Available online at www.sciencedirect.com
ScienceDirect
Food Chemistry 104 (2007) 500–509
Food Chemistry
www.elsevier.com/locate/foodchem

Fatty acid composition and adipogenic enzyme activity of muscle and adipose tissue, as affected by Iberian × Duroc pig genotype

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Received 10 May 2006; received in revised form 19 July 2006; accepted 27 November 2006

Abstract

The adipogenic potential of subcutaneous fat (SCF) and muscles *Longissimus dorsi* (LD) and *Biceps femoris* (BF) were evaluated in three different Iberian × Duroc pig genotypes: GEN1: ♂ Iberian × ♀ Duroc1; GEN2: ♂ Duroc1 × ♀ Iberian; GEN3: ♂ Duroc2 × ♀ Iberian. Reciprocal crosses (GEN1 vs. GEN2) showed similar traits, while the genotype of the Duroc sire line (GEN2 vs. GEN3) significantly influenced the adipogenic character. GEN3 had lower fat depths and a more unsaturated SCF than GEN2. The intramuscular fat (IMF) content of the LD was higher in GEN2 than in GEN3, while BF showed a similar trend. The fatty acid compositions of IMF and neutral lipid fraction (NL) in LD and BF were more unsaturated in GEN3 than in GEN2. Glucose-6-phosphate dehydrogenase (G6PDH) and malic enzyme (ME) activities in SCF and in both muscles analysed were higher in GEN2 than in GEN3. The higher fat depths and IMF of GEN1 and GEN2 correspond to higher G6PDH and ME activities, which indicated that the lipid synthesis and deposition in muscles and in SCF were higher in GEN1 and GEN2 than in GEN3; these differences were associated with the Duroc sire line. Therefore, the use of Duroc selected genotypes reduced the adipogenic character of Iberian × Duroc crosses, which could have important repercussions on the quality of meat and dry-cured products.

Keywords: Lipogenic enzymes; Glucose-6-phosphate dehydrogenase; Malic enzyme; Intramuscular fat; Fatty acid; Duroc line; Iberian pig

1. Introduction

Nowadays, the Iberian pig breed has increased its popularity, because the meat and meat products traditionally obtained from this breed are highly appreciated by consumers for their excellent quality. Different studies have shown that meat from Iberian pigs has better quality (colour, fatty acid profile and sensory characteristics) than that obtained from industrial genotype pigs (Estévez, Morcuende, & Cava, 2003). As a result, the population of Iberian pigs has increased in the last years, which has led to an improvement of the feeding and production systems. As Iberian is a rustic breed with a slow growth rate and low prolificity (Dobao, García, De Pedro, Rodrigáñez, & Silió, 1986), to improve productive parameters, it is often crossed with Duroc at 50%. This increases the prolificity by 2–3 piglets, improves the growth rate, the feed efficiency and the lean content (Dobao et al., 1986) without a significant reduction in the quality of the meat and meat products (López-Bote, 1998). These crosses are so frequent that it is estimated that less than 25% of the animals slaughtered as "Iberian", are pure Iberian (Sierra Alfranca, 1992).

Despite the fact that consumption of fresh Iberian pig meat has increased in recent years, the production of Iberian pigs is mainly focused on obtaining raw meat to manufacture dry-cured meat products. For this purpose, the industry requires fat carcasses from castrated heavy pigs slaughtered at around 160 kg live weight. A high intramuscular fat content is important to aid a slow dehydratation during the curing process (Gandemer, 2002). Fat content and fatty acid composition are determinant factors for the quality of Iberian dry-cured meat products (Ruíz-Car-

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0308-8146/$ - see front matter © 2006 Published by Elsevier Ltd.
doi:10.1016/j.foodchem.2006.11.059

rascal, Ventanas, Cava, Andrés, & García, 2000). Cava, Ruíz, Ventanas, and Antequera (1999) observed a marked influence of intramuscular fatty acid composition of fresh meat on the flavour of Iberian dry-cured meat products. Also intramuscular fat with high levels of linoleic acid can affect water migration, as very unsaturated fat retards water migration within the meat and, hence lengthens the drying process (Girard, Bucharles, Berdague, & Ramihone, 1989; López-Bote, 1998).

