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Crambe meal in supplements for culling cows: animal performance and carcass characteristics

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ABSTRACT. The influence of the replacement of soybean meal by crambe crushed in concentrated supplement at proportions 0, 5, 10, 15%, on the performance and carcass traits of grazing cows is assessed. Within a completely randomized design, twenty Nellore cows, fed on *Brachiaria humidicola*, were supplemented during the rain-drought transition period and monitored with regard to weight and body conditions every 28 days. Total forage mass and percentages of leaf, stem and senescent material were quantified in loco. The estimation of forage quality consumed by animals was performed by the simulated grazing method. There were no significant differences between the levels of inclusion of crambe crushed on animal performance or carcass characteristics. Replacement did not affect weight, carcass yield, Brazilian commercial cuts, morphometric measures of carcass, characteristics of loins, thickness of carcass fat, perirenal-pelvic fat and total meat. Replacement of soybean meal by crambe crushed up to 15% in the concentrated supplement does not affect performance and carcass characteristics of cows finished on pasture.

Keywords: by-product, *Brachiaria humidicula*, *Longissimus* muscle area, rib cut.

Torta de crambe em suplementos para vacas de descarte: desempenho animal e característica de carcaça

RESUMO. Avaliou-se a influência da substituição do farelo de soja pela torta de crambe no suplemento concentrado sobre o desempenho e as características de carcaça de vacas em pastejo, nas proporções 0, 5, 10, 15%. O delineamento foi inteiramente casualizado, em que foram utilizadas 20 vacas Nelore, que foram suplementadas durante a época de transição água – seca em pastagem de *Brachiaria humidicola*, e monitoradas quanto ao peso e condição corporal a cada 28 dias. Na pastagem foram quantificadas a massa de forragem total e as proporções de folha, colmo e material senescente. A estimativa da qualidade da forragem consumida pelos animais foi feita pelo método do pastejo simulado. O desempenho dos animais e as características de carcaça não apresentaram diferenças significativas entre os níveis de inclusão de torta de crambe estudados. Deste modo, não foram influenciados os pesos e os rendimentos de carcaça, os cortes comerciais brasileiros, as medidas morfométricas, as características do lombo, a espessura de gordura da carcaça, a gordura perirenal-pélvica, bem como a quantidade de carne aproveitável total. A substituição do farelo de soja pela torta de crambe até 15% no suplemento concentrado não afeta o desempenho e as características de carcaça de vacas terminadas a pasto.

Palavras-chave: sub-produtos, *Brachiaria humidicola*, área do músculo *Longissimus*, contra filé.

Introduction

Beef cattle breeding is a socially and economic important activity in Brazil. The advantages of Brazilian beef cattle may be underscored by economic competitiveness, meat production in a natural environment and the capacity to attend to demands of the most sophisticated markets. However, animal performance does not fully achieve the genetically desired potential in production systems based on forage as the sole nutrient source (Moreira et al., 2004; Prado et al., 2008). Food supplements are required for the maintenance of weight or slight weight gain in animals during the winter period (Moreira et al., 2006; 2008; Osmari et al., 2008). Supplements to animals during the summer-winter transition period may be undertaken with different protein and energy sources at different supplementation levels (El-Memari Neto et al., 2003; Farias et al., 2012; Prado & Martins, 1999; Silva et al., 2010).

Crambe, a highly interesting oleaginous plant due to the amount of oil in its seeds, is generally

used for the production of biodiesel. It has great amounts of erucic acid, classified as a bio-degradable fatty acid. High oil rates in crambe crushed are mainly due to the extraction method for the production of biodiesel and other activities (Souza, et al., 2009). Böhme et al., (2005) reported 26% of ether extract and 21% of crude protein in press-extracted crambe crushed. Consequently, crambe crushed has the required characteristics for a good quality protein concentrate as an alternative in the feed of ruminants.

Anderson et al. (1993) analyzed finishing steers and did not find any difference in performance from animals fed on soy bran which totally replaced crambe bran. There was a significant increase in marble fat deposition with regard to animals fed on high levels of crambe bran.

Current assay assessed the influence of replacement of soy bran by crambe crushed in the concentrated supplementation with regard to the performance and characteristics of culling cows' carcass finished on pasture.

