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ORIGINAL PAPER

Performance, feed efficiency, and carcass traits of finishing Nellore cull cows fed dry or rehydrated whole maize grain diets

R.M. Murta[1], B.A.A. Carvalho[1], F.V. Silva[2], F.P. Monção[2], M.I.B. Pereira[2], P.H.F. Silva[2,*], L.L.S. Oliveira[2] A.A.G. Versiani[2] and V.L.D. Matos[2]

[1] Instituto Federal de Educação, Ciência e Tecnologia do Norte de Minas Gerais, Department of Agricultural Science, 39480-000 Januária, Brazil
[2] State University of Montes Claros, Department of Agricultural Science, 39448-581 Janaúba, Brazil

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* Corresponding author:
e-mail: pehenrique1709@gmail.com

ABSTRACT. Rehydrating whole maize grain (WMG) causes swelling that may alter feed efficiency and digestibility in ruminants. This study assessed the effects of dry and rehydrated WMG on performance, feed efficiency, ingestive behaviour, blood parameters, and carcass traits of feedlot Nellore cows compared to a diet based on whole-plant maize silage. Twenty-four cull cows (351 ± 8.96 kg) were allocated to three dietary treatments: (i) whole-plant maize silage, (ii) rehydrated WMG, and (iii) dry WMG, in a completely randomised design over a 60-day evaluation period. Dry matter intake was lower in animals fed rehydrated WMG (6.29 kg/day) than in those fed maize silage (9.09 kg/day), while dry WMG diet (8.15 kg/day) was intermediate and did not differ significantly from either (P = 0.021). No differences were recorded between diets for daily average gain and final weight (P = 0.384). Feed efficiency was higher in cows fed rehydrated WMG (0.20 g/g) than in animals receiving dry WMG (0.12 g/g) (P = 0.040). Blood glucose, creatine kinase, and cortisol concentrations were unaffected by the diets (P = 0.134). Cows fed maize silage spent more time ruminating (15.98 min/h) than those fed with rehydrated (4.61 min/h) or dry WMG (4.43 min/h) (P = 0.009). Rehydrating WMG in non-roughage diets improved feed efficiency without compromising animal performance and carcass traits. Higher feed efficiency in cull cows supports the sustainability of beef production by reducing concentrate use without impairing feedlot system.

Introduction

From 2018 to 2023, nearly 40 mln cattle were slaughtered in Brazil, of which 40% were cows rather than steers or bulls (ABIEC, 2023). This indicates that fluctuations in livestock cycles are influenced not only by herd retention and replacement strategies but also by market dynamics and technological advances that improve productivity and increase culling rates. Consequently, using cull cows for finishing in feedlots has emerged as an alternative strategy to increase beef supply and improve the economic efficiency of cattle production systems (Silva et al., 2022a).

Maize is the main energy source for confined cattle, primarily due to its high starch digestibility (Mata et al., 2023). In Brazil, flint maize is predominant in ruminant diets, characterised by a hard and vitreous endosperm with low starch digestibility (Jacovaci et al., 2021). Maize rehydration can disrupt the protein matrix surrounding starch granules, improving its availability to rumen microbiota, thereby increasing rumen fermentation and starch digestibility, particularly in harder maize grains.

Rehydrating maize can increase dietary energy, animal performance and meat yield, as well as reduce environmental impact by lowering enteric methane emission (Thekkoot et al., 2024).

Some technologies have been employed in feedlots to alter the endosperm's protein matrix and improve the digestibility of maize grains. Rehydrated maize grain silage, rehydrated whole maize grain (WMG), and reconstituted maize grains are among the newer strategies (Daniel et al., 2019; Silva et al., 2025). However, most studies on maize grain processing for confined cattle focus on intact or castrated males, with limited information on cull cows fed rehydrated WMG. Improving feed efficiency of finishing cull cows can increase beef supply, contributing to global feed security objectives (Tinitana-Bayas et al., 2024).

We hypothesised that rehydrating WMG in diets without roughage could increase energy density and improve feed efficiency without compromising performance, blood parameters or carcass traits of finishing cull cows. The objective of this study was to compare no-roughage diets containing either dry or rehydrated WMG with maize silage-based diet for finishing cull cows. To this end, we assessed performance, feed efficiency, nutrient intake, ingestive behaviour, blood parameters, and carcass traits of confined Nellore cull cows.

