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Qualitative characteristics of meat from young bulls fed different levels of crude glycerin ☆

J.R.R. Carvalho [a], M.L. Chizzotti [a,1], E.M. Ramos [b], O.R. Machado Neto [a], D.P.D. Lanna [c], L.S. Lopes [d], P.D. Teixeira [a], M.M. Ladeira [a,1,*]

[a] Department of Animal Science, Universidade Federal de Lavras, Lavras, Minas Gerais, 37.200-000, Brazil
[b] Department of Food Science, Universidade Federal de Lavras, Lavras, Minas Gerais, 37.200-000, Brazil
[c] Department of Animal Science, Escola Superior de Agricultura Luiz de Queiroz — USP, Piracicaba, São Paulo, 13.418-900, Brazil
[d] Centro de Educação Superior do Oeste, Universidade do Estado de Santa Catarina, Chapecó, Santa Catarina, 89.800-000, Brazil

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ABSTRACT

The objective was to evaluate the fatty acid profile and qualitative characteristics of meat from young bulls fed crude glycerin. Forty-four animals with an initial live weight of 368 ± 4 kg were used in a completely randomized design, with four treatments: no glycerin or addition of 6, 12 or 18% glycerin. The animals were slaughtered with 519.5 ± 14.9 kg of live weight. The meat characteristics assessed were chemical composition, shear force, fatty acid concentration, color and lipid oxidation. The addition of glycerin increased the content of ether extract ($P<0.05$) in the muscle. A linear increase was observed ($P<0.05$) in the oleic acid contents (C18:1 *cis* 9). The saturated fatty acid (SFA) contents linearly decreased in the muscle as a function of glycerin addition. The lightness (L*) and yellowness (b*) indices increased with the use of crude glycerin ($P<0.05$). The crude glycerin increased the intramuscular fat and oleic acid content in the *longissimus dorsi* muscle.

1. Introduction

The interest in manipulating the fatty acid profile of meat stems from several studies that have demonstrated beneficial and harmful effects of certain fatty acids on human health (De La Torre et al., 2006; Enser et al., 1998; German et al., 2009; Gilmore et al., 2011; Raes, De Smet, & Demeyer, 2004).

Furthermore, a growing interest in the use of co-products in animal feed has been observed because these products can reduce the feeding costs. Several studies have evaluated the use of co-products on the beef quality (Dugan et al., 2010; Kazama et al., 2008; Oliveira et al., 2011), but few have evaluated the effect of crude glycerin on qualitative characteristics of beef. For example, Mach, Bach, and Devant (2009) found no effect of crude glycerin on the shear force of beef from feedlot Holstein bulls. Working with swine, Mendoza, Elis, Mckeith, and Gaines (2010) reported similar results.

In another study involving swine, Lammers et al. (2008) found that glycerin supplementation decreased the linoleic acid contents in the *longissimus dorsi* (LD) muscle of the animals. However, Terré, Nudda, Casado, and Bach (2011) in a study with lambs in the finishing phase, did not observe effects of glycerin on the fatty acid profile of the LD muscle. Therefore, both the results of the abovementioned studies and the lack of results involving cattle justify a more detailed evaluation of the effects of dietary crude glycerin on beef quality.

Krueger et al. (2010) demonstrated that the use of glycerin in ruminal diets has the potential to alter the fatty acid profile of meat because glycerol can act negatively on the lipolysis process in the rumen. This effect would allow more unsaturated fatty acids to reach the intestine and, after absorption, be deposited in the adipose and muscular tissues of the animals.

Therefore, the objective of the present study was to evaluate the fatty acid profile and qualitative characteristics of the meat from feedlot young bulls fed different levels of crude glycerin.

2. Materials and methods

Animal care and handling were approved by the Federal University of Lavras Animal Care and Use Committee before the research was initiated. The experiment was conducted at the Department of Animal Science of the Federal University of Lavras from August to November, 2010.

