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Nutrition Management Strategies for the Adaptation of Cull Beef Heifers to Feedlot

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ABSTRACT

Providing diets with high roughage in the first days of confinement is the common way of adapting beef cattle to intensive production. However, it is possible to offer the final finishing diet from the first day of adaptation. Our objective was to compare a traditional adaptation protocol, in which animals received a diet with a higher proportion of roughage, with an experimental protocol, in which animals received the final finishing diet in restricted amounts, on the productive performance of beef heifers in the first 42 days of confinement, divided into two periods (0–14 days, 15–42 days). A total of 552 heifers were evaluated and subjected to 2 adaptation strategies: (1) traditional protocol—ad libitum feed with a quantified greater proportion of roughage in the first 14 days, and (2) experimental protocol—gradual increase in the amount of final finishing feed. The nutrient intake and productive performance were evaluated. The intake was greater in the traditional protocol in all periods, 8.2 vs. 7.9 kg/day, 9.6 vs. 9.2 kg/day, and 9.2 vs. 8.8 kg/day, to 0–14, 15–42, and 0–42 days, respectively. However, performance was better in the experimental protocol in the initial period (0–14 days), 0.7 vs. 0.3 kg/day. After adaptation (15–42 days), the traditional protocol performed better, 1.5 vs. 1.3 kg/day. The nutritional protocol of gradual adaptation to total feed is recommended for heifers adapting to confinement.

1 | Introduction

The adaptation of beef cattle to confinement corresponds to a critical period due to the change in environment and nutritional plan (Pereira et al. 2020). The adaptation protocol commonly used in Brazil consists of providing diets with up to 50% roughage on the first day of confinement, which is gradually replaced by concentrate until reaching the level determined in the final diet (Silvestre and Millen 2021). This adaptation protocol has the main objective of adapting the microbiota and rumen papillae to large amounts of carbohydrates in the diet, mainly starch, and avoiding metabolic disorders that could harm animal health and performance (Melo et al. 2019; Pinto et al. 2020; Silvestre and Millen 2021).

Providing the final finishing diet from the first day of adaptation may be an alternative. In this protocol, animals receive the final finishing diet in previously calculated amounts, with a gradual increase until the expected intake is reached. Several studies (Bierman and Pritchard 1996; Brown et al. 2006; Perdigão et al. 2018; Barducci et al. 2019) demonstrated that beef cattle subjected to this adaptation protocol had greater feed efficiency compared to animals fed diets with a gradual increase in concentrate. In addition to the advantages in relation to greater feed efficiency, supplying the finishing diet from the first day of confinement compared to gradual adaptation may result in lesser production costs and facilitate feed management.

Studies evaluating different adaptation protocols in commercial feedlots in Brazil are not available in the literature. Although some studies (Perdigão et al. 2018; Parra et al. 2019; Barducci et al. 2019) are robust in terms of number of animals, they were carried out in experimental conditions. In this sense, it is important to evaluate and validate these practices in production systems and with other genetic groups than uncastrated males, which is the category of animals used in most experiments.

Another important aspect is feed costs, which can account for more than 80% of the total cost of an animal finished in confinement (Arcanjo et al. 2022; Santos et al. 2022). The use of cheaper diets can help to increase profitability and make the operation sustainable (Faulkner et al. 2010), reducing the possibility of errors in the quantity of ingredients or in mixing the feed. Even when the diet is simplified, with fewer ingredients, it must still provide adequate nutrients to meet the requirements for maintenance and the targeted weight gains.

The hypothesis of this study was that the strategy of providing complete feed from the beginning of confinement may affect the consumption and productive performance of finishing heifers. The objective of this study was to evaluate the effect of the nutritional protocol for adaptation to total feeding on nutrient consumption and productive performance of crossbred heifers during the first 42 days of confinement, divided into two periods (0–14 days and 15–42 days).

2 | Material and Methods

The experiment was carried out on a commercial feedlot located in Agua Clara, MS (19°25′43.0″ S 52°37′25.0″ W), September to November 2021, with an experimental period of 42 days, divided into two periods, adaptation (0–14 days) and an initial period of 28 days postadaptation (15–42 days). Research on animals was conducted according to the institutional committee on animal use (process number: 1216/2022).

