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REGULAR ARTICLES

Soybean grain is a suitable replacement with soybean meal in multiple supplements for Nellore heifers grazing tropical pastures

Daniel Mageste de Almeida[1] · Marcos Inácio Marcondes[1] · Luciana Navajas Rennó[1] · Leandro Soares Martins[1] · Faider Alberto Castaño Villadiego[2] · Mário Fonseca Paulino[1]

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Abstract

The research aimed to evaluate the effect of replacing soybean meal with soybean grain on the nutritional parameters and productivity of heifers grazing on *Urochloa decumbens* in the rainy-dry transition period. Forty crossbred heifers with the initial age and weight of 18 months and 292 ± 6.1 kg, respectively, were used. The experimental design was a completely randomized design, with five treatments and eight replications. The evaluated treatments were as follows: $SM_{0.5}$—supply of 0.5 kg/animal/day of soybean meal supplement; $SG_{0.5}$—supply of 0.5 kg/animal/day of soybean grain supplement; $SM_{1.0}$—supply of 1.0 kg/animal/day of soybean meal supplement; $SG_{1.0}$—supply of 1.0 kg/animal/day of soybean grain supplement; MM—only mineral mix ad libitum. The supplement was isoprotein with 350 g of crude protein/kg of dry matter. Supplementation improved the performance of the heifers and this fact can be verified by the higher average daily gain (ADG) and final BW (fBW) of the supplemented animals ($P < 0.10$). The two supplemented treatments with 1 kg/day demonstrated similar performance ($P > 0.10$), the same happens for the two treatments receiving 0.5 kg/day ($P > 0.10$). However, animals receiving 1 kg/day of supplementation had an ADG and final BW higher than animals receiving 0.5 kg/day ($P < 0.10$). Supplementation ($P < 0.10$) affected the intake of dry matter (DM), organic matter, crude protein, ether extract, non-fiber carbohydrates, total digestible nutrients, and neutral detergent fiber corrected for ash and protein (apNDF). Supplementation improved DM digestibility and all constituents of the diet ($P < 0.10$), except for apNDF ($P > 0.10$). In summary, it is concluded that multiple supplementations improve the performance of grazing heifers in the rainy-dry transition period and the total replacement of soybean meal by soybean grain does not alter the performance of the animals.

Keywords Animal nutrition · Animal production · Beef cattle · Supplementation

Introduction

Evaluating the Brazilian production of beef cattle, it is clear that its success is based on the low cost of production, which is possible due to the predominant pasture-based production system. To obtain an extremely competitive cost, the duration and efficiency of the post-weaning phase is very important. In the case of the female, it is the period of greatest growth when the animal uses the nutritional resources to reach the stage that allows it to reproduce.

Most areas in Brazil experience drastic changes in qualitative and quantitative production of tropical forage, and because of this seasonality, one must define strategies for grazing management based on the conditions of the pasture in order to establish targets of management for each season of the year. This is because the morphological differentiation must be minimized in the rainy-dry and dry seasons and coexist with the senescence (Paulino et al. 2008).

In this context, the supply of protein/energy/mineral supplements would increase the availability of nutrients, which may improve the balance of the diet and provide positive effects on the performance of grazing animals (Detmann et al. 2014). Another advantage is the reduction of animal categories within the farm, with a consequent increase in the herd slaughter rate (Saturnino and Amaral 2004).

✉ Daniel Mageste de Almeida
danielmagestedealmeida@hotmail.com

[1] Department of Animal Science, Universidade Federal de Viçosa, Viçosa, Minas Gerais 36570-000, Brazil

[2] Department of Veterinary Medicine, Universidade Federal de Viçosa, Viçosa, Minas Gerais 36570-000, Brazil

One of the feed sources most used in supplementation is soy and its co-products, which contain protein with a balanced amino acid composition. Because soybean grain is rich in fat and protein, the prospect of its use in ruminant diets is great. The substitution of soybean meal by the grain can promote similar gains (Detmann et al. 2009), offering an economic advantage over the supplements formulated with soybean meal, since it has a lower market price. There are few studies involving the use of soybean grain in the formulation of multiple supplements for grazing cattle (Paulino et al. 2006).

The objective of this study was to evaluate the effect of soybean meal replacement with soybean grain on nutritional characteristics and the productive performance of heifers grazing on *Urochloa decumbens* during the rainy-dry transition period.

