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Meat quality assessment from young goats fed for long periods with castor de-oiled cake

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ABSTRACT

Diet can influence both the qualitative and quantitative traits of ruminant meat. This study evaluated the effects of castor de-oiled cake on the meat of mixed-breed male goat kids. After 165 days of diet treatment, no alterations ($p > 0.05$) were observed in the *in vivo* performance, anatomic components, dissection and proximate composition of the *Longissimus dorsi* muscle, as well as in the color and pH of the carcasses. However, diet had an effect ($p < 0.05$) on energy metabolites, fatty acid profile, and expression of certain proteins of the *Longissimus dorsi* muscle. To conclude, this study showed that the establishment of castor de-oiled cake diet for a long period to goats led to alterations in meat quality, without compromising its consumption qualities.

1. Introduction

For the past years, there has been an increasing demand from governmental programs to implement sustainable and economic biodiesel production and consumption from oleaginous seeds such as those of the castor oil plant (*Ricinus communis* L.) (Rodrigues, 2007). However, one of the major concerns related to biodiesel production is the generation of by-products. Castor de-oiled cake is a biodiesel by-products that may be considered in animal diets because of its high protein content (Severino, 2005) and ease of degradation by ruminants (Moreira et al., 2003). Despite its potential, this by-product has ricin, a potent protein toxin that inactivates ribosomal activity (Barbieri, Battelli, & Stirpe, 1993) and thus, compromises its use as part of animal diets.

The effects of ingesting ricin-containing residues in animals remain elusive. Feeding ruminants with castor de-oiled cake, either treated or untreated, has not caused symptoms of intoxication. Likewise, ingestion of castor de-oiled cake has not influenced consumption or hepatic function, nor has any ricin been transferred to the milk or accumulated in the muscle of milk-nourished calves (Furtado et al., 2012; Oliveira et al., 2010a; Oliveira et al., 2013; Robb, Laben, Walker, & Herring, 1974). However, treated castor de-oiled cake has affected the yield of warm and cold carcasses, ribs and racks of sheep (Pompeu et al., 2012), whereas as untreated cake reduced carcass yield, as well as fat and muscle content of the *Longissimus dorsi* (LD) of cattle (Diniz et al., 2010).

The type of diet can alter both qualitative and quantitative traits of the ruminant carcasses and, consequently, the quality of the meat. However, no studies have assessed the effects of using untreated castor de-oiled cake fed over a long period in goats. This information is necessary for the marketing of animals and for ensuring food safety to those who use goat products as an important protein source, but also for effective utilization of untreated castor de-oil as source of ruminant feeds. This study aimed to determine the influence of castor de-oiled cake diet provided for a long period on carcasses traits and quality of goat meat.

2. Materials and methods

2.1. Castor cake and ricin quantification

Castor meal was obtained from the factory BOM Brasil, located in Salvador — Bahia. Ricin was quantified by assaying the total proteins of samples of castor de-oiled cake, following the method of Bradford (1976) with albumin serum bovine as the protein standard. Later, the

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image of the polyacrylamide gel was digitized in ImageScanner™ of GE Healthcare (compatible with ImageMaster software) and then analyzed by the program Image Master Platinum. Protein bands were quantified in volume units (area *vs.* intensity) following the method described by Retamal, Thiebaut and Alves (1999).

2.2. Goats and experimental design

The present study was approved by the Ethics Committee for Animal use of the Ceara State University (Comitê de Ética para o uso de Animais da Universidade Estadual do Ceará — CEUA-UECE), under protocol number 09503497-8/82.

The experiment was conducted on Padre João Piamarta Farm, in Itaitinga-CE, located at 4° 01′ S and 38° 31′ W, from June to November. Fourteen mixed-breed growing male kids were grouped into two lots (n = 7), homogeneous (mean ± standard errors) in weight and age: group without de-oiled castor cake (WCC; 21.33 ± 1.72 kg and 282.66 ± 2.03 days); group with de-oiled castor cake (CC; 21.26 ± 1.16 kg and 284.5 ± 2.12 days). The goats were kept in individual shaded pens with *ad libitum* access to water and salt. The goats were adapted for 30 days. During this period, gastrointestinal and ectoparasite treatment was performed. The kids received two diets composed of a mixture of Bermuda grass hay and isoenergetic (73% of TDN) and isonitrogenous (15% of CP on DM basis) concentrates (Table 1): WCC group and CC group. In the first group (WCC), the ingredient composition comprised of Bermuda grass hay and concentrate feed (80% corn, 15% soy meal and 5% minerals). In the second group (CC), the diet contained Bermuda grass hay and concentrate feed with castor cake instead of soy meal (80% corn, 15% castor cake and 5% minerals). A mixture of urea/ammonium sulfate (9:1) was used to adjust the crude protein content of the diet to eliminate the difference between the feeds. Formulation of diets was based on the nutritional requirements (NRC, 2007) for male kids and presents the same concentrate:roughage ratio (40:60) for both groups (WCC and CC). The diets were provided twice a day (0700 h and 1500 h) for 165 days. Organic matter, ash, crude protein and ether extract contents of the diets were analyzed according to the procedures described by Silva and Queiroz (2002), and the neutral detergent fiber and acid detergent fiber contents were analyzed according to Van Soest, Robertson and Lewis (1991).