Material and methods

Animals, facilities and experimental site

The care and handling of animals in this experiment was approved by the Ethics Committee on Animal Use of the Instituto Federal de Educação. Ciência e Tecnologia do Norte de Minas Gerais (Protocol CEUA-IFNMG 010/2018).

The trial was conducted at the Beef Cattle Sector of IFNMG, located in Januária, Minas Gerais, Brazil (15°29′44″ S, 44°21′45″ W, 448 m a.s.l.). Twenty-four Nellore cull cows, weighing 351 ± 8.96 kg, were included in the study. Prior to the trial, all animals underwent endoparasite and ectoparasite control. Additionally, they received a 5-ml injectable vitamin complex (A-D-E®, Zoetis Inc., Parsippany, NJ, USA).

Feedlot, experimental design and treatments

Cull cows were confined for 74 days, including a 14-day adaptation period and a 60-day data collection period. A completely randomised design was used with three dietary treatments and eight replicates. The cows were assigned to the following diets: (i) whole-plant maize silage; (ii) rehydrated WMG; and (iii) dry WMG. Ingredient proportions and chemical composition of the isonitrogenous and isoenergetic diets are summarised in Table 1. Dry matter (DM, 934.01), nitrogen, ash (942.05), and ether extract (EE, 920.39) were determined according to AOAC guidelines (AOAC International, 2005), while neutral detergent fibre (NDF) was analysed using thermostable amylase and included ash (Van Soest et al., 1991). Organic matter (OM) was calculated as 100 minus the ash content; non-fibre carbohydrates were calculated as follows: NFC = 100 − (NDF + CP + ash + EE), according to Van Soest et al. (1991). Metabolisable energy was estimated using the equations proposed by Valadares Filho et al. (2023) for finishing Zebu cattle, as outlined in the 4th edition of the BR-Corte Nutritional Requirements guideline.

Table 1. Ingredient and nutrient composition of diets based on maize silage, dry whole maize grain (WMG) and rehydrated WMG supplied to finishing Nellore cull cows

Indices	Diet based on		
	maize silage	dry WMG	rehydrated WMG
Ingredient, % on DM basis			
whole-plant maize silage	56.0	–	–
whole corn grain	–	85.0	85.0
ground maize	34.0	–	–
pellets*	–	15.0	15.0
soybean meal	8.6	–	–
urea	1.0	–	–
limestone	0.4	–	–
Diet nutrient compositions, % on DM basis			
dry matter, %	56.3	89.2	68.0
organic matter	93.5	88.6	89.3
nitrogen	2.1	1.9	1.9
ether extract	2.6	2.9	2.9
neutral detergent fibre	34.8	12.4	12.4
ash	4.3	4.7	4.5
ME, Mcal/kg DM	3.29	3.33	3.34

ME – metabolizable energy based on BR-Corte Nutritional Requirements guideline, 4th edition (Valadares et al. 2023), DM – dry matter basis; * high-grain protein mineral premix

Commercial protein-vitamin-mineral pellets (Confipeso®, Bioinnova, Valinhos, SP, Brazil) was included in the diets of animals receiving dry or rehydrated WMG at a proportion of 15% of the total diet. Diets were offered twice daily *ad libitum* as a total mixed ration at 7:00 and 17:00, adjusted to ensure approximately 10% orts. Excess water from the rehydrated grains was removed using raffia bags as a sieve, and the grains were subsequently weighed and delivered to the animals.

Nutrient intake and performance

Nutrient intake was monitored over a 60-day period. The feed offered and orts were weighed and sampled daily for each individual cow. Samples were frozen (−20°C) and pooled by animal at the end of the experiment period. Feed samples were collected every 14 days to determine concentrations of DM (934.01), CP (920.87), EE (920.39) (Horwitz, 2005), NDF and OM (Van Soest et al., 1991). CP content was calculated by multiplying nitrogen content by 6.25 (Detmann et al., 2021). Dry matter intake (DMI) was calculated using the following equation:

$$\text{DMI (kg/day)} = \text{DM offered (kg/day)} - \text{DM in orts (kg/day)}.$$

Subsequently, DMI expressed as a percentage of body weight (BW, kg) was calculated using the formula:

$$\text{DMI (\%BW)} = \text{DMI (kg/day)} / \text{BW (kg)} \times 100.$$

Intake of CP, NDF, EE, ash, and OM was calculated on a DM basis using the following equation:

$$\text{Nutrient intake (kg/day)} = \text{Nutrient offered (kg/day)} - \text{Nutrient in orts (kg/day)}.$$