Material and methods

Animals, experimental design, and supplements

The experiment was conducted in the Beef Cattle Section of Federal University of Viçosa, Viçosa-MG, Brazil (20° 45′ S, 42° 52′ W), between the months of April and June of 2015, referring to the rainy-dry transition period. The experimental area presents an annual precipitation of 1300 mm. Forty heifers were used for the evaluation of the productive performance with average initial ages and weights of 18 months and 292 ± 6.1 kg, respectively.

Animals were assigned to an experimental area of 12.5 ha, consisting of five 2.5-ha paddocks uniformly covered with *Urochloa decumbens* grass. Paddocks were equipped with water troughs and feed bunks, which were covered and accessible from both sides. Animals were continuously stocked such that all five paddocks were stocked with cattle throughout the entire experiment, with animals from a given supplement treatment assigned to one of the 2.5-ha paddocks. Each treatment group of animals was moved sequentially from one paddock to the next one every 7 days in an attempt to minimize any effects of different paddock conditions on the response to supplement treatments.

The experimental design was completely randomized, with five treatments and eight replications. An individual heifer was considered to be the experimental unit. Supplement for a given treatment was fed in a common feeder in each paddock to represent what is done in commercial practice (Table 1). The strategies evaluated were as follows: $SM_{0.5}$—supply of 0.5 kg/animal/day of soybean meal supplement; $SG_{0.5}$—supply of 0.5 kg/animal/day of soybean grain supplement; $SM_{1.0}$—supply of 1.0 kg/animal/day of soybean meal supplement; $SG_{1.0}$—supply of 1.0 kg/animal/day of soybean grain supplement; MM—only mineral mix ad libitum. The supplement was isoprotein with 350 g of crude protein (CP)/kg of dry matter (DM). The mineral mix consisted of 50% dicalcium phosphate, 47.2% sodium chloride, 1.5% zinc sulfate, 0.7% copper sulfate, 0.05% cobalt sulfate, 0.05% potassium iodate, and 0.5% manganese sulfate.

The urea was used to correct the difference of crude protein (CP) between the supplements of soybean meal and grain. Supplements were provided at 1000 h. Before the beginning of the experiment, all the animals were submitted to the control of ectoparasites and endoparasites, and during the experimental period when necessary.

Experimental procedures and sampling

The average daily gain of the heifers was estimated by the difference between the final weight and the initial weight, both taken after the fasting from solids for 14 h divided by the number of experimental days (84 days).

The forage was sampled every 28 days during the experiment to quantify the availability of DM and potentially digestible DM (pdDM) (Paulino et al. 2008) by cutting biomass at ground level in four randomly selected 0.5 × 0.5 m quadrats in each paddock. All samples were dried for 72 h at 60 °C with forced circulation of air and ground through 1- and 2-mm screens prior to analysis. Qualitative evaluations of the forage consumed by the animals were performed by the hand-plucking method every 28 days (Silva et al. 2017).

To evaluate the from the digestibility of the diet, on the 42th day of the experimental period, a digestibility assay was performed with duration of 9 days. To estimate fecal excretion, the external chromium oxide (Cr_2O_3) indicator, packed in paper cartridges, corresponding to 15 g per heifer, was fed to the 40 heifers using a metal probe directly in the esophagus, always at 0930 h. To estimate the individual intake of supplementation, titanium dioxide (TiO_2), provided via supplement, was used in the proportion of 10 g of indicator per animal

Table 1 Percentual composition of the supplements based on the natural material

Ingredients (%)	Supplements	
	SM	SG
Ground corn kernel	25.4	25.4
Wheat bran	3.0	0.5
Soybean meal	65.1	–
Soybean grain	–	65.1
Urea/SA (9:1)	1.5	4.0
Mineral mix[a]	5.0	5.0

SM supplement with soybean meal, *SG* supplement with soybean grain

[a] Percentual composition: dicalcium phosphate, 50.00; sodium chloride, 47.15; zinc sulphate, 1.50; copper sulfate, 0.75; cobalt sulfate, 0.05; potassium iodide, 0.05; and magnesium sulfate, 0.05

(Titgemeyer et al. 2001). To estimate the DM intake of pasture, an indigestible neutral detergent fiber (iNDF) was used as an internal indicator (Detmann et al. 2001).

From the 9 days of the test, five were destined to adapt the animals to Cr_2O_3 and TiO_2. During the last 4 days, feces samples were collected at different times, at 1600 h, 1300 h, 1000 h, and 0700 h, respectively. The feces samples were collected directly in the rectum of the animals, in an approximate amount of 200 g. They were identified by animal and oven dried with forced air circulation (60 °C/72 h) and milled with a knife mill (1 and 2 mm). On the fifth day of the test, a hand-plucking was performed on each paddock separately, and these samples were used to estimate the intake and digestibility coefficients.

