Effects of *Megasphaera elsdenii* administration on performance and carcass traits of finishing *Bos indicus* feedlot cattle[1]

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ABSTRACT: This study evaluated the effects of *Megasphaera elsdenii* administration at the beginning of the feedlot period on performance of *Bos taurus indicus* bulls. On d 0, 383 Nellore bulls (initial shrunk body weight 384 ± 29.2 kg; initial age = 24 ± 2 mo) were assigned to treatments in a randomized complete block design. Treatments consisted of 1) 14 d adaptation diet and transition to a finishing diet (**CONT**), 2) CONT plus oral administration of 20 mL of Lactipro-NXT (*M. elsdenii*) on d 0 of the study (**MEG-14**), 3) CONT diet, consisting of 6 d of adaptation diet plus oral administration of 20 mL of Lactipro-NXT on d 0 of the study (**MEG-6**), and 4) No adaptation diet and oral administration of 20 mL of Lactipro-NXT on d 0 of the study (**MEG-0**). Experimental period lasted 119 d. No treatment effects were observed for any of the performance parameters evaluated herein ($P \geq 0.15$). Nonetheless, a treatment × wk interaction was observed for DM, NE_m, and NE_g intakes ($P < 0.0001$). For all these parameters, MEG-0 and MEG-6 had a reduced intake vs. MEG-14 and CONT in the first wk of the study ($P \leq 0.05$). For the carcass traits, no effects were observed for HCW ($P \geq 0.24$), whereas MEG-6 had a greater REA when compared with MEG-0 and MEG-14 (quadratic effect; $P = 0.04$) and MEG-administered bulls tended to have a greater BFT vs. CONT ($P = 0.08$). In summary, *M. elsdenii* administration at the beginning of the feedlot period did not improve performance, whereas reducing the length of the adaptation period for 6 d improved REA of finishing *Bos taurus indicus* bulls.

Key words: beef cattle, *Bos taurus indicus*, carcass, feedlot, *Megasphaera elsdenii*, performance

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INTRODUCTION

During the initial feedlot period, nutritional management practices should be employed to ensure an adequate rumen health and animal performance (Brown et al., 2006). Among these practices, multiple step-up diets in which the roughage: concentrate ratio, amount of feed offered, and dietary energy content change over time are often used (Samuelson et al., 2016; Pinto and Millen, 2019). On the ruminal health standpoint, an overconsumption and/or erratic intake behavior of a diet containing high levels of readily fermentable

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carbohydrates leads to a greater amount of acid production that the rumen epithelium can absorb and ruminal microbes utilize (Owens et al., 1998). In turn, these organic acids will accumulate in the rumen, causing a drastic reduction in rumen pH (Nagaraja and Lechtenberg, 2007) that may negatively impact feedlot performance (Owens et al., 1998). Therefore, it is imperative to evaluate technologies that improve rumen health and reduce the risk of acidosis in the beginning of the feedlot period.

Megasphaera elsdenii (**MEG**), a gram-negative, lactate-utilizing bacteria seems to be a feasible alternative for maintaining rumen health (Counotte et al., 1981), since under *in vitro* and *in vivo* settings, its inoculation alleviated the decrease in pH when increasing amounts of concentrates were inoculated in the medium or fed to the animals (Kung and Hession, 1995; McDaniel et al., 2009). Nonetheless, most of the published studies in the literature have evaluated MEG inoculation in different step-up diets management (Drouillard et al., 2012; DeClerck et al., 2020a; DeClerck et al., 2020b), whereas no other study evaluated its efficacy on performance of *Bos taurus indicus* animals receiving a high-energy diet throughout the feedlot period, without offering an adaptation diet. Based on this rationale, we hypothesized that MEG inoculation at the beginning of the feedlot period would increase performance and carcass traits of feedlot animals, even without the offer of an adaptation diet. Therefore, our objective was to evaluate the effect of MEG inoculation at the beginning of the feedlot period on performance and carcass characteristics of *Bos taurus indicus* bulls receiving or not an adaptation diet.

MATERIALS AND METHODS

This experiment was conducted at the experimental feedlot located at the University of São Paulo (USP), Escola Superior de Agricultura Luiz de Queiroz (ESALQ), located in Piracicaba, São Paulo, Brazil (22°43′31″ S, 47°38′51″ W, and elevation of 546 m) from May to September 2020. Average temperature within each month from the experimental period (from May to September) was 19, 17, 17, 18, and 20°C, respectively, whereas total rainfall was 43, 41, 25, 26, and 55 mm, respectively. All animals utilized herein were cared for in accordance with acceptable practices and experimental protocols reviewed and approved by the ESALQ/USP Institutional Animal Care and Use Committee (# 6727310720).

Animals, Housing, and Diets

From d −7 to −1 of the study, all animals were housed in group-pens with *ad libitum* access to water and *Brachiaria brizantha* cv. Marandu hay, in order to acclimate animals to the facilities prior to the beginning of the experiment.