Material and methods

Current assay was approved by the Committee for Ethics in the use of Animals (CEUA) of the Federal University of Grande Dourados (UFGD), following protocol 004/2013. The experiment was performed on the Fazenda Cerro Azul in the municipality of Itaporã, Mato Grosso do Sul State, Brazil during the rain-drought transition period, or rather, between February and April 2011. Animals' adaptation period had a duration of 14 days and the experimental period lasted 56 days, subdivided into two 28-day periods.

The assay was performed on pasture area planted with *Brachiaria humidicola* between 1997 and 1998, and continually used since that period. The experimental area of approximately 12 hectares was divided into four 3-ha enclosures, with meal tank and trough. Pastures were not cut to warrant sufficient forage mass throughout the experiment.

Twenty 5-year old Nellore cows were used, with initial mean body weight (BW) of 363.2 ± 38.6 kg and body condition score (BCS) at 4 points (in a 9-point scale) (Nicholson & Butterworth, 1986). The animals were distributed at random, with five animals per enclosure and supplemented with a concentrate corresponding to 1% BW day^{-1}, based on the dry matter of the supplement, in a 3.0 x 0.5 m meal tank. Mean animal lot rate in the enclosures during the entire experimental period was 1.7 UA ha^{-1}, whereas rate was close to 0.3 UA ha^{-1} in central Brazil (ANUALPEC, 2014). Animals were alternated among the several enclosures at the end of each period to eliminate possible pasture-caused variations.

Every 28 days the animals were weighed and monitored with regard to finishing degree by BCS. The 9-point scale was employed to evaluate BCS where 1 corresponds to very lean conditions and 9 to very fat conditions, following methodology by Nicholson & Butterworth (1986). Assessment was performed by a trained person and a minimum 5-point BCS was defined as a finishing criterion. Animals were weighed after a 12-h solid and liquid fast.

Supplement amount was then adjusted according to the animals' BW. Table 1 provides the chemical composition of feed in the concentrate. Concentrate supplements were iso-energetic with 80% total digestible nutrients (TDN) and formulated for a daily weight gain (DWG) of 1.3 kg animal day^{-1} (NRC, 2000). Treatments replaced soy bran by crambe crushed at 0, 5, 10 and 15% of DM in concentrated supplements (Table 2) whose efficiency was determined by the relationship between DWG (kg day^{-1}) and the amount of supplement consumed (kg day^{-1}).

Forage mass of the enclosures (kg ha^{-1}) was evaluated at the start of each period by the square (0.50 m^2) method and randomly thrown at 10 points per enclosure. Forage within the square was cut close to the ground and harvested. The ten samples from each enclosure were then grouped and two representative sub-samples were removed: one sub-sample was used for the quantification of mass, leaf blade percentages, stem + sheath and senescent/dead material and the other for the quantification of total forage mass of the pasture.

Table 1. Dry matter (DM, % of natural matter – NM) and chemical composition (% of DM) of feed in the formulation of concentrated supplements.

Ingredients	DM	PB	EE	FDN	FDA	MM
Crambe crushed	94.30	26.19	18.27	30.23	19.44	4.78
Soy bran	85.64	50.99	6.71	34.14	20.08	9.68
Whole rice bran	88.71	13.95	16.14	24.11	14.06	8.48
Corn	87.86	11.68	3.28	13.93	5.43	1.70
Mineral nucleus[1]	96.31	-	-	-	-	-

[1] guarantee levels (kg $product^{-1}$): Calcium: 120.00 g; Phosphorus: 88.00 g; Iodine: 75.00 mg; Manganese: 1,300.00 mg; Sodium: 126.00 g; Selenium: 15.00 mg; Sulfur: 12.00 mg; Zinc: 3,630.00 mg; Cobalt: 55.50 mg; Copper: 1,530.00 mg; Iron: 1,800.00 mg. CP = Crude protein; EE = Ether extract; NDF = neutral detergent fiber; ADF = acid detergent fiber; MM = Mineral matter.

Table 2. Percentage of ingredients (% of DM), DM rate (% of natural matter – MN) and chemical composition (% DM) of concentrated supplements with and without the inclusion of crambe crushed replacing soy bran.

