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ANIMAL PRODUCTION

Influence of low and medium intake supplements in the growing phase of steers grazing in the tropical pasture and finished in feedlot

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ABSTRACT: The objective was to evaluate the animal production and ingestive behavior of the steers fed different supplements during the growth phase in Aruana grass, and the influence of this supplementation on production performance in feedlot phase. The treatments consisted of three supplements during the growing phase: mineral salt (0.12 g/kg of body weight – BW), low intake energy-protein supplement (1.26 g/kg of BW), and medium intake (3.76 g/kg of BW). Forage canopy characteristics, animal production, and animal behavior on pasture were evaluated in a completely randomized design with three replicates (paddocks). The titanium dioxide marker was used to determine the intake and apparent digestibility during the pasture phase. The production performance in feedlot was evaluated in a completely randomized design with eight replicates (animals). Twenty-four Aberdeen Angus steers (15 ± 1.5 months old; 364.8 ± 21.7 kg BW) were used. At the end of the growth phase the animals were confined and fed a single diet. Dry matter, crude protein, and neutral detergent fiber (NDF) contents of forage and intake were not influenced by the treatments. The average daily gain was higher for the medium intake supplement in pasture phase. The apparent digestibility of NDF (P = and chewing rate were higher for the medium intake supplement. The average daily gain and fat thickness of carcasses were higher for the medium intake supplement in the feedlot phase. The supplements of medium intake increase animal productivity during the growing phase on pastures and cattle's finishing performance in intensive production systems.
Key words: average daily gain, dry matter intake, fat thickness, ingestive behavior, self-fed supplements.

Influência de suplementos de baixo e médio consumo na fase de crescimento de novilhos mantidos em pastagem tropical e terminados em confinamento

RESUMO: O objetivo deste trabalho foi avaliar a produção animal e o comportamento ingestivo de novilhos alimentados com diferentes suplementos durante a fase de crescimento em capim Aruana, e a influência desta suplementação sobre o desempenho produtivo durante a fase de terminação em confinamento. Os tratamentos consistiram de três suplementos durante a fase de crescimento: sal mineral (0,12 g/kg do peso corporal – PC), suplemento energético-proteico de baixo consumo (1,26 g/kg do PC) e suplemento energético-proteico de médio consumo (3,76 g/kg do PC). As características do dossel forrageiro, a produção animal e o comportamento ingestivo em pastos de capim Aruana foram avaliados utilizando um delineamento inteiramente ao acaso com três repetições (piquetes). O marcador externo dióxido de titânio foi utilizado para determinar o consumo e digestibilidade aparente dos nutrientes na fase de pastagem. O desempenho em confinamento foi avaliado utilizando-se um delineamento inteiramente ao acaso com oito repetições (animais). Vinte e quatro novilhos Aberdeen Angus (15 ± 1,5 meses de idade; 364,8 ± 21,7 kg de peso corporal médio inicial) foram utilizados. Ao final da fase de recria, os animais experimentais foram confinados e alimentados com uma dieta única. Os teores de matéria seca, proteína bruta e fibra de detergente neutro (FDN) da forragem, bem como o consumo destas frações não foram alterados pelos tratamentos. O ganho médio diário foi superior para o suplemento de ingestão média na fase de pastagem. A digestibilidade da FDN e a taxa de ruminação na fase pastagem foram mais elevadas para o suplemento de média ingestão. O ganho médio diário e a espessura de gordura das carcaças foram mais elevados para o suplemento de ingestão média na fase de acabamento em confinamento. Suplementos de ingestão média aumentam a produtividade animal durante a fase de crescimento em pastagens e o desempenho em confinamento de bovinos provenientes de sistemas intensivos de produção.
Palavras-chave: ganho de peso médio diário, consumo de matéria seca, espessura de gordura, comportamento ingestivo, suplementos auto-alimentados.

INTRODUCTION

Fluctuations in the quantity and quality of forage in tropical pastures make maintaining the growth of cattle challenging because there is rarely a balance between the requirements and supply of nutrients (BARBERO et al., 2021). The low post-weaning growth rates produces lighter and leaner carcasses (SILVA et al., 2017). These problems can be overcome by optimizing animal performance and improving pasture utilization efficiency through supplementation (CASAGRANDE et al., 2013).