On d 0 of the study, 383 Nellore (*Bos taurus indicus)* bulls were ranked by initial shrunk body weight (**BW**; after 16 hours of feed and water restriction; 384 ± 29.2 kg; initial age = 24 ± 2 mo) and randomly assigned to treatments in a randomized complete block design. Within blocks (n = 15), animals were randomly assigned into pens (n = 6 to 8 animals/pen) and pens were randomly assigned to receive 1 of 4 treatments: 1) 14 d adaptation with 2 step-up diets and transition to a high-concentrate finishing diet on d 15 (**CONT**; n = 15), 2) CONT plus oral administration of 20 mL of Lactipro-NXT (*M. elsdenii* NCIMB 41125, 1 × 10^{10} CFU/head; MS Biotec, Wamego, KS) on d 0 of the study (**MEG-14**; n = 15), 3) Six d of adaptation with 2 step-up diets plus oral administration of 20 mL of Lactipro-NXT on d 0 of the study (**MEG-6**; n = 15), and 4) Finishing diet and oral administration of 20 mL of Lactipro-NXT on d 0 of the study (**MEG-0**; n = 15). The mixing of the MEG with the saline solution and oral administration of Lactipro-NXT was performed individually following manufacturer´s recommendations. Regardless of treatment, all animals received the same step-up diets during the adaptation period (if applicable) and the same finishing diet during the experimental period, which lasted 119 d. For CONT and MEG-14, the adaptation diet was offered for 14 d and consisted of 2 step-up dies (7 d each), whereas MEG-6 also had 2 step-up diets in a shorter period of time (6 d). The roughage:concentrate ratio for the adaptation diets was 25:75 and 20:80, respectively, whereas the finishing diet had an 8.5:91.5 ratio. The entire composition and nutritional profile of the diets are reported in Table 1. Corn was processed through a hammer mill (Indústria e Comercial Lucato, Limeira, SP, Brazil) to achieve a mean particle size of 1.93 mm (Table 2), according to procedures described by Yu et al. (1998), using sieves with 6.0, 3.5, 2.0, and 1.25-mm square pores (Produtest T model; Telastem Peneiras para Análises Ltda., São Paulo, SP, Brazil). Diets were formulated using NASEM (2016) to provide an average daily gain (**ADG**) of 1.5 kg during the experimental period.

On d 0, all bulls were individually identified with ear tags, vaccinated against clostridial (Covexin-9; MSD, São Paulo, Brazil) pathogens and dewormed

Table 1. Composition and nutritional profile of the diets offered during the experimental period[1,2]

Item, % dry matter (DM)	ADAP-1	ADAP-2	FIN
Sugarcane bagasse	25.0	20.0	8.5
Ground corn	37.8	42.8	54.3
Corn gluten feed	20.0	20.0	20.0
Whole cottonseed	15.0	15.0	15.0
Urea	0.2	0.2	0.2
Mineral-vitamin mix[3]	2.0	2.0	2.0
Nutritional profile			
DM	69.1	72.5	81.8
Crude protein, % DM	13.0	13.2	13.8
Ether extract, % DM	5.3	5.4	5.8
Neutral detergent fiber, % DM	36.8	33.5	25.9
Starch	31.2	34.7	42.9
Total digestible nutrients, % DM[4]	74.5	76.7	81.5
Metabolizable energy, Mcal/kg[5]	2.69	2.77	2.94
Net energy for maintenance, Mcal/kg[5]	1.79	1.86	2.03
Net energy for gain, Mcal/kg[5]	1.15	1.21	1.36

[1]Experimental period lasted 119 d.

[2]ADAP-1: adaptation diet (step-up 1) offered for 7 d to CONT and MEG-14 and for 3 d to MEG-6; ADAP-2: adaptation diet (step-up 2) offered for 7 d to CONT and MEG-14 and for 3 d to MEG-6. FIN: finishing diet offered for all animals following or not an adaptation diet.

[3]Mineral-vintamin mix (MCassab Comércio e Indústria; São Paulo, SP, Brazil) contained 21.0% Ca, 2.0% Mg, 15.0% Na, 23.1% Cl, 750 ppm Cu, 2,000 ppm Mn, 3,000 ppm Zn, 16.7 ppm Co, 30 ppm I, 5 ppm Se, 115 IU Vitamin A, 14 IU Vitamin D3, 180 IU Vitamin E, and 1,500 ppm sodium monensin (Rumensin; Elanco Animal Health, São Paulo, SP, Brazil).

[4]Calculated according to Weiss et al. (1992) and chemical composition of ingredients.

[5]Estimated with the equations proposed by NRC (1996; Level 1) with the addition of ionophore (sodium monensin) and using the TDN values, which had been calculated with equation proposed by Weiss et al. (1992).

with 1 mL/50 kg BW of an antiparasitic (Evol; Ouro Fino Saúde Animal, Cravinhos, SP, Brazil). Throughout the experimental period, diets were supplied once daily as a total mixed ration using a feed wagon (Rotormix-40; Casale Equipamentos, São Carlos, SP, Brazil) with an electronic scale (ez3400VL; Digi Star, Fort Atkinson) and offered to ensure *ad libitum* intake and result in 3% orts. Additionally, all animals had full access to water and were maintained into open-sided paved pens with a coverall in the feed bunk (4.0 m of linear feed bunk for pens housing 6 animals and 5.0 m of linear feed bunk for pens housing 8 animals).

