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Carcass fat partitioning and meat quality of Alentejana and Barrosã young bulls fed high or low maize silage diets

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ABSTRACT

This study assessed the effect of breed and diet on carcass composition, particularly fat partitioning, and meat quality in young bulls. An experiment with forty young bulls from two phylogenetically distant Portuguese bovine breeds, Alentejana and Barrosã, fed two diets with different maize silage to concentrate ratios, but isoenergetic and isonitrogenous, was carried out until the animals reached 18 months of age. In the *longissimus lumborum* muscle, Barrosã bulls fed the low silage diet had the highest intramuscular fat (IMF) content. Bulls fed the low silage diet also had the highest IMF content in the *semitendinosus* muscle. Diet determined the proportions of total visceral fat and individual fat depots. Under these experimental conditions, it was shown that the genetic background is a major determinant of carcass composition and meat quality, and that the dietary differences studied had limited effect on carcass composition.

1. Introduction

Carcass composition reflects the differential growth pattern of the major component tissues and determines the commercial value of carcasses in meat-producing animals (Berg, Andersen, & Liboriussen, 1978). In fact, the weight, proportion and carcass distribution of fat, bone and muscle have a high economic impact on beef cattle production (Kempster, 1986). In addition, intramuscular fat (IMF) has become a key factor of carcass quality for the beef industry, which, in order to comply with the European market requirements, has shifted towards the production of lean beef.

A large amount of subcutaneous and visceral adipose tissues, regarded as “waste fat”, is deposited in parallel to IMF, or “taste fat”, during the maturing phase of cattle (Fiems et al., 2000; Gotoh et al., 2009). The current beef production is focused on reducing the deposition of “waste fat”, while maintaining high meat sensory and nutritional quality standards. Genetic and environmental factors, particularly nutrition, determine fat partitioning among the subcutaneous, intermuscular and visceral depots (Kempster, 1986). Therefore, it is important to quantify each fat depot proportion in the carcass. This is particularly relevant for IMF due to its contribution to eating quality, which should not be compromised (Savell & Cross, 1988). Thus, the development of strategies to manipulate adipose tissue deposition in farm animals has been one of the major breeding goals for some years (De Smet, Raes, & Demeyer, 2004). Nonetheless, the relationship between the deposition of IMF and “waste fats”, as well as the patterns of their changes during growth, remain rather unclear (Aldai, Nájera, Dugan, Celaya, & Osoro, 2007; Gotoh et al., 2009).

A wide range of factors influence meat quality of ruminant animals. Insights on the relationship among productive traits, carcass composition and meat quality would contribute to improve beef production through genetic selection, as well as to understand the final product acceptability (Piedrafita et al., 2003). Much has been hypothesized about the role of diet on animal performance and meat quality, although the results are often contradictory. While some authors reported negative effects of silage-based diets on productive and carcass traits compared to concentrate-based diets (Priolo, Micol, & Agabriel, 2001), others found slight (Blanco et al., 2010) or no differences at all (French et al., 2001) between feeding strategies. Moreover, breed has been referred to as one of the main factors influencing feed intake, growth rate and, consequently, carcass composition (Albertí et al., 1998; Clarke et al., 2009) and beef quality (Bartoň, Bureš, & Kudrna, 2010; Bressan et al., 2011; Chambaz, Scheeder, Kreuzer, & Dufey, 2003). However, the effect of genotype on meat quality has yielded conflicting results because some studies failed to demonstrate differences in meat between breeds (Muir, Wallace, Dobbie, & Bown, 2000; Vieira, Cerdeño, Serrano, Lavín, & Mantecón, 2007). These apparently contradictory results should be interpreted with caution

Abbreviations: ADG, average daily gain; ADF, acid detergent fibre; DM, dry matter; DMI, dry matter intake; HCW, hot carcass weight; HS, high silage; InterMF, intermuscular fat; IMF, intramuscular fat; KKCF, kidney knob and channel fat; ML, muscle in the leg joint; NDF, neutral detergent fibre; LL, *longissimus lumborum*; LS, low silage; LT, *longissimus thoracis*; SCFL, subcutaneous fat in the leg joint; ST, *semitendinosus*; SW, slaughter weight; WBSF, Warner–Bratzler shear force.

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because some of the studies compared breeds selected for meat production and/or with similar genetic background, whereas others used breeds which differed in purpose (milk, meat or both), growth rate and mature weight.

Previous studies from our research group found differences in lipid content, composition and nutritional quality between beef obtained from Alentejana and Barrosã breeds produced with distinct management (Alfaia et al., 2007, 2009; Costa et al., 2010), with consistently higher IMF contents for the Barrosã breed. However, it must be taken into account that in these works the animals were reared according to their local production systems. On the other hand, published information regarding the productive and carcass traits of these two phylogenetically distant Portuguese bovine breeds (Beja-Pereira et al., 2003), with different frame size and precociousness, remains scarce. Works by Silva, Lemos, Monteiro, and Portugal (1998), and Simões and Mira (2002) compared Alentejana and Barrosã breeds reared under experimental intensive conditions. Silva et al. (1998) found that as Alentejana young bulls approach maturity the deposition of fat in internal depots increases, whereas in the Barrosã breed fat was preferentially deposited in subcutaneous and intermuscular depots. In contrast, Simões and Mira (2002) observed that these breeds tend to show similar fat partitioning, when compared at the same total carcass fat.