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Research with low and medium levels of energy-protein supplementation of cattle on tropical pastures indicate that nutritional plans that allow more constant growth rates during the growing phase are more advantageous, as they a reduction in the finishing period (ROTH et al., 2017; SAMPAIO et al., 2017). PERIPOLLI et al. (2017) recommend that animals receive adequate nutritional management during the growing phase to maximize their future performance in intensive beef cattle growing-finishing systems. However, few studies have evaluated the effect of supplementation during the growing phase on cattle's finishing performance, which needs further investigation (ROTH et al., 2017), especially in intensive beef cattle production systems.

Therefore, we hypothesized that: (1) low to medium levels of energy-protein supplementation would optimize the productive performance of cattle during the growing phase on tropical pastures, and (2) low to medium levels of energy-protein supplementation during the growing phase on tropical pastures would optimize the performance and carcass traits of steers in the finishing phase. Thus, this study evaluated the influence of low and medium intake supplements on the growing phase of steers on tropical pasture and finished in feedlot. Productive responses were assessed from nutrient intake, animal behavior, apparent digestibility, animal performance, and carcass traits.

MATERIALS AND METHODS

Experimental period, grazing area, and feedlot

This study comprised the growing and finishing phases of Aberdeen Angus steers (twenty-four). The growing phase had 135 days (December 04, 2016, to April 18, 2017), followed by the finishing phase of 74 days (April 20, 2017, to July 03, 2017).

During the growing phase, the grazing area consisted of Aruana grass (*Megathyrsus maximum* cv. Aruana) divided into nine paddocks (0.5 ha each). Each paddock had covered water and feed troughs for the supplements. During the finishing phase, the animals were housed in a feedlot with individual pens (10 m^2), partially covered, concrete floors, and equipped with water troughs and feed bunks.

Experimental animals, treatments, experimental design, and feedlot diet

All tester animals belonged to the same commercial herd and were managed the same way until the beginning of the experimental period. Three experimental animals were used in each paddock, except for one paddock of each treatment in which two tester animals were used. Twenty-four Aberdeen Angus steers with 15 ± 1.5 months old and 364.8 ± 21.7 kg BW were used. In addition to the tester animals, other nine steers were used to adjust the height of the pasture (management criterion). These animals remained in an adjacent Aruana grass paddock, being placed or removed from the experimental paddocks after measuring the pasture height every 15 days. The animals were treated for endoparasites and ectoparasites with Ivermectin at a concentration of 1% (Ivomec® - Boehringer Ingelheim) and individually identified with ear tags.

In the growing phase, the experiment was conducted as a completely randomized design with three treatments and three replicates (paddocks). The treatments consisted of different supplementation strategies (SS) (self-fed supplements): mineral salt (MS) supplementation and energy-protein supplementation for the intake of 1.26 g/kg BW (low intake - LI), and 3.76 g/kg BW (medium intake - MI). The LI and MI supplements were composed of ground corn, soybean meal, mineral salt, common salt, urea, and calcitic limestone (Table 1). The supplements were provided *ad libitum* (once every seven days) but with daily visual monitoring of intake. The weekly supply was determined by the previous week's intake per animal + 15%. Supplement intake was determined by weighing feed and orts.

In the feedlot, the experiment was conducted as a completely randomized design with three treatments (growing phase supplements) and eight replicates (animals). A single diet was provided (crude protein: 119 g/kg DM; digestible energy: 14.2 MJ/kg DM). The finishing diet was composed (DM basis) by corn silage (222.7 g/kg), corn grain (684.0 g/kg), soybean meal (73.8 g/kg), mineral mixture (12.4 g/kg), urea (3.9 g/kg), and common salt (3.1 g/kg). The animals were submitted to a feedlot adaptation period of 15 days. During the adaptation period, the animals received two transition diets (550 and 650 g of concentrate feed/kg DM of the diet) for 8 days (4 days each), and then the finishing diet was provided. The ration was offered once daily (0930 h), feed was manually mixed prior to provision each morning. Feed intake was recorded daily by weighing the feed provided and as orts from the previous day, maintaining orts at 5%.

Pasture management, forage characteristics, digestibility, and dry matter intake

The pasture was fertilized with nitrogen (N) as urea (150 kg N/ha) and split into three topdressing applications (16 December, 03 February,

Table 1 - Composition of supplements (Dry matter basis).

