Crossbred young bulls and heifers sired by double-muscled Piemontese or Belgian Blue bulls exhibit different effects of sexual dimorphism on fattening performance and muscularity but not on meat quality traits

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1. Introduction

Crossbreeding dairy cows with beef bulls is an effective way to increase beef production, meat quality and farm income from dairy herds (Clarke et al., 2009) and to improve the ecological footprint of both milk and beef production when they are considered as a single system (Puillet, Agabriel, Peyraud, & Faverdin, 2014). The recent availability and wider use of X-sorted semen in dairy herds can reduce the number of cows needed for replacement production while increasing the number of females available for insemination with beef semen. Several studies in the past have focussed on crossing beef and dairy cattle, and the differences between dairy and beef purebred cattle and beef crossbreds in both performance and economic traits are widening with time (Gallo, De Marchi, & Bittante, 2014) due to divergent genetic improvements to these different groups of cattle breeds. Beef crossbred calves, both males and females, have a much greater economic value than their purebred counterparts, especially if they are sired by double-muscled (DBM) bulls (Dal Zotto et al., 2009; Mc Hugh, Fahey, Evans, & Berry, 2010).

Belgian Blue (BB) and Piemontese (PIEM) are two DBM beef breeds with different genetic backgrounds and selection objectives. Muscular hypertrophy (mh) is a result of many different mutations of myostatin (GDF8, gene; Dunner et al., 2003), which have different effects on animal phenotype (O'Rourke, Greenwood, Arthur, & Goddard, 2013). PIEM cattle are homozygous for a missense mutation (C313Y, a G-A transition in the coding region), which changes a tyrosine into a cysteine, thereby inactivating the myostatin produced, while BB cattle are homozygous for an 11-bp deletion in exon 3 (821del11) that leads to a frameshift that eliminates the hormone’s entire active region (Kambadur, Sharma, Smith, & Bass, 1997; McPherron & Lee, 1997).

Belgian Blue breeding focusses on beef traits through performance testing of artificial insemination (AI) young bulls (Coopman, Krafft, Dewulf, Van Zeveren, & Gengler, 2007), while PIEM breeding couples performance testing with progeny testing of bulls for direct and maternal calving ease, these last two traits together representing 60% of the selection index weight (Albera, Mantovani, Bittante, Groen, & Carnier, 2001; Kizilkaya, Carnier, Albera, & Templeman, 2003). These two schemes produce purebred cows with different calving performances: caesarean section is routine with BB cows (Kolkman, Carnier, & Bittante, 2001; Kizilkaya, Carnier, Albera, & Templeman, 2003). These two schemes produce purebred cows with different calving performances: caesarean section is routine with BB cows (Kolkman et al., 2007), but accounts for < 10% of calvings of PIEM heifers and 3% of calvings of PIEM cows (Albera, 2015). These different selection objectives, coupled with genetic correlations between traits, may have differently affected the genetic response of the two breeds, particularly the females. However, little or no information is available on growth improvements to these different genetic backgrounds and selection objectives. Muscular hypertrophy (mh) is a result of many different mutations of myostatin (GDF8, gene; Dunner et al., 2003), which have different effects on animal phenotype (O’Rourke, Greenwood, Arthur, & Goddard, 2013). PIEM cattle are homozygous for a missense mutation (C313Y, a G-A transition in the coding region), which changes a tyrosine into a cysteine, thereby inactivating the myostatin produced, while BB cattle are homozygous for an 11-bp deletion in exon 3 (821del11) that leads to a frameshift that eliminates the hormone’s entire active region (Kambadur, Sharma, Smith, & Bass, 1997; McPherron & Lee, 1997).

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performance, and carcass and meat quality traits of crossbred heifers and bulls from recently selected DBM sires, especially when fed on high-energy, low-CP diets (Schiavon, Tagliapietra, Dalla Montà, Cecchinato, & Bittante, 2012).

The aim of this study, therefore, was to compare the growth performance, DM intake, feed efficiency, and carcass and meat quality traits of crossbred young bulls and heifers sired by recently tested AI BB and PIEM bulls mated to dairy cows, and to test for possible differences in sexual dimorphism between the two DBM paternal breeds.

2. Material and methods

2.1. Animals

The project was approved by the University of Padua’s Ethical Committee for the Care and Use of Experimental Animals. The number of animals used in the trial was calculated to be the minimum required to detect significant differences between groups for a growth rate of 0.10 kg/day with a residual standard deviation of 0.10 kg/day and a power of 0.90 (Lerman, 1996).

Brown Swiss dairy cows registered in the Herd Book and reared in the Italian Alpine area (Bazzoli, De Marchi, Cecchinato, Berry, & Bittante, 2014; Cecchinato, Albera, Cipolat-Gotet, Ferragina, & Bittante, 2015; Gallo, Sturaro, & Bittante, 2017) were artificially inseminated with semen from 8 DBM Piemontese and 8 DBM Belgian Blue sires. The semen of the Belgian Blue bulls, all registered in the Belgian Herd Book with semen from 8 DBM Piemontese and 8 DBM Belgian Blue sires. The semen of the Belgian Blue bulls, all registered in the Belgian Herd Book of this breed and imported into Italy, was provided by Alpenseme (Toss di Ton, TN, Italy). These bulls were tested on local dairy cows for high-energy, low-CP diets (Schiavon et al., 2013).