Cull cows were weighed individually at the beginning and end of the trial to estimate average daily gain (ADG). Feed efficiency was calculated using DM intake and ADG data utilising the following formula:

$$\text{Feed efficiency (kg BW gained/kg DM intake)} = \text{ADG} / \text{DM intake}.$$

Ingestive behaviour

Ingestive behaviour was monitored from day 27 to day 55 for all animals over 24-h periods at 5-min intervals. Observations followed the methodology described by Bürger et al. (2000), which classifies animal activities as feeding, rumination and idleness.

Blood parameters

Blood samples were collected from the jugular vein at the end of the feedlot period and immediately prior to slaughter. Samples were centrifuged at 3000 rpm for 10 min to separate serum and plasma. The extracted material was transferred into designated tubes and stored at −20 °C. Concentrations of glucose, urea, albumin, alanine aminotransferase, and creatine kinase were determined using Bioclin® commercial kits (Quibasa Química Básica LLC, Belo Horizonte, MG, Brazil) and a spectrophotometer. Cortisol concentrations were determined using enzyme-linked immunosorbent assay (ELISA) kits (Meridian Bioscience, Cincinnati, OH, USA).

Animal slaughter and carcass traits

Animals were fasted for 12 h prior to transport to a commercial slaughterhouse located 173 km from the experimental site, with free access to water during the rest period prior to slaughter. Stunning was performed using a captive bolt pneumatic gun, followed by immediate exsanguination in accordance with Brazilian legislation (Ministry of Agriculture, Livestock and Food Supply, 2021). After slaughter, carcasses were weighed and stored in a cold chamber at 2 °C for 24 h to determine cold carcass weight. Carcass length was measured using the method described by Gomide et al. (2014), and carcass compactness was calculated as cold carcass weight divided by carcass length. Carcass pH and fat thickness were recorded at the 12th rib using a digital pH meter and pachymeter, respectively.

Statistical analysis

Data on animal performance, blood parameters, and carcass traits were processed using analysis of variance (ANOVA) implemented in the R® software normality and homogeneity of residuals were assessed using the Shapiro-Wilk and Bartlett tests ($P \geq 0.05$). When the F-test was significant, means were compared using the Tukey test. Differences were considered significant at $P < 0.05$. The following model was applied:

$$Y_{ij} = \mu + \alpha_i + e_{ij},$$

where: Y_{ij} – dependent variable, μ – overall mean, α_i – effect of the WMG diet, and e_{ij} – residual error of each observation.

Residuals of creatine kinase data did not meet the assumption of normality. Thus, the data were transformed using base-10 logarithms and re-tested for normality of residuals.

The 24-h ingestive behaviour data were divided into four equidistant periods: 00:00–06:00, 07:00–12:00, 13:00–18:00, and 19:00–24:00. A mixed linear model was fitted using the glmer function (family = 'Poisson') from the lme4 package. Diets and time periods were considered fixed effects, while collection days were treated as random effects. When the model was significant ($P < 0.05$), means were compared using the Tukey test ($P < 0.05$). The following model was used:

$$Y_{ijk} = \mu + X\alpha_i + X\beta_j + Z\delta_k + X(\alpha\beta)_{ij} + Z(\alpha\delta)_{ik} + Z(\beta\delta)_{ik} + Z(\alpha\beta\delta)_{ijk} + e_{ijk},$$

where: Y_{ijk} – dependent variable, μ – overall mean, $X\alpha_i$ – fixed effect of diet i (maize-based diet type), $X\beta_j$ – fixed effect of time period, – random effect of collection day, $X(\alpha\beta)_{ij}$ – interaction between fixed effects, $Z(\alpha\delta)_{ik}$, $Z(\beta\delta)_{jk}$, $Z(\alpha\beta\delta)_{ijk}$ – interactions between fixed and random effects, and – residual error of each observation.

Results

Nutrient intake and performance

The type of maize-based diet type affected feed efficiency and nutrient intake variables, except for EE and ash. Cows fed rehydrated WMG had higher feed efficiency than those fed dry WMG ($P < 0.05$), while the maize silage-based diet did not differ significantly from either treatment (Table 2). DM, OM, CP, and NDF intake was higher in cows fed the silage-based diet compared to those receiving rehydrated WMG ($P < 0.05$), while the dry WMG diet did not differ from either treatment. No significant differences were observed in EE and ash intake between the experimental treatments ($P > 0.05$). Final BW and ADG were not affected by the diets ($P > 0.05$). Mean final BW was 427.3 kg, and mean ADG was 1.11 kg/day.

