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Extensive feeding versus oleic acid and tocopherol enriched mixed diets for the production of Iberian dry-cured hams: Effect on chemical composition, oxidative status and sensory traits

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Abstract

The present study aimed to analyse the chemical composition and oxidative status of Iberian dry-cured hams from pigs fed different finishing diets: extensive feeding on acorns and pasture in a "Montanera" traditional system (MON), fed in confinement with a mixed diet containing high-oleic sunflower oil (115 g/kg of diet) and supplemented with 250 mg/kg α-tocopherol (HOVE), and fed in confinement control mixed diet (CON) without added tocopherol and oleic acid fat. Muscles from MON dry-cured hams contained significantly ($p < 0.05$) higher amounts of intramuscular fat (IMF) than those from HOVE and CON hams. The feeding background affected the tocopherol levels in dry-cured hams as those from MON and HOVE pigs had significantly higher levels of α-tocopherol than those from CON pigs whereas the extensive feeding provided muscles from MON pigs with significantly higher levels of γ-tocopherol than the experimental diets did to CON and HOVE pigs. The HOVE diet significantly increased the levels of oleic acid in Iberian dry-cured hams with these levels being similar to the oleic acid levels found in MON hams and significantly higher than those in CON hams. Compared to dry-cured hams from CON pigs, those from MON and HOVE pigs exhibited a higher oxidative stability as a likely result of a most favourable fatty acid composition and the presence of higher tocopherol levels. The principal component analysis (PCA) successfully discriminated between dry-cured hams from pigs fed different finishing diets.

Keywords: Iberian ham; Extensive feeding; Tocopherol; Oleic acid; Intramuscular fat; Oxidation; Sensory features

1. Introduction

The Iberian ham is a Spanish high-priced dry-cured product obtained from Iberian pigs and subjected to a long ripening process (above 30 months). Apart from the traditional ripening procedure, the extraordinary sensory features of this product are mainly due to the genetic background of the animals and the traditional outdoor feeding for Iberian pigs (Ventanas, Ventanas, Ruiz, & Estévez, 2005). The extensive feeding involves the intake of natural resources from ever-green oak forests, mainly acorns and pasture, during autumn months until slaughter in winter time (López-Bote, 1998). This feeding strategy affects the chemical composition and oxidative stability of Iberian pigs' tissues and the sensory quality of the Iberian dry-cured products (Ventanas et al., 2005). Acorns provide high-levels of MUFA (mainly oleic acid) and γ-tocopherol to Iberian pigs whereas the grass is a recognised source of $n-3$ fatty acids (mainly linolenic acid) and α-tocopherol (Daza, Rey, Ruiz, & López-Bote, 2005; Rey, Daza, López-Carrasco, & López-Bote, 2006). Tocopherols are lipid soluble antioxidants which are accumulated in cellular membranes where the initiation of oxidative processes in muscle foods takes place. The protective role of tocopherols against lipid oxidation in Iberian dry-cured ham is manifested by a reduction of the generation of lipid oxidation products during ripening and improving some particular

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sensory characteristics such as flavour and odour intensity (Cava, 1999; Ruiz & López-Bote, 2002). According to findings by Ruiz, Ventanas, Cava, Andrés, and García (2000), the high-levels of intramuscular fat and oleic acid in Iberian hams are responsible for certain texture and appearance traits which influence consumer's acceptability such oiliness, brightness, juiciness and marbling.

Unfortunately, the traditional extensive feeding regime is not always feasible because the availability of the natural resources is largely influenced by environmental factors and therefore, is limited up to one pig per hectare. In fact, only half a million hams amongst the 2.6 million Iberian dry-cured hams produced per year are derived from free-range reared Iberian pigs. Therefore, it was necessary to develop alternative feeding systems which generally involve using mixed diets (López-Bote, 1998). In order to minimise costs, conventional mixed diets in semi-intensive conditions were used at the beginning which led to products with a considerably higher oxidative instability and lower nutritional and sensory quality (García et al., 1996; Timón, Martín, Petrón, Jurado, & García, 2001). The high-levels of linoleic acid in the green hams increased the incidence of 'floppy meats' and were responsible for the development of unpleasant flavour notes during the ripening process (Ventanas et al., 2005). Consequently, great efforts have been made in the last 10 years to improve the characteristics of the mixed diets in order to enhance the oxidative stability of the product and improve its nutritional and technological quality (Ruiz & López-Bote, 2002). Nowadays, Iberian pigs which cannot be fed outdoors, are raised in confinement and fed on oleic acid-enriched diets supplemented with α-tocopherol up to 200 mg/kg in order to imitate the favourable effects of the traditional extensive feeding system on Iberian dry-cured hams' quality (Daza et al., 2005; Isabel et al., 2003; Rey et al., 2004). However, dry-cured hams from free-range reared Iberian pigs are much more appreciated than those from pigs fed in confinement and the price of the former is twice as much as the price of the latter (35–50 €/kg versus 15–20 €/kg).