Sampling and Carcass Measurements

Individual shrunk BW of bulls was collected on d 0 and 119 after 16 hours of feed and water withdrawal and used to calculate the BW change (final minus initial BW) and ADG during the experiment. Total dry matter intake (**DMI**) and individual nutrient intake were evaluated daily throughout the experimental period by weighing the feed offered and refused in the following day (approximately 24 hours). At the end of the experiment, total BW gain and total DMI were used for feed efficiency (**FE**) calculation, whereas mean BW was used for determination of DMI as a percentage of BW.

Table 2. Corn grain particle size distribution

Pores in the sieve	% of total
> 6.0 mm	0.67
≤ 6.0 and > 3.5 mm	5.31
≤ 3.5 and > 2.0 mm	26.67
≤ 2.0 and > 1.25 mm	48.06
≤ 1.25 mm	19.30
Mean particle size of corn, mm[1]	1.93

[1]Corn retained on the 6 mm screen was determined in 20 randomly particles using a digital caliper. The residue retained in the bottom was assumed to have a mean particle size of 0.625 mm. Based on Yu et al. (1998).

Samples of ingredients were collected at the beginning of the experiment and analyzed for nutrient concentration (ESALQ Lab; Piracicaba, SP, Brazil). All samples were analyzed in duplicates by wet chemistry procedures for concentrations of crude protein [**CP**; method 984.13; AOAC (2006)], neutral detergent fiber [**NDF**; Van Soest et al. (1991); modified for use in an Ankom-200 fiber analyzer; Ankom Technology Corp., Fairport, NY], and acid detergent fiber [**ADF**; method 973.18 modified for use in an Ankom-200 fiber analyzer; Ankom Technology Corp.; AOAC (2006)]. Moreover, total digestible nutrient (**TDN**) concentration was calculated according to equations proposed by Weiss et al. (1992).

The observed net energy (**NE**) for each diet was calculated from the performance data using the equation reported by Zinn and Shen (1998) based on pen average values. Energy gain (**EG**) was calculated as EG = $(0.0557 \times BW^{0.75}) \times ADG^{1.097}$ (NRC, 1984), in which EG is daily energy deposited (Mcal/d) and BW is mean shrunk BW. The equation used to calculate maintenance energy expended (**MEx**; Mcal/d) was metabolizable energy (**ME**) = $0.077 \times BW^{0.75}$ (Lofgreen and Garrett, 1968). From the calculated amounts of energy required for maintenance (**NE$_m$**) and gain (**NE$_g$**), the NE_m of each diet was obtained by the quadratic equation $NE_m = [-b \pm (b^2 - 4ac)^{1/2}]/2a$, in which $a = -0.41 \times EM$, $b = 0.877 \times ME_x + 0.41 \times DMI + EG$, and $c = -0.877 \times DMI$ and NEg of each diet was obtained by the equation $NE_g = 0.877 \times NE_m - 0.41$

(Zinn and Shen, 1998). Expected dietary NE_m and NE_g were predicted using the equations proposed by the NRC (1996; Level 1) with the addition of an ionophore, based on the numeric sum of TDN values (Weiss et al., 1992). The observed NE_m: expected NE_m and observed NE_g: expected NE_g were then calculated.

On d 116 of the experimental period, all animals were submitted to ultrasound evaluations (Aloka SSD-500V with a 17.2 cm/3.50 MHz convex probe; Hitachi Healthcare Americas, Twinsburg, OH), performed by the same trained technician (DGT Brasil, Presidente Prudente, SP, Brazil). Evaluations were conducted according to procedures described by the Ultrasound Guidelines Council (UGC, 2014) and measurements of the ribeye area (**REA**), marbling, and backfat thickness (**BFT**) were collected on the *Longissimus thoracis* muscle between the 12th and 13th ribs.

All animals were slaughtered following a waiting period of approximately 16 hours, in a commercial packing plant (Frigorífico Angelelli, Piracicaba, SP, Brazil). Hot carcasses were separated into two symmetrical sections, weighed to obtain hot carcass weight (**HCW**), and individually identified. Dressing percent (**DP**) was calculated by dividing the HCW and final BW of each animal. At the beginning of the study, initial DP of the animals was estimated in 50% and then it was calculated the amount of carcass gained by the animals during the experimental period (d 0 to 119). Lastly, carcass ADG was calculated by dividing the carcass gain and the number of d on feed.

