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Nutritional and sensory quality of porcine raw meat, cooked ham and dry-cured shoulder as affected by dietary enrichment with docosahexaenoic acid (DHA) and α-tocopheryl acetate

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Abstract

The effects of dietary enrichment of pig diets with DHA from a marine source (*Algatrium*®) and α-tocopheryl acetate on the nutritional and sensory characteristics of pork and pork products were evaluated. Raw and cooked hams, and dry-cured shoulders from pigs fed with three diets (control, control supplemented with 0.3% DHA plus 50 ppm α-tocopheryl acetate and control with 200 ppm α-tocopheryl acetate) were used. The treatments did not cause any significant differences in proteolytic and antioxidant enzyme activities, except on catalase (CAT) which increased significantly in raw hams from pigs fed DHA supplemented diets. Vitamin E accumulated in samples with α-tocopheryl acetate supplementation. DHA added to the diet increased the DHA level by 87% compared with the control treatment in both raw and dry-cured shoulders, and exceeded 82% in cooked hams. In consequence, the incorporation of the $n-3$ source in the diet significantly reduced the $n-6/n-3$ ratio in all products. The ratio reduction ranged from 51% in dry-cured shoulders to 65% in cooked and raw hams.

No significant differences were found among treatments in the sensory parameters evaluated in the cooked hams. Fishy odour and flavour were not detected in any sample by the trained panel. However, reduced cured and aged flavours and a stronger fishy flavour were found in dry-cured shoulders from pigs on the DHA enriched treatment; while, α-tocopheryl acetate supplementation had negligible influence on flavour.

Keywords: DHA; Vitamin E; Raw meat; Cooked ham; Dry-cured shoulder; Dietary supplementation; Nutritional quality; Sensory quality

1. Introduction

There is strong evidence supporting the relationship between diet and cardiovascular diseases, obesity and cancer. Governments are promoting integrated policies and programmes to minimise these risks (AESA, 2005; WHO, 2003), and the scientific community is attempting to identify causative food compounds. Meat contributes to the human diet high quality proteins, essential minerals and vitamins, and is also an important source of fat. There is a tendency to produce leaner meat through breeding and feeding strategies, especially in pig production (Plastow et al., 2005). Currently, there is increased concern not only about the quantity but also about the composition of the fat. The importance of the balance between $n-6$ and $n-3$ polyunsaturated fatty acid (PUFA) in the diet has been established. The recommended ratio has been set at less than 4 (Mantzioris et al., 2000; Williams, 2000). In this sense, monogastric animals are a good model for nutritional studies by means of $n-3$ PUFA (α-linolenic acid, ALA, C18:3, eicosapentaenoic acid, EPA, C20:5 and docasahexaenoic acid, DHA, C22:6) supplemented diets because fat is incorporated unchanged into the tissues.

Changes in $n-3$ fatty acid composition could increase lipid oxidative processes causing the loss of nutritional,

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technological and sensory quality as well as the formation of potentially harmful compounds that compromise meat safety and reduce shelf life (Gray, Gomaa, & Buckley, 1996; Morrissey, Sheehy, Galvin, Kerry, & Buckley, 1998; for review: Wood et al., 2003). These effects could be minimised by addition of antioxidants to the feed which can protect meat against oxidation. In this sense, studies on the effects of dietary supplementation by natural antioxidants (α-tocopheryl acetate, β-carotene and lycopene) individually and in combination have confirmed the effectiveness of vitamin E in protecting meat against lipid oxidation (Carreras et al., 2004; Grau, Guardiola, Grimpa, Barroeta, & Codony, 2001; Maraschiello, Sárraga, & García Regueiro, 1999; Nam et al., 2003; Sárraga & García Regueiro, 1999; Young, Stagsted, Jensen, Karlsson, & Henckel, 2003).

Several works have suggested that fish oil supplementation is more efficient than vegetable fat in improving the production of $n-3$ PUFA enriched meat; especially in the case of poultry (Bou, Guardiola, Tres, Barroeta, & Codony, 2004; Enser, Richardson, Wood, Gill, & Sheard, 2000; Hulan, Ackman, Ratnayake, & Proudfoot, 1989; Kouba, Enser, Whittington, Nute, & Wood, 2003; Schreiner, Hulan, Razzazi-Fazeli, Böhm, & Moreira, 2005).