2.1. Animals, diet and slaughter

Forty-four Red Norte young bulls, with an average initial age of 20 months and an average initial live weight of 368 ± 4 kg, were allotted

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* Corresponding author. Tel.: +55 35 3829 1244; fax: +55 35 3829 1231.
E-mail address: mladeira@dzo.ufla.br (M.M. Ladeira).
[1] CNPq and INCT – Ciência Animal researchers.

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in a completely randomized design, with four treatments and 11 repetitions. The animals were housed in group pens, according to the diets, with 30 m^2 per animal, and each animal was the experimental unit.

The experimental period lasted 84 days and was preceded by an adaption period of 14 days, during which the animals received the same diet. At the beginning of the adaption period, the animals were treated for internal and external parasites (Ivomec®, Paulína, Brazil). The animals were weighed at the beginning and end of the experimental period, after a 16-h fasting period.

The diets contained corn silage as forage, and four different levels of crude glycerin in replacement of ground corn grains were used (Table 1). The diets were formulated according to National Research Council (NRC, 2000) to be isonitrogenous and were provided *ad libitum* to the animals at 7:30 and 15:30. Corn gluten meal (CGM-21) was used in the diets containing crude glycerin to provide similar levels of crude protein and similar amino acid profiles.

Samples of the corn silage and the ingredients of the concentrate were collected every 14 days. From these samples, a composite sample was created, which were dried in a forced-air oven at 65 °C for 72 h and were ground to a mesh size of 1 mm. The chemical analyses of the dry matter (DM), crude protein (CP), and ether extract (EE) in the diets were performed according to the Association of Official Agricultural Chemists (AOAC, 1990). The non-fibrous carbohydrates (NFC) were obtained according to Sniffen, O'Connor, and Van Soest (1992), and the metabolizable energy (ME) was calculated according to NRC (2001) and Mach et al. (2009).

The animals were slaughtered at an average weight of 519.5 ± 14.9 kg by captive bolt and exsanguination, followed by hide removal and evisceration, without electrical stimulus. The carcasses were identified, washed, and divided into halves. The initial pH was subsequently measured between the 12th and 13th ribs, in the center of the LD muscle, using a Mettler M1120x pH meter (Mettler, Toledo International Inc., Columbus, EUA). After the operation, the half carcasses were individually weighed and put into cold storage at 2 °C for approximately 24 h. After cooling the carcass, the final pH were measured at the same place.

Table 1
Percentage of ingredients and chemical composition of the experimental diets.

	Glycerin levels			
	0%	6%	12%	18%
Ingredients, % of DM				
Corn silage	30.0	30.0	30.0	30.0
Corn ground grain	56.0	48.0	37.0	26.0
Soybean meal	12.0	12.0	12.0	12.0
Corn gluten meal (CGM-21)	–	2.0	7.0	12.0
Crude glycerin[a]	–	6.0	12.0	18.0
Premixed mineral[b]	2.0	2.0	2.0	2.0
Nutrients, % of DM				
Dry matter[c]	59.2	58.8	58.4	58.0
Crude protein	13.1	12.9	13.1	13.3
Neutral detergent fiber	22.2	22.4	23.6	24.8
Non-fiber carbohydrate	56.6	56.6	55.0	53.3
Glycerol	–	5.6	11.2	16.8
Ether extract	3.4	3.4	3.3	3.2
Metabolizable energy (Mkal/Kg DM)	2.79	2.79	2.78	2.78
Fatty acids, % of DM				
Myristic acid	0.01	0.01	0.01	0.01
Palmitic acid	0.57	0.53	0.48	0.43
Stearic acid	0.18	0.17	0.16	0.15
Oleic acid	0.95	0.86	0.78	0.70
Linoleic acid	1.45	1.32	1.18	1.05
Linolenic acid	0.10	0.10	0.09	0.08

[a] Crude glycerin composition (% of NM): 10.79% moisture; 83.12% glycerol; 6.06% ashes; 3.67% chlorides, <0.01% organic matter, and 0.02% methanol.
[b] Assurance levels per kilogram of product: Ca: 170 g; P 31 g; Na: 155 g; Zn: 2 mg; Cu: 396 mg; Mn: 515 mg: Co: 15 mg; I: 29 mg; Se: 5.4 mg; Vit. A: 111.000 UI; Vit. D3: 22.000 UI; Vit. E: 265 UI;
[c] Natural matter basis.