Table 2. Nutrient intake and performance of finishing Nellore cull cows fed diets based on maize silage, dry whole maize grain (WMG), and rehydrated WMG

Variable	Diet based on			SEM	*P*-value
	maize silage	rehydrated WMG	dry WMG		
DMI, kg/day	9.09[a]	6.29[b]	8.15[ab]	0.423	0.021
DMI, %BW	2.12[a]	1.46[b]	1.93[ab]	0.113	0.018
OM intake, kg/day	8.50[a]	5.62[b]	7.28[ab]	0.423	0.009
CP intake, kg/day	1.21[a]	0.74[b]	0.95[ab]	0.065	0.002
EE intake, kg/day	0.23	0.18	0.23	0.013	0.100
NDF intake, kg/day	3.16[a]	0.78[b]	1.01[b]	0.257	<0.001
Ash intake, kg/day	0.39	0.29	0.38	0.026	0.061
Final BW, kg	429.86	430.06	422.00	11.12	0.857
ADG, kg/day	1.13	1.27	0.93	0.093	0.377
Feed efficiency, kg of gained BW/kg of ingested DM	0.12[b]	0.20[a]	0.11[b]	0.012	0.034

DMI (kg/day) – daily dry matter intake, DMI (%BW) – dry matter intake as a percentage of body weight, OM – organic matter, CP – crude protein, EE – ether extract, NDF – neutral detergent fibre, BW – body weight, ADG – average daily gain, SEM – standard error of the mean; [ab] – means within a row with different superscripts are significantly different at $P < 0.05$

Blood parameters

No effect of a WMG-based diet type was found for blood concentrations of glucose, creatine kinase, and cortisol in cull cows at the end of the feedlot period ($P > 0.05$; Table 3). In contrast, urea, albumin, and ALT levels were affected by the diets at this stage ($P < 0.05$). Cows fed maize silage had higher urea, albumin, and ALT levels than those receiving rehydrated WMG. The dry-WMG diet resulted in lower blood urea levels compared to the maize silage diet, but no differences were recorded for albumin or ALT. Additionally, cows receiving dry WMG had higher ALT blood levels than those fed rehydrated WMG, while no differences were detected in urea and albumin levels (Table 3). At slaughter, only albumin and ALT concentrations were influenced by diet. Albumin was higher in cows fed rehydrated WMG compared those fed whole-plant maize silage, while the opposite was observed for ALT ($P < 0.05$; Table 3). Albumin concentrations in cows fed dry WMG did not differ from either group, whereas ALT levels were lower than in cows fed maize silage.

Table 3. Blood parameters of finishing Nellore cull cows fed diets based on maize silage, dry whole maize grain (WMG), and rehydrated WMG, at feedlot end and slaughter

Feedlot end	Diet based on			SEM	*P*-value
	maize silage	rehydrated WMG	dry WMG		
Blood parameter					
glucose, mmol/l	8.0	6.2	7.8	0.356	0.053
urea, mg/dl	48.1[a]	40.2[b]	39.0[b]	1.590	0.004
albumin, g/l	32.2[a]	28.2[b]	28.8[ab]	0.633	0.027
ALT, U/ml	17.2[a]	14.7[b]	16.0[a]	0.277	<0.001
CK, U/l	79.4	63.1	63.3	1.101	0.694
cortisol, nmol/l	133.1	139.1	137.0	4.938	0.905
Slaughter					
glucose, mmol/l	9.9	12.5	12.1	0.862	0.497
urea, mg/dl	44.4	41.4	37.2	1.720	0.279
albumin, g/l	37.9[a]	33.2[b]	33.8[b]	0.785	0.033
ALT, U/ml	15.3[a]	13.7[b]	13.4[b]	0.253	0.002
CK, U/l	100.0	125.8	39.8	1.240	0.166
cortisol, nmol/l	152.4	142.7	120.9	6.045	0.162