2.1 | Animals, Treatments, and Experimental Design

In this experiment, 552 crossbred beef heifers, 292 Angus × Nellore, and 260 Charolais × Nellore, with an average initial body weight (BW) of 374.23 ± 55 kg and 24.0 ± 2 months of age, distributed in a completely randomized design. The heifers used in this study were culled from fixed-time artificial insemination programs. After two unsuccessful attempts, the heifers were sent for finishing in confinement. Two adaptation strategies were tested: (1) traditional protocol—supply of an adaptation feed, with a higher proportion of roughage compared to the finishing feed, during the first 14 days of confinement, with no restrictions on consumption, and (2) experimental protocol—supply of the final finishing diet, restricted to 50% of the estimated amount on the first day and increased by 5% from the second day onward. One day before the start of the experiment, the heifers were weighed after a 16-h solid fast, identified individually, and sanitary protocol procedures were carried out, through the application of dewormer (Cydectin, Zoetis Indústria de Medicamentos Veterinários Ltda., Campinas, SP), vaccine for clostridiosis (Excell-10, Dechra Brasil Produtos Veterinários Ltda., Londrina, PR), rabies vaccine (Rabmune, Ceva Saúde Animal Ltda., Paulínia, SP, Brazil), and respiratory vaccine (Inforce-3, Zoetis Indústria de Medicamentos Veterinários Ltda., Campinas, SP).

The heifers were distributed in four collective pens, with the following dimensions: 50 m front × 25 m side, two pens/treatment. The groups were formed according to BW and genetic group, with a similar number of animals in each treatment. The pens had concrete floors, cover over the feeder, shadow in the center of the pen (5 × 25 m), and sprinkling system, which was turned on during the hottest hours of the day. Each pen had a feeder (50 m) and a drinking fountain with a capacity of 2000 L, which was located between two pens. The chemical composition of the ingredients used to formulate the diets are described in Table 1. More details about the inputs can be accessed in Paranhos da Silva et al. (2024).

The treatments were based on two adaptation protocols: (1) tadicional protocol—supply of an adaptation feed, with a higher proportion of roughage compared to the finishing feed, during the first 14 days of confinement, with no restrictions on consumption, and (2) experimental protocol—supply of the final finishing diet, restricted to 50% of the estimated amount on the first day and increased by 5% from the second day onward. In both protocols, feed was provided four times a day, allowing for 5%–8% refusal. The diets were formulated to meet the requirements for

TABLE 1 | Chemical composition of the inputs used in the experimental feeds.

	DM	OM	CP	EE	NDF	ADF	Ash	US$/kg DM	US$/kg FM
Silage (g/kg)	293.70	964.70	67.18	13.74	755.25	657.76	35.30	0.08	0.02
Ground corn (g/kg)	872.86	988.83	72.72	22.23	137.48	35.16	11.17	0.41	0.36
Dried distillers grains (g/kg)	913.25	965.01	415.87	65.47	541.10	314.06	34.99	0.48	0.44
Coated urea (g/kg)	994.96	999.80	256.00	58.45	—	—	0.20	1.36	1.36
Livestock urea (g/kg)	975.09	999.59	280.91	—	—	—	0.41	0.73	0.71
Protected fat (g/kg)	963.86	783.77	—	75.85	—	—	216.23	1.30	1.25
Extruded urea (g/kg)	950.39	995.81	228.1	26.11	24.73	7.13	4.19	0.78	0.74
Mineral mix (g/kg)[a]	984.95	118.63	—	—	—	—	881.37	0.63	0.62

Abbreviations: ADF = acid detergent insoluble fiber; CP = crude protein; DM = dry matter; EE = ethereal extract; FM = fresh matter; NDF, neutral detergent insoluble fiber; OM = organic matter.

[a]Levels of guarantee: calcium, 200 g/kg; phosphorus, 27 g/kg; sodium, 80 g/kg; magnesium, 25 g/kg; sulfur, 32 g/kg; fluorine, 400 mg/kg; cobalt, 30 mg/kg; copper, 680 mg/kg; iodine, 51 mg/kg; manganese, 1.100 mg/kg; selenium, 9 mg/kg; zinc, 2.750 mg/kg; vitamin A, 100,000 IU; 25-hydroxyvitamin D3, 20,000 IU; vitamin E, 600 mg/kg; monensin, 1100 mg/kg; virginiamicin, 730 mg/kg.