On the last day of the digestive test, were obtained spot samples of blood, via jugular vein puncture, performed 4 h after supplementation. Blood samples were collected using a vacuum tube activating blood clots, and separating gel (BD Vacuntainer®, SST II Advance). The blood was immediately centrifuged at 2700 g for 15 min and the serum was stored at − 20 °C, for later evaluation of the concentration of urea.

Chemical analyses

The supplement and forage samples obtained by the hand-plucking method were quantified with regard to DM (INCT-CA G-003/1), crude protein (CP; INCT-CA N-001/1), ether extract (EE; INCT-CA G-004/1), neutral detergent fiber corrected for ash, and protein (apNDF; INCT-CA F-002/1), using thermostable α-amylase, without using sodium sulfite; nitrogen insoluble in neutral detergente (NDIN; INCT-CA N-004/1) according to Detmann et al. (2012); iNDF, according to Valente et al. (2011), obtained after in situ incubation in (F57 Ankom®) bags for 288 h.

The pdDM was estimated according to the following equation (Paulino et al. 2008):

$$pdDM = 0.98 \times (100 - NDF) + (NDF - iNDF)$$

where NDF = neutral detergent fiber (%), iNDF = indigestible neutral detergent fiber (%), pdDM = potentially digestible dry matter (%), and 0.98 = true digestibility of the cell contents.

For quantification of DM mass and pdDM, analyses were performed to quantify DM, apNDF, and iNDF contents in the forage samples.

A sample composed of feces from the 4 days of collection was assessed individually and later analyzed for the contents of chromium and titanium. The analysis was conducted by using atomic absorption (Souza et al. 2013) and colorimetry (Titgemeyer et al. 2001), respectively. We also evaluated the contents of DM; CP; EE; apNDF and iNDF, as previously described. Fecal excretion and individual supplement intake were calculated according to equations described by Lopes et al. (2014) and Almeida et al. (2015), respectively. Individual forage DM was estimated using iNDF as internal marker in the following equation:

$$DMI(kg/day) = \{[(FE \times CMF) - MS]/CMFO\} + SDMI$$

where FE = fecal excretion (kg/day), CMF = concentration of the marker in the feces (kg/kg), MS = intake of marker from supplement (kg), CMFO = concentration of the marker in the forage (kg/kg), and SDMI = supplement DM intake (kg/day).

Statistical analyses

The results were assessed using analysis of variance, adopting the initial body weight (BW) as a covariate when significant. The comparisons between the averages were performed by decomposing the sum of the squares of the treatments using orthogonal contrasts relative to the comparison between supplemented and nonsupplemented animals, the presence of soybean meal or soybean grain in the supplements, and the amount of supplement, 0.5 or 1 kg. The PROC GLM procedure of SAS software (SAS Institute Inc, 2015) was used for all statistical analyses. For all statistical procedures, $\alpha = 0.10$ was adopted.

Results

Supplementation improved the performance of the heifers and this fact can be verified by the higher average daily gain (ADG) and final BW (fBW) of the supplemented animals ($P < 0.10$). The two supplemented treatments with 1 kg/day demonstrated similar performance ($P > 0.10$), the same happens for the two treatments receiving 0.5 kg/day ($P > 0.10$). However, animals receiving 1 kg/day of supplementation had an ADG and final BW higher than animals receiving 0.5 kg/day ($P < 0.10$). Total replacement of soybean meal by soybean grain did not change performance (Table 3; $P > 0.10$).

Supplementation increased (Table 4; $P < 0.10$) the nutrient intake in kg/day and the DM and neutral detergent fiber corrected for ash and protein (apNDF) in g/kg of BW. However, the intake of forage DM and forage organic matter in kg/day and forage DM in g/kg of BW was similar ($P > 0.10$) among all treatments. Animals receiving 1 kg/day of supplement had higher intake of DM, CP, ether extract (EE), apNDF, digested dry matter (dDM), and total digestible nutrients (TDN; $P < 0.10$) than animals receiving 0.5 kg/day of supplementation. The treatments supplemented with soybean grain had lower intake of apNDF ($P < 0.10$) and higher EE ($P < 0.10$) intake than animals supplemented with soybean meal.