Ingredients	Inclusion of crambe crushed (% DM)			
	0	5	10	15
Crambe crushed	0.0	5.0	10	15
Soy bran	15	10	5.0	0.0
Whole rice bran	40	40	40	40
Corn	37	37	37	37
Urea	0.3	0.7	1.0	1.4
Salt	1.0	1.0	1.0	1.0
Limestone	2.5	2.5	2.5	2.5
Sulfur	1.0	1.0	1.0	1.0
Bicalcium phosphate	1.5	1.5	1.5	1.5
Mineral mixture[1]	1.0	1.0	1.0	1.0
Chemical composition				
Dry matter	92.70	93.70	92.30	92.20
Crude protein	15.30	15.50	14.60	14.00
Ether extract	9.60	9.91	9.98	11.40
Neutral detergent fiber	51.90	42.10	36.40	39.10
Acid detergent fiber	7.49	9.11	6.47	6.71
Hemicellulose	43.40	32.60	30.20	32.30
Lignin	4.72	4.91	2.81	3.13
Non-fiber carbohydrates	38.40	47.60	53.20	49.20
Total digestible nutrients	84.30	79.70	80.20	81.30
Total carbohydrates	63.60	61.80	63.10	62.00

[1] guarantee levels (kg product^{-1}): Calcium: 120.00 g; Phosphorus: 88.00 g; Iodine: 75.00 mg; Manganese: 1,300.00 mg; Sodium: 126.00 g; Selenium: 15.00 mg; Sulfur: 12.00 mg; Zinc: 3,630.00 mg; Cobalt: 55.50 mg; Copper: 1,530.00 mg; Iron: 1,800.00 mg. % total carbohydrates = 100 - (% CP + % EE + % MM); % non-fiber carbohydrates = % TC - % FDNcp; % Total Digestible Nutrients = 9.6134 + 0.829 ⋆ DMS.

Forage quality ingested by the animals was estimated by simulated grazing method, by observing animal behavior with regard to ingested parts of the plant, grazed area, height and consumed parts of the plant (Burns, Lippke & Fisher, 1989). Samples were harvested by the same person to avoid any discrepancies between harvests.

Samples of meals used in the formulations of concentrated supplements in the assay were sent to the Animal Nutrition Laboratory of the Faculty of Agrarian Sciences of the UFGD where rates of dry matter (DM), crude protein (CP), ether extract (EE) and mineral matter (MM) were analyzed, following methodology by AOAC (1998); the rates of neutral detergent fiber (NDF), acid detergent fiber (ADF) and lignin were determined by sequential method, following Van Soest et al. (1991).

Further, in vitro digestibility of dry matter was determined by in vitro incubator Tecnal® (TE-150), in two 48-h stages. The first step comprised in vitro ruminal fermentation for 48 hours; after this period, fermentation was interrupted and 40 mL of HCl at 6 N and 8 g pepsin (1:10.000) were added in each jar. Pepsin was previously dissolved in 34 mL of H_2O distilled at 39ºC for 5 minutes in a magnetic shaker; pH was adjusted to 2.0-3.5.

TDN rates of forage harvested by sham grazing and rates of concentrated supplements were calculated by equations suggested by Cappelle et al. (2001). Forage's TDN rate was calculated on ADF according to equation: % TDN = 74.49 – 0.5635 ⋆ ADF (r^2 = 0.82); TDN rates of concentrated supplements were estimated by in vitro digestibility of dry matter (DDM), where % TDN = 9.6134 + 0.829 ⋆ DDM (r^2 = 0.98).

By the end of the experimental period, when the cows had a minimum BCS of 5 points and 444.6 ± 43.1 kg BW, they underwent a 24-h fast in solid meals and then killed in a commercial abattoir in Dourados, Mato Grosso do Sul State, Brazil. After bleeding, exfoliation and evisceration, the liver and the perirenal-pelvic fat were weighed; the length and depth of the carcass and the length of the leg were measured; the hot carcass was also weighed (WHC). In fact, WHC helped calculate hot carcass yield (HCY) by comparing percentage and weight at slaughter. Finally the carcasses were identified and stored in a cold chamber at 2ºC for 24 hours.