TABLE 2 | Formulation and nutrient concentration of the experimental diets.

	Adaptation (0–14 days)		Finishing (15–42 days)	
	Traditional protocol	**Experimental protocol**	**Traditional protocol**	**Experimental protocol**
Diet formulation (g/kg DM)				
Silage	412.0	348.8	326.2	348.8
Dried distillers grains	79.5	95.5	71.2	95.5
Ground corn	466.0	519.2	557.9	519.2
Protected fat	4.9	—	10.0	—
Urea	6.6	—	4.9	—
Coated urea	9.7	—	8.8	—
Extruded urea	—	15.6	—	15.6
Mineral mix	213.	20.9	21.1	20.9
Nutrient concentration (g/kg DM)				
Dry matter	642.32	678.41	691.91	678.41
Organic matter	952.09	956.04	954.63	956.04
Crude protein	172.49	162.20	151.55	162.20
Ether extract	25.46	25.87	25.42	25.87
Neutral detergent fiber	290.25	275.70	251.88	275.70
Acid detergent fiber	181.74	163.36	145.34	163.36
In vitro digestibility of dry	546.2	596.1	659.9	596.1

Abbreviation: DM = dry matter.

maintenance and daily weight gain of 1.5 kg/day, according to the requirements described in Valadares Filho et al. (2016). To evaluate the supply protocol strategies, the heifers in the traditional treatment received an adaptation diet (Table 2), with a greater forage content in relation to the final finishing diet, without restriction in consumption, while the heifers in the experimental treatment received the finishing diet (Table 2) from the first day of adaptation, with a restriction of 50% of the total estimated feed and an increase of 5% from the second day, until reaching maximum feed intake.

2.2 | Performance, Dry Matter Intake, and Feed Conversion

The performance was evaluated in two distinct periods, the first being 0–14 initial days, corresponding to adaptation to the diet and nutritional management. The second period comprised the performance in the following 28 days after adaptation (15–42 days), and finally, the initial total period of confinement (0–42 days) was considered. All weighing was carried out after a 16-h solid fast. Total weight gain (TWG) was determined by the difference in weight between weighings, and average daily gain (ADG) was obtained by dividing TWG by the number of days between weighings, according to the following equations:

$$\text{TWG(kg)} = \text{Initial weight(kg)} - \text{Final weight(kg)}/n\text{days between weighings}$$

$$\text{ADG(kg/day)} = \text{TWG(kg)}/n\text{days between weighings}$$

Dry matter intake (DMI) was measured daily by weighing the rations offered and the leftovers recovered the following day. The feed was distributed in the trough with the help of a mixing wagon equipped with an attached scale, which allowed the quantities offered in each supply to be recorded. The feed was provided four times a day at the following hours: 7 a.m., 10 a.m., 1 p.m., and 4 p.m., with each tract offering 35%, 15%, 15%, and 35%, respectively, of the total amount of feed estimated for the day. The next day, before the first supply, the leftovers were removed, weighed, sampled, and discarded. The DMI was calculated based on the dry matter (DM) of the diets and leftovers and was obtained by the following equations:

$$\text{DMI(kg/animal/day)} = (\text{amount of feed offered} - \text{leftovers/animals in the pen})$$

Samples of ingredients used in feed, feed, and leftovers were collected during the experiment, identified, and then stored at −20°C until analyzed.

2.3 | Laboratory Analyses

Analyses of samples of ingredients used in the diets, complete diets, and leftovers were carried out at the Applied Nutrition Laboratory, Faculty of Veterinary Medicine and Animal Science (FAMEZ) of the Federal University of Mato Grosso do Sul (UFMS) (Table 3). To determine the chemical composition, the samples were first dried in a forced ventilation oven at 55°C for 72 h and then ground in a knife mill with a 1-mm sieve.

TABLE 3 | Nutrient intake in the first 42 days of confinement of crossbred beef heifers submitted to different adaptation protocols.