ALT – alanine aminotransferase, CK – creatine kinase, DM – dry matter, OM – organic matter, CP – crude protein; EE – ether extract, NDF – neutral detergent fibre, BW – body weight, ADG – average daily gain, SEM – standard error of the mean; [ab] – means within a row with different superscripts are significantly different at $P < 0.05$

Ingestive behaviour

Isolated effects were observed of maize-based diet type and evaluation period on feeding time ($P < 0.05$; Table 4). Cows spent more time feeding in the evening (19:00–24:00) than at dawn (00:00–06:00), irrespective of diet. Morning and afternoon feeding times did not differ from dawn or evening periods. Cows fed the maize silage-based diet spent more time feeding than those receiving no-roughage diets (rehydrated or dry WMG) ($P < 0.05$). Feeding time did not differ between rehydrated and dry WMG diets.

A significant interaction effect between diet type and time of day was observed for rumination in cull cows ($P < 0.05$; Table 4). For the no-roughage diets (rehydrated or dry WMG), rumination time did not differ between dawn, morning, afternoon, or evening.

Table 4. Ingestive behaviour parameters of finishing Nellore cull cows fed diets based on maize silage, dry whole maize grain (WMG), and rehydrated WMG, at four time periods

Time	Diet based on			Mean	SEM	*P*-value		
	maize silage	rehydrated WMG	dry WMG			D	T	D × T
Feeding time, min/h								
dawn	1.87	0.52	0.18	0.86^{b}	1.575	0.049	0.038	0.076
morning	7.13	3.28	2.98	4.46^{ab}				
afternoon	8.64	3.85	2.86	5.12^{ab}				
evening/night	12.76	5.78	7.92	8.82^{a}				
mean	7.60^{A}	3.36^{B}	3.49^{B}					
Rumination time, min/h								
dawn	17.76^{Aa}	6.20^{B}	3.86^{B}	9.27	1.384	0.009	0.308	0.023
morning	10.26^{Ab}	4.89^{B}	4.64^{B}	6.60				
afternoon	18.24^{Aa}	3.38^{B}	4.76^{B}	8.79				
evening/night	17.72^{Aa}	3.96^{B}	4.46^{B}	8.71				
mean	16.00	4.61	4.43					
Idleness time, min/h								
dawn	40.36^{Ba}	53.28^{A}	55.95^{Aa}	49.86	2.193	<.001	0.054	0.003
morning	42.60^{Ba}	51.82^{A}	52.38^{Aab}	48.93				
afternoon	33.12^{Bb}	52.76^{A}	52.38^{Aab}	46.09				
evening/night	29.53^{Bb}	50.26^{A}	47.61^{Ab}	42.47				
mean	36.40	52.03	52.08					

SEM – standard error of the mean; dawn – 00:00 – 06:00, morning – 07:00 – 12:00, afternoon – 13:00 –18:00, evening/night – 19:00 – 24:00; when no interaction effect was found, means were compared in both labelled 'mean' rows (diet effect, uppercase letters) and columns (time effect, lowercase letters); ^{AB} – means within a row with different superscripts differ significantly at $P < 0.05$, ^{ab} – means within a column with different superscripts are significantly different at $P < 0.05$

In contrast, cows fed the silage-based diet ruminated for the shortest time in the morning. Overall, cows spent considerably more time ruminating on the maize silage diet than on the no-roughage diets at all evaluated time periods. The average rumination time was 15.98 min/h for the silage diet, compared with 4.61 and 4.43 min/h for the rehydrated and dry WMG diets, respectively.

An interaction effect was also recorded for idleness time ($P < 0.05$; Table 4). In cows fed the whole-plant maize silage diet, idleness was longer at dawn and in the morning than in the afternoon and evening. No time-related differences were observed for the rehydrated WMG-based diet. For the dry WMG diet, cows were idle longer at dawn than at night. Overall, cows spent more time idle on both rehydrated and dry WMG diets compared with those fed maize silage at all time periods. The average idle time for cows fed maize silage was only 36.41 min/h, compared to 52.03 min/h and 52.08 min/h for cows fed rehydrated and dry WMG, respectively.

Carcass traits

No effect of diet type was observed on carcass traits ($P > 0.05$; Table 5). Diets composed of maize silage, rehydrated WMG, or dry WMG did not significantly alter carcass traits, from hot carcass weight to ultimate pH in finishing Nellore cull cows.