2.3. Blood sampling, liver and renal enzymes, urea, glucose, cholesterol and NEFA assays

Before fasting, blood samples were collected through jugular venipuncture using heparinized vacutainer tubes (Labor import, Wei Hai, China). The blood samples were centrifuged at 600 g for 15 min, and the plasma obtained was stored −20 °C for subsequent quantification of the main hepatic and renal function-related metabolites. Plasma concentrations of urea, albumin, creatinine, lactate dehydrogenase (LDH), alanine aminotransferase (ALT), aspartate aminotransferase (AST), glucose and cholesterol were determined using an automated biochemical analyzer (Labmax 240, Labtest® or Mindray BS 120, Mindray®) with commercial kits (Labtest® — Lagoa Santa, MG, Brazil or Bioclin®, Quibasa — Minas Gerais, Brazil). Non-esterified fatty acids (NEFA) were analyzed using a semi-automated biochemical analyzer (Randox RX Monza TM, Randox Laboratories®, Crumlin, UK), by commercial kits (Randox Laboratories®, Crumlin, UK).

2.4. Anatomical and carcass components

At the end of the feeding period, the following parameters of the *Longissimus dorsi* (LD) muscle were evaluated using real-time B-mode ultrasonography (Chisson® D600 VET, Chisson Medical Imaging Co., China): muscle area (LMA), muscle depth (LMD), depth of the subcutaneous backfat thickness (SBT), subcutaneous sternum fat thickness (SSFT) and internal sternum fat thickness (ISFT). To conduct such measurements, animals were immobilized, and the areas to be analyzed were subjected to trichotomy and cleaned. A carboxymethylcellulose gel was applied on the areas for appropriate propagation of ultrasound waves.

The evaluations were made using a linear transducer of 5.0 MHz on the left side of the animal. The evaluation of the LMA was performed as described by Silva et al. (2011b). LMD and SBT were determined according to Ripoll, Joy, Alvarez-Rodriguez, Sanz, and Teixeira (2009) with minor modifications. Briefly, measurements of the LMD were made at three points of the image, with two of the measurements immediately above the third and fourth lumbar vertebrae, and the third measurement between the other two, to avoid over- or underestimation. For the measurement of the sternum fat thickness, the recommendations of Teixeira, Joy, and Delfa (2008) were followed, with minor modifications. Briefly, sternum fat measurements were divided into two: ISFT, with two measurements of the internal fat; and SSFT, with one measurement in the central area of the subcutaneous fat. The images were saved and analyzed in triplicates by using the program Image J (Image J®, National Institutes of Health, Millersville, USA).

Before slaughter, the goats were weighed and then subjected to solid and liquid fasting for 16 h. Subsequently, the animals were weighed again to obtain the fasting body weight and then slaughtered according to RIISPOA (1980) standards. After skinning, evisceration and removal of the head and extremities, the anatomical components (the lungs, heart, spleen, liver, kidneys, tongue, empty stomach, empty intestines, omentum, cardiac and renal adipose tissues, skin and reproductive trait) were weighed. Each carcass was weighed to obtain the hot carcass weight. The carcasses were then stored at 4 °C for 24 h. Next, carcasses were again weighed to obtain the cold carcass weight. The carcasses were then longitudinally cut into two half-carcasses and the ham, shoulder, loin, neck and ribs were collected from the left half-carcass, as described by Cesar and Sousa (2007) and Silva Sobrinho (2001).

After slaughter, the pH and muscle color of the LD and semimembranosus muscles (SM) were determined. The pH of the muscle was determined at 30 min post-slaughter (pH-30 min) and at 24 h (pH-24 h) by using a pH meter (TESTO 205®, Germany). Muscle color was determined by conducting three measurements immediately after slaughter by using a spectrophotometer (CM-2500d®, Japan) and a CIELAB evaluation system, with L^* corresponding to lightness, b^* to the

Table 1
The chemical composition of the dietary ingredients.

Ingredients	Chemical composition (g/kg)					
	Organic Matter	Crude Protein	Ether Extract	Ash	Neutral Detergent Fiber	Acid Detergent Fiber
Bermuda grass hay	923.0	78.0	19.0	77.0	776.8	363.5
Castor Cake	893.5	413.5	20.0	106.5	400.7	338.0
Concentrate-based supplements						
Without Castor Cake-diet	972.0	150.0	31.5	28.0	–	–
Castor Cake-diet	970.9	149.9	34.8	29.1	–	–