Variables	----------Supplements----------		
	Mineral Salt	Low intake	Medium intake
---------------------Feedstuff composition------------------------			
Ground corn (g/kg)	-	493	670
Soybean meal (g/kg)	-	164	138
Mineral salt (g/kg)[1]	1000	133	68.8
Common salt (g/kg)	-	166	79.1
Urea (g/kg)	-	33.1	32.9
Calcite limestone (g/kg)	-	11.1	11.3
----------------------Chemical Compounds------------------------			
Dry matter (g/kg)	1000	960	939
Ash (g/kg)	1000	336	170
Crude protein (g/kg)	-	249	254
Crude fat (g/kg)	-	31	24
Neutral detergent fiber (g/kg)	-	148	199

[1]Composition: calcium, 170; phosphorus, 60; sodium, 136; manganese, 5.0; zinc, 2.52; iron, 1.2; cobalt, 0.02; copper, 0.06; iodine, 0.07; selenium, 0.02; fluorine, 0.45; and sulphur, 0.1.

and 14 March). Continuous stocking rate with the put-and-take method (MOTT & LUCAS, 1952) to maintain the same forage allowances in all paddocks was used. The criterion for pasture management was the average height of the forage canopy, aiming to maintain it at 40 to 50 cm in height. The height of the pasture was measured every 15 days at 20 points/ picket using a graduated ruler.

Forage mass (FM) was estimated every 30 days (BARTHRAM, 1985) in three sites (1 m^2). The daily forage accumulation rate (FAR) was measured using three grazing exclusion cages per paddock. All samples were clipped at ground level. The forage allowance (FA) was calcu-lated as FA = (FMmean) / (kg BW/ha) (SOLLENBERGER et al., 2005). The stocking rate (SR) was calculated as the sum of the animals' body weight, considering the days that the animals remained in each paddock.

Forage samples for chemical analysis were obtained by hand-plucking (VRIES, 1995). Samples were dried at 55 °C in a forced air oven for 72 h, ground (1-mm screen sieve) in a Wiley mill (Thomas Model 4 Wiley, Thomas Scientific, Swedesboro, NJ, USA), and stored for further chemical analysis.

Another three Aberdeen Angus steers (15 ± 1.5 months old and 296.5 ± 8 kg BW) were used to determine dry matter intake (DMI) and digestibility, following a double Latin square design. The animals were managed together with the experimental animals, and their effects on the stocking rate were considered. The DMI was estimated using the Equation 1:

DMI (kg/day) = fecal production (kg DM/day)/1 - diet DM digestibility

Titanium dioxide (TiO_2) was used as an external marker to estimate fecal production. TiO_2 was supplied in the amount of 10 g/steer (vegetable paper cartridges) directly into the animal's esophagus with the aid of an esophageal probe, once a day (1600 h) for 12 days. The supply of TiO_2 started after six days of adaptation of the animals in the paddocks. Fecal collection occurred from the eighth to the twelfth day, directly from the animals' rectum twice a day (1200 h and 1600 h) (PENNING & RUTTER, 2004). After each evaluation period (12 days), a composite fecal sample per animal was obtained, and the TiO_2 concentration was determined by UV–visible spectrophotometry (MYERS et al., 2004). Fecal production (FP, kg of DM/day) was determined as: FP = intake TiO_2/fecal TiO_2. The apparent digestibility (AD, g/kg of DM) was determined using Equations 2:

AD = (nutrient intake – nutrient excretion) / nutrient intake

The ingestion behavior was evaluated by visual observation (every 10 min) of rumination, grazing, and other activities time (idle, social interaction, water intake, supplement intake) (FORBES, 1988). These evaluations were carried out during 14 hours in the daytime (0500 h to 19000 h), totaling two evaluations with 60 days of interval. Two animals were observed per paddock. The chewing rate (CR) was determined from the number of chews per ruminal bolus and the chewing time per ruminal bolus (BÜRGER et al., 2000).

Animal performance

The animals were weighed at the beginning and end of each experimental period (135 days to the growing phase; 74 days to the finishing phase) after fasting for 14 h. The average daily gain (ADG) was calculated by difference between the final and initial body weights, divided by the number of days of the experimental period. The body weight gain per area (BWGA) was calculated by multiplying ADG by the average number of animals per hectare and number of grazing days. Stocking rate was obtained by the sum of the weight of the tester and regulator animals during grazing, divided by the area of the paddock.

