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Fatty acid profile, carcass and meat quality traits of young Nellore bulls fed crude glycerin replacing energy sources in the concentrate

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ABSTRACT

Carcass and meat quality traits of 60 Nellore young bulls fed diets without crude glycerin (CG); with CG replacing corn (CGc; 10% of dry matter — DM) in the concentrate; and with CG replacing soybean hull (CGsh; 10% of DM) in the concentrate were evaluated. Diets were evaluated at two concentrate levels (CLs). The CL did not affect cold carcass weight (CCW; $P = 0.6074$), cold carcass dressing (CCD; $P = 0.9636$), rib fat thickness (RFT; $P = 0.8696$) and longissimus muscle area (LMA; $P = 0.7524$). Animals fed diets with CGc or CGsh showed meat with greater deposition of monounsaturated fatty acid (MUFA; $P = 0.0022$) and CLA (18:2 *cis*-9, *trans*-11) contents ($P = 0.0001$) than animals fed diets without CG. The inclusion of 10% of CG in diets CGc or CGsh does not affect the carcass and meat quality traits; however, it increases the MUFA and CLA contents in beef, although these changes are very small in nutritional terms.

1. Introduction

Crude glycerin is a biodiesel byproduct that has been reported as a potential energy source for ruminant animals, particularly when included at levels up to 10% of total dry matter of the diet (Drouillard, 2012; FAO, 2012; Schroder & Sudekum, 2009; Versemann, Wiegand, & Kerley, 2008).

Changes in carcass and meat quality traits of animals fed crude glycerin may occur as a result of the increase in the availability of gluconeogenic compounds that would be used as precursors for fatty acid synthesis leading to an increase in marbling of meat (Evans, Wiegand, & Kerley, 2008; Versemann et al., 2008). This phenomenon occurs because glycerol can be converted to propionate in the rumen or absorbed by the ruminal epithelium and thus converted into glucose (Krehbiel, 2008) which in turn is the main source of carbon used for the fatty acid synthesis (Schoonmaker, Fluharty, & Loerch, 2004).

The inclusion of crude glycerin in diets of ruminant animals may also increase the level of unsaturated fatty acid in meat. Krueger et al. (2010) reported that glycerol likely inhibits lipolysis – a prerequisite for rumen biohydrogenation, which is responsible for the saturation of dietary fatty acids consumed by ruminant animals – decreasing the accumulation of free fatty acids in the ruminal environment of animals by 48 and 77% supplementing 2 or 20% of glycerol in vitro to mixed populations of ruminal microbes. Thus, feeding with crude glycerin has a potential to increase the amount for unsaturated fatty acids available to be incorporated in meat products.

According to Edwards et al. (2012) supplementing glycerol at or near 8 to 15% of diet DM would be expected to achieve effective reductions in lipolysis without adversely affecting rumen DM digestion; however, results obtained during culturing of mixed populations of ruminal microbes and from assays of pure cultures of rumen bacteria have not adequately established the mechanism by which glycerol inhibits ruminal lipolysis. Glycerol (up to 21% of diet DM) has the potential to beneficially affect fatty acid profiles from subcutaneous adipose tissue in lambs, increasing 18:0 and 9c-18:1 and reducing 10t-18:1 and n − 6/n − 3 ratio (Avila-Stagno et al., 2013), but the effects on beef have not been assessed and the needs are to be studied.

Several studies have shown the effect of crude glycerin on carcass and beef quality traits using diets with high levels of starch (Mach, Bach, & Devant, 2009; Parsons, Shelor, & Drouillard, 2009; Ramos & Kerley, 2012). However, the production of propionate is typically greater in animals fed high concentrate diets which reduce the chances of improving energy efficiency by the inclusion of glycerol (Drouillard, 2008), when compared to roughage based diets or diets with low levels of starch. Soybean hulls are widely used in feedlot in Brazil as a substitute for corn in concentrate diets (Mendes, Ezequiel, Galati, & Feitosa, 2005; Silva et al., 2002) mainly due its lower cost as feedstuff. As such, this study aimed to evaluate the inclusion of crude glycerin at 10% of total dry matter as a replacement for different energy sources (corn or soybean hulls) in diets with two different concentrate:roughage proportions on carcass and meat quality traits.

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2. Material and methods

2.1. Animals and management

The trial was carried out at the Sao Paulo State University (UNESP, Jaboticabal, SP, Brazil), following the humane animal care and handling procedures, according to the guidelines of the Sao Paulo State University (UNESP, Brazil). Sixty Nellore bulls with average initial body weight of 373.70 ± 24.70 kg and age of 18 months were used. Initially, cattle were weighed, identified and housed in individual pen with feeders and automatic drinkers. Cattle were submitted to 21 days of adaptation to experimental installations and diets.

After adaptation, cattle were randomly assigned to one of the following experimental diets: Control — without crude glycerin and corn as ingredient of concentrate; inclusion of crude glycerin (10% of DM) that replaced corn in the concentrate; and inclusion of crude glycerin (10% of DM) that replaced soybean hulls in the concentrate. All the three diets were offered at two roughage:concentrate proportions (60:40 and 40:60). Crude glycerin was acquired from a soybean oil-based biodiesel production company ADM, Rondonópolis, Brazil (80.34% of glycerol; 1.59% of ether extract; 5.03% of ash and 12.02% of water). Corn silage was used as the only source of roughage and concentrates were composed of ground corn or soybean hulls, soybean meal, urea/ammonium sulfate and mineral mixture. Ingredient proportion and chemical composition of the experimental diets are presented in Table 1. The fatty acid profile of the ingredients of the experimental diets is presented in Table 2.