Statistical Analysis

For all analyses performed herein, pen was considered the experimental unit. All data were analyzed using the PROC MIXED procedure of SAS (Version 9.4; SAS Inst. Inc.; Cary, NC) and the Satterthwaite approximation to determine the denominator *df* for the test of fixed effects. The model statement used for all performance and carcass data contained the fixed effects of treatment. All data were analyzed using block and pen(treatment) as random variables, whereas animal(pen) was also included in the random statement for BW, ADG, and carcass ultrasound data. With the exception of DMI, orthogonal contrasts were used to partition specific treatment effects: 1) *M. elsdenii* effect: CONT vs. MEG, 2) Linear, and 3) Quadratic effect of d of adaptation. For daily DM, NE_m, and NE_g intakes, values were averaged within each week (n = 17 weeks) and analyzed as repeated measures. The specified term for the repeated statement was week, the subject was pen(treatment), and the covariance structure was autoregressive 1, which provided the best fit for these analyses according to the smallest Akaike Information Criterion (**AIC**).

All results are reported as least square means and separated using the PDIFF structure of SAS (SAS Inst. Inc.). For all the data, significance was set at $P \le 0.05$ and tendencies were denoted if $P > 0.05$ and $P \le 0.10$. Moreover, specifically for DM and nutrient intake, results are reported according to the main effects if no interactions were significant or according to the highest-order interaction detected.

RESULTS

Regardless of treatment, no cases of rumen acidosis, laminitis, and/or animal removal due to related ruminal disorders were observed throughout the experimental period.

Intake and Performance

No treatment effects were observed ($P = 0.89$) on initial BW, demonstrating the similar management animals were reared to prior to the beginning of the experiment (Table 3). Similarly, neither contrast effect was significant for final BW ($P \ge 0.29$), mean DMI ($P \ge 0.15$), ADG ($P \ge 0.24$), FE ($P \ge 0.43$), observed NE_m and NE_g ($P \ge 0.21$), as well as observed:expected NE_m and NE_g ratios ($P \ge 0.61$; Table 3).

Nonetheless, a treatment × wk interaction was observed for DM, NE_m, and NE_g intakes ($P < 0.0001$; Fig. 1A–C). For DMI, MEG-0 had a reduced DMI vs. CONT from wk 1 through 5 ($P < 0.01$), reduced DMI vs. MEG-14 from wk 1 through 4 ($P \le 0.02$), and reduced DMI vs. MEG-6 in wk 1 only ($P < 0.01$; Fig. 1A). From wk 2 through 5, MEG-6 also had a reduced DMI vs. CONT ($P \le 0.03$) and vs. MEG-14 on wk 2 and 3 of the study ($P \le 0.0001$; Fig. 1A). Lastly, MEG-14 had a reduced DMI vs. CONT on wk 4 and 5 of the experimental period ($P \le 0.05$), whereas no further treatment differences were observed from wk 6 through 17 of the study ($P \ge 0.12$; Fig. 1A).

Similarly, NE_m intake was reduced for MEG-0 and MEG-6 vs. CONT from wk 2 through 5 ($P \le 0.05$), but also reduced for MEG-14 vs. CONT in the 4th and 5th wk of the study ($P \le 0.02$; Fig. 1B), with no further treatment differences through the remainder of the study ($P \ge 0.11$). For NE_g, intake was reduced in MEG-0 vs. CONT from wk 2

Table 3. Performance of *Bos taurus indicus* bulls administered or not *Megasphaera elsdenii* (Lactipro-NXT; 1×10^{10} CFU/head; MS Biotec, Wamego, KS) and offered an adaptation diet for 14, 6, or 0 d[1]

	Treatments				SEM	*P* =[2]		
Item	CONT	MEG-14	MEG-6	MEG-0		CONT vs. MEG	*L*	*Q*
Initial BW, kg	386.6	386.7	386.6	386.6	7.66	0.89	0.81	0.80
Final BW, kg	572.1	570.7	572.9	566.4	8.26	0.59	0.36	0.29
Average daily gain, kg/d	1.59	1.58	1.60	1.54	0.26	0.59	0.24	0.26
Dry matter intake, kg	10.85	10.74	10.73	10.42	0.219	0.22	0.15	0.42
Feed efficiency, g/kg	147	147	149	148	2.7	0.43	0.68	0.52
Net energy for maintenance, Mcal/kg								
Observed[3]	1.90	1.90	1.92	1.93	0.020	0.34	0.21	0.62
Expected[4]	2.02	2.02	2.03	2.04	--	--	--	--
Observed: Expected ratio[5]	0.94	0.94	0.95	0.95	0.001	0.61	0.61	0.62
Net energy for gain, Mcal/kg								
Observed[3]	1.25	1.26	1.28	1.28	0.018	0.34	0.21	0.62
Expected[4]	1.36	1.36	1.37	1.38	--	--	--	--
Observed: Expected ratio[5]	0.92	0.92	0.93	0.93	0.013	0.66	0.62	0.62

[1]Experimental period lasted 119 d. CONT: 14 d adaptation with 2 step-up diets and transition to a high-concentrate finishing diet on d 15 (n = 15), MEG-14: CONT plus oral administration of 20 mL of Lactipro-NXT (*M. elsdenii* NCIMB 41125, 1×10^{10} CFU/head; MS Biotec, Wamego, KS) on d 0 of the study (n = 15), MEG-6: Six d of adaptation with 2 step-up diets plus oral administration of 20 mL of Lactipro-NXT on d 0 of the study (n = 15), and MEG-0: Finishing diet and oral administration of 20 mL of Lactipro-NXT on d 0 of the study (n = 15).

