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Fatty acid profile, carcass and quality traits of meat from Nellore young bulls on pasture supplemented with crude glycerin

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ABSTRACT

The aim of this study was to evaluate the carcass traits and meat quality of Nellore bulls (279.5 ± 16.3 initial body weight) raised on pasture supplemented with crude glycerin at 0%, 7%, 14%, 21% or 28% (DM basis). The diets were similar in energy and protein levels, and the glycerin replaced corn in the supplement. After slaughter, the carcass characteristics were measured, and the longissimus muscle was collected to determine the meat quality. The inclusion of crude glycerin in the supplement did not change ($P > 0.05$) any of the carcass characteristics and meat quality assessed; however, the pH decreased linearly ($P = 0.03$), and margaric acid (17:0) increased ($P = 0.02$) in the longissimus muscle with the addition of glycerin in the diet. Our conclusion is that the inclusion of crude glycerin up to the level of 28% of dry matter in the supplement does not alter the carcass characteristics or the meat quality from animals raised on pasture.

1. Introduction

Grass-fed beef contains higher ratios of unsaturated fatty acids, especially n-3 fatty acids, which are beneficial for human health (Dannenberger, Nuernberg, Nuernberg, & Ender, 2006; Mann, Ponnampalam, Yep, & Sinclair, 2003). Furthermore, grass-fed beef is produced naturally and has minimal environmental impact compared to the intensive system, thus, there is an increasing interest both in grass-fed beef consumption and in its production.

Research has shown that supplementation of animals raised on pasture improves production efficiency (Horn, Beck, Andrae, & Paisley, 2005; Reis, Ruggieri, Casagrande, & Páscoa, 2009), reduces the lifetime of the animal and improves meat quality. Government incentives for biofuel production have increased the demand for grain, preventing its use in animal feed and therefore creating a need for alternative ingredient sources.

Crude glycerin is a potential food supply that can meet the need for alternative ingredient sources as it is a co-product of biodiesel derived from the agricultural industry and is widely reported to be a viable energy source for cattle (Halles, Bondurant, Luebbe, Cole, & MacDonald, 2013; Mach, Bach, & Devant, 2009; Parsons, Shelor, & Drouillard, 2009; Ramos & Kerley, 2011). However, studies that use glycerin supplementation in animals raised on pasture are still scarce, particularly those assessing the effects of the inclusion of crude glycerin on carcass characteristics and meat quality.

The possible effects of supplying crude glycerin in the diet of ruminants on meat quality and carcass characteristics may be mainly related to the increased availability of gluconeogenic compounds; these compounds can be used as precursors for fatty acids to be deposited intramuscularly, resulting in improvements in the marbling score of the meat (Versemann, Wiegand, & Kerley, 2008; Mach et al., 2009). This outcome would occur because the glycerol is preferentially converted to propionate in the rumen (Wang et al., 2009), or absorbed directly by the ruminal epithelium and then converted to glucose (Krehbiel, 2008). Also, glycerol inhibits lipolysis in the rumen, a prerequisite for rumen fatty acid biohydrogenation (Edwards et al., 2012), thus reducing the accumulation of free fatty acids in the rumen and potentially improving the meat quality through the incorporation of a higher proportion of unsaturated fatty acids (Krueger et al., 2010).

The addition of glycerol improves the efficiency of ruminants fed forage more than in those fed concentrate diets (Drouillard, 2008), and it also improves digestibility (Avila et al., 2011). These effects are possibly due to the association between the feed ingredients, thereby altering the kinetics of the fermentation of glycerol (Lee et al., 2011).

Based on the above-mentioned data, our hypothesis is that crude glycerin can be included up to 28% (DM basis) to replace corn grain in the supplement of animals raised on pasture, which will improve the fatty acid profile without compromising carcass characteristics. The study objective was to evaluate the effect of including crude glycerin at levels of 0%, 7%, 14%, 21%, and 28% (DM basis) in the supplement of pasture-raised Nellore cattle on carcass characteristics, meat quality and the profile of fatty acids in the longissimus muscle.

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2. Materials and methods

Procedures for this experiment followed the humane animal care and handling procedures, according to the guidelines of the University Estadual Paulista (UNESP, Brazil).

2.1. Animals and management

The trial was conducted at the University Estadual Paulista (UNESP, Jaboticabal, SP, Brazil) from June 2011 to May 2012 and was divided into two phases: the 1st growth phase was characterized by the dry season (June to October 2011) and used 50 Nellore bulls, with an average age of 12 months and an initial body weight (IBW) of 279.5 ± 16.3 kg. The 2nd finishing phase was characterized by the rainy season (December 2011 to May 2012) where we used the same animals from the first phase (n = 50, BW = 426.66 ± 19.41 kg). Initially, the animals were weighed, identified and treated against ecto- and endoparasites by administration of ivermectin (Ivomec, Merial, Paulínea, BR), and were allocated into 10 paddocks, with 1.8 ha, consisting of *Brachiaria brizantha* cv. Xaraés. The animals were distributed in a completely randomized design (five animals per paddock and two paddocks per treatment) with two replicates per treatment.

Grazing method used was a continuous grazing system with a variable stocking rate (put and take), maintaining a sward height of 30 cm. Forage sampling was collected monthly, by handling plucking methodology to simulate the diet consumed by the bulls.

The diets used consisted of 0%, 7%, 14%, 21% and 28% inclusion of crude glycerin (DM basis) in the supplement. Crude glycerin (87.98% DM; 5.72% mineral matter; 1.15% crude protein; 1.81% ether extract; 80.34% glycerol; 0.003% methanol) was acquired from a soybean oilbased biodiesel production company (ADM, Rondonópolis, Brazil). The proportion of ingredients and chemical composition are presented in Appendix 1 (1st phase) and Table 1 (2nd phase), and the fatty acid profile of the supplements is shown in Table 2.