Yield of hindquarters was determined after 24-h refrigeration. A transversal cut between the 12th and 13th rib exposed the *Longissimus* muscle of the left half-carcass and determine the loin eye area (LEA). A decal of LEA was performed and the latter was calculated by the quadrant method, following the United States Standard for Grades of Carcass Beef (USDA, 1997). Covering fat thickness (CFT) on the loin eye was measured by a digital caliper at the third quarter of its length between the 12th and 13th rib from the vertebral column.

Total Useful Meat (TUM) and Brazilian Retail Cuts (BRC) yields were estimated by prediction equations according to Felício & Allen (1981), where TUM = 72.92 – 0.489 ⋆ CFT – 0.02 ⋆ WHC + 0.119 ⋆ LEA; and BCC = 60.33 – 0.015 ⋆ WHC – 0.462 ⋆ CFT + 0.11 ⋆ LEA. According to methodology by gomide, Ramos & Fontes (2006), yields of spare-rib and retail cuts from the hindquarters of the right half carcass were determined, namely, tenderloin, strip loin, trip-tip, shank, beef-loin, topside, outside flat, eye round, knuckle, thin skirt, loin eye, muscle.

The experiment had a totally randomized design, comprising four treatments and five replications, according to model:

$$Yij = \mu + Ti + e(i)j;$$

where:

μ = general constant; Ti = effect of inclusion level of crambe crushed i, with i = 1, 2, 3 and 4 and e(i)j = random error.

Analyses of variance and regression were carried out by statistic package Statistical Analysis System 9.1 (SAS, 2004).

Results and discussion

Pasture restriction occurred during the first fortnight in December to guarantee sufficient forage throughout the entire experimental period from February to April (rainy season) and to provide high rates of total forage mass and green forage mass, respectively 9,006 and 6,337 kg ha^{-1} (Table 3). As a rule, tropical pastures have a greater growth between November and May (Moreira et al., 2004).

Supplementation by protein source, such as crambe crushed, with approximately 52.8% of protein, reported by Goes et al. (2010), is an asset in the availability of nitrogen. In fact, it produces a great amount of ruminal ammonia for the development of ruminal microorganisms.

Table 3. Structural and morphological characteristics of pasture and chemical composition of forage harvested by sham grazing on *Brachiaria humidicola* pasture.

Structural and morphological characteristics of pasture	
Total forage mass (kg DM ha^{-1})	9.006
Mass of Green/live forage (kg DM ha^{-1})	6.337
Height (cm)	67.3
Leaf blades (% DM)	40.3
Stems + sheath (% DM)	30.0
Senescence/dead material (% DM)	29.6
Chemical composition of forage harvested by sham grazing	
Dry matter (% of natural matter – NM)	41.6
Crude protein (% DM)	4.02
Neutral detergent fiber (% DM)	79.4
Acid detergent fiber (% DM)	53.8
Lignin (% DM)	4.11
Mineral matter (% DM)	7.49
Ether extract (% DM)	0.47
Total digestible nutrients (% DM) ⋆	45.6

⋆ TDN = 74.49 – 0.5365 ADF (Cappelle et al., 2001).

A visual assessment of the troughs showed a longer ingestion period taken by the animals with regard to concentrates with a high concentration of crambe crushed (treatments 10 and 15%), due to epigoitrin (epi-PG) and aglucon levels. The latter have a bitter taste and make the crambe crushed rather less appetizing (Tripathi & Mishra, 2007). In spite of the above anti-nutrition liability, there was no significant difference between inclusion levels for the variables initial BW, final BW, initial BCS, final BCS, DWG, total weight gain and daily intake of supplements (Table 4).

DWG of culling cows on pasture system featured an average of 1.37 kg day^{-1}. High gain may be due to the time the animals underwent food restriction, represented by initial BCS. Prior to current experiment, the animals had never received supplemented feed. From the start of the experiment they received a concentrated supplement formulated according to their requirements. Since speed in weight gain was higher during nutrient reposition or re-feeding, a compensation in weight gain occurred.

Rates of the loin eye area (LEA) are actually a reference since they represent a positive relationship with muscle development. As LEA rates increase, the eatable sections of the carcass also increase and thus cuts in the area indicate the carcass's muscle development (Luchiari Filho, 2000). The loin eye area on the largest muscle of the most appreciated beef cuts was not affected by the inclusion of up to 15% of crambe crushed (Table 5).