[2]Contrast analysis: 1) *Megasphaera elsdenii* effect = CONT vs. MEG, 2) Linear effect of d of adaptation = L, and 3). Quadratic effect of d of adaptation = Q.

[3]Calculated using the equation proposed by Zinn and Shen (1998), where estimates of cattle performance were pen averages.

[4]Calculated using observed NE values based on equation of Zinn and Shen (1998).

[5]Estimated with the equations proposed by NRC (1996; Level 1) with the addition of ionophore (sodium monensin) and using the TDN values, which had been calculated with equation proposed by Weiss et al. (1992).

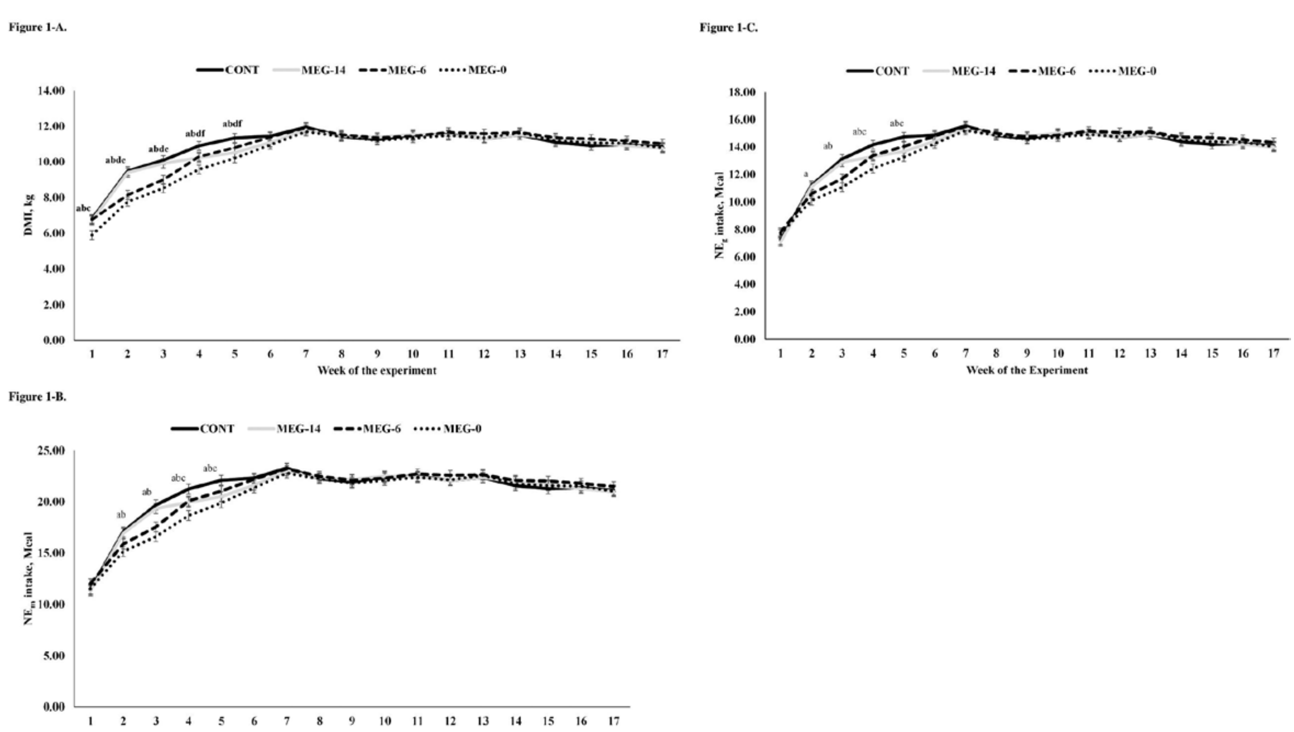

Figure 1. Dry matter (**DM**; A), net energy for maintenance (**NEm**; B), and net energy for gain (**NEg**; C) intake of *Bos taurus indicus* bulls administering or not *Megasphaera elsdenii* (Lactipro-NXT; 1×10^{10}CFU/head; MS Biotec, Wamego, KS) and offered an adaptation diet for 14, 6, or 0 d. A treatment × wk interaction was observed for all nutrient intakes ($P < 0.0001$). (A) (DM intake): a = CONT vs. MEG-0 ($P > 0.01$); b = MEG-14 vs. MEG-0 ($P \leq 0.02$); c = MEG-6 vs. MEG-0 ($P < 0.01$); d = CONT vs. MEG-6 ($P \leq 0.03$); e = MEG-14 vs. MEG-6 ($P \leq 0.001$); f = CONT vs. MEG-14 ($P \leq 0.05$); SEM = 0.49. (B) (NE_m intake): a = CONT vs. MEG-6 ($P \leq 0.05$); b = CONT vs. MEG-0 ($P \leq 0.0001$); c = CONT vs. MEG-14 ($P \leq 0.02$); SEM = 0.49. (C) (NE_g intake): a = CONT vs. MEG-0 ($P < 0.01$); b = CONT vs. MEG-6 ($P \leq 0.05$); c = CONT vs. MEG-14 ($P \leq 0.02$); SEM = 0.32.

to 5 ($P < 0.01$), reduced for MEG-6 vs. CONT from wk 3 to 5 ($P \le 0.05$), and also reduced for MEG-14 vs. CONT on wk 4 and 5 of the study ($P \le 0.02$; Fig. 1C).