The semen of the Piemontese bulls, all registered in the Italian Herd Book of this breed, was provided by the Italian National Association of Piemontese Cattle Breeders (ANA-BoRaPi, Carrù, CN, Italy). The bulls were selected on the basis of their breeding values for direct effects on the calving ease of cows and the growth rate and muscularity of young bulls in the purebred Piemontese population.

Crossbred calves were taken from the dairy herds at about three weeks of age and were weaned in the same farm under the same ad libitum feeding regime and housing conditions. Thirty-two crossbred bull calves and 30 crossbred heifer calves (212 ± 34 kg BW) selected on the basis of their sire, age and BW, were then moved to the “Lucio Toniolo” experimental farm of the University of Padua for the purposes of the current experiment.

On arrival, the calves were housed in 14 pens with fully-slatted floors, four bull calves or five heifer calves per pen. The first and last pens, both containing male calves, were considered border pens and were excluded from the data analyses, leaving 6 pens of each paternal breed for analysis, 3 containing males, and 3 containing females.

2.2. Feeding

The calves were fed a transition diet for 26 day during which meadow hay was progressively replaced with the experimental diet. All calves were fed the same total mixed ration for the entire duration of the trial until slaughter. The composition of the diet was constant and comprised on a DM basis: 40.0% ground corn grain, 27.6% corn silage, 11.3% dried sugar beet pulp, 7.0% wheat bran, 6.6% chopped wheat straw, 3.3% soybean meal, 2.6% vitamin and mineral premix, 0.9% calcium soap and 0.7% hydrogenated soybean oil. This low-protein diet was similar to the one used with satisfactory results in a previous trial conducted on Belgian Blue crossbred young bulls and heifers to test the effects of suboptimal protein diets and phase feeding on the performance, and carcass and meat traits of calves (Schiavon et al., 2013).

For each paternal breed and gender, one pen was given the ration without any supplement, while the other two pens were given, respectively, 8 g/day or 80 g/day per head of a conjugated linoleic acid (CLA) supplement containing 8.9% 18:2c9,11 and 8.6% 18:2t10,c12 CLA isomers. The TMR diet contained 11.0% CP, 39.5% starch, 29.7% NDF, 14.2% ADF, 4.2% lipids and 11.96 MJ/kg DM of metabolizable energy. Details of the diets and feeding practices are described in Schiavon et al. (2013). The feed was prepared daily using a mixer-wagon fitted with a monthly-calibrated computer-assisted weighing scale. As the animals were not fed individually, DMI and feed efficiency were computed on a pen basis.

2.3. Weighing and scoring

The calves were individually weighed once a month before morning feeding and scored by a skilled operator licensed for carcass evaluation according to the SEUROP grading system (Anonymous, 1991). The operator evaluated the body conformation and condition of each calf in vivo and scored them in terms of expected carcass conformation according to the 6-point scale of the SEUROP grid, which ranges from S (all muscle profiles extremely convex; exceptional muscle development) to P (all muscle profiles concave to very concave; very poor muscle development), based on the profiles of the shoulders, loins, rump, thighs and buttocks. Each score was subdivided into three sub-scores (Schiavon, Tagliapietra, Dal Maso, Bailoni, & Bittante, 2010). Fat covering was also scored linearly, based on a combination of visual appraisal and palpation focussing on the presence and thickness of subcutaneous fat depots at specific points of the body, from 1 (very lean: no palpable fat detectable, the ribs, bone structure and head of the tail are very prominent) to 5 (very fat: thick fat depots are present over the shoulders, ribs and around the head of the tail, bone structure is no longer visible). Health status was monitored by a technician daily and by a veterinary three times per week.

2.4. Slaughter

At the end of the fattening trial, the calves were deprived of feed for one day and then slaughtered. In accordance with the local meat market, heifers were slaughtered when they had reached an average in vivo fatness score of around 2.5 (after 269 day on trial), and young bulls when their average score was around 2.0 (after 324 day on trial).

Carcasses were individually weighed and measured according to De Boer, Dumont, Pomeroy, and Weniger (1974), and scored for conformation (6 classes with 18 subclasses, as described above for in vivo scoring) and fat covering (5 classes) according to the SEUROP system. Carcass yield was computed as the ratio between the carcass weight at 24 h from slaughter (sum of the left and right halves) and the body weight recorded the day before slaughter.

Twenty-four hours after slaughter the left half-carcasses were sectioned into the main carcass regions (hind leg, loin, brisket-flank and chuck-rib), each of which was processed to obtain the commercial cuts classified as 1st and 2nd quality meat cuts, fat trimmings and bones. These were measured as percentages of the carcass weight.

2.5. Meat quality measurements

When the carcass halves were sectioned the whole cut of the 5th rib was collected and weighed and was separated into lean, fat and bones, each of which was weighed. The Longissimus thoracis muscle was then separated and meat samples of about 1 kg each were taken from the Biceps femoris muscle (silverside, 1st quality cut) and the Semitendinosus muscle (eye of round, 2nd quality cut) during commercial processing of the main carcass regions (UNECE, 2004). These three muscle samples were analysed for physical and chemical parameters. The cuts were vacuum packed and transferred to the laboratory where they were aged at 4°C in a chilling room for 10 days. After ageing, drip losses were measured as the ratio of the difference between the wet and dried empty pack to the weight of the sample. Muscle pH was measured using
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