Table 4. Mean rates for performance and total intake of supplement of Nellore cows supplemented on pasture with concentrate, with and without the inclusion of crambe crushed replacing soy bran.

Characteristics[I]	Inclusion of crambe crushed (% DM)				EPM	P[II]	
	0	5	10	15		L	Q
Initial BW (kg)	351,62	369,30	366,60	362,90	1,74	NS	NS
Final BW (kg)	428,75	463,30	441,80	441,30	3,21	NS	NS
Initial BCS (1 - 9 points)	3,62	3,80	4,30	4,40	0,08	NS	NS
Final BCS (1 - 9 points)	6,00	5,50	5,90	6,30	0,07	NS	NS
DWG(kg dia^{-1})	1,22	1,49	1,34	1,40	0,03	NS	NS
Total gain(kg)	77,10	94,00	75,20	78,40	1,93	NS	NS
SI (kg dia^{-1})	4,06	4,12	3,99	3,95	0,96	NS	NS

[I]BW = body weight; BCS = body condition score; DWG = daily weight gain; SI = supplement intake. [II]Significance: ⋆ $p < 0.05$; ⋆⋆ $p < 0.01$; ⋆⋆⋆ $p < 0.0001$; NS – not significant.

Table 5. Mean rates for carcass and loin, fat thickness, weight of liver and weight of perirenal-pelvic fat of Nellore cows supplemented on pasture with and without the inclusion of crambe crushed replacing soy bran.

Characteristics[I]	Inclusion of crambe crushed (% DM)				EPM	P[II]	
	0	5	10	15		L	Q
WHC (kg)	213.2	224.8	209.4	213.0	1.30	NS	NS
HCY (%)	50.3	48.4	47.4	48.2	0.23	NS	NS
Carcass length (m)	1.30	1.33	1.25	1.29	0.01	NS	NS
Carcass depth (cm)	65.3	68.4	65.6	66.4	0.27	NS	NS
Length of leg (cm)	83.7	88.0	78.8	85.4	0.75	NS	NS
TUM (%)+	72.4	71.7	73.8	73.2	0.18	NS	NS
BRC (%)++	60.6	59.9	61.9	61.3	0.16	NS	NS
LEA (cm^2)	53.0	57.0	62.8	58.2	0.78	NS	NS
Fat thickness (mm)	4.92	6.35	4.86	4.92	0.14	NS	NS
Liver (kg)	4.42	5.19	5.15	4.85	0.07	NS	NS
Perirenal-pelvic fat (kg)	5.98	6.79	7.62	5.22	0.20	NS	NS

[I]WHC = weight of hot carcass; HCY = hot carcass yield; TUM = total useful meat; BRC = Brazilian retail cuts; LEA = loin eye area. [II] Significance: ⋆ $p < 0.05$; ⋆⋆ $p < 0.01$; ⋆⋆⋆ $p < 0.0001$; NS – not significant.

Due to lack of standardization, carcasses vary a lot in covering fat thickness. Thickness ranging between 6 and 10 mm is necessary so that fat covering may have a homogeneous distribution and efficiency in the protection of the carcass against negative cooling effects (Gomide et al., 2006). In current experiment, mean fat thickness coverage was 5.26 mm. Carcasses, in fact, reached the finishing stage and they were above the acceptable minimum limit from the commercial point of view and close to the best minimum limit from the point of view of quality and homogeneity in fat distribution on the carcass.

Similarities in the quantitative characteristics of carcasses may be due to similar weight of animals at slaughter since traits are greatly related (Arboitte et al., 2004) when carcass yield is not affected. In fact, differences in finishing animals' body composition are not expected. According to Missio et al. (2010), characteristics of the physical composition of carcasses may be associated to the difference in age and genotype, two factors which were not provided in current experiment since the animals belonged to the same genetic group and age.

According to Van Soest (1994), the liver has an active part in energy and protein metabolism, with the retrieval of about 80% of propionate which passes through the portal system for glucose conversion. In fact, the size of the liver responds rapidly to changes in feed intake and reveals a linear development as a response to metabolizable energy consumption. Nevertheless, no significant difference was reported for liver weight when crambe crushed was included in the diet (Table 5).