The supplementation improved (Table 5; $P < 0.10$) the digestibility coefficients of DM, organic matter, CP, and TDN. Supplementation with 1 kg/day of supplementation improved all analyzed coefficients ($P < 0.10$) compared to treatments that received 0.5 kg/day of supplement. On the other hand, supplementation with soybean meal improved the digestibility of CP and apNDF ($P < 0.10$) in relation to the groups that received soybean grain.

The supplementation increased serum urea nitrogen (SUN) levels (Table 5; $P < 0.10$). Supplementation with 1 kg/day allowed an increase in SUN levels ($P < 0.10$). On the other hand, the animals that received soybean grain had higher SUN levels ($P < 0.10$) than animals that were supplemented with soybean meal.

Discussion

In the present study, an average of 5700 kg/ha of DM was observed, which corresponded to 70.6 g/kg of BW and is in the range of 70 to 110 g/kg for high ADG without affecting the gain per area (Oliveira et al. 2014). For Paulino et al. (2008), the interpretation of forage available for grazing as a basal nutritional resource should be conducted from the viewpoint of the fraction potentially convertible into animal product, which can be obtained by applying the pdDM concept since it integrates quantity and quality regardless of the time of year. The average mass of 3300 kg/ha of pdDM corresponds to an offer of 40.7 g/kg of BW and is in accordance with the recommendation of Paulino et al. (2004) from 40 to 50 g/kg of BW of the pasture pdDM supply for animals for satisfactory performance.

The observed difference between the performance of the supplemented and nonsupplemented animals should be related to the increase in nitrogenous dietary intake, which allows for better energy balance, and the dietary protein of the animals that received multiple supplementations (McLennan et al. 2017). By providing 1 kg/animal/day supplement with 250 or 400 g PB/kg containing soybean meal or soybean grain for heifers in the dry period, Almeida et al. (2015) also found no difference in performance between treatments.

The higher availability of better forage with 10.2% CP at the beginning of the experiment (Table 2) may have contributed to the control treatment gaining significant weight during this period, resulting in a satisfactory BW gain at the end of the experiment (+ 17.4 kg). However, the average concentration of 7.6% CP in forage DM is within the minimum limit required to maintain microbial growth and promote the digestion of low quality forage fibrous carbohydrates (Lazzarini et al. 2009). This value is also below 10% (Sampaio et al. 2009), which optimizes the use of forage energetic substrates, explaining the lower performance of the animals receiving only mineral supplementation.

During the experiment, the forage presented 31.9% of the protein in the form of neutral detergent insoluble nitrogen, which is slowly available to the animal, justifying the use of protein supplements even during the rainy-dry season (Tables 2 and 3). In addition, the neutral detergent fiber (NDF) content was 22.4%, which has been attributed to a high portion of the ruminal repletion effect of tropical forages (Benatti et al. 2014), causing intake reduction. The inclusion of protein in catalytic doses via multiple supplementations increases the presence of nitrogenous compounds that are a priority in the rumen and exerts a positive effect on forage intake by increasing the rate of passage of the indigestible residue, optimizing the performance of the animals.

Table 2 Chemical composition of the supplements and the forage

Item	Supplements		Forage[d]		
	SM	SG	Period 1	Period 2[e]	Period 3
Dry matter[a]	905	909	338	353	374
Organic matter[b]	902	912	927	922	931
Crude protein[b]	357	362	102	74	52
NDIN[c]	279	281	296	311	350
Ether extract[b]	13.6	136	12.4	12.2	10.2
apNDF[b]	207	201	617	652	720
NFC[b]	338	202	196	184	150
iNDF[b]	8.9	9.9	171	226	275

NDIN neutral detergent insoluble nitrogen, *apNDF* neutral detergent fiber corrected for ash and protein, *NFC* nonfibrous carbohydrates, *iNDF* indigestible neutral detergent, *SM* supplement with soybean meal, *SG* supplement with soybean grain

[a] In g/kg of natural matter

[b] In g/kg of dry matter

[c] In g/kg of total nitrogen

[d] Samples obtained by manual simulation of grazing

[e] Samples collected during the digestibility test

The higher DM intake observed in supplemented animals refers to an additive effect provided by supplement intake (Table 4). Zin and Garces (2006) explained that, from the supply of concentrate at levels above 0.3% of the BW, the reduction of forage intake can be expected. As in this work, the maximum supply did not exceed this level, and no reduction in forage intake was observed.