In addition to fatty acid composition, other aspects such as storage, handling, curing, ageing and cooking of meat can affect the extent of oxidative damage leading to the development of off-flavours. Sensory evaluation in combination with chemical analyses has been shown to be a suitable tool to evaluate some quality parameters (Arnau, Guerrero, & Sárraga, 1998; Guerrero, Gou, & Arnau, 1999; Kouba et al., 2003; Pieszka, Barowicz, Pietras, Migdal, & Kedzior, 2004; Ponnampalam, Trout, Sinclair, Egan, & Leury, 2001; Wistuba, Kegley, & Apple, 2006).

The aim of the present study was to evaluate the nutritional and sensory quality of raw meat, cooked ham and dry-cured shoulder made with meat from animals fed diets enriched with a marine source of DHA and α-tocopheryl acetate, emphasizing the stability of the compounds at the end of the elaboration processes. For these objectives proteolytic and antioxidant activities, thiobarbituric acid reactive substances (TBARS) and vitamin E levels, fatty acid composition, and sensory attributes were determined.

2. Materials and methods

2.1. Animals and dietary treatments

Fifteen females (20 kg of weight) of a Landrace based line were allocated to individual pens and housed indoors. The pigs were allowed ad libitum access to water and feed throughout the raising, which lasted 4 months. The basal diet contained lard as saturated fat and 15 ppm of vitamin E (Table 1). The animals were distributed randomly to three experimental treatments:

Table 1
Composition of the basal diets

Ingredient	Percentage
Barley	81.0789
Lard	4.000
Soya	12.0505
DL-Methionine	0.0816
L-Lysine	0.3049
L-Threonine	0.1138
Calcium carbonate	0.9689
Dicalcium phosphate	0.6649
Salt	0.3367
Minerals and vitamins[a]	0.4000

[a] One kilogram of feed contained the following: retinol, 1,720 μg; cholecalciferol, 2.5 μg; all-*rac*-α-tocopheryl acetate, 15 μg; menadione, 2 mg; thiamine, 1.3 mg; riboflavin, 3.5 mg; pyridoxine, 1.5 mg; cyanocobalamin, 25 μg; folic acid, 0.6 mg; biotin, 100 μg; calcium pantotenate, 10 mg; nicotinic acid, 15 mg; Mn, 30 mg; Zn, 6 mg; I, 0.75 mg; Fe, 60 mg; Co, 0.75 mg; Cu, 6 mg; Se, 0.1 mg; ethoxyquin, 150 mg.

1. Treatment 1 (T1): Control group fed only with the basal diet.
2. Treatment 2 (T2): Pigs were fed the basal diet where 15% of the lard was substituted by 0.3% of pure DHA from *Algatrium*® 50% (BRUDY S.L. Barcelona, Spain) as marine oil source and 50 ppm of α-tocopheryl acetate for 50 days approximately, covering the fattening period (from 60 to 100 kg of weight).
3. Treatment 3 (T3): Group fed the basal diet and 200 ppm of α-tocopheryl acetate during the fattening period.

Animal management and veterinary control were according to routine practice guidelines. They were slaughtered at a body weight of about 100 kg at the IRTA-Food Technology experimental abattoir. At 24 h post-mortem hams and shoulders were excised. The left ham of each carcass was used for raw material analyses and the right for cooked ham processing. Shoulders were dry-cured.

2.2. Cooked ham process

The hams were deboned and subcutaneous and intermuscular fat, connective tissue and rind were removed. Brine was injected into the pork legs to increase their weight by 21% and to obtain 0.3% pentasodium tripolyphosphate, 0.05% sodium ascorbate, 1.8% NaCl and 0.01% sodium nitrite after injection. Hams were then placed in a vacuum tumbler at 4 °C at a pressure of 200 mbar. The tumbling schedule was set for the hams to rotate a total of 2000 times at 14 rpm. After a 48 h maturation period, the hams were packed in bags (CN330, Sealed Air, Italy), and moulded in aluminium moulds and placed in a steam oven and cooked to an internal temperature of 66 °C using an external temperature of 68 °C.

2.3. Dry-cured shoulder process

Green shoulders were salted with a mixture of 40 g NaCl, 0.3 g KNO_3, 0.3 g $NaNO_2$, 0.6 g sodium ascorbate and 2 g