	Protocol			
	Traditional	Experimental	SEM	*p*-value
$DMI_{0–14\ days}$ (kg/day)	8.2	7.9	1.775	0.0001
$DMI_{15–42\ days}$ (kg/day)	9.6	9.2	1.278	0.0001
$DMI_{0–42\ days}$ (kg/day)	9.2	8.8	1.586	0.0001
$NDFI_{0–14\ days}$ (kg/day)	2.4	2.2	0.787	0.0001
$NDFI_{15–42\ days}$ (kg/day)	2.8	2.5	0.529	0.0001
$NDFI_{0–42\ days}$ (kg/day)	2.7	2.4	0.662	0.0001
$CPI_{0–14\ days}$ (kg/day)	1.4	1.3	0.250	0.0001
$CPI_{15–42\ days}$ (kg/day)	1.7	1.5	0.169	0.0001
$CPI_{0–42\ days}$ (kg/day)	1.6	1.4	0.205	0.0001

Abbreviations: CPI = crude protein intake; DMI = dry matter consumption; NDFI = neutral detergent fiber intake; SEM = standard error of the mean.

DM was then determined in an oven at 105°C for 24 h (method 930.15; AOAC, 2000), total nitrogen (method 976.05; AOAC, 2000), ethereal extract (method 920.39; AOAC, 2000), minerals (method 942.05; AOAC, 2000), and organic matter, calculated based on the loss of mass through incineration. Neutral detergent fiber (NDF) and acid detergent fiber were determined according to the methodology described by Mertens (2002).The in vitro DM digestibility of the diets was determined according to the methodology of Tilley and Terry (1963), as adapted and described in Ítavo et al. (2021) using the ANKOM Daisy system (ANKOM Technology Corp., Macedon, NY, United States).

2.4 | Statistical Analysis

To analyze nutrient intake, the pen was considered an experimental unit (2 pens per treatment), and for performance, the animal was considered an experimental unit (276 repetitions per treatment). The design was entirely randomized. The data was analyzed according to the following statistical model:

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

where Y_{ij} is the value observed in treatment i and repetition j, μ is the general average, t_i is the treatment effect (i = adaptation protocols), and e_{ij} is the random error associated with each observation.

All variables were analyzed using analysis of variance using the SAS GLM procedure, and the means for treatments were compared using the Tukey test ($p \leq 0.05$).

3 | Results

Table 3 shows DMI, NDF intake (NDFI), and crude protein intake (CPI) of crossbred beef heifers in the first 42 days of confinement. A significant difference ($p < 0.05$) was observed in DMI in the three periods evaluated (Table 3). Heifers that were fed the for the adaptation period had greater DMI than experimental protocol in the three periods evaluated. Similar results were found for NDF and CP intakes, with greater values for heifers that were subjected to the traditional protocol during adaptation ($p < 0.05$).

There was a significant effect of the adaptation protocol on BW, TWG, and ADG in the first 14 days of confinement ($p < 0.05$; Table 4). Heifers fed the final finishing diet from the first day (experimental protocol), with a gradual increase in the supply of the total final diet, had greater TWG and ADG after 14 days of adaptation (Table 4). However, considering the post-adaptation period (15–42 days), which lasted 28 days, there was a significant effect for TWG and ADG, with greater values for animals in the traditional protocol ($p < 0.05$). At 42 days of confinement, no significant difference was found in BW ($p > 0.05$). Likewise, there was no significant effect ($p > 0.05$) of the adaptation protocols on TWG and ADG in the first 42 days of confinement (0–42 days), with averages of 46.02 and 1.1 kg/day, respectively (Table 4).

The animals in the experimental protocol showed regular intake during the first few days, which was achieved through controlled increases in the amount of feed provided, with consumption stabilizing on the 11th day (Figure 1). The animals in the traditional protocol received a larger amount of feed during the first 4 days;

TABLE 4 | Performance of crossbred beef heifers in confinement subjected to different adaptation protocols.

	Protocol			
	Traditional	Experimental	SEM	*p*-value
BW initial (kg)	373.9	373.2	1.465	0.8098
$BW_{14\ days}$ (kg)	378.0	382.4	1.625	0.0177
$TWG_{0–14\ days}$ (kg)	4.1	9.2	1.337	0.0063
$ADG_{0–14\ days}$ (kg/day)	0.3	0.7	0.007	0.0280
$BW_{42\ days}$ (kg)	420.4	418.7	3.306	0.2367
$TWG_{15–42\ days}$ (kg)	42.38	36.3	1.228	0.0001
$ADG_{15–42\ days}$ (kg/day)	1.5	1.3	0.043	0.0001
$TWG_{0–42\ days}$ (kg)	46.5	45.5	1.305	0.1801
$ADG_{0–42\ days}$ (kg/day)	1.1	1.1	0.031	0.1801

Abbreviations: ADG = average daily gain; BW = body weight; SEM = standard error of the mean; TWG = total weight gain during the period.