Soybean grain supplementation increased the level of EE in the total diet by 1.5% (treatments with soybean meal and control) to 2.2% of EE ($SG_{0.5}$) and 2.9% of EE ($SG_{1.0}$). The difference in CP, nonfiber carbohydrates, and EE intake occurred due to the increase in the supply of multiple supplementations, and this was the largest source of these nutrients in relation to the pasture (Table 4).

The use of oil in ruminant feed has been related to the reduction in DM intake. This fact is explained by the interference of the unsaturated lipids on the activity of Gram-positive bacteria, which are responsible for the degradation of the fiber (Jouany 2006), and the direct action on intestinal hormones (Allen 2000). In the present work, the soybean grain content

Table 3 Performance of Nellore heifers supplemented or non-supplemented during the rainy-dry transition period

Item	Treatments[a]					CV (%)	Contrasts (value – P)[b]		
	MM	$SM_{0.5}$	$SM_{1.0}$	$SG_{0.5}$	$SG_{1.0}$		MM × SUP	0.5 × 1.0	Meal × grain
iBW (kg)	293	292	293	293	293	–	–	–	–
fBW (kg)	310	316	323	314	321	2.1	0.002	0.048	0.120
ADG (kg)	0.207	0.276	0.353	0.249	0.330	26.94	0.002	0.048	0.120

iBW initial body weight, *fBW* final body weight, *ADG* average daily gain

[a] $SM_{0.5}$, supply of 0.5 kg/animal/day of soybean meal supplement; $SG_{0.5}$, supply of 0.5 kg/animal/day of soybean grain supplement; $SM_{1.0}$, supply of 1.0 kg/animal/day of soybean meal supplement; $SG_{1.0}$, supply of 1.0 kg/animal/day of soybean grain supplement; and MM, only mineral mix ad libitum

[b] Significance indicatives for the contrast between supplemented animals and nonsupplemented (MM × SUP), contrast between animals that received 0.5 and 1.0 kg of supplement (0.5 × 1.0), contrast between animals that received supplement with soybean meal and with soybean grain (meal × grain)

did not activate any mechanism that influenced intake, which can be explained by the maximum level of 2.9% EE, below the minimum limit of 5% recommended by Naik (2013) to avoid intake reduction.

The higher intake of TDN by the supplemented animals is primarily due to the greater digestibility of the total DM and its constituents. In relation to the supplemented animals, there was an increase of EE in the diet, a fraction with a more energetic characteristic.

The intake of apNDF via pasture, coupled with the higher intake of the same via a supplement that has the characteristic of rapid degradation of the potentially degradable fraction contributed to the intake increase of the apNDF and digested neutral detergent fiber (dNDF) (Table 4). This fraction responds on average to 60 to 80% of the total DM of tropical forages, being the least-cost energy source for cattle production systems in the tropics (Detmann et al. 2004). Thus, this rational exploration of the energy potential of food produced

Table 4 Intake of Nellore heifers supplemented or nonsupplemented in the rainy-dry transition period

Item	Treatments[a]					CV (%)	Contrasts (value – P)[b]		
	MM	$SM_{0.5}$	$SM_{1.0}$	$SG_{0.5}$	$SG_{1.0}$		MM × SUP	0.5 × 1.0	Meal × grain
	Intake, kg/day								
DM	5.16	6.53	6.72	5.66	6.63	15.05	0.003	0.092	0.150
FDM	5.16	6.06	5.77	5.20	5.70	15.19	0.147	0.748	0.130
OM	4.68	6.01	6.21	5.25	6.18	15.44	0.002	0.101	0.160
FOM	4.68	5.58	5.35	4.83	5.33	15.67	0.137	0.712	0.134
CP	0.40	0.66	0.75	0.56	0.77	16.17	0.001	0.001	0.291
EE	0.08	0.10	0.10	0.13	0.20	17.20	0.001	0.001	0.001
apNDF	3.41	4.09	4.01	3.64	3.81	15.35	0.058	0.836	0.129
NFC	0.79	1.16	1.36	0.92	1.40	14.92	0.001	0.001	0.115
dDM	2.82	3.93	4.24	3.30	4.22	15.56	0.001	0.005	0.113
dNDF	2.31	2.72	2.78	2.32	2.62	15.24	0.073	0.211	0.049
TDN	2.82	3.82	4.08	3.26	4.20	15.45	0.001	0.005	0.271
	Intake, g/kg of BW								
DM	15.8	19.7	20.4	17.6	20.4	14.85	0.003	0.089	0.314
FDM	15.8	18.3	17.5	16.2	17.6	14.97	0.147	0.734	0.273
apNDF	9.55	12.6	11.4	12.5	12.7	15.17	0.058	0.834	0.273