The supplement was provided to the animals in collective feeders, at the rate of 700 g/100 kg BW in the 1st phase and 300 g/100 kg BW in the 2nd phase, daily, the 1000 h. Individual animal BW was recorded at the initiation and termination of each grazing period, after a 16-h withdrawal period from feed and water.

Table 1
Diet composition (DM basis).

Item	Supplements					Forage[a]
	Concentrations of crude glycerin, % DM					
	0	7	14	21	28	
Ingredient proportion, % DM						
Corn	50	41	33.2	25.3	17.5	–
Crude glycerin	–	7	14	21	28	–
Corn gluten	–	2	2.8	3.7	4.5	–
Soybean meal	42	42	42	42	42	–
Urea/ammonium sulfate	3	3	3	3	3	–
Commercial premix[b]	5	5	5	5	5	–
Chemical composition, % DM						
Dry matter	91.7	91.5	91.4	91.2	91.0	90.2 ± 0.373
Crude protein	37.5	37.9	37.6	37.4	37.1	12.8 ± 0.665
NDF[c]	14.4	13.1	12.0	10.8	9.7	59.5 ± 1.441
Ether extract	3.8	3.5	3.2	2.9	2.6	1.47 ± 0.121
Nonfiber carbohydrates[d]	40.7	41.6	43.0	44.4	45.9	19.1 ± 1.148

[a] Average and standard deviation of the mean of samples obtained by technique of simulated grazing in five periods.
[b] Composition = calcium: 210 g; phosphorus: 20 g; sulfur: 37 g; sodium: 80 g; copper: 490 mg; manganese: 1.424 mg; zinc: 1.830 mg; iodine: 36 mg; cobalt 29 mg; selenium: 9 mg; fluorine (max): 333 mg.
[c] NDF = neutral detergent fiber.
[d] Non-fiber carbohydrates = 100 − (CP + EE + ash + NDF).

Table 2
Percentages of the principal fatty acids in the corn, crude glycerin, corn gluten, soybean meal and pasture.

Item[a]	Supplements					Forage
	Concentrations of crude glycerin, % DM					
	0	7	14	21	28	
Capric C10:0	0	0.22	0.44	0.66	0.87	0.36
Lauric C12:0	0	0.34	0.68	1.02	1.36	1.86
Myristic C14:0	0.07	0.10	0.13	0.15	0.18	1.31
Palmitic C16:0	13.35	13.16	12.99	12.81	12.63	30.61
Margaric C17:0	0.09	0.18	0.28	0.37	0.47	0.64
Stearic C18:0	2.96	3.25	3.54	3.83	4.11	3.63
Palmitoleic C16:1	0.13	0.12	0.11	0.10	0.09	0.15
Oleic C18:1 cia-9	25.31	25.36	25.42	25.48	25.54	4.33
Linoleic C18:2	44.76	43.79	42.82	41.85	40.88	15.15
Linolenic C18:3	3.00	3.12	3.23	3.34	3.46	36.92
SFA	17.53	18.24	18.96	19.67	20.39	42.71
UFA	74.47	73.76	73.04	72.33	71.61	57.29
MUFA	26.71	26.85	26.99	27.13	27.27	5.22
PUFA	47.75	46.91	46.05	45.20	44.34	52.07

[a] SFA = saturated fatty acids; UFA = unsaturated fatty acids; MUFA = monounsaturated fatty acids; PUFA = polyunsaturated fatty acids.

2.2. Slaughter, carcass data and sample collection

After 277 days of feeding, all the animals were slaughtered at commercial beef plant with 550.1 ± 30.6 kg of shrunk body weight. Preharvest handling was in accordance with good animal welfare practices, and slaughtering procedures followed the Sanitary and Industrial Inspection Regulation for Animal Origin Products (Brasil, 1997).

After the slaughter, the carcass was weighed and all carcasses were refrigerated at 4 °C for approximately 24 h and the weight was recorded (CCW). After the postmortem chill period, ultimate carcass pH (pHu), 12th rib fat thickness (RFT) and 12th rib longissimus muscle area (LMA) were measured on the left side of each carcass. Longissimus muscle areas were traced on transparencies and measured later with a planimeter and RFT measurements were taken 3/4 of the length ventrally over the longissimus muscle (Greiner, Rouse, Wilson, Cundiff, & Wheeler, 2003). Dressing percent (CCD) was calculated using CCW divided by final SBW and then multiplying the result by 100.

A boneless longissimus section 10 cm thick was removed from the posterior end of the wholesale rib. Longissimus muscle samples were individually vacuum-packaged and held at −20 °C for 2 days. Each frozen longissimus sample was standardized from the posterior end into one 2.54 cm thick steak sample (AMSA (American Meat Science Association), 1995) for Warner–Bratzler shear force measurement and two 1 cm thick steaks, for the determination of the other analysis. All steaks were vacuum-packaged and held at −20 °C for 10 days until the analysis was performed.

2.3. Meat and subcutaneous fat color

The determination of meat and fat color was performed as described by Houben, Van Dijk, Eikelenboom, and Hoving-Bolink (2000), using a Minolta colorimeter (Model CR 300, Minolta Camera Co. Ltd., Osaka, Japan) evaluating the lightness (L*), redness (a*), and yellowness (b*). The color aspects were assessed by the CIE L*a*b* color system using 0°/45°. Thirty minutes prior to the assessment, cross sections were made at the samples' surface to expose the myoglobin to oxygen, the same steps were made for the fat color measurement. After this step the color was measured at three different points and average values were calculated. The colorimeter was calibrated before analyzing the samples against white and black standards.