Slaughter procedure and carcass traits

The animals were slaughtered in a commercial abattoir with a State Inspection System (SIE) 36 km from the study site. After removal of non-carcass components (bleeding, skinning, disarticulation of the head, and evisceration), the carcasses were identified, divided in half, weighed, washed, and chilled (2°C) for 24 h. Afterward, the carcasses were weighed again. The hot carcass yield (HCY) and cold carcass yield (CCY) were determined as HCY = hot carcass weight (HCW) / final BW (FBW) from the feedlot and CCY = cold carcass weight (CCW) / FBW from the feedlot. Carcass chilling losses (CCL) were determined as CCL = (HCW - CCW) / HCW × 100.

The section comprised the 9, 10, and 11th ribs of the right carcass dissected in the laboratory into muscle, fat, and bone, these components being weighed to determine the physical composition of the carcasses according to the methodology by HANKINS & HOWE (1946). The subcutaneous fat thickness (SFT) was determined between the 11th and 12th ribs using a digital caliper.

Chemical analysis

Standard procedures of AOAC (2000) were followed to determine the composition of the feed, forage, and fecal samples: DM (method 934.01), ash (method 924.05), and CP (method 920.87). Using alpha-amylase, the NDF was determined following the ANKOM 2000 methodology (ANKOM 2000 Fiber Analyzer, ANKOM Technology Corporation, Fairport, NY, USA).

Statistical analysis

Forage characteristics, animal performance, animal behavior, and carcass traits data were by the PROC MIXED procedure of SAS (Statistical Analysis System, version 8.02) using the treatments such as fixed effect and the paddocks or animals as a random effect. The model was represented by:

$Y_{ijk} = \mu + T_i + \beta_1 X_{ij} + e_{ijk}$,

Where, Y_{ijk} is the dependent variable; μ is a constant; T*i* is the effect of diets; $\beta_1 X_{ij}$ is the random effects; and e_{ijk} is the residual experimental error.

A 3 x 3 double Latin square (three treatments and three periods) repeated over time (one-degree freedom) to evaluate the DMI and apparent digestibility of nutrients during the pasture phase was used. For the Latin square design, the model was represented by:

$Y_{ijk} = \mu + T_i + P_j + A_k + T_i{*}P_j + e_{ijk}$,

Where, Y_{ijk} is the dependent variable; μ is a constant; T*i* is the effect of the supplements (fixed effect); P_j is the effect of the period (random effect); A_k is the animal effect (random effect); $T_i{*}P_j$ is the effect of the interaction between treatment and period (random effect), and e_{ijk} is the residual experimental error.

A non-linear regression test (linear plateau) on DMI was conducted during the feedlot period to estimate the time of DMI stabilization (days). The model was represented by:

$Y_{ij} = U \times (X_i \; b \; r) \times (r - X_i) + l + \varepsilon_{ij}$,

Where, Y_{ij} = dependent variable; U = no biological interpretation; X_i = time; r = breaking point (theta b); l = intake estimated at the plateau; and ε_{ij}= random error.

The means of the variables were considered different when a significant effect by the Tukey test was observed (P < 0.05).

RESULTS

Growing phase

The supplementation strategies did not influence (P > 0.05) the FM, FAR, FA, and pasture's nutritive value (Table 2). In the same way, the final BW did not differ (P > 0.05) among supplements (Table 3) during the growing phase on tropical pasture. However, ADG and BWGA increased (P = 0.029) for the MI compared to the LI and MS supplement. The MI supplement provided a higher (*P* = 0.045) SR than the MS supplement (2918 *vs*. 2357 kg/ha).

The MI supplement presented the highest (P < 0.05) SI and DMI during the growing phase on tropical pasture (Table 3). The crude protein intake (CPI) was higher (P = 0.019) for the MI than for the MS supplement (6.0 vs. 4.9 g/kg of BW/day). The supplements did not influence (P > 0.05) NDF intake. There was no difference (P > 0.05) between treatments for the apparent digestibility of dry matter (ADDM), organic matter (DAOM), and crude protein (DACP). The apparent digestibility of NDF was higher (P = 0.005) for the MS.