Table 5. Carcass traits of finishing Nellore cull cows fed diets based on maize silage (control), dry whole maize grain (WMG), and rehydrated WMG

Carcass traits	Diet based on			SEM	*P*-value
	maize silage	rehydrated WMG	dry WMG		
Hot carcass weight, kg	221.86	224.50	220.71	6.383	0.827
Hot carcass yield, %	51.62	52.11	52.39	0.584	0.888
Cold carcass weight, kg	220.69	223.19	219.36	6.315	0.830
Cold carcass yield, %	51.36	51.81	52.06	0.581	0.902
Drip loss, %	0.61	0.59	0.62	0.047	0.950
Subcutaneous fat thickness, mm	5.18	3.99	3.44	0.385	0.156
Carcass compactness, kg/cm	1.68	1.65	1.65	0.046	0.741
Ultimate pH	5.66	5.64	5.76	0.038	0.341

^{ab} – means within a row with different superscripts differ significantly at $P < 0.05$; letters were not assigned when $P > 0.05$. SEM – standard error of the mean

Discussion

Nutrient intake and performance

DM intake of cull cows fed whole-plant maize silage and dry WMG (9.09 and 8.15 kg/day, respectively) matched the predicted DM intake of 7.58 kg/day for finishing Nellore cows weighing around 350 kg with an expected ADG of 1.0 kg/day, according to BR-Corte nutrient requirements

(Valadares Filho et al., 2023). In contrast, the rehydrated WMG diet lowered DM intake (6.29 kg/day) compared to the other diets, despite no reduction in ADG (Table 2). A similar pattern was observed for other nutrient intake variables, including CP, OM, and NDF.

The reduced DM intake in cows fed WMG can be attributed to the swelling of maize grains during the 72-h prior to mixing the ration, which caused volumetric expansion of the diet, enhancing the rumen-fill effect. Additionally, high-grain diets typically increase digestible starch concentration, leading to reduced feed intake and earlier satiety due to neuro-hormonal and metabolic mechanisms (Mata et al., 2023).

The rehydration process disrupts the pericarp of maize grains and breaks starch-prolamin bonds, thereby increasing short-term nutrient digestibility. Consequently, nutrient requirements can be met even with reduced DM intake, as improved nutrient availability and absorption compensate for lower feed consumption (Roseira et al., 2023). This mechanism is supported by the absence of significant differences in ADG and final BW, among dietary groups, alongside the highest feed efficiency observed in cows fed the rehydrated WMG-based diet (Table 2). Rehydration likely facilitated ruminal starch colonisation and degradation by amylolytic bacteria and protozoa, increasing the production of carbon skeletons necessary for microbial protein synthesis and volatile fatty acid production, primarily propionic acid (Kozloski, 2011; Silva et al., 2022a). Elevated propionate levels from grain-based diets increase anaplerosis in the Krebs cycle and ATP production, promoting rapid satiety and reducing feed ingestion (Oba and Allen, 2003; Allen, 2020). Similarly, Silva et al. (2022b) also reported higher feed efficiency in finishing feedlot Angus crossbred bulls fed rehydrated maize grain compared to dry maize grain (0.15 and 0.13 kg of gained BW/kg of ingested DM, respectively).

The combination of these factors resulted in high feed efficiency in the finishing feedlot animals observed in the study. Feed efficiency is a key parameter in the livestock production systems' economics, as it allows to reduce production costs without compromising animal performance by decreasing the requirement for expensive concentrates such as soybean meal and maize grains (Greenwood, 2021).

Blood parameters

The lack of significant differences in blood glucose concentrations indicates nutritional and metabolic balance in animals regardless of the diet type. Glycemic stability is typical in ruminants as glucose is mainly derived from hepatic gluconeogenesis of propionate; thus, hypoglycaemia occurs only under severe malnutrition (Guliński, 2021).

The higher blood urea concentration in cows fed maize silage compared to those fed rehydrated or dry WMG can be explained by the higher DM intake (Table 3). In addition, roughage feeds such as whole-plant maize silage often contain higher concentrations of ammonia nitrogen in comparison to concentrate feeds (Kozloski, 2011). Blood urea reflects rumen nitrogen metabolism where dietary proteins are degraded and microbial proteins are synthesised. Ammonia released during this process is converted to urea in the liver. This nitrogen recycling is crucial for ruminant homeostasis since circulating ammonia absorbed from the rumen epithelium is neurotoxic for these animals (Rastgoo et al., 2020).