Carcass Traits and Ultrasound Measurements

No contrast effects were observed for HCW ($P \ge 0.24$), DP ($P \ge 0.44$), carcass ADG ($P \ge 0.25$; Table 4).

Regarding ultrasound measurements, MEG-6 had a greater REA when compared with MEG-0 and MEG-14 (quadratic effect; $P = 0.04$), whereas no CONT vs. MEG ($P = 0.87$) or linear effects of decreasing adaptation length ($P = 0.23$) were detected for this parameter (Table 4). Additionally, MEG administered bulls tended to have a greater BFT vs. CONT cohorts at the end of the experimental period ($P = 0.08$; Table 4) and no differences were observed for marbling ($P \ge 0.15$; Table 4).

DISCUSSION

The primary goal of the present study was to evaluate whether administration of *M. elsdenii* at the beginning of the feedlot period would improve performance and carcass characteristics of *Bos taurus indicus* bulls offered a high-concentrate diet. *Megasphaera elsdenii* is a gram-negative bacterium that consumes a major fraction of lactic acid produced in the rumen (Counotte et al., 1981) and, therefore, reduces the occurrence of rumen acidosis (Kung and Hession, 1995). The utilization of a commercial patented strain (Lactipro NXT; *M. elsdenii* NCIMB 41125) has demonstrated positive results in controlling acidosis under *in vitro* (Horn et al., 2009; McDaniel et al., 2009) and *in vivo* (Drouillard et al., 2012; DeClerck et al., 2020a; DeClerck et al., 2020b; DeClerk et al., 2020c) experimental settings.

An interesting observation from the present experiment was that clinical ruminal acidosis was not observed in any of the animals enrolled to the study. This is not surprising for CONT and MEG-14, given that animals received a 14-d adaptation period and this is in agreement with the current feedlot management practices in Brazil (16.2 d; Pinto and Millen, 2019). Conversely, the lack of ruminal disorders in MEG-0 and MEG-6 supports the efficacy of MEG in alleviating the occurrence of digestive disorders in beef cattle offered a high-concentrate diet without a step-up adaptation period (Kettunen et al., 2008; Horn et al., 2009; McDaniel et al., 2009; DeClerck et al., 2020b). DeClerk et al. (2020c) also did not report any case of clinical acidosis in beef calves abruptly transitioned from a grower to a finishing diet over a short period of time, supporting the efficacy and success of ruminal colonization after exogenous MEG drench. Removing the adaptation diet from the feedlot might benefit the entire operation, given the elevated cost per unit of energy and that the use of forage and consequent the space required to store this bulky material will consequently decrease (Buttrey et al., 2012; Schneider et al., 2017). Moreover, a rapid adaptation to a calorically dense diet might stimulate a higher growth of the superior epithelial surface area and, consequently,

Table 4. Carcass and ultrasound data of *Bos taurus indicus* bulls administered or not *Megasphaera elsdenii* (Lactipro-NXT; 1×10^{10}CFU/head; MS Biotec, Wamego, KS) and offered an adaptation diet for 14, 6, or 0 d[1,2]

	Treatments				SEM	$P =$[3]		
Item	CONT	MEG-14	MEG-6	MEG-0		CONT vs. MEG	*L*	*Q*
Carcass traits								
Hot carcass weight, kg	324.7	324.3	324.2	321.0	5.17	0.51	0.24	0.51
Dressing percent, %	56.6	56.8	56.7	56.6	0.25	0.61	0.44	0.98
Carcass average daily gain, kg	1.10	1.10	1.10	1.07	0.018	0.49	0.25	0.49
Ultrasound measurements								
Ribeye area, cm^2	86.3	86.4	87.8	85.0	0.97	0.87	0.23	0.04
Backfat thickness, mm	5.41	5.62	5.71	5.66	0.131	0.08	0.83	0.63
Marbling, %	2.98	2.90	2.89	3.06	0.085	0.74	0.15	0.35

[1]Experimental period lasted 119 d. CONT: 14 d adaptation with 2 step-up diets and transition to a high-concentrate finishing diet on d 15 ($n = 15$), MEG-14: CONT plus oral administration of 20 mL of Lactipro-NXT (*M. elsdenii* NCIMB 41125, 1×10^{10} CFU/head; MS Biotec, Wamego, KS) on d 0 of the study ($n = 15$), MEG-6: Six d of adaptation with 2 step-up diets plus oral administration of 20 mL of Lactipro-NXT on d 0 of the study ($n = 15$), and MEG-0: Finishing diet and oral administration of 20 mL of Lactipro-NXT on d 0 of the study ($n = 15$).