Feeding time, rumination, and other activities were not influenced (P > 0.05) by the supplements during the pasture phase (Table 3). The LI provided a higher (P = 0.028) CR than the MS supplement, with intermediate values observed for the MI supplement.

Finishing phase

The DMI, FBW, HCW, CCW, HCY, CCY, CL, carcass muscle, carcass fat, carcass bone, and muscle + fat/bone relation did not differ (P > 0.05) between supplements at the end of the feedlot period (Table 4). Steers supplemented with MS required a longer time (P = 0.001) for DMI stabilization (20.6

Table 2 - Yield parameters and nutritive value of the Aruana grass pasture grazed by steers receiving different supplements.

Variables	--------------------------Supplements----------------------------			
	Mineral Salt	Low intake	Medium intake	P-value
-----Yield parameters-----				
Forage mass (kg)	7710 ± 378	7452 ± 365	7780 ± 381	0.346
Daily forage accumulation (kg/day)	82.0 ± 25.0	116 ± 36.0	117 ± 36.0	0.168
Forage allowance (kg/kg BW)	3.29 ± 0.20	2.94 ± 0.20	2.70 ± 0.20	0.389
-----Chemical Compounds-----				
Dry matter (g/kg)	280 ± 14.0	270 ± 14.0	270 ± 14.0	0.494
Crude protein (g/kg of DM)	174 ± 5.40	172 ± 5.30	173 ± 5.30	0.927
Neutral detergent fiber (g/kg of DM)	612 ± 8.90	602 ± 8.80	611 ± 8.90	0.178

BW, body weight; *DM*, dry matter; Means followed by different lowercase letters in a row differ ($P \leq 0.05$) by the Tukey-Kramer test.

days) compared to steers fed with LI (14.6 days) and MI (17.1 days) supplements.

The ADG and FT were greater ($P < 0.05$) for the MI than for the MS supplement during the finishing phase in the feedlot (Table 4). The MI increased ($P = 0.005$) the feed efficiency (FE) in feedlot (+0.02 kg of BW gain/kg of DMI) compared to the LI supplement.

Table 3 - Animal performance of steers fed different supplements in the growing phase.

Variables	---------------------------------Supplements--------------------------			
	Mineral Salt	Low intake	Medium intake	P-value
-----Animal performance-----				
Initial live weight (kg)	337 ± 13.4	324 ± 12.9	337 ± 13.4	0.743
Final live weight (kg)	411 ± 17.8	397 ± 17.1	431 ± 18.7	0.395
Average daily gain (kg/day)	0.62 ± 0.07[b]	0.61 ± 0.07[b]	0.78 ± 0.07[a]	0.022
Body weight gain per area (kg/ha/day)	4.10 ± 0.50[b]	4.30 ± 0.60[b]	6.50 ± 0.80[a]	0.029
Stocking rate (kg/ha)	2357 ± 158[b]	2544 ± 156[ab]	2918 ± 161[a]	0.045
-----Feed intake-----				
Supplement intake (g/kg BW)	0.12 ± 0.04[c]	1.30 ± 0.40[b]	3.80 ± 1.20[a]	<0.001
Dry matter intake (g/kg BW)	23.1 ± 1.70[b]	25.7 ± 2.10[ab]	27.8 ± 2.10[a]	0.034
Protein intake (g/kg BW)	4.90 ± 0.50[b]	5.60 ± 0.60[a]	6.00 ± 0.70[a]	0.019
NDF Intake (g/kg BW)	14.0 ± 1.30	15.0 ± 1.30	15.0 ± 1.40	0.593
-----Apparent Digestibility-----				
Dry matter (g/kg DM)	545 ± 16.1	533 ± 10.9	542 ± 23.1	0.240
Organic matter (g/kg DM)	592 ± 21.0	586 ± 12.6	600 ± 24.3	0.520
Crude protein (g/kg DM)	630 ± 61.6	625 ± 51.3	678 ± 44.5	0.661
Neutral detergent fiber (g/kg DM)	625 ± 21.7[a]	604 ± 28.1[b]	595 ± 37.1[b]	0.005
-----Animal behavior-----				
Grazing (min)	400 ± 26.0	443 ± 27.4	387 ± 25.6	0.326
Rumination (min)	97 ± 36.5	92 ± 34.6	128 ± 56.9	0.639
Other activities (min)	327 ± 42.9	277 ± 36.5	290 ± 38.1	0.473
Chewing rate (chews/min)	58 ± 1.60[b]	62 ± 1.70[a]	60 ± 1.70[ab]	0.028

BW, body weight; *DM*, dry matter; Means followed by different lowercase letters in a row differ ($P \leq 0.05$) by the Tukey-Kramer test.