2.2. Meat collection and analysis

Twenty-four hours after the slaughter, samples of the LD muscle were collected from the left side of the carcass from the 13th rib, for chemical composition, fatty acid profile, and physical-chemical (color, TBARS) analysis. These samples were storage at −20 °C until analysis procedure.

After thawing at room temperature, the meat samples were lyophilized to obtain homogeneous and moisture-free samples, and the centesimal composition was determined according to AOAC (1990). Crude protein was quantified by the Kjeldahl method, EE was extracted by the Soxhlet method and the ashes were obtained through a muffle furnace at 550 °C.

Four 2.54 cm-thick steaks collected from each animal were identified and vacuum packed in polyethylene bags (water vapor permeability <10 g/m^2/24 h at 38 °C and oxygen permeability <40 mL/m^2/24 h at 25 °C) to determine the color, cooking weight loss (CWL) and shear force (SF) at four aging times (0, 7, 14 and 21 days *post mortem*) at 1 °C. After the color analysis, the samples were stored at −20 °C prior to the CWL and SF analyses.

The CWL was determined using samples thawed at room temperature as the difference between the weight of a steak before and after cooking on a pre-heated grill at 200 °C. A thermometer was used to monitor the internal temperature of the steak until the center reached 71 °C. Subsequently, each steak was conditioned to room temperature, and after temperature stabilization, the steak was weighed to obtain the CWL (AMSA, 1978).

The SF was obtained from the same samples used for the CWL. Six slices samples per steak, with 1-cm-thick and 5-cm-long, free of visible fat and connective tissue, were obtained from the center of cooked samples, with the direction of the muscle fibers parallel to the length. The slice were completely sheared perpendicularly to the muscle fibers with a Warner–Bratzler blade of 1.016 mm at a speed of 200 mm/min (Ramos & Gomide, 2007) using a TA.XT.plus texture analyzer (Stable Micro Systems Ltd., Vienna Court, UK).

2.3. Fatty acid extraction and gas chromatography analysis

The muscle and subcutaneous fat lipids were extracted according to the procedures established by Hara and Radin (1978) and methylated according to Christie (1982). After transmethylation, the samples were analyzed in a gas chromatographer (model Focus GC-Finnigan, Thermo Finnigan, San Jose, CA), with a flame ionization detector and a capillary column (CP-Sil 88; Varian, Palo Alto, CA) with 100 m × 0.25 μm internal diameter and 0.20 μm film thickness (Supelco, Bellefonte, PA). Hydrogen was used as the carrier gas at a flow rate of 1.8 mL/min. The starting programmed temperature of the oven was 70 °C, which was maintained for 4 min, followed by an increase of 13 °C/min up to 175 °C, maintenance for 27 min, an increase of 4 °C/min up to 215 °C, maintenance for 9 min and an increase of 7 °C/min up to 230 °C, maintenance for 5 min, totaling 65 min. The vaporizer temperature was 250 °C, and the detector was at 300 °C.

The different fatty acids were identified by comparison of the retention times of methyl esters in the samples with standards of fatty acids from butter. Fatty acids were quantified by normalizing the areas of methyl esters. Fatty acid results were expressed as percentage of the area (%) obtained using Chromquest 4.1 software (Thermo Electron, Milan, Italy).

The Δ^9 desaturase and elongase enzyme activity indices were determined according to Malau-Aduli, Siebert, Bottema, and Pitchford (1997). The atherogenic index was calculated according to Ulbricht and Southgate (1991) as an indicator of the risk of cardiovascular disease. The calculations were performed as follows:

Δ^9 desaturase activity 16: 100 [(C16:1cis9)/(C16:1cis9 + C16:0)];
Δ^9 desaturase activity 18: 100 [(C18:1cis9)/(C18:1cis9 + C18:0)];