[2]Ultrasound measurements were performed on d 116 of the study.

[3]Contrast analysis: 1) *Megasphaera elsdenii* effect = CONT vs. MEG, 2) Linear effect of d of adaptation = L, and 3). Quadratic effect of d of adaptation = Q.

improve the production and absorption of volatile fatty acids, such as propionate and butyrate (Muya et al., 2015; DeClerck et al., 2020a), resulting in a better rumen energetic efficiency. Therefore, it can be speculated that a greater energy intake in the beginning of the feedlot period might increase performance (Richeson et al., 2019), but health issues (i.e., bovine respiratory disease complex) might also be more recurrent in this period (Lofgreen et al., 1975). Nonetheless, no cases of respiratory diseases were observed in the present study.

It was hypothesized that MEG administration would improve performance of the animals throughout the feedlot phase, but no benefits were observed herein. In agreement with our data, DeClerck et al. (2020b) also did not observe improvements in performance of cull beef cows receiving MEG and transitioned to a high-energy finishing diet for a 35-d period. Similar results were observed when MEG administration was evaluated in beef cows receiving a low- and high-roughage diet (10% and 25% diet DM, respectively) for 42 d (DeClerck et al., 2020a). Conversely, the same group of researchers reported improvements in performance over a 72-d period of newly-weaned beef calves receiving MEG and offered a high-concentrate diet containing 22.7% and 38.7% starch from steam-flaked corn during the growing and finishing diets, respectively (DeClerck et al., 2020c). In the present study, animals were offered high-starch diets containing 31.2% to 42.9% starch from ground *flint* corn for 119 (MEG-0), 112 (MEG-6), and 105 (MEG-14 and CONT) d, which is a significantly longer feeding period than the aforementioned studies and others reported in the literature. Therefore, it is likely to speculate that the amount of starch available in the rumen might impact the efficacy of MEG on performance of beef animals and its benefits might be greater in processed grains, such as steam-flaking, high-moisture, and/or rehydrated corn.

The lack of statistical significance on mean DMI for animals dosed with MEG corroborate with other studies in beef (Drouillard et al., 2012; DeClerck et al., 2020a; DeClerck et al., 2020b; DeClerck et al., 2020c) and dairy cattle (Aikman et al., 2011; Henning et al., 2011). Evaluating a subacute ruminal acidosis (**SARA**) model, Mazon et al. (2020) demonstrated that MEG administration 4 d prior to the challenge reduced the time-period and area at which rumen pH remained below 5.8 and 5.6, as well as improved DMI and milk production of mid-lactation dairy animals. Conversely, no effects were observed when MEG was inoculated 1 d prior to the SARA challenge, indicating that in high-risk SARA animals, MEG should be administered at least 4 d prior to the challenge in order to improve DMI and production. These authors also reported that DMI was greater for MEG-administered animals 1 d following the SARA challenge, but only when MEG was inoculated 4 d prior to the challenge (Mazon et al., 2020).

The observed treatment × wk interactions observed for DMI, NE_m, and NE_g (Fig. 1A–C) might preclude the occurrence of digestive disorders, such as rumen acidosis, laminitis, and hepatic abscesses (Owens et al., 1998). However, as aforementioned, no cases of digestive disorders were observed during the present experiment. Nonetheless, SARA might have occurred in the first wk of the study, which could explain the reduced nutrient intakes observed herein (Nagaraja et al., 2007). As ruminal pH was not measured herein, this warrants additional research efforts regarding the effects of MEG inoculation without an adaptation diet on rumen pH changes, rumen metabolism and microorganism profile, as well as occurrence of SARA in beef animals offered a high-concentrate diet (Ogunade et al., 2019).

In an extensive review, Brown and colleagues (2006) reported that cattle performance, as well as rumen health and function, might be impaired when animals are adapted to a high-concentrate diet in less than 14 d. Therefore, several strategies that could be used during the adaptation period were reported by these authors, including progressive changes in the roughage:concentrate ratio, a better control of the energy content on step-up diets, and gradual increases in feed offer and intake on a BW basis during this period (Brown et al., 2006). In U.S. feedlots, multiple step-up diets are often offered to beef animals during the adaptation period (Samuelson et al., 2016), with the initial diet containing approximately 40.7% forage and transitioning to the finishing diets over a 24-d period. In a similar fashion, Brazilian nutritionists also prefer the multiple step-up programs over 16.2 d with the initial diet containing 45.1% forage (Pinto and Millen, 2019). Therefore, current withdrawal of the adaptation diet is not encouraged by feedlot consultants/nutritionists, whereas technologies that address this matter are warranted in order to demonstrate potential benefits in performance and/or health.

