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Breed effect on quality veal production in mountain areas: emphasis on meat fatty acid composition

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ABSTRACT

This study was designed to compare the quality of veal produced from 'Tudanca × Charolais' cross (n = 6) and Limousin (n = 6) breeds when allowed to feed freely on mountain pastures and suckle naturally from birth to 7 months of age. After 80 days of age calves also had access to concentrate (maximum of 3 kg/day), while mothers did not. At slaughter, Limousin calves were heavier ($P<0.01$) and provided better carcass yield ($P<0.05$) and conformation ($P<0.001$) than Tudanca calves. Tudanca beef provided higher fat content ($P<0.05$) was less tough ($P<0.05$), and was scored as more tender and juicy ($P<0.1$) with higher acceptability than Limousin beef ($P<0.1$). In general, Tudanca had a better fatty acid profile than Limousin beef, especially in terms of the content of polyunsaturated ($P<0.05$), long-chain polyunsaturated fatty acids ($P<0.05$) and their n−6/n−3 ratios ($P<0.1$), as well as vaccenic acid ($P<0.1$) and the overall *trans*-18:1 isomer profile.

1. Introduction

Mountain areas of northern Spain are traditionally dedicated to beef production utilizing mostly local breeds, including crossbred animals (Bispo et al., 2011; Humada, Serrano, Sañudo, Rolland, & Dugan, 2011; Lavín, Jaroso, Palencia, & Mantecón, 2011a; Vieira, García, Cerdeño, & Mantecón, 2005). Such a production system meets a number of expectations in terms of sustainability and multifunctionality in rural areas. The most common beef production system in this mountain region (steep topography; between 520 and 580 m above sea level; longitude −4° 51′, latitude 43° 25′) is centered on calf production and farmers then selling them to bigger feedlots for final intensive-fattening and commercialization; calves are generally 8–9 months of age at slaughter. According to recent findings (Lavín, Jaroso, Palencia, & Mantecón, 2011b) it was concluded that this system did not provide local farmers with significant economic benefits, and therefore it was decided to evaluate an alternative system. The alternative production system focused on producing veal locally instead of calves for intensive fattening. Calves would be reared outdoors on local pastures and suckled naturally by their mothers from birth to 6–7 months of age, and were subsequently slaughtered.

It is known that breed or genotype and production system are determinant factors of the carcass and meat quality (Martínez, Aldai, Celaya, & Osoro, 2010; Piedrafita et al., 2003; Vieira et al., 2005), and these will also affect the fatty acid composition of the meat (Aldai et al., 2006, 2011). In order to test the present local production system and evaluate the quality of the meat, two breeds were investigated reared under the same mountain pasture conditions to evaluate the quality of the final beef produced. The study included a local cross ('Tudanca × Charolais') and a foreign breed that has been well-adapted to the area (Limousin). These two breeds have different maternal traits (personal communication).

Economical comparisons associated with raising each breed under this local production system have been reported elsewhere (Lavín et al., 2011b). In the present study a comparison was undertaken of the carcass (*i.e.*, EU classification) and meat quality (*i.e.*, color, tenderness, and sensory analysis) characteristics with special emphasis of fatty acid (FA) in meat having nutritional implications.

2. Materials and methods

2.1. Animals, management and diet composition

Twelve male calves from 'Tudanca × Charolais' cross (n = 6) and Limousin (n = 6) were studied. From birth (March–April 2010), calves were naturally suckled by their mothers in mountain areas of Cantabria (Nansa Valley, northern Spain). The major botanic species in the fields were *Lolium perenne*, *Agrostis capillaris* and *Trifolium repens*. After an average of 79.3 ± 1.55 days of age calves received *ad*

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libitum access to concentrate up to a maximum of 3 kg/day/head, while mothers did not have access to concentrate (only access to pasture).

