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Effect of feeding system and breed on growth performance, and carcass and meat quality traits in two continental beef breeds

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ABSTRACT

A total of 100 young bulls were allotted a 2 × 2 factorial arrangement of treatments to determine the effect of the feeding system (concentrate and wheat straw: T; total mixed ration comprised of the same concentrate, maize silage and wheat straw: TMR) and breed (Limousine: LI; Retinta: RE) on growth performance, carcass characteristics and meat quality. The diets were administrated ad libitum for 193 days. The average daily weight gain was similar ($P > 0.05$) for both diets, while the LI bulls grew significantly ($P < 0.05$) more than RE. T bulls showed higher L*, a* and rib bone percentage. TMR bulls showed higher carcass yield, conformation and fatness, and greater changes in ultrasound measurements, except Δ UGMD and rib fat percentage. Instrumental meat quality, except shear force at 1 and 21 days of ageing, was not affected ($P > 0.05$) by the diets. Breed significantly affected most of the analyzed characteristics.

1. Introduction

Marketing differentiated products has recently become a priority for beef producers. It is recognised that the factors affecting ruminant carcass and meat quality are directly linked with the animal and its environment (Dannenberger, Nuernberg, Nuernberg, & Ender, 2006), and of these, breed and diet are probably the most important.

Beef production in southwest Spain is mainly based on pure breeds (e.g., Retinta, Limousine) or their crosses (MAPA, 2003), raised under a semi-extensive system in the *dehesa* (wooded pasturelands). Retinta is a local Spanish beef breed of early maturity and large size when fully grown (Albertí et al., 2005). Limousine is a late-maturing specialized beef breed of French origin characterized by high muscularity and carcasses of lean to medium fatness (Albertí et al., 2008). Calves are reared with their dams until weaning at about 7–8 months of age. In many European countries, and particularly in Spain, weaned calves are transferred to commercial feedlots, where they are usually fed ad libitum high concentrate diets, comprising cereal–soybean meal-based concentrates and cereal straw, given separately during the fattening period in order to promote maximum daily gain and adequate rumination (Campbell, Marshall, Mandell, & Wilton, 1992). However, in recent years, this system has suffered a profitability crisis as a result of the highly variable prices of feed.

In order to increase the economic returns on beef operations and simultaneously obtain differentiated products, some authors have proposed feeding fattening cattle on pastures supplemented with conserved forages and small amounts of cereals (Vieira, Cerdeño, Serrano, & Mantecón, 2006) or in feedlots using local by-products and conserved forages (Casasús, Ripoll, & Albertí, 2012; Villalba et al., 2010). The first option seems inappropriate in southwest Spain since the production potential of the pasturelands (*dehesa*) is limited due the climate (low and irregular precipitations) and the low fertility of the soil (Olea & San Miguel-Ayanz, 2006), thus allowing a very low stocking rate. However, feeding diets based on silage are a feasible option, because they can easily be produced in irrigated areas located near the feedlots.

Including maize silage in diets given as total mixed rations (TMR) for fattening cattle has aroused much interest in recent years (Casasús et al., 2012; Cooke, Monahan, Brophy, & Boland, 2004; Keady, Lively, Kilpatrick, & Moss, 2007; Mazzenga, Gianesella, Brscic, & Cozzi, 2009). Maize silage lowers the cost of rations by increasing forage consumption without decreasing energy concentration, while the risk of low roughage supply due to improper processing in the mixer wagon can easily be avoided by adding small amounts of grass hay or cereal straw to the diet (Cozzi, Mazzenga, Contiero, & Burato, 2008), thus providing a basic level of physically effective fibre to reduce the risk of subclinical ruminal acidosis and enhance the rumen function. On the other hand, some authors have observed no changes or improvements in growth performance and meat quality in animals finished with maize silage based rations compared with other feeding systems (Casasús et al., 2012; Keady et al., 2007; Moloney, Mooney, Kerry, Stanton, & O'Kiely, 2013). Moreover, some authors have reported a lower $n-6/n-3$ fatty acid ratio in beef from cattle finished on TMR that included maize silage compared with those fed on high concentrate rations (Cooke et al., 2004; Martínez Marín, Peña Blanco, Avilés Ramírez, Pérez Alba, & Polvillo Polo, 2013). However, there is still very little

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published research on the effects of maize silage-based TMR on carcass (Bidner, Schupp, Montgomery, & Carpenter, 1981) and meat quality (Bowling, Smith, Carpenter, Dutson, & Oliver, 1977) traits, and on the appearance and sensory characteristics of beef in different breeds (Keady et al., 2007).

The aim of this study was to compare the effects of two fattening feeding systems – firstly. high concentrate plus cereal straw and secondly, systems based on maize silage – on growth and carcass and meat quality characteristics in Limousine and Retinta bulls kept in feedlot conditions.

2. Material and methods

2.1. Experimental management

All the experimental procedures used in this study were in compliance with the Spanish guidelines for the care and use of animals in research (BOE, 2005), and the animals were considered a representative sample of sex and ages commonly slaughtered in the area.