At the beginning of the experiment the animals were weighed after 16-h solid fast to obtain the values of shrunk body weight (SBW) and assigned in a completely randomized design in 2 × 3 factorial schemes (two roughage:concentrate proportions and three feeding regimes) with 10 animals per treatment.

2.2. Slaughter, carcass data and sample collection

After 94 days of feeding, all the animals were slaughtered at a commercial beef plant with 498.35 ± 33.55 kg of shrunk body weight. Pre-harvest 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, carcasses were weighed and then refrigerated at 0 °C for approximately 24 h. After the postmortem chill period, the cold carcass weight (CCW), 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. The LMA was traced on transparencies and measured later with a planimeter and RFT measurements were taken 3/4 the length ventrally over the longissimus muscle (Greiner, Rouse, Wilson, Cundiff, & Wheeler, 2003). Cold carcass dressing (CCD) percent 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. After that, each frozen longissimus sample was standardized from the posterior end into one 2.54 cm thick steak sample (AMSA, 1995) for Warner–Bratzler shear force measurement and other analyses as described later. All steaks were vacuum package and held at −20 °C for 10 days until the analysis was performed.

Table 1
Ingredient proportion and chemical composition of the experimental diets without crude glycerin (Cn), crude glycerin plus corn (CGc) and crude glycerin plus soybean hulls (CGsh) evaluated on two concentrate levels.

Item	Diets					
	60:40			40:60		
	Cn	CGc	CGsh	Cn	CGc	CGsh
Ingredients proportion (% DM)						
Corn silage	60.00	60.00	60.00	40.00	40.00	40.00
Corn	26.30	16.00	–	46.40	36.10	–
Soybean meal	10.00	10.00	10.00	10.00	10.00	10.00
Soybean hulls	–	–	16.20	–	–	36.60
Crude glycerin	–	10.00	10.00	–	10.00	10.00
Urea/ammonium sulfate	0.70	1.00	0.80	0.60	0.90	0.40
Commercial premix[1]	3.00	3.00	3.00	3.00	3.00	3.00
Chemical composition (% DM)						
Dry matter	57.60	57.90	58.60	67.08	67.38	68.90
Crude protein	14.30	14.70	14.60	14.45	14.20	14.10
NDF	30.14	28.53	37.60	25.19	23.59	42.95
Ether extract	3.13	3.01	2.92	3.18	3.05	2.83
Nonfiber carbohydrates	47.00	49.46	40.14	53.93	55.48	35.46

[1]/Composition (Cálcio: 210 g; Fósforo: 20 g; Enxofre: 37 g; Sódio: 80 g; Cobre: 490 mg; Manganês: 1.424 mg; Zinco: 1.830 mg; Iodo: 36 mg; Cobalto: 29 mg; Selênio: 9 mg; Flúor máx.: 333 mg).

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

Item[1]	Corn silage	Corn	Soybean meal	Soybean hulls	Crude glycerin
Capric C10:0	0.10	–	–	–	3.12
Lauric C12:0	0.19	–	–	–	4.87
Myristic C14:0	0.21	0.04	0.11	0.17	0.46
Palmitic C16:0	15.30	13.15	16.12	14.16	10.71
Margaric C17:0	0.15	0.08	0.11	0.32	1.45
Stearic C18:0	2.96	2.40	4.20	4.10	6.53
Palmitoleic C16:1	0.16	0.14	0.14	0.42	–
Oleic C18:1 *cis*-9	30.58	34.87	18.74	22.85	35.79
Linoleic C18:2	45.32	46.25	51.50	45.37	32.27
Linolenic C18:3	2.37	0.89	6.08	7.45	2.48
SFA	20.34	16.84	21.70	20.19	27.14
UFA	79.66	83.16	78.30	79.81	72.86
MUFA	31.97	36.02	20.72	26.99	38.11
PUFA	47.69	47.14	57.58	52.82	34.75

[1]/SFAs = saturated fatty acids; UFAs = unsaturated fatty acids; MUFAs =monounsaturated fatty acids; PUFAs = polyunsaturated fatty acids.

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, samples were removed from vacuum package and surface samples were exposed to air for oxygenation of myoglobin. Same procedure was 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.

2.4. Warner–Bratzler shear-force measurement and cook loss

Warner–Bratzler shear force (WBSF) steaks were thawed at 4 °C for 24 h and oven-broiled in an electric oven (Layr, Luxo Inox) preheated at 150 °C. Internal steak temperatures were monitored by 20-gauge copper-constantan thermocouples (Omega Engineering, Stamford, CT) placed in the approximate geometric center of each steak and attached to a digital monitor. When internal steak temperature reached 35 °C, the steak was turned over and allowed to reach an internal temperature of 70 °C before removal from the oven. Cooked WBSF steaks were cooled for 24 h at 4 °C (AMSA, 1995). Eight round cores (1.27 cm diameter) were removed from each steak parallel to the long axis of the muscle fibers (AMSA, 1995). Each core was sheared once through the center, perpendicular to the fiber direction by a Warner–Bratzler shear machine (G-R Manufacturing Company, Manhattan, KS, USA). Cook loss