To our knowledge, there are no previous studies comparing the effect of different dietary maize silage/concentrate ratios on Alentejana and Barrosã carcass and meat traits, under controlled experimental conditions. We hypothesized that the comparison of a large-framed breed (Alentejana) with a small-framed breed (Barrosã), at the same age, would reveal different carcass composition and fat partitioning. In addition, the use of isoenergetic and isonitrogenous diets with different maize silage/concentrate ratios (30/70% vs. 70/30%) would add depth to the study of the carcass fat distribution, thus contributing to the knowledge on the features of adipose tissue deposition. Therefore, this study aimed to assess the effect of breed and diet on the carcass composition, particularly fat partitioning, and meat quality of the two Portuguese autochthonous breeds, Alentejana and Barrosã, fed high or low silage diets.

2. Material and methods

This study was conducted under the guidelines for the care and use of experimental animals of Unidade de Produção Animal, L-INIA, INRB (Fonte Boa, Vale de Santarém, Portugal) over a 11 month period.

2.1. Animals, feeding and performance

Twenty purebred young bulls from Alentejana (large-framed) and twenty Barrosã (small-framed) breeds were assigned to either high or low silage diets (four experimental groups of 10 animals each, $n=10$). Diets were approximately isoenergetic and isonitrogenous, and composed of 30/70% (low silage, LS) and 70/30% (high silage, HS) of maize silage and concentrate, respectively, on a dry matter (DM) basis. The ingredients and chemical composition of diets are described in Table 1.

Samples of the diets were collected three times during the course of the experimental trial ($n=3$). Feed samples were analysed for dry matter (DM) by drying a sample at 100 °C to a constant weight. Nitrogen content was determined by Kjeldahl (AOAC, 1990) and crude protein was calculated as 6.25 × N. Neutral detergent fibre (NDF) and acid detergent fibre (ADF) were determined by the procedure of Van Soest, Robertson, and Lewis (1991). The samples were extracted with petroleum ether, using an automatic Soxhlet extractor (Gerhardt Analytical Systems, Königswinter, Germany), to determine crude fat. Determination of ash and starch contents was carried out according to the procedures described by the AOAC (1990) and Clegg (1956), respectively. Gross energy in the feed was determined by adiabatic bomb calorimetry (Parr 1261, Parr Instrument Company, Moline, IL, USA).

Table 1
Ingredients and chemical composition of the high (HS) and low silage (LS) diets ($n=3$).

	HS	LS	Concentrate feed
Ingredients (%)[a]			
Maize silage	70	30	
Concentrate feed	30	70	
Maize			32.5
Wheat			20.1
Barley			19.7
Soybean meal			13.5
Sunflower meal			8.0
Hydrogenated fat			1.3
Calcium carbonate			2.0
Sodium bicarbonate			1.0
Calcium phosphate			0.9
Salt			0.8
Vitamin premix			0.2
Chemical composition (unit/kg DM)			
Crude protein (g)	142	125	
Crude fat (g)	28.7	31.7	
Crude fibre (g)	198	150	
NDF (g) [b]	403	321	
ADF (g)[c]	249	186	
Ash (g)	55.3	61.7	
Starch (g)	285	376	
Gross energy (MJ)	19.1	18.6	

[a] Fresh weight basis.
[b] NDF = neutral detergent fibre.
[c] ADF = acid detergent fibre.

Bulls were housed in eight pens, two pens *per* breed and diet. Replicate pens within a treatment were positioned in different parts of the facility. The initial age was 11 ± 1.0 months and 9 ± 0.3 months for Alentejana and Barrosã young bulls, respectively. At the start of experiment, the average live weight was 266 ± 45.8 kg and 213 ± 16.3 kg for Alentejana and Barrosã young bulls, respectively. The experiment lasted from January to November 2009. One Alentejana bull from the HS dietary group was removed from the study due to a limp.

A pre-trial period of three weeks was followed by the finishing period that lasted until each animal reached 18 months of age. Bulls had free access to water and were fed *ad libitum*, twice daily, with the experimental diets. During the experiment, animals were individually weighed every 14 days, before feeding. Feed offered and refusals were recorded daily to calculate feed intake for each pen. The ratio between weight gain and DM intake was used to calculate the feed efficiency *per* pen. The DM intake and feed efficiency were calculated for the period during which each pen was complete (five animals).

2.2. Slaughter and sampling procedures

2.2.1. Carcass measurements

Each animal was slaughtered when reached 18 months of age, at the INRB Experimental Abattoir, by exsanguination after stunning with a cartridge-fired captive bolt stunner. Cod, kidney knob and channel fat (KKCF), mesenteric and omental fat depots were excised and weighted. The carcasses were split along the column, half carcass weights were recorded and dressing percentage was calculated from the ratio between slaughter weight (SW) and hot carcass weight (HCW). Muscle pH and temperature were measured at 45 min, 3 and 24 h after slaughter using a pH meter equipped with a penetrating electrode (Hanna Instruments, HI8424, Smithfield, RI, USA), at the *longissimus thoracis* (LT) muscle between the 12th and 13th ribs. Carcass conformation and carcass fatness scores were determined according to the EUROP classification (Commission of the European Communities, 1982) on a continuous 15 point scale, as described by Hickey, Keane, Kenny, Cromie, and Veerkamp (2007).