Inoculation of MEG in animals assigned to reduced number of step-up diets during the adaptation period (3 vs. 5 diets) resulted in a maintenance of live feedlot performance (final BW, ADG, and feed conversion rate) and DMI over a 95-d period, whereas carcass ADG and HCW were positively impacted by MEG orally drenched to cattle (Drouillard et al., 2012). Subsequently, DeClerck et al. (2020c) demonstrated that MEG inoculation in beef calves abruptly transitioned to a finishing diet improved ADG and FE when compared to cohorts fed a growing diet during the initial feedlot period. To the best of our knowledge, no other research trial evaluated the effects of MEG in feedlot animals without any type of adaptation/transition diet management protocol. In the present experiment, a treatment × wk interaction was observed for DM, NE_m, and NE_g intake (Fig. 1A–C). In fact, removing (MEG-0) and/or reducing (MEG-6) the adaptation period reduced nutrient intake for the first 5 wk of the study, which, in turn did not compromise overall feedlot performance and health. This reduction could be attributed to the additional organic acid production potential that the finishing diet provided compared with the adaptation diet (NASEM, 2016). As aforementioned, to the best of our knowledge, Mazon et al. (2020) is the only study that reported daily DMI following MEG oral drench, but for a short period of time (7 to 10 d).

The lack of treatment effects on carcass traits agrees with previous studies where MEG was inoculated at the beginning of the feedlot period (DeClerck et al., 2020c). In fact, DeClerck et al. (2020c) suggested that offering a higher energy dense diet since the beginning of the feedlot period could result in heavier carcasses at slaughter, which was not observed herein and concurs with the aforementioned feedlot performance data.

In ultrasound measurements, we observed a greater REA in MEG-6 vs. MEG-0 and MEG-14 bulls, a tendency for a greater BFT in MEG vs. CONT cohorts, but no treatment effects were observed for marbling scores (Table 3). In a recent published experiment, DeClerck et al. (2020c) reported greater marbling scores, but numerically lower REA in MEG orally drenched early-weaned beef animals. A possible explanation for this tendency in BFT might be related to an increased acetate production in MEG-administered animals, safeguarding the fibrolytic microflora against acidotic pH levels, even though the bacteria itself might be proliferating propionate (DeClerck et al., 2020c). Muya et al. (2015) also observed a greater butyrate production in MEG-administered animals that positively impacted rumen morphometrics parameters and, in turn, might result in a greater acetate concentration as well, as this is a common volatile fatty acid conversion path in the rumen (Bergman et al., 1965; Bergman and Wolff, 1971; Sutton et al., 2003). Therefore, the intrinsic diet and the resulting pH specific to a study may impact acetate production that, in turn, would favor BFT deposition in feedlot animals receiving MEG.

Based on previous experiments, it was speculated that marbling scores would be greater in animals offered MEG and receiving a high-energy diet (DeClerk et al., 2020c), likely by the greater starch utilization in the rumen and an elevated flux of glucose arising from this fermentation and thus, entering the adipocytes for differentiation and utilization (Gilbert et al., 2003; Johnson and Chung, 2007; Smith and Johnson, 2016). Conversely, MEG inoculation at the beginning of the feedlot period did not improve marbling scores at the end of the study (Table 4). Nonetheless, it is important to mention that marbling is not solely dependent on starch content of the diet and its intake, given that breed, BW at slaughter, plasma triglyceride, and plasma circulating fatty acids (**FA**) also control adipocyte differentiation and lipid synthesis in intramuscular tissue (Hocquette et al., 2010; Choi et al., 2015; Smith and Johnson, 2016).

In fact, in a traditional feedlot production setting, subcutaneous depots are stored and formed prior to intramuscular fat depots (i.e., marbling; Vernon, 1981; Sainz and Hasting, 2000; Oliveira et al., 2011) and, therefore, it can be speculated that intramuscular fat depot differentiation would still occur in non-castrated *Bos taurus indicus* animals as they would achieve mature BW (Valadares Filho et al., 2016). Likewise, Costa et al. (2020) reported similar marbling scores in non-castrated *Bos taurus indicus* animals slaughtered at similar BW and offered high-concentrate diets with similar ether extract contents as used herein. This lack of marbling might change when starch is offered to beef cattle early in life, resulting in epigenetic effects (Reis et al., 2015) that will improve marbling scores later in life (Scheffler et al., 2014). Therefore, more research efforts are warranted to understand how age of the animals might impact MEG efficacy in promoting marbling at the end of the finishing period.

In summary, removing or shortening the adaptation diet in MEG-treated *Bos taurus indicus* bulls resulted in similar performance and carcass traits as untreated cohorts, while a reduction in DMI was observed in the first 5 weeks of the study. Nonetheless, REA was greater for MEG-6 and BFT tended to be positively impacted when animals were dosed with MEG. Therefore, MEG administration at the beginning of the feedlot might be used as a feasible alternative to remove the adaptation diet of the feedlot production setting, while maintaining the desirable performance and carcass characteristics in *Bos taurus indicus* finishing animals.

Conflict of interest statement. The authors declare no conflicts of interest.

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