DM dry matter, *FDM* forage dry matter, *OM* organic matter, *FOM* forage organic matter, *CP* crude protein, *EE* ether extract, *apNDF* neutral detergent fiber corrected for ash and protein, *NFC* non-fibrous carbohydrates, *dDM* digested dry matter, *dNDF* digested neutral detergent fiber, *TDN* total digestible nutrients

[a] $SM_{0.5}$, supply of 0.5 kg/animal/day of soybean meal supplement; $SG_{0.5}$, supply of 0.5 kg/animal/day of soybean grain supplement; $SM_{1.0}$, supply of 1.0 kg/animal/day of soybean meal supplement; $SG_{1.0}$, supply of 1.0 kg/animal/day of soybean grain supplement; and MM, only mineral mix ad libitum

[b] Significance indicatives for the contrast between supplemented animals and nonsupplemented (MM × SUP), contrast between animals that received 0.5 and 1.0 kg of supplement (0.5 × 1.0), contrast between animals that received supplement with soybean meal and with soybean grain (meal × grain)

Table 5 Total apparent digestibility of the constituents of the diet and serum urea nitrogen in function of the different treatments

Item	Treatments[a]					CV (%)	Contrasts (value – P)[b]		
	MM	$SM_{0.5}$	$SM_{1.0}$	$SG_{0.5}$	$SG_{1.0}$		MM × SUP	0.5 × 1.0	Meal × grain
DM	57.5	60.2	63.1	58.3	63.6	2.45	0.001	0.001	0.201
OM	60.1	63.9	65.4	61.2	66.2	5.04	0.001	0.001	0.185
CP	46.7	63.7	66.2	54.9	65.1	5.06	0.001	0.001	0.001
apNDF	67.7	65.8	69.1	63.7	68.7	2.14	0.153	0.001	0.020
TDN	54.5	58.5	60.5	57.6	63.3	2.84	0.001	0.001	0.119
SUN (mg/dL)	11.5	12.9	16.4	17.7	19.4	12.6	0.001	0.001	0.001

DM dry matter, *OM* organic matter, *CP* crude protein, *apNDF* neutral detergent fiber corrected for ash and protein, *TDN* total digestible nutrients, *SUN* serum urea nitrogen

[a] $SM_{0.5}$, supply of 0.5 kg/animal/day of soybean meal supplement; $SG_{0.5}$, supply of 0.5 kg/animal/day of soybean grain supplement; $SM_{1.0}$, supply of 1.0 kg/animal/day of soybean meal supplement; $SG_{1.0}$, supply of 1.0 kg/animal/day of soybean grain supplement; and MM, only mineral mix ad libitum

[b] Significance indicatives for the contrast between supplemented animals and nonsupplemented (MM × SUP), contrast between animals that received 0.5 and 1.0 kg of supplement (0.5 × 1.0), contrast between animals that received supplement with soybean meal and with soybean grain (meal × grain)

in the tropics in a systemic and nonpunctual way attributes the role of "nutritional virtue" to NDF in the sense of allowing high energy production by the area (Detmann et al. 2008).

The higher intake of nutritional entities of easy digestion by the supplemented animals may have caused higher digestibility of the DM. This is clear, considering that there was no change in the total digestibility of apNDF ($p > 0.10$) in response to supplement intake. The average CP of the forage remained above the minimum of 7%, sufficient to promote the adequate utilization of the low quality fiber. This possibly explains the absence of a significant effect on the digestibility of the apNDF (Table 5).

A difference in the digestibility of apNDF between the treatments that received soybean meal and grain was observed. This may have occurred due to the greater accessibility of the ruminal microorganisms to CP originating from soybean meal, which does not have the shell as a coating, allowing greater digestibility of CP and, consequently, the apNDF.

The SUN levels are affected by nutritional status and, in a general context, are a sensitive and immediate indicator of protein intake (Gonzales and Scheffer 2002), corroborating with the higher concentrations of SUN observed in the supplemented animals (Table 5).

In summary, it is concluded that multiple supplementations improve the performance of grazing heifers in the rainy-dry transition period and that the total replacement of soybean meal by soybean grain does not alter the performance of the animals.

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Compliance with ethical standards

All animal care and handling procedures were approved by the Animal Care and Use Committee of the Federal University of Viçosa, Brazil (CEUAP-UFV).

Conflicts of interest The authors declare that they have no conflict of interest.

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