Special hindquarter yields and retail cuts were not affected by the inclusion of crambe crushed in the supplement (Table 6).

Yield estimates of carcass cuts are highly important to complement the assessment of animal performance during its development. According to Luchiari Filho (2000), a good quality and excellent yield beef carcass should provide an adequate relationship between its composing parts (maximum in muscle; lowest in bones and an adequate amount of fat) to warrant the product minimum handling conditions and tastiness.

Basic cuts in cattle carcass on the Brazilian retail market consist of the forequarters with five ribs comprising chuck, shank, plate and the special hindquarter which comprises the loin and flanks (Peron et al., 1993). A greater yield in special hindquarter beef is more feasible to other cuts due to its greater economic value.

Kuss et al. (2005) reported that, due to weight increase at the finishing phase, increase of conformation is caused by the deposition of intermuscle and intramuscle fat and by the accumulation of protein in the muscles. This datum has not been reported in current analysis even though animals had mean rates of 444.6 ± 43.1 for final body weight. Costa et al. (2010) assessed the yield of retails cuts of culling cow carcasses and provided lower rates for the final body weight, with 360.28 kg and higher rates for yield in meat cuts such as tenderloin, short loin, rump, sirloin, silverside, topside and muscle. Goes et al. (2012) replaced soy bran by sunflower meal in supplements to steers and provided very similar rates with regard to meat cut yields.

A range between 14 and 16 arrobas or between 210 and 225 kg is the best weight for finish cows within Brazilian conditions and taking into account the economic aspects and yields of meat cuts (Cervieri et al., 2001). Thus, the weights of carcasses of the animals in current study are within the proper commercialization range.

Table 6. Mean rates for full hindquarter yields and hindquarter retail cut yields of Nellore cows supplemented on pasture with concentrate, with and without the inclusion of crambe crushed replacing soy bran.

Cut	Inclusion of crambe crushed (% DM)				EPM	P[1]	
	0	5	10	15		L	Q
Complete hindquarters	66.8	70.7	62.4	66.6	0.76	NS	NS
Tenderloin	2.40	2.35	2.21	2.46	0.02	NS	NS
Strip loin	8.25	7.71	7.62	7.53	0.07	NS	NS
Trip-tip	3.16	3.36	3.18	3.24	0.02	NS	NS
Shank	1.96	1.69	2.02	2.04	0.04	NS	NS
Beef-loin	4.42	4.18	4.14	4.31	0.03	NS	NS
Topside	2.14	2.01	1.86	2.02	0.03	NS	NS
Outside flat	1.20	1.38	1.19	1.41	0.03	NS	NS
Eye round	4.55	4.75	4.13	4.55	0.06	NS	NS
Knuckle	8.32	8.58	7.69	8.19	0.08	NS	NS
Thin skirt	3.84	5.24	3.60	3.93	0.17	NS	NS
Loin eye	12.1	13.4	12.3	12.5	0.13	NS	NS
Muscle	3.44	2.58	3.16	3.55	0.10	NS	NS

[1] Significance *p < 0.05; **p < 0.01; ***p < 0.0001; NS – not significant.

Conclusion

The replacement of soy bran by crambe crushed in up to 15% of dry matter of the concentrated supplement did not affect the performance and the characteristics of cow carcasses finished on pasture. The crambe crushed is thus recommended in the finishing stage of cattle raised on pasture.

References

Anderson, V., Slanger, W., Boyles, S. & Berg, P. (1993). Crambe meal is equivalent to soybean meal for backgrounding and finishing beef steers. *Journal of Animal Science*, 71(10), 2608-2613.

ANUALPEC. (2014). *Anuário da Pecuária Brasileira* (20th ed. Vol. 1). São Paulo, SP, Brasil: Instituto FNP.

AOAC. (1998). Association of Official Analytical Chemists. *Official Methods of Analysis.* 16th.

Arboitte, M. Z., Restle, J., Alves Filho, D. C., Pascoal, L. L., Pacheco, P. S. & Soccal, D. C. (2004). Características da carcaça de novilhos 5/8 Nelore-3/8 Charolês abatidos em diferentes estádios de desenvolvimento. *Revista Brasileira de Zootecnia*, 33(4), 969-977.