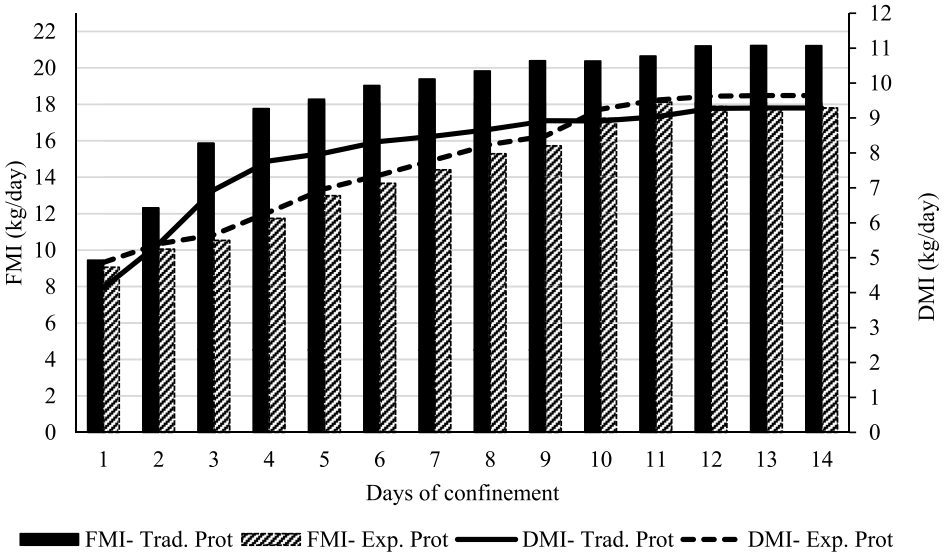

FIGURE 1 | Fresh matter intake (FMI) and dry matter intake (DMI) of beef heifers submitted to different adaptation protocols in the first 14 days of confinement.

after this period, intake continued to increase gradually, but at a slower rate (Figure 1).

4 | Discussion

Dividing the total confinement period into shorter periods is a way to better understand each phase and seek strategies to optimize production. In this study, differences in consumption were expected between treatments for the adaptation period, due to the fact that animals in the traditional protocol received an ad libitum diet rich in fiber, while animals in the experimental protocol were fed pre-established amounts of the definitive confinement ration (Table 2).

After the adaptation period (15–42 days), the higher consumption in the traditional protocol may be related to changes in the diet, which now had a higher concentrate content compared to the adaptation diet. Even with ad libitum consumption of the traditional diet during the adaptation period, the higher NDF content may have been one of the main limitations for the animals to consume larger amounts (Melo et al. 2019). Understanding the feeding behavior of animals subjected to different nutritional strategies at the beginning of confinement helps to find more efficient practices through nutritional adjustments or feed supply (Brown et al. 2006; Silvestre et al. 2023).

The higher DMI recorded in the traditional protocol during the initial periods of confinement was also reflected in higher CP and NDF intake, as these nutrients are directly linked to the volume of DM ingested (Table 3). However, despite the higher intake in the traditional protocol, heifers in the experimental protocol performed better during adaptation. This difference is explained by the fact that heifers in this treatment received the finishing diet from the first day and intake stabilized after the 11th day of confinement, which allowed for more days of consumption with a high-energy diet. Another important factor is feed efficiency in this type of protocol. According to Choat et al. (2002), animals subjected to feed restriction in the first days of confinement have higher organic matter digestibility.

Similar results were found by Perdigão et al. (2018) and Parra et al. (2019), who observed greater feed efficiency in Nellore steers in the first 28 days of finishing, fed a final diet from the first day of confinement, compared to animals that received a specific adaptation diet. Limiting the amount of feed consumed by the animal favors digestibility, since restricted consumption increases the rate of feed retention in the rumen, promoting greater ruminal digestion of nutrients (Pino et al. 2018).