The concentrate meal was composed approximately by 40% corn meal, 45% barley meal, 10% soya meal, 2% fat, 3% minerals, vitamins and oligoelements. Samples were analyzed for dry matter (DM; ISO, 1999), ash (ISO, 2002), and crude protein (CP; ISO, 2005). Ether extract (EE) was determined using the Ankom filter bag technology (American Oil Chemists' Society Official Procedure Am 5-04; AOCS, 2008) while the fatty acid composition was determined using a direct transesterification procedure as detailed by Alves, Cabrita, Fonseca, and Bessa (2008). Therefore, on DM basis, chemical composition of the concentrate was as follows: 16.2% CP, 6.7% ash, and 3.9% EE, while the percentages of major FAs were as follows: 18% 16:0, 2.1% 18:0, 20% 9*c*-18:1, 50% 18:2n−6, and 3.3% 18:3n−3.

Calves were slaughtered in October at an average age of 7 months. At this point the calves were subjectively inspected to see whether they reached an adequate conformation and degree of fat cover. Live weight at slaughter (LWS) was recorded.

2.2. Carcass measurements and sample collection

Slaughtering was performed in a commercial abattoir according to standard procedures. After dressing, carcasses were chilled at 2 °C for 24 hours (h). Twenty-four hours *post-mortem*, cold carcass weight (kg) and length (cm) were recorded. The carcass yield (%) was calculated based on LWS and cold carcass weight, while carcass compactness was calculated based on carcass weight and length as described in De Boer, Dumont, Pomeroy, and Weniger (1974). Carcasses were classified by visual assessment on conformation and fat cover degree by a trained and experienced evaluator. For conformation, development of carcass profiles was taken into consideration according to SEUROP classification (S: super, E: excellent, U: very good, R: good, O: fair, P: poor), and for fat cover degree the amount of fat on the outside of the carcass and in the thoracic cavity using a classification range from 1 to 5 (1: low, 2: slight, 3: average, 4: high, 5: very high; OJEC, 1981a,b). Each level of both scales (conformation and fat cover) was subdivided in 3 sub-classes (*i.e.*, conformation: R+, R, R− and fat cover: 3+, 3, 3−) to a transformed scale ranging from 1 to 18 for conformation (18 being the best conformation) and from 1 to 15 for fat cover (15 being the thickest fat cover). Carcass pH (penetration portable pH Meter, Metrohm®, Switzerland) and color (portable Minolta® CM2002, Konica-Minolta Sensing, Inc., Germany) were also measured on the left half carcass at 24 h *post-mortem*. Two pH measurements were taken in the *longissimus thoracis et lumborum* muscle (LTL; 3rd lumbar vertebrae). Color (D65 illuminant and 10° standard observer; L*, brightness; a*, red–green axis; b*, yellow–blue axis; Commission Internationale de l'Eclairage, 1978) was measured at the *pectoralis profundus* muscle and subcutaneous fat (6th to 10th rib area) with 3 measurements per tissue.

After 5 days of ageing at 2 °C in the abattoir cooler, commercial carcass fabrication was performed and the percent of boxed beef (*i.e.*, saleable meat) calculated relative to the cold carcass weight. At 11 days *post-mortem*, the rib joint between the 5th to the 9th ribs of the left half carcass was cut and transported to the laboratory for further analyses.

2.3. Meat quality

Drip loss was determined (Hönikel, 1998) on the first steak of the LTL muscle of the rib joint. Approximately two 50 g samples of raw meat were sampled from the 5th rib and weighed. The two portions were placed within a container with a supporting mesh that was then sealed in order to avoid water evaporation. After a period of 72 h at 4 °C, the samples were weighed again to determine water loss, and that weight difference was expressed as the percentage of the initial weight. From the second steak (LTL muscle), color measurements were recorded after exposing the muscle to atmospheric oxygen for 20 min and using the equipment and procedure described above (Section 2.2). Then, the LTL was ground and freeze-dried, and percentages of moisture, EE, CP and ash were determined using standard procedures described in Section 2.1 as per feedstuff. A subsample of 15–20 g of freeze-dried meat was stored at −80 °C for subsequent FA determination.