Böhme, H., Kampf, D., Lebzien, P. & Flachowsky, G. (2005). Feeding value of crambe press cake and extracted meal as well as production responses of growing-finishing pigs and dairy cows fed these by-products. *Archives of animal nutrition*, 59(2), 111-122.

Burns, J., Lippke, H. & Fisher, D. (1989). The relationship of herbage mass and characteristics to animal responses in grazing experiments. *Grazing Research: Design, Methodology, and Analysis*(grazingresearch), 7-19.

Cappelle, E. R., Valadares Filho, S. d. C., Silva, J. F. C. d. & Cecon, P. R. (2001). Estimates of the energy value from chemical characteristics of the feedstuffs. *Revista Brasileira de Zootecnia*, 30(6), 1837-1856.

Cervieri, R. d. C., Arrigoni, M. D. B., Oliveira, H. N. d., Silveira, A. C., Chardulo, L. A. L., Costa, C. & Martins, C. L. (2001). Desempenho e características de carcaça de bezerros confinados recebendo dietas com diferentes degradabilidades da fração protéica. *Revista Brasileira de Zootecnia*, 30, 1590-1599.

Costa, D. P. B. d., Mourão, R. d. C., Moustacas, V. S., Abreu, J. B. R. d., Sousa, J. C. D. d. & Vieira, A. d. O. (2010). Rendimento dos cortes comerciais da carcaça de vacas de descarte e de novilhos inteiros nelore, terminados em Brachiaria decumbens. *Agropecuária Científica no Semiarido*, 6(1).

El-Memari Neto, A. C., Zeoula, L. M., Cecato, U., Prado, I. N., Caldas Neto, S. F., Kazama, R. & Oliveira, F. C. L. (2003). Suplementação de novilhos nelore em pastejo de *Brachiaria brizantha* com diferentes níveis e fontes de concentrado. *Revista Brasileira de Zootecnia*, 32(6 SUPPL. 2), 1945-1955.

Farias, M. S., Prado, I. N., Valero, M. V., Zawadzki, F., Silva, R. R., Eiras, C. E., Lima, B. S. (2012). Níveis de glicerina para novilhas suplementadas em pastagens: desempenho, ingestão, eficiência alimentar e digestibilidade. *Semina: Ciências Agrárias*, 33(3), 1177-1188.

Felício, P. d. & Allen, D. (1981). Previsão de rendimentos em carne aproveitável da carcaça de novilhos Zebu. *Coleção Ital*, 12, 203-217.

Goes, B., Tonissi, R. H., Cerilo, S. L. N., Lima, H. L., Fernandes, A. R. M., Oliveira, E. R. d., Gressler, M. G. d. M. (2012). Torta de girassol em substituição ao farelo de soja nos suplementos de novilhas: desempenho e características de carcaça. *Revista Brasileira de Saude e Producao Animal*, 13(2).

Goes, R. d. T., de Souza, K., Patussi, R., Cornelio, T. d. C., de Oliveira, E. & Brabes, K. d. S. (2010). In situ ruminal degradability of crambe, sunflower and soybean seeds and their by-products in sheep feeding. *Acta Scientiarum. Animal Sciences*, 32(3), 271-277.

Gomide, L. A. d. M., Ramos, E. M. & Fontes, P. R. (2006). *Tecnologia de abate e tipificação de carcaças*: UFV.

Kuss, F., Restle, J., Brondani, I. L., Pascoal, L. L., Menezes, L. F. G., Pazdiora, R. D. & Silva, L. F. (2005). Características da carcaça de vacas de descarte de diferentes grupos genéticos terminadas em confinamento com distintos pesos. *Revista Brasileira de Zootecnia*, 34(3), 915-925.

Luchiari Filho, A. (2000). *Pecuária da carne bovina*. São Paulo: LinBife.

Missio, R. L., Brondani, I. L., Filho, D. C. A., Restle, J., Arboitte, M. Z. & Segabinazzi, L. R. (2010). Características da carcaça e da carne de tourinhos terminados em confinamento, recebendo diferentes níveis de concentrado na dieta. *Revista Brasileira de Zootecnia*, 39(7), 1610-1617. doi: 10.1590/S1516-35982010000700030

Moreira, F. B., Mizubuti, I. Y., Prado, I., Rocha, M., Ribeiro, E., Matsubara, M. T. & DognaniI, R. (2006). Níveis de uréia em suplementos protéicos para novilhos mantidos em pastagem de capim Mombaça no inverno. *Acta Scientiarium. Animal Science*, 28(1), 63-71.