DISCUSSION

Growing phase

Different supplementation strategies are expected to alter grazing behavior and forage use (WYFFELS et al., 2019), which can change the pasture's structure and nutritional composition. However, the similar pasture characteristics confirm the similarity of the forage canopy conditions between treatments of this study, ruling out any confounding effect and inferring that the animal performance responses are due to the supplementation strategies in the growth phase of animals.

The nutritional imbalance in tropical pastures during the growing phase is characterized by excess energy due to an imbalanced protein/energy ratio (DETMANN et al., 2014). Therefore, an unused individual gain potential can be achieved through supplementation, which was only achieved with the MI supplement (+0.16 kg/day). The greater ADG of supplemented grazing animals is usually associated with an increased intake (MCLENNAN et al., 2016) and greater energy-protein supplementation. The BWGA and SR can be explained, in part, by the ADG. Furthermore, these results are related to the nutritional complementation of the energy-protein supplementation, which allowed the pasture to increase the stocking rate and, consequently, the BWGA.

In addition to improving the nutritional plan, the positive effect of energy-protein supplementation is the improved energy/protein ratio, resulting in increased microbial protein synthesis and digestion rates (DETMANN et al., 2014). In our study, the benefits of supplementation on digestibility may have been neglected by the increase in passage rate caused by the DMI increase. Increasing dry matter intake decreases the retention time of particles in the rumen, reducing the digestibility of dietary components (MISSIO et al., 2012). In addition, the extra salt in self-fed supplements increases water intake, negatively influencing the digestibility of fibrous fractions (KUNKLE et al., 2000).

The ingestion behavior is explained by similar forage quality between supplementation strategies and the low to moderate level of supplementation used. Conversely, the CR can be explained by the DMI, suggesting that the animals improved their rumination efficiency when they increased the DMI. Chewing the feed reduces the particle size and increases density and ruminoreticulum escape. The efficiency of this process is influenced by dry matter intake (ULYATT et al., 1986).

Finishing phase

Dry matter intake increase in the finishing phase can be a performance compensation mechanism in cattle submitted to low nutritional plans in the growing phase. It is mainly observed when the animals are subjected to different nutritional plans (pasture vs. confinement; systems with *ad libitum* vs. restricted intake) in the growth phase (SAINZ et al., 1995; PERIPOLLI et al., 2017). In addition, the feedlot diet's digestible energy content (DE, 14.2 MJ/kg DM) may have contributed to reducing the DMI variation between treatments. This DE content is within the upper limit for caloric density (13.4–16.8 MJ DE/kg DM), considered a limiting factor for feed intake in finishing diets (KREHBIEL et al., 2006).

Table 4 - Performance and carcass traits of feedlot-finished Aberdeen Angus steers receiving different supplements during the growing phase on pasture.

