	6.16	0.023	0.29
Σ branched-chain FA	1.23	1.26	0.007	0.04
Saturated:unsaturated ratio	1.45	1.46	0.002	<0.01
c9 14:1/14:0	0.08	0.076	0.001	0.42
c9 16:1/16:0	0.06	0.06	0.001	0.84
c9 18:1/18:0	1.78	1.76	0.004	0.02

[1]Treatments: rbST: animals (n = 15) treated with 500 mg of rbST (Lactotropin®, União Química, São Paulo, Brazil), every 14 days; 2) Yeast: animals (n = 20) fed diets containing 40 g/d of live yeast (Levumilk®, 20 × 10^9 colony-forming units of *Saccharomyces cerevisiae* KA 500 per g, Kera Animal Nutrition, Bento Gonçalves, Brazil);
[2]Standard error of mean;
[3]Probability of treatment effect (rbST *vs.* Yeast).

DISCUSSION

Yeast increased dairy cows' production and productivity by improving the digestion, which resulted in reduced particle size and starch content in feces samples. In addition, yeast increased saturated milk saturated fatty acids, reduced serum glucose, and milk SCC and had no effect on feed intake. Considering a short-time evaluation, yeast utilization was more effective than rbST application.

There was no treatment effect on cows' feed intake during the evaluating period in the present study. Previous studies reported no effects of live yeast on cows' DM and nutrient intake (Jiang et al., 2017; Dias et al., 2018a; Perdomo et

al., 2020). However, LY is able to reduce meal duration and increase rumination time (Dias et al., 2018a), reducing the risks of acidosis, and increasing the sorting index of large particles (Dias et al., 2018b). These positive effects on the digestion process have been associated with positive effects on the feed intake of cows during the hot season (Moallem et al., 2009). No treatment effect on feed intake observed in the present study occurred because rbST whole is also null or positive (Gandra et al., 2020). Positive effects are normally observed in a long-term evaluation in consequence of increased milk yield (Baldwin & Knapp, 1993).

Although treatments showed no effects on DM and nutrient intake, yeast increased large particle selection index, as observed by Dias et al. (2018b). According to these authors, an increased selection index of large particles occurred because yeast improves ruminal digestion. One of the most accepted action mechanism of live yeast is the oxygen uptake: Newbold et al. (1996) observed that S. cerevisiae reduces ruminal redox potential and favor cellulolytic bacteria. In addition, we also observed a reduced concentration of particles higher than 2-mm in the feces of yeast-treated cows. According to Gregorini et al. (2015), a lower concentration of large particles in feces could be considered an indicator of improved ruminal digestibility, and it is normally observed in cows that show lower residual feed intake. On the other hand, Jiang et al. (2017) reported an increased abundance of cellulolytic, amylolytic, and lactate-utilizing microorganisms in cows fed diets containing live yeast. We also observed a decreased concentration of starch in the feces of yeast-treated cows. According to Dennis et al. (2017), fecal starch could be considered a tool to evaluate starch digestibility in dairy cows. These positive effects observed in the digestion process explain higher productive efficiency observed in animals fed yeast compared to rbST treated animals. No effects of rbST on the digestion process had been reported in a short term-evaluation (Baldwin & Knapp, 1993).

Considering similar feed intake and improved digestion observed in yeast-treated animals, it was expected a positive effect on glucose and a negative effect on cholesterol concentration. However, it was observed exactly the opposite effect: yeast decreased glucose and increased cholesterol serum concentration compared to rbST. It is essential to considerer that metabolic effects of rbST are more prominent than those observed by yeast. Recombinant bovine somatotropin is used to improve IFG-1 production, with consequent effects on glucose utilization and cows production (Bauman, 1992). Peripartum application of rbST has been associated with increased glucose and decreased non-esterified fatty acids and beta-hydroxybutyrate concentration (Putnam et al., 1999; Carriquiry et al., 2009). Perdomo et al. (2020) observed no effects of yeast on glucose and urea plasma concentration, but, Yeast linearly increased fatty acids concentration. We need to highlight that circulating glucose and cholesterol concentration is highly affected by milk yield, once these are the substrates for milk synthesis.

Live yeast increased milk yield, fat corrected and energy corrected milk yield compared to rbST. As no difference was observed in feed intake, rbST-treated animals also showed reduced production efficiency. As previously mentioned, positive effects observed in yeast-treated animals are a consequence of an improved digestion process, as observed with reduced feces

large particles, and starch content. On the other hand, it is essential to highlight that the rbST effect is accumulative through lactation (Morais et al., 2017), and lower positive effects are normally observed in a short-term evaluation (Baldwin and Knapp, 1993). Although differences were observed in milk yield, treatments showed no effects on milk composition. However, rbST animals had higher SCC than yeast-treated cows.