Moreira, F. B., Mizubuti, I. Y., Prado, I. N., Matsushita, M., Matsubara, M. T. & Dognani, R. (2008). Protein and mineral supplementation for calves grazing a Mombaça pasture during the winter. *Semina: Ciências Agrárias*, 29(1), 203-210.

Moreira, F. B., Prado, I. N., Cecato, U., Wada, F. Y. & Mizubuti, I. Y. (2004). Forage evaluation, chemical composition, and in vitro digestibility of continuously grazed star grass. *Animal Feed Science and Technology*, 113(1), 239-249.

Moreira, F. B., Prado, I. N., Cecato, U., Zeoula, L. M., Wada, F. Y. & Torii, M. S. (2004). Níveis de suplementação com sal mineral proteinado para novilhos Nelore terminados em pastagem no período de baixa produção forrageira. *Revista Brasileira de Zootecnia*, 33(6), 1814-1821.

Nicholson, M. & Butterworth, M. H. (1986). *A guide to condition scoring of zebu cattle*. Addis Ababa: International Livestock Center for Africa.

NRC. (2000). *Nutrient Requirements of Beef Cattle*: 7th ed. National Academic Press, Washington, DC.

Osmari, M. P., Arboitte, M. Z., Brondani, I. L., Kuss, F., Filho, D. C. A. & Restle, J. (2008). Vacas terminadas em campo nativo suplementadas com farelo de trigo ou farelo de arroz integral contendo ou não monensina sódica. *Ciência Agrotecnologia*, 32(6), 1974-1980.

Peron, A., Fontes, C., Lana, R., Silva, D., Queiroz, A. & Paulino, M. (1993). Tamanho de órgãos internos e distribuição da gordura corporal, em novilhos de cinco grupos genéticos, submetidos à alimentação restrita e ad libitum. *Revista da Sociedade Brasileira de Zootecnia*, 22(5), 813-819.

Prado, I. N., Aricetti, J. A., Rotta, P. P., Prado, R. M., Perotto, D., Visentainer, J. V. & Matsushita, M. (2008). Carcass characteristics, chemical composition and fatty acid profile of the *Longissimus* muscle of bulls (*Bos taurus indicus vs. Bos taurus taurus*) finished in pasture systems. *Asian-Australasian Journal of Animal Sciences*, 21(10), 1449-1457.

Prado, I. N. & Martins, A. S. (1999). Effect of cottonseed meal replacement by canola meal on performance of feedlot Nellore heifers. *Revista Brasileira de Zootecnia*, 28(6), 1390-1396.

SAS. (2004). *SAS/STAT User guide, Version 9.1.2*. Cary, NC, USA: SAS Institute Inc.

Silva, R. R., Prado, I. N., Carvalho, G. G. P., Silva, F. F., Santana Junior, H. A., Souza, D. R., Paixão, M. L. (2010). Novilhos nelore suplementados em pastagens: consumo, desempenho e digestibilidade. *Archivos de Zootecnia*, 59(228), 549-560.

Souza, A. D. V., Fávaro, S. P., Ítavo, L. C. V. & Roscoe, R. (2009). Caracterização química de sementes e tortas de pinhão-manso, nabo-forrageiro e crambe. *Pesquisa Agropecuparia Brasileira*, 44(10), 1328-1335.

Tripathi, M. & Mishra, A. (2007). Glucosinolates in animal nutrition: A review. *Animal Feed Science and Technology*, 132(1), 1-27.

Van Soest, P. J. (1994). *Nutritional ecology of the ruminant* (Vol. 1). Ithaca, NY, USA: Cornell University Press.

Van Soest, P. J., Robertson, J. B. & Lewis, B. A. (1991). Methods for dietary fiber, neutral detergent fiber, and nonstarch polysaccharides in relation to animal nutrition. *Journal of Dairy Science*, 74(10), 3583-3597. doi: 10.3168/jds.S0022-0302(91)78551-2

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