The differences observed in the fresh matter intake (FMI) curves are related to greater dietary moisture (Table 2) and greater nutrient intake (Table 3). Different from what was observed in the FMI of the heifers submitted to the experimental protocol, the FMI curve of the traditional protocol presented in Figure 1 demonstrates greater variation in consumption, with a greater quantity of feed in the first 4 days, and from day 10, consumption below that observed in the experimental protocol.

The DMI observed in both treatments in the period of 0–42 days was greater than that found by Ferreira et al. (2023) at 45 days of confinement of Nellore heifers in confinement (7.10 kg/day) and also at the values observed by Buessing et al. (2020) after 35 days of confinement of crossbred heifers (7.35 kg/day). However, comparing only the consumption results after adaptation to those found by Buessing et al. (2020), the values are similar to those observed in this work (8.9 kg day). The ADG obtained in the two treatments in this study was lesser in the periods of 0–14 and 0–42 days, compared to the results obtained by Buessing et al. (2020), 1.35 and 1.5 kg/day, for periods of 0–14 and 0–35 days, respectively. For the period after adaptation (15–42 days), the ADG observed in the traditional protocol was similar to the aforementioned study.

Regarding the adaptation time, in the evaluated protocol (experimental protocol), the animals began to receive 100% of the total estimated feed from the 11th day of adaptation. This period is shorter than that recommended by nutritionists in Brazil, 19 days (Silvestre and Millen 2021), and shorter than that recommended by Barducci et al. (2019), Estevam et al. (2020), and Watanabe et al. (2022), which is 14 days. However, studies that evaluated

periods shorter than 14 days inconcentrate rich did not observe changes in ingestive behavior or rumen parameters (Pinto et al. 2023) that would harm animal consumption and performance (Perdigão et al. 2018).

As demonstrated by Bierman and Pritchard (1996), feed supply management can be a determining factor in increasing profit, improving feed efficiency, and reducing operating costs. Comparing the restriction feeding system, in which animals received the final finishing diet from the first day onward, 63% of the estimated total, with a progressive increase up to 12° or provision of ad libitum diets with a gradual reduction in roughage and an increase in concentrate, Bierman and Pritchard (1996) observed lesser DMI in the first 29 days and in the total period of confinement and greater feed efficiency of animals that received the final diet from the first day onward, without significant difference in ADG and carcass characteristics.

The lower feed consumption of heifers in the experimental protocol, but with no differences in ADG from 0 to 42 days, is a promising economic indicator, as it indicates that animals need to consume less feed to gain the same weight. According to Santos et al. (2022), feed costs for confined cattle can represent more than 90% of the total cost. The use of strategies to reduce this cost, either through feed substitution (Arcanjo et al. 2022) or through adjustments in feed management (Bierman and Pritchard 1996), is a tool that ensures a greater financial return from the activity.

In addition to greater feed efficiency, providing the final diet from the first day, and regulating the quantity to be supplied, is a way to avoid variations in DM consumption, which can occur if animals have free access to feed (Brown et al. 2006; Barducci et al. 2019). In the first days of confinement, it is common for cattle to have a greater appetite, as they underwent food restriction before confinement, whether due to separation, transportation (Buessing et al. 2020), or less pasture availability (Pereira et al. 2020), and as a result, they consume large quantities, which, if it is a diet with high levels of fiber, can cause a reduction in the passage rate, with a direct impact on consumption.

An important aspect of this study is that it was conducted during the rainy season. Traditionally, in Brazil, feedlot finishing is concentrated in the dry season, when pasture availability and quality are limited. However, recent data from ABIEC (2024) show a consistent increase in the use of feedlot systems throughout the year, with a record 8.8 million cattle finished in feedlots in 2024, representing 19.2% of total slaughters. This reflects the expansion of more intensive production systems, such as the farm where this study was carried out, which operate feedlot finishing continuously, regardless of season. According to Santos et al. (2022), confinement of cattle may be viable during the rainy season; despite the greater cost, the appreciation in the price of the animal compensates for the investment. However, it is necessary to assess economic viability in advance, mainly due to fluctuations in the price of inputs and meat (Faulkner et al. 2010; Dias et al. 2016).

5 | Conclusion

Providing the final finishing diet from the first day of confinement proved to be a viable alternative for the adaptation phase, as it reduced feed waste, which leads to a reduction in the cost of weight gain, without compromising overall performance. The nutritional protocol of gradual adaptation to total ration is recommended for finishing crossbred heifers in confinement.

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