Variables	------------Supplements----------			
	Mineral Salt	Low intake	Medium intake	P-value
Dry matter intake (DMI, g/kg BW)	21.0 ± 1.80	20.0 ± 2.40	20.0 ± 2.40	0.461
DMI stabilization,	20.6 ± 1.65[a]	14.6 ± 1.17[b]	17.1 ± 1.37[b]	0.001
Average daily gain (g/day)	0.86 ± 0.10[b]	0.89 ± 0.30[ab]	1.12 ± 0.20[a]	0.047
Feed efficiency (kg gain/kg of	0.10 ± 0.01[b]	0.10 ± 0.02[b]	0.12 ± 0.01[a]	0.005
Slaughter body weight (kg)	463 ± 40.8	455 ± 50.1	493 ± 58.1	0.322
Hot carcass weight (kg)	260 ± 11.0	253 ± 9.8	271 ± 15.1	0.320
Hot carcass yield (%)	56.1 ± 0.80	55.8 ± 0.60	55.2 ± 1.50	0.250
Cold carcass weight (kg)	256 ± 24.4	251 ± 29.3	268 ± 33.9	0.480
Cold carcass yield (%)	55.5 ± 0.80	55.1 ± 0.60	54.7 ± 1.50	0.365
Chilling loss (%)	1.11 ± 0.30	1.15 ± 0.20	0.97 ± 0.20	0.533
Fat thickness (mm)	6.60 ± 2.40[b]	7.70 ± 1.50[ab]	8.00 ± 2.40[a]	0.002
Muscle (M, %)	52.9 ± 2.90	52.9 ± 3.70	53.1 ± 3.70	0.993
Fat (F, %)	28.0 ± 3.90	27.7 ± 5.20	28.4 ± 4.60	0.964
Bone (B, %)	19.1 ± 1.40	19.4 ± 2.00	18.6 ± 2.50	0.733
Muscle + fat/bone	4.26 ± 0.40	4.22 ± 0.60	4.46 ± 0.70	0.939

BW, body weight; Means followed by different lowercase letters in a row differ ($P \leq 0.05$) by the Tukey-Kramer test.

Cattle supplemented in the growing phase have ruminal conditions adapted to the greater concentrate feed intake and stabilize the intake more quickly in feedlot (BARBERO et al., 2017), which also was observed for LI and MI supplements in this study. In addition, the greater frequency in feeders with a higher amount of supplement associated with the presence of people for visual monitoring of daily intake may have given the animals better adaptation to feeding in the feedlot initial phase. According BARBERO et al. (2017), managing the daily supply of supplements in the growing phase also influences the conditioning of cattle to human presence, easing the adaptation to facilities and feedlot management. These aspects improve animal welfare and the capacity of animals to maintain a production trajectory over time (SALVIN et al., 2020), which may explain the better ADG for the MI supplement. Even though protein-energy supplementation (up to 5 g/kg BW) during the growing phase decreases ADG in feedlot, the high BW at the beginning of the finishing phase is sufficient to reduce the time of the feedlot (SAMPAIO et al., 2017), a process that requires diets with high energy density and is more expensive (ROTH et al., 2017).

The greater ADG for steers fed MI supplement resulted in a more significant FE in feedlot. The ADG explains the FT since higher rates of weight gain increase fat deposition (PETHICK et al., 2004). This result showed that animals receiving a greater nutritional supply in the growing phase start were more advanced in depositing body fat and can be finished in less time. According to MACITELLI et al. (2007), values of FT above 7 mm suggest that the animals had already reached the ideal slaughter weight. It may be an indication that steers fed MI supplements in the growing phase could have been feedlot-finished and slaughtered earlier in this study without impairing carcass quality, as reported by SIMIONI et al. (2021).

The ADG and FT of the steers fed with LI and MI supplements during the growing phase did not improve carcass weight, yield, and proportion of carcass tissues (muscle, fat, and bone) at the end of the feedlot. Changes in carcass traits are usually observed when BW at the end of the finishing phase is changed by the nutritional plans of the growing phase or when the growing phase is characterized by more severe feed restriction (SAINZ et al., 1995; ROTH et al., 2017), which is not the present case. Prior to the beginning of the present experiment, all animals were reared on winter pasture (oats + ryegrass), which ensured performance compatible with the desired intensification (slaughter up to 24 months of age).

CONCLUSION

The energy-protein supplements of medium intake increase animal productivity during the growing phase on tropical pastures and cattle's finishing performance in intensive production systems. This increase in performance may reduce the feedlot period due to faster achievement of body weight and fat thickness of carcasses. Still, it does not improve carcass yield and the edible portion of the carcass compared to low levels of energy-protein and mineral salt supplementation.

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DECLARATION OF CONFLICT OF INTEREST

The authors declare no conflicts of interest.

AUTHORS' CONTRIBUTIONS

All authors contributed equally for the conception and writing of the manuscript. All authors critically revised the manuscript and approved the final version.

BIOETHICS AND BIOSSECURITY COMMITTEE APPROVAL

All procedures and protocols adopted in this experiment were approved by the Committee of Ethics on Animal Use of the Universidade Tecnológica Federal do Paraná (Protocols 2016-002 and 2017-003), located at 25°44'S and 53°04'W.

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