In Spain, a specific law for Iberian products was passed in 2001, to regulate the market (Quality regulation of Iberian products – Norma de Calidad sobre productos del cerdo Ibérico, B.O.E., 2001). One of the most important aspects that this law regulates is the genotype used for the manufacture of dry-cured meat products (hams, forelegs and loins) labelled as "Iberian". The law allows the use of pure Iberian pigs as well as Iberian × Duroc crosses, but the mother of the crossbreed must be Iberian, to preserve the genetic patrimony and biodiversity of the Iberian breed. Selection of the Duroc paternal line is crucial; because the Duroc breed is so widespread, it cannot be considered as an homogeneous breed, since important differences in its production and carcass parameters and in the quality of its meat and meat products have been reported (Cilla et al., 2006; Lonergan, Huff-Lonergan, Rowe, Kuhlers, & Jungst, 2001). However, Morcuende, Estévez, Ramírez, de Alba, and Cava (2003) did not find important differences between Iberian × Duroc reciprocal crosses.

In contrast to other species, in which the lipogenesis of fatty acids takes place in the liver, in pigs it mainly takes place *in situ*, in the adipose tissues (O'Hea & Leveille, 1969). The synthesis of triglycerides of the adipose tissue comes from fatty acids derived from existing triglycerides, as a result of adipose lipoprotein lipase activity (Steffen, Brown, & Mersmann, 1978) and from fatty acid synthesised *de novo* (mainly from dietary starch) in that tissue (O'Hea & Leveille, 1969). The NADPH for synthesis of *de novo* fatty acids is supplied by malic enzyme (ME) and by glucose-6-phosphate dehydrogenase (G6PDH) (Young, Sharago, & Lardy, 1964; Wise & Ball, 1964). G6PDH takes part in the pentose phosphate pathway, while ME transforms malic acid to pyruvic acid. Endogenous synthesis of fatty acids comes from acetyl CoA and malonyl CoA molecules, to produce palmitic acid (C16:0), from which can be synthesised stearic acid (C18:0) by elongation. These fatty acids are unsaturated, by means of desaturase enzymes, to palmitoleic acid (C16:1 $n-7$) and oleic acid (C18:1 $n-9$). Differences in the lipogenic enzyme activity are mostly caused by animal genotype and to a lesser extent by diet (Morales, Pérez, Baucells, Mourot, & Gasa, 2002). In this respect, higher lipogenic activity has been found in rustic breeds with high intramuscular fat levels than in industrial ones (Mourot & Kouba, 1998; Morales et al., 2002). Moreover, we have found important differences among genotypes in a previous study (Ramírez & Cava, 2006) on meat quality. The objectives of this study were to assess the consequences of the use of different Duroc paternal lines in Iberian × Duroc crosses, as well as the differences between Iberian × Duroc reciprocal crosses on the adipogenic character and fatty acid composition of subcutaneous and intramuscular fat.

2. Materials and methods

2.1. Animals

In order to develop this work, 3 groups of 10 pigs were studied (five males and five females) from different genotypes: GEN1: ♂ Iberian × ♀ Duroc 1; GEN2: ♂ Duroc 1 × ♀ Iberian; GEN3: ♂ Duroc 2 × ♀ Iberian. GEN1 and GEN2 are reciprocal crosses, while the difference between GEN2 and GEN3 is the Duroc sire line. The genotype Duroc 1 (DU1) were pigs selected for the production of dry-cured meat products (hams, loins and forelegs), with a high level of fattening. The genotype Duroc 2 (DU2) were animals selected for meat production, with high percentages of muscle and with low carcass fattening. Pigs were raised all together in an intensive system and were fed ad libitum with the concentrate feeds shown in Table 1. Pigs were randomly slaughtered after 316 days of rearing, at 150–165 kg live weight.

2.2. Back fat and ham thickness

The backfat thickness (BFT) and ham fat thickness (HFT) were measured at the 5th rib and in the *Biceps femoris* muscle in the carcass and ham, respectively. *Biceps femoris* (BF) and *Longissimus dorsi* (LD) muscles were removed from the carcasses and stored at −80 °C until analysis. For the analyses, the central part of the muscles was taken. Subcutaneous fat (SCF) was taken from the inner layer of the backfat at the 7th and 8th thoracic rib and also was stored at −80 °C until analysis.

Table 1
Proximate composition (%) and fatty acid composition (% total fatty acids) of the pig diets

	Mixed Diet I from 60 to 100 kg l.w.	Mixed Diet II from 100 to 165 kg l.w.
Proximate composition (%)		
Crude protein	16.0	13.5
Crude fat	3.3	5.0
Crude fibre	4.8	3.7
Ash	6.9	6.2
Lysine	0.9	0.5
Metabolisable energy (kcal/kg)	3072	3184
Fatty acid composition (% total fatty acids)		
C14:0	0.1	0.1
C16:0	14.6	21.0
C18:0	4.4	5.6
C18:1 $n-9$	23.3	31.3
C18:2 $n-6$	34.7	35.1
C18:3 $n-6$	2.0	2.3