From the last LTL portion three steaks of approximately 2 cm thickness were cut. The first steak was used to determine shear force in cooked meat according to the Warner–Bratzler test (Hönikel, 1997). Sensory analysis was performed using the other two steaks with an eight-member trained panel who evaluated the samples for odor intensity, tenderness, juiciness, flavor intensity, and overall acceptability (5-point scale). Details regarding shear force, including equipment description and sensory analysis have been previously described by Vieira, Cerdeño, Serrano, Lavín, and Mantecón (2007).

2.4. Fatty acid analysis

Lipids were extracted from 1 g of freeze-dried muscle using a mixture of chloroform–methanol (1:1, v/v) (Kramer et al., 1998). Details of this procedure have been published elsewhere (Aldai, Dugan, Rolland, & Kramer, 2009). Lipid aliquots (~10 mg) from each steak were methylated separately using acidic (methanolic HCl) and basic (sodium methoxide) reagents to ensure complete methylation of all lipids and avoid isomerization of conjugated linoleic acids (CLAs), respectively (Aldai, Murray, Nájera, Troy, & Osoro, 2005; Kramer, Hernandez, Cruz-Hernandez, Kraft, & Dugan, 2008). For quantitative purposes, 1 mL of internal standard (1 mg/mL of 23:0 methyl ester, n−23-M from Nu-Chek Prep Inc., Elysian, MN, USA) was added prior to methylation. The contents of fatty acid methyl esters (FAMEs) were expressed as mg per 100 g of fresh meat, and as percentage (%) of total FAME quantified.

The FAMEs were analyzed using a gas chromatograph equipped with a flame ionization detector (Agilent Technologies, Model 7890A, Wilmington, DE, USA) and an automatic injector (Agilent Technologies, Model 7693 Autosampler). The FAMEs, including the *trans*-18:1 isomers, were analyzed using a 100 m SP-2560 column (Supelco, Bellefonte, PA, USA) and two complementary gas chromatography (GC) temperature programs plateauing at 175 °C and 150 °C (Kramer et al., 2008) and a split ratio of 50:1. The CLA isomers were separated and identified using a 100 m SLB-IL111 ionic liquid stationary phase column (Supelco, Bellefonte, PA, USA) as described by Delmonte et al. (2011). On the ionic liquid column the FAMEs were injected using a 20:1 split ratio and the following temperature program: 168 °C for 40 min, increased 6 °C/ min to 185 °C, and maintained for 35 min. With both columns hydrogen was used as carrier gas with a flow rate of 1 mL/min, and the injector and detector temperatures were set at 250 °C.

For identification of the FAMEs, reference standards #463 and #603, individual FAMEs 21:0 and 23:0, and CLA mixture #UC-59M (9*c*,11*t*-/8*t*,10*c*-/11*c*,13*t*-/10*t*,12*c*-/8*c*,10*c*-/9*c*,11*c*-/10*c*,12*c*-/11*c*,13*c*-/11*t*,13*t*-/10*t*,12*t*-/9*t*,11*t*-/8*t*,10*t*-18:2 isomers) were used, all obtained from Nu-Chek Prep Inc. (Elysian, MN, USA). Branched-chain FAs (BCFA) were identified using a bacterial FAME mixture purchased from Matreya (Pleasant Gap, PA, USA). Many of the *trans*-18:1 and CLA isomers, not included in the standard mixtures, were identified by their retention times and elution orders as reported in the literature (Alves & Bessa, 2009; Cruz-Hernandez et al., 2004; Cruz-Hernandez et al., 2006; Delmonte et al., 2011; Kramer et al., 2008; Rego et al., 2009). In general, only FAMEs representing over 0.05% of the total FAME content were included in the tables and figures, except for CLA that includes all quantified isomers.