Fifty Limousine (LI, initial age 219 days and live weight 249 kg) and fifty Retinta (RE, initial age 220 days and live weight 254 kg) were purchased from several commercial farms specializing in the production of purebred breeding animals, and then transferred to a commercial feedlot. The calves were reared in a semi-extensive regime together with their mothers on pasture and suckled and grazed until weaning (at approximately 8 months of age). In the feedlot, they were assigned in groups of 12–13 to 1 of 8 pens (four per breed × 2 diets) to ensure uniformity in age and body weight among pens. The pens included an area with a roof, concrete floor and straw (bedded area) in front of the feed bunk (which allowed all animals to eat at the same time) and an external area of soil away from the feed bunk. The bulls were provided with a continuous supply of fresh water, and they had permanent access to mineral salt blocks. After a 14-day adaptation period, the two adjacent feedlot pens within each breed were randomly assigned to one of two feeding treatments. The treatments were a traditional diet comprised of a concentrate mix and wheat straw offered separately (T), or a total mixed ration made of the same concentrate mix partially replaced with maize silage, and wheat straw (TMR) (Table 1). All feeds were delivered twice daily, at 8.00 am and 2.00 pm, and were provided as ad libitum intake, which ensured a 5 to 10% daily refusal. In the T groups, the straw was given in a separate area of the trough. Feed offered and leftovers were recorded daily for each group over the length of the experiment.

2.2. Growth performance

Individual body weight, 2 h before morning feed delivery, and feed intake per breed and treatment were recorded at the beginning of the trial, every 30 ± 5 days and before slaughter. The average daily gain was determined by dividing body weight gain by the number of days on feed. Total feed intake was calculated as the difference between given and refused feed in the experimental period. Average daily feed intake was calculated by dividing the total feed intake by the days of trial and the number of animals in each group, and this figure was expressed as a DM basis. Dry matter intake (DMI) was calculated in kilogrammes per day.

Table 1
Ingredients and nutrition composition of diets fed in the treatments (T = traditional feeding system, TMR = total mixed ration feeding system).

Ingredients, dry matter basis	T	TMR
Concentrate mix[a] (%)	90	58
Wheat straw (%)	10	11
Maize silage (%)	–	31
Composition[b], dry matter basis		
Crude protein (%)	13.2	11.1
Crude fat (%)	5.9	5.2
Ash (%)	6.1	5.8
Neutral detergent fibre (%)	23.8	32.7
Metabolisable energy (MJ/kg)	12.3	11.5

[a] Ingredients (% as fed): maize, 35.0, barley, 32.4; corn gluten feed, 17.0; soybean meal 44, 8.7; minerals and vitamins, 3.6; palm oil, 3.3.
[b] Calculated from FEDNA (2010).

2.3. Ultrasound equipment and measurements

Ultrasound measurements were taken every 30 ± 5 days on feeding (approximately 250 days old) and at the end of the fattening phase (within seven days prior to slaughter), and subsequently interpreted by a single technician to avoid inter-operator variance using an Aquila Pro (Esaote PieMedical) diagnostic real-time ultrasound with an 18 cm 3.5 MHz linear array transducer (ASP-18). To obtain the ultrasound images, the cattle were immobilized and held by the head in a squeeze chute and the image sites were chosen by physical palpation to accurately ascertain the scanning sites. The animals were held manually to avoid causing them excessive stress, and they were only scanned in a relaxed posture, thus permitting accurate measurements. Ultrasound images were measured over the skin without shearing or clipping of hair. Vegetable oil tempered at 25–30 °C was used as a coupling agent to achieve a better acoustic contact surface between the probe and the skin. Ultrasound measurements were conducted concurrently with the measurement of individual body weights. The measurements taken on the live animals were, as described by Wall, Rouse, Wilson, Tait, and Busby (2004) and Bergen, Miller, Mandell, and Robertson (2005): *longissimus thoracis* (LT) muscle area at a point between the 12th and 13th ribs (UREA), subcutaneous fat thickness (UFT) between the 12th and 13th ribs over the LT at a point 3/4 the length ventrally of the ribeye, intramuscular fat content or marbling (UIMF), measured in the longitudinal image of the LT directly over the 12th and 13th ribs, as well as rump fat thickness (URFT) at the junction of the *biceps femoris* and *gluteus medius* (GM) muscles between the ischium and ilium (Greiner, Rouse, Wilson, Cundiff, & Wheeler, 2003). The GM depth (UGMD) was measured immediately below the juncture of the GM and the *biceps femoris* muscle between the hook and pin bones with the transducer placed approximately 2.5 cm dorsal to the hook bone and parallel to the backbone. Each animal was scanned once for UREA, UFT, URFT and UGMD, and four independent scans were collected for UIMF. To ensure the independence of the images, the probe was removed between consecutive images and hide re-oiled before the probe was placed in the next position. The UIMF, URFT and UGMD images were collected without a stand-off pad. In addition, the ultrasound measurements were expressed as values per 100 kg live weight (WREA, WFT, WRFT, WGMD, and WIMF) using the formula presented by Turner, Pelton, and Cross (1990):

$$\text{WREA} = (\text{UREA} * 100/\text{Slaughter weight}).$$

2.4. Slaughtering groups and procedures

When the bulls reached the commercial weight (540–580 kg for LI; 500–525 kg for RE), they were weighed (LWE, live weight at end of the fattening period), transported to an officially approved abattoir (approximately 30 min and 20 km from feedlot) the afternoon before the slaughter, and placed in collective pens with access to water. Travel conditions and handling were the same for all the young bulls. At 8–10 am, approximately 12 h after arrival, the animals were weighed (SLW, live weight at slaughter), slaughtered by captive-bolt pistol and dressed according to European regulations for the Protection of Animals at Slaughter or Killing (93/119/EC, D., 1993). Electrical stimulation was not used in the processing operation. The welfare of the animals was taken into account when handling them. In order to ensure that the slaughtering groups were balanced, each day a total of 32–34 animals from each feedlot pen, breed and feeding system were slaughtered.