Besides the positive effects of yeast on nutrient digestion, Perdomo et al. (2020) also observed an increased ruminal concentration of short-chain fatty acids. Previously mentioned studies have reported a potential effect of yeast against acidosis (Dias et al., 2018b). There are two main sources of milk fatty acids: incorporation from blood, and *de novo* synthesis from short-chain fatty acids. It has been largely studied milk-fat depression by rumen-derived bioactive fatty acids (Bauman et al., 2011). This theory highlighted that these compounds, produced by partial ruminal bio-hydrogenation, could inhibit de novo synthesis of fatty acids, which finally resulted in higher unsaturated fatty acids content (Jenkins et al., 2011). According to Bauman et al. (2011), milk fat depression occurs in two conditions: 1) change in the rumen environment and a shift in the bacteria population that is often characterized by a decrease in rumen pH, and 2) a dietary supplementation of unsaturated fatty acids. In the present study, besides reduction in linoleic conjugated acid (*cis*-9 *trans*-11 C18:2) content, we also observed an increasingly saturated and reduced unsaturated fatty acids content in yeast-treated animals. Nowadays, *cis*-9 *trans*-11 C18:2 has been not directly associated with milk fat depression (Moya-Camarena et al., 1999) which explains no effects of treatments on milk fat content, in the present study. However, previously mentioned results could be associated with a more stable ruminal digestion, reducing rumen bioactive fatty acids production. Finally, it is essential to highlight the low fatty acids content of diet limits the magnitude of this effect and reduces practical implications.

CONCLUSIONS

Yeast increases dairy cows' production and productivity and reduces particle size and starch content in feces samples. In addition, yeast increases saturated milk saturated fatty acids, reduces serum glucose and milk SCC, and has no effect on feed intake. Considering a short-term evaluation, yeast utilization is more effective than rbST application.

REFERENCES

Bauman, D.E., Harvatine, K.J., Lock, A.L., 2011. Nutrigenomics, rumen-derived bioactive fatty acids, and the regulation of milk fat synthesis. Annu. Rev. Nutr. 31, 299-319.

Dell'Orto, V., Savoini, G., Salimei, E., Cattaneo, D., Secchi, C., Rosi, F., 1993. Effects of recombinant bovine somatotropin (rbst) on productive and physiological parameters related to dairy cow welfare. Livest. Prod. Sci. 36(1), 71-75.

Dennis, T.S., Hu, W., Suarez-Mena, F.X., Hill, T.M., Quigley, J.D., Schlotterbeck, R.L., 2017. Short communication: Use of fecal starch concentration as an indicator of dry feed digestion in preweaned dairy calves. J. Dairy Sci. 100(8), 6266-6271.

Dias, A.L.G., Freitas, J.A., Micai, B., Azevedo, R.A., Greco, L.F., Santos, J.E.P., 2018a. Effect of supplemental yeast culture and dietary starch content on rumen fermentation and digestion in dairy cows. J. Dairy Sci. 101(1), 201-221.

Dias, J.D.L., Silva, R.B., Fernandes, T., Barbosa, E.F., Graças, L.E.C., Araujo, R.C., Pereira, R.A.N., Pereira, M.N., 2018b. Yeast culture increased plasma niacin concentration, evaporative heat loss, and feed efficiency of dairy cows in a hot environment. J. Dairy Sci. 101(7), 5924-5936.

European Food Safety Authority, 2015. EFSA's assistance for the 2015 codex committee on residues of veterinary drugs in food (CCRVDF) in relation to rbST. EFSA. 12(6), 828E.

Food and Agriculture Organization of the United Nations, 2014. Residue evaluation of certain veterinary drugs. In 78th meeting 2013 of the Joint FAO/WHO Expert Committee on Food Additives, Geneva, 5-14 November 2013. Available online: https://www.fao.org/3/i3745e /i3745e.pdf (Accessed on January 18, 2017).

Gregorini, P., Waghorn, G.C., Kuhn-Sherlock, B., Romera, A.J., Macdonald, K.A., 2015. Short communication: Grazing pattern of dairy cows that were selected for divergent residual feed intake as calves. J. Dairy Sci. 98(9), 6486-6491.

Moallem, U., Lehrer, H., Livshitz, L., Zachut, M., Yakoby, S., 2009. The effects of live yeast supplementation to dairy cows during the hot season on production, feed efficiency, and digestibility. J. Dairy Sci. 92(1), 343-351.

Moya-Camarena, S.Y., Vanden Heuvel, J.P., Blanchard, S.G., Leesnitzer, L.A., Belury, M.A., 1999. Conjugated linoleic acid is a potent naturally occurring ligand and activator of pparalpha. J. Lipid Res. 40(8), 1426-1433.

Newbold, C.J., Wallace, R.J., McIntosh, F.M., 1996. Mode of action of the yeast saccharomyces cerevisiae as a feed additive for ruminants. Br. J. Nutr. 76(2), 249-261.

Perdomo, M.C., Marsola, R.S., Favoreto, M.G., Adesogan, A., Staples, C.R., Santos, J.E.P., 2020. Effects of feeding live yeast at 2 dosages on performance and feeding behavior of dairy cows under heat stress. J. Dairy Sci. 103(1), 325-339.

Singer, R.S., Ruegg, P.L., Bauman, D.E., 2017. Quantitative risk assessment of antimicrobial-resistant foodborne infections in humans due to recombinant bovine somatotropin usage in dairy cows. J. Food. Prot. 80(7), 1099-1116.

St-Pierre, N.R., Milliken, G.A., Bauman, D.E., Collier, R.J., Hogan, J.S., Shearer, J.K., Smith, K.L., Thatcher, W.W., 2014. Meta-analysis of the effects of sometribove zinc suspension on the production and health of lactating dairy cows. J. Am. Vet. Med. Assoc. 245(5), 550-564.

Westerveld, A., 2017. Innovation is critical. Dairy. Mail. 24(5), 87-91. Available online: https://journals.co.za/doi/epdf/10.10520/EJC-7084167a9

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