Findings by Daza et al. (2005) and Ventanas, Estévez, Tejeda, and Ruiz (2006) confirmed that muscles from Iberian pigs subjected to dietary supplementation with 200 mg/kg α-tocopherol contain similar levels of such antioxidant than those from free-range reared Iberian pigs. Also recently, Isabel et al. (2003) and Ruiz et al. (2005) reported the positive effect of feeding on MUFA-enriched diets on the levels of oleic acid in muscles from industrial genotype and Iberian pigs, respectively. However, no comparative study has been deliberately carried out to evaluate the effect of both feeding systems (traditional extensive versus mixed diets) on the chemical composition and oxidative stability of Iberian dry-cured hams. Likewise, the effect of such feeding systems on relevant sensory features in Iberian dry-cured hams is currently poorly understood.

The present study was carried out to evaluate the effects of the aforementioned feeding systems on the chemical composition and oxidative stability of Iberian dry-cured hams and their implications on technological, nutritional and sensory aspects.

2. Material and methods

2.1. Animals and sampling

This study was carried out with 30 Iberian pigs with an initial live weight of 80 kg. Pigs were divided into three batches ($n = 10$) according to the type of feeding during the finish-fattening period. The trial was carried out simultaneously for all groups of animals. The fattening period for HOVE and CON pigs lasted 60 days while MON pigs were fattened for 90 days in order to reach the same weight at slaughter as it is generally known that feed conversion and the average daily gain are lower in pigs fed outdoors.

MON pigs were free-range reared and exclusively fed on acorns and grass according to the traditional 'Montanera' feeding system. Each pig had an approximate space of 5 ha and the averaged temperature from November to February was 8 °C. According to estimations made on Iberian pigs with free access to the feeds, the average daily intake of acorns and grass is around 6 kg and 2 kg, respectively (Rey et al., 2006). The energy level provided by the acorns to the pigs is around 4.7 Mcal/kg (Nieto, Rivera, García, & Aguilera, 2002).

HOVE pigs were reared indoors and fed on a mixed diet containing high-oleic sunflower oil (57.5 g/kg of diet) and supplemented with 250 ppm of vitamin E (*all-rac*-α-tocopheryl acetate). The composition of the HOVE diet was as follows (mg/kg of diet): barley 48×10^4, wheat 15×10^4, wheat bran 15×10^4, soybean meal 8.5×10^4, beet pulp 5×10^4, sunflower high-oleic 5.75×10^4, calcium carbonate 9×10^3, calcium phosphate 7×10^3, sodium chloride 4×10^3, vitamin/mineral mix 5×10^3, mix vit E 250.

Finally, CON pigs were reared indoors and fed on a control mixed diet without added tocopherol and oleic acid fat. The control diet contained (mg/kg of diet): barley 15×10^4, wheat 50×10^4, corn 20×10^4, soybean meal 11.1×10^4, lard 1.2×10^4, calcium carbonate 8×10^3, calcium phosphate 1.1×10^4, sodium chloride 4×10^3 and vitamin/mineral mix 5×10^3.

Mixed diets and water were supplied to Iberian pigs ad libitum and the estimated average daily intake per Iberian pig was around 4.5 kg of mixed diet. Both mixed diets were isocaloric and provided around 3.3 Mcal/kg to the pigs.

Animals from the three batches were slaughtered by electrical stunning and exsanguinated at the same slaughterhouse at a live weight of around 140 kg. Pigs fed on mixed diets (HOVE and CON) and MON pigs were slaughtered one month part. No differences were observed between batches for carcass yield (80% in average). Sampling of hams was carried out within the hour following slaughter. Hams were removed from the carcasses and kept under refrigeration (24 h) before being subjected to the ripening process following the procedure described by García