Cows fed maize silage instead of rehydrated WCG showed higher blood concentrations of albumin and ALT. Roughage feeds such as maize silage are richer in albumin, whereas concentrates are abundant in prolamins and glutens (González and Silva, 2017). The increased albumin concentration was a physiological response to the maize silage diet, supporting metabolic functions such as bilirubin formation and nutrient transport. Nevertheless, albumin concentrations remained within the normal range of 27.0 and 38.0 g/dl (González and Silva, 2017), irrespective of diet (Table 3). ALT levels also remained within the reference values, ranging from 11 to 40 U/ml (Kaneko et al., 2008). Similar responses were observed at slaughter, with higher blood albumin and ALT concentrations of cows fed maize silage.

It should be noted that all diets, including the high-grain ones, maintained creatine kinase (CK) levels below 94 U/l during the trial, indicating absence of muscle or tissue damage. These values also suggest no metabolic acidosis, as abnormal blood CK concentrations can be indicative of inflammatory conditions in the ruminal epithelium caused by rumen acidification (González and Silva, 2017). In contrast, CK levels were high at slaughter, most likely due to the reactive behaviour characteristic of Nellore bovines (Conceição et al., 2019).

Cortisol blood levels were unaffected by the diets, as the animals were not exposed to high stress during the trial (González and Silva, 2017). Although higher feed efficiency has been associated with reduced cortisol levels due to shorter feeding times (Llonch et al., 2016), this effect was not observed in the present study. No differences were detected at slaughter either.

Ingestive behaviour

Cull cows spent less time eating and more time idle at dawn, which was consistent with their circadian rhythm. Domestic animals are naturally programmed to alternate activity and rest, and darkness at dawn stimulates melatonin synthesis and release, promoting rest (Li et al., 2021). In contrast, cows spent more time eating and ruminating in the evening/night, likely because half of the ration was supplied at 17:00, and temperatures at that time were lower than in the morning or afternoon. Warm conditions often cause heat stress, leading ruminants to reduce DM intake and rumination to limit heat production and maintain homeostasis, including appropriate body temperature and pH in individual tissues (Chang-Fung-Martel et al., 2021).

Cull cows fed a maize silage-based diet spent more time eating and ruminating because the higher NDF content in this diet required more chewing time and stimulated rumination (Allen et al., 2020). Within this diet type, animals preferred to eat in the evening and night, ruminate in the afternoon and dawn, and remain idle in the morning likely as a strategy to avoid heat stress. In contrast, grain-based diets significantly reduced feeding and rumination times compared to the maize silage diet, which may be advantageous in feedlot finishing due to the energy savings from these activities (Argenta et al., 2019).

Despite the difference in feed efficiency between the rehydrated and dry WMG diets (Table 2), no changes were recorded in the ingestive behaviour of cows fed these two high-grain diets. The grain swelling effect caused by rehydration management did not alter ingestive patterns or activity times. Chewing and rumination are affected more by roughage NDF quality and effectiveness than by grain processing methods, such as rehydration or grinding (Silva et al., 2022b).

Carcass traits

Similar carcass weights in cull cows fed maize silage or dry and rehydrated WMG, can be attributed to the comparable ADG and final BW observed in the trial (Table 2). No effects were observed regarding fat characteristics and marbling. We hypothesised that rehydrating maize grains would enhance animal performance and carcass weight as grain rehydration could allow more starch to bypass the rumen, increasing ADG and glucose availability for lipogenesis in intramuscular adipose tissue (Andrade et al., 2020). However, these effects were not observed. Although cows fed rehydrated WMG showed higher feed efficiency when fed rehydrated maize gains, this improvement alone was insufficient to enhance overall performance or carcass quality.

Nevertheless, the carcasses met standard values for cull cows, i.e., exceeding 180 kg of hot carcass weight, 50% hot carcass yield, and 3-mm subcutaneous fat thickness (Freitas et al., 2021). Based on our results, rehydrating maize grains was more effective for reducing concentrate use without compromising animal performance than for improving beef finishing.

Conclusions

Rehydrating whole maize grains in non-roughage diets for cull cows enhances feed efficiency without compromising animal performance and carcass characteristics. Therefore, it is a suitable strategy to improve feedlot productivity. Better feed efficiency in cull cows contributes to the sustainability of beef production by reducing concentrate use without impairing overall system performance.

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Conflict of interest

The Authors declare that there is no conflict of interest.

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